

TECHNICAL MEMORANDUM

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Date	March 2, 2011		

Subject Windsor Essex Parkway Project
Bridge B-8: Preliminary Geotechnical Recommendations for Alternative
Design Option using Concrete Box Structure – Rev.0

As requested by Biljana Rajlic, we examined the geotechnical aspects for an alternative concrete box option for Bridge B-8. The proposal design for Bridge B-8 (in WEMG proposal) involved a rigid frame structure founded on deep end bearing piles. It is understood that an alternative option involving a box structure founded on native soil is being considered. The geotechnical assessment in this memo was intended to provide the designers with information to assess and design the foundation and other components of the proposed box structure.

The geotechnical assessment of the alternative design option is based on the geotechnical information (subsurface soil and groundwater conditions and soil property interpretations) obtained from investigations carried out previously by Golder Associates Ltd. for the RFP phase. In this regard, the comments and recommendations presented below are subjected to revision once the proposed site specific soil information becomes available.

The proposed box structure has been assumed to be a single rigid frame box with 11.9 m inside width and 6.5 m inside height. The invert elevation (i.e., the base slab surface inside the box) was assumed at 174.0 m. It is anticipated that the structure will be constructed using a cast-in-place concrete box section. For the purposes of geotechnical modeling and design the construction and loading stages for this structure were assumed as follows:

- a) Temporary excavation to approximately 9.5 m below grade
- b) Construction of the concrete structure of an assumed weight of 1235 kN/lineal meter of bridge width
- c) Completion of side drainage and backfill behind the abutments
- d) Completion of the pavement layer (assumed as a distributed load of 15 kPa) over the bottom slab.

1. FOUNDATIONS

- All topsoil and other deleterious materials are to be completely removed from the footprint area of the structure so that it is founded directly on the competent native soils.
- Based on the earlier subsurface information and the proposed structure invert, the box structure may be founded in the stiff grey silty clay at or below elevation 172.5 m (assuming 1.5 m thick concrete base).
- The grey silty clay within the zone of influence below elevation 172.5 m has firm to stiff (generally stiff) consistency and is considered to be suitable for supporting the proposed box structure. A net factored geotechnical resistance at Ultimate Limit States (ULS) of 130 kPa may be used during construction (before completion of the backfill behind the abutments). A total factored geotechnical resistance at ULS of 275 kPa is available at end of construction. A net geotechnical reaction (net soil stress increase) of 100 kPa at Serviceability Limit States (SLS) (based on a 25 mm allowable post-construction settlement) may be used in the preliminary structural design.
- Any low areas should be brought to grade using granular engineered fill or lean concrete fill. The footing excavations should be inspected in accordance with OPSS 902.
- A preliminary stress and deformation analysis was conducted on a structure – subgrade soils model. The model used in the stress and deformation analysis is shown in Figure 1. The analysis indicated the following stress-deformation behavior at the base of the structure foundation:

Construction Stage	Unfactored Average Bearing Pressure (kPa)	Average Total settlement (mm) ⁽¹⁾	Average Incremental settlement (mm)
Completion of the concrete structure	90	23	23 ⁽²⁾
Completion of Backfilling behind abutments	160	40	17 ⁽³⁾
Completion of pavement structures	185	43	3 ⁽³⁾

Notes:

(1) Settlements are measured relative to the reference base represented by the stabilized finished subgrade elevation (bottom of finished excavation)

(2) The estimated settlement is anticipated to occur during concreting

(3) These are settlements anticipated to occur after the concrete structure has been completed

- Structural deflections of raft type foundations (base slab of the box may be modeled using the modulus of subgrade reaction (MSR) method or other recognized approach. The MSR is a theoretical parameter and is not a unique property of the soil. Its value depends on many factors, such as the size and shape of the foundation, the type and thickness of the underlying soil, the relative stiffness of the foundations and the soil, the duration of loading relative to the hydraulic conductivity of the loaded soil, and the like. The value of modulus of subgrade reaction can also vary from one point to another beneath a foundation (i.e. centre, edge or corner) and can change with time, in particular for soil with low hydraulic conductivity. Therefore, both geometry and time scale effects are important and need to be appropriately taken into account. In general, the value of subgrade reaction modulus decreases with increasing size of the loaded area on a soil subgrade. Based on the stress and deformation analysis results summarized in table above, a value of vertical modulus of subgrade reaction of about 5 MPa/m may be used for the initial stages of structural analysis. This MSR is only for the structural slab design under permanent distributed loads. In the case of point live loads, a MSR of 25 MPa/m may be considered for the base slab design. These modulus values should be reviewed once the proposed structural design details are available to ensure that the recommended values remain consistent with the structure geometry, applied loadings and upcoming new information from proposed geotechnical investigation at the structure site.

2. FROST PROTECTION

Frost treatment is to be symmetrical about the box structure centreline and provided in accordance with Ontario Provincial Standard Drawing (OPSD) 803.010.

3. EXCAVATION AND TEMPORARY CUT SLOPES

- Excavations will likely encounter surficial layers of topsoil and some deleterious materials, and will be extended into the stiff silty clay. All excavation works should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities and should follow the guidelines outlined in OPSS 902. The native soils would be classified as Type 3 soils.
- The slope stability analyses for temporary open cut slopes were carried out using Slope/W Version 2007, the Morgenstern-Price method of analysis and circular failure surfaces. A minimum calculated factor of safety (FS) value of 1.3 has been adopted as the criterion. Based on the analyses, temporary open cut slopes should be maintained no steeper than 1 horizontal to 1 vertical with a 4 to 5 m bench if the excavation depth is greater than 7 m. The model used for the preliminary slope stability design is shown in Figure 2.
- The recommendations provided herein are based on the assumptions that (a) the temporary slopes are properly protected at all times against surface erosion due to

runoff, desiccation, freeze-thaw effects, etc., and (b) the duration of the slope exposure is in general limited to 4 to 5 months.

- Based on the results of the stress and deformation analysis, a basal heave after excavation for box construction was estimated to be about 65 millimeters.

4. BACKFILLING

- The cast-in-place box structure is to be backfilled in accordance with OPSD 803.010. Granular fill should be placed in the zone behind the walls in accordance with the Canadian Highway Bridge Design Code CAN/CSA-S6-06 (CHBDC). Beyond this granular backfill a select clay backfill may be used under the direction of a geotechnical engineer. According to the Code, granular backfill materials should consist of free-draining, non-frost susceptible granular materials. A synthetic insulation with drainage blanket and site generated clay fill behind the walls may be an alternative option to the granular backfilling.
- Heavy compaction equipment should not be used immediately adjacent to the walls of the structure. The height of backfill adjacent to the structure walls should be maintained at approximately the same level on both sides of the walls during all stages of backfill placement. Effects of backfill compaction activities should be simulated as live load over and above the static lateral earth pressure for structural design in accordance with the Canadian Highway Bridge Design Code CAN/CSA-S6-06.
- The postconstruction settlement of box structure is estimated to be about 20 mm. This movement does not include deformations caused by seasonal temperature and moisture variations.

5. LATERAL EARTH PRESSURE

- The lateral pressures acting on the box structure walls will depend on the backfill soils, the type and method of placement of the backfill materials behind the walls, the nature of soil behind the backfill, the magnitude of surcharge including construction loadings, the drainage conditions behind the walls and the subsequent lateral movement of the structure.
- Compaction equipment should be used in accordance with Special Provision 105S10. Other surcharge loadings should be accounted for in the design, as required.
- The pressures are based on the backfill as placed and the following parameters (unfactored) may be assumed:

Parameter	<u>Group I Soils</u>	<u>Group II Soils</u>	<u>Group III Soils</u>
Fill unit weight:	22 kN/m ³	21 kN/m ³	20.5 kN/m ³
Coefficients of static lateral earth pressure:			
'active' or unrestrained, K_a	0.27-0.30	0.30-0.35	0.35-0.45
'at rest' or restrained, K_o	0.45-0.50	0.50-0.55	0.60-0.70

Group I Soils: Coarse grained soils (e.g. Granular A and B Type 2)

Group II Soils: Finer grained than Group I noncohesive soils (e.g. Granular B Type1, pitrun, etc)

Group III Soils: Finer grained soils (e.g. approved site generated silty clay).

- If the wall support allows lateral yielding (unrestrained structure), active earth pressures may be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

The recommendations in this memo are for preliminary purposes of the option evaluation only. The detailed geotechnical recommendations will be provided after additional soil information at the structure site becomes available.

NR/dd/nsv

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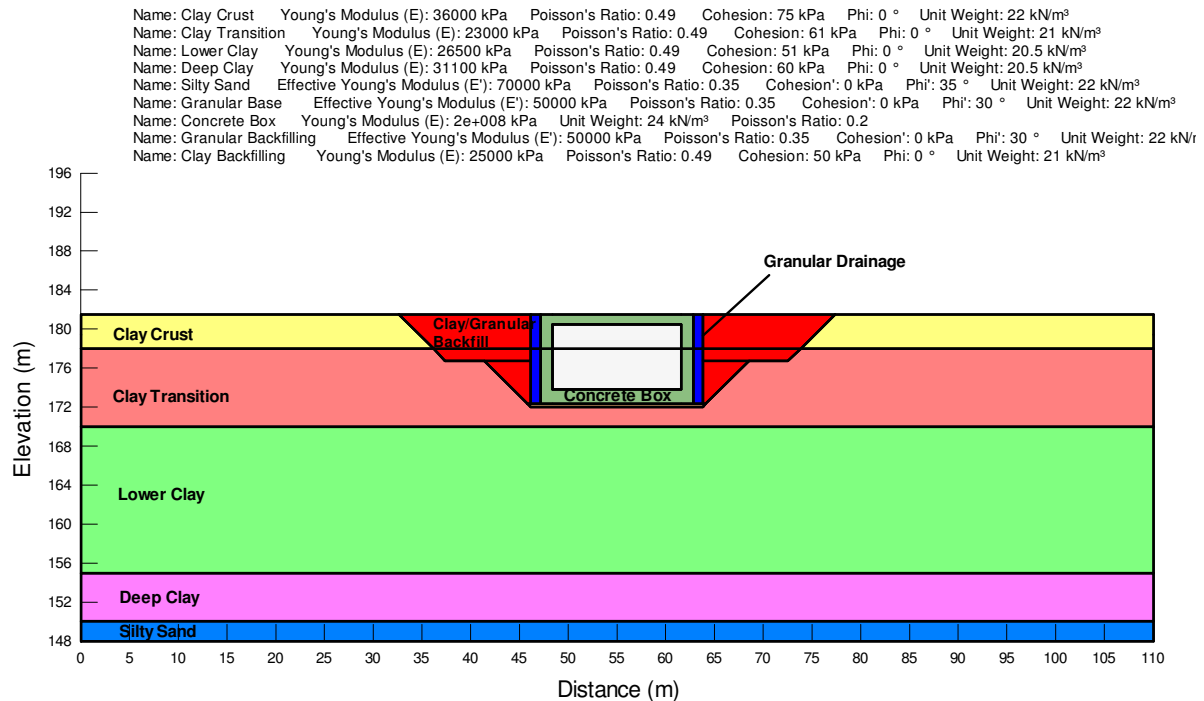


Figure 1: Stress-Deformation Model for Concrete Box Structure B-8.

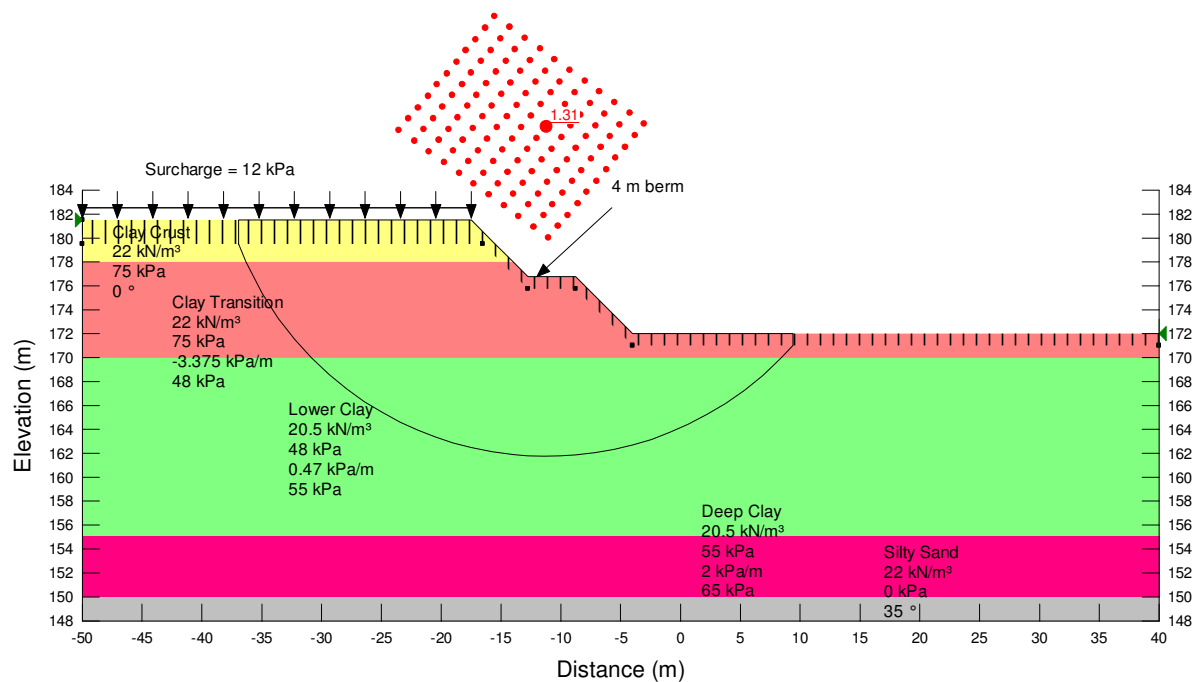


Figure 2: Slope Stability Model of Temporary Excavation for Concrete Box Structure B-8.