STATIC PILE LOAD TEST REPORT

Highway 400/Essa Road Overpass Replacement
City of Barrie, County of Simcoe
GWP 2337-16-00

Submitted to:

Stantec Consulting Ltd.
835 Paramount Drive, Suite 200
Stoney Creek, Ontario
L8J 0B4

Submitted by:

Golder Associates Ltd.
100 Scotia Court, Whitby, Ontario, L1N 8Y6, Canada
+1 905 723 2727

GEOCRES No.: 31D-756
Latitude: 44.361710°
Longitude: -79.698115°

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a full-scale static pile load testing program, as part of the foundation engineering services for the Highway 400/Essa Road interchange reconstruction, which includes the replacement of the Highway 400/Essa Road Overpasses and other associated works (Assignment No. 2017-E-0076) in Barrie, Ontario. The purpose of the pile load testing program is to assess the ultimate bearing resistance of driven steel HP 310x110 piles to support the proposed Essa Road Overpass structure.

This report provides a summary of the pile load testing program carried out at the pile load testing site located within the existing E/W-S Ramp at the Highway 400/Essa Road interchange, as shown on Figure 1. In general, the pile load testing program consists of the following major sequenced activities:

- Subsurface investigation;
- Site preparation;
- Test pile installation and associated dynamic testing; and
- Static pile load testing.

The terms of reference and scope of work for the full-scale static pile load testing are outlined in MTO's Request for Proposal, dated July 2018. Golder's scope of work for the detail foundation investigation and pile load testing program are contained in Section 7.7 of Stantec's *Technical Proposal* for this assignment as well as Golder's letter entitled *"Foundations Scope Change Letter No. 1"*, dated September 10, 2019.

2.0 BACKGROUND

The existing Essa Road overpass (Site No. 30-178/1&2) is a single-span rigid frame structure that has a span length of 17.4 m carrying six lanes of traffic on Highway 400. The existing overpass is to be replaced by a new structure that accommodates six lanes of traffic, with provision for future construction of an ultimate ten-lane configuration of Highway 400. In addition to the widening of Highway 400, Essa Road is to be widened to accommodate six lanes of traffic, a sidewalk on the south side, a 3 m multi-use path on the north side, and a center median. To accommodate the local road widening, the proposed replacement is planned to be a two-span bridge with semi-integral abutments with a total span length of about 94 m. Furthermore, Essa Road will require lowering by as much as 1.5 m in places so that the new overpass meets the requirements for vertical clearance over roadways as specified in *Canadian Highway Bridge Design Code* (CHBDC CSA S6:19).

3.0 INVESTIGATION, TEST PILE INSTALLATION AND TESTING PROCEDURES

3.1 Borehole Investigation

As part of the detail foundation investigation for the Essa Road Overpass, a total of twelve boreholes (designated as ERO-1 to ERO-12) were advanced for the proposed overpass and one borehole (designated as PLT-1) was advanced at the proposed pile load testing location. The borehole locations are shown on Figure 1.

Borehole PLT-1 was advanced using a CME-75 track-mounted drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The borehole was advanced through the overburden using 194 mm outside diameter hollow stem augers and mud rotary drilling techniques. Soil samples were generally obtained at intervals of depth about

0.75 m and 1.5 m, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1]. The groundwater conditions were observed during the drilling operations and a piezometer was installed in the borehole to allow monitoring of the groundwater level at the pile load test site.

The field work was observed by a member of Golder's engineering staff who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the borehole and examined the soil samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and geotechnical laboratory testing (water content, grain size distribution and Atterberg limits) was carried out on selected soil samples. All laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

The as-drilled borehole location and elevation were obtained by Golder using a Trimble GPS surveying unit and are presented in the table below and on the borehole record in Appendix A. The borehole location is given in MTM NAD83 (Zone 10) northing and easting coordinates as well as latitude and longitude coordinates, and the ground surface elevation is referenced to Geodetic datum. It is noted that this borehole was drilled prior to site preparation activities which included placement of granular fill and an associated grade increase, as described in the following section.

Location	Borehole ID	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
Pile Load Test	PLT-1	4,913,544.7 (44.361745)	289,011.1 (-79.698085)	246.2	35.3

3.2 Pile Load Test Site Preparation and Restoration

Upon completion of the detail foundation investigation for the Essa Road Overpass, and prior to installation of the test pile, the pile load testing site was prepared by GFL Environmental Inc. (GFL), under the supervision of Golder. Site preparation activities included vegetation removal, site grading, construction of an access road and test pad, and implementation of erosion/environmental protection measures. Underground utility locates and applicable permits were obtained prior to construction activities.

The access road and test pad subgrade were designed and inspected by Terraprobe Inc. (Terraprobe), a geotechnical engineering subconsultant retained by GFL. Approximately 2250 tonnes of 50 mm Crusher Run Limestone (CRL) was placed over biaxial geogrid to construct the access road and test pad. At the pile load testing location, the test pad was about 1.5 m thick, with the grade raised from about Elevation 246.2 m (at the time of borehole drilling) to Elevation 247.7 m. Field density testing (i.e. compaction testing) was carried out by Terraprobe during placement of the CRL. Silt fencing was installed along the west perimeter of the existing swale east of the test pile site. Select site photographs of the site preparation activities are provided in Appendix B.

The pile load test arrangement was removed from site on June 9, 2020. The area around the micropiles and test pile was excavated such that the micropiles and test pile were cut to a minimum depth of 1.5 m below the original

[1] ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soil

ground surface. The excavated areas were backfilled with granular materials consistent with those comprising the granular pad. The granular pad has been left in place for future use as an access/laydown or staging area during reconstruction of the interchange.

3.3 Test Pile Installation and Dynamic Testing

3.3.1 Test Pile and Micropile Installation

The test pile (designated TP-1) and associated reaction micropiles were installed between November 4 and 22, 2019, approximately 5 m west of Borehole PLT-1, as shown on Figure 1. The location of the test pile was determined by Golder in consultation with MTO Foundations Section, based on site access and proximity to the proposed structure. The location of the installed test pile and the ground surface elevation at the test pile location were obtained by Golder using a Trimble GPS surveying unit and are presented below. The test pile location is given in MTM NAD83 (Zone 10) northing and easting coordinates as well as latitude and longitude coordinates, and the ground surface elevation at the test pit location is referenced to Geodetic datum.

Test Pile ID	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Pile Depth (m)	Tip Elevation (m)
TP-1	4,913,540.8 (44.361710)	289,008.7 (-79.698115)	247.7	31.6	216.1
MP-1A	4,913,540.3 (44.361711)	289,012.0 (-79.698072)	247.7	30.0	217.7
MP-1B	4,913,538.8 (44.361692)	289,011.0 (-79.698085)	247.8	30.0	217.8
MP-2A	4,913,542.1 (44.361721)	289,004.8 (-79.698164)	247.7	30.0	217.7
MP-2B	4,913,543.5 (44.361734)	289,005.5 (-79.698155)	247.7	30.0	217.7

The steel HP 310x110 test pile, equipped with an OPSD 3000.100 Type I driving shoe, was driven to a tip elevation of Elevation 216.1 (about 31.6 m below ground surface) using a Liebherr H40/7 hydraulic hammer with a maximum rated energy of about 55 kJ. The test pile consists of two sections of HP 310x110 welded together, for a total test pile length of about 33 m. The piling rig details, hydraulic hammer details, and mill certificate are provided in Appendix C.

The pile driving was carried out by GFL and was observed and recorded by Golder. The H-pile installation procedure, prepared by GFL, and the pile driving record are provided in Appendix D. Site photos of the pile installation are provided in Appendix D.

3.3.2 Hiley and High-Strain Dynamic Testing

The Hiley formula plotting was completed by Golder, in accordance with MTO's Standard Drawing SS103-11 included in Appendix D. High-Strain Dynamic Testing (more commonly known as Pile Dynamic Analyzer (PDA) testing) was carried out by exp. Services Inc. (EXP) in accordance with ASTM D4945. Both Hiley and PDA testing were carried out at the End of Initial Drive (EOID) on November 4, 2019 and at the Beginning of Restrike (BOR) on November 11, 2019.

3.4 Static Pile Load Tests

3.4.1 Pile Load Test Arrangement

The pile load test arrangement was designed, supplied and constructed by GFL, as shown on Drawings LT1 and LT2 in Appendix E. The load test arrangement was constructed between November 19 and 22, 2019 by GFL, under the supervision of Golder. The load test arrangement consisted of two W920x420 steel reaction beams, two timber cribs, and four reaction micropiles (46 mm diameter rebar grouted within 115 mm diameter holes to 30 m depth) to counteract jacking load.

A hydraulic cylinder jack was used to transfer the load between the top of the test pile and the reaction beam. To accommodate the hydraulic cylinder jack between the test pile and reaction frame, the test pile was cut slightly below the top of the granular pad.

A load cell was used to monitor the applied loads the test pile. Four dial gauges were set up radially on a reference frame to measure the vertical movements of the top of the pile as the test progressed. The dial gauge readings were used as the primary measurement system for pile axial movements and a wire line, comprised of a horizontal medal rod welded to the reference beam and vertical scale welded to the test pile plate, was used as the secondary system for pile axial movements. Calibration certificates for the hydraulic cylinder jack, load cell, and dial gauges used in Procedure A and Procedure B were provided by GFL and copies of the certificates are included in Appendix C. All calibrations were carried out within 6 months of the pile load testing, with the exception of the load cell used during *Procedure A – Quick Test* which was calibrated in January 2019, or about 11 months prior to the test. The load cell was subsequently calibrated in January 2020, immediately prior to carrying out *Procedure B – Maintained Test.*

Golder confirmed the pile load test arrangement was in general conformance with ASTM D1143M and select photographs of the pile load test arrangement are presented in Appendix E.

3.4.2 Procedure A – Quick Test

On December 10, 2019, approximately one month after the installation and restrike of the test pile, a static load test was carried out in general accordance with the *Procedure A – Quick Test* method of ASTM D1143M. Based on an anticipated failure load of 3,600 kN (equal to the anticipated ultimate bearing resistance), test loads were applied in increments of about 180 kN (or 5 per cent of the anticipated failure load). Each load increment was held for about 15 minutes. For the purpose of this test, the load increments were to be added until either the failure load (i.e. 3,600 kN) was achieved or 30 mm (or 10 per cent of the pile diameter) of cumulative pile displacement was observed.

During the Procedure A test, 29 mm of cumulative pile displacement was observed after applying a load of about 2350 kN (or at the 13th load increment). Therefore, upon completion of the 13th load increment, the loads were removed in six decrements of about 390 kN each.

At the direction of Golder engineering staff, a representative from GFL applied the load increments / decrements by adjusting the hydraulic jack pressures. Golder engineering staff verified loading increments / decrements on the load cell output and recorded the pile displacements from the dial gauges (i.e. primary measurement system) and wire line (i.e. secondary measurement system). The factual data and details of test load increments / decrements and displacement measurements are presented in Appendix F. The dial gauges used for Procedure A, and their location on the steel plate are presented with the factual data in Appendix F.

During loading, another member of Golder staff surveyed each of the reaction micropiles to verify that the load test arrangement (i.e. reaction frame) remained stable. The results of the measurements are provided in Appendix F and indicate the reaction pile deflection was less than 25 mm through the duration of the test. The survey results along with site observations by Golder conclude that the reaction frame remained stable throughout the loading procedure.

3.4.3 Procedure B – Maintained Test

On January 13 and 14, 2020, a static load test was carried out in general accordance with the *Procedure B – Maintained Test* method of ASTM D1143M. As the design load was unknown at the time of testing, a design load of 1,800 kN was assumed. Based on an assumed design load of 1,800 kN, test loads were applied in increments of about 450 kN (or 25 per cent of the anticipated design load). Each load increment was held for a minimum of 20 minutes and maximum of 2 hours, until the rate of axial movement did not exceed 0.25 mm per hour. For the purpose of this test, the load increments were to be added until either 200 per cent of the design load (or 3,600 kN) was achieved or progressive movement greater than 45 mm (i.e. 15 per cent of the pile diameter) was observed.

During the Procedure B test, about 40 mm of cumulative pile displacement was observed prior to applying the last load increment. Upon applying the eighth and final load increment, the flanges on the test pile yielded and the jack shifted at a load of about 3,500 kN, and no further loading or unloading could be carried out.

At the direction of Golder engineering staff, a representative from GFL applied the load increments by adjusting the hydraulic jack pressures. Golder engineering staff checked and verified loading increments on the load cell output and recorded the pile displacements from the dial gauges (i.e. primary measurement system) and measuring tape (i.e. secondary measurement system). The factual data and details of test load increments and displacement measurements are presented in Appendix F. The dial gauges used for Procedure B, and their location on the steel plate is presented with the factual data in Appendix F.

During loading, another member of Golder staff surveyed each of the reaction micropiles to ensure that the pile load test arrangement remained stable. The results of the measurements are provided in Appendix F and indicate reaction piles deflection was less than 2 mm prior to applying the last load increment, after which the reaction piles shifted, and the overall reaction frame failed and the upper portion of the test pile flanges deformed, as discussed further in the following section.

3.4.4 Failure of Test Pile and Reaction System

Photographs of the failed test pile are provided in Appendix F. On the basis of site observations and monitoring results, the cause of the failure is attributed to the uplifting (up to about 20 mm) of two of the four reaction micropiles that caused an eccentric / inclined loading condition to develop, which resulted in stress concentration in a portion of the top of the test pile, and led to the localized deformation/yielding of the flanges on the test pile.

As evident from the measured increased rate of displacement, it appears the test pile was approaching axial geotechnical failure. Based on this information and considering the penultimate load of 3150 kN was approaching the estimated ultimate bearing resistance for the HP 310x110 pile, the design team concurred that it is unlikely that a higher bearing resistance would be used in the design. As such, in consultation with MTO, it was determined that there would not be a significant benefit to repair the test pile and reaction micropiles to complete additional testing for an anticipated nominal gain in ultimate bearing resistance.

4.0 SUBSURFACE CONDITIONS

In general, the subsurface conditions at the Essa Road overpass consist of fill and surficial deposits underlain by a non-cohesive deposit consisting of loose to very dense sand to silty sand to sandy silt that extends to depths of about 31 m to 35 m below ground surface. The thick deposit of non-cohesive soils is underlain by a hard-silty clay to clay deposit extending to depths of 36 m to 43 m below ground surface. The silty clay to clay deposit is in turn underlain by a deposit of very dense sand to silty sand to sandy silt in which the borehole was terminated.

The subsurface soil and groundwater conditions encountered in Borehole PLT-1 are provided on the Record of Borehole in Appendix A. The subsurface conditions at the pile load testing site (prior to construction of the granular pad) consist of 200 mm of topsoil underlain by a 2 m thick deposit of surficial soils comprised of 1.3 m of very loose to compact silt and 0.7 m of stiff clayey silt and sand. This 2 m thick layer of surficial soils was underlain by a deposit of compact to very dense sand to silty sand, extending to the borehole termination depth of about 35.3 m (Elevation 210.9 m). SPT 'N' values greater than 100 blows per 0.3 m of penetration were measured within the lower silty sand portion of this deposit, at a depth of about 28.7 m (Elevation 217.5 m).

The water level in the piezometer installed within Borehole PLT-1 was measured to be 5.0 m, 5.4 m, and 4.8 m below ground surface, corresponding to Elevations 241.6 m, 240.8 m, and 241.4 m, on June 24, 2019, August 1, 2019, and April 2, 2020, respectively.

5.0 GEOTECHNICAL RESISTANCE ASSESSMENT

5.1 Static Analysis

Based on the results of the detail design foundation investigation, the ultimate (unfactored) geotechnical resistances were assessed using various methods for steel HP 310x110 piles installed to depths ranging from about 25 m to 35 m below ground surface (i.e., pile tip elevations ranging from Elevation 226.5 m to 210.8 m) at the static pile load testing site and at the proposed north and south abutments for the overpass replacement. The estimated ultimate geotechnical resistances range from 3,000 kN to 3,800 kN. A summary of the pile depths, tip elevations, and ultimate geotechnical resistances calculated at the pile load testing site and abutments is summarized below.

Structure Location	Pile Depth (m)	Pile Tip Elevation (m)	Ultimate (Unfactored) Geotechnical Resistance (kN)
Pile Load Testing Site	26.5	219.7	3,300
	30.0	216.2	3,700
North Abutment	31.0	215.5	3,450
	34.0	210.8	3,800
South Abutment	25.0	226.5	3,000
	29.5	217.2	3,000

These estimated ultimate geotechnical resistances were compared against the ultimate geotechnical resistances obtained in static pile load tests conducted at selected Ontario sites with similar conditions (i.e., static pile load tests for H-piles installed to about 25 m to 35 m depths in non-cohesive soils), obtained from MTO pile load testing records (*Pile Load and Extraction Tests 1954-1992, Engineering Materials Office – Foundation Design Section, Report EM-48 (Rev. 93), dated September 1993)*. These previous pile load test data are summarized below. Based on the comparison of Golder's analysis results with the historic pile load test results from other similar sites, the estimated ultimate geotechnical resistances for the Essa Road overpass site are considered comparable with the failure loads summarized below.

Site No. / Pile No.	Location	Pile Depth (m)	Maximum Applied Load (kN)	Failure Load (kN)
17 / 1	Highway 401 Basket Weave Bridge	25.7	2669	2402
33 / 1	Highway 404 and 16th Ave	34.9	3559	~3559
35 / 5	CNR and CPR Crossing, Toronto	27.6	2891	2713

The above-noted estimated ultimate geotechnical resistances, and maximum applied loads and failure loads from previous testing at similar sites, were presented and discussed with MTO Foundations Section on July 17, 2019. In consultation with MTO Foundations Section, an ultimate (unfactored) geotechnical resistance of 3,600 kN was considered suitable for HP 310x110 piles driven to a depth of about 30 m below existing ground surface at the plie load testing site and at the proposed north and south abutments for the Essa Road overpass replacement. Further, as the current design load was unavailable at that stage of the project, an estimated design load of 1,800 kN (50% of the ultimate geotechnical resistance) was considered suitable for the purpose of the static pile load testing program.

5.2 Hiley Formula

The Hiley formula calculation was completed in accordance with the Standard Drawing SS103-11 included in Appendix D. The calculations are provided in Appendix D and the results are summarized below. It should be noted that Standard Drawing SS103-11 does not provide a value for the efficiency factor for a hydraulic hammer; however, the ratio between the measured energy and the energy input by the pile driving operator (i.e. a measure of the efficiency of the pile driving hammer) during PDA testing carried out at EOID and BOR is slightly above 1.0. Therefore, for the purpose of the Hiley formula calculation, the efficiency factor has been taken as equal to 1.0.

Test Pile No.	Pile Depth (m)	Test Condition[1]	Ultimate Pile Resistance (kN)
PLT-1	31.6 to 31.8	EOID	1,675
	31.8	BOR	1,625

Notes:
1. EOID denotes Initial Drive, and BOR denotes Beginning of Restrike.
2. The ultimate bearing capacities presented are unfactored values.

If a hydraulic hammer is used for installation of future production piles, OPSS.PROV 903 (Deep Foundations) requires the contractor to submit information on the hammer energy, rated energy and operating efficiency; if this cannot be demonstrated in advance for a hydraulic hammer, the efficiency of the pile driving hammer should be verified during production pile installation using PDA testing.

5.3 High-Strain Dynamic Testing (PDA Testing)

The results of the PDA testing are provided in EXP's report included in Appendix D and are summarized below.

Test Pile No.	Pile Depth (m)	Test Condition[1]	Ultimate Geotechnical Resistance[2] (kN)
PLT-1	31.6 to 31.8	EOID	1,500
	31.8	BOR	1,550

Notes:
1. EOID denotes Initial Drive, and BOR denotes Beginning of Restrike.
2. The ultimate bearing capacities presented are unfactored values.

5.4 Static Pile Load Test Procedure A – Quick Test

A summary of the results of the Procedure A "Quick" pile load test is shown on Figure F-1 in Appendix F, including plots of the following:

i) applied load versus time;
ii) pile movement versus time; and
iii) pile movement versus applied load.

The pile movement shown on Figure F-1 is based on the average of the four dial gauge readings, and the applied load was measured from the load cell output. Based on the results of Procedure A, the ultimate (unfactored) geotechnical resistance of the test pile was assessed, and the results are summarized below.

Assessment Method	Ultimate Geotechnical Resistance (kN)
Davisson Offset Method[1]	2,600
10 per cent of Pile Diameter	2,300

Note:
1. Davisson Offset Method based on linear extrapolation of the test data.

5.5 Static Pile Load Test Procedure B – Maintained Test

A summary of the results of the Procedure B "Maintained" pile load test is shown on Figure F-2 in Appendix F, including plots of the following:

i) applied load versus time;
ii) pile movement versus time; and
iii) pile movement versus applied load.

The pile movement measurement shown on Figure F-2 is based on the average of the four dial gauge readings. The applied load on the test pile was measured from the load cell output. Based on the results of Procedure B without extrapolation, the ultimate (unfactored) geotechnical resistance of the pile is assessed to be at least 3,150 kN, which is equal to the last maintained load increment prior to the termination of the test. Based on the results of Procedure B with linear extrapolation, the ultimate (unfactored) geotechnical resistance of the test pile was further assessed, and the results are summarized below.

Assessment Method	Ultimate Geotechnical Resistance (kN)
Davisson Offset Method[1]	3,300
10 per cent of Pile Diameter	2,750

Note:
1. Davisson Offset Method based on linear extrapolation of the test data.

Although Procedure B was not completed in its entirety, the test reached the penultimate load increment and the data obtained up to that point are considered good and valid. The test was approaching the failure load as defined by ASTM D1143M, which is the load at which the total axial movement exceeds 15 per cent of the pile diameter/width (or 45 mm for an HP 310x110 pile). Based on the trend of the data, it is anticipated that the test would have reached 45 mm of pile movement prior to reaching and maintaining 200 per cent of design load at 3,600 kN, at which time the unloading portion of Procedure B would have commenced.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Factored Ultimate Geotechnical Resistance

A comparison of the ultimate (unfactored) geotechnical resistances and the factored ultimate geotechnical resistances from the Hiley testing, PDA testing, and static pile load testing (SPLT) Procedure A and Procedure B is presented below.

Test / Test Condition	Assessment Method	Ultimate Geotechnical Resistance (kN)	Geotechnical Resistance Factor [2] ϕ_{gu}	Factored Ultimate Geotechnical Resistance (kN)
Pile Driving – End of Initial Drive (EOID)	PDA Testing	1,500	0.5	750
	Hiley Testing	1,675	0.5	840
Pile Driving – Beginning of Restrike (BOR)	PDA Testing	1,550	0.5	775
	Hiley Testing	1,625	0.5	810
SPLT – Procedure A	Davisson Method	2,600	0.6	1,560
	10% of Pile Diameter	2,300	0.6	1,380
SPLT – Procedure B	Davisson Method	3,150	0.6	1,890
	10% of Pile Diameter	2,750	0.6	1,650

Notes:
1. Number of days between initial test pile installation and test.
2. Geotechnical resistance factor is based on Table 6.2 of CHBDC CSA-S6:19 and corresponding to a typical degree of understanding.

It is noted that the Davisson Method is commonly used to estimate the geotechnical resistance of HP 310x110 piles, based on pile load test data (CFEM, 2004), whereas the 10% of Pile Diameter method is better suited to estimate the geotechnical resistance of larger piles. As such, it is recommended that a factored ultimate geotechnical resistance of 1,890 kN be used for detail design of HP 310x110 piles that are driven to or below Elevation 216 m and into the very dense, native silty sand to sand deposit.

6.2 Factored Serviceability Geotechnical Resistance

Based on the load versus displacement data from the Procedure B static pile load test, as plotted on Figure F-2 in Appendix F, it is estimated that the unfactored serviceability geotechnical resistance for 25 mm of movement is approximately 2,500 kN. The factored serviceability geotechnical resistance for 25 mm of movement is therefore 2,250 kN based on a geotechnical resistance factor, ϕ_{gu}, of 0.9 for a static test and a consequence factor, ψ, of 1.0 for a typical degree of site understanding (CHBDC CSA-S6:19). For detail design, HP 310x110 piles are to be driven to or below Elevation 216 m.

6.3 Anticipated Strength Gain with Time and Recommendations for Pile Acceptance by the Foundation Engineering Specialist During Construction

The results of the PDA and Hiley tests performed at EOID have been compared against the results of the PDA and Hiley tests performed at BOR, the results of Static Pile Load Testing ASTM D1143M Procedure A, and Procedure B, as summarized in the table below.

Test Method and Condition	Set-Up Period (days)	Ultimate Geotechnical Resistances (kN)	Approximate Average Strength Gain[3] (%)
Pile Driving – End of Initial Drive (EOID)	0	1,500 to 1,675[1]	-
Pile Driving – Beginning of Restrike (BOR)	7	1,550 to 1,625[1]	Approximately 0 (±3)
Static Pile Load Test – ASTM D1143M Procedure A	38	2,600[2]	155 to 175
Static Pile Load Test – ASTM D1143M Procedure B	70	3,150[2]	190 to 210

Notes:
1. The range of ultimate geotechnical resistance is obtained from the Hiley formula and PDA testing.
2. The ultimate geotechnical resistance is obtained using Davisson method, as this method is understood to be better suited for HP 310x110 piles.
3. The approximate average strength gain has been compared to the PDA and Hiley test results at EOID.

Overall, there was up to a 210% increase in the estimated ultimate geotechnical resistance over a period of 70 days. It is anticipated that the geotechnical resistance of the production piles will similarly increase over time, provided the piles are driven to or below Elevation 216 m and into very dense, native silty sand to sand deposit. Based on Golder's borehole investigation across this site, there is some variability in the composition and relative density/consistency of the soils near this tip elevation, and further discussion on this aspect is provided in the Foundation Investigation and Design Report for the Essa Road overpass replacement structure under this assignment.

As there was not an appreciable increase in geotechnical resistance measured at 7 days after EOID, it is considered that there is little value in prolonging the waiting period before restrike testing per OPSS.PROV 903. Therefore, it is recommended that the acceptance criteria for production piles be taken as follows:

Test Method	Test Condition	Minimum Ultimate (Unfactored Geotechnical Resistance) (kN)
High-Strain Dynamic (PDA) Testing	EOID	1,500
	BOR	1,550
Hiley Testing	EOID	1,625
	BOR	1,625

The above recommendations are based on the observed increase in geotechnical resistance from the 70-day pile load test results and are appropriate provided that the superstructure construction will not occur for at least two months following production piling. An Operational Constraint is recommended in this regard, and will be prepared for the Essa Road overpass; Golder will work with Stantec to optimize this period based on the anticipated construction schedule, such that commencement of substructure construction can be permitted prior to this two-month period.

Given the variability of the subsurface conditions at this site, it is recommended that any test results below the acceptance criteria be assessed by the Foundation Engineering Specialist (FES) in conjunction with the Design Team, including consideration of the measured results from PDA and Hiley testing for nearby piles.

6.4 Considerations for Future Pile Load Tests

The following suggestions / recommendations are provided for MTO's awareness and consideration where pile load tests are included on future MTO design assignments or construction contracts. These recommendations should be addressed in the Terms of Reference/specifications for the static pile load test where applicable.

- The installation of the reaction micropiles and the setup of the reaction frame should be supervised and signed off by the structural engineer who designs the reaction frame, prior to commencement of the static pile load test(s). An on-site inspection of the reaction frame should be carried out by the reaction frame designer prior to each pile load test if and where multiple load test procedures are completed. As part of this inspection, the reaction frame designer/contractor should confirm and document that the center of the reaction frame is plumb with the center of the test pile, and that the hemispherical bearing, jack, and load cell are centered prior to commencing each pile load test. An inspection letter confirming the reaction frame is constructed as per design should be provided from the designer to the project team. Where relatively high ultimate test loads are applied, the upper portions of the test pile flanges should be reinforced to minimize the potential for localized deformation or buckling that may be associated with non-concentric loading on the top of the pile.
- The grout mixture (i.e. the cement, bentonite, and water ratio) used for reaction micropile installation should be recorded and grout samples should be obtained at the time of installation and submitted for laboratory testing to confirm adequate grout strength. Confirmation of grout strength should be provided prior to commencement of any pile load tests.

- Each reaction micropile should be proof tested to confirm each micropile can withstand the planned maximum test load. Proof testing should be carried out by the reaction frame designer/contractor with observation by the foundations subconsultant (for design assignments) or foundation engineering specialist (if during construction contracts), and the results of the proof testing should be provided to the design team (for design assignments) or the Contract Administrator (for construction contracts).
- It is recommended that the contract documents specify surveying of the reaction frame be carried out using optical level shooting of fixed points on each reaction pile at a specified frequency (i.e. every hour), to provide more accurate observations of movement. It is further recommended that review and alert levels for differential movement of dial readings be established as a safety precaution related to the potential failure of the reaction system and/or the test pile.
- It is recommended that data acquisition technology be used in place of manual dial gauges to collect consistent, real time data throughout the static pile load tests. Implementation of data acquisition system will allow for field staff to be at a safe distance from the hydraulic jack and reaction frame should any sudden shifts/movements (failure) of the reaction system or test pile occur.
- Where possible, consideration should be given to starting future pile load tests at a time that results in the final test load being applied during the day (i.e. to avoid applying the final test load during the night shift), which will better allow the project team and contractor to respond to issues that may occur on site.
- Where possible, static pile load testing should be carried out in non-winter conditions. This would minimize requirements for construction of a shelter/enclosure around the load testing apparatus and permit greater space (and hence greater safety) for personnel observing and monitoring the progress of the pile load test.
- At the time of the static load tests for this site, the bridge design was still preliminary and the anticipated design load was not yet known and, as such, the estimated (unfactored) ultimate geotechnical resistance was used in its place to establish the loading intervals. However, in accordance with ASTM D1143M Procedure B, the anticipated design load, rather than the estimated (unfactored) ultimate geotechnical resistance, should be used for calculating the applied load at each interval. It is recognized that this is not always possible.
- Consideration should be given to installing instrumentation (i.e. vibrating wire piezometers, VWPs) to measure porewater pressures prior to, during, and after test pile installation, which will allow for an improved understanding of initial porewater pressure development and dissipation over time, and in turn could be used to correlate strength gain or relaxation over time.
- It is recommended that more research / understanding is required to determine whether the Hiley test method (which remains MTO’s standard test on production piles) is still applicable and can be appropriately modified for use with a hydraulic hammer (as opposed to conventional diesel hammer). This could include PDA testing to confirm the efficiency of the hydraulic hammer, as well as continued comparison of Hiley and PDA testing on production piles. It is noted that some in the deep foundation industry are migrating toward the use of PDA testing and elimination of Hiley testing, which has safety implications related to placing personnel in or near to the “line of force”.

7.0 CLOSURE

This report was prepared by Ms. Anastasia Poliacik, P.Eng., and reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and Associate with Golder, with technical input from Dr. (Yogi) Yogendrakuma, P.Eng. (B.C), a senior geotechnical engineer and Principal with Golder. Ms. Lisa Coyne, P.Eng., a Principal and Designated MTO Foundations Contact with Golder conducted an independent technical and quality control review of this report.

Signature Page

Golder Associates Ltd.

Anastasia Poliacik, P.Eng.
Geotechnical Engineer

Christopher Ng, P.Eng.
Associate, Senior Geotechnical Engineer

Lisa Coyne, P.Eng.
MTO Foundations Designated Contact, Principal

AMP/CN/LCC;ljv

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LEGEND

- MICROPILE LOCATION
- TEST PILE LOCATION
- PILE LOAD TEST BOREHOLE LOCATION
- PREVIOUS BOREHOLE LOCATION
- ESSA ROAD OVERPASS BOREHOLE LOCATION
- PILE LOAD TESTING SITE
- GRANULAR PAD

0 25 50

1:600 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE.

REFERENCE(S)

1. BASE IMAGE: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: TRANSVERSE MERCATOR NAD1983 UTM ZONE 17N

CLIENT

STANTEC C/O MINISTRY OF TRANSPORTATION ONTARIO

PROJECT

STATIC PILE LOAD TEST REPORT
HIGHWAY 400 AND ESSA ROAD OVERPASS REPLACEMENT
CITY OF BARRIE, ONTARIO

TITLE

PILE LOAD TESTING - SITE PLAN
MTO GEOCRES NO.: 31D-756

CONSULTANT

GOLDER

YYYY-MM-DD	2020-04-07
DESIGNED	CGE
PREPARED	CGE
REVIEWED	AP
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
18105050	0003		1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

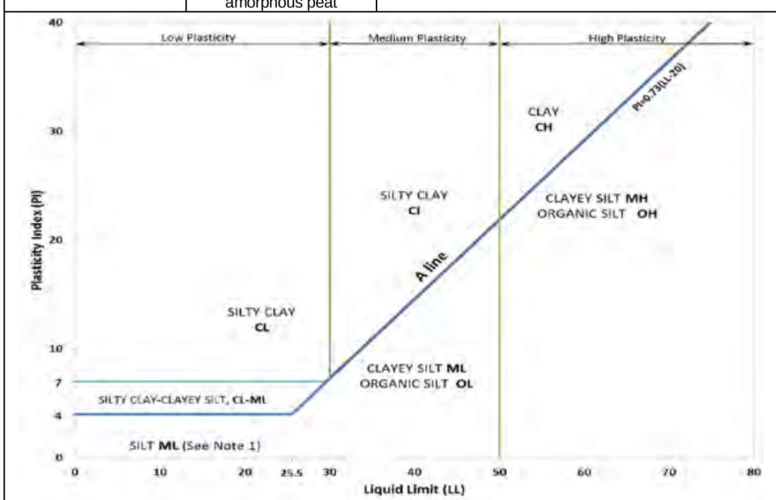
APPENDIX A

Borehole Record

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators: Dilatancy	Field Indicators: Dry Strength	Field Indicators: Shine Test	Field Indicators: Thread Diameter	Field Indicators: Toughness (of 3 mm thread)	Organic Content	USCS Group Symbol	Primary Name
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan\delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1. $\tau = c' + \sigma' \tan\phi'$
2. shear strength = (compressive strength)/2

GOLDER

RECORD OF BOREHOLE No PLT-1

SHEET 1 OF 3 **METRIC**

PROJECT 18105050

G.W.P. 2337-16-00 LOCATION N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745; LONG. -79.698085) ORIGINATED BY SK

DIST Central HWY 400 BOREHOLE TYPE Power Auger; 210 mm O.D. Hollow Stem Augers; Mud Rotary COMPILED BY ML

DATUM Geodetic DATE May 8 to 10, 12 and 13, 2019 CHECKED BY AMP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
246.2	GROUND SURFACE
0.0	TOPSOIL (200 mm)
0.2	Sandy SILT (ML) of slight plasticity Very loose to compact Brown Moist
244.8 / 1.5	CLAYEY SILT (CL) and sand, trace gravel Stiff Brown Moist
244.0 / 2.2	SILTY SAND (SM), trace to some gravel Compact to very dense Brown to grey - Becoming grey below a depth of 6.7 m (Elev. 239.5 m) - Tricone grinding at a depth of 8.2 m (Elev. 238.0 m)
237.5 / 8.7	SILTY SAND (SM) of slight plasticity , trace gravel Dense Grey Moist - Tricone grinding at a depth of 9.1 m (Elev. 237.1 m)
236.0 / 10.2	SAND (SP-SM/SW-SM), trace to some silt, trace gravel Dense to very dense Grey - Tricone grinding at a depth of 11.3 m (Elev. 234.9 m) - Wet below a depth of 13.3 m (Elev. 232.9 m) - Tricone grinding at a depth of 14.6 m (Elev. 231.6 m)

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	3				
2	SS	13				
3	SS	9				
4	SS	21				
5	SS	38	7	49	38	6
6	SS	36				
7	SS	78				
8	SS	23	12	57	25	6
9	SS	32	7	55	31	7
10	SS	53				
11	SS	32	0	91	9	0
12	SS	37				

ELEVATION SCALE: 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235, 234, 233, 232

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_400_ESSA_RD\02_DATA\GINT\HWY_400_ESSA_RD.GPJ GAL-GTA.GDT 7/9/20

GOLDER

RECORD OF BOREHOLE No PLT-1

SHEET 2 OF 3 **METRIC**

PROJECT	18105050		
G.W.P.	2337-16-00	LOCATION	N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745; LONG. -79.698085)
DIST	Central	HWY	400
BOREHOLE TYPE	Power Auger; 210 mm O.D. Hollow Stem Augers; Mud Rotary		
DATUM	Geodetic	DATE	May 8 to 10, 12 and 13, 2019
ORIGINATED BY	SK	COMPILED BY	ML
CHECKED BY	AMP		

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	SAND (SP-SM/SW-SM), trace to some silt, trace gravel Dense to very dense Grey	13	SS	37	231				
					230				
		14	SS	33	229	5	84	11	0
	- Tricone grinding at a depth of 17.7 m (Elev. 228.5 m)				228				
		15	SS	36	227				
226.8 19.4	SILTY SAND (SM), trace to some gravel Compact to very dense Grey Wet	16	SS	21	226	3	69	23	5
	- Tricone grinding at a depth of 20.4 m (Elev. 225.8 m)				225				
	- Tricone grinding at a depth of 21.9 m (Elev. 224.3 m)	17	SS	62	224				
	- Tricone grinding at a depth of 22.9 m (Elev. 223.3 m)	18	SS	61	223				
	- Tricone grinding at a depth of 23.8 m (Elev. 222.4 m)				222				
	- Tricone grinding at a depth of 24.7 m (Elev. 221.5 m)	19	SS	94	221	11	67	20	2
	- Tricone grinding at a depth of 26.5 m (Elev. 219.7 m)	20	SS	109	220				
		21	SS	87	219 / 218				
	- Tricone grinding at a depth of 29 m (Elev. 217.2 m)	22	SS	101	217				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\HWY_400_ESSA_RD\02_DATA\GINT\HWY_400_ESSA_RD.GPJ GAL-GTA.GDT 7/9/20

GOLDER

RECORD OF BOREHOLE No PLT-1

SHEET 3 OF 3

METRIC

PROJECT 18105050

G.W.P. 2337-16-00

LOCATION N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745; LONG. -79.698085)

ORIGINATED BY SK

DIST Central HWY 400

BOREHOLE TYPE Power Auger; 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY ML

DATUM Geodetic

DATE May 8 to 10, 12 and 13, 2019

CHECKED BY AMP

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILTY SAND (SM), trace to some gravel Compact to very dense Grey Wet - Tricone grinding at a depth of 30.2 m (Elev. 216.0 m)				216					
		23	SS	172/0.25		~9	19	51	24	6
					215					
		24	SS	100/0.13	214					
	- Tricone grinding at a depth of 32.6 m (Elev. 213.6 m)									
	- Tricone grinding at a depth of 33.2 m (Elev. 213.0 m)				213					
		25	SS	176		~10				
					212					
	- Tricone grinding at a depth of 34.4 m (Elev. 211.8 m)									
210.9		26	SS	100/0.13	211					
35.3	END OF BOREHOLE									

NOTES:

1. Borehole dry inside augers prior to Tricone (Mud Rotary) drilling.

2. Tricone (Mud Rotary) drilling carried out below a depth of 3.0 m below ground surface (Elev. 243.2 m).

2. Water level measured in piezometer as follows:

Date	Depth (m)	Elev. (m)
24-Jun-19	5.0	241.2
01-Aug-19	5.4	240.8
02-Apr-20	4.8	241.4

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

APPENDIX B

Site Preparation Documents

Photograph 1: Unloading of 50 mm CRL for Granular Pad

Photograph 2: Installing Geo-Grid with 30 cm Overlap

Photograph 3: Installing Geo-Grid and Placing 50 mm CRL

Photograph 4: Compaction of first lift of 50 mm CRL (30 cm lift)

Photograph 5: Granular Pad under construction.

Photograph 6: Completed Granular Pad.

APPENDIX C

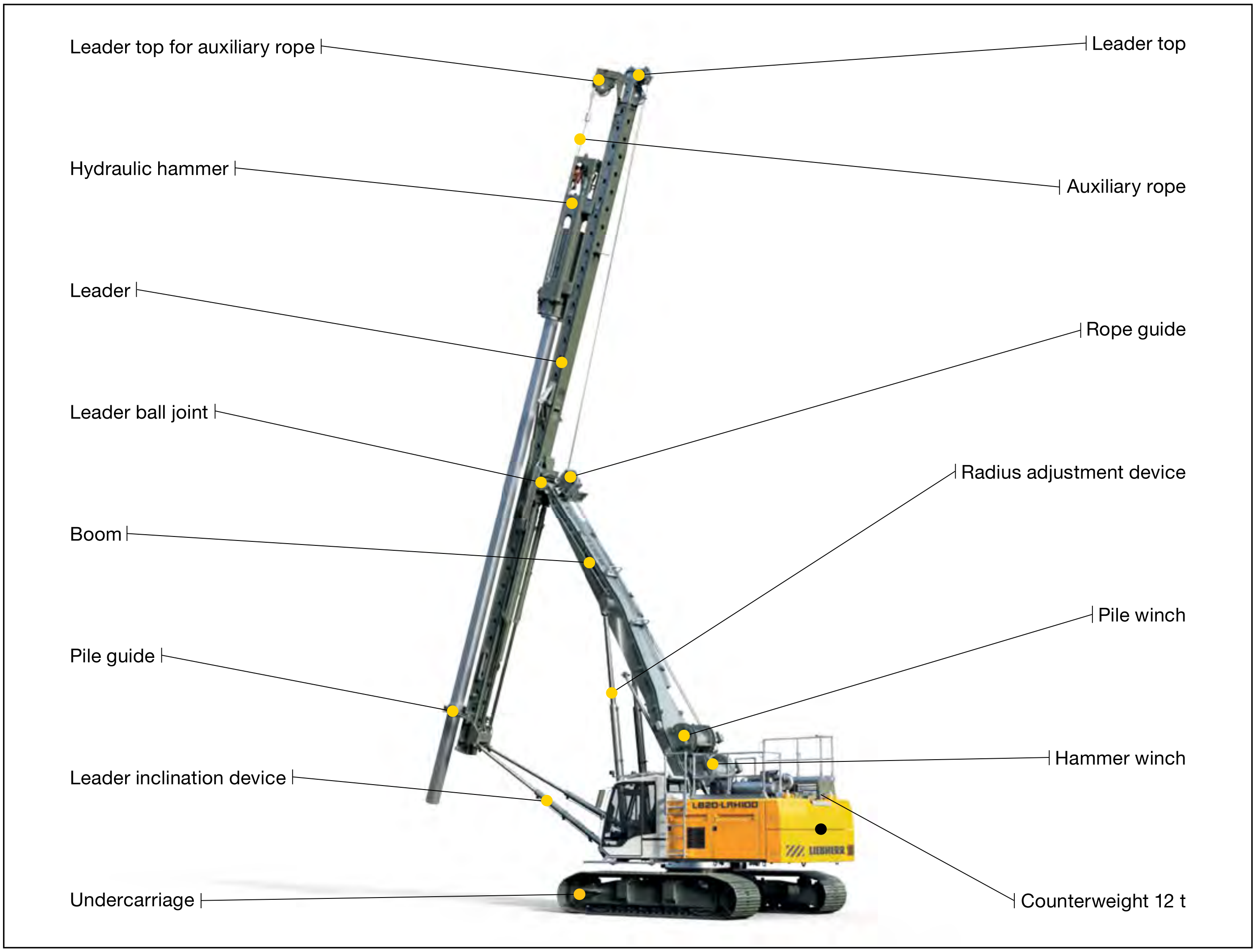
Equipment and Material Certificates and Details

Technical data
Piling rig

LRH 100
Litronic®

LIEBHERR

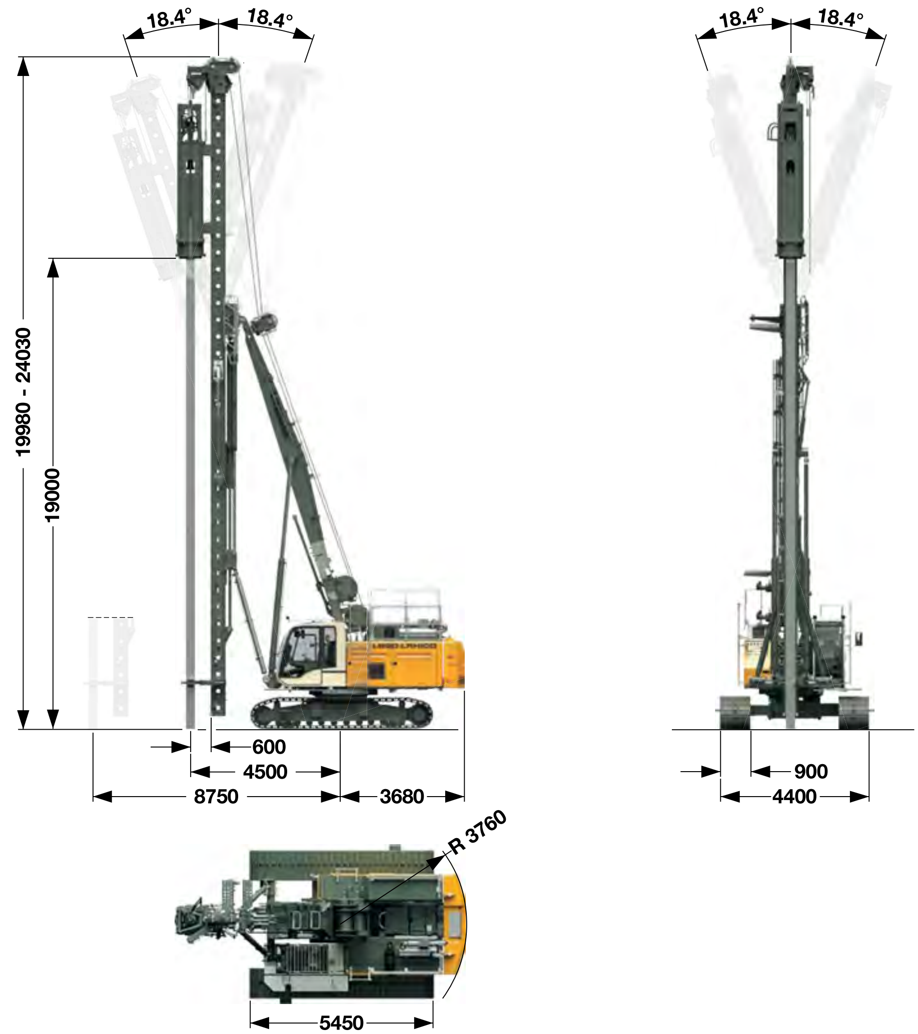
Concept and characteristics



- The LRH 100 is based on the well-proven LB 20 basic machine
- Thanks to the special leader kinematics a radius of 8.75 m as well as a continuous inclination adjustment of 1:3 in all directions is achieved
- The flexible hammer design offers the possibility of mounting drop weights between 2.5 t and 7 t. This guarantees optimum adaptation to the required pile type
- A new joystick design allows for leader movements to be carried out at all times and simultaneously to other machine movements
- Automatic vertical leader alignment at the push of a button
- Automatic parallel adjustment in both axes
- Automatic slack rope prevention
- Automatic slack rope preventionTransport fully assembled with or without mounted hammer
- Completely self-rigging (no auxiliary machines required)
- Simultaneous control of several movements via Load-sensing multi-circuit hydraulics
- Small rear swing radius
- Equipment design according to latest European regulations and standards
- High manufacturing quality through quality control by PDE system
- Evaluation and visualisation using the new Liebherr process data report software (PDR)

Dimensions

Basic machine LRH 100



Technical data

Total height	19.98 - 24.03 m
Max. pile length	19.0 m
Drop weight*	2500 - 7000 kg
Hammer weight incl. drop weight*	5600 - 10400 kg
Leader inclination continuously variable	
Lateral inclination	± 18.4°
Forward inclination	18.4°
Backward inclination	18.4°

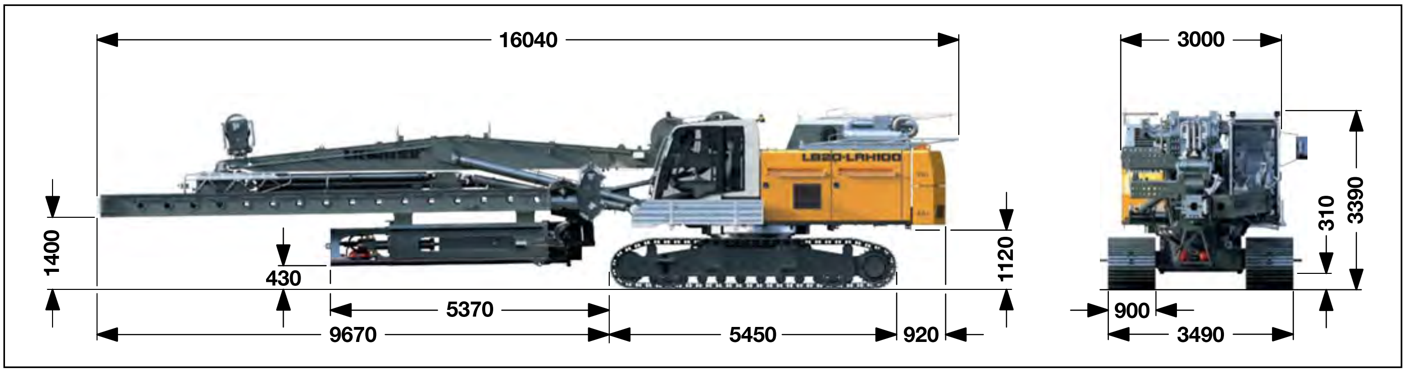
*) See table on page 6

Operating weight

Total weight with 900 mm 3–web grousers	65 t
Weight of hydraulic hammer H 40	see table on page 6

The operating weight includes the basic machine (hydraulic hammer H 40/2.5 with 5.6 t dead weight) and 12 t counterweight.

Transport dimensions and weights



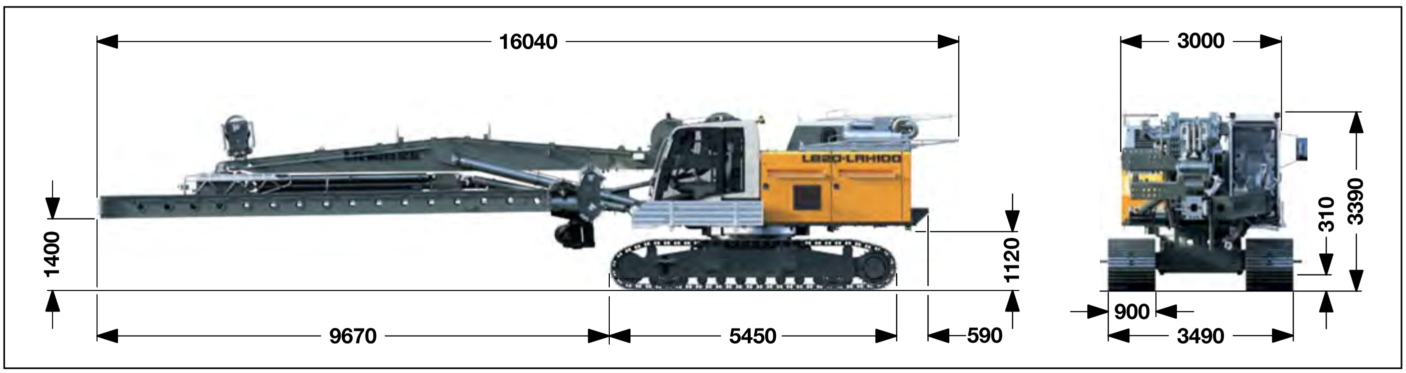
Transport - with hydraulic hammer

includes the basic machine (ready for operation) with leader, hydraulic hammer type H 40 and counterweight.

Weights

Weight complete with hydraulic hammer and counterweight — 65 t
Weight of hydraulic hammer —— see table on page 6

The operating weight includes the basic machine (hydraulic hammer H 40/2.5 with 5.6 t dead weight) and 12 t counterweight.



Transport - standard

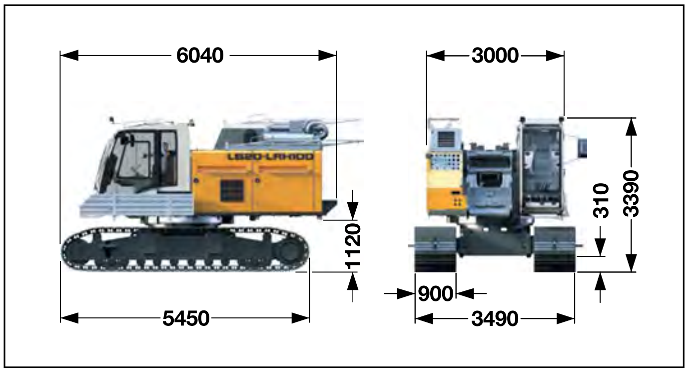
includes the basic machine (ready for operation) with leader without working tools and counterweight.

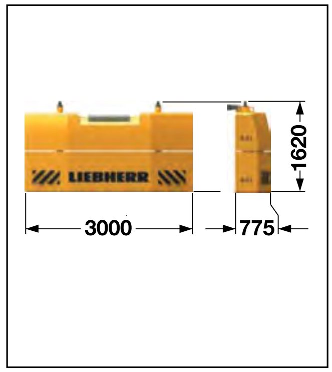
Weights can vary with the final configuration of the machine.

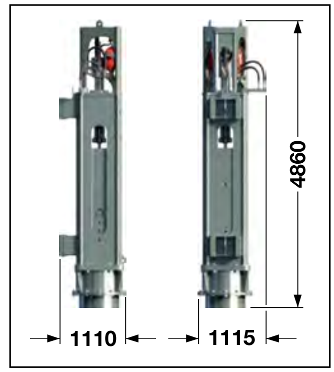
Weights

Weight complete without counterweight —— 47.5 t

Transport dimensions and weights







Transport basic machine

ready for operation, without counterweight.

Transport weight ——— 31.5 t

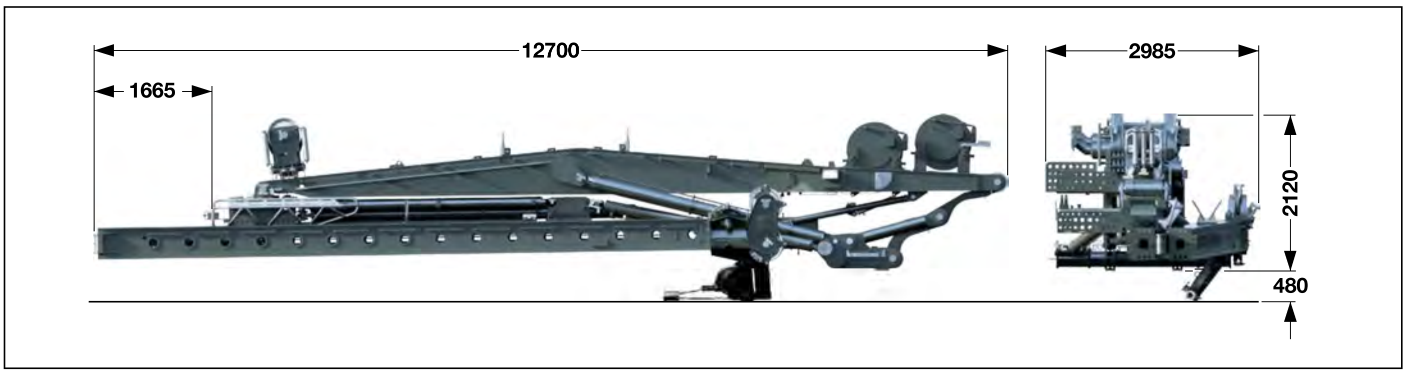
Counterweight

Counterweight ——— 6 t + 6 t

Hammer

Transport weight

H 40/2.5 ——— 5.6 t



Transport leader

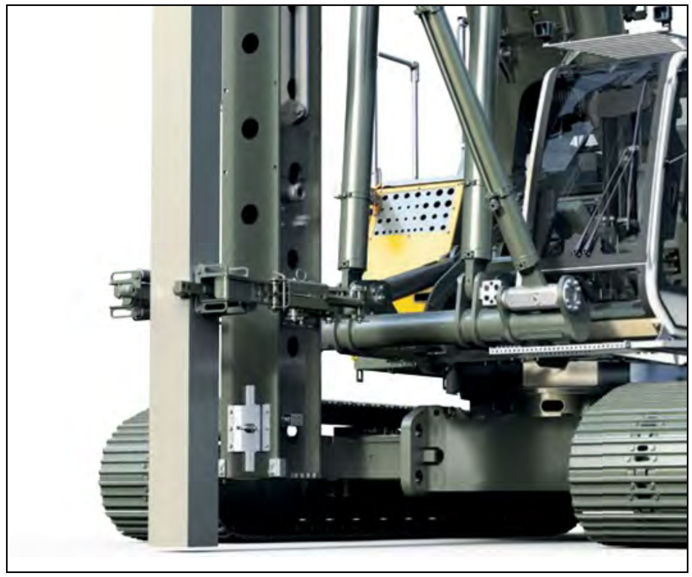
includes the leader without working tools (hydraulic hammer, pre-drill etc.).

The figures include options which are not within the standard scope of supply of the rig.
Weights can vary with the final configuration of the machine.

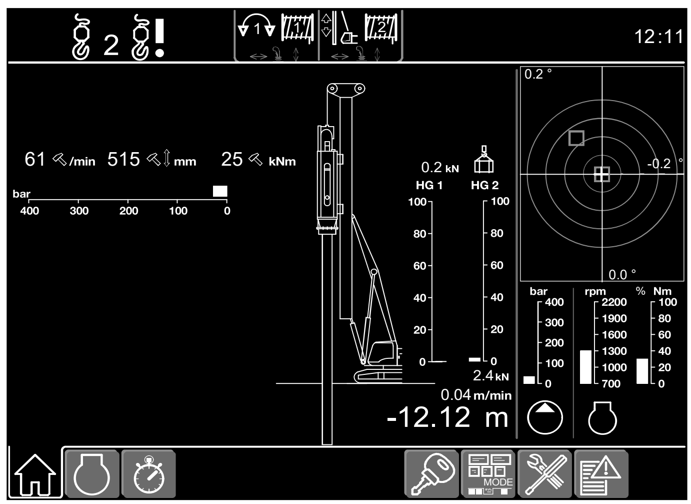
Weights

Weight complete ——— 16 t

Hydraulic hammer
Type H 40



Pile with pile guide



Display for hydraulic hammer

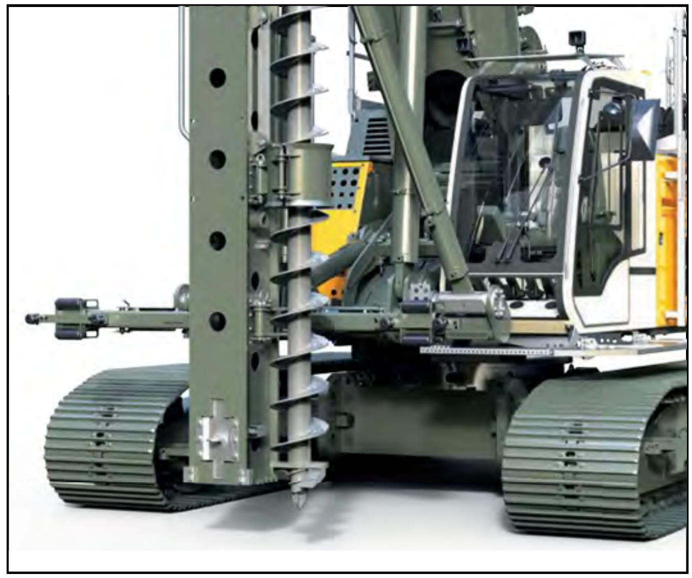
Technical data H 40

Hammer type	H 40/2.5	H 40/4	H 40/5	H 40/7*
Drop weight	2500 kg	4000 kg	5000 kg	7000 kg
Max. rated energy	20 kNm	30 kNm	40 kNm	55 kNm
Blow rate - blows/min	55-80	50-80	50-80	40-80
Hammer weight incl. drop weight	5600 kg	7100 kg	8100 kg	10400 kg

*) Only in combination with extension hammer cage

Various drive cap sizes between 400 mm and 700 mm diameter available on request.

Pre-drill
Type BA12



Auger with auger guide

Technical data

Rotary drive - torque	0 – 12 kNm
Rotary drive - speed	0 – 65 rpm
Max. drilling diameter	0 – 350 mm

Other drilling diameters available on request.

Technical data

Engine

Power rating according to ISO 9249, 270 kW (362 hp) at 2000 rpm

Engine type	Liebherr D 936 A7 SCR
Fuel tank	700 l capacity with continuous level indicator and reserve warning

Engine complies with NRMM exhaust certification EPA/CARB Tier 4i or 97/68 EC Stage III B.

Hydraulic system

The main pumps are operated by a distributor gearbox. Axial piston displacement pumps work in open circuits supplying oil only when needed (flow control on demand). The hydraulic pressure peaks are absorbed by the integrated automatic pressure compensation, which relieves the pump and saves fuel.

Pumps for working tools	2x 240 l/min
Separate pump for kinematics	137 l/min
Hydraulic oil tank	600 l
Max. working pressure	350 bar

The cleaning of the hydraulic oils occurs via an electronically monitored pressure and return filter. Any clogging is shown on the monitor in the cab. The use of synthetic environmentally friendly oil is also possible.

Crawlers

Propulsion through axial piston motor, hydraulically released spring loaded multi-disc brake, maintenance-free crawler tracks, hydraulic chain tensioning device.

Drive speed of telescopic undercarriage	0 – 1.8 km/h
Track force	460 kN
Width of 3–web–grousers	900 mm
Transport width	3490 mm

Swing

Swing ring with triple row roller bearing, external teeth and one swing drive, fixed axial piston hydraulic motor, spring loaded and hydraulically released multi-disc holding brake, planetary gearbox and pinion. Selector for 3 speed ranges to increase swing precision.
Swing speed from 0 – 3.5 rpm is continuously variable.

Control

The control system - developed and manufactured by Liebherr - is designed to withstand extreme temperatures and the many heavy-duty construction tasks for which this machine has been designed. Complete machine operating data are displayed on a high resolution monitor. A GSM/GPRS/GPS-modem allows for remote inquiry of machine data and error indications. To ensure clarity of the information on display, different levels of data are shown in enlarged lettering and symbols.
Control and monitoring of the sensors are also handled by this high technology system. Error indications are automatically displayed on the monitor in clear text. The machine is equipped with electro-hydraulic continuous proportional control for all movements, which can be carried out simultaneously. Two joysticks are required for operation. Pedal control can be changed to hand control.
Options:

- PDE: process data recording
- GSM/GPRS/GPS-modem

Hammer winch with free fall

Line pull (effective)	104 kN
Rope diameter	24 mm
Rope speed	0-55 m/min

The winches are noted for compact, easily mounted design. Propulsion is via a maintenance-free planetary gearbox in oil bath. Load support by the hydraulic system; additional safety factor by a spring-loaded, multi-disc holding brake.

Pile winch with free fall

Line pull (effective)	80 kN
Rope diameter	20 mm
Rope speed	0-55 m/min

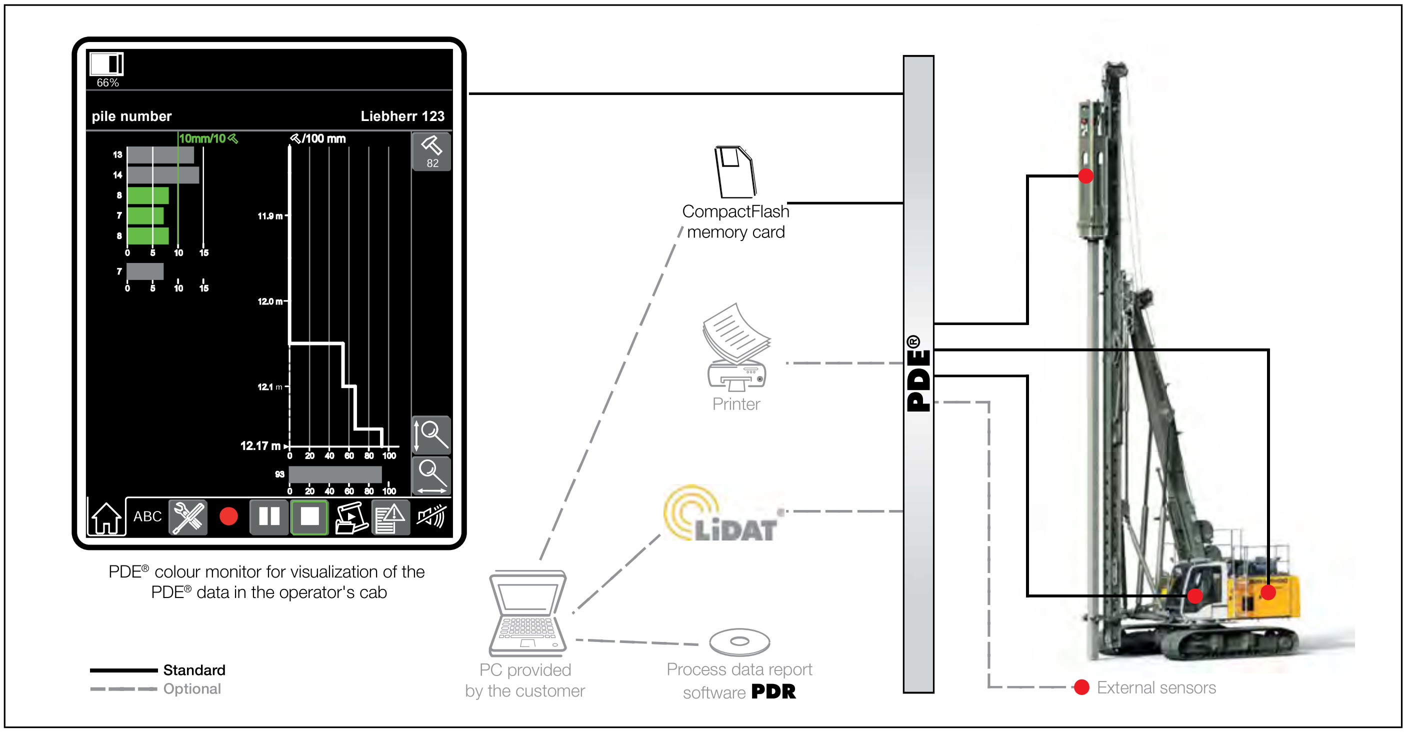
The winches are noted for compact, easily mounted design. Propulsion is via a maintenance-free planetary gearbox in oil bath. Load support by the hydraulic system; additional safety factor by a spring-loaded, multi-disc holding brake.

Noise emission

Noise emissions correspond with 2000/14/EC directive on noise emission by equipment used outdoors.

Process data recording system - PDE® (additional equipment)

The Liebherr process data recording system PDE® constantly records the relevant process data during the working process.



Depending on the application the recorded and processed data are displayed on the PDE® touchscreen in the operator‘s cab, e.g. in the form of an online cast-in-place pile.

At the same time the PDE® is operated using this touchscreen. The operator can enter various details (e.g. jobsite name, pile number, etc.) and start and stop recordings. A recording of every start-stop cycle carried out in the PDE® is established on a CompactFlash memory card.

The PDE® can be configured in a number of ways, e.g. for the connection of external sensors, for the generation of a simple protocol as graphic file and/or for a printout directly in the operator‘s cab.

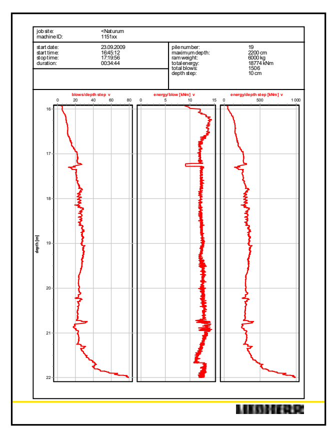
Process data reporting - PDR (additional equipment)

Comprehensive data evaluation and generation of reports on a PC is possible using the software PDR.

Recordings management - The recordings generated by the PDE® system can be imported and managed in PDR. The data can be imported directly from the CompactFlash card or via the Liebherr telematics system LiDAT. Certain recordings, e.g. for a particular day or jobsite, can be found using filter functions.

Viewing data - The data in each record is displayed tabularly. Combining several recordings provides results, for example, regarding the total concrete consumption or the average depth. Furthermore, a diagram editor is available for quick analysis.

Generating reports - A vital element of PDR is the report generator, which allows for the generation of individual reports. These can be printed out directly or stored as pdf files. In the process the size, colour, line thickness or even the desired logo can be configured. Moreover, the reports can be displayed in different languages, e.g. in English and in the national language.



LRH 100 at work


LB20-LRH100

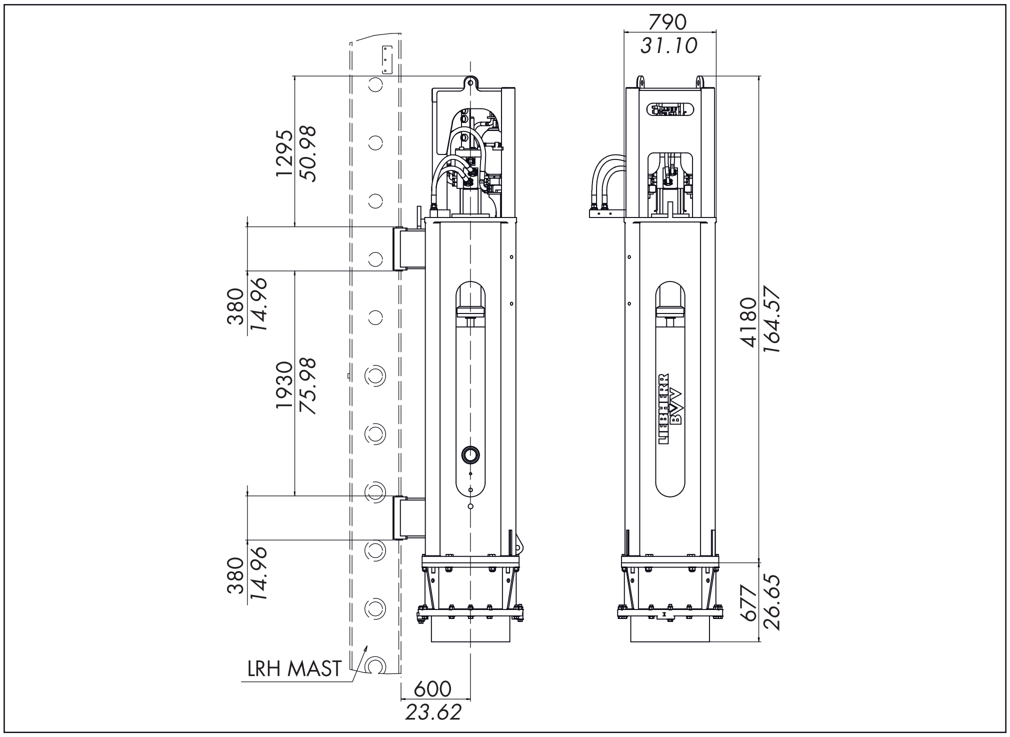

LIEBHERR

Technical Data
Hydraulic Hammers

H-Series

LIEBHERR
BVV

Hydraulic Hammer **H40**



Specifications	H40/2.5	H40/4	H40/5	H40/7*
Ram mass	2500 kg *5500 lbs*	4000 kg *8800 lbs*	5000 kg *11000 lbs*	7000 kg *15500 lbs*
Maximum energy	20 kNm *14500 ft.lbs*	30 kNm *21750 ft.lbs*	40 kNm *29000 ft.lbs*	55 kNm *39800 ft.lbs*
Blow rate **	40 – 80 bpm			
Basic hammer weight	4500 kg *9921 lbs*	6000 kg *13228 lbs*	7000 kg *15432 lbs*	9000 kg *19842 lbs*
Hydraulic pressure	265 bar *3800 psi*			
Hydraulic flow **	130 l/min *34 US Gall.*			

* Only in combination with cage extension.
** Performance can vary depending on hydraulic output of base machine.

Special features of the H40

- Designed for heavy duty applications with steel, concrete and wooden piles
- Interchangeable drop weights
- Easy installation onto Liebherr LRH 100 hydraulic piling rig
- Short body maximises length of pile that can be driven
- Energy infinitely variable and able to be electronically monitored in cab

Basic machine

	LRH 100	LRB 125	LRB 125XL	LRB 155	LRB 255
H40	x				
H50		x	x		
H85				x	
H110					x

All dimensions in **mm**/***inch***; only metric values are valid.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

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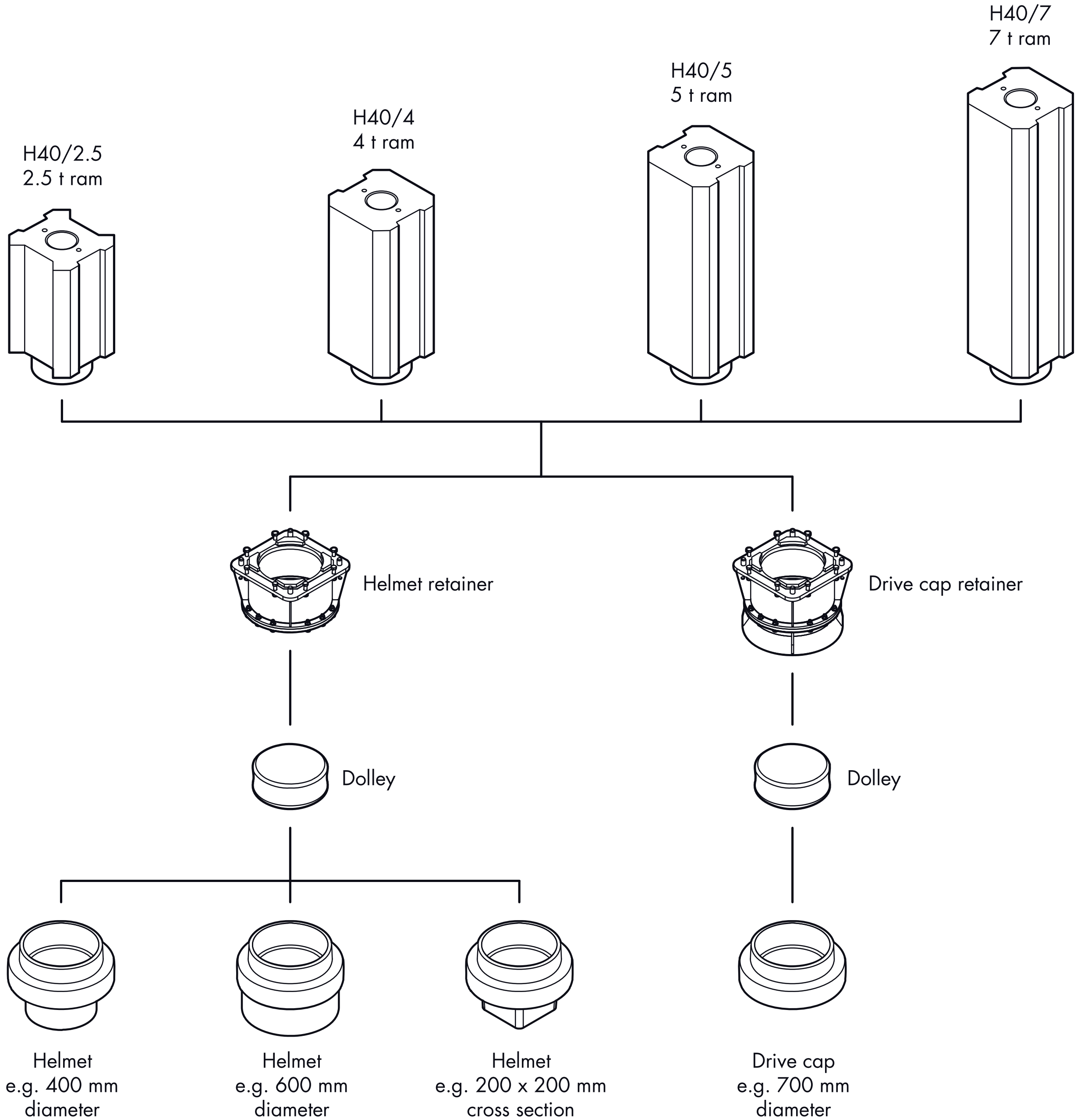
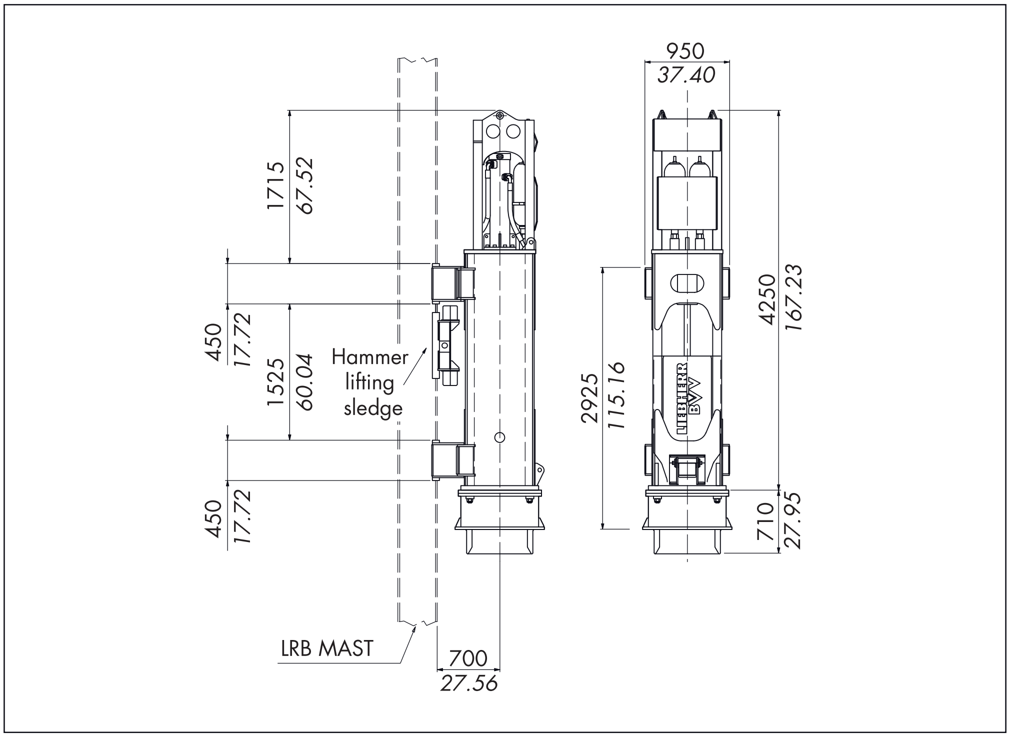


Other configurations can be supplied on request.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

Hydraulic Hammer H50



Specifications	**H50/4**				**H50/3 ***			
Ram mass	4000	kg	*8800*	*lbs*	3000	kg	*6600*	*lbs*
Maximum energy	51	kNm	*35000*	*ft.lbs*	40	kNm	*29000*	*ft.lbs*
Blow rate **	50 – 100	bpm			50 – 100	bpm		
Basic hammer weight	7200	kg	*15875*	*lbs*	6200	kg	*13670*	*lbs*
Hydraulic pressure	210	bar	*3000*	*psi*	200	bar	*2900*	*psi*
Hydraulic flow **	160	l/m	*42*	*US Gall.*	160	l/m	*42*	*US Gall.*

* Instead of 4000 kg ram a 3000 kg ram can be installed.
** Performance can vary depending on hydraulic output of base machine.

Special features of the H50

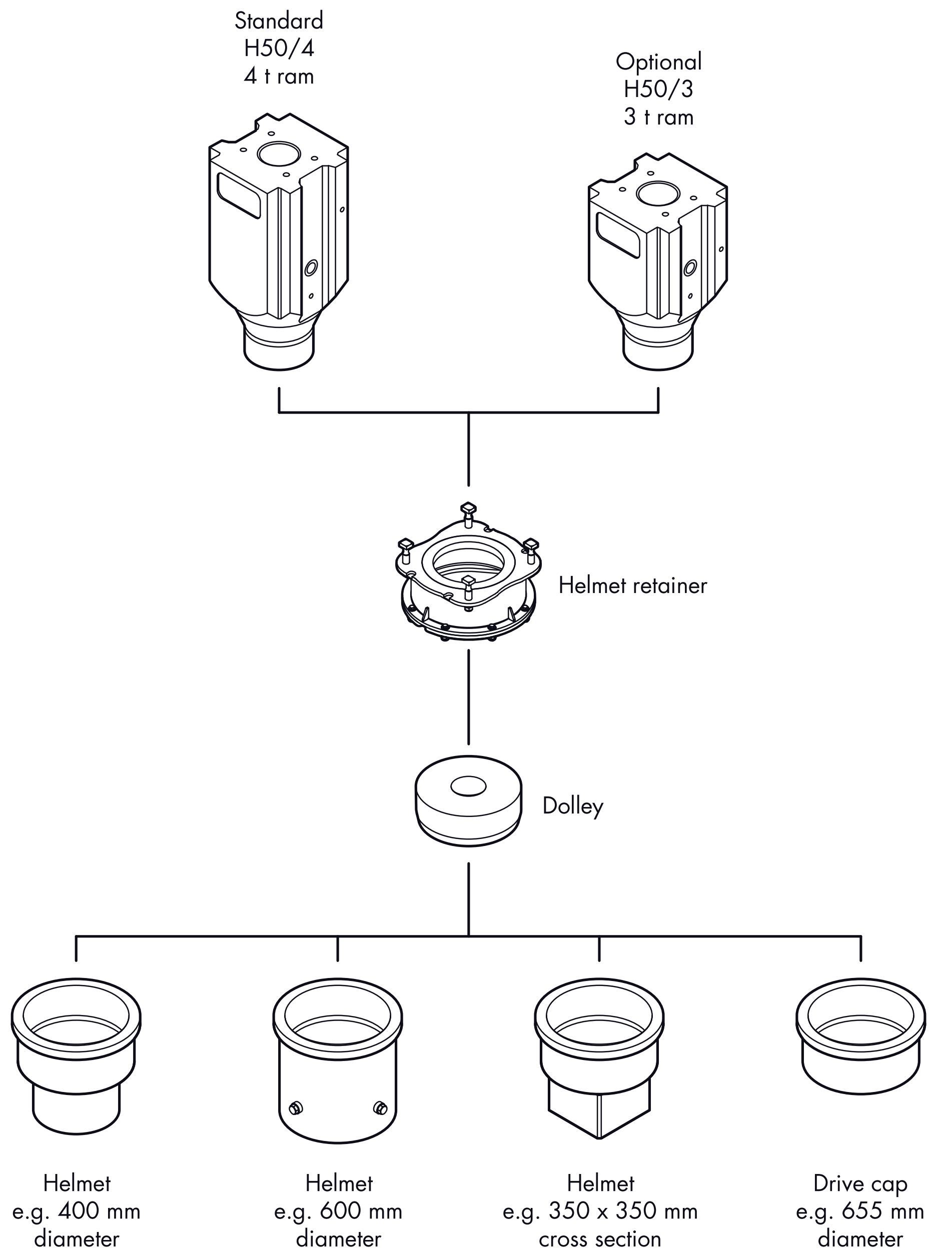
- Designed for heavy duty applications with steel, concrete and wooden piles
- Interchangeable drop weights
- Easy installation onto Liebherr LRB-Series hydraulic piling rig
- Short body maximises length of pile that can be driven
- Energy infinitely variable and able to be electronically monitored in cab

Basic machine

	LRH 100	**LRB 125**	**LRB 125XL**	LRB 155	LRB 255
H40	x				
H50		**x**	**x**		
H85				x	
H110					x

All dimensions in **mm**/***inch***; only metric values are valid.

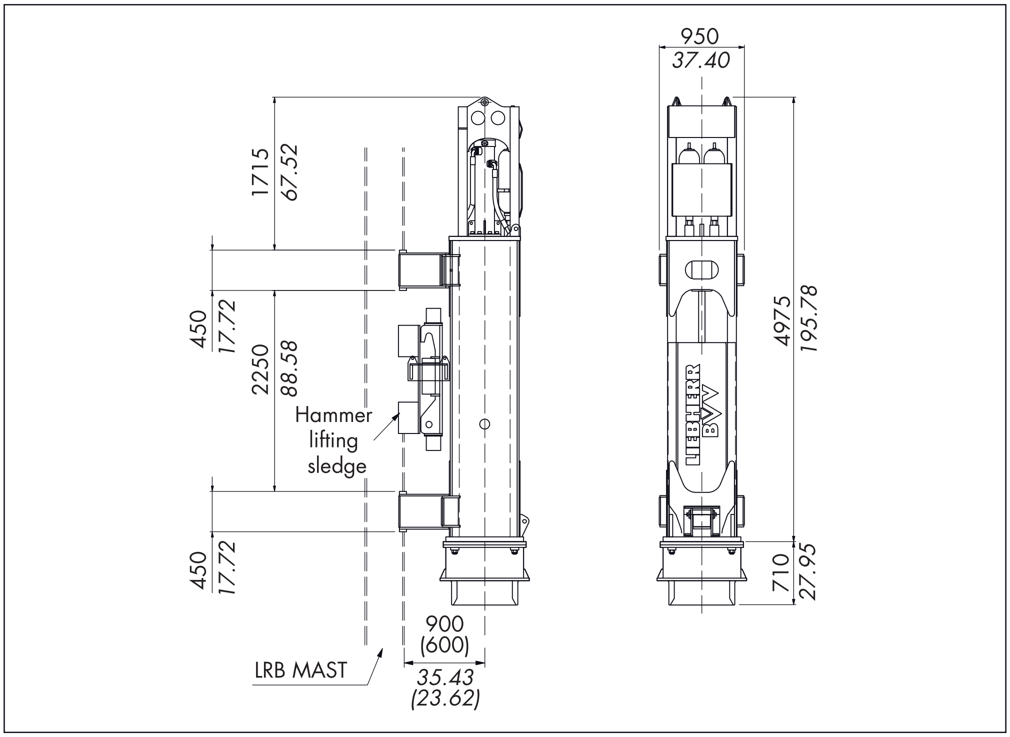
Due to improvement and engineering progress we reserve the right to change specifications without notice.



Other configurations can be supplied on request.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

Hydraulic Hammer H85



Specifications	H85/7				H85/5 *			
Ram mass	7000	kg	*15425*	*lbs*	5000	kg	*11000*	*lbs*
Maximum energy	83	kNm	*60000*	*ft.lbs*	60	kNm	*43300*	*ft.lbs*
Blow rate **	45 – 100	bpm			50 – 100	bpm		
Basic hammer weight	10525	kg	*23204*	*lbs*	8620	kg	*19004*	*lbs*
Hydraulic pressure	240	bar	*3500*	*psi*	210	bar	*3000*	*psi*
Hydraulic flow **	200	l/m	*52*	*US Gall.*	200	l/m	*52*	*US Gall.*

* Instead of 7000 kg ram a 5000 kg ram can be installed.
** Performance can vary depending on hydraulic output of base machine.

Special features of the H85

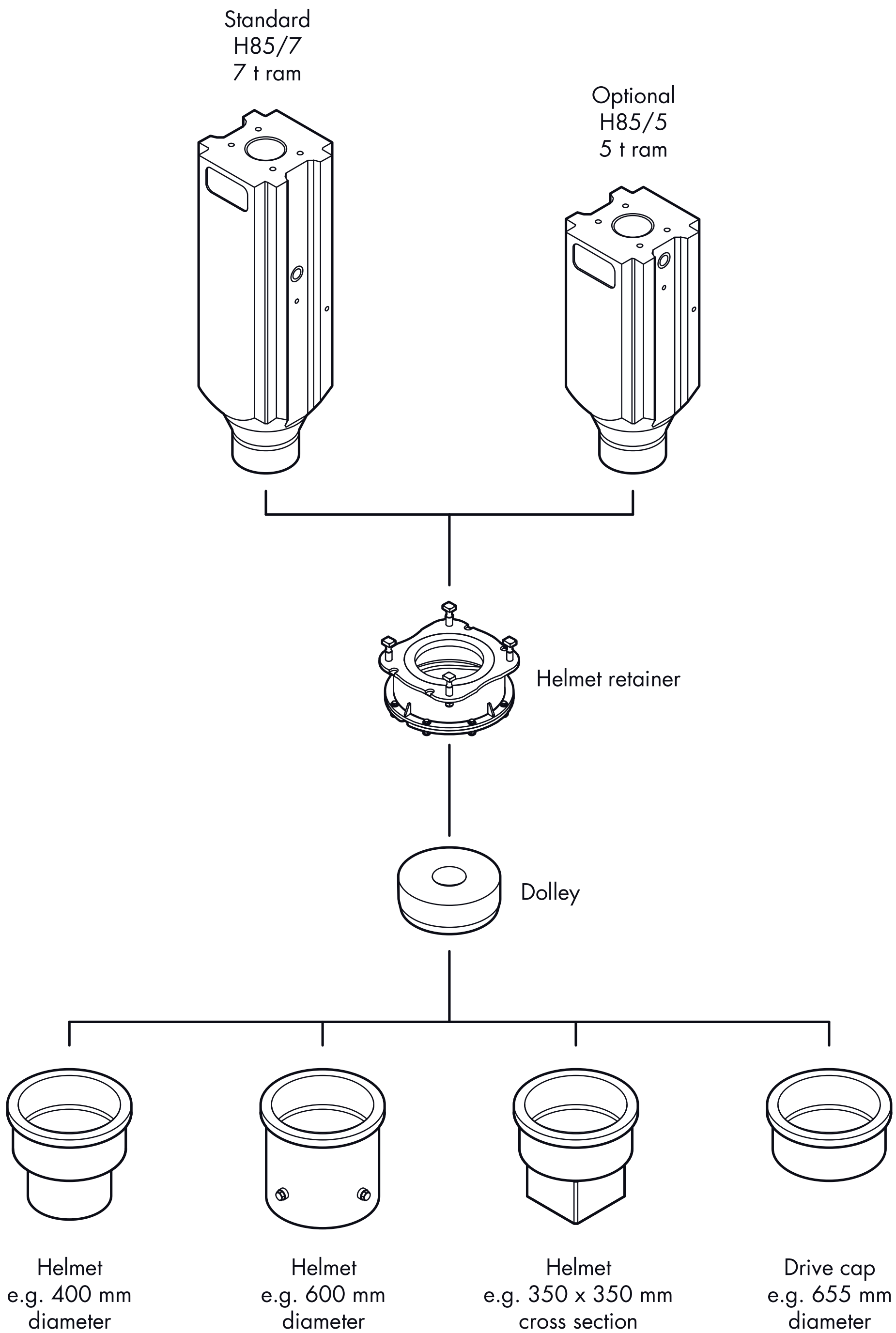
- Designed for heavy duty applications with steel, concrete and wooden piles
- Interchangeable drop weights
- Easy installation onto Liebherr LRB-Series hydraulic piling rig
- Short body maximises length of pile that can be driven
- Energy infinitely variable and able to be electronically monitored in cab

Basic machine

	LRH 100	LRB 125	LRB 125XL	**LRB 155**	LRB 255
H40	x				
H50		x	x		
H85				**x**	
H110					x

All dimensions in **mm**/***inch***; only metric values are valid.

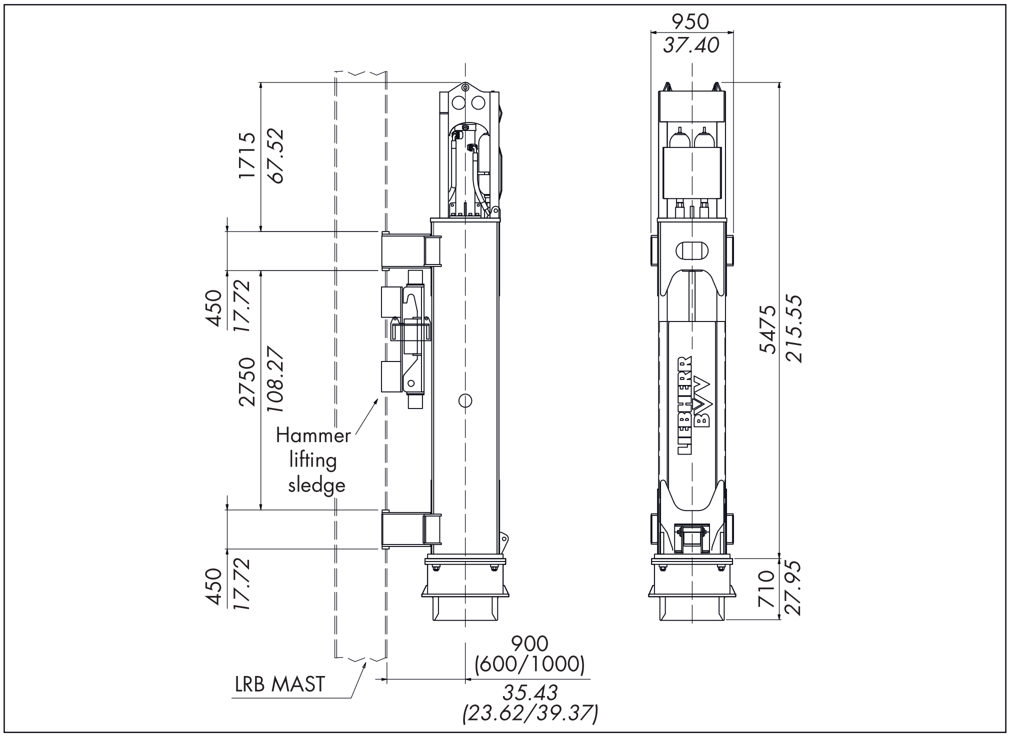
Due to improvement and engineering progress we reserve the right to change specifications without notice.



Other configurations can be supplied on request.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

Hydraulic Hammer H110



Specifications	H110/9				H110/7 *			
Ram mass	9000	kg	*19850*	*lbs*	7000	kg	*15425*	*lbs*
Maximum energy	106	kNm	*78000*	*ft.lbs*	83	kNm	*60000*	*ft.lbs*
Blow rate	36 – 100	bpm			40 – 100	bpm		
Basic hammer weight	12685	kg	*27966*	*lbs*	10550	kg	*23259*	*lbs*
Hydraulic pressure	250	bar	*3625*	*psi*	230	bar	*3335*	*psi*
Hydraulic flow	215	l/m	*55*	*US Gall.*	215	l/m	*55*	*US Gall.*

* Instead of 9000 kg ram a 7000 kg ram can be installed.

Special features of the H110

- Designed for heavy duty applications with steel, concrete and wooden piles
- Interchangeable drop weights
- Easy installation onto Liebherr LRB-Series hydraulic piling rig
- Short body maximises length of pile that can be driven
- Energy infinitely variable and able to be electronically monitored in cab

Basic machine

	LRH 100	LRB 125	LRB 125XL	LRB 155	LRB 255
H40	x				
H50		x	x		
H85				x	
H110					**x**

All dimensions in **mm**/***inch***; only metric values are valid.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

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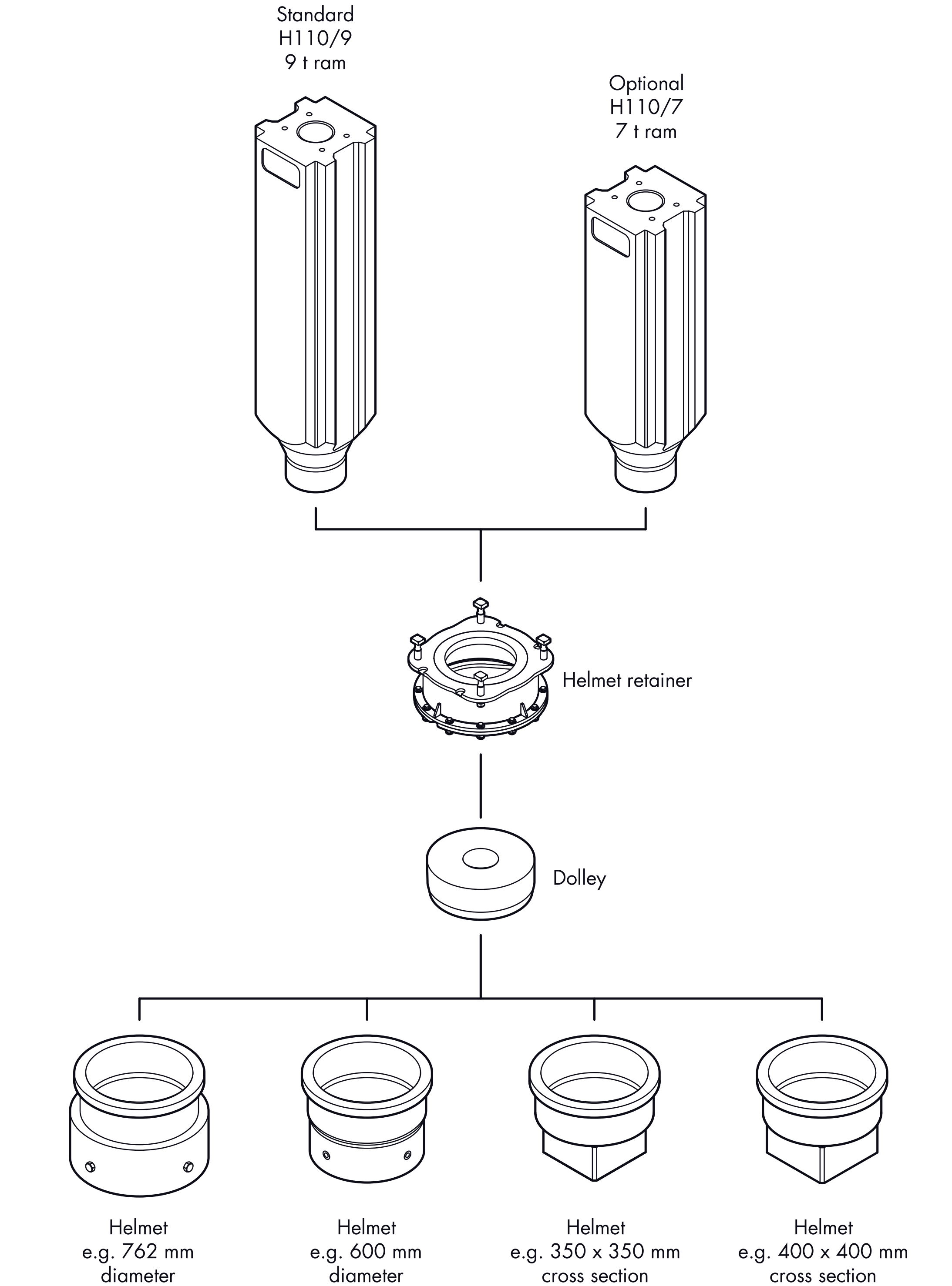
Configuration



Other configurations can be supplied on request.

Due to improvement and engineering progress we reserve the right to change specifications without notice.

Exova
15 High Ridge Court
Cambridge
Ontario
Canada
N1R 7L3

T: +1 (519) 621-8191
F: +1 (519) 621-7700
E: sales@exova.com
W: www.exova.com

Test Certificate

Crawford Metal Corporation
1091 Heritage Road
Burlington, ON
L7L 4Y1

REF No G755409 : Issue 1
Page 1 of 2
Ord No 3068M
Date Tested 07/28/17
Date Reported 07/31/17

Attn: Dave Gordon

Item - Ref: Heat #P86492, Bearing Pile, 12" @ 74#

Specification - ASTM A992-15 / ASTM A572-15 Grade 50 / CSA G40.21-04 350W

Tensile Test - ASTM A 370-17

	Dimensions [mm]	Area [mm^2]	GL [mm]	0.20%YS [N/mm^2]	UTS [N/mm^2]	%El	%RA	Comments
001:Longitudinal	6.04	28.65	25.00	369	545	26	69	Nil

Chemical Analysis - See Below

	C [%]	Mn [%]	P [%]	S [%]	Si [%]	Ni [%]	Cr [%]	Mo [%]	Cu [%]	Al [%]	Sn [%]	Comments
002:	0.13	1.36	0.018	0.019	0.19	0.14	0.15	0.02	0.13	<0.005	0.01	See Below
	V [%]	Nb [%]	Ti [%]	Co [%]								Comments
002:	0.025	<0.005	<0.005	0.01								See Below

Item 002: For Copper Steel, Cu = 0.20 min.
Carbon Equivalent (CE) = 0.41%
Nb+V = 0.02

Certificate Comments

Item 001: Conforms to the requirements of ASTM A992-15/ASTM A572-15 Grade 50/CSA G40.21-04 350W.

Item 002: Chemical analysis conducted in accordance with ASTM E415-15. Sample(s) tested meet the Chemistry requirements of CSA G40.21-13 Grade 350W, ASTM A992-11(2015) and ASTM A572-15 Grade 50 Type 2 with respect to the tests conducted above.

Tested by **Exova Burlington & Chris Hernandez**

Roger Graham
General Manager
For and on authority of
Exova

[illegible] false, fictitious or fraudulent statements or entries [illegible]
[illegible] not be reproduced other than in full [illegible]
[illegible] pertain only to the sample(s) tested as [illegible]

Canadian BBR Inc.
3450 Midland Avenue
Agincourt Ontario

Calibration of Hydraulic Components 29-Oct-19

600 ton Pine

No. 1

Ram Area (sq. in.) 172
Friction Calibration 1.028

LICENSED PROFESSIONAL ENGINEER
T. R. PAHAPILL
29 Oct 19
PROVINCE OF ONTARIO

Calibrated with Digital pressure gauge
Enerpac Model DGB / 10000 psi
Load cell BBR no.2

Gauge psi	Voltage run 1	Voltage run 2	Voltage run 3	Voltage (avg)	Load kips
1000	1.189	1.187	1.190	1.189	166.40
2000	2.400	2.405	2.430	2.412	337.63
3000	3.584	3.589	3.611	3.595	503.27
4000	4.784	4.790	4.799	4.791	670.77
5000	5.971	5.984	6.000	5.985	837.93
6000	7.143	7.173	7.172	7.163	1002.77
6500	7.738	7.771	7.756	7.755	1085.67

Load Cell - Procedure A

innovation in geotechnical instrumentation

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

VIBRATING WIRE LOAD CELL

Customer: Williams Form Hardware
Calibration Date: 14-Jan-19
Temperature °C: 15.4

Serial Number: **VC1451**
Order Number: 219871
Model Number: VWA-800-4

Units = B Units = $Hz^2 \times 10^{-3}$
Cable Length: 5 m
Reference: SC3320

Applied Load KIPS	Gauge # 1	Gauge # 2	Gauge # 3	Gauge # 4	Average All Four
Run #1					
0.0	6939.8	6875.1	6997.1	6990.2	6950.6
80.0	6698.2	6651.5	6766.7	6737.5	6713.4
160.0	6448.0	6410.9	6516.5	6470.4	6461.4
239.9	6197.5	6172.3	6266.3	6203.3	6209.8
320.0	5944.2	5932.9	6012.8	5931.4	5955.3
400.0	5691.6	5693.4	5762.3	5663.1	5702.6
480.0	5435.7	5452.4	5507.5	5395.3	5447.7
560.0	5182.0	5208.8	5257.2	5126.3	5193.6
639.9	4929.3	4968.7	5005.7	4855.3	4939.7
719.9	4671.8	4727.0	4750.4	4585.5	4683.7
800.0	4417.7	4485.0	4496.7	4315.6	4428.7
Run #2					
0.0	6937.7	6872.3	6994.0	6987.4	6947.8
79.9	6694.6	6655.4	6768.6	6733.1	6712.9
160.0	6444.5	6415.3	6518.5	6464.1	6460.6
239.9	6193.3	6177.3	6269.5	6197.4	6209.4
320.0	5940.3	5939.1	6016.7	5924.5	5955.1
400.0	5687.3	5699.5	5765.3	5655.2	5701.8
479.9	5432.1	5459.5	5511.4	5387.7	5447.7
560.0	5177.9	5216.8	5260.6	5116.8	5193.0
639.9	4925.1	4975.9	5008.7	4846.8	4939.1
720.1	4667.3	4735.0	4753.7	4576.5	4683.1
799.9	4414.6	4494.3	4500.6	4307.5	4429.2
Run #3					
0.0	6937.7	6872.1	6993.8	6987.4	6947.8
79.9	6698.1	6649.4	6766.2	6739.6	6713.3
160.0	6447.8	6408.6	6515.6	6472.8	6461.2
240.0	6196.2	6168.9	6265.5	6206.1	6209.2
320.1	5943.4	5929.8	6012.2	5934.5	5955.0
399.9	5691.6	5691.2	5761.8	5665.8	5702.6
480.0	5435.2	5450.6	5507.8	5397.3	5447.7
559.9	5181.6	5207.4	5257.2	5128.1	5193.6
640.0	4928.3	4965.9	5005.0	4857.2	4939.1
719.9	4672.1	4725.7	4750.9	4587.6	4684.1
799.8	4417.6	4482.9	4497.4	4318.6	4429.1

JAN 15 2019

Average Load	Run 1	Run 2	Run 3	Average
0.0	6950.6	6947.8	6947.8	6948.7
79.9	6713.4	6712.9	6713.3	6713.2
160.0	6461.4	6460.6	6461.2	6461.1
239.9	6209.8	6209.4	6209.2	6209.5
320.0	5955.3	5955.1	5955.0	5955.1
400.0	5702.6	5701.8	5702.6	5702.3
479.9	5447.7	5447.7	5447.7	5447.7
560.0	5193.6	5193.0	5193.6	5193.4
639.9	4939.7	4939.1	4939.1	4939.3
720.0	4683.7	4683.1	4684.1	4683.6
799.9	4428.7	4429.2	4429.1	4429.0

	Wiring Code	
Gauge 1	Pin S	Black
Ground 1	Pin T	Green
Gauge 2	Pin P	Brown
Ground 2	Pin R	Green
Gauge 3	Pin M	Red
Ground 3	Pin N	Green
Gauge 4	Pin K	Orange
Ground 4	Pin L	Green
Thermistor	Pin B	Blue
Thermistor	Pin C	White
Shield	Pin U	Shield

Force (KIPS) = (A - average) * B

A = 6963.1 **B = 0.31628**

Calibrated by: J.Tam

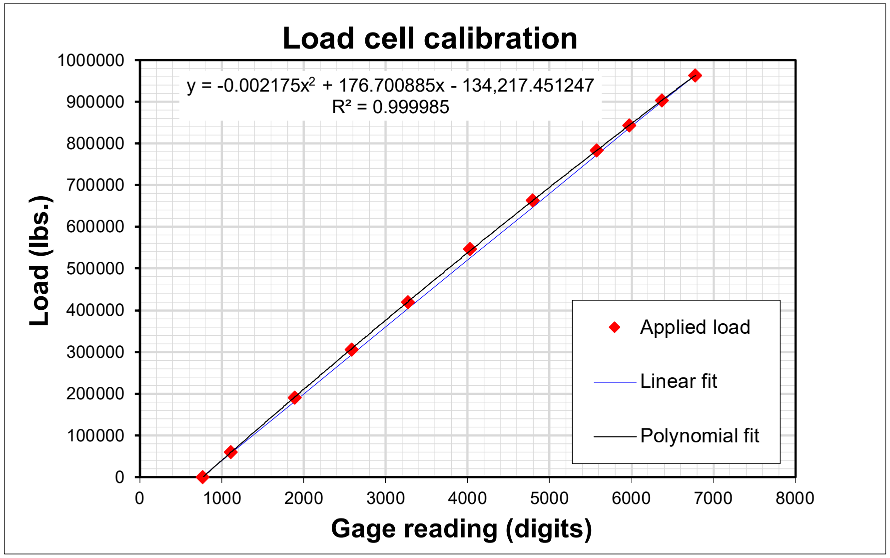
Document Number.: LPL0027F

Recycled
MIG0106B

Load Cell - Procedure B

AATech Scientific Inc.

Calibration of Load Cell (S/N: SC3322)



1	2	3	4
Applied load (lbs)	**Gage Reading (digits)**	**Computed Gage Factor Lbs./digit**	**Linear Fit lbs.**
Reg. zero >>	755		0
0	765	N/A	1,604
60,000	1107	175.439	56,411
190,000	1887	166.667	181,409
306,000	2582	166.906	292,785
420,000	3275	164.502	403,840
546,000	4032	166.446	525,152
663,000	4793	153.745	647,105
783,500	5578	153.503	772,904
843,600	5975	151.385	836,525
903,700	6373	151.005	900,306
963,500	6780	146.929	965,529
0	767		1,925

Manufacturer: RST Instruments **Temperature:** 18 °C

Model No.: SGA-1200-6.0LC

Gage Type: Resistive strain gage

Serial No.: SC3322

Gage Factor (G): (Linear) 160.2535 lbs./digit; 0.7128 kN/digit (1 mV/V = 4,000 digits) 1 kN = 224.82 lbs

Regression zero (R_0): 754.99 digits

Linear function: L = (R - R0) * G

L = Load in lbs or kN, depending on G
R = Cell reading in digits

Calibrated by: H. (Sam) Salem, Mudasser Noor
Calibrated on: January 03, 2020

Polynomial gage factors: A = -0.002175; B = 176.700885; !! C = -134,217.45

$L = A R^2 + B R + C$

L = Load in lbs
R = Cell reading in digits

!! Recalculate C based on your field setup by setting L = 0 and R = initial fie
zero reading in the polynomial equatio

Important note:
When testing within a low range of load (below 10,000 lbs), use the polynomial factors for calculating the load. Readings for specific loads can be computed using:

$$R = \frac{-B + \sqrt{B^2 - 4A(C-L)}}{2A}$$

Where R is the reading corresponding to load L

Dial Gauge #4 - Procedure B

E & E PROCESS INSTRUMENTATION

CALIBRATION CERTIFICATE

CERTIFICATE No. ACPG45-2019

INSTRUMENT: Indicator, Dial
CAL. DATE: June 6, 2019
SERIAL_ASSET No.: ACPG45
CAL. DUE DATE: **June 6, 2020**
MODEL No.: 3428S-19
CUSTOMER: GFL ENVIRONMENTAL INC.
STREET ADDRESS:
GRADUATION: 0.001 in
CITY:
ACCURACY: ± 0.001 in (First 2.5 Rev.) ; ± 0.005 in (Rest of Range)
RANGE: (0 to 4) in
TEMPERATURE: 20 ± 2°C
HUMIDITY: (20 to 60)%
MANUFACTURER: Mitutoyo Corporation
METHOD USED: Comparison
CAL. PROCEDURE: CP-315
UNIT OF MEASUREMENT: Inch (in)
LOCATION: IH-1

PARAMETER	NOMINAL	AS FOUND	AS LEFT	MIN.	MAX.	TOLERANCE (AS LEFT)
Repeatability	0	0.00000	0.00000	-0.00091	0.00091	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
Inward	0	0.00000	0.00000	-0.00091	0.00091	IN
	1	1.00000	1.00000	0.99509	1.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	3	3.00000	3.00000	2.99509	3.00491	IN
	4	4.00000	4.00000	3.99509	4.00491	IN
Outward	2	2.00000	2.00000	1.99509	2.00491	IN
	0	0.00000	0.00000	-0.00091	0.00091	IN

TRACEABLE REFERENCE STANDARD	
INSTRUMENT	ASSET No.
Indicator Calibration System	MRM-1060

RECEIVED CONDITION: New, In Tolerance.
FINAL CONDITION: In Tolerance

Uncertainty of Measurement: ± 0.0003 in

Uncertainty of Measurement is recognized in statements of compliance according to Decision Rule 4.2 of ASME B89.7.3.1-2001

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Reference Standards are traceable to SI through NIST, NRC or other recognized NMI.

Calibration results are only related to the instrument specified on this certificate.

This certificate shall not be reproduced, except in full, without written approval

APPROVAL

40 North Rivermede Road, Unit 4, Concord, ON L4K 2H3 • Phone: (905) 669-4857
Website: www.eeprocess.com • Email: sales@eeprocess.com • Fax: (905) 669-2158

Dial Gauge #3 - Procedure A and B

E & E PROCESS INSTRUMENTATION

CERTIFICATE No. 997333-2-2019

INSTRUMENT: Indicator, Dial

SERIAL_ASSET No: 997333-2

MODEL No: 25-3041

GRADUATION: 0.001 in

ACCURACY: ± 0.004 in

RANGE: (0 to 3) in

MANUFACTURER: The L.S. Starrett Company Ltd

CAL. PROCEDURE: CP-315

CAL. DATE: June 19, 2019

CAL. DUE DATE: June 19, 2020

CUSTOMER: GFL ENVIRONMENTAL INC.

STREET ADDRESS:

CITY:

TEMPERATURE: 20 ± 2°C

HUMIDITY: (20 to 60)%

METHOD USED: Comparison

UNIT OF MEASUREMENT: Inch (in)

PARAMETER	NOMINAL	AS FOUND	AS LEFT	MIN	MAX	TOLERANCE (AS LEFT)
Repeatability	0	0.00000	0.00000	-0.00376	0.00376	IN
	1	1.00025	1.00025	0.99624	1.00376	IN
	1	1.00025	1.00025	0.99624	1.00376	IN
	1	1.00025	1.00025	0.99624	1.00376	IN
Inward	0	0.00000	0.00000	-0.00376	0.00376	IN
	0.5	0.50025	0.50025	0.49624	0.50376	IN
	1	1.00025	1.00025	0.99624	1.00376	IN
	2	2.00100	2.00100	1.99624	2.00376	IN
	3	3.00125	3.00125	2.99624	3.00376	IN
Outward	1	1.00025	1.00025	0.99624	1.00376	IN
	0	0.00000	0.00000	-0.00376	0.00376	IN

TRACEABLE REFERENCE STANDARD:	
INSTRUMENT	ASSET No.
Indicator Calibration System	MRM-1060

RECEIVED CONDITION: In Tolerance.

FINAL CONDITION: In Tolerance.

Uncertainty of Measurement: ± 0.00079 in

Uncertainty of Measurement is recognized in statements of compliance according to Decision Rule 4.2 of ASME B89.7.3.1-2001

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Reference Standards are traceable to SI through NIST, NRC or other recognized NMI.

Calibration results are only related to the instrument specified on this certificate.

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Website: www.eeprocess.com • Email: sales@eeprocess.com • Fax: (905) 669-2158

E & E PROCESS INSTRUMENTATION

Dial Gauge #1 - Procedure A
Dial Gauge #2 - Procedure B

CALIBRATION CERTIFICATE

INSTRUMENT: Indicator, Dial
SERIAL_ASSET No: ACPG35
MODEL No: 3428S-19
GRADUATION: 0.001 in
ACCURACY: ± 0.001 in (First 2.5 Rev.) ; ± 0.005 in (Rest of Range)
RANGE: (0 to 4) in
MANUFACTURER: Mitutoyo Corporation
CAL PROCEDURE: CP-315

CAL DATE: April 30, 2019
CAL DUE DATE: **April 30, 2020**
CUSTOMER: GFL ENVIRONMENTAL INC.
STREET ADDRESS:
CITY:
TEMPERATURE: 20 ± 2°C
HUMIDITY: (20 to 60)%
METHOD USED: Comparison
UNIT OF MEASUREMENT: Inch (in)
LOCATION: IH-1

PARAMETER	NOMINAL	AS FOUND	AS LEFT	MIN	MAX	TOLERANCE (AS LEFT)
Repeatability	0	0.00000	0.00000	-0.00091	0.00091	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
Inward	0	0.00000	0.00000	-0.00091	0.00091	IN
	1	1.00000	1.00000	0.99509	1.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	3	3.00000	3.00000	2.99509	3.00491	IN
	4	4.00000	4.00000	3.99509	4.00491	IN
Outward	2	2.00000	2.00000	1.99509	2.00491	IN
	0	0.00000	0.00000	-0.00091	0.00091	IN

TRACEABLE REFERENCE STANDARD:	
INSTRUMENT	ASSET No.
Indicator Calibration System	MRM-1060

RECEIVED CONDITION: New. In Tolerance.
FINAL CONDITION: In Tolerance
Uncertainty of Measurement: ± 0.0003 in
Uncertainty of Measurement is recognized in statements of compliance according to Decision Rule 4.2 of ASME B89.7.3.1-2001
The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%
Reference Standards are traceable to SI through NIST, NRC or other recognized NMI
Calibration results are only related to the instrument specified on this certificate
This certificate shall not be reproduced, except in full, without written approval

Approval

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Dial Gauge #2 - Procedure A
Dial Gauge #1 - Procedure B

E & E PROCESS INSTRUMENTATION

CALIBRATION CERTIFICATE

CERTIFICATE No. ACPG26-2019

INSTRUMENT: Indicator, Dial
SERIAL_ASSET No. ACPG26
MODEL No. 3428S-19
GRADUATION: 0.001 in
ACCURACY: ± 0.001 in (First 2.5 Rev.) ; ± 0.005 in (Rest of Range)
RANGE: (0 to 4) in
MANUFACTURER: Mitutoyo Corporation
CAL. PROCEDURE: CP-315

CAL. DATE: May 7, 2019
CAL. DUE DATE: **May 7, 2020**
CUSTOMER: GFL ENVIRONMENTAL INC.
STREET ADDRESS:
CITY:
TEMPERATURE: 20 ± 2°C
HUMIDITY: (20 to 60)%
METHOD USED: Comparison
UNIT OF MEASUREMENT: Inch (in)

PARAMETER	NOMINAL	AS FOUND	AS LEFT	MIN	MAX	TOLERANCE (AS LEFT)
Repeatability	0	0.00000	0.00000	-0.00091	0.00091	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
Inward	0	0.00000	0.00000	-0.00091	0.00091	IN
	1	1.00000	1.00000	0.99509	1.00491	IN
	2	2.00000	2.00000	1.99509	2.00491	IN
	3	3.00000	3.00000	2.99509	3.00491	IN
	4	4.00000	4.00000	3.99509	4.00491	IN
Outward	2	2.00000	2.00000	1.99509	2.00491	IN
	0	0.00000	0.00000	-0.00091	0.00091	IN

TRACEABLE REFERENCE STANDARD	
INSTRUMENT	ASSET No.
Indicator Calibration System	MRM-1060

RECEIVED CONDITION: New. In Tolerance

FINAL CONDITION: In Tolerance

Uncertainty of Measurement: ± 0.0003 in

Uncertainty of Measurement is recognized in statements of compliance according to Decision Rule 4.2 of ASME B89.7.3.1-2001

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Reference Standards are traceable to SI through NIST, NRC or other recognized NMI.

Calibration results are only related to the instrument specified on this certificate.

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Approval

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Website: www.eeprocess.com • Email: sales@eeprocess.com • Fax: (905) 669-2158

Pump Pressure Gauge

Calibration certificate

WIKA

Certificate no	00070771

General

Calibration certificate	
Customer	[illegible] CONSTRUCTION PRODUCTS LTD - [illegible] 12 WALLACE STREET CA-L7J 2V6 ACTON
Customer order number	
Order date	
Date of calibration	11/01/2019
Operator	Monika Humelbrinck

Device under test (DUT)

Mechanical pressure gauge	
Model	233.50.100
Serial number	8971HUFL
Scale range	(0 ... 10000) psi g
Accuracy	1 % FS
Resolution (scale division)	10 psi
TagNo	

Ambient conditions

- Temperature (23.0 ± 0.1) °C
- Atmospheric pressure (1013.0 ± 0.1) mbar
- rel. humidity (32 ± 1) %

Place of calibration

- Oakville

Measurement conditions

Working standard (WS) Hand-held / Pressure transmitter	
Model	OAK L004
Calibration mark	3993685
Date of calibration	01/14/2019
Scale range	(0 ... 1000) bar g
Accuracy	0.025 % FS

Measurement results

Reading DUT psi	Reference value WS psi	
	↑	↓
0	0.00	0.00
3000	2995.00	2935.00
5000	5000.00	4940.00
7000	7000.00	6940.00
10000	9985.00	9985.00

Reading DUT psi	Deviation %	
	↑	↓
0	0.0	0.0
3000	0.1	0.7
5000	0.0	0.8
7000	0.0	0.6
10000	0.1	0.1

Calibration certificate

Certificate no.	00070771

Statement of compliance

The calibration item keeps the manufacturer specifications!

Additional information

Calibration is carried out according to the following norms:
- ASME B40.1 (latest revision)
- Calibration of WIKA test instruments is carried out on an annual basis and test instruments are traceable to NIST
- Validity of certification of WIKA's test instruments is one year from the date of issuance.

APPENDIX D

Pile Installation Documents

18 – 0173 - Pile Installation Highway 400/Essa Rd

903.04 Submissions and Design Requirements

903.04.02.02 Site Survey

Site survey work will be done by the general contractor and submitted to the Contract Administrator.

903.04.02.03 Materials

903.04.02.03.01 Mill certificates

Mill certificates for the piling material will be submitted to the Contract Administrator as received from the pile supplier

903.04.02.04 Installation

903.04.02.04.01 Driven Piles

1) Schedule to be mutually agreed upon.
2) Type of equipment and hammer details including hammer energy operating efficiency weight of ram, and anvil and helmet are listed on a separate attachment, enclosed.
3) Monitoring pile installation will be witnessed by a QVE appointed by general contractor.
4) Details of the method of attaching proprietary driving shoes.
5) Hiley formula is attached to be completed by QVE
6) Installation sequence will be determined in the field by all parties involved.

903.05.02.01 H-Piles

Steel H-Piles shall be in accordance with CAN/CSA G40.20/G40.21, Grade 350W

903.05.02.04 Straightness Tolerance for Steel Piles

All Steel piles shall conform to a straightness tolerance of 1.5mm maximum per metre of length.

903.06 Equipment

903.06.01 Hammers

The hammers shall be capable of driving the piles to the prescribed depth or resistance without damaging the piles.

903.06.02 Helmets and Striker Plates

The helmet shall distribute the hammer energy evenly throughout the cross-sectional area of the pile head.

903.06.03 Leads

Leads supplied will be with a fixed and rigid

903.06.04 Followers

Followers will not be used on site.

903.07 Construction

903.07.01 Transportation, Handling, Storage

Piles shall be transported, stored and handled in such a manner that damage and distortion is prevented and the strength and integrity are maintained.

903.07.02.01 Driven Piles: Pile Driving Requirement & Restrictions

Piles shall be installed at the locations indicated and to the set or depth specified without being damaged.

Pre-drilling is not required.

Piles shall not be driven within a radius of 8m of concrete, which is in place for less than 72 hours. Piles shall not be driven within a radius of 15m of concrete, which is in place for less than 72 hours without the approval of the contract administrator.

Piles shall not be forced into proper alignment by use of excessive manipulation. Pile damage due to excessive driving shall be avoided.

903.07.02.02 Driving Shoes

Driving/pile shoes shall be used to protect piles due to anticipated hard driving.

Driving shoes shall be welded in accordance with the Contract Documents.

Piles shall have driving shoes as approved.

903.07.02.07.05 Hammer Performance

When requested by the Contract Administrator, the hammer performance shall be verified using the Pile Driving Analyzer. GFL shall provide the equipment for testing as directed by the Contract Administrator. Hammer performance shall be verified to ensure that the actual potential energy is not less than 90% of the stated potential energy. Should the verification test confirm GFL's chosen equipment to be acceptable, the client will be responsible for all associated cost. Testing of piles shall be witnessed by Project Co's contract administrator and third party appointed by Project Co.

903.07.02.07.06 Retapping Tests on Piles

Piles shall be retapped no sooner than 24 hours after installation of the individual pile to confirm that the ultimate axial resistance has been sustained.

903.07.02.07.07 Retapping and Redriving Piles

When the retapping tests indicate that the ultimate axial resistance has not been achieved on any one pile, all piles in the group shall be retapped. Where the retapping reveals that the ultimate axial resistance of the piles has not been achieved, the piles that have not achieved the ultimate axial resistance shall be redriven to the specified resistance. Where piles have risen, the piles shall be redriven to the original depth. The Contract Administrator shall provide direction should piles need to be driving past the specified elevation to achieve the initial set dertermined by the Hiley Formula.

The client shall be responsible for all costs associated with redriving piles.

903.07.02.03.01 General

Any damaged material shall be cut-off prior to splicing.

903.07.02.07.01 Monitoring Driven Piles

The piles will be driven by GFL and monitored by the general contractor's Q.V.E.'s designated representative. Pile driving records shall be obtained for all piles, certified by the Quality Verification Engineer and submitted to Project Co's contract administrator.

903.07.02.07.02 Driving to a Specified Elevation

Piles shall be driven to an elevation specified in the Contract Documents. Initial pile will be driven to specified elevation and load shall be verified using the Hiley Formula. All other piles will be driven to specified elevation and verified using the set determined by initial Hiley Formula.

Piles shall not be overdriven as per 903.07.02.07.01. Should the piles achieve a set of 20 blows per inch above the specified elevation, the Hiley Formula shall be used to determine the capacity of the pile. All other piles shall be driven to set or specified elevation, whichever is achieved first.

903.07.05 Tolerances

903.07.05.01 Driven Piles

1) Cut off +/- 25mm from within elevation shown on the contract documents.

2) Deviation from vertical not more than 1 in 50. Except in the case of a pile cap or footing supporting only a single row of piles the deviation shall not be more than 1 in 75.

3) The deviation from the specified inclination for battered piles shall not exceed 1 in 25.

4) Horizontal location not more than 75mm from their designed positions at the working level of the piling rig.

5) The center of the pile at the junction with the pile cap shall be within 150mm measured horizontally of that specified except in the case of a pile cap or footing supported on a single row of piles the deviation shall not be more than 75mm measured horizontally in the direction of the span.

903.07.08 Quality Control

903.07.08.03 Certificate of Conformance

Upon completion of the work, Project Co's contract administrator and Project Co appointee QVE representative will submit a certificate of conformance signed and sealed by the QVE stating that the work is in general conformance with the contract documents and specifications. A copy shall be furnished to GFL. It is imperative that Project Co's QVE is experienced in projects requiring similar pile driving methods and testing.

Non-conformance caused by boulders or sloping bedrock will be reviewed by the CA for acceptability. Remedial work to correct problems due to conditions beyond GFL control will be at the direction of the CA Such work will be deemed extra and suitable remuneration will be negotiated prior to commencement of the work.

Equipment List

Anticipated equipment is as follows:

Liebherr LRH 100

Equipment information has been attached to this procedure. Should alternative equipment be chosen for the project, applicable information will be submitted for review.

Ontario Ministry of Transportation

Bridge Construction - Pile Driving Record

(Please refer to Page 2 if clarification is required.)

Contract Information

Contract No.: 2017-E-0076 District: - Region: Central

Str. Site No.: 30X-0178/B1, 30X-0178/B2 Assignment No.: 2017 E 0076 Location: Barrie, Ontario

Piling Contractor: GFL

Pile Details

Pile No. and Location: PLT-1 Pile Type: HP Design Capacity: 3600 kN

Size: 310 Mass: 110 kg/m Pile Shoe: YES Batter: 0

Initial Pile Length: 16.8 m	Spliced	1	2	3	4	5	6	Final Pile Length after Cut-off
Total Length of Pile being driven after splicing:		33						31.6

Cut-off Elevation: 247.4 Actual Tip Elev.: 215.9 Design Tip Elev.: 216.2 m

Hammer Details

Mechanical Hammer Type: H40/7 Hydraulic Hammer Rated Energy: 55,000 Joules/Blow

Drop Hammer Mass (W): NA kg Fall(h) NA m Energy (Wgh)* 32,000 Joules/Blow

Mass of Anvil: 600 kg Mass of Mechanical hammer Ram (W) 7000 kg Follower used: ☐ Yes ☐ No

Hammer Cushion Details: N/A Pile Cushion Details: N/A

Ground Elevation at Pile Locations: 247.7 m Driving record: PLT-1 Date(s): 04-Nov-19

Length in ground (m)	Penetration Blows/0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m
0.2	21	6.2	7	12.2	10	18.2	6	24.2	7	30.2	13	36.2	
0.4	3	6.4	9	12.4	12	18.4	8	24.4	9	30.4	13	36.4	
0.6	4	6.6	10	12.6	13	18.6	6	24.6	8	30.6	17	36.6	
0.8	5	6.8	13	12.8	13	18.8	8	24.8	8	30.8	13	36.8	
1.0	6	7.0	11	13.0	10	19.0	7	25.0	8	31.0	12	37.0	
1.2	7	7.2	9	13.2	11	19.2	7	25.2	7	31.2	7	37.2	
1.4	6	7.4	9	13.4	10	19.4	7	25.4	7	31.4	12	37.4	
1.6	3	7.6	8	13.6	10	19.6	8	25.6	7	31.6	13	37.6	
1.8	2	7.8	8	13.8	11	19.8	8	25.8	6	31.8	18	37.8	
2.0	2	8.0	8	14.0	10	20.0	7	26.0	8	32.0		38.0	
2.2	1	8.2	8	14.2	11	20.2	7	26.2	7	32.2		38.2	
2.4	2	8.4	7	14.4	10	20.4	8	26.4	8	32.4		38.4	
2.6	2	8.6	7	14.6	10	20.6	7	26.6	10	32.6		38.6	
2.8	2	8.8	6	14.8	10	20.8	8	26.8	10	32.8		38.8	
3.0	4	9.0	5	15.0	9	21.0	7	27.0	9	33.0		39.0	
3.2	4	9.2	6	15.2	10	21.2	7	27.2	9	33.2		39.2	
3.4	5	9.4	5	15.4	5	21.4	7	27.4	11	33.4		39.4	
3.6	5	9.6	8	15.6	8	21.6	8	27.6	10	33.6		39.6	
4.0	5	10.0	7	16.0	8	22.0	7	28.0	9	34.0		40.0	
4.2	6	10.2	6	16.2	8	22.2	6	28.2	10	34.2		40.2	
4.4	5	10.4	7	16.4	8	22.4	6	28.4	10	34.4		40.4	
4.6	12	10.6	7	16.6	7	22.6	7	28.6	10	34.6		40.6	
4.8	14	10.8	6	16.8	7	22.8	8	28.8	9	34.8		40.8	
5.0	11	11.0	7	17.0	7	23.0	8	29.0	10	35.0		41.0	
5.2	12	11.2	7	17.2	8	23.2	7	29.2	9	35.2		41.2	
5.4	15	11.4	7	17.4	8	23.4	8	29.4	10	35.4		41.4	
5.6	11	11.6	11	17.6	8	23.6	8	29.6	11	35.6		41.6	
5.8	9	11.8	10	17.8	7	23.8	9	29.8	14	35.8		41.8	
6.0	8	12.0	10	18.0	7	24.0	9	30.0	16	36.0		42.0	

Ontario

Instructions for completing Pile Driving Record Form

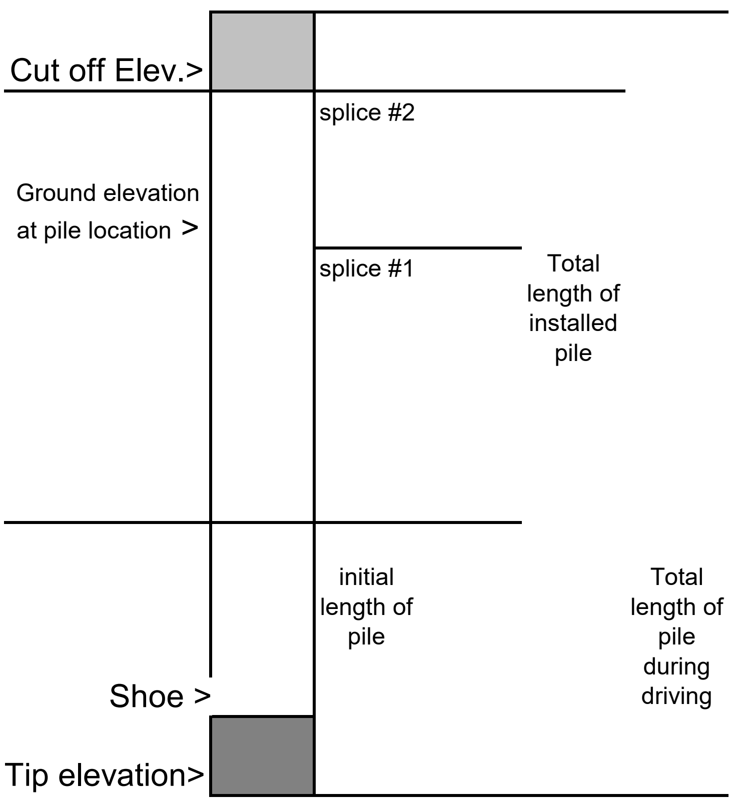
1) This form must be completed for at least every tenth pile in a group but at least one is required for each pier or abutment. Piles driven vertically should be selected where possible.

2) Where SS 3-10 or SS 3-11 applies to the contract, this form must be completed in its entirety.

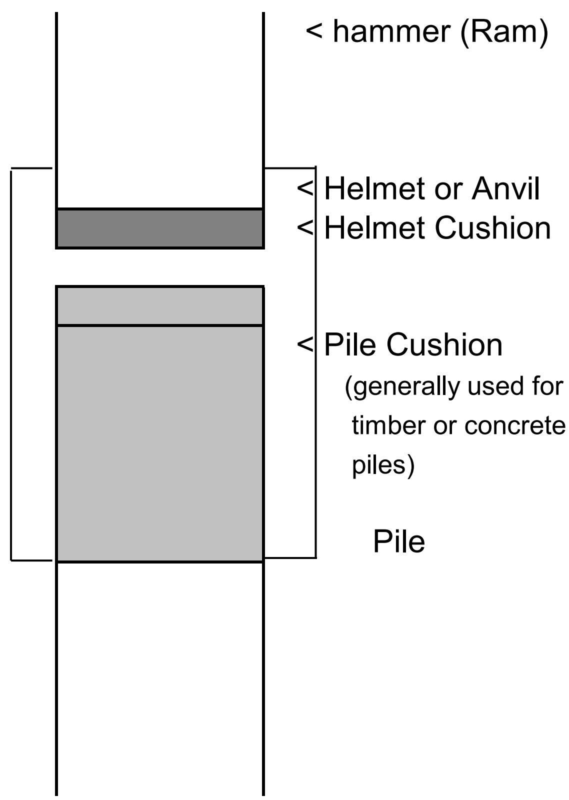
3) Where SS 3-10 or SS 3-11 does not apply to the contract, "Record of Last 100mm of Penetration" is not required, but the rest of the "Pile Drving Record" is required.

4) Explanation of information requested is given below:
   a) **Contract Information** - this must be completed in its entirety
   b) **Pile Details : Pile No. Location** - show number of pile in pile in group
      - location refers to structure element (eg. N. Abutment, E. Pier etc.)
      Batter - indicate slope of batter (eg. 3:1/ 4:1 / vertical)
      Length - refer to sketch I below for definition of terms used.
   c) **Hammer Details: Cushioning details** - describe materials and thicknesses (eg. Micarta 50mm / Plywood 25mm / Micarta 50mm) See sketch II below for explanation.

Sketch I



Sketch II



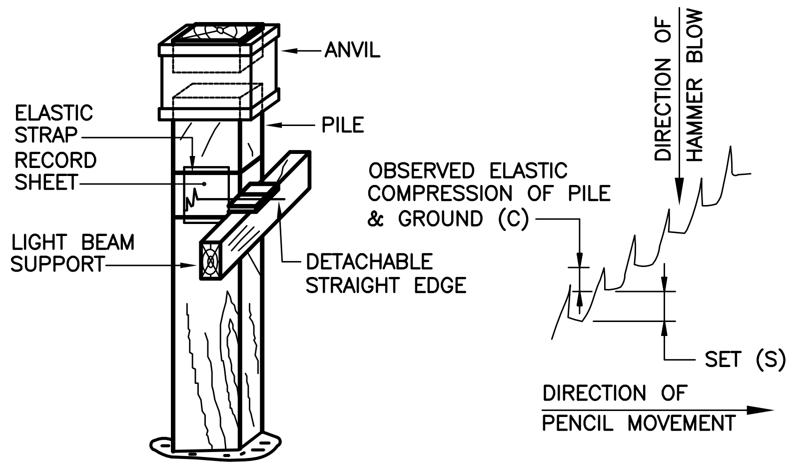
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No

SHEET

PILE DRIVING CONTROL



FIELD MEASUREMENT TECHNIQUE DURING PILE DRIVING

HAMMERS*		
TYPE	MASS OF RAM W (Kilograms)	RATED ENERGY E (Joules/blow)
9B3	726	12419
10B3	1361	16948
50C	2268	20337
11B3	2268	26005
D12	1250	30506
B225	1360	39300
LB520	2300	40675
B300	1700	46100
D22	2200	53826
B400	2268	62400
D22–02	2200	67000
D22–13	2200	67000
D30–02	3000	91000
D30–13	3000	91000
B500	3129	107100
D36–02	3600	115000
D36–13	3600	115000

NOTE:

Ram may also be referred to as Piston

* See General Notes 5) and 6).

METHOD OF APPLYING THE HILEY FORMULA

The Hiley Formula for:

(a) Double–acting, differential–acting Steam and Diesel Hammers,

$$R = \frac{n\ e_f\ E}{S + C/2} \qquad e_f = 0.6 \text{ to } 0.8 \text{ for steam hammers}, \quad e_f = 1.0 \text{ for diesel hammers}$$

(b) Drop Hammers and single–acting Steam Hammers,

$$R = \frac{n\ e_f\ WgH}{S + C/2} \qquad e_f = 0.75 \text{ for drop hammers}, \quad H = \text{height of free fall of mass in metres}$$

Where
- R = Ultimate pile resistance in kilonewtons
- S = Measured penetration of pile per hammer blow in millimetres
- C = Measured rebound of pile per hammer blow in millimetres
- E = Rated Energy of hammer blow in joules
- e_f = efficiency based on manufacturer's gross rated energy (typ. 0.6 to 0.8)
- n = efficiency of blow
- e = coefficient of restitution
- g = 9.80665 m/s^2
- $n = \frac{W + Pe^2}{W + P}$

where e = 0.32 for steel (or e = 0.55. See Note 1 below.)
= 0.25 for timber
P = Mass of pile + anvil or helmet in kilograms (See Note 2 below)
W = Mass of ram (piston) in kilograms

NOTE 1:

It is assumed that piles are driven with a pile cushion. Where Steel H–Piles are driven without a cushion, the ultimate pile capacity R should be calculated assuming a coefficient of Restitution e = 0.55.

NOTE 2:

Assume mass of anvil = 600 kg unless otherwise noted.

NOTE 3:

The resulting Ultimate Pile Resistance, R, as calculated by Hiley Formula must exceed the Ultimate Geotechnical Resistance given in the Pile Driving Notes on the Contract Drawings.

EXAMPLE FOR DIESEL HAMMERS

Given: Pile HP 310x110, length = 50m
Mass of anvil = 600 kg
Pile driven without a cushion
Hammer is Delmag D22–13
From the Pile Driving Notes on the Contract Drawings,
Ultimate Geotechnical Resistance = 3000 kN

Observations: measured penetration = S = 5mm
measured rebound = C = 10mm

Hiley Formula Calculations

P = 50(110) + 600 = 6100 kg

W = 2200 kg e = 0.55

$$n = \frac{W + Pe^2}{W + P} = \frac{2200 + 6100\ (0.55)^2}{2200 + 6100} = 0.49$$

E = 67,000 Joules/blow

$$R = \frac{n\ e_f\ E}{S + C/2} = \frac{0.49\ (1.0)\ (67{,}000)}{5 + (10/2)} = \underline{3283\ kN} > 3000\ kN \quad O.K.$$

EXAMPLE FOR DROP HAMMERS

Given: Timber Pile: length = 15m, density = 641 kg/m^3
butt dia. = 0.36m, tip dia. = 0.20m
Mass of Helmet = 300 kg
Mass of Hammer = 2268 kg = W
Fall of Hammer = 1.0 metre = H
e = 0.25
From Pile Driving Notes on Contract Drawings,
Ultimate Geotechnical Resistance = 750 kN

Observations: measured penetration = S = 5mm
measured rebound = C = 20mm

Hiley Formula Calculations

$$P = \left(15 \times \frac{\pi}{4}\left(\frac{0.36 + 0.20}{2}\right)^2 \times 641\right) + 300 = 892\ kg$$

e_f = 0.75

W = 2268 kg

$$n = \frac{W + Pe^2}{W + P} = \frac{2268 + 892(0.25)^2}{2268 + 892} = 0.74$$

$$R = \frac{n\ e_f\ WgH}{S + C/2} = \frac{0.74(0.75)(2268)(9.806)(1.0)}{5 + (20/2)} = \underline{823\ kN} > 750\ kN \quad O.K.$$

NOTES:

1. THIS STANDARD DRAWING IS FOR THE CONTROL OF PILE INSTALLATIONS BY VALIDATING DESIGN ASSUMPTIONS.
2. THE HILEY FORMULA SHALL BE USED TO CONFIRM PILE RESISTANCE FOR FRICTION–TYPE PILES IN NON–COHESIVE SOILS. FOR USE IN COHESIVE SOILS, THE GEOTECHNICAL ENGINEER WILL HAVE TO BE CONSULTED.
3. DURING PILE DRIVING, THE HAMMER HAS TO REBOUND ENOUGH TO MAINTAIN ITS ENERGY PER BLOW. ACCORDINGLY, THE SOIL MUST PROVIDE SUFFICIENT REBOUND FOR THE HILEY FORMULA TO BE EFFECTIVE.
4. IF THE ULTIMATE PILE RESISTANCE, AS CALCULATED BY THE HILEY FORMULA, IS NOT REACHED WHEN REFERENCED TO A PRESCRIBED PILE TIP ELEVATION OR RANGE OF ELEVATIONS, THE ADVICE AND RECOMMENDATIONS OF A GEOTECHNICAL ENGINEER SHALL BE SOUGHT.
5. THE CONTRACTOR SHALL SUBMIT THE PERTINENT HAMMER PROPERTIES, AS REQUIRED BY OPSS 903.
6. THE TABLE OF HAMMERS GIVEN ON THIS STANDARD DRAWING CAN BE USED FOR COMPARING THE SUBMITTED HAMMER PROPERTIES. IT IS APPROXIMATE AND MAY NOT INCLUDE ALL HAMMERS. THE CONTRACTOR SHALL CONTACT THE MANUFACTURER FOR RATED AND ACTUAL HAMMER ENERGIES.
7. WHEN APPLYING THE HILEY FORMULA, THE HAMMER SHALL BE OPERATED AT FULL CAPACITY.

NOTES TO DESIGNER

1. WHEN USING THIS STANDARD THE DESIGNER SHOULD ENSURE THAT THE ULTIMATE GEOTECHNICAL RESISTANCE IS GIVEN ON THE CONTRACT DRAWINGS AS DETAILED IN SECTION 3.3.2/3 OF THE STRUCTURAL MANUAL.
2. THE 'NOTES TO DESIGNER' SHALL BE DELETED FROM THIS DRAWING PRIOR TO ISSUING OF THE CONTRACT.

REFER TO 1.1.8 IN THE STRUCTURAL MANUAL FOR PROFESSIONAL ENGINEER STAMPING REQUIREMENTS.

DRAWING NOT TO BE SCALED 100mm ON ORIGINAL DRAWING

STANDARD DRAWING APRIL 2008 | SS103–11

PILE DRIVING CONTROL

REVISIONS | DESCRIPTION

DESIGN | CHK | CODE CHBDC–00 | CL 625–ONT | DATE
DRAWN | CHK | SITE | | DWG

MINISTRY OF TRANSPORTATION, ONTARIO PR–D–707 88–05

DRAWING NAME: s103–11.dwg CREATED: 1996/12/17 MODIFIED: 2008/03/27 14:26:49

HILEY CALCULATION
Beginning of Restrike
November 4, 2019

Hiley Formula for Double-acting, Differential-acting Steam and Diesel Hammers:

$$n = \frac{W + Pe^2}{W + P}$$

L	Length of Pile (m)	33	m	As per Pile Installation Record
W	Mass of Piston/Ram	7000	kg	As per Hydraulic Hammer H40/7 Specification
M_{pile}	Mass of Pile	3630	kg	For HP310x110 M_{pile} = L*110kg/m
M_{anvil}	Mass of Anvil	600	kg	Assumed - See Note 1
P	Mass of Pile + Anvil	4230	kg	
e	Coefficient of Restitution	0.55	-	No cushion
n	**Efficiency of Blow**	**0.74**	**-**	

$$R = \frac{ne_f E}{S + C/2}$$

e_f	Efficiency Based on Manufacturer's Gross Rated Energy	1	-	Assumed for Hydraulic Hammer
E	Energy of Hammer Blow (Wgh)	28,000	joules	For 40 Blows per Minute (i.e. Max Stroke) From Specifications
S	Measured Penetration of Pile Per Hammer Blow	7.0	mm	From Hiley Graph
C	Measured Rebound of Pile Per Hammer Blow	11.5	mm	From Hiley Graph
R	**Ultimate Pile Capacity**	**1625**	**kN**	

Notes:
1. As per Standard Drawing SS103-11, assume mass of anvil = 600 kg unless otherwise noted.
2. As per Standard Drawing SS103-11, e = 0.32 for steel with cushion, 0.55 for steel without cushion, 0.25 for timber

HILEY CALCULATION
Beginning of Restrike
November 4, 2019

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Notes:
1. As per Standard Drawing SS103-11, assume mass of anvil = 600 kg unless otherwise noted.
2. As per Standard Drawing SS103-11, e = 0.32 for steel with cushion, 0.55 for steel without cushion, 0.25 for timber

Golder Associates Ltd.
100 Scotia Court
Whitby, Ontario
L1N 8Y6

Dynamic Testing of Piles
Highway 400 and Essa Road
Barrie, ON

Project Number
BRM-00607448-A0

Prepared By:

exp Services Inc.
1595 Clark Boulevard
Brampton, Ontario L6T 4V1
Telephone: (905) 793-9800
Facsimile: (905) 793-0641

Date Submitted
2019-11-07

Table of Contents

Tables

Appendices

1 Introduction

Exp Services Inc. (**exp**) was retained by Golder Associates Ltd. to carry out dynamic testing of piles for the Highway 400 and Essa Road project. This report presents the results of the dynamic pile testing carried out on November 4, 2019.

One test pile (No. PLT-1) was monitored near the end of initial driving with the instrumentation from the Pile Driving Analyzer attached. The pile tested was a HP310 mm x 110 kg/m steel HP-section (HP12 in. x 74 lbs./ft.) and was monitored while being driven with a LRH H40/7 hydraulic hammer. The manufacturer's maximum rated energy of the H40/7 hammer is ~55 kJ (39,800 ft-lbs.).

The purpose of the dynamic testing was to evaluate the ultimate geotechnical resistance of the pile tested.

2 Fieldwork and Analysis

On November 4, 2019 one pile (No. PLT-1) was monitored near the end of initial driving (from ~31.0 to 31.8 m depth) with the instrumentation from the Pile Driving Analyzer attached.

The dynamic monitoring was undertaken in general accordance with the ASTM D4945-12 procedures. The instrumentation for the Pile Driving Analyzer consisted of two reusable strain gauges and two accelerometers securely bolted on the pile. For each hammer blow, electronic signals were fed into the pre-programmed Pile Driving Analyzer (Model PAX) and the basic measurements of strain and acceleration were converted into force and velocity parameters as a function of time.

From the force and velocity parameters, the ultimate (mobilized) bearing capacities were automatically computed. In addition, the maximum compressive and tensile forces, the developed energies and the hammer blow rate, etc., are some of the output data for the Analyzer. The force and velocity traces were continually observed in the field and their digital signals were recorded and stored in memory.

A selected representative hammer blow from the end of initial driving of Pile No. PLT-1 was used to perform CAPWAP (CAse Pile Wave Analysis Program) analysis in order to evaluate the ultimate resistance of the pile and the corresponding CASE damping factors.

The CAPWAP program is an iterative method to analyze the static resistance and resistance distribution along a pile with the dynamic measurements obtained from the Pile Driving Analyzer Testing. In the CAPWAP analysis, the program utilizes the fact that the force and velocity are related to each other by the pile impedance, which is readily calculable by:

$$Z = \frac{EA}{C}$$

where

Z	=	impedance of pile
E	=	modulus of elasticity of pile
A	=	cross-sectional area of pile
C	=	speed of stress wave in the pile

In the CAPWAP program, the pile is divided into a number of mass points and springs. The soil reaction forces on these mass points are assumed to consist of elastoplastic (static) and linear viscous (dynamic) components. In the analysis, a measured force was used as input and by varying the ultimate static resistance, resistance distribution, quake, elastic soil deformation, soil damping constants, etc., a computed force or velocity is calculated.

When a good match is obtained by varying the above components, the pile-soil interaction is modeled and a solution for the ultimate static resistance along the pile can be calculated. Based on this calculated resistance, an estimate of the frictional resistance can also be obtained.

Static computations can then be used to predict the load versus deformation characteristics of the pile, which is often referred to as a "simulated load test".

3 Test Results

3.1 Pile Driving Analyzer

One test pile (No. PLT-1) was monitored near the end of initial driving (from ~31.0 to 31.8 m depth) with the instrumentation from the Pile Driving Analyzer attached. The pile tested was a HP310 mm x 110 kg/m steel HP-section (HP12 in. x 74 lbs./ft.) and was monitored while being driven with a LRH H40/7 hydraulic hammer. The manufacturer's maximum rated energy of the H40/7 hammer is ~55 kJ (39,800 ft-lbs.).

The results obtained from the dynamic testing are presented in Table No. 1 and are summarized below.

The average energy transferred to the top of the pile during monitoring ranged from ~34 to 62 kJ with the operator controlled reported energy input ranging from ~31 to 58 kJ (~23,000 to 42,500 ft-lbs.).

The average maximum force at the instrumentation location ranged from ~2180 to 2980 kN which corresponds to a maximum stress ranging from ~155 to 211 MPa.

The evaluated ultimate geotechnical resistance at the end of initial driving of Pile No. PLT-1 was ~1500 kN.

The reported penetration resistance at the end of initial driving was 13 blows for 118 mm penetration with the pile being driven to ~31.8 m depth below grade.

3.2 CAPWAP Analysis Results

CAPWAP analysis was undertaken on a selected representative hammer blow from the end of initial driving of Pile No. PLT-1. A summary of the results is presented in Table No. 2. The Case Method Capacities and Pile Profile and Model tables, the CAPWAP Force matches, Force-Velocity Wave forms, Resistance Distributions, Simulated Compression Load Test Curves, etc. are presented in Appendix A.

The evaluated ultimate geotechnical resistance at the end of initial driving of Pile No. PLT-was ~1500 kN of which ~550 kN is evaluated as shaft resistance and ~950 kN evaluated as toe resistance.

4 Summary

The evaluated ultimate geotechnical resistance at the end of initial driving of Pile No. PLT-1 was ~1500 kN. It should be noted the evaluated pile geotechnical resistance presented is the pile capacity at the time of testing.

The reported penetration resistance at the end of initial driving was 13 blows for 118 mm penetration with the operator controlled energy input reported at ~31 kJ (~23,000 ft-lbs.). The pile was driven to a final depth of ~31.8 m below grade.

The average maximum stress at the instrumentation location was ~211 MPa which is well below the anticipated yield strength (350 MPa min.) of the HP310 x 110 HP-section.

The pile driving record and subsurface conditions at the test pile location (by others) are presented in the attached Appendices.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

Exp Services Inc.

A. D. Maini P. Eng.
Sr. Project Engineer

Stephen S. M. Cheng P. Eng.
Manager, Geotechnical Division

Table 1
Summary of Pile Driving Analyzer Results
Hwy. 400 – Essa Road
November 4, 2019

PILE NO.	EVENT	HAMMER	DEPTH BEL. GRADE	REPORTED PENETRATION RESISTANCE	ENERGY		FORCE		EVALUATED ULT. GEOTECHNICAL RESISTANCE	REMARKS
			(m)	Blows/mm	Operator Input kJ (ft-lbs)	Transferred (kJ)	Max. (kN)	Stress (MPa)	(kN)	
PLT-1	DD	LRH H40/7	~31.0 – 31.2	5 / 105 *	~58 (~42,500)	~62	2980	211	-	PDA BN 1 - 8
	DD		~31.2 – 31.6	~12, 13 / 200	~54 (~40,000)	~58	2840	202	-	PDA BN 9 - 37
	EOID		~31.6 – 31.8	13 / 118 *	~31 (~23,000)	~34	2180	155	~1500	PDA BN 38 - 53

EOID – End Of Initial Driving
DD – During Driving
* From Hiley graph

Table 2
Summary of CAPWAP Analysis Results
Hwy. 400 – Essa Road
November 4, 2019

Pile I.D.	Event	Depth Below Grade (m)	Evaluated Ult. (Mob.) Geo. Resistance (kN)			Reported Penetration Resistance (blows/mm)
			Total	Shaft	Toe	
30	EOID	~31.8	1500	550	950	13 / ~118

EOID – End Of Initial Driving

Appendix A – CAPWAP Tables and Figures

Pile No. PLT-1
EOID
November 4, 2019

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1500.0; along Shaft 550.0; at Toe 950.0 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
				1500.0			
1	2.0	1.6	22.3	1477.7	22.3	13.83	11.19
2	4.0	3.6	33.2	1444.5	55.5	16.50	13.35
3	6.0	5.6	33.2	1411.3	88.7	16.50	13.35
4	8.0	7.6	29.8	1381.5	118.5	14.81	11.98
5	10.1	9.7	22.2	1359.3	140.7	11.03	8.92
6	12.1	11.7	22.2	1337.1	162.9	11.03	8.92
7	14.1	13.7	35.8	1301.3	198.7	17.79	14.39
8	16.1	15.7	46.4	1254.9	245.1	23.06	18.65
9	18.1	17.7	46.4	1208.5	291.5	23.06	18.65
10	20.1	19.7	38.0	1170.5	329.5	18.88	15.28
11	22.1	21.7	35.8	1134.7	365.3	17.79	14.39
12	24.2	23.8	34.6	1100.1	399.9	17.19	13.91
13	26.2	25.8	33.2	1066.9	433.1	16.50	13.35
14	28.2	27.8	34.6	1032.3	467.7	17.19	13.91
15	30.2	29.8	37.9	994.4	505.6	18.83	15.24
16	32.2	31.8	44.4	950.0	550.0	22.06	17.85
Avg. Shaft			34.4			17.30	13.99
Toe			950.0				9949.73

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.36	0.17
Quake	(mm)	3.5	9.0
Case Damping Factor		0.35	0.28
Damping Type		Sm+Visc	Viscous
Unloading Quake	(% of loading quake)	60	110
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake) (mm)			2.0

CAPWAP match quality = 3.07 (Wave Up Match) ; RSA = 0
Observed: Final Set = 9.0 mm; Blow Count = 111 b/m
Computed: Final Set = 9.0 mm; Blow Count = 111 b/m

max. Top Comp. Stress = 153.9 MPa (T= 26.1 ms, max= 1.005 x Top)
max. Comp. Stress = 154.6 MPa (Z= 2.0 m, T= 26.3 ms)
max. Tens. Stress = -9.17 MPa (Z= 27.2 m, T= 33.0 ms)
max. Energy (EMX) = 32.8 kJ; max. Measured Top Displ. (DMX)= 25.0 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	2169.6	-107.6	153.9	-7.63	32.8	3.78	24.6
2	2.0	2179.5	-114.1	154.6	-8.09	32.5	3.76	24.2
4	4.0	2168.5	-111.4	153.8	-7.90	31.1	3.72	23.3
6	6.0	2142.7	-96.1	152.0	-6.82	29.4	3.68	22.5
8	8.0	2115.0	-76.7	150.0	-5.44	27.8	3.64	21.7
10	10.1	2087.8	-60.9	148.1	-4.32	26.3	3.61	21.0
12	12.1	2071.6	-57.4	146.9	-4.07	25.2	3.58	20.3
14	14.1	2063.9	-55.0	146.4	-3.90	24.0	3.53	19.5
16	16.1	2045.1	-21.1	145.0	-1.50	22.5	3.48	18.7
18	18.1	2013.4	0.0	142.8	0.00	20.8	3.43	18.0
20	20.1	1977.8	0.0	140.3	0.00	19.1	3.39	17.3
22	22.1	1951.7	0.0	138.4	0.00	17.8	3.35	16.6
23	23.1	1915.0	0.0	135.8	0.00	16.8	3.34	16.2
24	24.2	1927.8	0.0	136.7	0.00	16.6	3.31	15.9
25	25.2	1893.0	0.0	134.3	0.00	15.6	3.30	15.5
26	26.2	1905.2	-12.2	135.1	-0.87	15.4	3.27	15.2
27	27.2	1872.8	-129.3	132.8	-9.17	14.6	3.26	14.8
28	28.2	1880.6	-39.1	133.4	-2.77	14.4	3.25	14.5
29	29.2	1745.9	0.0	123.8	0.00	13.5	3.48	14.1
30	30.2	1563.3	0.0	110.9	0.00	13.3	4.12	13.8
31	31.2	1191.7	0.0	84.5	0.00	12.5	4.66	13.4
32	32.2	1213.2	0.0	86.0	0.00	12.1	4.74	13.1
Absolute	2.0			154.6			(T =	26.3 ms)
	27.2				-9.17		(T =	33.0 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	1835	1578	1321	1065	808	552	295	38	0	0
RX	1917	1823	1738	1672	1608	1550	1507	1465	1422	1380
RU	1835	1578	1321	1065	808	552	295	38	0	0

RAU = 1092 (kN); RA2 = 1695 (kN)

Current CAPWAP Ru = 1500 (kN); Corresponding J(RP)= 0.13; J(RX) = 0.62

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
3.86	25.93	2199	2202	2202	25.0	9.0	9.0	33.0	1941	136

PILE PROFILE AND PILE MODEL

Depth m	Area cm^2	E-Modulus MPa	Spec. Weight kN/m^3	Perim. m
0.0	141.0	206842.7	77.287	1.24
32.2	141.0	206842.7	77.287	1.24

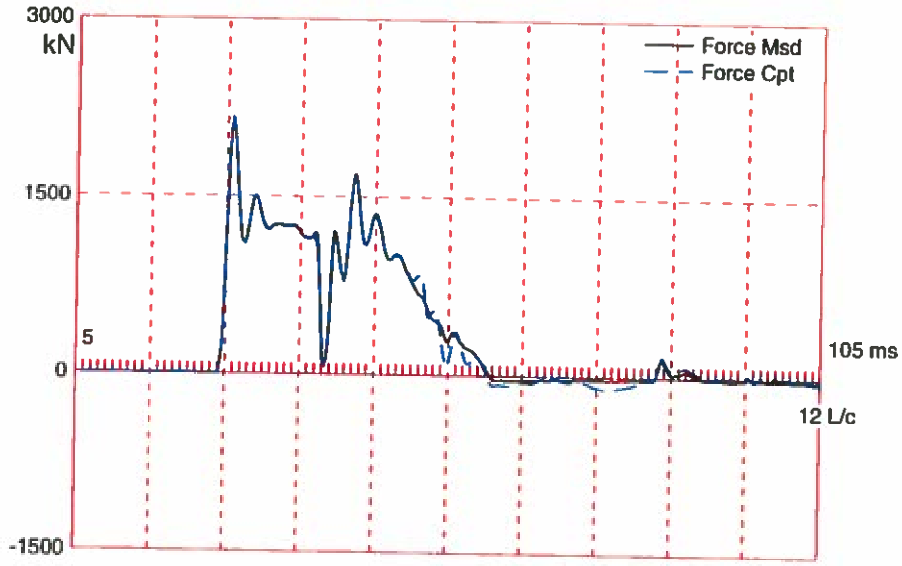
Toe Area 954.8 cm^2

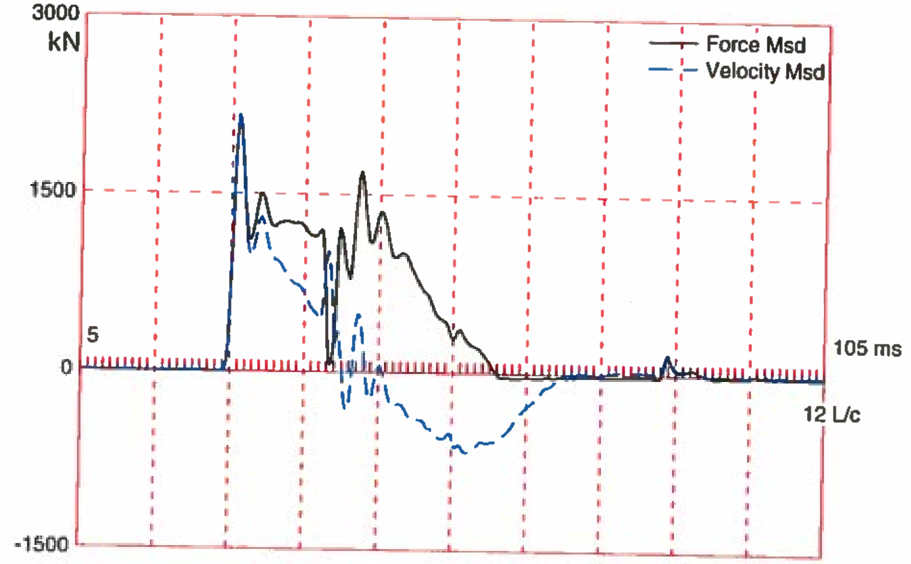
Top Segment Length 1.01 m, Top Impedance 569 kN/m/s

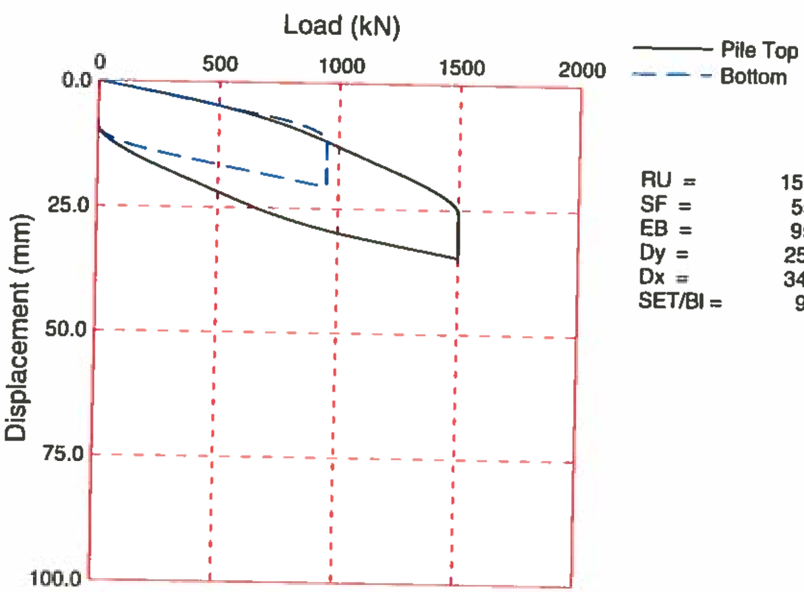
Wave Speed: Pile Top 5123.0, Elastic 5123.0, Overall 5123.0 m/s
Pile Damping 1.00 %, Time Incr 0.196 ms, 2L/c 12.6 ms
Total volume: 0.454 m^3; Volume ratio considering added impedance: 1.000

400ESSA; Pile: PLT-1; HP310X110; Blow: 49 (Test: 04-Nov-2019 14:00:)
exp Services, Inc.

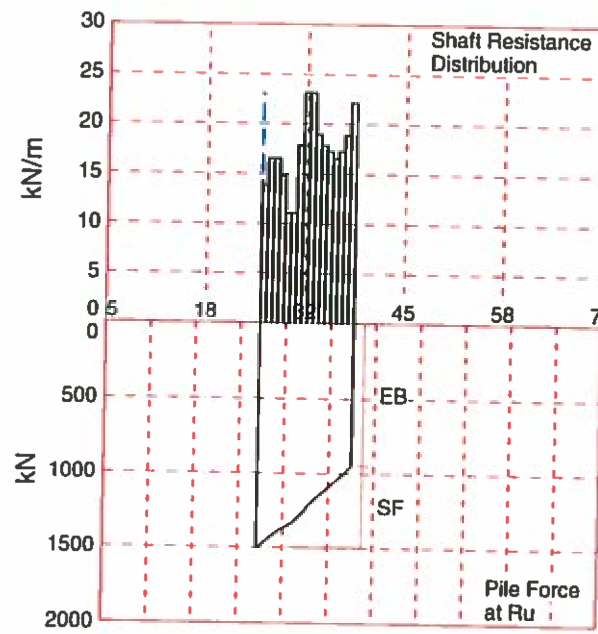
06-Nov-2019
CAPWAP(R) 2014-3







RU	=	1500 kN
SF	=	550 kN
EB	=	950 kN
Dy	=	25.6 mm
Dx	=	34.6 mm
SET/Bl	=	9.0 mm



Length b. Sensors	32.2 m
Embedment	31.8 m
Top Area	141.0 cm²
End Bearing Area	954.8 cm²
Top Perimeter	1.24 m
Top E-Modulus	206843 MPa
Top Spec. Weight	77.3 kN/m³
Top Wave Spd.	5123 m/s
Overall W.S.	5123 m/s
Match Quality	3.07
Top Compr. Stress	153.9 MPa
Max Compr. Stress	154.6 MPa
Max Tension Stress	-9.17 MPa
Avg. Shaft Quake	3.5 mm
Toe Quake	9.0 mm
Avg. Shaft Smith Dpg.	0.36 s/m
Toe Smith Damping	0.17 s/m

CAPWAP(R) 2014-3 Licensed to exp Services, Inc.

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

Appendix B:
Pile Driving Record

Ontario Ministry of Transportation

Bridge Construction - Pile Driving Record

(Please refer to Page 2 if clarification is required.)

Contract Information

Contract No.: ______ District: ______ Region: ______

Str. Site No.: ______ Str. WP No.: ______ Location: ______

Piling Contractor:

Pile Details

Pile No. and Location: PLT-1 Pile Type: H-Pile Design Capacity: 3700 kN

Size: HP310 Mass: 110 kg/m Pile Shoe Batter

Initial Pile Length: m

Spliced	1	2	3	4	5	6
Total Length of Pile being driven after splicing:						

Final Pile Length after Cut-off ______ m

Cut-off Elevation: Actual Tip Elev.: Design Tip Elev.: 216.2m

Hammer Details

Mechanical Hammer Type: H40/7* Rated Energy: ______ Joules/Blow

Drop Hammer Mass (W): ______ kg Fall(h) ______ m Energy (Wgh)* 55 KNm Joules/Blow

Mass of Anvil: 7000 kg Mass of Mechanical hammer Ram (W) ______ kg Follower used: ☐ Yes ☐ No

Hammer Cushion Details: Pile Cushion Details:

Ground Elevation at Pile Locations: ______ Driving record: ______ Date(s): ______

Length in ground (m)	Penetration Blows/0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m
0.2	21	6.2	7	12.2	10	18.2	6	24.2	7	27.2	9	30.2	13
0.4	3	6.4	9	12.4	12	18.4	8	24.4	9	27.4	11	30.4	13
0.6	4	6.6	10	12.6	13	18.6	6	24.6	8	27.6	10	30.6	17
0.8	5	6.8	13	12.8	13	18.8	8	24.8	8	27.8	10	30.8	13
1.0	6	7.0	11	13.0	10	19.0	7	25.0	8	28.0	9	31.0	12
1.2	7	7.2	9	13.2	11	19.2	7	25.2	7	28.2	10	31.2	87
1.4	6	7.4	9	13.4	10	19.4	7	25.4	7	28.4	10	31.4	12
1.6	3	7.6	8	13.6	10	19.6	8	25.6	7	28.6	10	31.6	13
1.8	2	7.8	8	13.8	11	19.8	8	25.8	6	28.8	9	31.8	18 *
2.0	2	8.0	8	14.0	10	20.0	7	26.0	8	29.0	10	32.0	
2.2	1	8.2	8	14.2	11	20.2	7	26.2	7	29.2	9	32.2	
2.4	2	8.4	7	14.4	10	20.4	8	26.4	8	29.4	10	32.4	
2.6	2	8.6	7	14.6	10	20.6	7	26.6	10	29.6	11	32.6	
2.8	2	8.8	6	14.8	10	20.8	8	26.8	10	29.8	14	32.8	
3.0	4	9.0	5	15.0	9	21.0	7	27.0	9	30.0	16	33.0	
3.2	4	9.2	6	15.2	10	21.2	7						
3.4	5	9.4	5	15.4	5	21.4	7						
3.6	5	9.6	8	15.6	8	21.6	8						
3.8	5	9.8	6	15.8	8	21.8	9						
4.0	5	10.0	7	16.0	8	22.0	7						
4.2	6	10.2	6	16.2	8	22.2	6						
4.4	5	10.4	7	16.4	8	22.4	6						
4.6	12	10.6	7	16.6	7	22.6	7						
4.8	14	10.8	6	16.8	7	22.8	8						
5.0	11	11.0	7	17.0	7	23.0	8						
5.2	12	11.2	7	17.2	8	23.2	7						
5.4	15	11.4	7	17.4	8	23.4	8						
5.6	11	11.6	11	17.6	8	23.6	8						
5.8	9	11.8	10	17.8	7	23.8	9						
6.0	8	12.0	10	18.0	7	24.0	9						

Record of last 100mm of penetration from graph produced on pile blows/20mm

Penetration	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100
Blows/20mm					
Rebound (C)					

*Note: g = acceleration due to gravity = 9.81 m/s2

Mail completed form or copy to:
Pavements and Foundations Section
Room 223, Building 'C'
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

PH-D-205 Aug-09

*energy dropped to 20,000 ft·lbs

Appendix C:
Subsurface Conditions

GOLDER

Foundation Design

RECORD OF BOREHOLE No PLT-1

SHEET 1 OF 3

METRIC

PROJECT 18105050
G.W.P. 2337-16-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745; LONG. -79.698085)
BOREHOLE TYPE Power Auger, 210 mm O.D. Hollow Stem Augers
DATE May 8, 2019

ORIGINATED BY SK
COMPILED BY ML
CHECKED BY AMP

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.2	GROUND SURFACE						
0.0	TOPSOIL (200 mm)						
0.2	SILT (ML), some sand, Very loose, Brown, Moist	1	SS	3	246		
245.5 / 0.7	CLAYEY SAND (SC), trace gravel, Compact, Brown, Moist	2	SS	13	245	o	
244.8 / 1.5	CLAYEY SILT (CL) and SAND, trace gravel, Stiff, Brown, Moist	3	SS	9			
244.0 / 2.2	SILTY SAND (SM), trace to some gravel, trace clay, Compact to very dense, Brown to grey	4	SS	21	244	o	
		5	SS	38	243	o	7 49 38 6
		6	SS	36	242 / 241	o	
	- Becoming grey below a depth of 6.7 m	7	SS	78	240 / 239		
	- Tricone grinding at a depth of 8.2 m	8	SS	23	238	o	12 57 25 6
	- Tricone grinding at a depth of 9.1 m - Slight plasticity at a depth of 9.5 m	9	SS	32	237	o–I	7 55 31 7
236.0 / 10.2	SAND (SP-SM), trace to some silt, trace to some gravel, Dense to very dense, Grey, Moist to wet at a depth of about 13.3 m - Tricone grinding at a depth of 11.3 m	10	SS	53	236 / 235		
		11	SS	32	234 / 233	o	0 91 9 0
	- Tricone grinding at a depth of 14.6 m	12	SS	37	232	o	

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; STRAT PLOT; GROUND WATER CONDITIONS

Preliminary DRAFT

Continued Next Page

+ 3, × 3 Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

GOLDER

Foundation Design

PROJECT 18105050 | **RECORD OF BOREHOLE No PLT-1** | SHEET 2 OF 3 | **METRIC**

G.W.P. 2337-16-00 | LOCATION N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745, LONG. -79.698085) | ORIGINATED BY SK

DIST Central HWY 400 | BOREHOLE TYPE Power Auger, 210 mm O.D. Hollow Stem Augers | COMPILED BY ML

DATUM Geodetic | DATE May 8, 2019 | CHECKED BY AMP

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SAND (SP-SM), trace to some silt, trace to some gravel Dense to very dense Grey Moist to wet at a depth of about 13.3 m	13	SS	37	231					
					230					
		14	SS	33	229	o	5	84	11	0
	- Tricone grinding at a depth of 17.7 m				228					
		15	SS	36						
226.8 19.4	SILTY SAND (SM), trace to some gravel, trace clay Compact to very dense Grey Wet				227					
	- Tricone grinding at a depth of 20.4 m	16	SS	21	226	o	3	69	23	5
					225					
	- Tricone grinding at a depth of 21.9 m	17	SS	62	224					
	- Tricone grinding at a depth of 22.9 m	18	SS	61	223	o				
	- Tricone grinding at a depth of 23.8 m				222					
	- Tricone grinding at a depth of 24.7 m	19	SS	94	221	o	11	67	20	2
	- Tricone grinding at a depth of 26.5 m	20	SS	109	220					
		21	SS	87	219	o				
29.2	- Tricone grinding at a depth of 29 m	22	SS	101	218 217					

Continued Next Page

+3, ×3 Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Preliminary DRAFT

GOLDER

Foundation Design

RECORD OF BOREHOLE No PLT-1

SHEET 3 OF 3 **METRIC**

PROJECT 18105050

G W P 2337-16-00

DIST Central HWY 400

DATUM Geodetic

LOCATION N 4913544.7 E 289011 1 MTM NAD 83 ZONE 10 (LAT. 44 361745; LONG. -79 698085)

BOREHOLE TYPE Power Auger, 210 mm O D Hollow Stem Augers

DATE May 8, 2019

ORIGINATED BY SK

COMPILED BY ML

CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —						
	SILTY SAND (SM), trace to some gravel, trace clay Compact to very dense Grey Wet - Tricone grinding at a depth of 30 2 m				216		
		23	SS	72/0 25		o	19 51 24 6
31.2 —					215		
		24	SS	100/0.1	214		
	- Tricone grinding at a depth of 32 6 m						
	- Tricone grinding at a depth of 33 2 m				213		
		25	SS	76		o	
	- Tricone grinding at a depth of 34 4 m				212		
210.9		26	SS	100/0 1	211		
35 3	END OF BOREHOLE						

NOTES:

1 Tricone (Mud Rotary) drilling carried out from a depth of 3 0 m to 35.3 m.

2 Water level measurements in piezometer as follows

Date	Depth (m)	Elev. (m)
06/24/19	5 03	

Preliminary DRAFT

GTA-MTO 001 S:\CLIENTS\MTO\HWY_400_ESSA_RD\02_DATA\GINT\HWY_400_ESSA_RD.GPJ GAL-GTA.GDT 19-7-16

+ 3, × 3 Numbers refer to Sensitivity   o 3% STRAIN AT FAILURE

Golder Associates Ltd.
100 Scotia Court
Whitby, Ontario
L1N 8Y6

Dynamic Testing of Piles
Highway 400 and Essa Road
Barrie, ON
November 11, 2019 Visit (Visit No. 2)

Project Number
BRM-00607448-A0

Prepared By:

exp Services Inc.
1595 Clark Boulevard
Brampton, Ontario L6T 4V1
Telephone: (905) 793-9800
Facsimile: (905) 793-0641

Date Submitted
2019-11-12

Table of Contents

Tables

Appendices

1 Introduction

Exp Services Inc. (**exp**) was retained by Golder Associates Ltd. to carry out dynamic testing of piles for the Highway 400 and Essa Road project. This report presents the results of the dynamic pile testing carried out on November 11, 2019 (Visit No. 2).

On this date, one test pile (No. PLT-1) was monitored at the beginning of restrike with the instrumentation from the Pile Driving Analyzer attached. Pile No. PLT-1 was previously monitored at the end of initial driving on November 4, 2019, the results of which are presented under separate cover.

The pile tested was a HP310 mm x 110 kg/m steel HP-section (HP12 in. x 74 lbs./ft.) and was monitored while being driven with a LRH H40/7 hydraulic hammer. The manufacturer's maximum rated energy of the H40/7 hammer is ~55 kJ (39,800 ft-lbs.).

The purpose of the dynamic testing was to evaluate the ultimate geotechnical resistance of the pile tested.

2 Fieldwork and Analysis

On November 11, 2019 one pile (No. PLT-1) was monitored at the beginning of restrike with the instrumentation from the Pile Driving Analyzer attached.

The dynamic monitoring was undertaken in general accordance with the ASTM D4945-12 procedures. The instrumentation for the Pile Driving Analyzer consisted of two reusable strain gauges and two accelerometers securely bolted on the pile. For each hammer blow, electronic signals were fed into the pre-programmed Pile Driving Analyzer (Model PAX) and the basic measurements of strain and acceleration were converted into force and velocity parameters as a function of time.

From the force and velocity parameters, the ultimate (mobilized) bearing capacities were automatically computed. In addition, the maximum compressive and tensile forces, the developed energies and the hammer blow rate, etc., are some of the output data for the Analyzer. The force and velocity traces were continually observed in the field and their digital signals were recorded and stored in memory.

A selected representative hammer blow from the beginning of restrike of Pile No. PLT-1 was used to perform CAPWAP (CAse Pile Wave Analysis Program) analysis in order to evaluate the ultimate resistance of the pile and the corresponding CASE damping factors.

The CAPWAP program is an iterative method to analyze the static resistance and resistance distribution along a pile with the dynamic measurements obtained from the Pile Driving Analyzer Testing. In the CAPWAP analysis, the program utilizes the fact that the force and velocity are related to each other by the pile impedance, which is readily calculable by:

$$Z = \frac{EA}{C}$$

where	Z	=	impedance of pile
	E	=	modulus of elasticity of pile
	A	=	cross-sectional area of pile
	C	=	speed of stress wave in the pile

In the CAPWAP program, the pile is divided into a number of mass points and springs. The soil reaction forces on these mass points are assumed to consist of elastoplastic (static) and linear viscous (dynamic) components. In the analysis, a measured force was used as input and by varying the ultimate static resistance, resistance distribution, quake, elastic soil deformation, soil damping constants, etc., a computed force or velocity is calculated.

When a good match is obtained by varying the above components, the pile-soil interaction is modeled and a solution for the ultimate static resistance along the pile can be calculated. Based on this calculated resistance, an estimate of the frictional resistance can also be obtained.

Static computations can then be used to predict the load versus deformation characteristics of the pile, which is often referred to as a "simulated load test".

3 Test Results

3.1 Pile Driving Analyzer

One test pile (No. PLT-1) was monitored at the beginning of restrike with the instrumentation from the Pile Driving Analyzer attached. The pile tested was a HP310 mm x 110 kg/m steel HP-section (HP12 in. x 74 lbs./ft.) and was monitored while being driven with a LRH H40/7 hydraulic hammer. The manufacturer's maximum rated energy of the H40/7 hammer is ~55 kJ (39,800 ft-lbs.).

The results obtained from the dynamic testing are presented in Table No. 1 and are summarized below.

The average energy transferred to the top of the pile during monitoring was ~28 kJ with an operator controlled reported energy input of ~27 kJ (~20,000 ft-lbs.).

The average maximum force at the instrumentation location was ~1920 kN which corresponds to a maximum stress ranging of ~136 MPa.

The evaluated ultimate geotechnical resistance at the beginning of restrike of Pile No. PLT-1 was ~1550 kN.

The reported penetration resistance at the beginning of restrike was 5 blows for ~35 mm penetration with the pile at ~31.8 m depth below grade.

3.2 CAPWAP Analysis Results

CAPWAP analysis was undertaken on a selected representative hammer blow from the beginning of restrike of Pile No. PLT-1. A summary of the results is presented in Table No. 2. The Case Method Capacities and Pile Profile and Model tables, the CAPWAP Force matches, Force-Velocity Wave forms, Resistance Distributions, Simulated Compression Load Test Curves, etc. are presented in Appendix A.

The evaluated ultimate geotechnical resistance at the beginning of restrike of Pile No. PLT-was ~1550 kN of which ~600 kN is evaluated as shaft resistance and ~950 kN evaluated as toe resistance.

exp.

4 Summary

The evaluated ultimate geotechnical resistance at the beginning of restrike of Pile No. PLT-1 was ~1550 kN, only marginally greater than that evaluated at the end of initial driving approximately one week prior (~1500 kN). It should be noted the evaluated pile geotechnical resistance presented is the pile capacity at the time of testing.

The reported penetration resistance at the beginning of restrike was 5 blows for ~35 mm penetration with the operator controlled energy input reported at ~27 kJ (~20,000 ft-lbs.). The pile had been previously driven to a depth of ~31.8 m below grade.

The average maximum stress at the instrumentation location was ~136 MPa which is well below the anticipated yield strength (350 MPa min.) of the HP310 x 110 HP-section.

The pile driving record and subsurface conditions at the test pile location (by others) are presented in the attached Appendices.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

Exp Services Inc.

A. D. Maini P. Eng.
Sr. Project Engineer

Stephen S. M. Cheng P. Eng.
Manager, Geotechnical Division

Table 1
Summary of Pile Driving Analyzer Results
Hwy. 400 – Essa Road
November 11, 2019

PILE NO.	EVENT	HAMMER	DEPTH BEL. GRADE	REPORTED PENETRATION RESISTANCE	ENERGY		FORCE		EVALUATED ULT. GEOTECHNICAL RESISTANCE	REMARKS
			(m)	Blows/mm	Operator Input kJ (ft-lbs)	Transferred (kJ)	Max. (kN)	Stress (MPa)	(kN)	
PLT-1	BOR	LRH H40/7	~31.8	5 / ~35 *	~27 (~20,000)	~28	1920	136	~1550	-

BOR – Beginning Of Restrike
* From Hiley graph

Table 2
Summary of CAPWAP Analysis Results
Hwy. 400 – Essa Road
November 11, 2019

Pile I.D.	Event	Depth Below Grade (m)	Evaluated Ult. (Mob.) Geo. Resistance (kN)			Reported Penetration Resistance (blows/mm)
			Total	Shaft	Toe	
PLT-1	BOR	~31.8	1550	600	950	5 / ~35

BOR – Beginning Of Restrike

Appendix A –
CAPWAP Tables and Figures

Pile No. PLT-1
BOR
November 11, 2019

exp.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1550.0; along Shaft 600.0; at Toe 950.0 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)
				1550.0			
1	2.0	1.6	24.3	1525.7	24.3	15.07	12.19
2	4.0	3.6	36.7	1489.0	61.0	18.24	14.75
3	6.0	5.6	36.6	1452.4	97.6	18.19	14.71
4	8.0	7.6	30.3	1422.1	127.9	15.06	12.18
5	10.1	9.7	23.2	1398.9	151.1	11.53	9.33
6	12.1	11.7	23.2	1375.7	174.3	11.53	9.33
7	14.1	13.7	36.5	1339.2	210.8	18.14	14.67
8	16.1	15.7	48.7	1290.5	259.5	24.20	19.58
9	18.1	17.7	48.7	1241.8	308.2	24.20	19.58
10	20.1	19.7	38.8	1203.0	347.0	19.28	15.60
11	22.1	21.7	36.8	1166.2	383.8	18.29	14.79
12	24.2	23.8	35.6	1130.6	419.4	17.69	14.31
13	26.2	25.8	33.6	1097.0	453.0	16.70	13.51
14	28.2	27.8	45.5	1051.5	498.5	22.61	18.29
15	30.2	29.8	50.7	1000.8	549.2	25.19	20.38
16	32.2	31.8	50.8	950.0	600.0	25.24	20.42
Avg. Shaft			37.5			18.87	15.27
Toe			950.0				9949.73

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.30	0.20
Quake	(mm)	2.2	6.6
Case Damping Factor		0.32	0.33
Damping Type		Sm+Visc	Viscous
Unloading Quake	(% of loading quake)	51	53
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	65	
Resistance Gap (included in Toe Quake) (mm)			1.1
Soil Plug Weight	(kN)		0.200

CAPWAP match quality = 3.88 (Wave Up Match) ; RSA = 0
Observed: Final Set = 7.0 mm; Blow Count = 143 b/m
Computed: Final Set = 7.0 mm; Blow Count = 143 b/m

max. Top Comp. Stress = 133.3 MPa (T= 26.1 ms, max= 1.008 x Top)
max. Comp. Stress = 134.4 MPa (Z= 2.0 m, T= 26.3 ms)
max. Tens. Stress = -8.16 MPa (Z= 2.0 m, T= 60.7 ms)
max. Energy (EMX) = 26.6 kJ; max. Measured Top Displ. (DMX)= 22.0 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	1879.8	-106.6	133.3	-7.56	26.6	3.24	21.5
2	2.0	1895.1	-115.0	134.4	-8.16	26.3	3.21	21.0
4	4.0	1882.4	-104.0	133.5	-7.38	25.0	3.15	20.2
6	6.0	1845.0	-87.4	130.8	-6.20	23.4	3.10	19.3
8	8.0	1802.2	-70.4	127.8	-4.99	21.8	3.06	18.5
10	10.1	1766.4	-80.0	125.3	-5.68	20.5	3.03	17.6
12	12.1	1746.2	-82.0	123.8	-5.81	19.5	2.99	16.8
14	14.1	1738.1	-97.6	123.3	-6.92	18.4	2.94	16.0
16	16.1	1716.0	-102.8	121.7	-7.29	17.1	2.88	15.1
18	18.1	1679.1	-85.3	119.1	-6.05	15.6	2.82	14.3
20	20.1	1637.3	-77.4	116.1	-5.49	14.3	2.77	13.5
22	22.1	1608.3	-70.1	114.1	-4.97	13.2	2.73	12.8
23	23.1	1567.1	-56.8	111.1	-4.03	12.4	2.72	12.4
24	24.2	1581.6	-68.9	112.2	-4.88	12.2	2.69	12.0
25	25.2	1542.5	-53.4	109.4	-3.78	11.5	2.68	11.7
26	26.2	1556.6	-64.6	110.4	-4.58	11.4	2.65	11.3
27	27.2	1522.9	-53.0	108.0	-3.76	10.7	2.63	11.0
28	28.2	1535.9	-64.7	108.9	-4.59	10.6	2.61	10.7
29	29.2	1422.9	-47.1	100.9	-3.34	10.0	2.76	10.4
30	30.2	1313.8	-62.7	93.2	-4.45	9.8	3.18	10.2
31	31.2	1182.4	-43.4	83.9	-3.08	9.1	3.47	9.9
32	32.2	1175.2	-53.9	83.3	-3.82	8.8	3.50	9.6
Absolute	2.0			134.4			(T =	26.3 ms)
	2.0				-8.16		(T =	60.7 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	1810	1615	1419	1224	1028	833	637	442	246	51
RX	1860	1799	1738	1678	1620	1563	1506	1455	1425	1394
RU	1810	1615	1419	1224	1028	833	637	442	246	51

RAU = 1030 (kN); RA2 = 1670 (kN)

Current CAPWAP Ru = 1550 (kN); Corresponding J(RP)= 0.13; J(RX) = 0.52

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
m/s	ms	kN	kN	kN	mm	mm	mm	kJ	kN	kN/mm
3.31	25.93	1884	1881	1881	22.0	7.0	7.0	27.0	1861	173

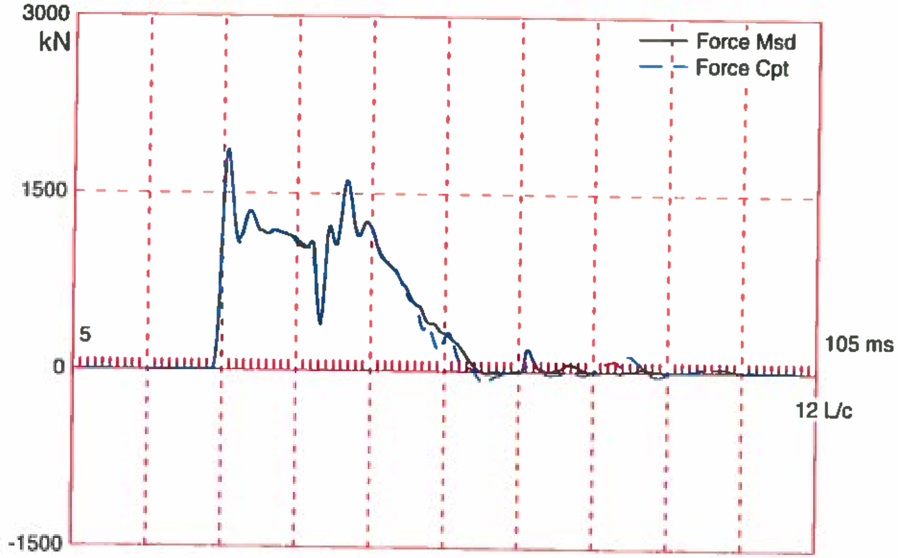
PILE PROFILE AND PILE MODEL

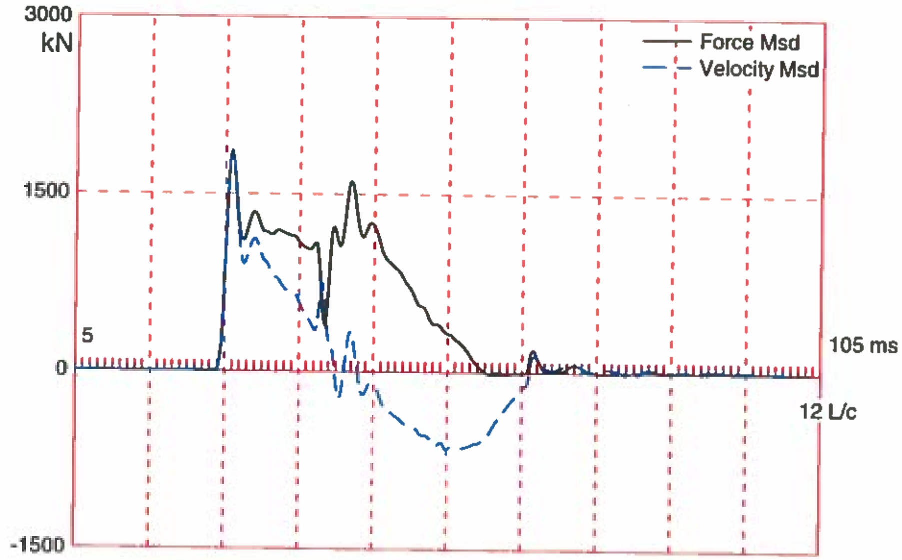
Depth	Area	E-Modulus	Spec. Weight	Perim.
m	cm^2	MPa	kN/m^3	m
0.0	141.0	206842.7	77.287	1.24
32.2	141.0	206842.7	77.287	1.24

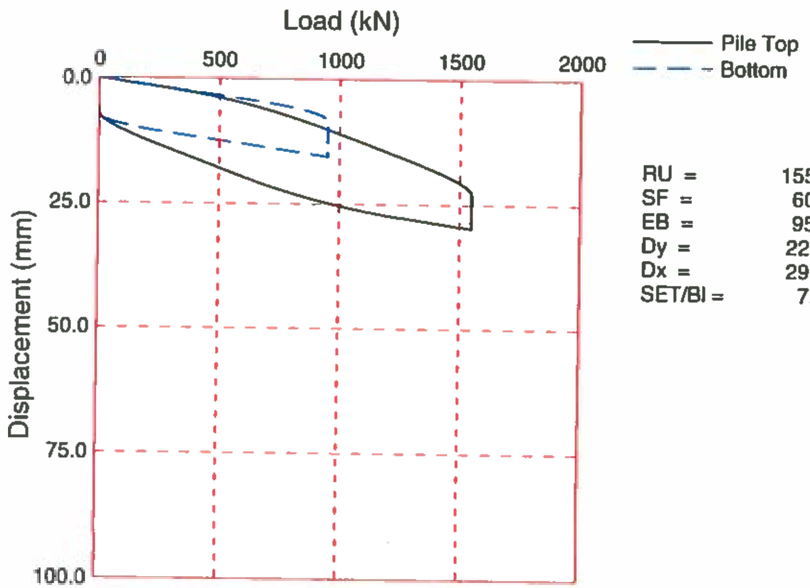
Toe Area 954.8 cm^2

Top Segment Length 1.01 m, Top Impedance 569 kN/m/s

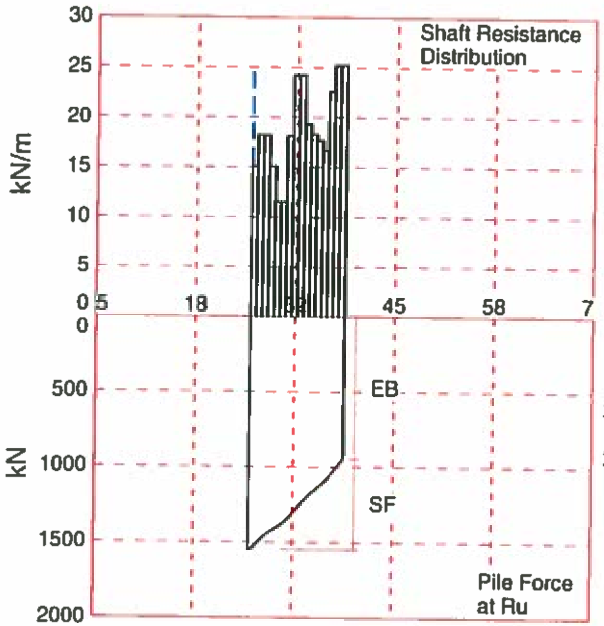
Wave Speed: Pile Top 5123.0, Elastic 5123.0, Overall 5123.0 m/s
Pile Damping 1.00 %, Time Incr 0.196 ms, 2L/c 12.6 ms
Total volume: 0.454 m^3; Volume ratio considering added impedance: 1.000







RU =	1550 kN
SF =	600 kN
EB =	950 kN
Dy =	22.9 mm
Dx =	29.8 mm
SET/Bl =	7.0 mm



Length b. Sensors	32.2 m
Embedment	31.8 m
Top Area	141.0 cm²
End Bearing Area	954.8 cm²
Top Perimeter	1.24 m
Top E-Modulus	206843 MPa
Top Spec. Weight	77.3 kN/m³
Top Wave Spd.	5123 m/s
Overall W.S.	5123 m/s
Match Quality	3.88
Top Compr. Stress	133.3 MPa
Max Compr. Stress	134.4 MPa
Max Tension Stress	-8.16 MPa
Avg. Shaft Quake	2.2 mm
Toe Quake	6.6 mm
Avg. Shaft Smith Dpg.	0.30 s/m
Toe Smith Damping	0.20 s/m

CAPWAP(R) 2014-3 Licensed to exp Services, Inc.

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

Appendix B:
Pile Driving Record

Ontario Ministry of Transportation

Bridge Construction - Pile Driving Record

(Please refer to Page 2 if clarification is required.)

Contract Information

Contract No.: ____ District: ____ Region: ____

Str. Site No.: ____ Str. WP No.: ____ Location: ____

Piling Contractor:

Pile Details

Pile No. and Location: PLT-1

Size: HP310 Mass: 110 kg/m Pile Type: H-Pile Design Capacity: 3700 kN

Initial Pile Length: ____ m Pile Shoe ____ Batter

Spliced	1	2	3	4	5	6
Total Length of Pile being driven after splicing:						

Final Pile Length after Cut-off ____ m

Cut-off Elevation: ____ Actual Tip Elev.: ____ Design Tip Elev.: 216.2m

Hammer Details

Mechanical Hammer Type: H40/7* Rated Energy: ____ Joules/Blow

Drop Hammer Mass (W): ____ kg Fall(h) ____ m Energy (Wgh)* 55 KNm Joules/Blow

Mass of Anvil: 7000 kg Mass of Mechanical hammer Ram (W) ____ kg Follower used: ☐ Yes ☐ No

Hammer Cushion Details: ____ Pile Cushion Details: ____

Ground Elevation at Pile Locations: ____ Driving record: ____ Date(s): ____

Length in ground (m)	Penetration Blows/0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m	Length in ground (m)	Penetration Blows / 0.2m
0.2	21	6.2	7	12.2	10	18.2	6	24.2	7	27.2	9	30.2	13
0.4	3	6.4	9	12.4	12	18.4	8	24.4	9	27.4	11	30.4	13
0.6	4	6.6	10	12.6	13	18.6	6	24.6	8	27.6	10	30.6	17
0.8	5	6.8	13	12.8	13	18.8	8	24.8	8	27.8	10	30.8	13
1.0	6	7.0	11	13.0	10	19.0	7	25.0	8	28.0	9	31.0	12
1.2	7	7.2	9	13.2	11	19.2	7	25.2	7	28.2	10	31.2	87
1.4	6	7.4	9	13.4	10	19.4	7	25.4	7	28.4	10	31.4	12
1.6	3	7.6	8	13.6	10	19.6	8	25.6	7	28.6	10	31.6	13
1.8	2	7.8	8	13.8	11	19.8	8	25.8	6	28.8	9	31.8	18 *
2.0	2	8.0	8	14.0	10	20.0	7	26.0	8	29.0	10	32.0	
2.2	1	8.2	8	14.2	11	20.2	7	26.2	7	29.2	9	32.2	
2.4	2	8.4	7	14.4	10	20.4	8	26.4	8	29.4	10	32.4	
2.6	2	8.6	7	14.6	10	20.6	7	26.6	10	29.6	11	32.6	
2.8	2	8.8	6	14.8	10	20.8	8	26.8	10	29.8	14	32.8	
3.0	4	9.0	5	15.0	9	21.0	7	27.0	9	30.0	16	33.0	
3.2	4	9.2	6	15.2	10	21.2	7						
3.4	5	9.4	5	15.4	5	21.4	7						
3.6	5	9.6	8	15.6	8	21.6	8						
3.8	5	9.8	6	15.8	8	21.8	9						
4.0	5	10.0	7	16.0	8	22.0	7						
4.2	6	10.2	6	16.2	8	22.2	6						
4.4	5	10.4	7	16.4	8	22.4	6						
4.6	12	10.6	7	16.6	7	22.6	7						
4.8	14	10.8	6	16.8	7	22.8	8						
5.0	11	11.0	7	17.0	7	23.0	8						
5.2	12	11.2	7	17.2	8	23.2	7						
5.4	15	11.4	7	17.4	8	23.4	8						
5.6	11	11.6	11	17.6	8	23.6	8						
5.8	9	11.8	10	17.8	7	23.8	9						
6.0	8	12.0	10	18.0	7	24.0	9						

Record of last 100mm of penetration from graph produced on pile blows/20mm

Penetration	0 to 20	20 to 40	40 to 60	60 to 80	80 to 100
Blows/20mm					
Rebound (C)					

*Note: g = acceleration due to gravity = 9.81 m/s2

Mail completed form or copy to:
Pavements and Foundations Section
Room 223, Building 'C'
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

PH-D-205 Aug-09

*energy dropped to 20,000 ft lbs

Appendix C: Subsurface Conditions

GOLDER

Foundation Design

PROJECT 18105050 — **RECORD OF BOREHOLE No PLT-1** — SHEET 1 OF 3 — **METRIC**

G.W.P. 2337-16-00 — LOCATION N 4913544.7, E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745, LONG -79.698085) — ORIGINATED BY SK

DIST Central HWY 400 — BOREHOLE TYPE Power Auger, 210 mm O.D. Hollow Stem Augers — COMPILED BY ML

DATUM Geodetic — DATE May 8, 2019 — CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.2	GROUND SURFACE						
0.0	TOPSOIL (200 mm)				246		
0.2	SILT (ML), some sand; Very loose; Brown; Moist	1	SS	3			
245.5 / 0.7	CLAYEY SAND (SC), trace gravel; Compact; Brown; Moist	2	SS	13	245	o	
244.8 / 1.5	CLAYEY SILT (CL) and SAND, trace gravel; Stiff; Brown; Moist	3	SS	9			
244.0 / 2.2	SILTY SAND (SM), trace to some gravel, trace clay; Compact to very dense; Brown to grey	4	SS	21	244	o	
		5	SS	38	243	o	7 49 38 6
		6	SS	36	242 / 241	o	
	- Becoming grey below a depth of 6.7 m	7	SS	78	240 / 239		
	- Tricone grinding at a depth of 8.2 m	8	SS	23	238	o	12 57 25 6
	- Tricone grinding at a depth of 9.1 m; - Slight plasticity at a depth of 9.5 m	9	SS	32	237	H	7 55 31 7
236.0 / 10.2	SAND (SP-SM), trace to some silt, trace to some gravel; Dense to very dense; Grey; Moist to wet at a depth of about 13.3 m; - Tricone grinding at a depth of 11.3 m	10	SS	53	236 / 235		
		11	SS	32	234 / 233	o	0 91 9 0
	- Tricone grinding at a depth of 14.6 m	12	SS	37	232	o	

Columns also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

Continued Next Page

$+^3, \times^3$ Numbers refer to Sensitivity — $○^{3\%}$ STRAIN AT FAILURE

Preliminary DRAFT

GOLDER

Foundation Design

PROJECT 18105050	RECORD OF BOREHOLE No PLT-1	SHEET 2 OF 3	METRIC
G.W.P. 2337-16-00	LOCATION N 4913544.7; E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745, LONG. -79.698085)		ORIGINATED BY SK
DIST Central HWY 400	BOREHOLE TYPE Power Auger, 210 mm O.D. Hollow Stem Augers		COMPILED BY ML
DATUM Geodetic	DATE May 8, 2019		CHECKED BY AMP

SOIL PROFILE — ELEV / DEPTH — DESCRIPTION — STRAT PLOT | SAMPLES: NUMBER, TYPE, "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100) | PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

— CONTINUED FROM PREVIOUS PAGE —

ELEV / DEPTH	DESCRIPTION
	SAND (SP-SM), trace to some silt, trace to some gravel Dense to very dense Grey Moist to wet at a depth of about 13.3 m - Tricone grinding at a depth of 17.7 m
226.8 / 19.4	SILTY SAND (SM), trace to some gravel, trace clay Compact to very dense Grey Wet - Tricone grinding at a depth of 20.4 m - Tricone grinding at a depth of 21.9 m - Tricone grinding at a depth of 22.9 m - Tricone grinding at a depth of 23.8 m - Tricone grinding at a depth of 24.7 m - Tricone grinding at a depth of 26.5 m 28.2 - Tricone grinding at a depth of 29 m

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
13	SS	37				
14	SS	33	5	84	11	0
15	SS	36				
16	SS	21	3	69	23	5
17	SS	62				
18	SS	61				
19	SS	94	11	67	20	2
20	SS	109				
21	SS	87				
22	SS	101				

ELEVATION SCALE: 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217

Continued Next Page

$+^3, \times^3$ Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Preliminary DRAFT

GOLDER

Foundation Design

PROJECT 18105050

RECORD OF BOREHOLE No PLT-1 SHEET 3 OF 3 **METRIC**

G W P. 2337-16-00

LOCATION N 4913544.7 E 289011.1 MTM NAD 83 ZONE 10 (LAT. 44.361745 LONG -79.698085) ORIGINATED BY SK

DIST Central HWY 400

BOREHOLE TYPE Power Auger. 210 mm O D Hollow Stem Augers COMPILED BY ML

DATUM Geodetic

DATE May 8 2019 CHECKED BY AMP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —						
	SILTY SAND (SM), trace to some gravel, trace clay Compact to very dense Grey Wet				216		
	- Tricone grinding at a depth of 30.2 m	23	SS	72/0.2		o	19 51 24 6
31.2 —					215		
		24	SS	100/0.1	214		
	- Tricone grinding at a depth of 32.6 m						
	- Tricone grinding at a depth of 33.2 m				213		
		25	SS	76		o	
	- Tricone grinding at a depth of 34.4 m				212		
210.9 35.3	END OF BOREHOLE	26	SS	100/0.1	211		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTES

1. Tricone (Mud Rotary) drilling carried out from a depth of 3.0 m to 35.3 m.

2. Water level measurements in piezometer as follows.

Date	Depth (m)	Elev (m)
06/24/19	5.03	

Preliminary DRAFT

+3 ×3 Numbers refer to Sensitivity   o3% STRAIN AT FAILURE

Photograph 1: Installing H-40/7 Hydraulic Hammer

Photograph 2: One of the Two Pile Driving "Shoes"

Photograph 3: Interval Markings (20 cm) on H-Pile Lengths

Photograph 4: Positioning of Pile

Photograph 5: Pile Driving of First Pile Segment (18 m length)

Photograph 6: Lifting of Second Pile Segment (18 m length)

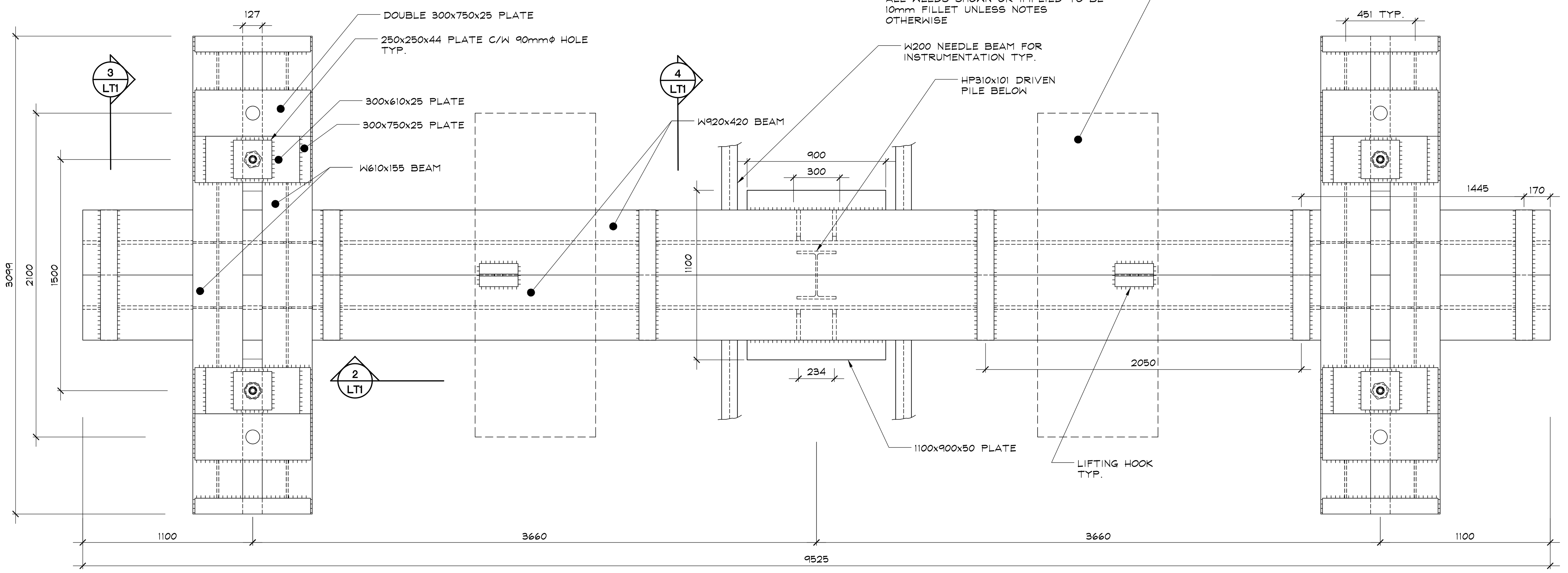
Photograph 7: Welding of Pile Segment 1 and Pile Segment 2

Photograph 8: Setup of Hiley Test and PDA Test Equipment

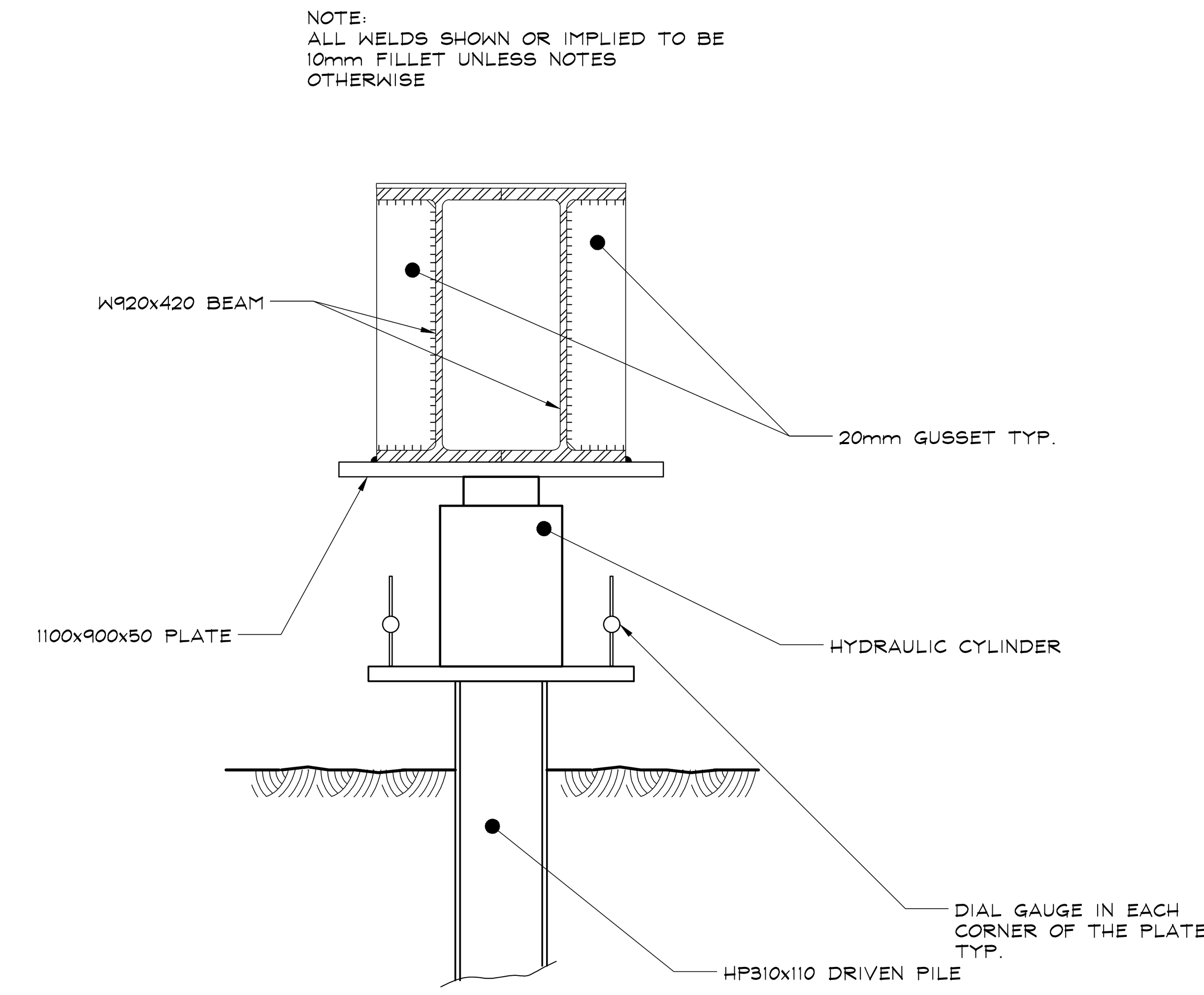
Photograph 9: Final driven Elevation of Pile to 31.8 m

APPENDIX E

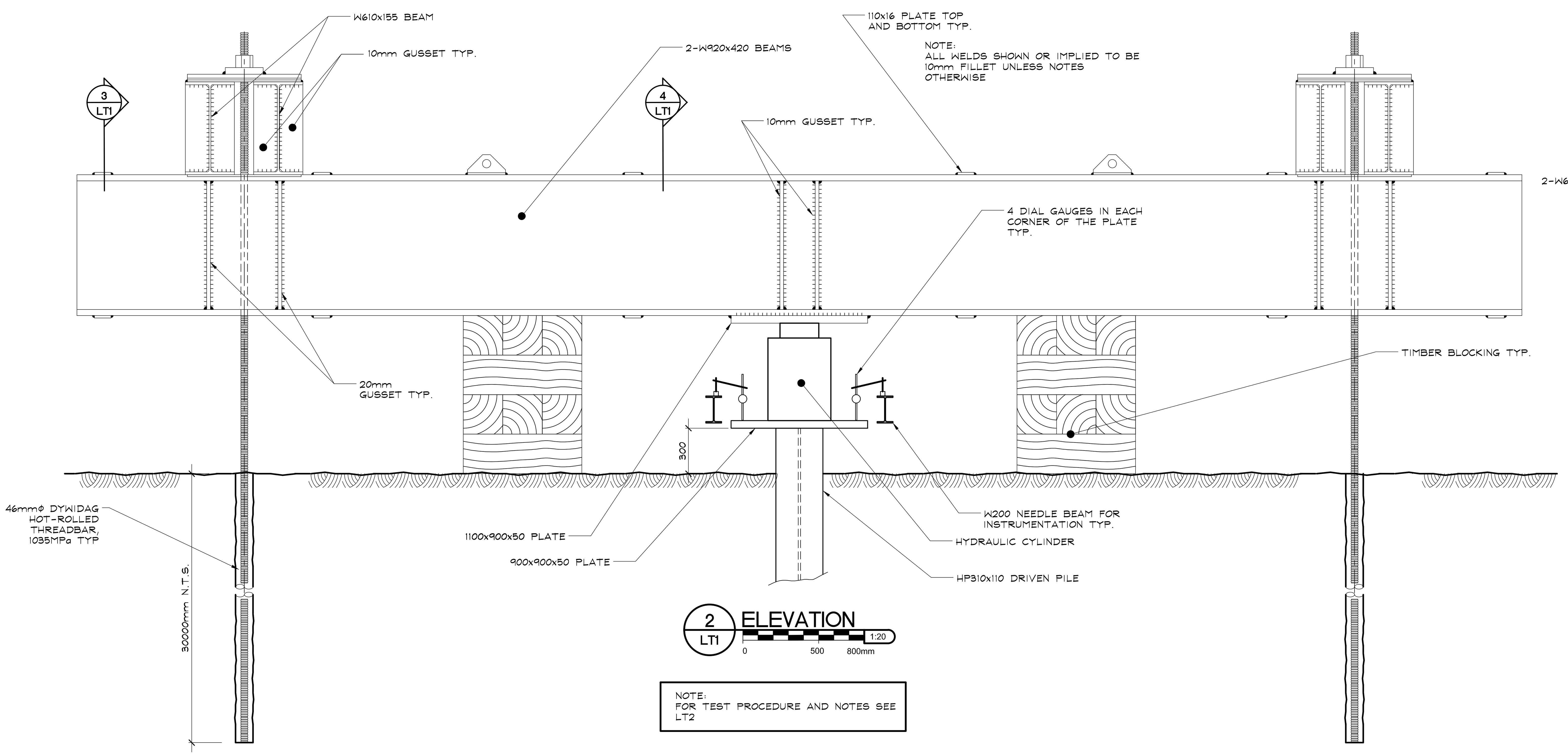
Static Pile Load Test Arrangements



1 PLAN LT1 — 1:20 (0, 500, 800mm)

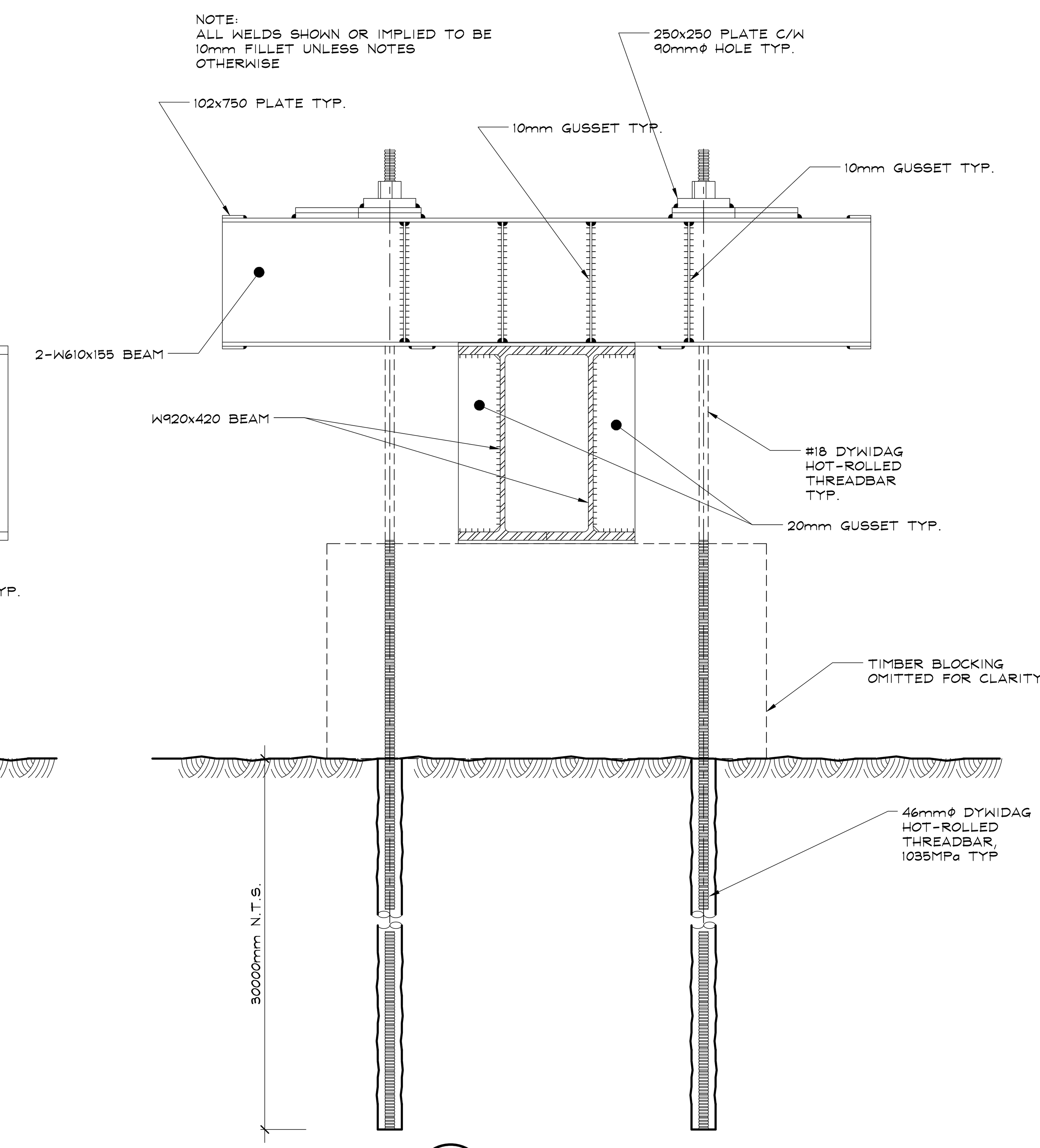


4 SECTION LT1 — 1:20 (0, 500, 800mm)



2 ELEVATION LT1 — 1:20 (0, 500, 800mm)

NOTE:
FOR TEST PROCEDURE AND NOTES SEE LT2



3 SECTION LT1 — 1:20 (0, 500, 800mm)

TEST BEAM: TBM01	
MAIN BEAMS	W920x420
REACTION BEAMS	W610x155
REACTION CENTRES	7319mm
TOTAL WIGHT, kg	17800

No.	DESCRIPTION	Date
	ISSUED FOR REVIEW	19/08/27

NOTES

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Stamp: LICENSED PROFESSIONAL ENGINEER — B. KONDRATENKO — 2019/AUG/28 — PROVINCE OF ONTARIO

Client: GFL GREEN FOR LIFE environmental — TORONTO ONTARIO

Consultant: SUBSTRUCTION ENGINEERING — P.O. Box 699 Stouffville, ON L4A 7J7 — Telephone (416) 937-6999, (416) 254-5759

Project: HIGHWAY 400/ESSA ROAD INTERCHANGE RECONSTRUCTION — BARRIE ONTARIO

Drawing Title: LOAD TEST ARRANGEMENT

Drawn: JC — Scale: AS NOTED

Checked: TOR — Date: 8/28/2019 7:25:56 AM

Project No.: S1928-9 — Drawing Number: LT1

Wednesday, August 28, 2019 7:25:56 AM

A. TEST

1. ALL ASPECTS OF THE TEST MUST COMPLY WITH THE O.B.C. AND THE OCCUPATIONAL HEALTH AND SAFETY ACT.
2. THE TEST PILE IS TO BE TESTED TO A MAXIMUM LOAD OF 3600kN FOR TEST 1 AND 4,1400 kN FOR TEST 2.
3. REFER ALSO TO THE FULL-SCALE PILE LOAD TEST SPECIFICATION FOR THIS PROJECT.

B. REFERENCES

4. DESIGN IS IN ACCORDANCE WITH THE STRUCTURAL REQUIREMENTS OF THE ONTARIO BUILDING CODE AND THE CANADIAN HIGHWAY BRIDGE DESIGN CODE.

C. MATERIALS:

5. STRUCTURAL STEEL DESIGN, CONNECTIONS, FABRICATION AND ERECTION IS TO CONFORM TO REQUIREMENTS OF CAN / CSA S16-14 AND CAN / CSA S136-16.
6. STRUCTURAL STEEL TO CONFORM TO CSA G40.20-13/G40.21-13, GRADE 350W FOR WIDE FLANGES, CHANNELS AND HOLLOW STRUCTURAL SECTIONS AND GRADE 300W MIN. FOR PLATES AND ALL OTHER SHAPES. STEEL TO BE FABRICATED AND ERECTED BY A SHOP CERTIFIED BY THE CANADIAN WELDING BUREAU TO THE REQUIREMENTS OF CSA W47.1-09.
7. TIE ANCHORS SHALL BE FABRICATED FROM THE FOLLOWING MATERIALS: ASTM A615 517/690MPA (DESIGNATED BY # I.E. #11 THREADBAR). EXACT SIZES AS SHOWN IN SECTIONS OR WHEN NOT SHOWN TO BE CHOSEN LATER FOR LOADS SHOWN IN THE SCHEDULE.
8. WELDING TO CONFORM TO CSA W59-13. WELDERS TO BE QUALIFIED TO CSA W47.1-09.
9. ALTERNATIVE SECTIONS OR GRADES OF EQUIVALENT STRENGTH MAY BE SUBSTITUTED SUBJECT TO APPROVAL BY SUBSTRUCTION ENGINEERING INC.
10. CONCRETE MATERIALS, MIXING, HANDLING, DESIGN, FORMWORK, REBAR, PLACEMENT, CUTTING AND FINISHING TO COMPLY WITH CSA A23.1,2 & 3, UNLESS MODIFIED IN WRITING BY THE ENGINEER.
11. CONCRETE STRENGTHS TO BE AS FOLLOWS UNLESS NOTED:

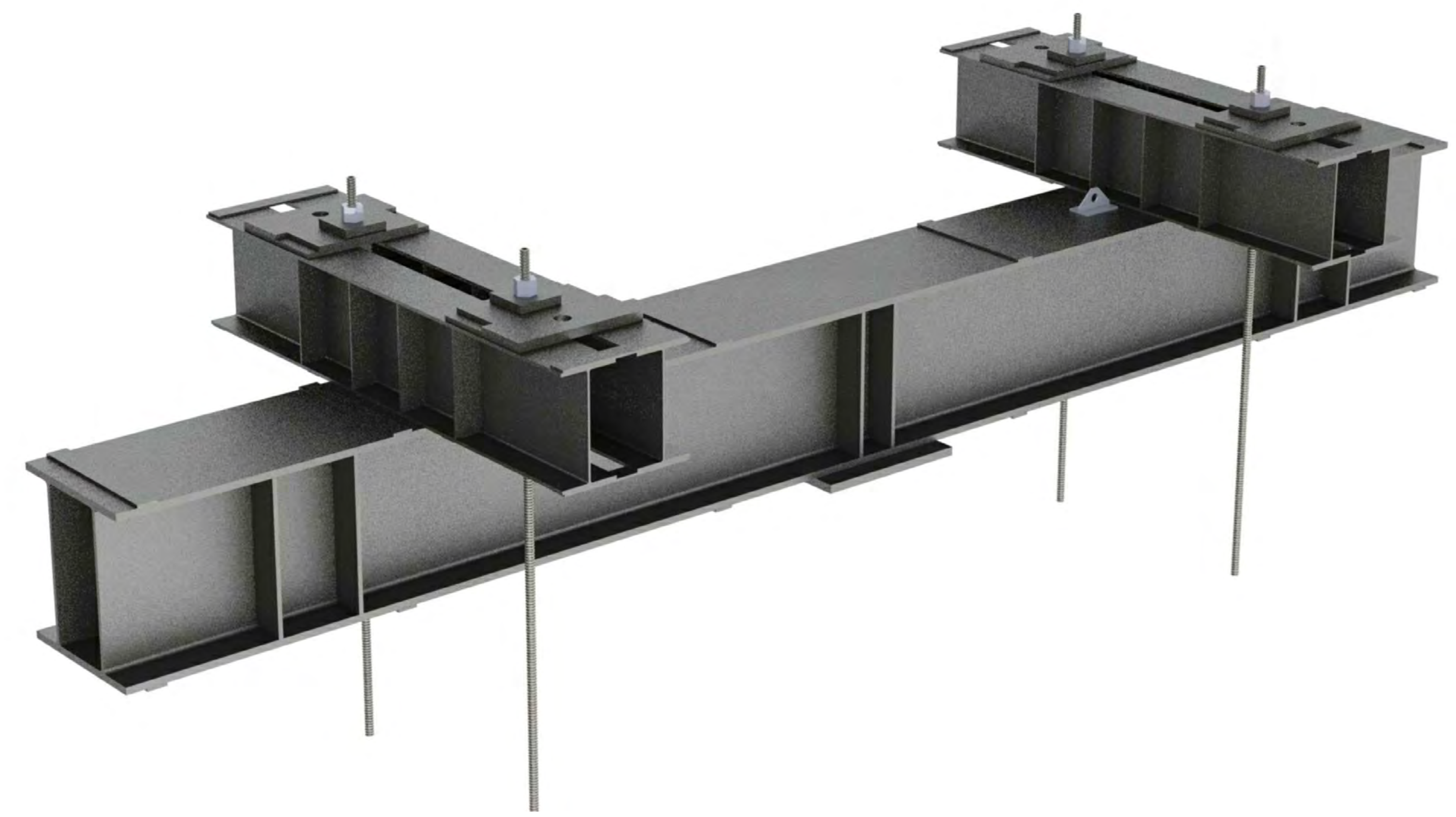
REACTION MICROPILES .... 30 MPA;

D. PROCEDURE

12. LAYOUT PROPOSED LOCATION OF REACTION MICROPILES AROUND PILE TO BE TESTED AND CHECKED AGAINST THE TEST BEAM DRAWING. CHECK THE LAYOUT WITH THE ACTUAL TEST BEAM WHICH WILL BE USED.
13. DRILL REACTION MICROPILES IN THE NORMAL FASHION USING LINERS IF NECESSARY TO AVOID CAVING TO THE DEPTH SHOWN ON THE TEST BEAM DRAWING. PLACE REACTION TENSION BARS ACCURATELY TO MATCH TEST BEAM.
14. PLACE AND SECURE TEST BEAMS AS SHOWN ON THE TEST BEAM DRAWING USING WOODEN BLOCKING TO STABILIZE. CONNECT ALL REACTION MICROPILES BARS AND ENSURE THE BARS AND CENTERLINE OF PILE TO BE TESTED ARE IN ALIGNMENT.
15. BUILD UP OR CUT DOWN TEST PILE TO ENSURE THAT THE REACTION POINT IS FLAT AND LEVEL. WELD ON PLATE TO TOP OF TEST PILE.
16. PLACE THE HYDRAULIC JACK AND ALL REQUIRED TUBES AND WIRING. ENSURE EVERYTHING IS IN PROPER WORKING ORDER.
17. ASSEMBLE NEEDLE BEAMS AND THEIR SUPPORTS IN A SOLID AND SECURE CONFIGURATION. ASSEMBLE STRAIN GAUGES PLACING ONE ON EACH CORNER OF THE TEST PILE TOP PLATE.
18. CHECK THAT ALL PARTS OF THE TEST BEAM ASSEMBLY ARE LEVEL, PLUM AND IN ALIGNMENT.
19. APPLY A 10% LOAD INCREMENT TO ENSURE THAT ALL PARTS ARE BEDDED IN PROPERLY AND EVERYTHING IS FUNCTIONING PROPERLY. FOR LOADING INCREMENTS AND THE DURATION THEY SHOULD BE HELD SEE THE ATTACHED TABLE 1 AND 2, THIS DRAWING.
20. SURVEY THE TOPS OF THE REACTION PILES BEFORE STARTING THE TEST. CHECK AT 50% LOAD LEVEL AND AFTER THE APPLICATION OF 100% OF THE TEST LOAD.
21. CONDUCT THE TEST AS PER THE ENGINEER'S INSTRUCTIONS AND ACCORDING TO ASTM D1143.
22. ENSURE THE ASSEMBLY STAYS IN ALIGNMENT AND DOES NOT DISTORT OR BUCKLE DURING THE TEST.
23. RECORD THE JACK HYDRAULIC PRESSURES, THE APPLIED LOAD AND THE STRAINS MEASURED AT EACH LOAD INCREMENT DURING THE TEST. PRESENT THE RESULTS IN A CLEAR, LEGIBLE AND DESCRIPTIVE REPORT.
24. MEASURE STRAINS AND REACTION CAISSON ELEVATIONS WHEN ALL STRESSES HAVE BEEN REMOVED.

E. CONTRACTOR

25. PREPARE THE TEST AREA SO THAT THE TEST PILE MAY BE DRIVEN AND THE PILE TEST CONDUCTED WITHOUT ENCOUNTERING OBSTRUCTIONS.
26. ENSURE THAT TEST AREA IS ALWAYS DRAINED WITH NO STANDING WATER.
27. ENSURE THAT ALL SERVICES IN OR NEAR THE TEST AREA ARE IDENTIFIED. ENSURE THE PILE DRIVER AND THE PILE TESTER IS MADE AWARE OF SUCH SERVICES.



2 / LT2 LOAD TEST BEAM ISOMETRIC VIEW (N.T.S.)

TABLE 1

Axial Pile Load Test 1 Increments

Load	Minimum Hold Times (Minutes)	Load, kN
AL	-	
12.5	5,10,20	
25.0	5,10,20	
37.5	5,10,20	
50.0	5,10,20	
62.5	5,10,20	
75.0	5,10,20	
87.5	5,10,20	
100.0	5,10,20,40,60,80,100	3600kN
100.0	120,180…….12h	3600kN
75.0	5,10,20,40,60	
50.0	5,10,20,40,60	
25.0	5,10,20,40,60	
AL	-	

AL = Alignment Load
DL = Design Load = 3600 kN

Hold load until acceptance criterion for creep movement is satisfied as per ASTM D1143

TABLE 2

Axial Pile Load Test 2 Increments

Load	Minimum Hold Times (Minutes)	Load, kN
AL	-	
25	5,10,20	
50	5,10,20	
75	5,10,20	
100	5,10,20	3600kN
105	5,10,20	
110	5,10,20	
115	5,10,20,40,60,80,100	4140kN
115	120	4140kN
92.5	5,10,20	
70.0	5,10,20	
47.5	5,10,20	
25.0	5,10,20	
AL	-	

AL = Alignment Load
DL = Design Load = 4140 kN

Hold load until acceptance criterion for creep movement is satisfied as per ASTM D1143

No.	DESCRIPTION	Date
	ISSUED FOR REVIEW	19/08/27

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Client: GFL GREEN FOR LIFE environmental — TORONTO ONTARIO

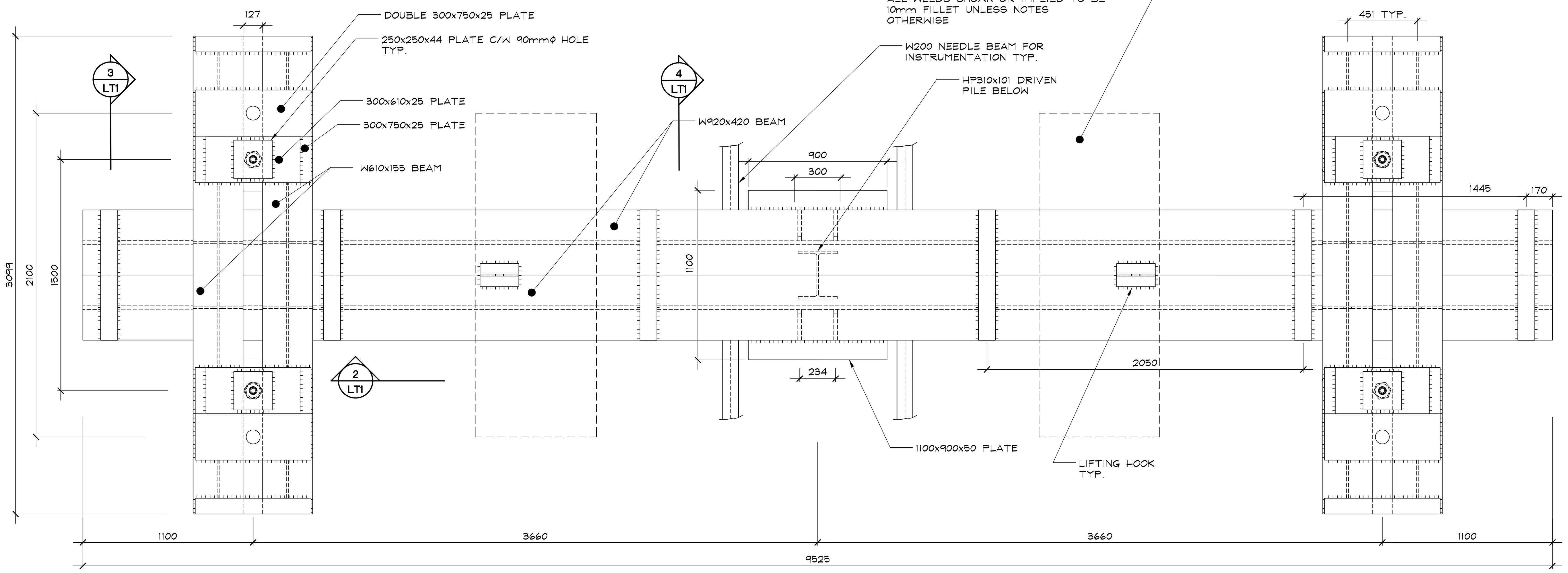
Consultant: SUBSTRUCTION ENGINEERING
P.O. Box 699 Stouffville, ON L4A 7Z7
Telephone (416) 937-6999, (416) 254-5759

Project: HIGHWAY 400/ESSA ROAD INTERCHANGE RECONSTRUCTION
BARRIE ONTARIO

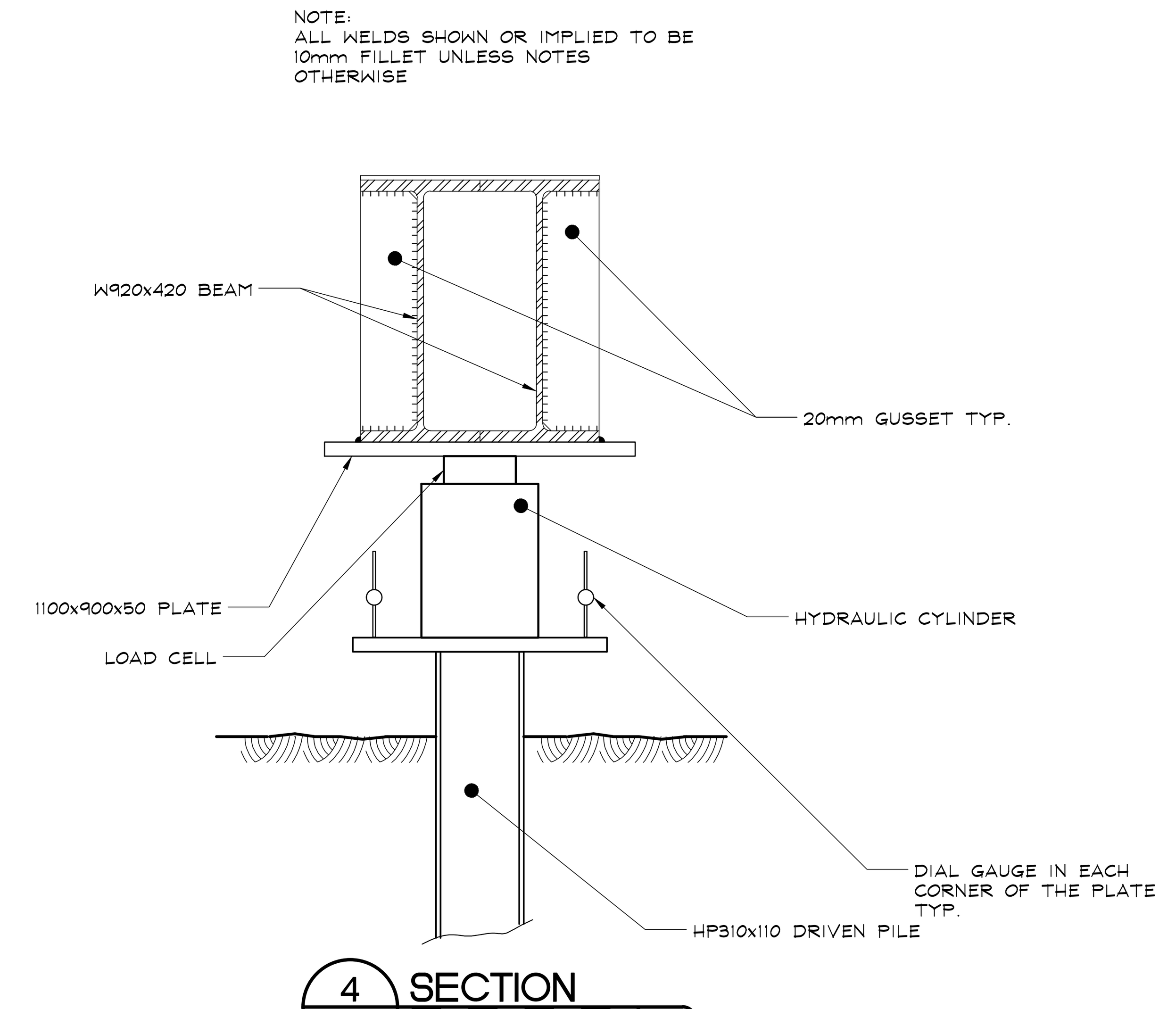
Drawing Title: LOAD TEST ARRANGEMENT

Drawn:	JC	Scale	AS NOTED
Checked:	TOR	Date	8/28/2019 7:26:13 AM
Project No.	S1928-9	Drawing Number	LT2

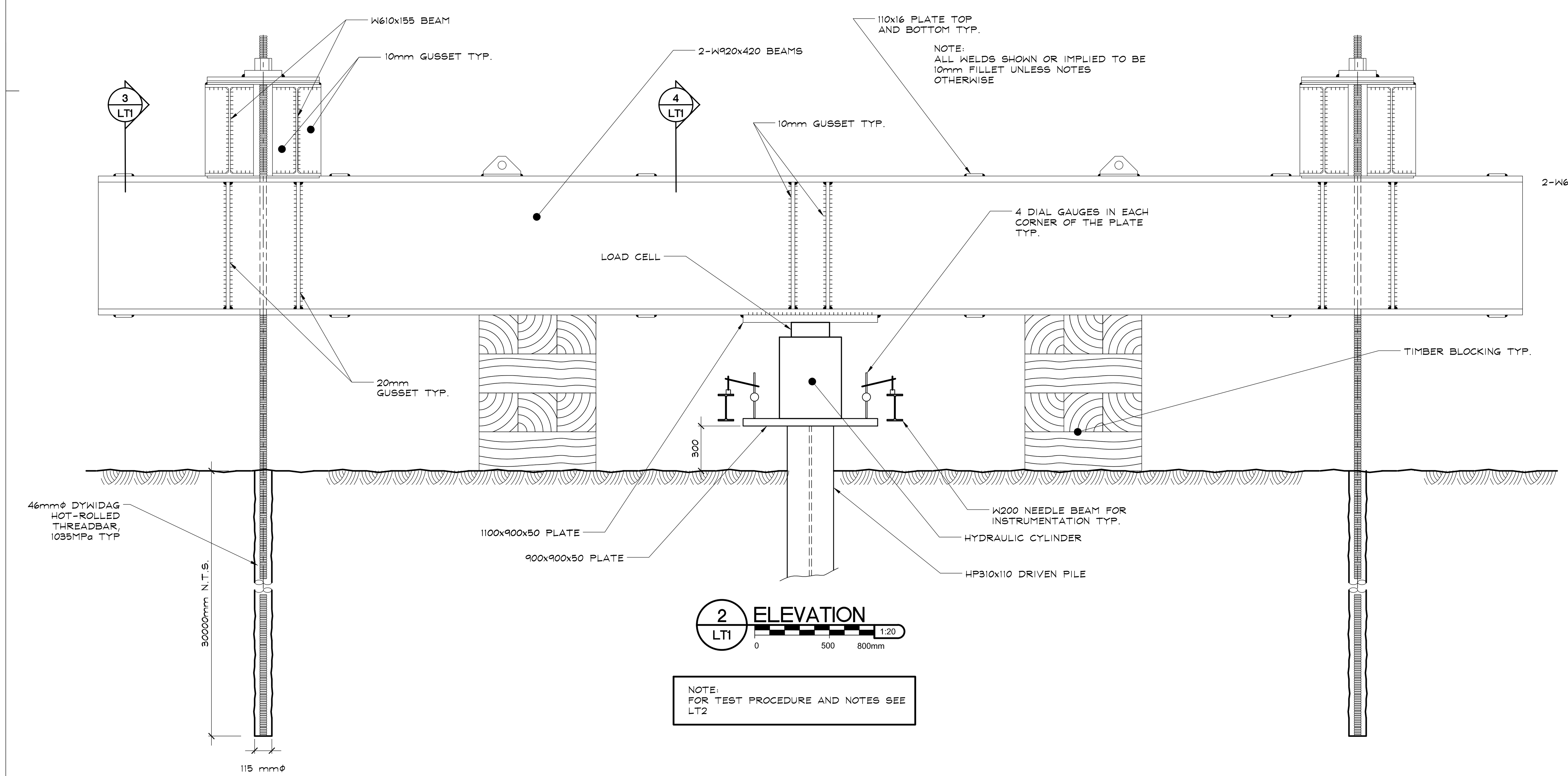
Wednesday, August 28, 2019 7:26:13 AM



1 LT1 PLAN 1:20 0 500 800mm

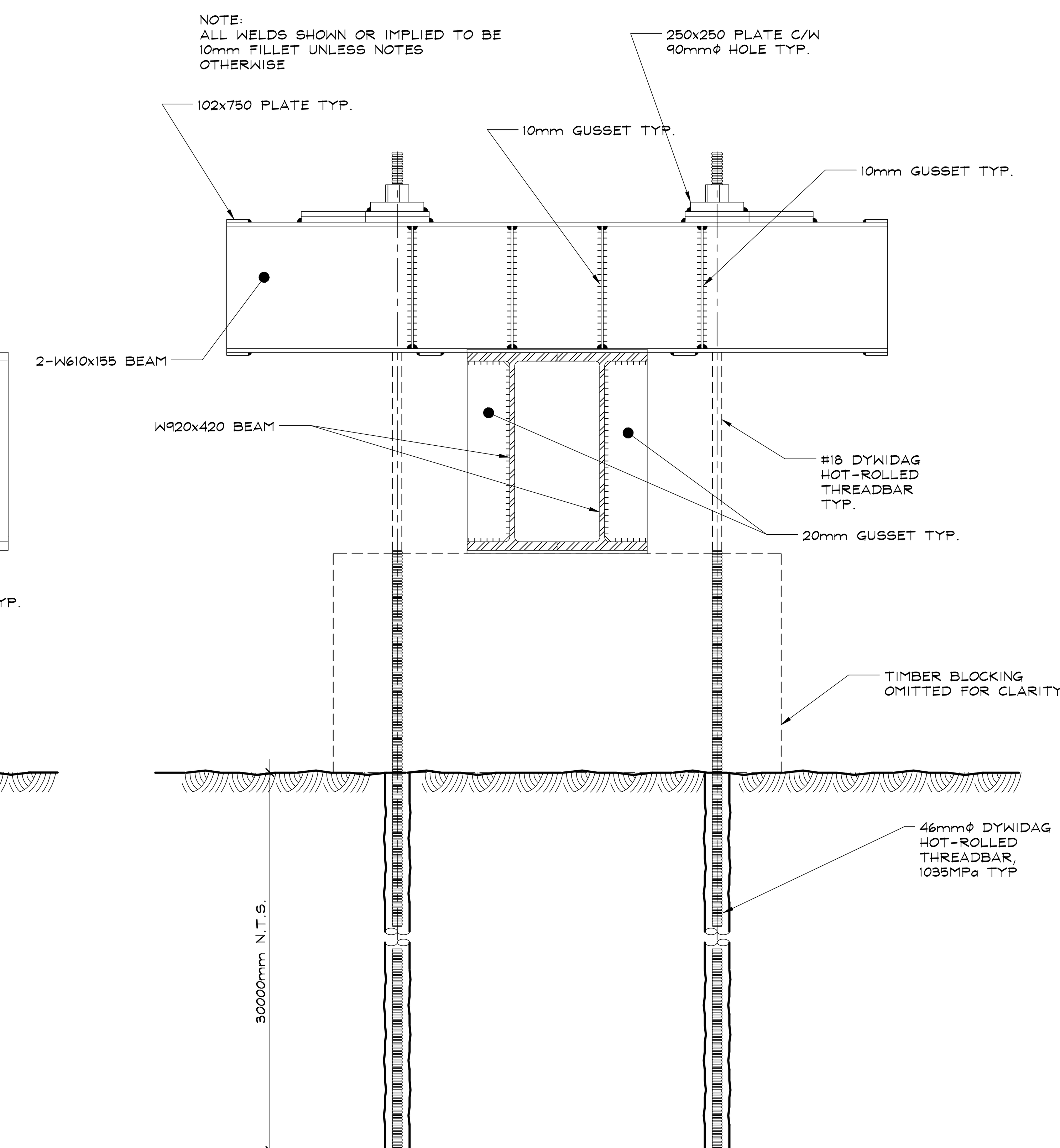


4 LT1 SECTION 1:20 0 500 800mm



2 LT1 ELEVATION 1:20 0 500 800mm

NOTE:
FOR TEST PROCEDURE AND NOTES SEE LT2



3 LT1 SECTION 1:20 0 500 800mm

TEST BEAM: TBM01	
MAIN BEAMS	W920x420
REACTION BEAMS	W610x155
REACTION CENTRES	7319mm
TOTAL WIGHT, kg	17800

No.	DESCRIPTION	Date
1.	ISSUED FOR REVIEW	19/09/17
	ISSUED FOR REVIEW	19/08/27

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LICENSED PROFESSIONAL ENGINEER B. KONDRATENKO 2019/SEP/17 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER 34891507 T.H. O'ROURKE 2019/SEP/17 PROVINCE OF ONTARIO

Client

GFL GREEN FOR LIFE environmental

TORONTO ONTARIO

Consultant

SUBSTRUCTION ENGINEERING

P.O. Box 699 Stouffville, ON L4A 7J7
Telephone (416) 937-6999, (416) 254-5759

Project

HIGHWAY 400/ESSA ROAD INTERCHANGE RECONSTRUCTION

BARRIE ONTARIO

Drawing Title

LOAD TEST ARRANGEMENT

Drawn: JC
Scale: AS NOTED
Checked: TOR
Date: 9/17/2019 10:32:09 AM
Project No. S1928-9
Drawing Number LT1

A. TEST

1. ALL ASPECTS OF THE TEST MUST COMPLY WITH THE O.B.C. AND THE OCCUPATIONAL HEALTH AND SAFETY ACT.

2. THE TEST PILE IS TO BE TESTED TO A MAXIMUM LOAD OF 3600kN FOR TEST 1 AND 4,140 kN FOR TEST 2.

3. REFER ALSO TO THE FULL-SCALE PILE LOAD TEST SPECIFICATION FOR THIS PROJECT.

B. REFERENCES

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11. CONCRETE STRENGTHS TO BE AS FOLLOWS UNLESS NOTED:

REACTION MICROPILES .... 30 MPA;

D. PROCEDURE

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19. APPLY A 10% LOAD INCREMENT TO ENSURE THAT ALL PARTS ARE BEDDED IN PROPERLY AND EVERYTHING IS FUNCTIONING PROPERLY. FOR LOADING INCREMENTS AND THE DURATION THEY SHOULD BE HELD SEE THE ATTACHED TABLE 1 AND 2, THIS DRAWING.

20. CONDUCT THE TEST AS PER THE ENGINEER'S INSTRUCTIONS AND ACCORDING TO ASTM D1143.

21. ENSURE THE ASSEMBLY STAYS IN ALIGNMENT AND DOES NOT DISTORT OR BUCKLE DURING THE TEST.

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E. CONTRACTOR

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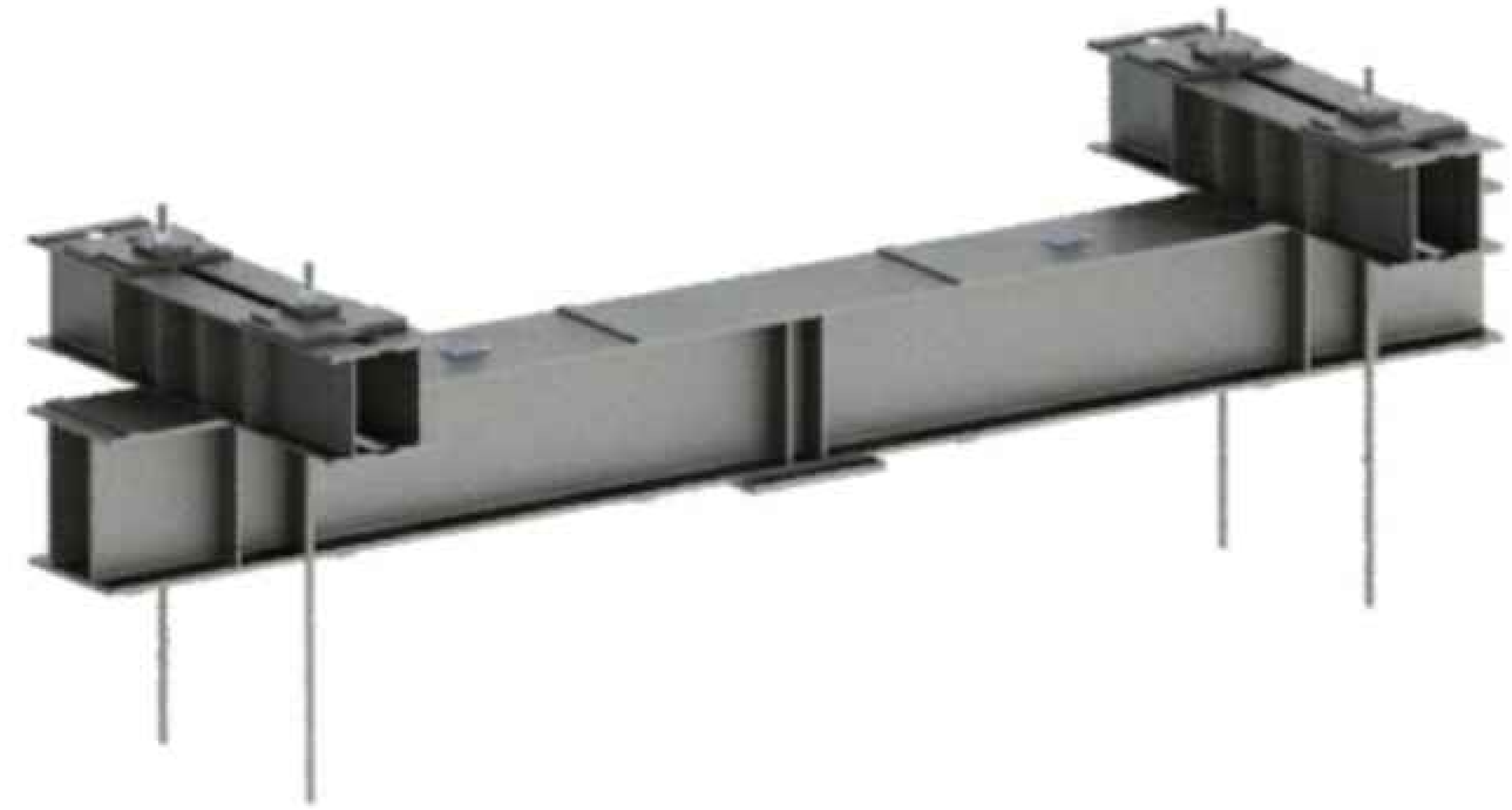

2/LT2 LOAD TEST BEAM ISOMETRIC VIEW (N.T.S.)

TABLE 1

Axial Pile Load Test 1 Increments

Load	Reading Intervals (Minutes)	Load, kN
AL	0	
12.5	0,5,10,20	450
25.0	0,5,10,20	900
37.5	0,5,10,20	1350
50.0	0,5,10,20	1800
62.5	0,5,10,20	2250
75.0	0,5,10,20	2700
87.5	0,5,10,20	3150
100.0	0,5,10,20,40,60,80,100	3600
100.0	120,180.......12h	3600
75.0	0,5,10,20,40,60	2700
50.0	0,5,10,20,40,60	1800
25.0	0,5,10,20,40,60	900
AL	0	
AL = Alignment Load		
DL = Design Load = 3600 kN		
Hold load until acceptance criterion for creep movement is satisfied as per ASTM D1143		

TABLE 2

Axial Pile Load Test 2 Increments

Load	Reading Intervals (Minutes)	Load, kN
AL	0	
25	0,5,10,20	900
50	0,5,10,20	1800
75	0,5,10,20	2700
100	0,5,10,20	3600
105	0,5,10,20	3780
110	0,5,10,20	3960
115	0,5,10,20,40,60,80	4140
115	100,120	4140
92.5	0,5,10,20	3330
70.0	0,5,10,20	2520
47.5	0,5,10,20	1710
25.0	0,5,10,20	900
AL	0	
AL = Alignment Load		
DL = Design Load = 4140 kN		
Hold load until acceptance criterion for creep movement is satisfied as per ASTM D1143		

NOTES:

1. LOADS SHOWN ON THE TABLE ARE AS MEASURED BY THE LOAD CELL.
2. LOADS MUST BE MAINTAINED THROUGHOUT EACH LOAD INCREMENT.
3. LOAD INCREMENTS MAY BE ADJUSTED BY SUBSTRUCTION ENGINEER DURING TESTING, AS REQUIRED.

No.	DESCRIPTION	Date
1.	ISSUED FOR REVIEW	19/09/17
	ISSUED FOR REVIEW	19/08/27

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LICENSED PROFESSIONAL ENGINEER — D. KONDRATENKO — 100120140 — 2019/SEP/17 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — 34891507 — T.H. O'ROURKE — 2019/SEP/17 — PROVINCE OF ONTARIO

Client

GFL GREEN FOR LIFE environmental

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Consultant

SUBSTRUCTION ENGINEERING
P.O. Box 699 Stouffville, ON L4A 7X7
Telephone (416) 937-6999, (416) 254-5759

Project

HIGHWAY 400/ESSA ROAD INTERCHANGE RECONSTRUCTION

BARRIE ONTARIO

Drawing Title

LOAD TEST ARRANGEMENT

Drawn:	JC	Scale	AS NOTED
Checked:	TOR	Date	9/17/2019 10:31:36 AM
Project No.	S1928-9	Drawing Number	LT2

Tuesday, September 17, 2019 10:31:36 AM

Photograph 1: Micropile Rods Prepared for Installation

Photograph 2: Casing Installation for Micropiles

Photograph 3: Grout Injection at Micropile MP-1A

Photograph 4: Anchor rods prepared for installation of Micropile MP-2A

Photograph 5: Micropile MP-1A

Photograph 6: Installation of Anchor Rod for Micropile MP-2A

Photograph 7: Test pile TP-1 and Micropiles MP-1A, MP-1B and MP-2A

Photograph 8: Test Pile TP-1 and Micropiles MP-1A, MP-1B at bottom left to right and Micropiles MP-2A and MP-2B at top left to right

Photograph 9: Silt Fence

Photograph 10: Pile Load Testing Site seen from Highway 400

Photograph 11: Reaction Frame Assembled

Photograph 12: Reaction Frame with Test Pile Cut to Below Existing Ground Surface

Photograph 13: Reaction Frame Setup with Tent

Photograph 14: Load Cell and Jack Setup

Photograph 15: Wire line Setup

APPENDIX F

Static Pile Load Test Results

Survey Monitoring of Micropiles
Static Pile Load Testing: Procedure A - Quick Test
December 10, 2019

	Movement (mm)			
Time	**MP-1A**	**MP-1B**	**MP-2A**	**MP-2B**
1115	0	0	10	5
1130	10	10	5	5
1145	0	0	0	0
1200	0	5	0	0
1215	0	0	0	0
1230	0	0	0	0
1245	0	0	0	0
1300	0	0	0	0
1315	0	0	0	0
1330	0	0	0	0
1345	0	0	0	0
1400	0	0	0	0
1415	0	0	0	0
1430	0	0	0	0
Total	10	15	15	10

Note: 1. Time is in 24-hour format

STATIC PILE LOAD TEST RECORD - PROCEDURE A - QUICK TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff	A.Poliacik / C.Comish
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL
Test Date:	December 10, 2019	Procedure :	A	Client:	Stantec / MTO

Target Load (kN): 3600
Max tolerable Mvmt : 10-15% of Pile Width (45 mm)
Max Rate of Mvmt: 0.0002 in per min . 0.004 mm per min

LOAD NO.	TIME			Target Load (kN)	GAUGE READING (KIP)	Actual Applied Load (kN)	PILE MOVEMENT										
							DIAL # 1		DIAL #2		DIAL #3		DIAL #4		Average Cumulative Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)		Reading (mm)	Cumulative Displacement (mm)
LOADING																	
1	0	0.0	11:05	180	34	150	6.045		17.297		59.487		10.719				
	1	0.0	11:06			145											
	2	0.0	11:07			145	6.020	0.025	17.297	0.000	59.487	0.000	10.744	-0.025	0.000		
	4	0.1	11:09		29	130	6.033	0.013	17.297	0.000	59.500	-0.013	10.744	-0.025	-0.006		
	8	0.1	11:13			127	6.045	0.000	17.272	0.025	59.500	-0.013	10.744	-0.025	-0.003		
	15	0.3	11:20		28	125	6.083	-0.038	17.285	0.013	59.512	-0.025	10.795	-0.076	-0.032	5.561	
2	0	0.3	11:20	360	65	290	5.144	0.902	16.408	0.889	58.115	1.372	11.875	-1.156	0.502		
	1	0.3	11:21			290											
	2	0.3	11:22			290	5.105	0.940	16.345	0.953	58.115	1.372	11.875	-1.156	0.527		
	4	0.3	11:24			290	5.080	0.965	16.332	0.965	58.115	1.372	11.877	-1.158	0.536		
	8	0.4	11:28			290	5.080	0.965	16.332	0.965	58.115	1.372	11.875	-1.156	0.537	5.560	1.000
	15	0.5	11:35			290	5.080	0.965	16.332	0.965	58.115	1.372	11.877	-1.158	0.536	5.559	2.000
3	0	0.5	11:35	540	106	471	3.480	2.565	14.859	2.438	56.210	3.277	9.779	0.940	2.305	5.558	3.000
	1	0.5	11:36			467	3.454	2.591	14.834	2.464	56.210	3.277	9.779	0.940	2.318		
	2	0.5	11:37			464	3.454	2.591	14.834	2.464	56.210	3.277	9.754	0.965	2.324		
	4	0.6	11:39			462	3.429	2.616	14.757	2.540	56.210	3.277	9.754	0.965	2.350	5.558	3.000
	8	0.6	11:43		100	443	3.404	2.642	14.757	2.540	56.210	3.277	9.754	0.965	2.356	5.558	3.000
	15	0.8	11:50		99	440	3.404	2.642	14.757	2.540	56.210	3.277	9.754	0.965	2.356		
4	0	0.8	11:50	720	139	620	1.727	4.318	13.259	4.039	54.356	5.131	5.156	5.563	4.763	5.557	4.000
	1	0.8	11:51		138	615	1.702	4.343	13.246	4.051	54.356	5.131	5.131	5.588	4.778		
	2	0.8	11:52			613	1.676	4.369	13.246	4.051	54.356	5.131	5.118	5.601	4.788	5.556	5.000
	4	0.8	11:54			611											
	8	0.9	11:58		137	607	1.676	4.369	13.208	4.089	54.356	5.131	5.118	5.601	4.797	5.556	5.000
	15	1.0	12:05		136	603	1.651	4.394	13.183	4.115	54.331	5.156	5.334	5.385	4.763	5.556	5.000
5	0	1.0	12:05	900	179	794	0.000	6.045	11.862	5.436	50.978	8.509	3.124	7.595	6.896	5.554	7.000
	1	1.0	12:06			782											
	2	1.0	12:07		173	770	-0.025	6.071	11.862	5.436	50.978	8.509	3.124	7.595	6.902	5.554	7.000
	4	1.1	12:09			765	-0.025	6.071	11.862	5.436	50.978	8.509	3.124	7.595	6.902	5.554	7.000
	8	1.1	12:13		171	760	-0.025	6.071	11.862	5.436	50.978	8.509	3.124	7.595	6.902		
	15	1.3	12:20		171	762	-0.025	6.071	11.849	5.448	50.978	8.509	3.124	7.595	6.906	5.554	7.000

STATIC PILE LOAD TEST RECORD - PROCEDURE A - QUICK TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff	A.Poliacik / C.Comish
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL
Test Date:	December 10, 2019	Procedure :	A	Client:	Stantec / MTO

Target Load (kN):	3600
Max tolerable Mvmt :	10-15% of Pile Width (45 mm)
Max Rate of Mvmt:	0.0002 in per min . 0.004 mm per min

LOAD NO.	TIME			Target Load (kN)	GAUGE READING (KIP)	Actual Applied Load (kN)	PILE MOVEMENT										
							DIAL # 1		DIAL #2		DIAL #3		DIAL #4		Average Cumulative Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)		Reading (mm)	Cumulative Displacement (mm)
6	0	1.3	12:20	1080	226	1005	-2.184	8.230	9.804	7.493	47.727	11.760	0.521	10.198	9.420	5.552	9.000
	1	1.3	12:21			997											
	2	1.3	12:22			989	-2.210	8.255	9.779	7.518	47.701	11.786	0.508	10.211	9.442	5.552	9.000
	4	1.3	12:24		219	973	-2.235	8.280	9.716	7.582	47.701	11.786	0.495	10.224	9.468	5.552	9.000
	8	1.4	12:28		218	968	-2.261	8.306	9.703	7.595	47.676	11.811	0.483	10.236	9.487	5.552	9.000
	15	1.5	12:35		217	964	-2.261	8.306	9.703	7.595	47.650	11.836	0.483	10.236	9.493	5.552	9.000
7	0	1.5	12:35	1260	272	1208	-4.470	10.516	7.696	9.601	45.288	14.199	-2.108	12.827	11.786	5.550	11.000
	1	1.5	12:36			1197											
	2	1.5	12:37		267	1186	-4.483	10.528	7.671	9.627	45.288	14.199	-2.108	12.827	11.795	5.550	11.000
	4	1.6	12:39		266	1181	-4.496	10.541	7.645	9.652	45.263	14.224	-2.134	12.852	11.817	5.550	11.000
	8	1.6	12:43		264	1176	-4.509	10.554	7.633	9.665	45.237	14.249	-2.134	12.852	11.830	5.550	11.000
	15	1.8	12:50		263	1169	-4.534	10.579	7.620	9.677	45.212	14.275	-2.146	12.865	11.849	5.550	11.000
8	0	1.8	12:50	1440	313	1391	-6.452	12.497	5.817	11.481	43.155	16.332	-4.343	15.062	13.843	5.548	13.000
	1	1.8	12:51			1383											
	2	1.8	12:52			1374	-6.502	12.548	5.791	11.506	43.129	16.358	-4.343	15.062	13.868	5.548	13.000
	4	1.8	12:54		305	1356	-6.502	12.548	5.766	11.532	42.875	16.612	-4.369	15.088	13.945	5.548	13.000
	8	1.9	12:58		303	1347	-6.528	12.573	5.740	11.557	43.078	16.408	-4.394	15.113	13.913		
	15	2.0	1:05		301	1339	-6.541	12.586	5.728	11.570	43.078	16.408	-4.394	15.113	13.919	5.548	13.000
9	0	2.0	1:05	1620	355	1578	-8.776	14.821	3.505	13.792	40.615	18.872	-6.883	17.602	16.272	5.546	15.000
	1	2.0	1:06			1570											
	2	2.0	1:07			1562	-8.814	14.859	3.480	13.818	40.589	18.898	-6.896	17.615	16.297		
	4	2.1	1:09		347	1545	-8.865	14.910	3.429	13.868	40.589	18.898	-6.909	17.628	16.326	5.546	15.000
	8	2.1	1:13		345	1534	-8.890	14.935	3.404	13.894	40.513	18.974	-6.947	17.666	16.367		
	15	2.3	1:20		344	1529	-8.890	14.935	3.366	13.932	40.513	18.974	-6.960	17.678	16.380	5.545	16.000
10	0	2.3	1:20	1800	402	1788	-11.455	17.501	0.838	16.459	37.770	21.717	-9.703	20.422	19.025	5.543	18.000
	1	2.3	1:21			1776											
	2	2.3	1:22			1764	-11.506	17.551	0.762	16.535	37.719	21.768	-9.728	20.447	19.075	5.543	18.000
	4	2.3	1:24		391	1740	-11.557	17.602	0.737	16.561	37.668	21.819	-9.779	20.498	19.120	5.543	18.000
	8	2.4	1:28		389	1729	-11.570	17.615	0.686	16.612	37.643	21.844	-9.817	20.536	19.152	5.543	18.000
	15	2.5	1:35		387	1722	-11.595	17.640	0.673	16.624	37.617	21.869	-9.817	20.536	19.167	5.543	18.000

STATIC PILE LOAD TEST RECORD - PROCEDURE A - QUICK TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff	A.Poliacik / C.Comish
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL
Test Date:	December 10, 2019	Procedure :	A	Client:	Stantec / MTO

Target Load (kN):	3600
Max tolerable Mvmt :	10-15% of Pile Width (45 mm)
Max Rate of Mvmt:	0.0002 in per min . 0.004 mm per min

LOAD NO.	TIME			Target Load (KN)	GAUGE READING (KIP)	Actual Applied Load (kN)	PILE MOVEMENT										
							DIAL # 1		DIAL #2		DIAL #3		DIAL #4		Average Cumulative Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)		Reading (mm)	Cumulative Displacement (mm)
11	0	2.5	1:35	1980	448	1993	-14.326	20.371	-2.057	19.355	34.696	24.790	-12.725	23.444	21.990	5.540	21.000
	1	2.5	1:36			1978	-14.376	20.422	-2.134	19.431	34.646	24.841	-12.776	23.495	22.047	5.540	21.000
	2	2.5	1:37			1962	-14.478	20.523	-2.210	19.507	34.620	24.867	-12.776	23.495	22.098		
	4	2.6	1:39		434	1932	-14.478	20.523	-2.210	19.507	34.595	24.892	-12.827	23.546	22.117	5.540	21.000
	8	2.6	1:43		432	1919	-14.529	20.574	-2.286	19.583	34.519	24.968	-12.903	23.622	22.187	5.540	21.000
	15	2.8	1:50		430	1912	-14.580	20.625	-2.311	19.609	34.468	25.019	-12.929	23.647	22.225	5.540	21.000
12	0	2.8	1:50	2160	496	2205	-17.983	24.028	-5.461	22.758	31.191	28.296	-16.307	27.026	25.527	5.536	25.000
	1	2.8	1:51			2200											
	2	2.8	1:52			2194	-17.882	23.927	-5.588	22.885	31.090	28.397	-16.332	27.051	25.565	5.536	25.000
	4	2.8	1:54			2183	-17.932	23.978	-5.639	22.936	31.064	28.423	-16.408	27.127	25.616		
	8	2.9	1:58			2161	-17.958	24.003	-5.664	22.962	31.013	28.473	-16.459	27.178	25.654	5.536	25.000
	15	3.0	2:05			2122	-18.085	24.130	-5.817	23.114	30.886	28.600	-16.510	27.229	25.768	5.536	25.000
	20	3.1	2:10		471	2094	-18.110	24.155	-5.817	23.114	30.886	28.600	-16.510	27.229	25.775		
13	0	3.1	2:10	2340	536	2383	-20.955	27.000	-8.700	25.997	27.991	31.496	-19.558	30.277	28.692	5.533	28.000
	1	3.1	2:11			2376											
	2	3.1	2:12			2368	-21.057	27.102	-8.738	26.035	27.940	31.547	-19.609	30.328	28.753	5.533	28.000
	4	3.2	2:14			2354	-21.107	27.153	-8.763	26.060	27.889	31.598	-19.685	30.404	28.804		
	8	3.2	2:18			2324	-21.133	27.178	-8.839	26.137	27.813	31.674	-19.710	30.429	28.854	5.533	28.000
	15	3.3	2:25		511	2273	-21.234	27.280	-8.915	26.213	27.711	31.775	-19.812	30.531	28.950	5.533	28.000
UNLOADING																	
1	0	3.3	3:00	1950	479	2129	42.469	27.076	54.737	26.060	27.889	31.598	43.942	30.277	28.753	5.534	27.000
	1	3.4	3:01			2129	42.469	27.076	54.737	26.060	27.889	31.598	43.942	30.277	28.753		
	2	3.4	3:02			2129	42.469	27.076	54.737	26.060	27.889	31.598	43.942	30.277	28.753		
	4	3.4	3:04			2129	42.469	27.076	54.762	26.035	27.889	31.598	43.955	30.264	28.743		
	8	3.5	3:08		479	2131	42.469	27.076	54.762	26.035	27.889	31.598	43.967	30.251	28.740	5.534	27.000
	15	3.6	3:15		479	2131	42.494	27.051	54.762	26.035	27.889	31.598	43.967	30.251	28.734		
2	0	3.6	3:15	1560	389	1730	43.790	25.756	55.829	24.968	28.981	30.505	47.777	26.441	26.918	5.535	26.000
	1	3.6	3:16			1733				80.797		59.487		74.219			
	2	3.6	3:17		390	1735	43.790	25.756	55.829	24.968	29.007	30.480	47.777	26.441	26.911		
	4	3.7	3:19			1736	43.790	25.756	55.855	24.943	29.007	30.480	47.803	26.416	26.899	5.535	26.000
	8	3.7	3:23			1737	43.790	25.756	55.867	24.930	29.020	30.467	47.828	26.391	26.886	5.535	26.000
	15	3.8	3:30		391	1739	43.790	25.756	55.880	24.917	29.032	30.455	47.866	26.353	26.870	5.535	26.000

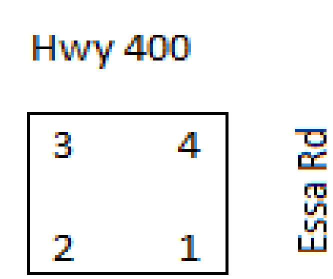
STATIC PILE LOAD TEST RECORD - PROCEDURE A - QUICK TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff	A.Poliacik / C.Comish	Target Load (kN):	3600
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL	Max tolerable Mvmt :	10-15% of Pile Width (45 mm)
Test Date:	December 10, 2019	Procedure :	A	Client:	Stantec / MTO	Max Rate of Mvmt:	0.0002 in per min . 0.004 mm per min

LOAD NO.	TIME			Target Load (KN)	GAUGE READING (KIP)	Actual Applied Load (kN)	PILE MOVEMENT										
							DIAL # 1		DIAL #2		DIAL #3		DIAL #4		Average Cumulative Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)	Reading (mm)	Cumulative Displacement (mm)		Reading (mm)	Cumulative Displacement (mm)
3	0	3.8	3:30	1170	289	1286	46.507	23.038	58.344	22.454	31.674	27.813	50.673	23.546	24.213	5.537	24.000
	1	3.9	3:31			1287		69.545		80.797		59.487		74.219			
	2	3.9	3:32			1288		69.545		80.797		59.487		74.219			
	4	3.9	3:34			1288	46.507	23.038	58.445	22.352	31.699	27.788	50.749	23.470	24.162	5.537	24.000
	8	4.0	3:38		291	1294	46.507	23.038	58.801	21.996	31.687	27.800	50.749	23.470	24.076		
	15	4.1	3:45		291	1294	46.507	23.038	58.471	22.327	31.699	27.788	50.749	23.470	24.155	5.537	24.000
4	0	4.1	3:45	780	194	863	50.394	19.152	61.976	18.821	35.585	23.901	54.813	19.406	20.320	5.541	20.000
	1	4.1	3:46			867	50.419	19.126	62.001	18.796	35.585	23.901	54.889	19.329	20.288		
	2	4.1	3:47			872	50.419	19.126	62.128	18.669	35.598	23.889	54.889	19.329	20.253	5.541	20.000
	4	4.2	3:49		198	881	50.419	19.126	62.128	18.669	35.598	23.889	54.889	19.329	20.253	5.541	20.000
	8	4.2	3:53		198	881	50.419	19.126	62.128	18.669	35.598	23.889	54.902	19.317	20.250	5.541	20.000
	15	4.3	4:00		199	883	50.444	19.101	62.154	18.644	35.611	23.876	54.915	19.304	20.231	5.541	20.000
5	0	4.3	4:00	390	96	425	55.194	14.351	66.612	14.186	40.665	18.821	60.325	13.894	15.313	5.546	15.000
	1	4.4	4:01			426	55.207	14.338	66.650	14.148	40.665	18.821	60.325	13.894	15.300		
	2	4.4	4:02			427	55.207	14.338	66.650	14.148	40.665	18.821	60.325	13.894	15.300		
	4	4.4	4:04			430	55.220	14.326	66.662	14.135	40.665	18.821	60.338	13.881	15.291	5.546	15.000
	8	4.5	4:08			434	55.245	14.300	66.662	14.135	40.691	18.796	60.350	13.868	15.275	5.546	15.000
	15	4.6	4:15		99	441	55.245	14.300	66.675	14.122	40.691	18.796	60.376	13.843	15.265	5.546	15.000
6	0	4.6	4:15	0	0	0	60.401	9.144	71.730	9.068	46.584	12.903	64.440	9.779	10.224	5.551	10.000
	1	4.6	4:16			0	60.797	8.748	71.907	8.890	46.685	12.802	64.668	9.550	9.997	5.551	10.000
	2	4.6	4:17			0	60.884	8.661	71.933	8.865	46.736	12.751	64.694	9.525	9.950	5.551	10.000
	4	4.7	4:19			0	60.935	8.611	71.958	8.839	46.787	12.700	64.770	9.449	9.900		
	8	4.7	4:23		0	0	60.985	8.560	71.984	8.814	46.838	12.649	64.834	9.385	9.852	5.551	10.000
	15	4.8	4:30			0	61.138	8.407	72.034	8.763	46.888	12.598	64.897	9.322	9.773		

DIAL GAUGE SETUP:

Dial Gauge #1	ACPG35
Dial Gauge #2	ACPG26
Dial Gauge #3	25-3041
Dial Gauge #4	KXB634



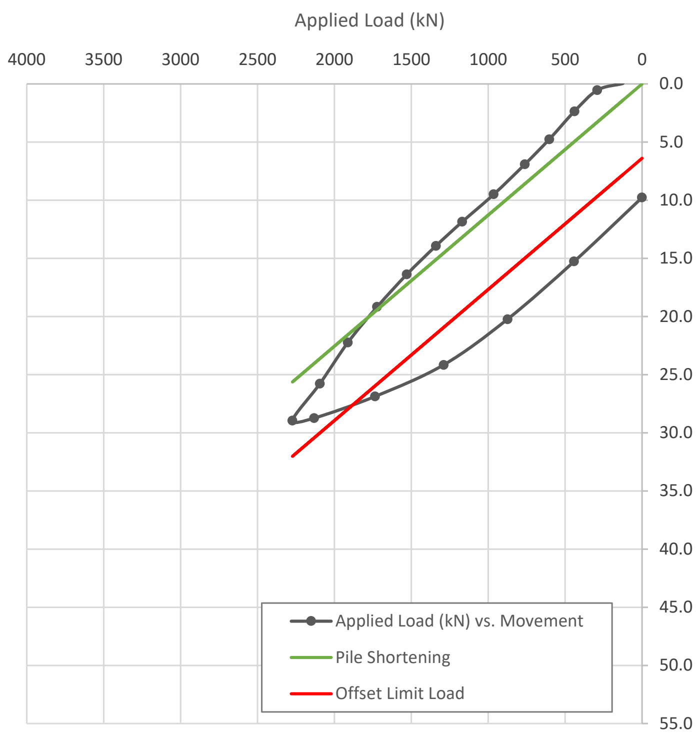
Dial Gauge Locations

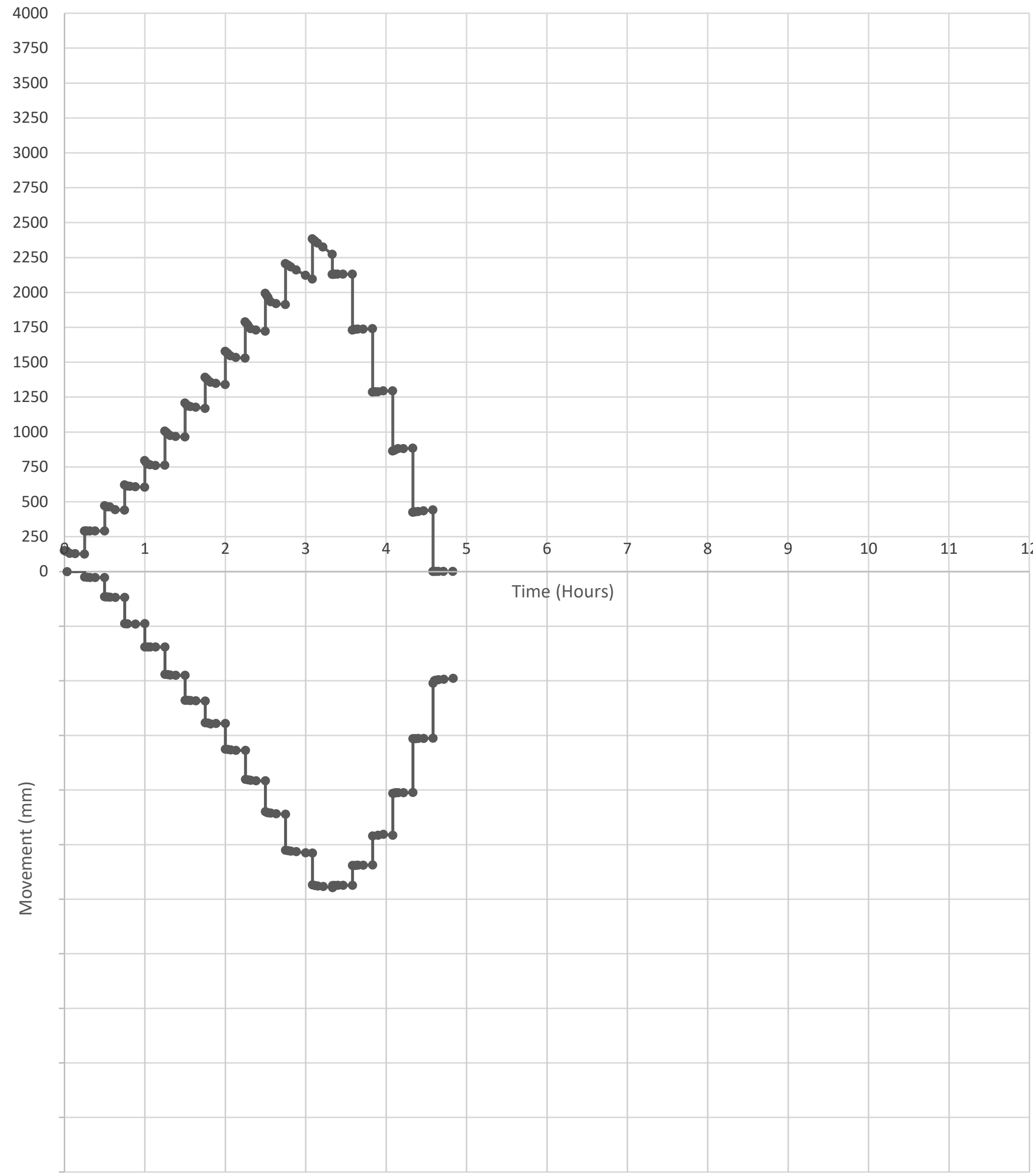
STATIC PILE LOAD TEST RESULTS - PROCEDURE A - QUICK TEST

FIGURE F-1

PILE No.	PLT-1	DATE DRIVEN	04-Nov-19
PILE TYPE	310 mm x 110 mm		
SHOE DETAILS	NA		
FINAL LENGTH DRIVEN	31.8 m		
LENGTH AFTER CUT-OFF	31.7 m		
EMBEDDED LENGTH	31.5 m		
CUT-OFF ELEVATION	249.1 m		
TIP ELEVATION	215.9 m		

LOAD TEST REULTS	
TEST No.	1
DATE	10-Dec-19
MAX LOAD APPLIED (kN)	2380
ESTIMATED FAILURE (kN) (Davisson Method)	2600
ESTIMATED FAILURE (kN) (10% of Pile Diameter)	2300





Survey Monitoring of Micropiles
Static Pile Load Testing: Procedure B - Maintained Test
January 12 and 13, 2020

	Movement (mm)			
Time	**MP-1A**	**MP-1B**	**MP-2A**	**MP-2B**
1426	0	0	0	0
1440	0	0	0	0
1450	0	0	0	0
1500	0	0	0	0
1512	0	0	0	0
1522	0	0	0	0
1532	0	0	0	0
1542	0	0	0	0
1552	0	0	0	0
1602	0	0	0	0
1612	0	0	0	0
1624	0	0	0	0
1636	0	0	0	0
1648	0	0	0	0
1710	0	0	0	0
1740	0	0	0	0
1802	0	0	0	0
1835	0	0	0	0
1901	0	0	0	0
1945	0	0	0	0
2130	20	0	0	10
2210	0	10	0	0
2300	0	0	0	0
2330	0	0	0	0
2338	FAILED	FAILED	FAILED	FAILED
Total*	20	10	0	10

*Prior to failure

Note: 1. Time is in 24-hour format

STATIC PILE LOAD TEST RECORD - PROCEDURE B - MAINTAINED TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff:	A.Poliacik / C.Comish
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL
Test Date:	January 13 and 14, 2020	Procedure :	B	Client:	Stantec / MTO

Target Load (kN):	3600
Max tolerable Mvmt :	10-15% of Pile Width (45 mm)
Max Rate of Mvmt:	0.0002 in per min . 0.004 mm per min

#SPILL!	TIME			Target Load (KN)	GAUGE READING (Digits)	Actual Applied Load (kN)	PILE MOVEMENT															
							DIAL # 1			DIAL #2			DIAL #3			DIAL #4			Average Cumulative Displacement (mm)	Average Rate of Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)			READING (m)	Cumulative Displacement (mm)
LOADING																						
AL	0	0.00		0	850	64	80.670			88.824			55.347			93.345					0.557	
1	0	0.00	14:16	450	1355	450	77.521	3.150	-	85.928	2.896	-	52.527	2.819	-	90.195	3.150		3.004		0.554	0.030
	5	0.08	14:21		1356	451	77.343	3.327	-0.036	85.801	3.023	-0.025	52.375	2.972	-0.030	90.018	3.327	-0.036	3.162	-0.032	0.554	0.030
	10	0.17	14:26		1351	447	77.241	3.429	-0.020	85.750	3.073	-0.010	52.299	3.048	-0.015	89.916	3.429	-0.020	3.245	-0.017	0.554	0.030
	20	0.33	14:36		1355	450	77.216	3.454	-0.003	85.649	3.175	-0.010	52.273	3.073	-0.003	89.891	3.454	-0.003	3.289	-0.004	0.554	0.030
	40	0.67	14:56		1352	448	77.140	3.531	-0.004	85.573	3.251	-0.004	52.248	3.099	-0.001	89.814	3.531	-0.004	3.353	-0.003	0.553	0.040
	60	1.00	15:16		1354	450	77.140	3.531	0.000	85.573	3.251	0.000	52.222	3.124	-0.001	89.814	3.531	0.000	3.359	0.000	0.553	0.040
2	0	1.00	15:18	900	1953	901	72.542	8.128		81.432	7.391		48.031	7.315		85.217	8.128	0.077	7.741	0.077	0.549	0.080
	5	1.08	15:23		1952	901	72.441	8.230	-0.020	81.407	7.417	-0.005	47.955	7.391	-0.015	85.115	8.230	-0.020	7.817	-0.015	0.549	0.080
	10	1.17	15:28		1950	899	72.390	8.280	-0.010	81.382	7.442	-0.005	47.879	7.468	-0.015	85.065	8.280	-0.010	7.868	-0.010	0.548	0.090
	20	1.33	15:38		1949	899	72.365	8.306	-0.003	81.331	7.493	-0.005	47.879	7.468	0.000	85.014	8.331	-0.005	7.899	-0.003	0.548	0.090
3	0	1.33	15:42	1350	2553	1347	67.920	12.751		77.572	11.252		44.348	10.998		80.823	12.522		11.881		0.545	0.120
	5	1.42	15:47		2550	1345	67.767	12.903	-0.030	77.521	11.303	-0.010	44.272	11.074	-0.015	80.670	12.675	-0.030	11.989	-0.022	0.544	0.130
	10	1.50	15:52		2549	1344	67.691	12.979	-0.015	77.470	11.354	-0.010	44.221	11.125	-0.010	80.594	12.751	-0.015	12.052	-0.013	0.544	0.130
	20	1.67	16:02		2552	1346	67.615	13.056	-0.008	77.419	11.405	-0.005	44.196	11.151	-0.003	80.518	12.827	-0.008	12.109	-0.006	0.544	0.130
	40	2.00	16:22		2554	1348	67.564	13.106	-0.003	77.495	11.328		44.196	11.151	0.000	80.467	12.878	-0.003	12.116	-0.002	0.544	0.130
4	0	2.00	16:29	1800	3163	1793	63.424	17.247		73.914	14.910		40.919	14.427		76.708	16.637		15.805		0.539	0.180
	5	2.08	16:34		3170	1798	63.195	17.475	-0.046	73.711	15.113	-0.041	40.742	14.605	-0.036	76.429	16.916	-0.056	16.027	-0.044	0.539	0.180
	10	2.17	16:39		3174	1801	63.043	17.628	-0.030	73.609	15.215	-0.020	40.640	14.707	-0.020	76.302	17.043	-0.025	16.148	-0.024	0.539	0.180
	20	2.33	16:49		3173	1800	62.941	17.729	-0.010	73.520	15.304	-0.009	40.538	14.808	-0.010	76.200	17.145	-0.010	16.246	-0.010	0.539	0.180
	40	2.67	17:09		3173	1800	62.814	17.856	-0.006	73.381	15.443	-0.007	40.462	14.884	-0.004	76.073	17.272	-0.006	16.364	-0.006	0.539	0.180
	60	3.00	17:29		3173	1800	62.814	17.856	0.000	73.330	15.494	-0.003	40.437	14.910	-0.001	75.895	17.450		16.427	-0.001	0.539	0.180
5	0	3.00	17:35	2250	3797	2249	58.039	22.631		69.469	19.355		37.186	18.161		71.984	21.361		20.377		0.538	0.190
	5	3.08	17:40		3800	2251	57.658	23.012	-0.076	69.393	19.431	-0.015	36.932	18.415	-0.051	71.628	21.717	-0.071	20.644	-0.053	0.538	0.190
	10	3.17	17:45		3793	2246	57.556	23.114	-0.020	69.063	19.761	-0.066	36.830	18.517	-0.020	71.552	21.793	-0.015	20.796	-0.030	0.538	0.190
	20	3.33	17:55		3797	2249	57.353	23.317	-0.020	68.872	19.952	-0.019	36.678	18.669	-0.015	71.374	21.971	-0.018	20.977	-0.018	0.538	0.190
	40	3.67	18:15		3796	2248	57.201	23.470	-0.008	68.707	20.117	-0.008	36.525	18.821	-0.008	71.247	22.098	-0.006	21.126	-0.007	0.538	0.190
	60	4.00	18:35		3797	2249	57.074	23.597	-0.006	68.580	20.244	-0.006	36.424	18.923	-0.005	71.120	22.225	-0.006	21.247	-0.006	0.538	0.190
	80	4.33	18:55		3799	2250	57.010	23.660	-0.003	68.478	20.345	-0.005	36.347	18.999	-0.004	71.069	22.276	-0.003	21.320	-0.004	0.538	0.190

STATIC PILE LOAD TEST RECORD - PROCEDURE B - MAINTAINED TEST

Project:	Highway 400 and Essa	Pile Type/Size:	HP310x110	Golder Staff:	A.Poliacik / C.Comish
Project No.:	18105050	Pile embedment / Stickup (m):	31.8 / -0.1	Contractor:	GFL
Test Date:	January 13 and 14, 2020	Procedure :	B	Client:	Stantec / MTO

Target Load (kN):	3600
Max tolerable Mvmt :	10-15% of Pile Width (45 mm)
Max Rate of Mvmt:	0.0002 in per min . 0.004 mm per min

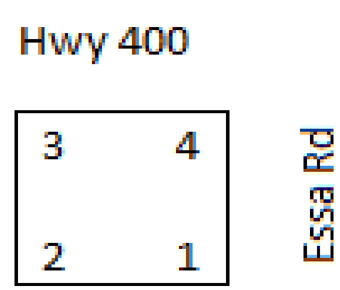
#SPILL!	TIME			Target Load (KN)	GAUGE READING (Digits)	Actual Applied Load (kN)	PILE MOVEMENT																	
							DIAL # 1			DIAL #2			DIAL #3			DIAL #4			Average Cumulative Displacement (mm)	Average Rate of Displacement (mm)	WIRE LINE	
	START	Cumulative Time (hrs)	TIME				Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)	Reading (mm)	Cumulative Displacement (mm)	Rate of Displacement (per min, per interval)			READING (m)	Cumulative Displacement (mm)
6	0	4.33	19:01	2700	4436	2700	50.368	30.302		62.941	25.883		31.648	23.698		65.151	28.194		27.019		0.526	0.310
	5	4.42	19:06		4430	2696	49.860	30.810	-0.102	62.535	26.289	-0.081	31.242	24.105	-0.081	64.745	28.600	-0.081	27.451	-0.086	0.526	0.310
	10	4.50	19:11		4437	2701	49.530	31.140	-0.066	62.281	26.543	-0.051	31.039	24.308	-0.041	64.465	28.880	-0.056	27.718	-0.053	0.525	0.320
	20	4.67	19:21		4434	2699	48.971	31.699	-0.056	61.773	27.051	-0.051	30.556	24.790	-0.048	63.932	29.413	-0.053	28.238	-0.052	0.524	0.330
	40	5.00	19:41		4432	2698	48.463	32.207	-0.025	61.341	27.483	-0.022	30.099	25.248	-0.023	63.449	29.896	-0.024	28.708	-0.023	0.524	0.330
	60	5.33	20:01		4433	2698	48.158	32.512	-0.015	61.062	27.762	-0.014	29.845	25.502	-0.013	63.195	30.150	-0.013	28.981	-0.014	0.524	0.330
	80	5.67	20:21		4437	2701	47.981	32.690	-0.009	60.909	27.915	-0.008	29.718	25.629	-0.006	63.030	30.315	-0.008	29.137	-0.008	0.523	0.340
	100	6.00	20:41		4433	2698	47.854	32.817	-0.006	60.782	28.042	-0.006	29.616	25.730	-0.005	62.916	30.429	-0.006	29.254	-0.006	0.523	0.340
	120	6.33	21:01		4436	2700	47.752	32.918	-0.005	60.681	28.143	-0.005	29.515	25.832	-0.005	62.840	30.505	-0.004	29.350	-0.005	0.523	0.340
7	0	6.33	21:12	3150	5084	3150	38.760	41.910		54.305	34.519		23.876	31.471		54.661	38.684		36.646		0.512	0.450
	5	6.42	21:17		5085	3151	37.490	43.180	-0.254	53.162	35.662	-0.229	23.114	32.233	-0.152	53.569	39.776	-0.218	37.713	-0.213	0.512	0.450
	10	6.50	21:22		5085	3151	36.982	43.688	-0.102	52.807	36.017	-0.071	22.758	32.588	-0.071	53.086	40.259	-0.097	38.138	-0.085	0.511	0.460
	20	6.67	21:34		5084	3150	36.246	44.425	-0.074	52.299	36.525	-0.051	22.327	33.020	-0.043	52.476	40.869	-0.061	38.710	-0.057	0.511	0.460
	40	7.00	21:52		5084	3150	35.636	45.034	-0.030	51.892	36.932	-0.020	21.996	33.350	-0.017	51.968	41.377	-0.025	39.173	-0.023	0.510	0.470
	60	7.33	22:12		5083	3150	35.255	45.415	-0.019	51.587	37.236	-0.015	21.742	33.604	-0.013	51.587	41.758	-0.019	39.503	-0.017	0.510	0.470
	80	7.67	22:32		5082	3149	34.976	45.695	-0.014	51.435	37.389	-0.008	21.615	33.731	-0.006	51.384	41.961	-0.010	39.694	-0.010	0.510	0.470
	100	8.00	22:53		5084	3150	34.798	45.872	-0.009	51.257	37.567	-0.009	21.463	33.884	-0.008	51.232	42.113	-0.008	39.859	-0.008	0.509	0.480
	120	8.33	23:14		5085	3151	34.595	46.076	-0.010	51.562	37.262	0.015	21.361	33.985	-0.005	51.054	42.291	-0.009	39.903	-0.002	0.509	0.480
	140	8.67	23:32		5058	3132	34.493	46.177	-0.005	51.562	37.262	0.000	21.336	34.011	-0.001	50.952	42.393	-0.005	39.961	-0.003	0.509	0.480
8	0	8.67	23:38	3600	NA	3500	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

1. Reaction Frame Failed at Time 23:38

DIAL GAUGE SETUP:

Dial Gauge #1	ACPG26
Dial Gauge #2	ACPG26
Dial Gauge #3	25-3041
Dial Gauge #4	ACPG45

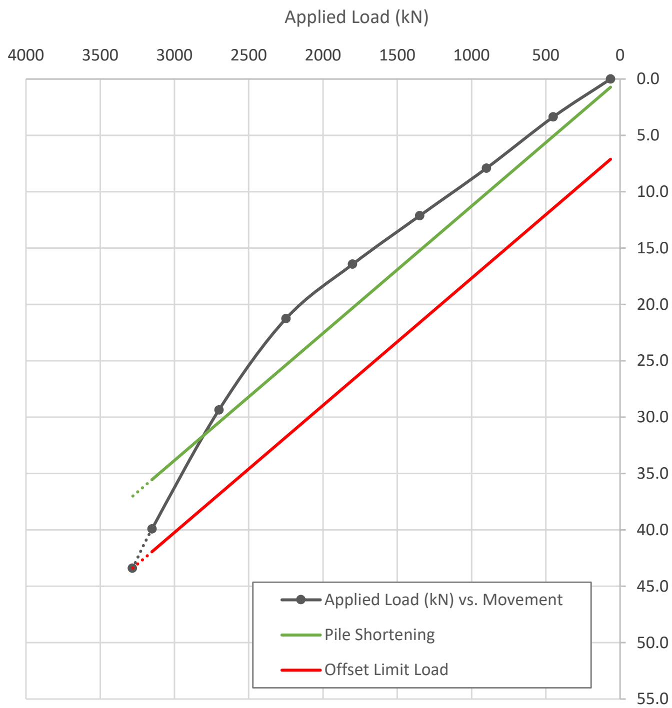


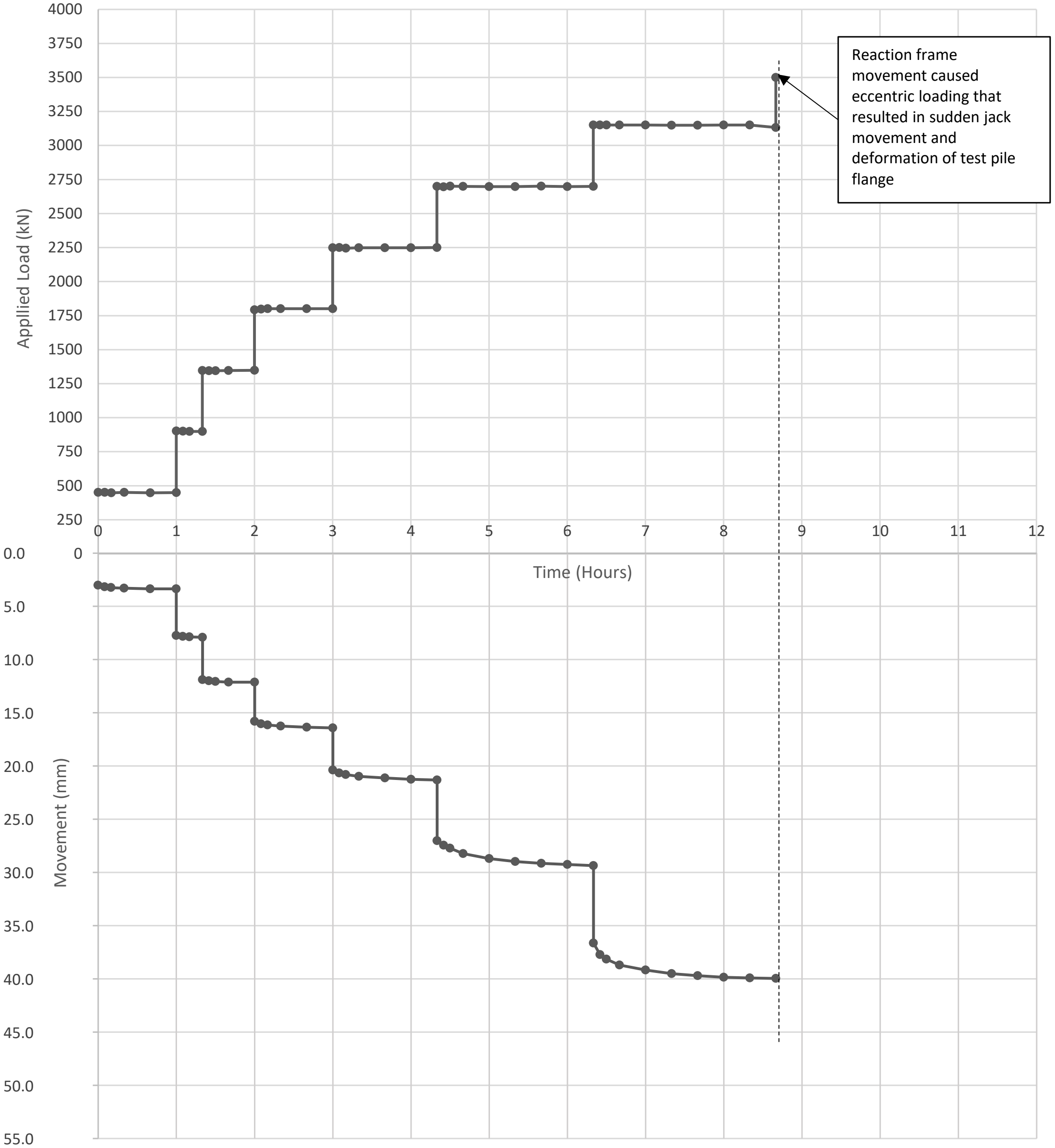
Dial Gauge Locations

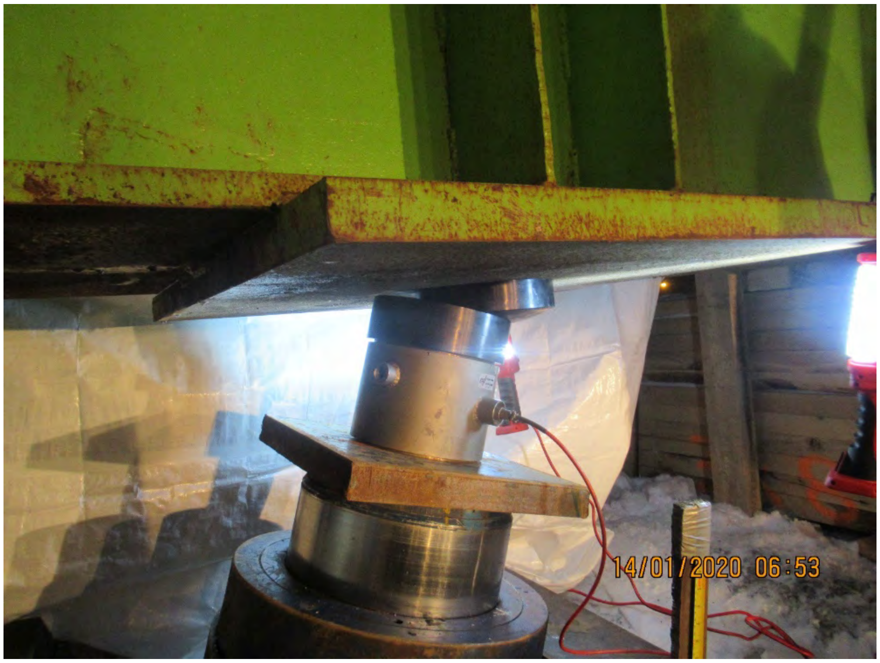
FIGURE F-2: STATIC PILE LOAD TEST RESULTS - PROCEDURE B - MAINTAINED TEST

PILE No.	PLT-1	DATE DRIVEN	04-Nov-19
PILE TYPE	310 mm x 110 mm		
SHOE DETAILS	NA		
FINAL LENGTH DRIVEN	31.8 m		
LENGTH AFTER CUT-OFF	31.7 m		
EMBEDDED LENGTH	31.5 m		
CUT-OFF ELEVATION	249.1 m		
TIP ELEVATION	215.9 m		

LOAD TEST REULTS	
TEST No.	2
DATE	13-Jan-20
MAX LOAD APPLIED (kN)	3150
ESTIMATED FAILURE (kN) (Davisson Method)	3150
ESTIMATED FAILURE (kN) (10% of Pile Diameter)	2750







Photograph 1: Load Cell and Jack upon Failure during Procedure B Static Pile Load Test

Photograph 2: Test Pile upon Failure during Procedure B Static Pile Load Test

Photograph 3: Reaction pile lateral movement (south side).

Photograph 4: Reaction pile lateral movement (north side)

Photograph 5: Load cell and jack taken down until assessment of frame complete.

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