Piling Industry Canada

PIC magazine

www.pilingindustrycanada.com

ISSUE 2 • 2023

Liebherr drilling rig put to the test

Structural aspects of the stabilization of Ten Mile Slide

JJA trades diesel hammer for Junttan Piling rig on Navy Yard Project

PUBLICATIONS MAIL AGREEMENT #40934510

H-Piles, Steel Sheet Piles*, Pipe Piles, and Structural Sections with **boron content of less than 0.0008%**

* Please contact your local Nucor Skyline sales office for additional information.

STEEL FOUNDATION SOLUTIONS

- The only supplier to offer the entire range of steel foundation and geostructural products
- Manufacturing, coating, fabrication, and engineering expertise
- As a part of the Nucor family, our ability to service our customers and the industry as a whole is unparalleled

nucorskyline.com

NUCOR®
SKYLINE

Piling Industry Canada
PIC
magazine

In this issue

Published by
DEL Communications Inc.
Suite 300, 6 Roslyn Road
Winnipeg, MB, Canada R3L 0G5
www.delcommunications.com

President & CEO: ***David Langstaff***

Managing Editor: ***Lyndon McLean***
lyndon@delcommunications.com

Sales Manager: ***Dayna Oulion***

Advertising Account Executives:
Jennifer Hebert | ***Michelle Raike***

Production services provided by:
S.G. Bennett Marketing Services

Creative Director / Design: ***Kathleen Cable***

Publications mail agreement #40934510
Return undeliverable
Canadian addresses to:
DEL Communications Inc.
Suite 300, 6 Roslyn Road
Winnipeg, Manitoba
Canada R3L 0G5
Email: david@delcommunications.com

PRINTED IN CANADA | 12/2023

DEL Communications Inc.

ECA Canada announces acquisition of Ridgeline Equipment Ltd.

ECA Canada announced in July the acquisition of Ridgeline Equipment, a premier aftermarket heavy equipment parts and service provider based out of Calgary, AB. This strategic move strengthens ECA Canada's position as an industry leader in Western Canada, expanding its aftermarket service and parts offerings to better serve the foundation, construction, oil & gas, and drilling sectors.

With expertise in engines, transmissions, torque converters, final drives, and hydraulic cylinders, Ridgeline specializes in delivering top-notch field service solutions. Their technicians are highly qualified, with over 100 years of experience and qualifications ranging from third-year apprentices to Red Seal Journeyman licensed mechanics.

With this acquisition, ECA Canada gains access to Ridgeline's extensive experience, fleet of equipment, and wide-reaching network, solidifying its position as the most comprehensive support system for field service throughout Canada. By combining their strengths, ECA Canada and Ridgeline Equipment can offer a unique and unparalleled service to Canadian businesses operating in the foundation, piling, and heavy construction equipment industries.

"We are delighted to welcome Ridgeline Equipment into the ECA family," said Roy Kern, President and CEO. "Their exceptional expertise in aftermarket heavy equipment service and parts perfectly complements our existing capabilities. Together, we will be able to provide our customers with an even broader range of solutions, ensuring their equipment operates at peak performance levels."

This acquisition aligns with ECA's commitment to continuously enhance its offerings and provide innovative solutions to the industry. By leveraging Ridgeline's market presence and their highly skilled workforce, ECA Canada is poised to expand its footprint in the foundation drilling and piling market and serve customers with unparalleled dedication and expertise.

ECA has been a leading supplier of foundation construction equipment for more than a century. We are the exclusive distributor for BAUER Drilling Rigs, KLEMM Anchor and Micropile Drilling Rigs, RTG Piling Rigs, and BAUER MAT Slurry Handling Systems. We also distribute HPSI Vibratory Pile Hammers, WORD International Drill Attachments, Pileco Diesel Hammers, Dawson Construction Products, ALLU Ground Improvement Equipment, Pile Master Air Hammers, DIGGA auger drives, and Olin Concrete Pumps. ECA offers sales, rentals, service, parts, and training from 11 facilities throughout the Eastern U.S. and all Canadian Provinces.

Ridgeline Equipment has established itself as a trusted partner, offering industry-leading aftermarket service and parts support for various construction equipment. Ridgeline Equipment specializes in field service, preventative maintenance, emergency on-call service, and remanufacturing and rebuilding programs for all types of heavy equipment. For more information, visit www.ridgelineequipment.ca. ●

New $100-million contract for semi-submersible rig Hercules

SFL Corporation Ltd. announced in August that it has signed a drilling contract in Canada with a subsidiary of Equinor ASA for the harsh environment semi-submersible rig Hercules. The estimated contract value is approximately $100 million.

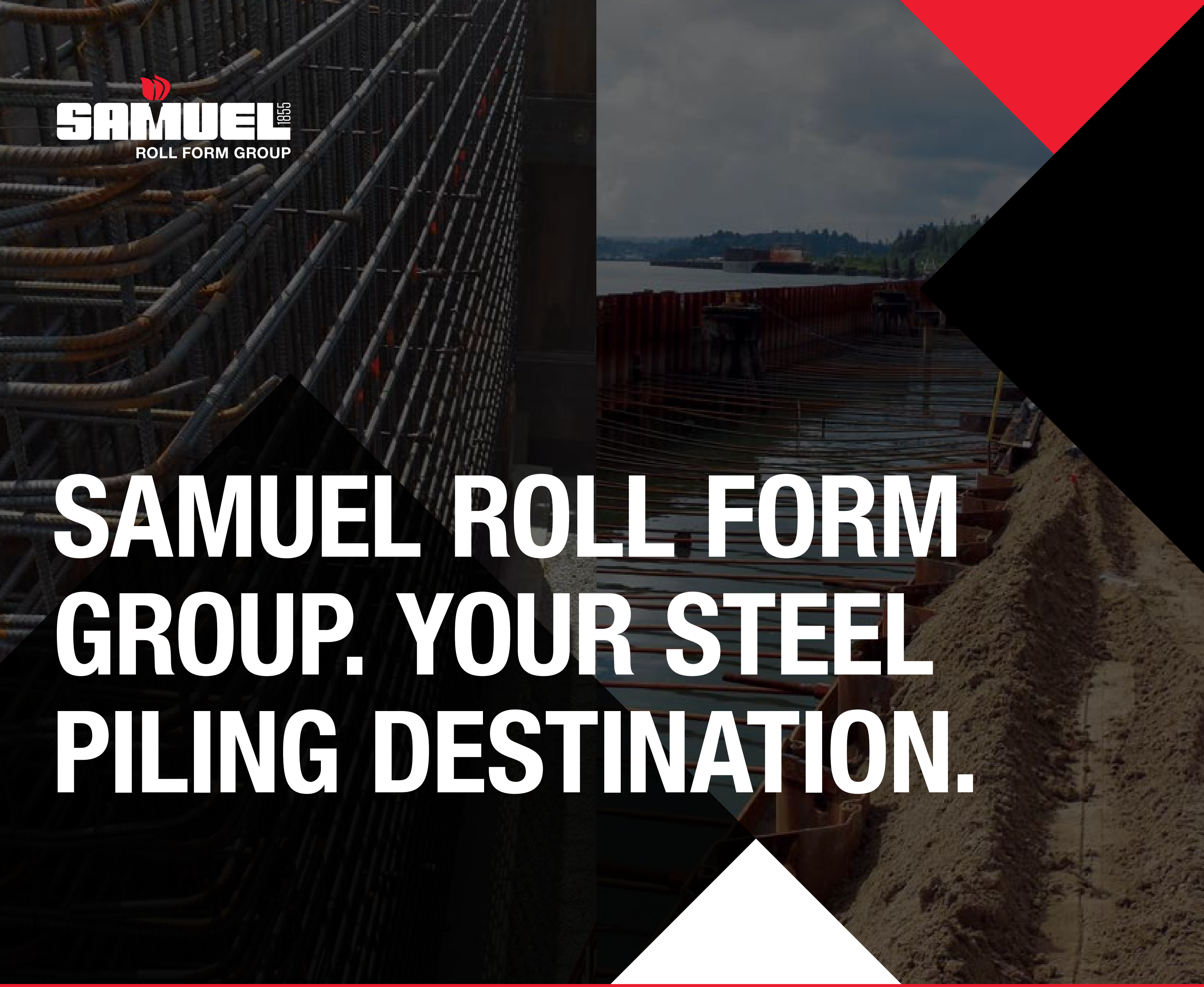
The contract is for one well plus one optional well, and it's expected to commence in the second quarter of 2024. The duration for the firm contract period is approximately 200 days including transit to and from Canada. Odfjell Drilling will manage the rig on behalf of SFL under the contract.

Hercules is currently drilling for ExxonMobil in Canada before it will transit to Namibia for a contract with Galp Energia expected to commence in the fourth quarter of 2023.

"We are pleased to sign the third contract for the Hercules since we took redelivery of the rig at the end of 2022 with yet another blue-chip operator," said Ole B. Hjertaker, CEO of SFL Management AS. "With this contract, SFL has now approximately $200 million of revenue backlog on Hercules and secured undisrupted employment for the rig until the fourth quarter of 2024. This contract together with other recent contract rewards in the industry illustrates that the market for advanced harsh environment semi submersibles is firming and expected to remain strong for a prolonged period."

About SFL

SFL has a unique track record in the maritime industry and has paid dividends every quarter since its initial listing on the New York Stock Exchange in 2004. The company's fleet of vessels is comprised of container vessels, car carriers, tanker vessels, bulkers, and offshore drilling rigs. SFL's long-term distribution capacity is supported by a portfolio of long-term charters and significant growth in the asset base over time. More information can be found at www.sflcorp.com. ●



SAMUEL 1855
ROLL FORM GROUP

SAMUEL ROLL FORM GROUP. YOUR STEEL PILING DESTINATION.

For over 45 years, Samuel Roll Form Group has been supplying quality cold formed and hot rolled sheet piling, H-piling, pipe piling, and piling accessories to the heavy construction industry across North America.

We are well versed in delivering end-to-end solutions and meeting our customers' needs with our wide range of roll forming and fabrication services, advanced engineering support and custom roll forming capabilities.

- **MARINE DEVELOPMENTS**
- **SLOPE STABILIZATION**
- **ENVIRONMENTAL REMEDIATION PROJECTS**
- **DEEP FOUNDATION**
- **BRIDGES AND TUNNELS**
- **AND OTHER CIVIL ENGINEERING APPLICATIONS**

Connect with our team.

800-233-6228
rollformgroup@samuel.com

www.rollformgroup.com

Project YEG2
Acheson, Alberta, Canada

To meet the client's fast-tracked schedule, Keller uses design expertise and vast resources to complete the foundations for a new warehouse.

The project

A 2.9M SF (270 square metre) warehouse was built in Acheson for a popular retailer. The five-story tall building includes a mezzanine level and office spaces. Due to the high load-bearing capacities required from the soils, a deep foundations solution was necessary.

The challenge

The owner had a fast-tracked schedule, requiring the entire project to be constructed in 16 months. Close coordination between all parties was required, with multiple trades working concurrently on site and limited access/egress.

The solution

Due to the strict timeline, Keller was awarded the project based on their close working relationship with the general contractor. With their expertise in the area and deep foundations techniques, Keller provided a design-build CFA pile solution to meet the required bearing capacities that was accepted by the project team.

Using CFA piles instead of other foundation techniques allowed for a faster installation that eliminated the need for temporary casing, resulting in significant cost savings for the owner.

To meet the project deadlines, Keller employed four rigs and four crews to install 2,017 CFA piles up to 96.8 feet (29.5 metres) deep. Foundation work was completed ahead of schedule with zero lost time incidents.

Project facts

- Owner(s): Highlands Business Park GP Inc.
- Keller business unit(s): Keller
- Main contractor(s): Ledcor Construction Ltd.
- Engineer(s): Tetra Tech Canada; Keller
- Solutions: Deep foundations
- Markets : Commercial
- Techniques : CFA (auger cast) piles. ●


Knock, knock.
Who’s there?
The hammer!
Knocks on steel pipes, beams or sheet piles.
www.liebherr.com
LIEBHERR
Deep foundation Hammer H 6

Structural aspects of the stabilization of Ten Mile Slide

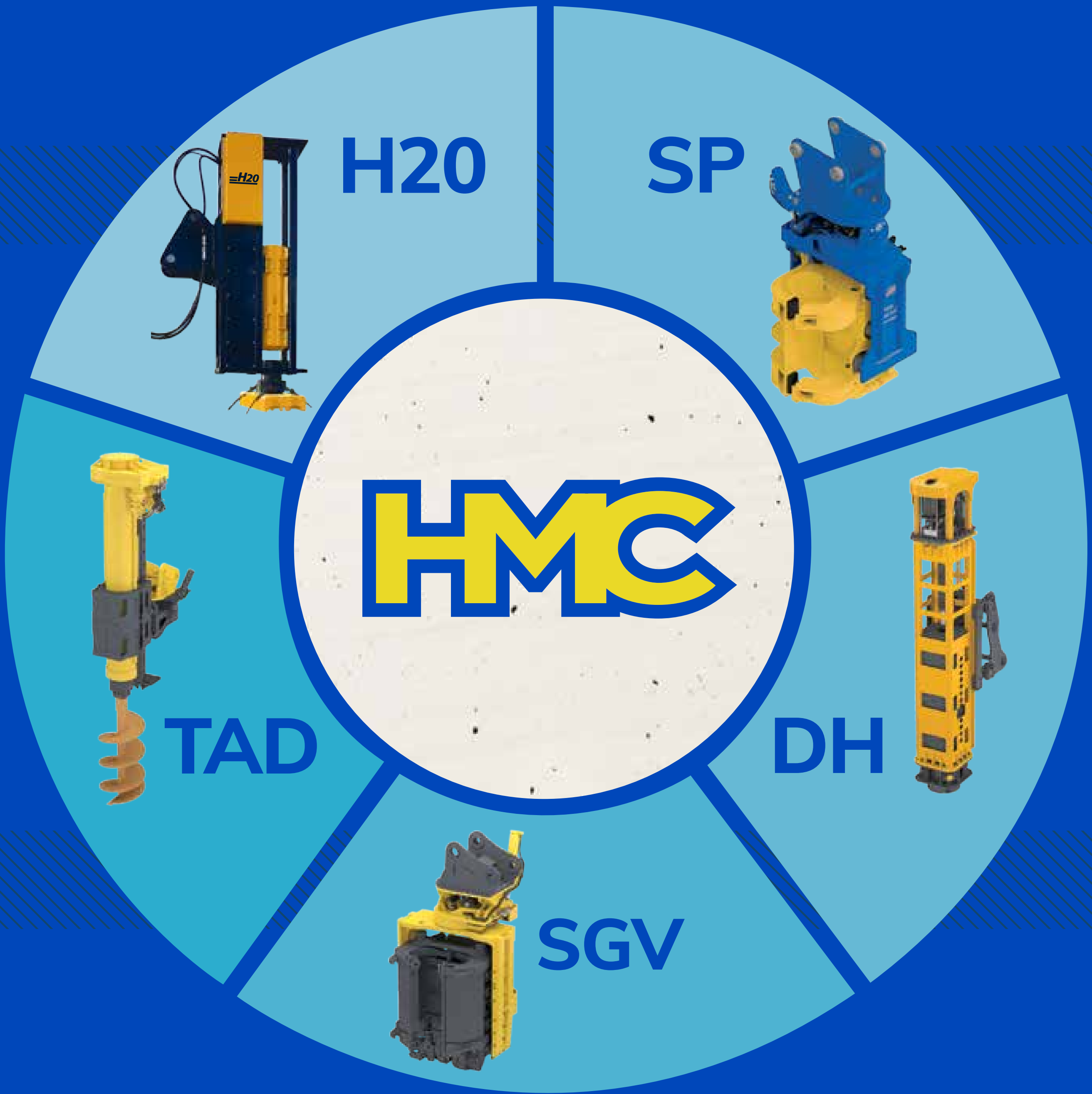
By Adrian Gygax, P.Eng., Gygax Engineering Associates, Rod Kostaschuk, P.Eng., BGC Engineering, and Sarah Gaib, P.Eng., Ministry of Transportation and Infrastructure

This article was originally published in DFI's bi-monthly member magazine, Deep Foundations, *July/August 2023 issue. DFI is an international technical association of firms and individuals in the deep foundations and related industries. To join DFI and receive the magazine, go to www.dfi.org.*

The British Columbia Ministry of Transportation and Infrastructure recently completed a slope stabilization project at the Ten Mile Slide on Highway 99, which is an essential part of the road network connecting the British Columbia coast with the interior of the province and which connects the communities of Lillooet and Xaxli'p to the regional services in the City of Kamloops. Approximately 1,600 vehicles travel this section of highway every day, and about 20 per cent of the traffic comprises heavy vehicles. A Canadian National Railways (CN) line crosses the top of the slide and was partially stabilized by the railway in an earlier project.

The landslide was first detected in 1988 and is estimated to have regressed more than 250 metres (800 feet) upslope in the last 40 years. Historical monitoring

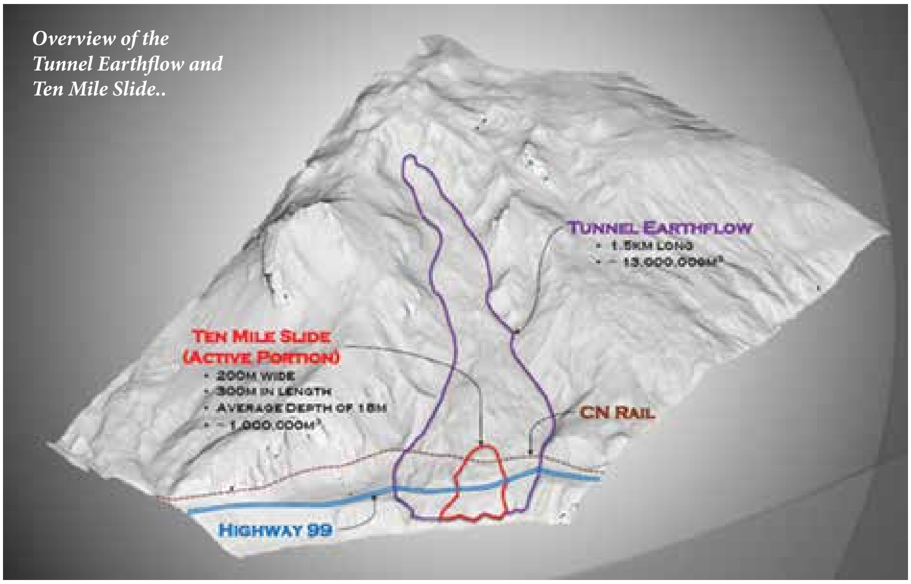
HMC Total Piling Solution



The Total Piling Solution: HMC's comprehensive range of piling and foundation equipment includes excavator mounted sidegrip® vibratory driver/extractors, piling hammers and piling drills. Hercules Machinery offers not just piling equipment but a most efficient, fast, flexible, accurate and safe solution.

Hercules Machinery Corporation
Manufacturer and Supplier of Foundation Equipment

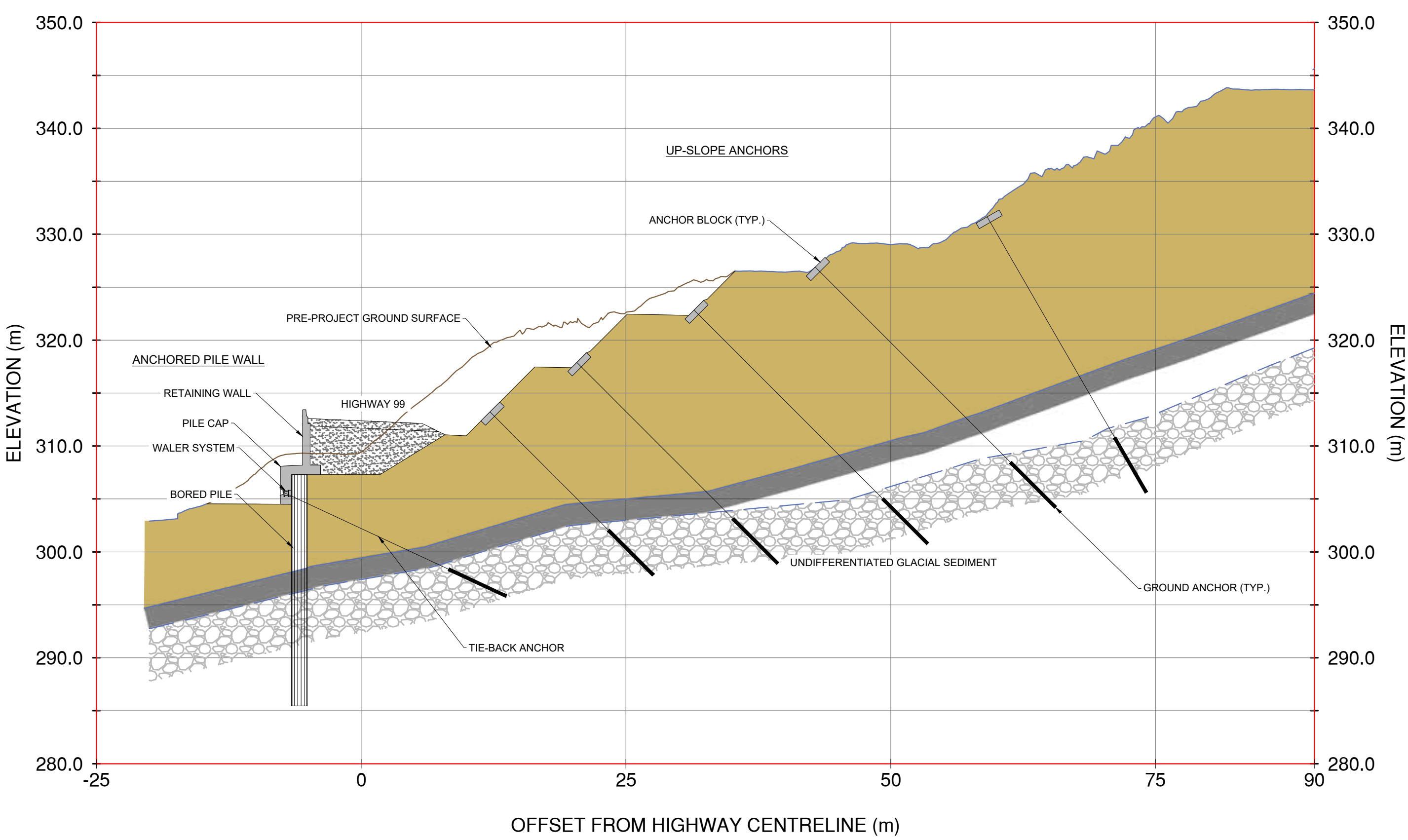
Call Toll Free // 800.348.1890
HMC-US.COM



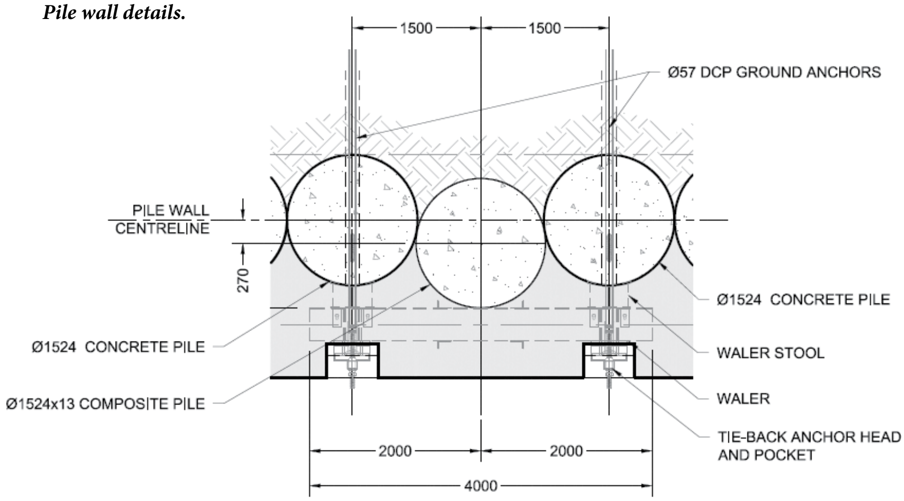
and remote sensing data shows that the landslide has moved at average rates ranging from 1.1–3.7 m (3.6–12.1 ft) per year. By late 2016, this section of highway was the most expensive, challenging and technically complex site in the province for the ministry to maintain, and was subject to 50 per cent load restrictions with 24-hour flagging to maintain single lane alternating traffic. Slide width has remained stagnant at the highway.

Ten Mile Slide is the active portion of the Tunnel Earthflow, a geological feature that is 1.5 km (1 mi) long and contains about 13 million m3 (460 million cubic feet) of soil materials. The active slide is about 300 m (1,000 ft) long and 200m (700 ft) wide and has an average depth to the shear zone of 18 m (60 ft). Prior to stabilization, the moving mass comprised about 1 million m3 (35.3 million cu ft) of soil material. Prior to stabilization, the slide was moving continuously at an average rate of 10 mm (0.4 in) per day, accelerating to 50 mm (two inches) per day following precipitation events. Sliding movement is translational, occurring along a 2 m (7 ft) thick roughly planar basal shear zone. The mobilized body of Ten Mile Slide is mainly dry, has higher strength than the basal shear surface, and behaves as a relatively stiff and cohesive mass. Previous efforts to stabilize the highway had only mitigated landslide movement temporarily.

The stratigraphy at the site includes, in order of increasing depth: Tunnel



Interpreted geological profile and selected stabilization solution: Basal shear zone (grey), undifferentiated glacial sediments (yellow).



Pile wall details.

Earthflow, undifferentiated glacial sediment, and Jackass Mountain Group Bedrock. The movement of the slide has resulted in a shear zone near the base of the Tunnel Earthflow unit. This shear zone has been characterized spatially and with depth by several boreholes from different investigation efforts over many years. The Tunnel Earthflow is approximately 20 m (65 ft) thick — the texture is heterogeneous and unsorted, and typically comprises plastic, well graded clayey silt, sand, and gravel with cobbles and boulders. Except in a few instances, water seepage or wet materials were not encountered. The undifferentiated glacial sediment directly below comprises permeable, dense, drained, coarse granular soil. Cobbles and boulders occur at any depth in this soil, as do seams and lenses of low permeability, clayey sediments. Bedrock is located at depth and is not relevant to the stabilization measures.

Stabilization Concept Design Criteria

An important step in the design process was determining an appropriate factor of safety (FoS) for slope stabilization. Ongoing movement of the landslide suggested the limit equilibrium FoS prior to stabilization was near 1.0. After completing a rigorous site investigation, design sensitivity analysis, geostructural numerical modelling, two test soil anchors, and consulting a technical panel comprising independent experts, the criteria adopted by the ministry were to design the stabilization measures to increase the FoS on each cross-section analyzed to a minimum of 1.2. To manage uncertainties and risks associated with the work it was further decided to adopt an observational method, comprising significant geotechnical and structural monitoring before, during and after construction for the implementation of the stabilization program.

The minimum design life of the stabilization measures is 30 years based on the rate of slide retrogression. If the combined effect of the stabilization measures constructed by the ministry and CN prevents future retrogression of the landslide, the design life of the stabilization measures is expected to be longer and largely determined by the life of the structures. The designs for all structural components of the stabilization measures were compliant with the Canadian Highway Bridge Code and a 475-year return-period earthquake event and met the retaining wall performance requirements for a 75-year design life.

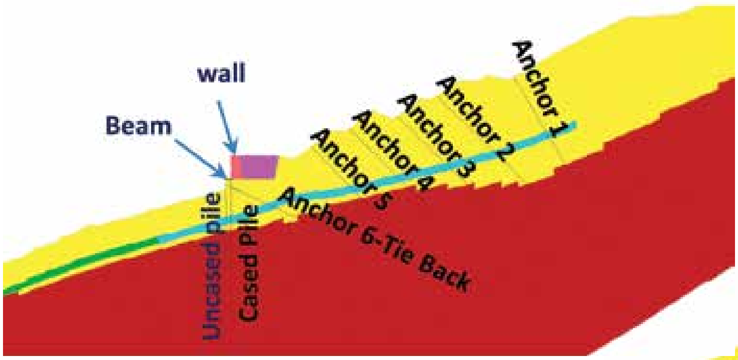
Climate change projections indicate a small increase in annual precipitation over the design life of the stabilization measures. The impact of these wetter conditions was considered regarding slope stability by checking the sensitivity of the FoS of the stabilized slide to a permanent and sustained increase in groundwater pressure to confirm the resulting FoS remained sufficiently high.

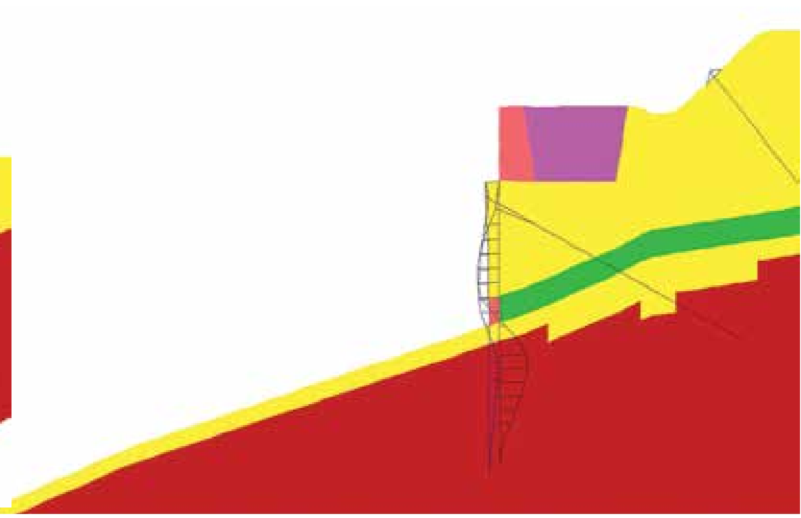
Selected Solution for the Stabilization Concept

Typical solutions such as rerouting the highway, unloading the crest or buttressing the toe of the slide were concluded not to be feasible due to the steep slope and proximity of the Fraser River at the toe of the slide and the railway at the crest. Groundwater drainage was expected to be ineffective because groundwater pressure is near-zero in both the coarse-grained undifferentiated glacial sediments below the slide and in the overlying Tunnel Earthflow soil, except for occasional perched aquifers. A structural solution that increased the shear resistance along the failure plane was therefore pursued. The design solution needed to consider ongoing slide movement during construction so that components installed in early construction phases could tolerate daily slide movement until enough additional structural support was installed to stop movement.

The solution adopted included 276 post-tensioned double corrosion protected soil anchors with 2.5x2.5x0.6 m (8.5x8.5x2 ft) precast concrete bearing blocks installed in five rows above the highway, a tied-back concrete tangent pile wall below the highway, and reconstruction of the highway to original alignment and grade. The pile wall comprises 148 bored piles of 1,524 mm (60 in) diameter, ranging in length from 20–26 m (65–85 ft); 125 tie-back soil anchors; a waler assembly and a cap

FLAC model, overall model (left) and pile wall with moment diagram (right).





beam with a cantilever wall stem that extends to 5 m (16 ft) in height. The piles are embedded 10 m (33 ft) into the dense, free-draining, coarse-grained undifferentiated glacial sediments.

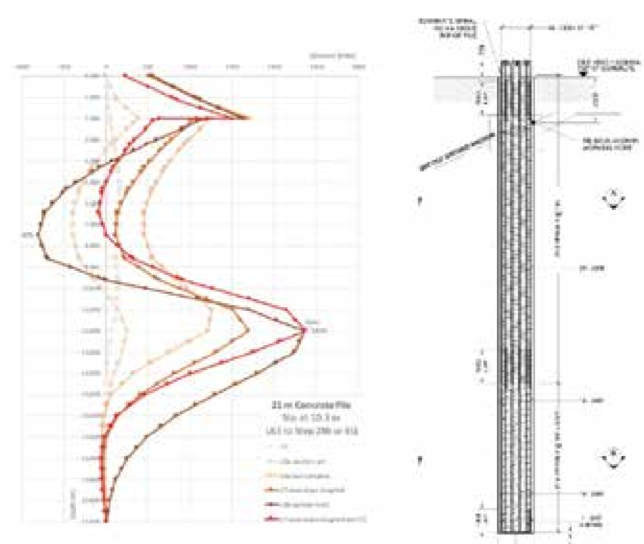
Working top-down, each row of anchored blocks was sized to slow, or even stop, the movement of the slide mass above it. After installation and testing, the anchors of a given row could be locked-off within a fairly short timeframe. However, the pile wall required a large number of piles to be installed, and during the time required, the soil mass below the lowermost row of anchored blocks continued to move. The design therefore required a pile solution that would exhibit considerable early shear strength and be tolerant of displacement until the tie-back anchors could be installed, tested and locked-off.

The solution selected was to use steel shell piles with concrete infill (composite piles), with the steel shell providing initial shear stiffness across the slide plane while the concrete infill cured. Installing tie-back anchors through steel shafts would have been prohibitively expensive, so only every third pile was a steel shell composite pile with the remainder being reinforced concrete bored piles. Drilling anchors through the concrete pile shafts is a common construction task. The composite piles were installed ahead of the concrete piles and successfully slowed slide movements to allow the concrete piles to reach adequate concrete strengths without being damaged.

To share the soil loading among both the concrete and the composite piles after the tie-back anchors were installed, a steel waler system was installed to link each composite pile with its adjacent two concrete ones. The waler system involved first attaching a waler stool to each concrete pile, the stool allowing position adjustments to ensure a flat vertical plane for the waler beam was achieved. The stools also incorporated a steel pipe shear stub that was inserted into the hole that was cored through the concrete pile for the tie-back anchor. The shear stub directly transferred the vertical component of the anchor testing and

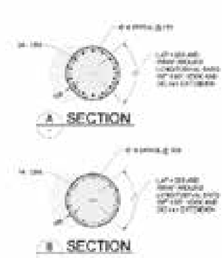
Table 1. Description of FLAC Analysis Steps.

FLAC Steps	Description
1 to 4	Model development (boundary conditions, soil properties, initial conditions)
5 to 7	Installation of anchor row 1 and subsequent slide movement
8 to 15	Installation of anchor rows 2 to 5
16	Installation of composite pile steel shell
17	Increase composite pile stiffness to account for hardening concrete fill
18 to 20	Installation of concrete piles
21 to 25	Excavation of tie-back and waler construction bench
26	Tensioning of tie-back anchors
27	Loss of soil downstream of wall and above basal shear zone, add earthquake
28	Check case of resetting and re-stressing anchor rows 1 to 5



Concrete pile: example moment development and provided reinforcement

Included photos that this image is made composed of.



Top-down construction.

Completed stabilization.

stressing force to the concrete pile shaft. The steel walers, comprising C380x50 (C15x33.9) channels back-to-back, were then attached to the stools and the tie-back anchors stressed. Subsequently, a concrete pile cap was constructed that encapsulated the pile tops and extended down to cover the walers, with pockets provided for permanent access to the tie-back anchors. By the time the pile wall could be constructed, the design road alignment was between 1–6 m (3–20 ft) above the pile tops, so the pile cap was topped with a cantilever wall stem that acts integrally with the pile wall system.

Design Methodology

Detailed 2D and 3D numerical time-step modelling of the slope movements and soil-structure interaction was used to predict stresses on the structural elements throughout construction, and to define time restrictions for the construction contracts. A combination of limit-equilibrium, finite difference and finite element methods were used for both the geotechnical analyses of the slope movements, upslope anchor stresses and the soil loads on the pile wall, and for the structural design of the pile wall components.

Geotechnical Analyses — Two-dimensional limit equilibrium stability analyses were used to evaluate and compare various landslide stabilization solutions. For the selected solution, the limit equilibrium stability analyses were then used for defining anchor spacing and loading and for establishing the pile configuration and capacity. The limit equilibrium stability analyses were also used for local stability assessments of the construction excavation and benches required for the installation of the stabilization measures.

More detailed analyses of the slide movement and impact of the stabilizing measures was then carried out on a cross section through the center of the landslide, which corresponded to one of the limit equilibrium models thus allowing for verification of results. These analyses were carried out on 2D finite difference numerical models using the computer program FLAC.

The staging of the stabilization work, and the coincident continual movement of the slide was analyzed in discrete steps. In general terms, each FLAC Step represented a stage of construction, with sub-steps used to calibrate the model to yield results that matched the known ground movements, see Table 1. The strength reduction method (SRM) was used at each step wherein the friction angle of the basal shear zone was reduced slightly below the calibrated value for existing conditions to initiate movement in the model, i.e., achieve a serviceability limit state (SLS) with a FoS against sliding of just under 1.0. The SRM was then used again to increase the FoS to 1.2 to determine the loads on the structures for the ultimate limit state (ULS). The models were run under SLS conditions to achieve the slide movements anticipated between each phase of construction. By FLAC Step 27, the model assumed all earthflow soil downhill of the pile wall and above the bottom of the basal shear zone will slide away and cease to support the pile wall.

For both the limit equilibrium and finite difference models, a sensitivity analysis was completed to evaluate changes in loading on structures to be expected from a transient rise in pore pressure. Furthermore, the predicted seismic response of the stabilization system was evaluated for the design earthquake by applying eight earthquake time histories to the long-term SLS case where it is assumed all soil downhill of the pile wall and above the basal shear zone moves downhill and ceases to support the pile wall. Each time, history was synthesized to match the site-specific target spectrum as defined by Canadian Highway Bridge Code.

Structural Analyses — The FLAC numerical model, being 2D, incorporated both composite and concrete piles as tiedback elements. Thus, the FLAC results do not provide a true representation of the load sharing between the directly tiedback concrete piles and the waler-restrained composite pile in between. For the detailed structural design, 3D structural analyses were conducted of the pile wall system incorporating the three triplets of one composite pile and two concrete piles each and the waler, tie-back anchors, pile cap cantilever wall stem and roadbed. Three models were developed to assess variations in pile lengths and location of the basal shear zone. This wall system was modeled and analyzed using the finite element program RFEM. The RFEM structural analyses results in the same load demand on tie-back system as the FLAC analyses but provides for a more accurate local distribution of load among the different pile types and the anchors.

For the composite and concrete piles, the effect of the landslide loading was transferred from the 2D FLAC model to the 3D RFEM model as follows:

1. The profile of shear force along the length of each pile type, as determined by FLAC, was used to calculate the profile of soil reaction loads acting on each pile for each relevant analytical FLAC Step.
2. The incremental loads on the piles were then derived for each construction stage. FLAC Step 20 was taken as the starting point. Step 26 minus Step 20 represents the effect of anchor stressing, Step 27 minus Step 26 that of SLS equilibrium being reached, etc.
3. For the pile embedment below the shear plane, the RFEM model used soil-springs determined by P-Y methods.
4. The FLAC analysis had all piles anchored, and as noted above, the anchor load is implicit in the pile soil loads obtained from the FLAC modelling. Therefore, in order to model the wall with only the concrete piles anchored, half of the composite pile soil loads above the plane of slip, for the incremental Step 26 minus Step 20, were added to that of each of the concrete piles.

Highway traffic loads per Canadian Highway Bridge Code were added as surcharge with lateral active earth pressures acting on the pile wall stem. Load and material resistance factors, again per the code, were applied to the non-geotechnical loads as appropriate to combine with the FLAC ULS loads.

The RFEM load increment analysis results were combined by superposition to yield the shears and moments in each type of pile with due account for load sharing. By way of a check, the total section forces of a concrete-composite-concrete triplet, divided by the wall length of the triplet were compared with the FLAC results and found to be in good agreement.

In one example of a moment diagram for a concrete pile obtained using the above approach, the effect of anchor installation and stressing is clearly visible (Step 26b) as is the increase in anchor load due to seismic effects (Step 27). FLAC Step 28b modelled the effects of destressing the upslope anchors, which of course would initiate some slide movement and commensurate increases in soil pressures on the pile wall. Meticulous readers will note the extra longitudinal reinforcement provided in the upper portion of the pile. This compensates for bars that were cut during the coring for tie-back anchor installation.

Observational Method During Construction — The 2D soil-structure interaction modelling in FLAC to estimate loading and response of the stabilization structures to construction and potential future conditions is complex and several assumptions were made that are based on estimated movement rates and soil parameters. While the analyses were considered representative and were the basis of engineering decisions and design, application of the observational method during construction was considered a key component to the project execution. Based on monitoring results, the design could be adapted to suit changing conditions as construction proceeded. The monitoring and instrumentation program included:

- Electronic vibrating wire load cells on selected soil anchors and the tie-back anchors.
- Slope inclinometer casings cast into selected composite piles of the pile wall and distributed on the slope above the highway.
- Ground surface displacement measurements by the contractor during construction using survey monuments, together with ground-based, terrestrial laser scanning and change detection analysis by BGC Engineering.

If monitoring showed that the predicted results were not being achieved, several contingency measures were available, including reducing tension in overstressed anchors and adding anchors. Monitoring results were retrieved daily via satellite upload and web-based plotting. Real-time monitoring was vital to determine when anchors required retensioning, which occurred several times for the initial, upper row of anchors until there was sufficient support to stabilize the slide. No additional anchors were required.

Monitoring has shown the slide response being as predicted and movement above the pile wall is also below detection limits. There is some localized, shallow movement and anchor load reduction associated with compression of tension cracks on the extreme eastern edge of the slide, which will be monitored and addressed if required. Displacement below the tangent pile wall continues to occur as anticipated in the design. Currently, anchor and tie-back loads are stable or decreasing very slowly.

Construction

Works were installed top-down starting at the upper row of soil anchors and defined time allowances were specified in the construction contracts for each stage to limit ground movements. The stabilization work was completed under three construction contracts. In early 2017, 30 soil anchors were installed, an additional 44 soil anchors installed in 2018, and the remaining 202 soil anchors and the tied-back pile wall were completed from 2019 to 2021.

The design solution remained the same throughout all construction phases, which speaks for its validity. Even though the project duration was longer than anticipated, much of the assignment was completed at an accelerated pace. Early phases of construction provided the design team with an understanding of the geotechnical conditions, soil anchor installation challenges, construction costs/productivity and validated the design approach, which allowed the team to incorporate lessons learned in subsequent construction contracts. Because of the importance of shear capacity, pile integrity testing was completed using the thermal integrity profiling method, which proved very successful. This method identified the need for smaller diameter reinforcing cages on the few occasions where it was necessary to complete the lower portion of the bored pile within the undifferentiated glacial sediments using open hole methods, resulting in a smaller diameter pile shaft with a more irregular exterior surface than the usual cased shafts.

Conclusion

Ten Mile Slide has been successfully stabilized, significantly reducing the operating costs of this stretch of BC Highway 99. This solution addressed stabilization for the unique landslide and offered many firsts for the ministry in terms of innovative design and monitoring during the construction phase. As a result, the ministry has contemplated this solution at other slide sites, including those impacted by recent flood events. The project has not only resulted in a safe and reliable highway alignment and minimized maintenance costs for this important corridor to national transportation routes, but it has been essential for Xaxli'p: by maintaining community connectivity and cohesiveness, by providing the most direct connection between Lillooet and Kamloops, and by providing community benefits and economic reliability.

Acknowledgements

The success of this project is due to many parties. The Xaxli'p Nation worked for many years with the ministry to develop a viable long-term stabilization solution and contributed labour to its construction. Contractors were Peter Kiewit and Sons (initial upslope work); Flatiron Construction, with subcontractors KanArm (upslope anchors) and Henry Drilling (pile wall). The authors were supported by Scott McKenzie and Brent McAfee (Ministry of Transportation and Infrastructure); Hamid Karimian, Andrew Mitchell, Michael Porter and Mark Pritchard (BGC); Ernie Naesgaard and Masoud Yazdi (Naesgaard-Amini Geotechnical); and Adam Williams (GEA). ●

JJA trades diesel hammer for Junttan piling rig on Navy yard project

James J. Anderson Construction Co., Inc. rented a PMx28 Pile Driving Rig with HHK5S Hydraulic Impact Hammer from Junttan USA to handle pile driving at the Broad Street Quay Wall project in the Philadelphia Navy Yard in October 2022.

JJA used the PMx28 to drive a line of NZ 38 sheet piles to create a new 700-foot steel seawall behind the existing concrete wall and drive 12-inch epoxy-coated piles in front to support a new concrete pedestrian walkway.

By Brian M. Fraley, Fraley Construction Marketing

Why would an established highway contractor with a history of using a crane with diesel hammer for pile driving be working at the Philadelphia Navy Yard with a sophisticated pile driving rig? That would be fair question by anyone familiar with James J. Anderson Construction Co., Inc. (JJA) and Junttan pile driving equipment.

Those familiar with the Philadelphia construction market tend to associate JJA with the region's most established companies. JJA only dates to 1981 when founded by Jim Anderson. Since then, the company has expanded its expertise into nearly every aspect of heavy civil construction. Expansion into new areas is in JJA's DNA.

Broad Street Quay Wall Project

The Broad Street Quay Wall project – owned by the Philadelphia Industrial Development Corporation (PIDC) – has been hailed as the new gateway to a reimagined Navy Yard. It's an engineering feat years in the making. When completed, it will include two vehicle lanes in each direction, a two-way elevated bike lane, and a scenic pedestrian plaza overlooking the Reserve Basin.

JJA's rectangular 700-foot-long jobsite – just inside the main gate of the Navy Yard – is a straight shot connecting Crescent Drive to Intrepid

Junttan USA conducted a stability analysis to ensure that the PMx28 would stay upright while supporting an 8,000-pound pile and 23,500-pound hammer while holding an extreme 2V:1H batter.

JJA has been at work on this project since June 2022, according to Crawford.

"There was an existing concrete seawall sitting on a timber deck," he says. "Our overall scope was first to drive a line of NZ 38 sheet piles to create a new 700-foot steel seawall behind the existing concrete wall, then remove the old seawall and timber deck on which it sat and drive 12-inch epoxy-coated piles in front to support a new concrete pedestrian walkway."

"The new steel seawall had to be anchored to a concrete tieback sitting on batter piles," says Crawford. "The tieback sits 50 feet behind the seawall. Three-inch diameter galvanized tendons go from the steel seawall back to the concrete tieback. Once that system and the utilities are all in, we reconstruct the Broad Street roadway, new sidewalk, bike path, and pedestrian plaza."

To construct the concrete tieback anchor, JJA drove 79 18-inch and 79 16-inch pipe piles, which were designed to be 80 feet long and driven on a 2V:1H batter. During test pile installation, it was determined that there were locations on the project where the tieback piles would need to be spliced and driven more than 100 feet to achieve design capacity due to changing soil conditions.

"None of the pipe piles on the project is seated in rock," Crawford says. "The 16-inch compression piles and 18-inch tension piles both derive their capacity from predominantly skin friction with only a minor contribution from end bearing for the compression piles."

JJA was able to meet or exceed estimated production for the installation of sheeting and the batter pipe piles during its first experience with the PMx28 thanks to Junttan USA's on-site training and JJA's diligent operator.

"We've seldom done friction piles so this was an experience to go through the test pile program and all the dynamic analysis iterations with Urban Engineers to determine that the production piles will attain the design capacity," says Crawford.

From Conventional to Unconventional

JJA had never used a Junttan pile driving rig but had seen them used locally and on the internet.

"JJA is accustomed to diesel hammers, air hammers, vibratory hammers and drilled piles installed with a crane, and our usual experience – primarily working for PennDOT – is end-bearing piles to rock," Crawford notes.

Since past work was performed with a crane-mounted hammer, JJA was first-time customer for Junttan USA. Junttan USA rented JJA a PMx28 Pile Driving Rig with HHK5S Hydraulic Impact Hammer to drive the pipe piles in October 2022, while the contractor simultaneously scheduled a rig from another vendor to vibrate in the sheet piles. When that rig became unavailable due to an emergency project, Junttan USA's sales engineer Matt Eastburn saw an opportunity to expand the role of its rig.

Junttan USA had never rented a rig with a vibro package and leaned on its partners in Canada to supply the package to be installed on the PMx28. The cross-continental partnership paid off.

"For the sheet piles, we had the rig equipped with a PTC variable moment hammer, so we had to mount the power pack on the back," Eastburn explains. "We took off the counterweight and essentially used the power pack in its place."

Junttan USA had Junttan Canada ship the vibro and power pack to the Navy Yard where the PMx28 was waiting. JJA provided crane support for the assembly. The transition between vibratory and standard pile driving was seamless.

When the time came to drive the 16- and 18-inch-diameter piles, the vibro components were removed, and the counterweight and HHK5S hammer were re-installed. Aside from a small portion where a Philadelphia Water Department culvert pokes through the seawall, all pile driving was ultimately done using the Junttan PMx28.

"We did all the engineering in house,"

The PMx28's ability to hoist and drive piles without falsework was the main factor for JJA choosing the Junttan rig over its traditional use of a crane-mounted hammer.

The transition between vibratory and standard pile driving was seamless. Junttan USA equipped the PMx28 with a PTC variable moment hammer and power pack (not pictured) to drive sheet piles, and an HHK5S for pipe piles.

explains Eastburn. "Junttan USA installed the vibro kit, which was supplied by Junttan Canada. They had retrofitted it to a PMx28 they had in stock. Junttan Oy is always supportive of our companies, but their main role here was engineering work for the batter piles."

"The most challenging part of the engineering we had to do was the stability analysis to ensure that the rig wasn't going to tip over while holding the 2V:1H batter and the 8,000-pound pile and 23,500-pound hammer," says Eastburn. "With the elimination of a portion of the counterweight, we were able to lay the leader back with a full-length pile."

"Junttan was amazing," Crawford says. "Matt (Eastburn) did a balancing act with the weight of the hammer. I don't know if it's near the limits of the PMx28's capability, but it's probably pretty close to get 26 degrees of incline and hold all that weight in place."

Extreme Batter Piles

The key issue for JJA was finding an unconventional way to drive 80-foot-long piles on an extreme batter that was not labor and material intensive, according to Crawford.

"We've done batter piles before, but not quite this extreme," Crawford says. "At this angle, we would have needed significant anchored false work to maintain the pile angle at such an extreme batter."

Crawford also believes its conventional equipment would have faced other challenges in this application.

"We've had problems in the past with diesel hammers on significant batters. Diesel hammers tend to misfire when tilted. We don't have that issue with the Junttan hydraulic hammer."

Although JJA has experience installing batter piles of lesser degrees, 26 degrees was a batter it had never encountered. This angle was necessary due to the heavy loads such as large trucks and transports that will enter the Navy Yard on Broad Street.

Because these live loads will exert high lateral pressure on the new steel sheet pile Seawall, they had to be counteracted by the batter piles in the tieback anchor. Due to the extreme batter, JJA required a follower to drive the batter piles the final few feet to grade. Junttan USA suggested the idea but did not supply the follower itself.

Training Supports Production

Adapting to a new pile driving machine is no easy task for an operator. JJA's operator, Steve, embraced the challenge and the pile driving productivity reflected that.

Steve was accustomed to operating JJA's standard setup – a crane with diesel hammer. Junttan USA sent in a tech and provided on-site training, which included an in-depth assessment of the rig's components and how to operate it. In addition to being a quick learner, Steve had studied the manual prior to training.

"Steve had quite the learning curve at the beginning, but once he got to know the machine, he was off to the races," says Eastburn.

Since JJA had never used a Junttan rig in the past, production was a serious concern, especially considering that the piles were to be driven with a 26-degree batter. JJA was ultimately able to meet or exceed estimated production for the installation of the sheeting as well as the batter pipe piles.

Although Crawford acknowledges that the PMx28's ability to hoist and drive piles without falsework was the main factor for choosing Junttan, the operator's ability was also factor.

"There's a learning curve, of course," he says, "but once it has been overcome, production reaches where it needs to be."

The narrow 700-foot-long site also made using a crane-mounted diesel hammer with leads and bottom falsework prohibitive, according to Crawford.

"The crane would have to be positioned to control the top end of the leads where a majority of the pre-driving

> “This pushes the pile off its design location and orientation. The Junttan held it where it had to be, so we were able to keep the pile on its designed line while penetrating the wall. The point penetrated and the hammer held up well under this added stress.”

weight is located,” he says. “This would then require falsework at the bottom of the pile to maintain orientation and position. After completing one pile, we’d have to move the entire set up ahead every time. With the Junttan, it’s self-contained – it holds the pile and moves it ahead without expending time to disassemble and reset falsework.”

The sheet piles were driven straight and accurately as well also without the need for alignment falsework. At the completion of driving the steel sheet pile seawall, JJA had to connect a double channel waler to the back of the sheet pile to accept the tieback tendon connections. The adjustments needed to attain proper bearing for the waler attachment were all less than one inch.

Junttan USA’s Eastburn adds that having a single rig offered JJA easier setup, better site access, and less equipment to maintain.

“Our PMx28 setup is transported in three loads – one lowboy for the rig itself and two falloff loads on standard flatbeds for the hammer and counterweights. It requires a little bit of machine support to assemble, but once it’s set up, you can track back and forth to each pile on site,” he says.

Under and Over the Navy Yard

The Navy Yard operated as a U.S. naval base from 1876 to 1996, so it stands to reason that the underground conditions are as diverse as its history.

During installation of the 16-inch pipe piles for the tieback anchors, JJA encountered the remains of a 700-foot-long timber bridge from the 1800s about 11 feet down. The bridge had once connected Broad Street with this area of the Navy Yard, which was once known as League Island.

The Pennsylvania Historic Museum Commission determined that the underground structure had low historical significance, so JJA was permitted to put points on the 16-inch pipe piles to penetrate the bridge wall, which was comprised of six- and 12-inch timbers. The tips allowed the contractor to drive 16-inch piles through roughly two feet of wood using the PMx28.

“If you’re driving a pile on a batter with a crane and leads and a timber wall is there, the pile will slide down the wall trying to find a weak spot and then penetrate there,” Crawford says. “This pushes the pile off its design location and orientation. The Junttan held it where it had to be, so we were able to keep the pile on its designed line while penetrating the wall. The point penetrated and the hammer held up well under this added stress.”

The pile driving challenges weren’t just under the ground. The Navy Yard is densely populated with buildings connected by a labyrinth of narrow streets and 90-degree turns. Transporting 80-foot-long piles on a 100-foot-long trailer was a logistical challenge, especially with the historic sycamore trees that bordered the site.

PIDC agreed to prune the fronts of the trees to provide access for the piles and the Junttan rig.

“PIDC needed a good reason just to prune them,” says Crawford. “To get approval to take them down would require an act of Congress. If we’d have done this pile driving conventionally with a crane boomed over those trees, it never would have happened. We don’t have the space or clearance to fit a rig holding a 26-degree batter through the tree canopies. Booming back just the mast of the Junttan rig where the trees had been pruned in the front worked for us, and more importantly, worked for PIDC.”

JJA finished its pile driving work with the Junttan setup in July 2023 but continued marching toward the timely completion of the project in December. As drivers and pedestrians enter the Navy Yard, they’ll see freshly paved roads, newly constructed granite clad wall with recreated stone piers, and a new pedestrian walkway with extensive landscaping, but they’ll never realize the complex geotechnical challenges below that were overcome by a forward-thinking project team and a willingness to break out of the comfort zone and engage with new equipment technologies. ●

Wood Buffalo Flood Mitigation, Reach 5

Fort McMurray, Alberta

Keller installs sheet piles as flood mitigation on the shore of the Clearwater River within a tight corridor near a high pedestrian area.

The project

The Regional Municipality of Wood Buffalo has a long history of overland flooding since 1835, with 17 notable floods, mostly caused by ice jams as the river breaks up. The Municipality has begun a multi-phase permanent flood mitigation program. As part of this program, Reach 5 includes the installation of sheet piles to protect apartments and villas on the banks of the Clearwater River.

The challenge

Site access was constrained due to the proximity of the apartments to the proposed sheet pile locations. As an area of high pedestrian activity, heightened safety awareness was required.

The solution

Keller was awarded the sheet pile contract, installing 2,080 linear feet (634 linear metres) of sheet piles to depths ranging from 38.7 feet to 41.3 feet (11.8 metres to 12.6 metres). An access ramp was installed on the south section to allow for easier access, and the outer wall was realigned for the sheet piles to be safely installed within the boundary. Work was completed ahead of schedule.

Project facts

Owner(s): Regional Municipality of Wood Buffalo
Keller business unit(s): Keller
Main contractor(s): ServcoCanada
Engineer(s): Associated Engineering
Solutions: Groundwater control
Markets: Infrastructure
Techniques: Sheet piles ●

Liebherr drilling rig put to the test

The water construction site in Seelisberg challenges the LB 30 drilling rig with extremely hard rock.

Kibag is using the LB 30 to install new mooring piles for the Lake Lucerne Navigation Company.

The Swiss company Kibag is installing new mooring piles for the Lake Lucerne Navigation Company. For the first time, Kibag is using a drilling rig from Liebherr's LB series. The LB 30 is facing challenges which literally couldn't be harder.

"The problem is that we can't drive the piles here," explains Markus Waldis, Foreman at Kibag. "The ground is too hard. We have to drill the piles and then fill them with concrete."

In Seelisberg, on the southern shore of Lake Lucerne, Waldis' team is drilling the piles from a pontoon using the LB 30 drilling rig from Liebherr – from the surface of the water around 12 metres deep and with a diameter of 1,300 millimetres. After three metres of water comes a stone segment and then at least six metres of drilling in the rocks.

This rock is an endurance test for the construction personnel and especially for the new LB 30.

"The stone is exceedingly hard! The whole machine vibrates," Waldis says of the extreme challenges. And insufficient pressure applied from the pontoon with the drilling rig makes it even more difficult. "Otherwise, we just lift the pontoon. We have to secure it very well so that it holds during drilling."

Successful premiere

Gianluca Diaco has been a machine operator for Kibag for 14 years, and this is his first time on a water construction site.

"Because the ground is very hard, we have to change the chisels on the auger starter quite often in order to be able to drill through the rocks." Despite the difficult conditions, he's pleased to be operating the Liebherr LB 30. "It's very strong, compact and moves fast. You can really do everything."

After the hydraulic engineering specialists from Kibag have concreted the outer casings, the mooring pile is inserted. A rubber strap between the outer casing and the pile ensures that the pile is not too rigid and can move a little when the boats moor. To prevent the mooring pile from rotating, it must be secured under water by a diver.

The construction site demands everything from the personnel and the drilling rig. Nevertheless, Waldis is pleased with the successful premiere of the LB 30.

"The machine works perfectly – tip-top. It has to withstand huge vibrations. It's a great endurance test for the machine, and so far, it is coping wonderfully."

A journey with obstacles

To bring the drilling rig to the construction site, the Kibag team travelled across the lake by pontoon for about six hours. The Acheregg Bridge in the southwest of Lake Lucerne was the first challenge, explains Waldis, "We had to watch the height and were only able to erect the drilling rig after the bridge, meaning at sea. Our pontoon is relatively large, about 18 metres wide and 40 metres long, and there's a lot of weight on it. That made things very difficult."

About the Liebherr Group

The Liebherr Group is a family-run technology company with a highly diversified product portfolio. The company is one of the largest construction equipment manufacturers in the world. It also provides high-quality and user-oriented products and services in a wide range of other areas. The Liebherr Group includes over 140 companies across all continents. In 2022, it employed more than 50,000 staff and achieved combined revenues of over 12.5 billion euros. Liebherr was founded in Kirchdorf an der Iller in Southern Germany in 1949. Since then, the employees have been pursuing the goal of achieving continuous technological innovation and bringing industry-leading solutions to its customers. ●

Index to advertisers

APE - 5 SERIES
HYDRAULIC IMPACT HAMMERS

We Drive Piledriving Technology. Just Ask a Piledriver.

ALL NEW DESIGNED FOR MAXIMUM PRODUCTIVITY

How? More info...

Model	Energy (Ft-lbs)	Energy (kNm)
15-5	150,000	203
20-5	200,000	271
25-5	250,000	339
30-5	300,000	407

800-248-8498

www.americanpiledriving.ca

AMERICAN PILEDRIVING EQUIPMENT, INC. A.P.E.

Locations & Phone Numbers

APE Northwest / Corporate Headquarters
7032 South 196th St.
Kent, Washington 98032
(253) 872-0141

APE Western Regional Office
2985 Loomis Rd.
Stockton, California 95205
(209) 942-2166

APE Northeast Regional Office
401 Hartle St.
Sayreville, New Jersey 08872
(732) 432-6604

APE Southeast Regional Office
1345 Industrial Park Rd.
Mulberry, Florida 33860
(863) 324-0378

APE Mid-Western Regional Office
50 Gerber Industrial Drive
St. Peters, Missouri 63376
(636) 397-8400

APE Gulf Regional Office
3975 FM Hwy 1485
Conroe, Texas 77306
(936) 271-1044

APE Mid-Atlantic Regional Office
500 Newtown Rd. #200
Virginia Beach, Virginia 23462
(757) 518-9740

APE Canada Office
1002 7th Street
Nisku, Alberta, Canada T9E 7P2
(780) 474-9888

APE Mexico & Central America Office
Avenida Periferico Sur 7800, Sta. Ma Tequetexpan
Tlaquepaque, Guadalajara Jalisco, Mexico CP. 45601
(732) 432-6604