AGENCY OF TRANSPORTATION **OFFICE MEMORANDUM**

To: Wendy Pelletier, P.E., Structures Project Manager

From: Marcy Meyers, Geotechnical Engineer, via Callie Ewald, P.E., Geotechnical Engineering Manager

Date: May 11th, 2016

Subject: Johnson BF 0248(4) – Geotechnical Recommendations

1.0 INTRODUCTION

Per your request, we have calculated geotechnical design parameters to be used in the retaining wall design for the Johnson BF 0248(4) project. This is an addendum report to the original geotechnical report provided by Clough Harbour & Associates (CHA) dated December 2015, which includes a summary of the subsurface investigation, boring logs, and design recommendations for a soldier pile and lagging wall. Since that report was written, the retaining wall concept was adjusted from a designed soldier pile and lagging wall to the contractor's choice of a wall system off of the Agency's list of approved retaining systems. We recommend a wall from either the Rigid Gravity and Semi-Gravity Walls or from the Prefabricated Modular Gravity Wall sections of the approved system selection chart. Provided herein are the geotechnical design parameters to be included in the plans for use by the wall designer. Design parameters were calculated in accordance with the 2014 AASHTO LRFD Bridge Design Specifications Manual.

2.0 DESIGN PARAMETERS

The retaining wall located along the northeast corner of Bridge No. 2 is anticipated to be founded on bedrock. The following design parameters assume the wall will be bearing on a competent bedrock surface throughout the length of the wall.

As per Section 10.5.5.1 of the 2014 AASHTO LRFD Bridge Design Specifications, a resistance factor of 1.0 should be applied to the unfactored bearing resistance for use in service limit state design. Service limit state design includes, but is not limited to, settlement and scour. Section 10.5.5.2.2 specifies that a resistance factor of 0.45 should be applied to the unfactored bearing resistance for use in strength limit state design for spread footings on rock.

Strength limit state design includes, but is not limited to, checks for bearing resistance, sliding, and constructability. Potential for overturning is limited by controlling the location of the resultant of the reaction forces (eccentricity). Eccentricity, e, shall be limited as follows:

Foundations on rock: $|e| < 0.45b$

Eccentricity should be considered for settlement and bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3.

The bedrock at this site had fair to excellent rock quality designation. Classified as hard, slightly weathered phyllite, AASHTO recommends a presumptive bearing resistance of 70 ksf per Table C10.6.2.6.1-1. Taken as the nominal bearing resistance, in combination with a resistance factor of 0.45 for spread footings on rock, per AASHTO 10.5.5.2.2-1, this yields a factored bearing resistance of 31.5 ksf. These values are summarized below in Table 2.1.

Table 2.1 Recommended Bearing Resistance Values

Nominal Bearing Resistance (ksf)	Resistance Factor, ϕ	Factored Bearing Resistance (ksf)
70	0.45	31.5

It is recommended that any incompetent, weathered and fractured bedrock encountered during construction be removed until competent bedrock is encountered. During excavation, the Agency's Geologist should inspect the ledge to determine the amount and extent of excavation needed. If uneven bedrock contours are encountered, the concrete subfootings should be stepped along the existing bedrock in order to transfer the footing pressure directly to the bedrock.

2.1 Settlement and Scour: Due to the footing bearing directly on bedrock, settlement is anticipated to be negligible. Due to the close proximity of the wall to the stream, the final wall should be designed assuming all of the soil in front of the wall is removed in the full scour condition.

2.2 Resistance Factors: Sections 10.5.2 and 10.5.3 of AASHTO outline all design states relevant to spread footing design and their respective resistance factors. Eccentricity should be considered for bearing resistance design of spread footings by using effective footing widths based on AASHTO Section 10.6.1.3. Table 2.2 shows the appropriate resistance factors for various design states.

Table 2.2 Resistance Factors for Design States

Design State	Resistance Factor, ϕ
Service (Scour)	1.0
Strength (Bearing Resistance)	0.45
Sliding	0.80

Additional sliding resistance can be accomplished by doweling the footing into bedrock.

2.3 Retaining Wall Selection: A conceptual plan (end result) approach to retaining wall solicitation is recommended for all wall systems except conventional reinforced concrete walls and bin walls in which case detailed plans should be included in the bidding documents.

In accordance with the Agency standard practice, projects containing earth retaining structures (except conventionally reinforced concrete and bin walls) shall use a concept drawing approach, i.e. fully detailed set of retaining wall plans will not be contained in the bidding documents. The design shall meet the requirements the 2014 AASHTO LRFD

Bridge Design Specifications. The concept drawing, furnished in the bidding documents will contain the following geometric and design project specific information:

A. Geometric
   1. Beginning and end of wall stations.
   2. Elevations on top of wall at beginning and end of wall station as well as all profile break points.
   3. Original and proposed ground line profiles in front of and behind the retaining wall.
   4. Cross sections at the retaining wall location at 24 foot intervals.
   5. Horizontal wall alignment.
   6. Details of wall appurtenances such as traffic barriers, coping, fencing, drainage, location and configurations of signs and lighting including conduit locations.
   7. Right of way limits.
   8. Construction sequence requirements if applicable, including traffic control, access, and stage construction sequences.
   9. Elevation of highest permissible level for foundation construction. Location, depth and extent of any unsuitable material to be removed and replaced.
   10. Quantities table showing estimated square feet of wall area, and quantity of appurtenances and traffic barriers.

B. Design
   1. Shear strength and consolidation properties of foundation soils.
   2. Shear strength and unit weight of select backfill.
   3. Shear strength of random fill or in-situ soil behind the wall.
   4. Required design life of the structure (example: permanent mechanically stabilized earth walls are commonly designed, based on corrosion, for minimum service lives of 75 years).
   5. Nominal bearing resistance for the foundation soil/rock and minimum footing embedment depth.
   6. Maximum tolerable total and differential settlement.
   7. Magnitude, location and direction of external loads due to bridges, overhead signs and lights, traffic surcharge and rapid groundwater draw down.
   8. Limits and requirements for drainage features beneath, behind, or through the retaining structure.
   9. Backfill requirements for both within and behind the retaining structure. (Both material and placement requirements should be specified, i.e., gradation, plasticity index, electrochemical, soundness, maximum loose lift thickness, minimum density and allowable moisture content).
   10. Special facing panel and module finishes or colors.

Geometric, geotechnical and structural considerations must be complementary for the conceptual plan to convey the desired end product to the bidders. In general, the specifications should refer to the Agency's list of Approved Wall Systems in following link. http://vtransengineering.vermont.gov/sites/aot_program_development/files/documents/materialsandresearch/MandRSoilAPPROVED_Retaining_Walls_8-2012_Final.pdf.

3.0 RECOMMENDATIONS

A maximum factored bearing resistance of 31.5 ksf is recommended for design purposes for the spread footings on bedrock. It is recommended that any incompetent, weathered, and fractured bedrock be removed to competent bedrock. If necessary a concrete subfooting should be poured. The bottom of footing elevations for the retaining wall should be stepped to maintain acceptable contact with the bedrock surface.

3.1 Construction Considerations

3.1.1 Cofferdams/Temporary Earthwork Support: The Contractor should be reminded that Section 208.07 of VTrans' *2011 Standard Specifications for Construction* indicates that "The Contractor shall prepare detailed plans and a schedule of its operation for each cofferdam specified in the Contract. The design and structural details of the cofferdam shall be signed, stamped, and dated by a Professional Engineer (Structural or Civil)."

3.1.2 Construction Dewatering: The bottom of footing elevation for the retaining wall is assumed to be below the expected water table. Therefore, temporary construction dewatering may be required to construct the foundation. Temporary dewatering will also be necessary to limit disturbance to and maintain the integrity of the bearing surface.

Temporary dewatering can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. Sumps should be provided with filters suitable to prevent pumping of fine-grained soil particles. The water trapped by the temporary dewatering controls should be discharged to settling basins or an approved filter "sock" so that the fine particles suspended in the discharge have adequate time to "settle out" prior to discharge. All effluent, or discharge, should comply with all applicable permits and regulations.

3.1.3 Placement and Compaction of Soils: Fills should be placed systematically in horizontal layers not more than 12 inches in thickness, prior to compaction. Cobbles larger than 8 inches should be removed from the fill prior to placement. Compaction equipment should preferably consist of large, self-propelled vibratory rollers. Where hand-guided equipment (such as a small vibratory plate compactor) is used, the loose lift thickness shall not exceed 6 inches. Cobbles larger than 4 inches should be removed from the fill prior to placement.

General embankment fills should be compacted to a dry density of at least 95% of the maximum dry density determined in accordance with AASHTO T-99. The current specification calls for 90%, however we are in the process of revising it to be 95% as recommended above. Granular Backfill for Structures, or other select materials placed within the roadway base section shall be compacted to a dry density equal to 95% of the maximum dry density as determined in accordance with AASHTO T-99.

3.2 Design Parameters: Table 3.1 highlights the geotechnical design parameters of the foundation bearing bedrock as well as regularly specified aggregates. These values should be

used when designing the substructure units. It is recommended that values of K_o be used for calculating earth pressures where the structure is not allowed to deflect longitudinally, away from or into the retained soil mass. Values for K_a should be utilized for an active earth pressure condition where the structure is moving away from the soil mass and K_p where the structure is moving toward the soil mass. The design earth pressure coefficients are based on horizontal surfaces (non-sloping and backfill) and a vertical wall face.

Table 3.1 Engineering Properties of Construction Materials

	703.01A - Granular Borrow	**704.08 - Granular Backfill for Structures**	**In-Situ Bedrock**
Density (lb/ft^3):	130	140	160
Internal Friction Angle, φ (degrees)	32	34	27
Coefficient of Friction, f			
- concrete cast against soil/rock:	0.45	0.55	0.70
- soil against formed concrete:	0.40	0.45	N/A
- Precast concrete against CIP subfooting	N/A	N/A	0.4*
Active Earth Pressure Coefficient, K_a:	0.31	0.28	0.38
Passive Earth Pressure Coefficient, K_p:	3.25	3.54	2.66
At-Rest Earth Pressure Coefficient, K_o:	0.47	0.44	0.55

*It should be noted that this value assumed a frictional surface beween the cast in place subfooting and precast concrete structure. The contact surface should be formed with a rough pattern to allow for proper adhesion.

4.0 CONCLUSION

Please feel free to contact us at (802) 828-2561 if you have any questions or you would like to further discuss this report. We recommend this report be included with the contract documents.

cc: Read File/DJH
Project File/CEE
MLM