MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 94-93-00
Highway 63, Township of Widdifield
Lees Creek Culvert

MEL Ref. No.: 05/05/05041-F June 12, 2006

Submitted to:

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1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by Earth Tech (Canada) Inc., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation for GWP 94-93-00. The general work project is located on Highway 63 from 35.7 km south of Highway 533, Northerly 18.9 km to 16.8 km south of Highway 533, from LHRS 34120 o/s 0.0 to LHRS 34133 o/s 4.7. Highway 63 is an undivided two lane Rural Arterial King's Highway (RAU100). The posted speed on this highway is 80 km per hour. This 65.4 km thoroughfare intersects at its south end with Highway 17B/11B (North Bay - Main Street), and runs generally in a northerly direction to the Ottawa River Bridge (E Channel), at the Ontario/Québec Boundary. The highway serves several small communities along its route.

Lees Creek presently crosses Highway 63 through three 1828 mm x 1422 mm CSPA culverts (see Figure No. 1: Plan and Profile). It is understood that these culverts were installed in the 1960’s, with extensions placed in the 1980’s. The culverts are to be replaced as part of the work project. Presently, it is proposed to replace the existing three culverts with two 2.4 m x 1.5 m precast concrete box culverts maintaining a ±700 mm cover.

The terms of reference for the scope of work are outlined in MEL’s proposal 05/05/05041-F dated October 28, 2005. The purpose of the investigation was to determine the subsurface conditions in the area of the culvert and provide foundation recommendations for culvert replacement and restoration of the highway embankment to proper cross-sections.

MEL investigated the foundation area by the drilling of boreholes (employing hollow stem augers), carrying out in-situ tests, and performing laboratory testing on selected samples. Based on the information recovered from this program and our interpretation of the conditions that were encountered at the subject site, we have provided comments and recommendations on the geotechnical aspects of the culvert replacement, along with discussions on excavations, fills and embankment design.

Plans and centerline profiles for Highway 17, in the area of the foundation investigation, were provided by Earth Tech (Canada) Inc. Prior to commencing the fieldwork, stations and offsets in the area of the foundation investigation were surveyed and painted on the pavement by others and this field data, along with existing drawings, was incorporated in preparation of the plans and profiles presented in this report. The locations of the boreholes are referenced to chainage painted in the field and the borehole elevations were established relative to centerline grade. The plan and profile information for the foundation area is presented on Figure No. 1. Stratigraphic information contained on the noted figure is based on our evaluation of conditions encountered in the field.

2.0 SITE DESCRIPTION

The location of the centerline culverts on Highway 63 is Station ± 12+975, Township of Widdifield, within the City of North Bay limits, some ±3 km east of the junction of Highway 63 and Highway 17B/11B.

2.1 Physiography and Surficial Geology

This Highway 63 project is located within limits of the geomorphic sub-province known as the Eastern Sandy Uplands. The topography at the site is generally rolling. There are exposed bedrock ridges; at some locations significant layers of earth overlay the bedrock. Within the project area overburden conditions consist primarily of sand containing varying amounts of silt, occasionally overlain by organic (peat) deposits.

The highway embankment is elevated above the surrounding topography in the investigation area by ±1 to 2 meters. The land to the north and south of the highway is developed residential and commercial respectively.

2.2 Existing Conditions

At Station ± 12+975, Township of Widdifield, there are three 1828 mm x 1422 mm CSPA centreline culverts oriented in a north-south direction. The culverts are approximately ±23 m in length and water flow through the culverts is in a north to south direction at this location. During site inspection, it was noted that the vertical alignment of the existing culverts was true, indicating that culvert settlement, which could be related to poor, weak subgrade conditions, has not developed. It is reported that the culverts were installed in the 1960's with extensions installed in the 1980's.

The vertical alignment of the centreline of the existing embankment was reviewed in the area of the existing culverts and did not show signs of excessive settlement or distortion which would trigger settlement or stability concerns. The existing embankment slopes are at approximately a 2.5H:1V slope at the culvert location. The slopes show no signs of instability.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out over a two (2) day period, during the early part of December 2005 and consisted of a total of four (4) sampled boreholes.

The field investigation was carried out using a Bombardier mounted CME 45B drilling rig, operated by MEL and supervised by a Senior Technician, Mr. E. Sullivan, of MEL. The drilling rig was equipped with hollow stem augers and all routine geotechnical sampling equipment. The boreholes were advanced using 165 mm O.D. continuous flight hollow stem augers or 110 mm O.D. continuous flight standard augers. Soil samples were obtained at regular intervals of depth (where possible) using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures or by sampling directly from the auger flights, generally at depths less than 1.0 m. At select boreholes, a Dynamic Cone Penetration Test (DCPT) was carried out to give a continuous plot of the soil resistance with depth. Maximum exploration depth by auger was 11.3 m at BH No. 2 and 13.4 m by DCPT at BH No. 2.

Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes and a temporary standpipe was installed in select boreholes for the duration of the drilling operation. A set of water level observations were taken prior to removal of any temporary standpipe. All open boreholes were backfilled upon completion with the auger cuttings, in the order they were removed, using reverse augering techniques. Where necessary, additional imported granular fill was used to backfill the upper portion of the hole to grade.

The fieldwork for this investigation was under the full time direction of a Senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included natural water content determination, grain size analysis (sieve and/or hydrometer) and Atterberg Limits. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B) with a summary of results presented on the laboratory sheets in Appendix C (Figures L-1 to L-4).

The location of the individual boreholes were established in the field using previously painted highway chainage and offset from existing highway centerline.

4.0 SUBSURFACE CONDITIONS

Details of subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. 1 (Appendix C). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, and the results of SPT, plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location.

4.1 Foundation Area: Culvert at ± 12+975, Widdifield Twp.

A plan and profile showing the borehole locations and stratigraphic sequences is shown on Figure No. 1. During the course of our exploration program, four (4) sampled boreholes were put down at four (4) locations at this site (Borehole Nos. 1, 2, 3, and 4). Borehole Nos. 2 and 4 were put down through the highway embankment on the north and south sides, respectively. Borehole Nos. 1 and 3 were put down near the ends of the existing culvert on the south and north ends respectively.

Borehole Nos. 2 and 4 were advanced from the left and right shoulder respectively. A surficial layer of asphalt was penetrated at BH No. 2, some 40 mm thick. Underlying the asphalt, and from the surface of BH No. 4, a deposit of crushed gravel was penetrated to depths of some 500 and 300 mm respectively. A thin surficial layer of grass and silty organics some 50 mm thick was present at the location of BH No. 3. Underlying these deposits and from the surface of BH

No. 1 a deposit of sand fill was penetrated. This deposit consisted of brown fine to medium sands trace to some silt and trace to with gravel. At BH Nos. 2 and 3, the fill deposit was found to contain occasional cobbles/boulders based on the drill response. At BH No. 1 and 3, a thin layer of organics some 50 mm thick was observed at a depth of some 0.3 m and 1.5 m respectively, the presumed underside of the fill layer. At BH No. 2, pieces of wood were observed at a depth of some ±2.5 m (elevation ±202.7 m) and the fill deposit turned to black in color at a depth of ±3 to 3.2 m. The sand fill encountered at the location of BH No. 4 was very similar in appearance to the underlying sand deposits and the fill interface was estimated to be at ±3 m depth based on SPT N values. Grain size analysis was carried out on four samples of the embankment fill and indicated 3 to 31% gravel size particles, 64 to 92% sand size particles, and 5 to 9% silt and clay size particles. The specific distribution curves are shown on the Summary of Grain Size Analysis Graph (Appendix C, Figure L-1). It must be noted that the standard split spoon is 37.5 mm inside diameter, as such gradation results do not reflect the coarse gravel, cobble, and boulder size content. The natural moisture content in these samples was measured at 5 to 25%. Standard Penetration Test “N” values recorded in conjunction with the split spoon sampling within this stratum returned values of 4 to 32 blows per 300 mm penetration, indicating a compactness of loose to compact in the embankment fill, although the higher N values are likely a result of the presence of cobbles in the fill deposit.

Underlying the fill at each of the boreholes a deposit of brown to grey sand was penetrated. This deposit consisted of fine to medium sand trace to some silt and trace gravel. Grain size analysis was carried out on six samples of the sand deposit the results of which indicated 0 to 4% gravel size particles, 81 to 97% sand size particles, and 3 to 18% silt and clay size particles. The specific distribution curves are shown on the Summary of Grain Size Analysis Graph (Appendix C, Figure L-2). The natural moisture content in these samples was measured at 18 to 30%. Standard Penetration Test “N” values recorded in conjunction with the split spoon sampling within this stratum returned values of 3 to 23 blows per 300 mm penetration, with an average of 9, indicating a compactness of loose to compact.

At the location of BH No. 2, at a depth of some 9.4 m (elevation 195.8 m), an interbedded stratum of silt and clay with occasional fine sand seams was observed that was some 600 mm thick. Below this depth (i.e. 10 m), occasional brown silt and clay seams were observed in the samples of the sand deposit. One gradation analysis was carried out on a sample of the silt and clay stratum, the results of which indicated 0% gravel size particles, 6% sand size particles, 46% silt size particles, and 48% clay size particles. The specific distribution curves are shown on the Summary of Grain Size Analysis Graph (Appendix C, Figure L-3). Atterberg Limits determinations carried out on one sample from this stratum indicate a CI (Inorganic Silty Clay of Medium Plasticity) designation with a Plastic Limit of 21.2% and a Liquid Limit of 38.3% (see Appendix C, Figure No. L-4). The natural moisture content in this sample was measured at 20%.

Sampling in each of the boreholes was terminated in the sand deposit at depths ranging from ±9.1 m (elevation ±194.4 m) at BH No. 1 to ±11.3 m (elevation ±193.9 m) at BH No. 2.

DCPT were driven from the surface adjacent to BH Nos. 1 and 2. The DCPT were terminated at depths of ±11.9 and 13.4 m respectively (elevations ±191.6 and 191.8 m) without encountering refusal.

4.2 Groundwater Conditions

Groundwater levels were recorded in Borehole Nos. 1, 2 and 3 at elevations 202.8, 203.4, and 203.3 m, respectively. The water level in the culvert (i.e. top of ice) was recorded at ±1.3 m below the obvert (elevation ±203 m) in March of 2006. Water levels will fluctuate seasonally.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

Lees Creek flows under Highway 63, at approximately Station 12+975, through three 1828 mm x 1422 mm CSPA culverts each of which is some ±23 m in length. Flow in the creek is in a north to south direction discharging into Trout Lake. It is understood that the culverts were installed in the 1960's with extensions placed in the 1980's. A review of the vertical alignment of the existing culverts indicates no sign of appreciable distortion/settlement along the obvert. The existing longitudinal alignment of the highway embankment over the culvert location was reviewed and did not reveal any sags or distortions which would be indicative of deep deposits of weak/compressible soils. It is proposed to replace the three culverts with precast concrete box culverts.

This section of the report provides our recommendations on the foundation aspects of design for the culvert(s). A foundation investigation was carried out at this location to obtain sufficient subsurface information to verify design assumptions and provide adequate subsurface descriptions to provide recommendations for culvert replacement. It must be noted that the interpretations and recommendations are intended only for use by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects that could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction method and scheduling.

5.2 Existing Conditions

At the culvert location, the embankment is approximately ±1 to 2 m higher than the ground surfaces to the north and south of the embankment respectively. Based on the embankment cross section through the culvert location provided by ET, the existing embankment has side slopes of approximately 2.5H:1V. Visual observations indicate these embankment slopes are stable. Based on our soils exploration program in the vicinity of this culvert, the embankment consists of granular fill overlying a natural deposit of sand. The sand was found to have a varying silt content and, at depth in one of the borings, occasional seams of silt and clay were observed.

Flow of the creek is controlled by three 1828 mm x1422 mm CSPA culverts each of which is some ±23 in length. No significant structural problems, other than aging, have been reported at this culvert system. It is proposed to replace the existing three culvert system with two, 2.4 m by 1.5 m precast concrete box culverts. The total effective opening area of the two box culverts will be approximately the same as existing. The top of the box culverts will be established at a similar elevation as the obvert of the existing culverts (i.e. some ±700 mm below the road surface). It is further proposed to leave one of the outside culverts in place during the replacement operation to allow the contractor to control the flow in the creek during construction.

The width of the highway alignment in the area of the culvert is fairly wide due to the presence of turn tapers. It is proposed to use the wider embankment at this location to allow continual flow of traffic during the replacement operations. The culvert replacement will be carried out as a continuous operation and traffic will be controlled by traffic control personnel as per Book 7. It is anticipated the operation will be completed in one, possibly two, days. No embankment construction for a detour will be required. The wider embankment in this area will allow the slopes of open excavations to be cut back to the geometry required by the OHSA. As such, a roadway protection system (i.e. shoring, etc.) is not anticipated. The vertical alignment at the culvert and along the embankment will essentially remain constant, or increase slightly (order of ±100 mm or less), to allow for proposed highway improvements.

Based on visual observations, the existing embankment is stable and does not exhibit any signs of distress that would indicate problems with settlement or embankment slippage. Frost heaving has not been reported at this location.

5.3 Foundations

The obvert of the existing culverts is at approximately ±700 mm below the centerline grade (i.e. elevation ±204.3 m) and the invert of the existing culvert is at approximately elevation ±202.9 m. Allowing for the thickness of the new bedding material (i.e. ±300 mm), the thickness of the bottom of the box culvert (i.e. ±200 mm) as well as a fill layer placed in the culvert bottom (i.e. ±300 mm), general excavation will be required to a minimum elevation of ±202.1 m. At this depth, the base of the excavation will encounter the underlying native brown to grey sand deposit. Based on the borehole data, at this depth, it is not anticipated that any deleterious materials will be encountered however, the contractor must be prepared to remove any organic pockets or cobbles/boulders protruding from the subgrade and replace with culvert bedding. Considering the “good” performance of the existing culverts with respect to settlement, we don’t anticipate that there will be any significant settlement of the new, slightly heavier box culverts, provided subgrade stability is maintained during construction. The thin silt and clay layer was encountered at a significant depth at BH No. 2 and will likely not influence the replacement operations or the new culvert system.

The embankment fill and underlying natural sand are considered Type 3 soils in accordance with the Occupational Health & Safety Act (OHSA) and Regulations for Construction Projects. As noted previously, the wider alignment in this area will allow temporary construction slopes of 1H:1V constructed in the embankment granular fills, provided adequate groundwater control is carried out.

Excavation, at a minimum, must be carried out locally to the underside of the culvert bedding at elevation ±202.1 m. Small, local excavations can be carried out at the ends of the culvert for placement of the cutoff walls if installed.

The water level in the culvert (i.e. top of ice) was measured at elevation ±203 m in March of 2006. It is proposed to control flow of water in the creek by diverting the water through one of the existing culverts and removing the other two. It is imperative that the groundwater pressures be controlled in the excavation under all circumstances in order to maintain a stable temporary open excavation face and a stable subgrade. As noted, the groundwater level was encountered at elevations ranging from ±202.8 m to 203.4 m during this investigation and the top of ice was measured at elevation ±203 m in March of 2006. Dependent upon the time of year the replacement operations are undertaken, it may be possible to control the groundwater in the excavation using the conventional construction method of pumping from filtered sump holes in the excavation base provided the head of water is ±1 m or less. If, at the time of construction, the water table level is higher, it will be necessary to use a more sophisticated groundwater control system, such as a well point system that surrounds the excavation. A deep well system is not considered a feasible option as it would impact a substantial area with higher risk due to radial extent of impact. Ultimately, groundwater control is the responsibility of the contractor and may vary depending upon their method of operation, experience, equipment, scheduling, etc. However, at a minimum, the groundwater control system must be engineered by a dewatering specialist and proposed method must be submitted for review by the Contract Administration before planned commencement of this operation. As part of the groundwater control system, cofferdams will be required at the ends of the existing culvert to isolate the excavation area. Special Provision No. 902S01, dated March 2005, covering excavation, backfilling, and dewatering should be included in the contract package.

Based on the results of gradation analysis of the existing embankment materials, frost tapers will not be necessary.

5.4 Design Bearing Resistance

Based on the above noted soil conditions, the culvert bedding will be supported on loose to compact sands. Once the bedding bearing surface is exposed, the subgrade should be proofrolled with a minimum of five passes of a heavy walk behind type vibratory compactor capable of operating in a non-vibratory (static) mode. The bedding layer can then be placed on the properly prepared subgrade and compacted as per OPSS 501. For this bearing surface we have determined a factored ultimate bearing resistance at ULS of 150 kPa. A SLS bearing resistance of 80 kPa reflects settlement considerations of 25 mm or less. The above values consider that the 300 mm thick bedding layer is properly proof rolled and leveled, with the middle third of the bedding left in an uncompacted state, prior to placement of the precast culvert sections and the subgrade is not unduly disturbed during construction.

5.5 Culvert and Embankment Fills

Refer to OPSS 422 and OPSD 803 for general requirements for backfill and cover for concrete culverts. Bedding for the box culverts shall consist of Granular 'A'. The bedding layer shall be 300 mm thick, with the upper 100 mm of the bedding acting as a leveling course and compacted as per OPSS 501. Culvert cover shall be a minimum of 300 mm thick. The cover material may be either granular materials or native materials, depending on the site conditions. If native backfill is used, it must be free of any cobbles greater than 100 mm in size. The native soil at this site is classified as Group I. If at the time of construction it is found that the native earth backfill material cannot be properly placed and compacted, granular backfill may be used. If the native material is not used, culvert backfill material should be Granular 'B' Type I.

The ends of the culvert (inlet and outlet) should be provided with rip rap (OPSS 511) or wing walls to protect the slope face from erosion at the intersection with the culvert and to reduce/eliminate the development of flow paths along the outside face of the culvert and the resultant risk of internal erosion within the embankment. A Class II Geotextile with an F.O.S. of between 50 to 100 μm should be used below the rock protection layer as this material will be used elsewhere on the project.

The existing embankment is constructed with predominately granular fills with occasional cobble and boulder sizes, as such the final embankment side slopes should be set at a stable angle of 2H:1V or shallower. Newly exposed earth cut slopes should be covered with top soil and seeded as soon as practical. Based on the MTO Manual, Aspects of Prolonged Exposure of Pavements to Sub-Zero Temperatures, the depth of frost penetration used for design on this project shall be 2.0 m. The actual frost depth may vary.

Once the new box culverts are installed and operational, the old culvert used to temporarily control the creek flow must be properly decommissioned. If the old culvert is left in place it should be filled with non-shrink fill (i.e. grout) to prevent the culvert from collapsing in the future, resulting in potential settlement in the highway embankment. Alternatively, the old culvert can be removed. Backfill to the trench post removal of the culvert can either be native materials, provided they are at an appropriate moisture content to allow for compaction, or alternatively, Granular B Type I can be used.

The reconstruction of the pavement structure is detailed in the Pavement Design Report produced for this work project by Merlex Engineering Ltd. under separate cover.

6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

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