MINIPILING AND SOIL ANCHORS

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INTRODUCTION

This paper outlines the development of small diameter grouted piling, to deal with foundation problems in difficult soils conditions and in very restricted access areas. A number of applications are outlined to show the way in which these piles have been used over the last sixteen years in Canada.

PICKERING GENERATING STATION - ONTARIO HYDRO

UNDERPINNING OF SCREENHOUSE - TRASH DISPOSAL AREAS

Between 12th July and 29th September 1971, 40 small diameter grouted piles were installed in the screenhouse at Pickering Generating Station. Access was extremely restricted as the screenhouse had been completed and the majority of mechanical equipment had been installed. The two ends of the screenhouse had been built on granular fill which overlies till and shale bedrock and settlements had been observed which it was decided had to be halted even though the rate of subsidence had decreased. Two diamond drills were employed to install 8 inch

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diameter casing through an upper 12 inch thick concrete slab and a lower 4 foot minimum thick heavily reinforced concrete slab. This casing was driven through the granular fill which was a minimum of 16 foot deep to the till and cleaned out by washing using a tricone bit. A 6-3/4 inch tricone bit was advanced through the till which was approximately 20 feet deep, the cuttings again being removed by washing and advanced into bedrock to a depth of 2 feet. A 5 inch slotted pipe pile with an open end was then placed inside the casing and driven to bedrock. After cleaning out, the pile was filled with a sand/cement grout with a water/cement ratio of 0.45 and the casing removed, keeping the pile full of grout. A packer was placed in the pipe pile and pressure grouted to 30 psi and then the pile was bonded into the lower reinforced concrete slab of the screenhouse. During testing of these piles one pile which was grouted into rock failed by buckling at 300 kips while another pile which had to be completed using a Dywidag anchor through a boulder in the till was loaded to 200 kips which failed with a punching type failure and a limiting deflection of 1/2 inch. Based on these tests an allowable design load of 60 tons per pile was used.

A total of 1,812 feet of slotted pipe was installed in a period of 8 weeks. Unlike the test piles several of the production piles took a considerable quantity of grout through the slots

into the surrounding fill which slowed production considerably. Headroom was restricted in the screenhouse but the main problem was moving the drills around the mechanical equipment and access to observe grouting in the lower basement of the screenhouse. The final cost to client was approximately $65,000.

BEVERLY SWAMP - ONTARIO HYDRO

FOUNDATIONS FOR 15 TRANSMISSION TOWERS

Between February 1976 and March 1977, 240 small diameter grouted piles were installed in an environmentally sensitive area for the foundations for 15 transmission towers. The four legs of the towers were supported on 4 No. 8 inch pipe piles driven at specified steep angles to the vertical. Because of the problem with access, the piles were driven closed ended using a Delmag D 4 hammer mounted on an airtrack which was in turn mounted on a Nodwell snow track vehicle. All travel by vehicles in the swamp was strictly controlled and was on corduroy timber roads installed by Ontario Hydro. Once the pile had been driven to a maximum depth of 48 feet through peat and silty sand and dense sandy silt to as close to dolomite bedrock as possible, a 5 inch diameter pipe was drilled through the 8 inch pipe and on into the bedrock using the top drive Odex System. The drill was again mounted on an airtrack on a Nodwell vehicle.

The 5 inch pipe was capable of being drilled through boulders and on into the bedrock where it was seated some 2 feet into the bedrock. Finally a two inch hole was drilled 10 feet deep into the rock and a 1 inch diameter Dywidag anchor installed into this then the anchor and piles were grouted including the annular space between the 5 inch and 8 inch pipes. These piles were tested prior to the production contract and were capable of sustaining a working load of 180 and 210 kips in uplift and compression respectively.

Environmental restraints meant that no drill cuttings or grout could be dropped on the site and these had to be collected in containers and taken away for disposal off the site. The dolomite proved to be extremely fractured in areas and considerable quantities of grout were required to seal off the artesian water encountered in the rock prior to re-drilling and installing the anchors. The total cost to the client was approximately $600,000 and 10,000 feet of grouted piles were installed during the period of a year in which this contract was carried out.

CANADA CEMENT LAFARGE LTD - EXSHAW ALBERTA

SOILS ENGINEER - TROW LTD

- UNDERPINNING OF EXISTINNG FOUNDATIONS PRIOR TO A PLANT EXTENSION BEING CONSTRUCTED

Between 3rd February and 15th May 1979, 106 grouted piles were installed at Exshaw, Alberta through existing foundations to minimize settlement due to extra loads from an extension being built beside an existing cement plant. The soil underlying the existing foundations contained areas of loose to compact silts and fine sands overlying dense sand and gravel some 30 to 35 feet deep. 6-1/2 inch diameter holes were diamond drilled through the existing footings prior to the installation of 5 inch pipes using the Down the Hole Odex system. In many areas the access was extremely restricted both in headroom and in floor area. A special mast was constructed which could be man-handled using block and tackle and anchored to the footings over the pre-drilled hole. Pipe had to be welded in short lengths as it was installed and preslotted on the bottom 10-15 feet. The piles were an average of 44 feet deep and were grouted from the top using a packer set in the footing. A remote power pack supplied hydraulic power to the drill and feed while the more accessible piles on the outside of the building were installed using an Acker Mark IV Hydraulic Rotary Drill. Testing was

carried out by installing anchor piles either side of the test pile and an 80 kips working capacity was used in the design. The total cost to the client was approximately $400,000.

GREAT LAKES FOREST PRODUCTS LIMITED, THUNDER BAY, ONTARIO

ENGINEER - PROCTOR & REDFERN LTD.

SOILS ENGINEER - DOMINION SOIL INVESTIGATIONS INC.

- UNDERPINNING OF EXISTING FOUNDATION TO CARRY THE EXTRA LOADS IMPOSED BY NEW EQUIPMENT ON TWO PAPER MACHINES.

Between August 11th and November 28th 1985, 41 piles were installed at an average depth of 78 feet through fill and sandy silt and then silty clay to sandstone bedrock. It was found that a reinforced concrete buttress wall had been constructed below the main floor slab of one of the machines. This wall was some 10 feet deep in places and after drilling through the floor slab a 10 inch casing was placed in the fill and grouted in position. A 8 inch thin wall core bit was used to drill through the foundation wall below and then a mud drilling technique used to drill a 7-5/8 inch hole through the silty clay and on into the bedrock. Headroom was very restricted in the majority of the areas where piles were installed and once again a hydraulic head and an independent mast was used to rotary

drill the hole under mud prior to installing the 6 inch pipe, two feet into the bedrock. The mud was displaced using a tremie grout and then the pile was pressure grouted. A test pile was installed in each of the two areas at this site and a design load of 50 tons was accepted as reasonable under the type of loading required by these piles. The cost to the client of this operation was approximately $640,000 which was considerably higher than originally estimated because of the foundation walls which had to be penetrated prior to installation of the grouted pipe piles.

SPRUCE FALLS POWER AND PAPER CO. LTD - KAPUSKASING ONTARIO

SOILS ENGINEER - DOMINION SOILS INVESTIGATION INC.

- UNDERPINNING OF EXISTING FOUNDATIONS TO ALLOW FOR INSTALLATION OF NEW MACHINERY WITHOUT EXCEEDING THE ALLOWABLE LIMITS OF SETTLEMENT.

Between 15th December 1985 and January 23rd 1986, 27 grouted piles were installed in the basement of this plant under very tight working conditions both in headroom and in plan area. Once again the concrete floor and existing footings were diamond drilled to provide a 10 inch hole in which was grouted a 9 inch stand pipe. Through this standpipe the silty clay below was

drilled using mud and a rotary tricone bit to produce a 7-7/8 inch diameter hole. This was carried 1 foot 6 inches into the granite bedrock. 6 inch Schedule 40 pipe was installed in the hole and grouted into position using tremie methods. The drill mast and head was moved using a small fork lift truck and the hydraulic power pack was located outside the basement area. The pile test in this case was taken to 50 tons with complete recovery being achieved after several reloadings. The cost to the client was approximately $150,000 which did not include the cost of the pipe and grout materials which were supplied by the client.

CITY OF NIAGARA FALLS - PORTAGE ROAD

ENGINEER - R.V. ANDERSON ASSOCIATES LTD.

SOILS ENGINEER - TROW LTD

MAIN CONTRACTOR - DIAMOND STONEBRIDGE CONTRACTING

- UNDERPINNING OF FOUNDATIONS OF PEDESTRIAN BRIDGE

Severe erosion on the escarpment above Niagara Falls had undermined a bridge footing so that one of the timber piles on the outer edge of the footing were exposed. During June 1987 two grouted pile tiebacks and four grouted piles were installed to

stabilize this bridge footing. It had initially been thought that the piles and tiebacks could be installed from the front of the footing on the slope after the erosion channel had been back filled, but this was not possible and it was decided to remove the back fill over the footing. The excavation revealed that the configuration of the footing in plan was not a box section as had previously been thought but consisted of two separated footings with some concrete infill. (See Figures 1 & 2). After tying back the columns of the bridge with Dwyidag bars at road level, an Atlas Copco ROC 601 Air Track was walked down the slope and on the very restricted area of the existing footing, the piles and tiebacks were installed. The top drive Odex system was used to install 5 inch galvanized pipe both for the tie backs at the rear of the footing and the four piles at the front of the footing. Once the fill below the footing had been penetrated the soil was found to be a firm sand, the length of each of the tiebacks being 48 feet and the piles 44 feet. Once the pipes had been installed they were pressure grouted to 250 psi and capped off to maintain this pressure while the grout set. Testing of the tiebacks was carried out to 1.6 times the design load of 41 kips while one of the piles was tested to 1.6 times the design load of 46 kips. One of the tiebacks failed initially due to a weld failure but after subsequent redrilling and the installation of a Dwyidag bar in the 5 inch pipe, passed a further test. After the installation of the first two inner

piles and the tiebacks, a new base was cast on top of the existing footing and following the testing of the tiebacks and one pile, two further piles were installed on the outer edge of the footing to take the load of the exposed timber piles beneath. The cost to the client for this operation was approximately $100,000.

CONCLUSION

As can be seen from these examples of the use of grouted piles, they have been used exclusively in areas of very restricted access and usually under difficult soils conditions. In each case different equipment has been used or has been modified to fit the conditions of the particular problem. Because of restricted headroom, it is often necessary to use very short lengths of pipe, which require a multitude of welds as well as short sections of drill pipe. But in some areas it is possible to use a longer mast and feed and increase production by cutting down on welds and changing rods. Each problem has to be tackled taking into account the access, the headroom and the soils conditions and although there are similarities in the methods and equipment used, each one has its own peculiarities. Certainly this has not led to cheap solutions but in each case a solution has been found which as far as could be ascertained was economic for the problem encountered.

It is likely that as plants grow older and modernizing creates heavier loads that grouted minipiles and anchors will become a more established solution to the problem of underpinning foundations. Certainly as land becomes more and more expensive so owners will look more and more to solutions which will allow them to use land which at one time on this continent would never have been considered.

Finally a personal footnote. We should remember that it is not we that have created the earth on which we build our structures but God, who also created us. I believe, as and when we listen to Him, we will be able to build our structures and more importantly our lives on a firm foundation.

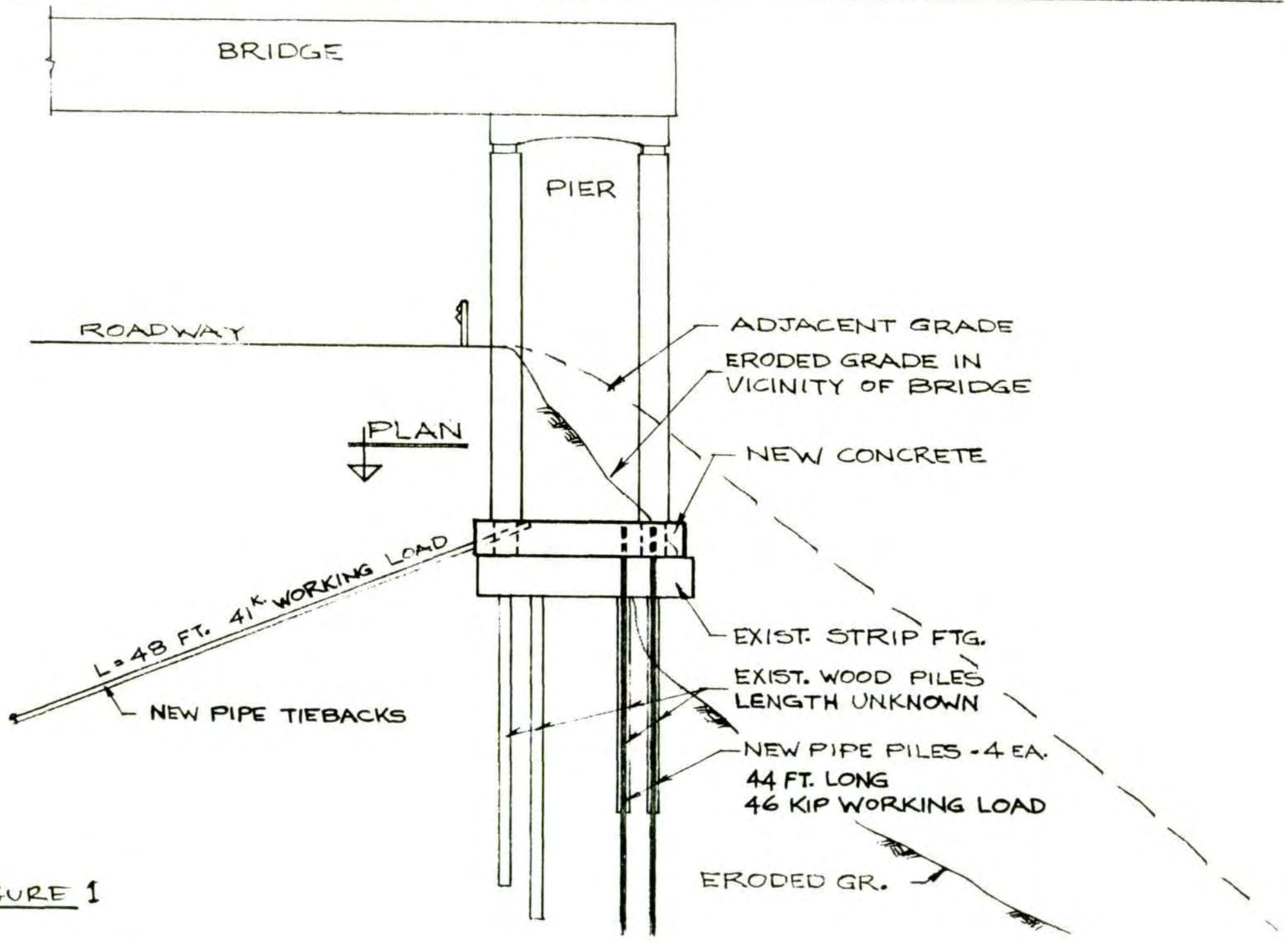
BRIDGE
PIER
ROADWAY
ADJACENT GRADE
ERODED GRADE IN VICINITY OF BRIDGE
PLAN
NEW CONCRETE
L=48 FT. 41K. WORKING LOAD
NEW PIPE TIEBACKS
EXIST. STRIP FTG.
EXIST. WOOD PILES LENGTH UNKNOWN
NEW PIPE PILES - 4 EA.
44 FT. LONG
46 KIP WORKING LOAD
ERODED GR.

FIGURE 1

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