PART 1 - GENERAL

1.1 RELATED SECTIONS

.1 Section 01 74 21 - Construction/Demolition Waste Management And Disposal.

.2 Section 01 33 00 - Submittal Procedures.

1.2 REFERENCES

.1 American Society for Testing and Materials (ASTM)

   .1 ASTM D 4791-99, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

1.3 SAMPLES

.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

.2 Allow continual sampling by Department's Designated Representative during production.

.3 Provide Department's Designated Representative with access to source and processed material for sampling.

.4 Pay cost of sampling and testing of aggregates, which fail to meet specified requirements.

.5 Provide water, electric power and propane to Department's Designated Representative's laboratory trailer at production site.

1.4 WASTE MANAGEMENT AND DISPOSAL

.1 Divert unused granular materials from landfill to local quarry as approved by Department's Designated Representative.

PART 2 - PRODUCTS

2.1 MATERIALS

.1 Aggregate quality: sound, hard, durable material free from soft, thin, elongated or laminated particles, organic material, clay lumps or minerals, or other substances that would act in deleterious manner for use intended.

.2 Flat and elongated particles of coarse aggregates: to ASTM D 4791.

.1 Greatest dimension to exceed 5 times least dimension.

.3 Coarse aggregates satisfying requirements of applicable section to be one of or blend of following:

.1 Crushed rock.
.2 Gravel composed of naturally formed particles of stone.

2.2 SOURCE QUALITY CONTROL

.1 Inform Department's Designated Representative of proposed source of aggregates and provide access for sampling at least 3 weeks prior to commencing production.

.2 If, in opinion of Department's Designated Representative materials from proposed source do not meet, or cannot reasonably be processed to meet, specified requirements, locate an alternative source or demonstrate that material from source in question can be processed to meet specified requirements.

.3 Advise 2 weeks in advance of proposed change of material source.

.4 Acceptance of material at source does not preclude future rejection if it fails to conform to requirements specified, lacks uniformity, or if its field performance is found to be unsatisfactory.

PART 3 - EXECUTION

3.1 PREPARATION

.1 Aggregate source preparation

.1 Prior to excavating materials for aggregate production, clear and grub area to be worked, and strip unsuitable surface materials. Dispose of cleared, grubbed and unsuitable materials as directed by the Department's Designated Representative.
.2 Clear, grub and strip area ahead of quarrying or excavating operation sufficient to prevent contamination of aggregate by deleterious materials.

.2 Processing

.1 Process aggregate uniformly using methods that prevent contamination, segregation and degradation.
.2 Blend aggregates, if required, to obtain gradation requirements, percentage of crushed particles, or particle shapes, as specified. Use methods and equipment approved by the Department’s Designated Representative.
.3 Wash aggregates, if required to meet specifications. Use only equipment approved by the Department’s Designated Representative.
.4 When operating in stratified deposits use excavation equipment and methods that produce uniform, homogeneous aggregate.

.3 Handling

.1 Handle and transport aggregates to avoid segregation, contamination and degradation.

.4 Stockpiling

.1 Stockpile aggregates on site in locations as indicated unless directed otherwise by the Department’s Designated Representative. Do not stockpile on completed pavement surfaces.
.2 Stockpile aggregates in sufficient quantities to meet Project schedules.
.3 Stockpiling sites to be leveled, well drained, and of adequate bearing capacity and stability to support stockpiled materials and handling equipment.
.4 Except where stockpiled on acceptably stabilized areas, provide compacted sand base not less than 200 mm in depth to prevent contamination of aggregate. Stockpile aggregates on ground but do not incorporate bottom 200 mm of pile into Work.
.5 Separate different aggregates by strong, full depth bulkheads, or stockpile far enough apart to prevent intermixing.
.6 Do not use intermixed or contaminated materials. Remove and dispose of rejected materials as directed by Department’s Designated Representative within 48h of rejection.
.7 Stockpile materials in uniform layers with maximum thickness of 1.5m.
.8 Uniformly spot-dump aggregates delivered to stockpile in trucks and build up stockpile as specified.

.9 Do not cone piles or spill material over edges of piles.
.10 Do not use conveying stackers.
.11 During winter operations, prevent ice and snow from becoming mixed into stockpile or in material being removed from stockpile.

3.2 CLEANING

.1 Leave aggregate stockpile site in tidy, well drained condition, free of standing surface water.
.2 Leave any unused aggregates in neat compact stockpiles as directed by the Department's Designated Representative.

PART 1 - GENERAL

1.1 RELATED SECTIONS

.1 Section 01 33 00 – Submittal Procedures.

.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

.3 Section 01 56 00 – Temporary Barriers and Enclosures.

.4 Section 01 35 43 – Environmental Procedures.

.5 Section 31 32 19.01 – Geotextile.

.6 Section 02 41 16 – Structure Demolition.

.7 Section 31 05 16 – Aggregate Material.

1.2 REFERENCES

.1 American Society for Testing and Materials International (ASTM)

- .1 ASTM C 117-95, Standard Test Method for Material Finer than 0.075 mm (No.200) Sieve in Mineral Aggregates by Washing.
- .2 ASTM C 136-96a, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
- .3 ASTM D 422-98, Standard Test Method for Particle-Size Analysis of Soils.
- .4 ASTM D 1557-00, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ^{3}) (2,700 kN-m/m ^{3}).
- .5 ASTM D 4318-00, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- .6 ASTM C 127-88(2001), Standard test Method for Specific Gravity and Absorption of Coarse Aggregate.
- .7 ASTM C 535 96e1, Standard Test Method for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

.2 Canadian General Standards Board (CGSB)

- .1 CAN/CGSB-8.2-M88, Sieves, Testing, Woven Wire, Metric.

1.3 SUBMITTALS

.1 Samples

.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit to Department's Designated Representative at least 4 weeks prior to beginning Work, the proposed source of supply of backfill material and ensure access for sampling purposes.

1.4 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.5 EXISTING CONDITIONS

.1 Protect existing Work in accordance with Section 01 56 00- Temporary Barriers and Enclosures, and with the local regulations that apply.

.2 Buried services:

.1 Size, depth and location of existing utilities and structures are indicated for guidance only. Drawings are not necessarily complete and accurate.
.2 Prior to beginning excavation work, notify Owner or applicable authorities and determine location of buried utilities and structures.
.3 Confirm locations of buried utilities by careful test excavations.
.4 Maintain and protect from damage, water, sewer, gas, electric, telephone and other utilities and structures encountered.
.5 Where utility lines or structures exist in area of excavation, obtain direction of Department's Designated Representative before removing or re-routing.
.6 Record location of maintained, re-routed and abandoned underground lines.
.7 Confirm locations of recent excavations adjacent to area of excavation.

.3 Existing buildings and surface features:

.1 Conduct, with the Department's Designated Representative, condition survey of existing buildings, trees and other plants, lawns, fencing, service poles, wires, rail tracks, pavement, survey bench marks and monuments which may be affected by Work.

.2 Protect existing buildings and surface features from damage while work is in progress. In event of damage, immediately make repair as directed by the Department's Designated Representative.

PART 2 - PRODUCTS

2.1 MATERIALS

.1 Fill material from any type:

.1 Gradations to be within limits specified when tested to ASTM C 136. Sieve sizes to CAN/CGSB-8.2.

.2 Following gradation must be respected:

Dimensions	% Passing
Less than 250 mm	85
Less than 150 mm	50
Less than 50 mm	15

.2 Selected unfrozen material from excavation, demolition or underwater dredging, approved by the Department's Designated Representative for intended use and free from waste or other deleterious materials.

Concrete from demolition will be used as all-type 0-300 mm after crushing according to required particle size and free of reinforcing bars and any other steel element.

PART 3 - EXECUTION

3.1 SITE PREPARATION

.1 Remove obstructions, ice and snow, from surfaces to be excavated within limits indicated.

3.2 STOCKPILING

.1 Stockpile fill materials in areas designated by the Department's Designated Representative. Stockpile granular materials in manner to prevent segregation.

.2 Protect fill materials from contamination.

3.3 COFFERDAMS, SHORING, BRACING AND UNDERPINNING

.1 Construct temporary Work, if required in trenching areas.

.2 During backfill operation:

- .1 Unless otherwise indicated or directed by the Department’s Designated Representative remove falsework and shoring from excavations.
- .2 Pull shoring in increments that will ensure compacted backfill.

.3 Upon completion of substructure construction: Remove cofferdams, shoring and bracing. Remove excess materials from site

3.4 DEWATERING AND HEAVE PREVENTION

.1 Keep excavations free of water while Work is in progress.

.2 Protect open excavations against flooding and damage due to surface run-off.

.3 Dispose of water in accordance with Section 01 35 43 - Environmental Procedures in a manner not detrimental to public and private property, or portion of Work completed or under construction.

3.5 EXCAVATION

.1 Excavate to lines, grades, elevations and dimensions as indicated in drawings.

.2 Remove obstructions encountered during excavation if not recoverable for backfilling.

.3 Excavation must not interfere with bearing capacity of adjacent foundations.

.4 For trench excavation, unless otherwise authorized by the Department’s Designated Representative in writing, do not excavate more than 30m of trench in advance of installation operations and do not leave open more than 15m at end of day's operation.

.5 Keep excavated and stockpiled materials at safe distance away from edge of trench as directed by the Department’s Designated Representative.

.6 Restrict vehicle operations directly adjacent to open trenches.

.7 Dispose of surplus and unsuitable excavated material off site.

.8 Earth bottoms of excavations to be undisturbed soil, leveled, free from loose, soft or organic matter.

.9 Notify the Department's Designated Representative when bottom of excavation is reached.

.10 Obtain the Department's Designated Representative's approval of completed excavation.

.11 Remove unsuitable material from trench bottom including those that extend below required elevations to extent and depth as directed by the Department's Designated Representative.

.12 Correct unauthorized over-excavation as follows:

  .1 Fill under areas and compact to not less than 95% of maximum dry density or to the satisfaction of the Department's Designated Representative.

.13 Hand trim, make firm and remove loose material and debris from excavations. Where material at bottom of excavation is disturbed, compact foundation soil to density at least equal to undisturbed soil.

.14 Install geotextile in accordance with Section 31 32 19.01 – Geotextiles.

3.6 FILL TYPES AND COMPACTION

.1 Use type of fill as indicated or specified below. Compaction densities are percentages of maximum densities obtained from ASTM D 1557.

3.7 BEDDING AND SURROUND OF UNDERGROUND SERVICES

.1 Place and compact granular material for bedding and surround of underground services as indicated.

.2 Place bedding and surrounding material in unfrozen condition.

3.8 BACKFILLING

.1 Do not proceed with backfilling operations before the Department's Designated Representative has inspected and approved installations.

.2 Areas to be backfilled to be free from debris, snow, ice, water and frozen ground.

.3 Do not use backfill material which is frozen or contains ice, snow or debris.

.4 Place backfill material in uniform layers not exceeding 300 mm compacted thickness up to indicated grades. Compact each layer before placing succeeding layer. The 0-75mm will be compacted to 95% of M.P., except in marine environment and otherwise specified by the Department's Designated Representative. All types shall be compacted with the mean of 4 caterpillar passages of maximum weight of 30 tons.

3.9 RESTORATION

.1 Upon completion of Work, remove waste materials and debris in accordance to Section 01 74 21 - Construction/Demolition Waste Management and Disposal, trim slopes, and correct deficiencies as directed by the Department's Designated Representative.

.2 Clean and reinstate areas affected by Work as directed by the Department's Designated Representative.

PART 1 - GENERAL

1.1 RELATED SECTIONS

.1 Section 01 33 00 - Submittal Procedures.

.2 Section 31 23 33.01 - Excavating, Trenching and Backfilling.

1.2 REFERENCES

.1 American Society for Testing and Materials International, (ASTM)

.1 ASTM D 4491-99a, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-4.2 No. 11.2-M89(April 1997), Textile Test Methods - Bursting Strength - Ball Burst Test (Extension of September 1989).

.2 CAN/CGSB-148.1, Methods of Testing Geotextiles and Complete Geomembranes.

.1 No.2-M85, Methods of Testing Geosynthetics - Mass per Unit Area.
.2 No.3-M85, Methods of Testing Geosynthetics - Thickness of Geotextiles.
.3 No.6.1-93, Methods of Testing Geotextiles and Geomembranes - Bursting Strength of Geotextiles Under No Compressive Load.
.4 No.7.3-92, Methods of Testing Geotextiles and Geomembranes - Grab Tensile Test for Geotextiles.
.5 No. 10-94, Methods of Testing Geosynthetics - Geotextiles - Filtration Opening Size.

1.3 SUBMITTALS

.1 Submit samples in accordance with Section 01 33 00 – Submittal Procedures.

.2 Submit to Department’s Designated Representative at least 2 weeks prior to beginning Work a sample of at least 30 cm x 30 cm.

.3 Submit to Department’s Designated Representative 2 copies of mill test data and certificate at least 2 weeks prior to start of Work, and in accordance with Section 01 33 00 - Submittal Procedures.

1.4 DELIVERY, STORAGE AND HANDLING

.1 During delivery and storage, protect geotextile from direct sunlight, ultraviolet rays, excessive heat, mud, dirt, dust, debris and rodents.

PART 2 - PRODUCTS

2.1 MATERIAL

.1 Geotextile: non-woven synthetic fiber fabric, supplied in rolls.

  .1 Composed of: minimum 85% by mass of polypropylene

.2 Physical properties:

Geotextile TEXEL 918 or equivalent

  .1 Thickness: to ASTM D5 199 minimum 3.5 mm.

  .2 Tensile strength: Pressure strength (CD) and pressure strength (MD): minimum of 1450N to ASTM 148.1-7.3.

  .3 Elongation at break: 70%-110% (MIN-MAX) to ASTM 148.1-7.3.

  .4 Tear strength (CD) and (MD): 600N to ASTM-4.2-12-2.

  .5 Ball burst strength: to ASTM-4.2-12-2. minimum 3500kPa, wet condition.

  Hydraulic properties:

    .1 Filtration opening size (FOS): 40-175 (MIN-MAX) to CAN/CGSB-148.1-10.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Place geotextile material by unrolling onto graded surface in orientation, manner and locations indicated and retain in position.

.2 Place geotextile material smooth and free of tension stress, folds, wrinkles and creases.

.3 Place geotextile material on sloping surfaces in one continuous length from toe of slope to upper extent of geotextile.

.4 Overlap each successive strip of geotextile 600 mm over previously laid strip.

.5 Protect installed geotextile material from displacement, damage or deterioration before, during and after placement of material layers.

.6 Level granular layers under the geotextile while avoiding voids and sharp edges

.7 After installation, cover with overlying layer within 24 h of placement.

.8 Replace damaged or deteriorated geotextile to the approval of the Department's Designated Representative.

.9 Put in place underlying rock layers in a way that does not damage the geotextile.

3.3 PROTECTION

.1 Vehicular traffic is not permitted directly on geotextile.

PART 1 - GENERAL

1.1 RELATED SECTIONS

.1 Section 01 33 00 - Submittal Procedures.

.2 Section 31 23 33.01 - Excavating, Trenching and Backfilling.

1.2 REFERENCES

.1 American Society for Testing and Materials International, (ASTM).

- .1 ASTM A 6/A 6M-02b, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
- .2 ASTM A 325M, Specification for High-Strength Bolts for Structural Steel Joint.
- .3 ASTM A 615/A 615M-01b, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
- .4 ASTM A 1011/A 1011M-09, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

.2 Canadian Standards Association (CSA International).

- .1 CAN/CSA G40.20/G40.21-F09, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.
- .2 CSA W47.1-F09, Certification of Companies for Fusion Welding of Steel Structures.
- .3 CSA W59-M1989-F08, Welded Steel Construction (Metal Arc Welding) (Metric Version).

1.3 SUBMITTALS

.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

.2 At least 3 weeks prior to fabrication, submit to the Department’s Designated Representative, 2 copies of steel producer certificates in accordance with ASTM A 1011/A 1011M, and mill test reports in accordance with CAN/CSA-G40.20/G40.21.

.3 Provide the Department's Designated Representative with a copy of certification for fusion welding in accordance with CSA W47.1 and CSA W47.1S1.

.4 Provide in writing to the Department's Designated Representative the work methodology including all the work sequences for the installation of the sheet piles in the soil and the sedimentary rock to the elevations specified on the drawings. This methodology must be signed and stamped by an engineer member of the Association of Professional Engineers and Geoscientists of New Brunswick.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Use slings for lifting piles so that mass is evenly distributed and piles are not subjected to excessive bending stresses.

.2 Store sheet piling on level ground or provide supports so that sheet piling is leveled when stored.

- .1 Provide blocking at spacing not exceeding 5 m so that there is no excessive sagging in piling.
- .2 Overhang at ends not to exceed 0.5 m.
- .3 Block between lifts directly above blocking in lower lift.

.3 If material is stock-piled on structure, ensure that structure is not overloaded.

PART 2 - PRODUCTS

2.1 MATERIALS

.1 Steel sheet piles: to ASTM A572 including chemical and mechanical requirements 50 grade 345MPa, and following:

.2 Continuous interlocking Z through section:

Sx = 3795

- .1 Minimum effective section modulus of at least 3795 cm3 per meter of wall.
- .2 Minimum flange thickness of 16 mm.
- .3 Minimum web thickness of 12.2 mm.
- .4 Area of minimal section: 230 cm2/m.

.3 Continuous interlocking Z through section:

Sx = 4595

.1 Minimum effective section modulus of 4595 cm3 per meter of wall.
.2 Minimum flange thickness of 18 mm.
.3 Minimum web thickness of 14 mm.
.4 Area of minimal section: 291,2 cm2/m

.4 Structural steel for wales, capping channels, support angles and miscellaneous steel: to CAN/CSA-G40.21, Grade 350W.

Steel for bearing plates and capping channels: to CAN/CSA-G40.21, Grade 300W.

.5 Tie rods, sleeve nuts and turnbuckles:

.1 Tie rods: to ASTM A 615, Grade 75 KSI (517 MPA).
.2 Sleeve nuts and connector sleeves: to have load capacity in excess of capacity of tie rod.
.3 Preassemble, mark and test tie rod assemblies in shop. Align threaded connection to following tolerances at sleeve nut or connector sleeve: 1/80 of normal rod diameter, deviation of centre line, 1 in 160.

.6 Nuts and bolts: hexagon nuts, bolts, and washers: to ASTM A 325.

.7 Backfill material: to Section 31 23 33.01 - Excavating, Trenching and Backfilling and 32 11 16.01 – Granular Sub-Base.

.8 Provide a steel shoe protection at the bottom of all sheet piles driven into sedimentary rock. The Contractor must submit for approval by the Department’s Designated Representative a shop drawing of this protection and specifications of the steel used.

2.2 SOURCE QUALITY CONTROL: HOT ROLLED SHEET STEEL PILING

.1 Provide results of tests of sheet piling material to be used on project as follows:

.1 One tension test and one bend test from each batch for quantities of finished material less than 50 tons.

.2 Two tension tests and two bend tests from each batch for quantities of finished material exceeding 50 tons.

.2 Tension tests in accordance with CAN/CSA-G40.20/G40.21. Bend tests in accordance with ASTM A 6/A 6M.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Do welding in accordance with CSA W59-04 (R2008), except where specified otherwise.

.2 Do not begin pile installation until required quality control tests have been completed and test results approved by Department's Designated Representative.

.3 Submit full details of method and sequence of installation of piling for the Department's Designated Representative's approval prior to start of pile installation work. Details must include templates, bracing, setting and driving sequence and number of piles in panels for driving.

.4 When installing sheet piles in bulkhead wall, use following procedure:

.1 Provide temporary templates or bracing to hold piles in alignment during setting and driving.

.2 Drive piles two at a time. Drive first double pile to full depth, then place panel of five to eight double sheet piles in templates and secure last (end) double pile in location to prevent spreading of piles in panel.

.3 Drive end double pile in panel sufficiently deep into ground to ensure that it will remain plumb, then, drive remaining double piles in panel to full depth beginning with double pile next to end double pile and finishing with double pile next to double pile first driven.

.4 After one panel has been driven, place and drive succeeding panels in similar manner. Complete the driving of end double pile of first panel after double piles of second panel have been driven.

.5 When installation is complete, face of wall at top of sheet piles to be within 75 mm of location as indicated and deviation from vertical not to exceed 4 in 100.

.6 Cut drain holes as indicated. Provide filter material in area of drain holes as indicated.

.7 The Contractor is responsible of the placement methodology for the steel sheet piles in the soil and sedimentary rock. He must determine the means required to install the sheet piles at the elevations specified on the drawings. Except for exceptional cases, for which he must provide written justifications and obtain written approval from the Engineer, the Contractor will not be authorized to abandon the driving of the sheet piles before reaching the specified elevation. In case of encountered difficulty, the Contractor will have to propose a method to complete the driving of the sheet piles. He will have to provide shop drawings and design briefs signed and stamped by an engineer member of the Association of Professional Engineers and Geoscientists of New Brunswick. The Department designated representative must provide final approval on the depth of the sheet piles.

.8 Driving tests were made during the design stage. The reports concerning those tests were written by Gemtec and are provided at the end of this section. Information provided in these reports is given to help the contractor evaluate the effort needed to drive the sheet piles. The information provided is only valid at the point the test were made. The contractor shall be aware he may encounter different driving condition during work. The information provided in the report cannot be used to claim compensation for the work. The contractor has the responsibility to evaluate the equipment needed and the driving energy required to perform the work. Materiel and methods used during the test shall not be taken as work instruction.

<u>3.2 OBSTRUCTIONS</u>

.1 If obstruction is encountered during driving, leave obstructed pile and proceed to drive remaining piles. Return and attempt to complete driving of obstructed pile later.

<u>3.3 HOLES</u>

.1 Patch holes in sheet pile wall, except where permanent holes are indicated.

  .1 Use 19 mm thick plate of material equal to that of piling to patch holes and overlap not less than hole diameter.
  .2 Weld to develop full strength of plate.

.2 Drill any required holes in piling. Do not use flame cutting.

3.4 CUTTING

.1 When flame cutting tops of piles, and flame cutting holes in piles, use following procedure:

  .1 When air temperature is above 0 degrees C, no pre-heat is necessary.
  .2 When air temperature is below 0 degrees C, pre-heat until steel 25 mm on each side of line of cut has reached a temperature very warm to hand (approximately 35 degrees C). Temperature indicating crayon marks may be used to measure temperature.
  .3 Use torch guiding device to ensure smooth round holes or straight edges.
  .4 Make cut smooth and free from notches throughout thickness. If grinding is employed to remove notch or crack, finished radius to be minimum 5 mm.

3.5 SPLICING

.1 Use full length piles unless splicing is approved on site by Department's Designated Representative.

3.6 TIE ROD ANCHORAGE SYSTEM

.1 Fit and adjust tie rod systems so that connections at waling and anchor end of tie rods are tight before backfilling. Follow indications on drawings for situations when wale joints are located in the same tank as tie rods.

3.7 BACKFILLING

.1 Backfill in accordance with Section 31 23 33.01 - Excavating, Trenching and Backfilling and as indicated.

.2 Protect piling tie rods and anchorage systems from damage or displacement during backfilling operations.

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

GEMTEC Limited
191 Doak Road
Fredericton, NB
E3C 2E6

tel: 506.453.1025
fax: 506.453.9470
fredericton@gemtec.ca
www.gemtec.ca

06 November 2014 File: 4735.42

Via Email: Jean.Girouard@pwgsc-tpsgc.gc.ca

Public Works & Government Services Canada
1075 Main Street
Moncton, NB
E1C 1H1

Attention: Mr. Jean Girouard, P.Eng.

Re: Sheet Pile Analysis and Monitoring
Wharf 401 Reconstruction Project, Shippagan, NB

Further to our conversation, we are pleased to provide an analysis and a procedural framework for the above noted project.

Reference is made to Stantec BH-01 and BH-02 (Project 1041315-968) and Roche drawings 3 and 6 (project P59583).

We understand that PWGSC intends to install, and subsequently extract several AZ 38-700N sheet pile test sections in advance of the construction of the above noted wharf. The test piles will be driven from the existing wharf at a location approximately 50 metres ± from the intersection of the existing wharf and shoreline. A 5500lb drop hammer is proposed for driving. Subsequent extraction efforts would be undertaken with a vibratory extractor. The tip elevation indicated on the drawings is 10.5 metres below Chart Datum. The Interpolated bedrock elevation in the test area is approximately 7.4 metres below Chart Datum, this corresponds to a 3.1 metre bedrock penetration.

For purposes of analysis and testing the AZ 38-700N section is considered to have the following properties:

- Yield Strength ASTM A 572 Grade 60 (415 MPa)
- Steel footprint area – 140 cm^2 / per section
- Steel shaft area (both sides) – 2.0 m^2 per metre length

In an effort to minimize significant damage to the section during driving a maximum rated hammer energy of 60,000 joules (~45,000 ft lbs) is proposed. This equates to a maximum drop height of around 8 feet for the project hammer. We would anticipate a penetration resistance of at least 15 blows per inch to advance the pile to the specified penetration of 3.1 metres. If more competent zones of bedrock are encountered, or if energy transfer becomes an issue, then a penetration in the 1 to 2 metre range would be anticipated.

The driving system should be equipped with a cushion capable of transferring at least 50% of the potential energy uniformly to the pile section. This would be typical for a “conbest” or hardwood cushion. The cushion will need to be durable enough to provide continuous blows for the duration of the driving without sustaining significant damage or efficiency losses.

Weak Axis pile bending is a concern during driving. As this will considerably reduce the energy reaching the pile tip. A mitigative measure is to provide a frame for lateral bracing. The minimum length of installed pile is approximately 14.5 metre (47.5 feet). We would suggest a minimum additional length of 12.5 feet for a total trial length of 60 feet to account for potential variability between borehole locations.

PDA (Pile Driving Analyzer) testing will be conducted on a stand-alone pile section. The PDA takes measurements of force and velocity during each hammer blow as a compression wave propogates through the pile. Estimates of driving stress, hammer efficiency, axial capacity, and pile damage are obtained from the PDA. Typically several specific blows in the driving record are analyzed with CAPWAP software (Case Pile Wave Equation Analysis Program). The program contains a comprehensive algorithm to confirm the field results. Excessive friction generated from coupling sections together will likely compromise the PDA data. For this reason we recommend in the first instance driving a stand-alone pile. Should single driving not prove successful due to bending we would attempt data collection on coupled piles (likely 4 or 5 coupled together).

We would anticipate some adjustment of procedures based upon the PDA results in the field. For example the drop height would be adjusted if possible to expedite driving time, provided driving stresses and damage were not a concern.

Complete driving logs would be recorded, with the assistance of the contractor. Also the extracted piles would be inspected for damage.

A summary of the driving results and pile extraction would be produced to document the testing. The report would be prepared in general conformance to ASTM D4945.

If you have any questions or comments please do not hesitate to contact the undersigned.

David J. Purdue, P.Eng.

DP/mj

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

GEMTEC Limited
520 Somerset Street
Saint John, NB
E2K 2Y7
tel: 506.657.0200
fax: 506.657.0201
saintjohn@gemtec.ca
www.gemtec.ca

December 17, 2014 File: 4735.45-L05

Public Works & Government Services Canada
1075 Main Street, Moncton, NB
E1C 1H1

Attention: Mr. Jean Girouard, P Eng.

Re: Dynamic Testing and Inspection, Test Sheet Pile, Wharf 401, Shippagan, New Brunswick

Introduction

GEMTEC Limited was retained by Public Works and Government Services Canada (PWGSC) to provide dynamic pile testing services using our Pile Driving Analyzer (PDA) and inspection services for one test sheet pile installed at Wharf 401 in Shippagan, New Brunswick.

PDA testing was conducted at the site on November 21 and December 17, 2014. Our dynamic testing equipment was attached to the test pile for the entire length of driving. For specific details on driving activities undertaken on November 21, 2014, please see our letter dated November 24, 2014 under the title *Preliminary Report – Dynamic Testing and Inspection, Test Sheet Pile, Wharf 401, Shippagan, New Brunswick.* The results form the testing conducted on November 21, 2014 are summarized in this report.

This report contains general project information and a summary of PDA testing carried out at the site. This report is in general conformance with ASTM Standard D4945.

Subsurface Conditions

A geotechnical investigation was conducted by others prior to the sheet pile installation. The test sheet pile was driven at approximately the midpoint between BH-3 and BH-4. With no borehole at the test pile location, geotechnical conditions were inferred from the soil and bedrock conditions encountered at the borehole locations.

The borehole logs show a layer of marine sediments underlain by weak sedimentary bedrock. The elevation of the bedrock at the test sheet pile location is estimated to be at elevation -7.4 metres (Chart datum), in accordance with the boreholes.

Drivability Analysis

The intent of the test pile program was to evaluate the ability to advance AZ 38-700N sections to elevation -10.5 metres chart datum without significantly damaging the piles. This work was undertaken as part of a proposed wharf rehabilitation design. For the initial event, Public Works and Government Services Canada (PWGSC) made use of locally available driving equipment (a 25 kN drop hammer). Prior to the November 21 driving event, GEMTEC undertook a desktop drivability analysis. The analysis indicted that the piling would advance 1 to 2 metres into the bedrock, corresponding to a maximum toe elevation of approximately -9.5 metres.

Since the test pile did not achieve the required elevation of -10.5 metres, GEMTEC was retained to complete an additional drivability analysis and specify a hammer that could potentially advance the desired results. Hammers available from Fundy Contractors were reviewed. Our analysis indicted that a 100 000 ft-lb (135 kN-m) hammer would be required. Fundy contractors 7600 lb (33kN) drop hammer was configured such that it could be dropped from a height of approximately 12 feet (3.7 metres), thus providing the required energy.

General Information

The following table summarizes the relevant information concerning pile driving activities undertaken on December 16, 2014:

Project	**Wharf 401, Shippagan**
Date of Driving	December 16, 2014
Pile Driving Contractor	Titanium Construction
Pile Driving Hammer	7600 lb (33 kN) drop hammer supplied by Fundy Contractors
Maximum Rated Hammer Energy	Approx. 100 kN-m (3 m drop)
Pile Type	Double section of AZ-38 700N
Pile Yield Strength	400 MPa
Area of Steel	321.5 cm^2

Pile Driving and PDA Testing Summary

The initial test pile installation was undertaken on November 21, 2014 using a 5500 lb (25 kN) cable drop hammer. See our previous report for details.

At the start of driving on December 16, 2014 the toe elevation of the test sheet pile was approximately elevation -9.5 metres (chart datum). Titanium construction removed the yielded steel at the top of the test sheet pile and added some steel plate at the top of the sheet pile, prior to driving. This allowed for better contact between the helmet and the test sheet pile.

Using the 33 kN hammer and a drop height between 2.4 and 3.3 metres, the test sheet pile was advanced a further 1.2 metres to a toe elevation of approximately -10.7 metres.

PDA testing was undertaken during the entire length of driving for the test sheet pile.

Excessive driving stresses or pile damage (Beta) were not detected during driving. Localized yielding was not noted at the impact point between the hammer helmet and the sheet pile on December 16, 2014.

The hammer was operating at an efficiency in the order of 45 to 60%, which is typical for this type of hammer.

The following is summary of key PDA measurements taken near the end of driving of the test sheet pile:

Pile	**Test-1**
Date	December 16, 2014
CME Capacity*	4000 to 4400 kN
Measured Stress (CSX)	160to 200 MPa
Measured Transferred Energy	45 to 60 kN-m
Observed Blows /25 mm	Approximately 15 at end of driving
Approx. Toe elevation at start of Driving	-9.5 metres (Chart Datum)
Approx. Toe elevation at the End of Driving	-10.7 metres (Chart Datum)

For a complete record of observed pile penetration over the entire length of driving of the test sheet pile, please see the attached Driving Record.

*The CME capacity is the ultimate axial pile capacity estimated during driving

Discussion

As described above, the test pile was driven to practical refusal on November 21, 2014 using a 25 kN hammer. After sitting for over 3 weeks, it was re-struck with a 33 kN hammer and advanced approximately 1.2 metres to an approximate toe elevation of -10.7 metres. There are several contributing factors that should be considered when interpreting this information.

- Using the larger 33 kN hammer as compared to the 25 kN hammer resulted in an increase in potential energy which could be mobilized to advance the pile. Using a 3 metre stroke as an example, the potential driving energy increased from 75 kN-m to 100 kN-m, representing an increase of about 33% in potential energy. This increase in energy is a definite factor for the capability for the contractor to further advance the test sheet pile. The larger hammer also allowed for an increase in the demonstrated CME capacity of the pile (November 21 CME approximately 2200 kN, December 16 CME capacity +4000 kN).
- Prior to driving on December 16, 2014, the contractor removed the locally yielded section of the pile which was at contact point between the hammer helmet and the pile (less than 150 mm of pile). This provided better contact between the hammer helmet and the test pile, which likely led to higher energy transfer from the hammer to the pile. This could potentially be a factor which allowed for the further advancement of the pile.
- A phenomena known as “relaxation” is noted to sometimes occur when driving piles into weak sedimentary bedrock. Relaxation is caused by water penetrating between the driven pile and bedrock, and weakening the rock. This can occur over a period as short as 24 hours.

  The bedrock at this site is noted to be weak sedimentary in nature (as described in the borehole logs provided to us.)

  When evaluating and considering the drivability of sheet piles for the construction of this wharf, it should be considered that the contractor may need to allow the bedrock to relax in order to achieve the required toe elevation for the sheet piles to be driven for the design.

  Due to the fact that two different hammers where used for the installation of the test sheet piles it is difficult for us to conclude whether or not relaxation did in fact occur at this site, however, it should be viewed as a potential factor.

- After the pile was advanced to the required depth, an ICE 416 vibratory pile installer/extractor was utilized to remove the pile. In order to overcome the friction on the two sections of AZ 38-700N sheet pile, each section had to be removed individually. Once removed the piles were laid on the wharf and their condition was observed for damage. No apparent damage or yielding was noted on either pile section. The pile shoes were noted to still be installed and in good condition as well. This observation confirms the data obtained during PDA monitored driving, which indicated that the piles were in good condition and that driving stresses were below the strength of the pile material. Several photos of the extracted piles are attached.

- The observed pile stresses during driving with either hammer did not exceed 200 MPa. This is well below the yield strength of the sheet piles (+400 MPa according to manufacturer's specifications. If at the time of the wharf construction the contractor is having difficultly installing the sheet piles to the require toe elevations, increasing the potential energy per square area of pile section could be considered (ie. increase the hammer size, or drive one section of pile at a time). A drivability analysis should be conducted to review the proposed driving equipment and sheet pile installation methods. Dynamic testing of some of the sheet pile during construction of the wharf may also be advantageous.

Conclusion

GEMTEC Limited provided full-time inspection and dynamic testing during the driving of the test sheet pile at Shippagan Wharf 401.

The pile was driven to an approximate tip elevation of approximately -10.7 metres, which we understand is the required depth for the design of the wharf rehabilitation. A total length of embedment in the bedrock is estimated to be approximately 3.3 metres.

Damage or excessive driving stresses were not observed during driving. Visual review of the extracted pile also showed no apparent damage, distortion, or yielding of the piles.

It should be noted that pile driving conditions at the time of the wharf rehabilitation are subject to vary from our findings. This test pile installation was conducted in one area of a large wharf.

We trust that this report meets your requirements at this time. If you have any questions please contact the undersigned.

Marco Sivitilli

Marco Sivitilli, P. Eng
GEMTEC Limited

Attachments : Pile Driving Record, CAPWAP Output, Photos of extracted sheet pile

(N:\Files\4700\4735.45\2014mls1216-L05.doc)

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

PILE DRIVING RECORD

GEMTEC Limited
520 Somerset Street
Saint John, NB
E2K 2Y7
tel: 506.657.0200
fax: 506.657.0201
saintjohn@gemtec.ca
www.gemtec.ca

CLIENT:	PWGSC	PILE ID:	TEST-1
PROJECT:	Shippagan Wharf 401 Test Installation	LOCATION:	Shippagan Wharf 401
PROJECT NUMBER:	4735.42	DATE DRIVING STARTED:	2014-Nov-21
HAMMER DETAILS:	25 kN and 33 kN Drop Hammers	DATE DRIVING FINALIZED:	2014-Dec-16
PILE DETAILS:	Double Section of AZ 38-700N Sheet Pile	HAMMER DROP HEIGHT :	See comments section
DRIVING CONTRACTOR:	Titanium Construction	PILE BATTER:	Vertical Alignment
FINAL CUT-OFF ELEVATION:	Approximately +4.0 m (from drawings)	ADDITIONAL COMMENTS:	
LOCATION OF SPLICE:		Hammer drop Heights	
DRIVING SHOE INSTALLED:	YES	From 10.0 to 11.3 m -0.6 to 1.0 m (25kN hammer) From 11.3 to 13.4 m – 2.0 to 2.6 m drop (25 kN Hammer)	
REQUIRED CAPACITY:		From 13.4 to 13.53 m – 3.0 metre drop (25kN Hammer) From 13.53 to 14.7 m – 2.5 to 3.4 metre drop (33kN hammer)	

LENGTH IN GROUND (FEET)	PENETRATION BLOWS / FT.	LENGTH IN GROUND (FEET)	PENETRATION BLOWS / FT.	LENGTH IN GROUND (FEET)	PENETRATION BLOWS / FT.	LENGTH IN GROUND (FEET)	PENETRATION BLOWS / FT.	LENGTH IN GROUND (FEET)	PENETRATION BLOWS / FT.
0	0	11.5	11	Driving resumed on Dec 16					
1	I	11.6	15	Using 33 kN hammer					
2	I	11.7	14	13.6	21				
3	I	11.8	15	13.7	26				
4	I	11.9	15	13.8	31				
5	I	12.0	16	13.9	36				
6	I	12.1	18	14.0	40				
7	I	.12.2	22	14.1	31				
8	I	12.3	23	14.2	27				
9	V	12.4	29	14.3	22				
10	10	12.5	31	14.4	28				
10.1	10	12.6	40	14.5	30				
10.2	11	12.7	46	14.6	30				
10.3	10	12.8	47	14.7	45				
10.4	13	12.9	45	End of Driving					
10.5	12	13.0	50						
10.6	10	13.1	50						
10.7	10	13.2	60						
10.8	11	13.3	70						
10.9	10	13.4	75						
11.0	10	13.5	80						
11.1	11	13.53	45						
11.2	13	Driving Stopped with 25 kN							
11.3	13	Hammer on Nov. 21							
11.4	13								

DETAILS FOR FINAL SIX INCHES FOR PENETRATION:	1	2	3	4	5	6
BLOWS PER INCH (INITIAL FINALIZATION):	10	10	10	15	15	15
BLOWS PER INCH (RE-STRIKE):						
FINAL TOTAL LENGTH OF PILE (TIP to CUT-OFF):	FINAL DEPTH OF PENETRATION: -10.7 metres (Chart Datum)					

NOTE:

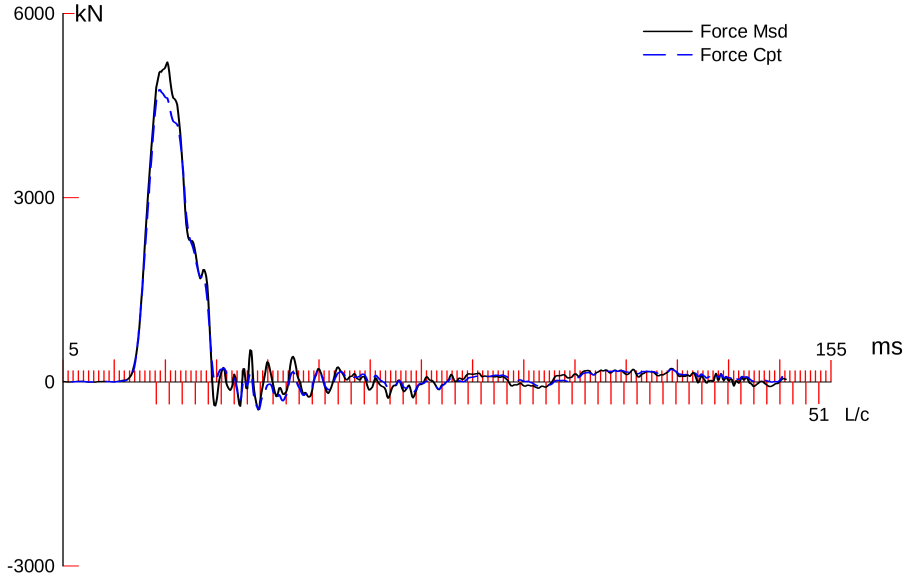
Details for the final six inches of penetration must be completed for all piles except in the case of an end bearing pile driven to bedrock. Final length of pile, and final cut off elevation must always be given

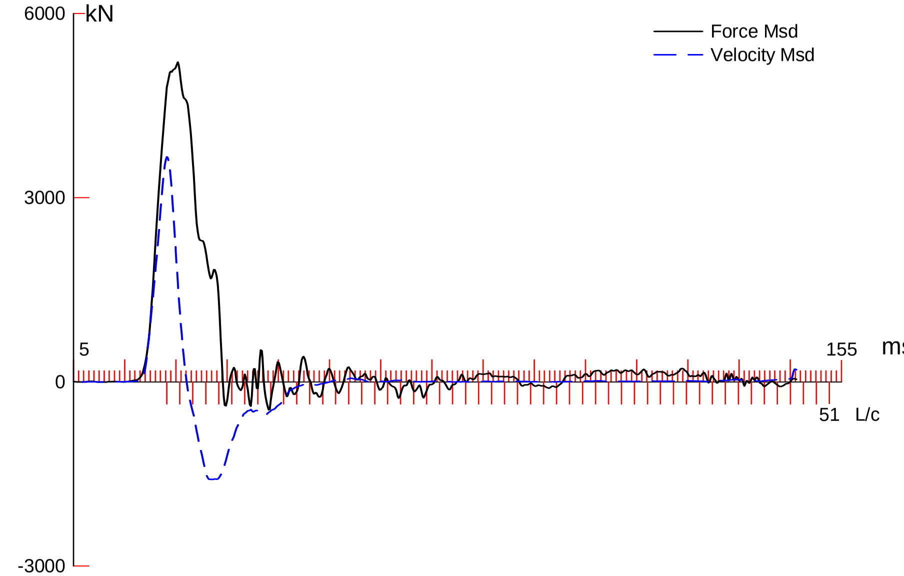
SIGNED: Marco [signature]

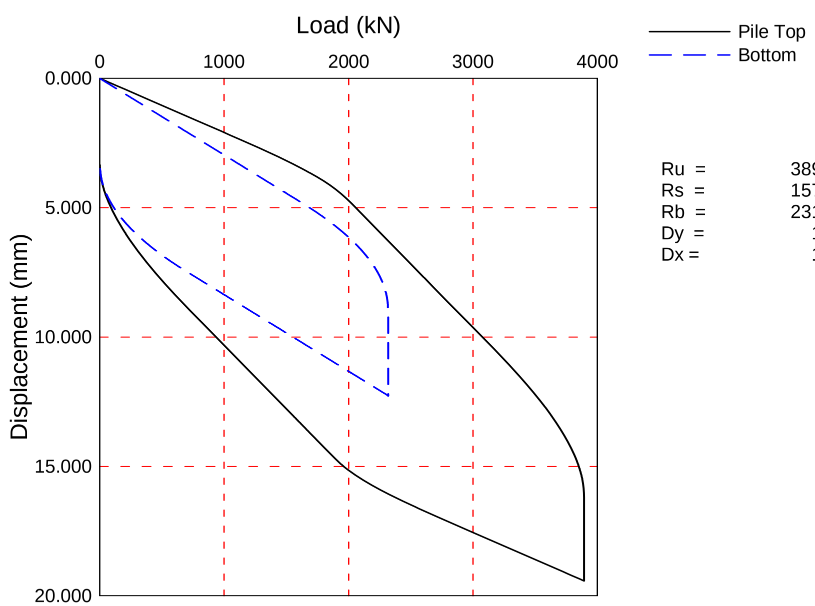
DATE: 2014-Dec-17

Shippagan Wharf 401; Pile: Test Sheet Pile; AZ38-700N (Double Section); Blow: 292 (Test: 15-Dec-2014 11:25:); Re-Strike with 33 kN Hammer
Gemtec Limited

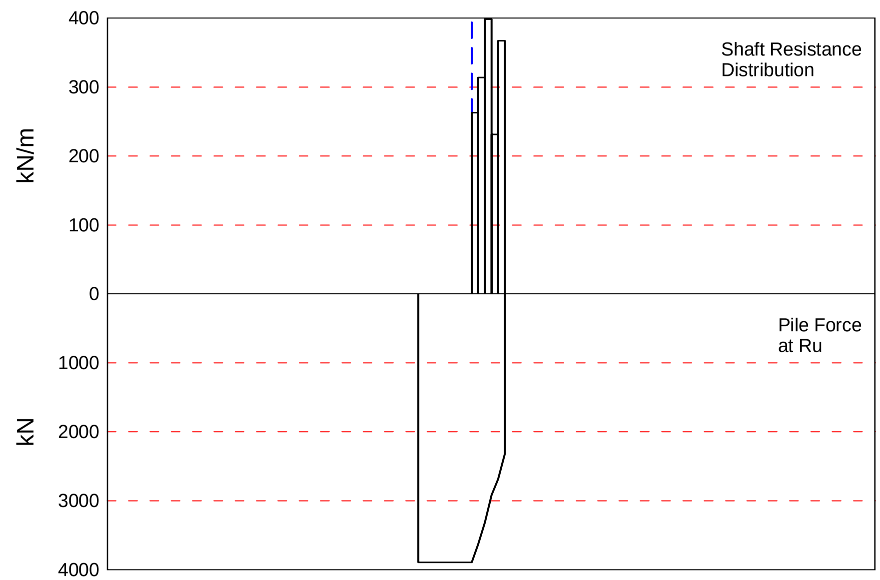
17-Dec-2014
CAPWAP(R) 2006-3







Ru = 3892.8 kN
Rs = 1573.6 kN
Rb = 2319.2 kN
Dy = 16.1 mm
Dx = 19.4 mm



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 3892.8; along Shaft 1573.6; at Toe 2319.2 kN

Soil Sgmnt No.	Dist. Below Gages m	Depth Below Grade m	Ru kN	Force in Pile kN	Sum of Ru kN	Unit Resist. (Depth) kN/m	Unit Resist. (Area) kPa	Smith Damping Factor s/m
				3892.8				
1	9.0	0.5	262.8	3630.0	262.8	525.60	128.20	1.313
2	10.0	1.5	313.8	3316.2	576.6	313.80	76.54	1.313
3	11.0	2.5	398.5	2917.7	975.1	398.50	97.20	1.313
4	12.0	3.5	231.3	2686.4	1206.4	231.30	56.41	1.313
5	13.0	4.5	367.2	2319.2	1573.6	367.20	89.56	1.313
Avg. Shaft			314.7			349.69	85.29	1.313
Toe			2319.2				72024.84	0.400

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(mm)	1.004	6.870
Case Damping Factor		1.592	0.715
Unloading Quake	(% of loading quake)	35	107
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	7	
Resistance Gap (included in Toe Quake) (mm)			2.807
Soil Plug Weight	(kN)		7.54

CAPWAP match quality = 5.02 (Wave Up Match) ; RSA = 0
Observed: final set = 3.333 mm; blow count = 300 b/m
Computed: final set = 2.333 mm; blow count = 429 b/m

max. Top Comp. Stress = 152.9 MPa (T= 24.4 ms, max= 1.319 x Top)
max. Comp. Stress = 201.7 MPa (Z= 9.0 m, T= 26.0 ms)
max. Tens. Stress = -19.58 MPa (Z= 9.0 m, T= 36.9 ms)
max. Energy (EMX) = 51.66 kJ; max. Measured Top Displ. (DMX)=12.21 mm

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages m	max. Force kN	min. Force kN	max. Comp. Stress MPa	max. Tens. Stress MPa	max. Trnsfd. Energy kJ	max. Veloc. m/s	max. Displ. mm
1	1.0	4915.8	-455.8	152.9	-14.18	51.66	2.9	13.220
2	2.0	5106.7	-452.5	158.8	-14.08	50.37	2.8	12.592
3	3.0	5340.0	-489.0	166.1	-15.21	49.10	2.7	12.000
4	4.0	5574.5	-517.0	173.4	-16.08	47.99	2.5	11.446
5	5.0	5797.8	-505.1	180.3	-15.71	46.92	2.3	10.907
6	6.0	6003.0	-445.0	186.7	-13.84	45.86	2.2	10.367
7	7.0	6193.4	-509.7	192.6	-15.85	44.80	2.0	9.823
8	8.0	6364.5	-560.8	198.0	-17.44	43.74	1.9	9.278
9	9.0	6484.0	-629.6	201.7	-19.58	42.73	1.7	8.742
10	10.0	5754.7	-536.5	179.0	-16.69	36.32	1.6	8.242
11	11.0	4847.7	-489.6	150.8	-15.23	29.57	1.6	7.777
12	12.0	3666.6	-357.6	114.0	-11.12	22.00	1.7	7.358
13	13.0	2977.3	-262.3	92.6	-8.16	12.03	1.7	6.974
Absolute	9.0			201.7			(T =	26.0 ms)
	9.0				-19.58		(T =	36.9 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	6110.4	5867.8	5625.1	5382.5	5139.8	4897.2	4654.5	4411.8	4169.2	3926.5
RX	6110.4	5867.8	5625.1	5382.5	5139.8	4897.2	4654.5	4411.8	4169.2	3926.5
RU	7101.4	6957.8	6814.3	6670.7	6527.2	6383.6	6240.1	6096.5	5953.0	5809.4

RAU = 1037.1 (kN); RA2 = 5585.8 (kN)

Current CAPWAP Ru = 3892.8 (kN); Corresponding J(RP)= 1.00; matches RX9 within 5%

VMX m/s	TVP ms	VT1*Z kN	FT1 kN	FMX kN	DMX mm	DFN mm	SET mm	EMX kJ	QUS kN
2.83	23.42	3598.6	4938.3	5235.1	12.210	3.336	3.333	49.2	6328.1

PILE PROFILE AND PILE MODEL

Depth m	Area cm^2	E-Modulus MPa	Spec. Weight kN/m^3	Perim. m
0.00	321.50	206842.7	77.287	4.100
13.00	321.50	206842.7	77.287	4.100

Toe Area 0.032 m^2

Segmnt Number	Dist. B.G. m	Impedance kN/m/s	Imped. Change %	Tension Slack mm	Tension Eff.	Compression Slack mm	Compression Eff.	Perim. m	Soil Plug kN
1	1.00	1298.06	0.00	0.000	0.000	-0.000	0.000	4.100	0.00
2	2.00	1298.06	0.00	0.000	0.000	-0.000	0.000	4.100	0.35
3	3.00	1298.06	0.00	0.000	0.000	-0.000	0.000	4.100	0.34
13	13.00	1298.06	0.00	0.000	0.000	-0.000	0.000	4.100	0.34

Pile Damping 1.0 %, Time Incr 0.195 ms, Wave Speed 5123.0 m/s, 2L/c 5.1 ms

Site Photos of Extracted Sheet Pile
Shippagan Wharf 401, December16, 2014

Photo 1

Photo 2