

Revolutionizing Contract Administration Web-Based Contract Management Services (WBCMS)

The Ministry of Transportation of Ontario (MTO) is revolutionizing contract management. With a transportation infrastructure network valued at over \$2 billion annually, MTO requires efficient information technology to effectively administer construction and operations work.

Managing the construction, maintenance and engineering service provider contracts in the Provincial Highways Management Division currently consists of a variety of labour-intensive paper-based methods of recording contract activities in diaries, spreadsheets and databases throughout the time span of each contract.

A Request for Proposals for the provision of Web-Based Contract Management Services (WBCMS) was issued in 2013. This innovative approach will result in a much more streamlined and efficient way of collecting, reporting, and validating data and creating many new efficiencies through transformation and automation of various related business processes.

What is it?

WBCMS is a sustainable solution that will provide an electronic means to capture field data, transmit and store data and provide reliable, complete information to decision makers.

The centrally located service will provide full contract lifecycle management functionalities through the entry and tracking of contract information, correspondence and documents.

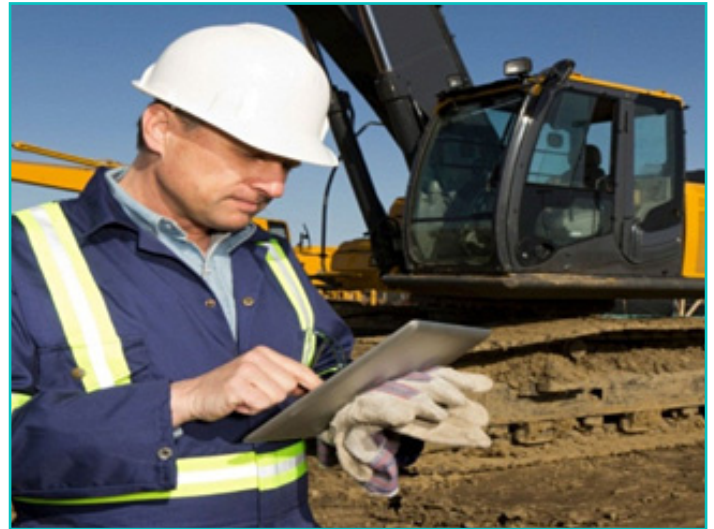
Service providers will be able to maintain digital diaries, electronically record daily activities, and refer to digital checklists, alerts, notifications and dashboards.

What's happened?

MTO has entered into an agreement with Aurigo Software Technologies Corp. to deliver a suite of Web-Based Management Services. The solution will offer a complete set of software, all hardware, facilities and services necessary to host and maintain the application.

Following launch in 2015, MTO, external service providers and the road-building industry will access the new system and its services through an internet browser where they can perform and electronically record activities associated with all contract administration functions.

"The Ministry of Transportation, Contract Management Office, is excited to launch this program to achieve significant efficiencies in all contract management functions," said Project Manager Sue Lefebvre.



WBCMS will revolutionize the contract administration functions of contract delivery.

Who will be using the service?

Internal MTO users as well as external service providers will utilize the centralized service through a subscription fee model.

MTO and its users will significantly benefit from this transformation, as the solution will ease the archiving and accessibility of vital contract documentation. This revolutionary change also supports environmental sustainability.

WBCMS Training

A certified training program will be provided for MTO and industry staff. The training will ensure a smooth and quick transition to the fully-automated solution.

Benefits:

- Streamline business processes
- Reduce risk of inaccuracy as a result of multiple data entries
- Improve consistency in oversight and reporting activities
- Improve overall accountability by easily tracking audit data
- Support environmental sustainability by reducing the number of paper-based documents •

For more information on WBCMS, contact the MTO Project Manager, Sue Lefebvre at Sue.G.Lefebvre@ontario.ca or (905) 704-2617

Deep in the Mire

Geophysical Test Methods Used for Characterizing Wetland Soil

Before the Ministry of Transportation (MTO) begins to design or construct structures or embankments near environmentally sensitive wetlands, subsurface conditions are assessed by collecting boreholes at each subject site. Knowledge of subsurface soil conditions and their engineering properties are required for the foundation design to ensure a stable structure. In 2012, the ministry partnered with various stakeholders to experiment with geophysical methods as alternatives to boreholes for soil profiling. It is expected that coupling borehole sampling with geophysical techniques will greatly improve the knowledge of subsurface soils especially within difficult to explore swamp areas.

The ministry uses borehole samples to obtain soil profile information, but borehole investigation has limitations. In order to provide adequate subsurface descriptions, the number of boreholes and their spacing need to be sufficient. Complex areas suspected of having irregular variations of soft clay over a firm bottom typically require additional boreholes. Collecting a large number of borehole samples to establish a subsurface model can sometimes be limited by factors such as drilling equipment access, environmental regulations, and obtaining permission to enter private property.

To mitigate these constraints, the ministry partnered with University of Waterloo and Thurber Engineering Ltd. to test new geophysical techniques and assess their potential to provide sufficient information on subsurface sediment and rock layers.

Geophysical techniques are non-invasive explorations that can be carried out from surface or from within the boreholes to image subsurface layers. They use energy and waves to remotely explore ground conditions. Since physical properties such as magnetism, density, electrical conductivity and elasticity vary depending on the type of soil, geophysical methods interpret stratigraphy, the relative position of strata and their relationship to geological chronology, by measuring and analyzing the change in physical properties of materials with depth. Geophysical methods have the potential to provide more sample points at less cost than conventional boreholes. A geophysical test setup for data acquisition can be performed within a relatively short duration as compared to a borehole investigation. Geophysical techniques are environmentally friendly and permit investigation in all seasons. Besides providing stratigraphical imaging, dynamic properties of subsurface soils can also be determined from geophysical

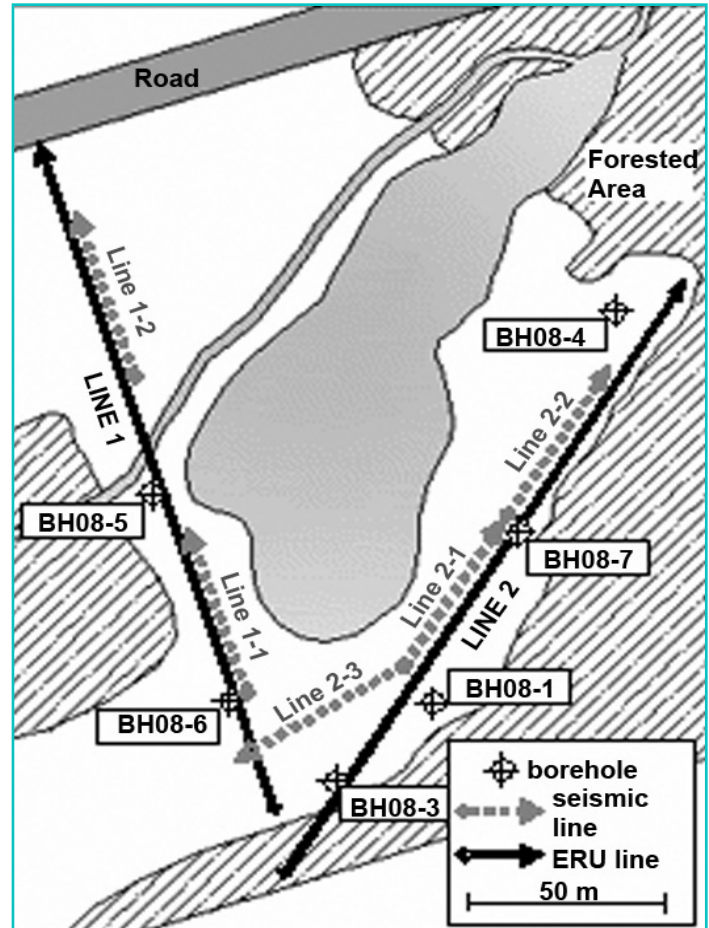


Figure 1: Survey line and borehole locations during geophysical method testing.

tests. The dynamic properties of soils are required for the analysis of any dynamic loading in geotechnical seismic design.

The accuracy and resolution of these techniques have improved significantly in recent years due to advances in equipment and data processing. Using geophysical test methods for shallow geotechnical investigations is increasingly valuable for detecting changes in sediment type and has been successfully used to delineate bedrock profiles even in complex geological environments.

In an effort to evaluate the effectiveness of these geophysical techniques, MTO selected an environmentally sensitive wetland area in Bowmanville, Ontario, along the Highway 407 east extension corridor as a study site. The project involved field measurements along two 188 m lines.➤

Geophysical Test Methods, continued

Line 1 ran south to north, passing west of a pond and ending near a road. Line 2 ran southwest to northeast along the southeast side of the pond (Fig. 1). This site was selected based on the findings from a borehole sample taken prior to testing, which suggested the presence of soft compressible soils covered by hard glacial till. Further, the site is located close to an environmentally sensitive wetland area.

Testing Methods and Procedure

Three methods known as electrical resistivity imaging (ERI), seismic refraction (SR), and multiple-channel analysis of surface waves (MASW) were performed to evaluate the effectiveness of geophysical methods for the geotechnical site characterization in environmental sensitive wetland areas.

Method 1: Electrical Resistivity Imaging (ERI)

The electrical resistivity-imaging test is accomplished by generating a current through the ground and measuring the resulting potential differences at the surface. The test requires many measurements, each of them involving four electrodes. Two electrodes introduce current flow into the ground and the two different electrodes measure the electrical changes in the ground due to the imposed current flow. The resistivity of a material is obtained by measuring potential differences. Increasing electrode spacing improves the current penetration depth. Data collected from the test are interpreted using inversion software, and a two-dimensional electrical resistivity structure of the ground below the survey line is generated.

To evaluate the ERI method, a 48-electrode switch system was used to obtain the resistivity measurements at the subject site. Electrodes were driven into the ground along a straight line at a selected spacing for each line (Line 1 and Line 2) with the resistivity meter positioned at the centre of the line. In addition to the two main lines, a higher resolution survey was performed on Line 2. This shorter length survey gave a shallower and more detailed indication of the resistivity structure of the upper stratigraphy over the middle part of Line 2.

Method 2: Seismic Refraction (SR)

The SR method measures the velocity of seismic waves (compression and shear waves) as they travel through different media at different velocities. The seismic refraction survey generates seismic waves and records their arrival times at numerous points on the ground surface. The SR requires an arrangement of equally spaced velocity transducers or geophones that measure vertical or horizontal motion and a seismic source such as a sledgehammer, weight drop or explosive charge. The SR surveys analyze the first arrival event at each geophone and the resulting data are presented as travel times versus distances.

The SR survey was conducted using a 48-channel seismograph and 48 horizontal geophones. Geophone sensitivities were verified by mounting them individually on a shaker and comparing the output response of each to an accelerometer attached to the geophone casing. Top soil was removed at the locations of the geophones and the seismic source to enhance the coupling of the transducers with the ground. Good coupling is required to increase the signal-to-noise ratio.

The SR survey was completed along five 47-metre lines: two along Line 1 and three along Line 2. The shorter line span was dictated by the geophone spacing necessary for the required depth resolution. The method required a 20 m clearance at each end of the transducer array for placement of the seismic source. A stream to the northwest of the pond interrupted Line 1. This resulted in only two seismic survey lines being completed along Line 1. Thick forest along the south border of the site required Line 2-3 alignment to deviate from Line 2 (Figure 1).

The seismic source was a 5 kg sledgehammer that generated S-waves by hitting a c-shaped steel plate in the direction perpendicular to the geophone line. The edges of the c-plate were partially inserted into the ground to enhance the coupling between the plate and the ground.

Seismic traces were collected at various source locations for each line. Source offsets were selected so sufficient refractions from the shallow and deep layers were obtained. For each source location, positive and negative polarity shear waves were generated by hitting the steel plate in opposite directions. Five blows on either side of the plate were recorded and stacked to improve the signal-to-noise ratio.

Method 3: Multiple-Channel Analysis of Surface Waves (MASW)

The MASW method uses dispersive nature of surface waves to evaluate soil profiles in multi-layered soils. When a seismic pulse is created on the ground surface most of the seismic energy travels in the form of surface waves. Surface wave velocity depends on the properties of the soil layers and the frequency of the pulse.

The depth of pulse penetration into the soil is a function of wavelength (wave velocity = frequency x wavelength), with longer wavelengths penetrating deeper. The penetration depth of a surface wave is commonly taken as one wavelength with most of its energy concentrated between the surface and a depth of one-third wavelength. High frequencies, or short wavelengths, propagate at the velocity of the upper layer whereas low frequencies, or large wavelengths, propagate at a velocity determined by the characteristics of subsequently deeper soil layers.

The MASW survey used the same test layout as described above for the SR method. It was completed with similar >

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equipment including 48-channel seismograph and low frequency geophones. Geophone spacing was 1 m for a total spread length of 47 m and again the top soil was removed from the selected source locations and geophone locations to enhance the coupling with the ground.

Different seismic sources were tested in a preliminary on-site investigation to select the best source for generating lower frequencies. The most effective seismic source was an 80-kg weight raised and dropped onto a steel plate using a tripod-pulley system.

Three source offsets were chosen on either side of the survey lines. Shorter offset distances were used to study the propagation of higher frequencies in shallower layers, whereas the larger offsets were used to study the propagation of lower frequencies in deeper layers.

Test Results and Discussion

Prior to the geophysical surveys, one borehole sample was obtained. Five more borehole samples were collected following the geophysical investigation. A cone Penetration test (CPT) was completed at four of the borehole locations. The subsurface information obtained from the borehole investigation revealed that the site is underlain by a soft silt and clay layer, a more competent sand and silt layer, and a soft silt clay overlying the very dense till deposit.

The MASW method identified the inversion of soft and stiff soils and gave the best indication of the layering in the area. The maximum average error in the evaluation of the depth of the hard layer was 30% when compared to the borehole information. The MASW method predicted depth to till less accurately than ERI. Using a source that generates higher energy in the lower frequency spectrum may help increase the depth resolution for this method.

Results from each geophysical test were analyzed and compared to the data from the boreholes. Among the three tested methods, the ERI survey results show the most accurate prediction of the depth of till layer with less than

19% error. However, the ERI resolution was not sufficient to accurately predict the upper strata. Electrical conductivity is affected by porosity, degree of saturation, concentration of dissolved electrolytes in the pore water, temperature of the water in the pore spaces, and amounts of clay minerals and colloidal material, making it difficult to determine the physical characteristics of soils or rocks from resistivity surveys alone.

The depth of the till layer could not be obtained accurately using SR survey due to the presence of a relatively stiff sand and silt over a soft silty clay layer. One significant limitation of the seismic refraction survey is the inability to determine inverse layering, or wave velocity decreasing with depth. The SR method overestimated the till depth.

Information from the three geophysical test methods assisted in evaluating the depth of the hard layer, with errors between 10 and 23 per cent. On average, the till layer depth is underestimated compared with the values from borehole information. The transition zone between the silty clay layer and the hard till layer is stiff enough to generate a significant increase in shear wave velocities, resulting in the geophysical methods detecting the till layer before the borehole data does.

Future use of Geophysical Testing for MTO Projects

Test results showed the three geophysical methods have potential to provide accurate and cost-effective subsurface modeling of soils and the depth to a competent layer. They are capable of successfully indicating depth to a competent layer when compared to borehole samples at the study site. These test methods have the potential to bridge information gaps between boreholes when borehole drilling is constrained by various factors. ●

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In Partnership

For the geophysical experiments, the ministry partnered with University of Waterloo for geophysical investigations and evaluation; Thurber Engineering Ltd., for logistics and field support during test measurements; and Zahid Khan for test results evaluation.
