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## FACSIMILE/ MAIL TRANSMISSION

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**Pages To Follow: 5**

**RE: BEARING AND EARTH PRESSURE/ RESISTANCE PARAMETERS**
**PROPOSED BRIDGE FOUNDATIONS**
**AND REINFORCED-CONCRETE RETAINING WALLS**
**3707 DOLLARTON HWY - NORTH VANCOUVER, BC**

## 1.0 TERMS OF REFERENCE

Further to our ongoing correspondence with David Nairne & Associates (DNA) and our Updated Geotechnical Investigation Report (dated September 4, 2011), the following provides preliminary geotechnical parameters for input to the structural design of the above elements. The ongoing design process can be expected to be iterative in nature. Furthermore, field review confirmation by the respective engineers-of-record will be required during construction.

## 2.0 SUBSURFACE CONDITIONS

During our recent test-pitting investigation (Nov.22/11), the observed soil conditions were in conformance with our subsurface data observations during the original investigation.

In the vicinity of the proposed bridge foundations, the stratigraphy generally consisted of 1 m to 1.5 m thickness of the combined UNIT 1 and 2 soil layers (ie. Topsoil and Compact Sand, respectively) overlying the dense UNIT 3 till-like sand deposit.

The following recommendations are based this estimated stratigraphy.

## 3.0 BEARING CAPACITY

Subject to field verification during construction, the above-described UNIT 3 undisturbed, native, dense, till-like sands are considered suitable for support of foundations, based on the Limit States bearing capacities described below.

Minimum pad footing dimensions of 0.6 m (2.0') and minimum strip footing widths of 0.45 m (1.5') are recommended. It is recommended that foundations be placed a minimum of 0.45 m (18") below the adjacent final exterior grade for frost protection. Foundations within the approved subgrade should step at no more than 1.0 vertical to 2.0 horizontal (1V:2H).

As discussed in our Investigation Report (Sept.4/11), local subsurface water is expected to primarily perch on the till-like sand. Nonetheless, an associated factored (ie. 0.5) bearing capacity/ resistance of 180 kPa (3760 psf) at Ultimate Limit State (ULS) would be applicable to the undisturbed, till-like sand subgrade. A bearing capacity of 100 kPa (2090 psf) would be applicable under the Serviceability Limit State (SLS).

As shown in Table 1, 5% damped horizontal spectral acceleration values are defined for a range of periods for the subject property.

**Table 1 – Surface Spectral Response – Local Ground Motions**

| Period (sec) | 0.2 | 0.5 | 1.0 | 2.0 |
|---|---|---|---|---|
| Spectral Acceleration* (g) | 0.88 | 0.61 | 0.33 | 0.17 |

From a geotechnical stand-point, it is judged that surface spectral response would be expected to correspond most closely to Site Class C. Hence, the tabulated ground motions would not be modified (ie. $F_a$=1.0), and Spectral Response would correspond to the tabulated values. The locally applicable Peak Ground Acceleration (PGA) would be 0.44 g.

## 4.0 PROTECTION OF BRIDGE FOUNDATIONS

Scour of foundations will require consideration. Ideally, structural spans should allow foundations to be placed at elevations beyond the points on the creek banks corresponding in elevation to the 200-year level creek flows. It should be remembered that the creek flows may also be subject to increased flow levels due to higher levels of runoff as urbanization of upslope areas increases.

Even if foundation supports are placed beyond this flood elevation, protection consisting of suitably sized Rip Rap or alternative protection schemes such as “Eco-Wrap” (by Deltalok) should be implemented (due to considerations such as increased neighbourhood densification).

## 5.0 SLIDING & PASSIVE RESISTANCE

As discussed with DNA (B.Fortier, P.Eng), structural walls may require inclusion of a foundation 'key' element to increase resistance to sliding forces.

To mobilize the passive resistance of a soil, strain must occur at the structure/soil interface. The tabulated coefficients (in Table 2, below) correspond to allowable structural displacements. These required displacements are summarized as rotation magnitudes, which are quantified as strain as a function of the contact depth (i.e., the embedded depth of the foundation key within the undisturbed, dense, till-like sand subgrade). It is imperative that the Client contact PECI to confirm the presence of the undisturbed, till-like sand at the time of excavation. For design purposes, it is suggested that an effective unit weight of 19 $kN/m^3$ be used for the dense till-like sand.

**Table 2: Design Passive Earth Pressure Coefficients**

| Allowable Foundation Element Rotation [% Strain as a function of Embedded Depth of Key] | Passive Earth Pressure Coefficient (Kp) Dense Till-like Sand (Resisting Soil Deposit) |
|---|---|
| 0 | 1.0 |
| 2 | 3.0 |
| 4 | 4.0 |
| 6 | 6.0 |

## 6.0 LATERAL PRESSURES

Our lateral pressure estimates assume that backfill does not slope more than 10°. When considering limit states, it should be noted that these lateral pressures are not factored.

### *6.1 General*

The lateral earth pressure on below-grade walls depends upon a number of factors, including the backfill material, surcharge loads, backfill slope, drainage, rigidity of the wall, and method of construction including sequence and degree of compaction.

The lateral pressure estimates below **include hydrostatic components** to account for elevated groundwater levels. If the foundation is to be drained (eg. suitable quantity of free-draining backfill, pumping, etc), then the estimates below can be reduced by an amount corresponding to the hydrostatic pressure, which is highlighted in italic text. If it is not possible to provide continuous drainage behind the wall, hydrostatic pressure should be assumed to act over the full depth of the wall; the hydrostatic pressure is additive to the static design lateral earth pressure.

The lateral earth pressure estimates provided below assume that the area behind the wall is horizontal and no adjacent structures or surcharges are situated within a horizontal offset from the base of the wall corresponding to a line projected at 3 Vertical to 2 Horizontal (3V:2H) from the base of the wall. Furthermore, the following design parameters are based on the assumption that all applicable walls will be backfilled with clean, granular, free-draining material such as Engineered Fill (described below).

### *6.2 Static Design*

**Unrestrained Condition**

For walls that can displace laterally an amount equivalent to 0.2% (min.) of the wall height, the condition is considered to be 'unrestrained'. For the unrestrained condition, we recommend that the wall be designed on the basis of a 16.2 x h (kPa) (ie. 6.4 x h + *9.8 x h* triangular earth pressure distribution where 'h' is the distance from the ground surface measured in metres). In imperial units this corresponds to 103 x h (psf), where 'h' is measured in feet.

**Restrained Condition**

If a 'restrained' condition is present (eg. some basement walls) then we recommend that the wall be designed on the basis of a 19.4·h (kPa) (ie. 9.6·h + *9.8·h*) triangular earth pressure distribution where 'h' is the distance from the ground surface measured in metres. In imperial units this corresponds to 124·h (psf), where 'h' is measured in feet.

### *6.3 Compaction-Induced Pressure*

If the backfill is to support settlement-sensitive structures, it will require compaction. For this condition, a compaction-induced, uniformly-distributed, lateral earth pressure of 20 kPa can be used in the uppermost approximate 3 m. In imperial units this corresponds to a uniformly-distributed, compaction-induced earth pressure of 400 psf in the top approximate 10 ft.

### *6.4 Base Friction*

It is envisioned that sliding resistance for footings would be derived from the undisturbed, till-like sand subgrade. A friction factor of 0.35 may be applied between the concrete and sand subgrade interface.

### *6.5 Seismic Design*

Seismic loading conditions can be assumed to represent an additional triangular pressure at the top of the wall that decreases to zero at the base of the wall. The seismic surcharge pressure can be assumed to be 3.2·(H-h) kPa, where 'h' is the distance from the top of the wall and 'H' is the total wall height in metres. In imperial units this corresponds to 20·(H-h) (psf), where the measurements are in feet.

The seismic loading is added to the static loading, but the compaction-induced loading represents a superimposed loading condition. Consequently, the maximum lateral earth pressure at any point over the depth of the wall would be the **greater of**:

***1.) For the Unrestrained Condition:***

- 3.2·H + 13·h (kPa) [i.e., the sum of 16.2·h (static) and 3.2·(H-h) (dynamic)], and
- 20 kPa (ie. compaction-induced pressure).

In imperial units, this amounts to:

- 20·H + 83·h (psf) [i.e., the sum of 103·h (static) and 20·(H-h) (dynamic)], and
- 400 psf (ie. compaction-induced pressure).

and,

***2.) For the Restrained Condition:***

- 3.2·H + 16.2·h (kPa) [i.e., the sum of 19.4·h (static) and 3.2·(H-h) (dynamic)], and
- 20 kPa (ie. compaction-induced pressure).

In imperial units, this amounts to:

- 20·H + 104·h (psf) [i.e., the sum of 124·h (static) and 20·(H-h) (dynamic)], and
- 400 psf (ie. compaction-induced pressure).

## 7.0 REVIEW & CLOSURE

The design process for bridge foundations is expected to be iterative in nature. As such, the above recommendations will be refined, as further consultation with the project team takes place.

Subsurface conditions will require verification during construction in accordance with the District of North Vancouver's Letters of Assurance. Our design information is based on test-pit data, our local experience and local geological data. Field reviews will be required to confirm that soil conditions are consistent with those estimated in this document. In accordance with the District of North Vancouver's Letters of Assurance, the Geotechnical Engineer-of-Record ("G.E.R.") shall be contacted to carry out field reviews for the following items:

- temporary excavation stability,
- foundation and retaining wall subgrades,
- stability of permanent slopes,

- excavation shoring, and
- Engineered Fill selection and placement.

Please feel free to contact us, if you have any questions.

**PUAR ENGINEERING CONSULTANTS INC**
**Per:**

**Surinder Puar, P.Eng.**
**Principal**

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