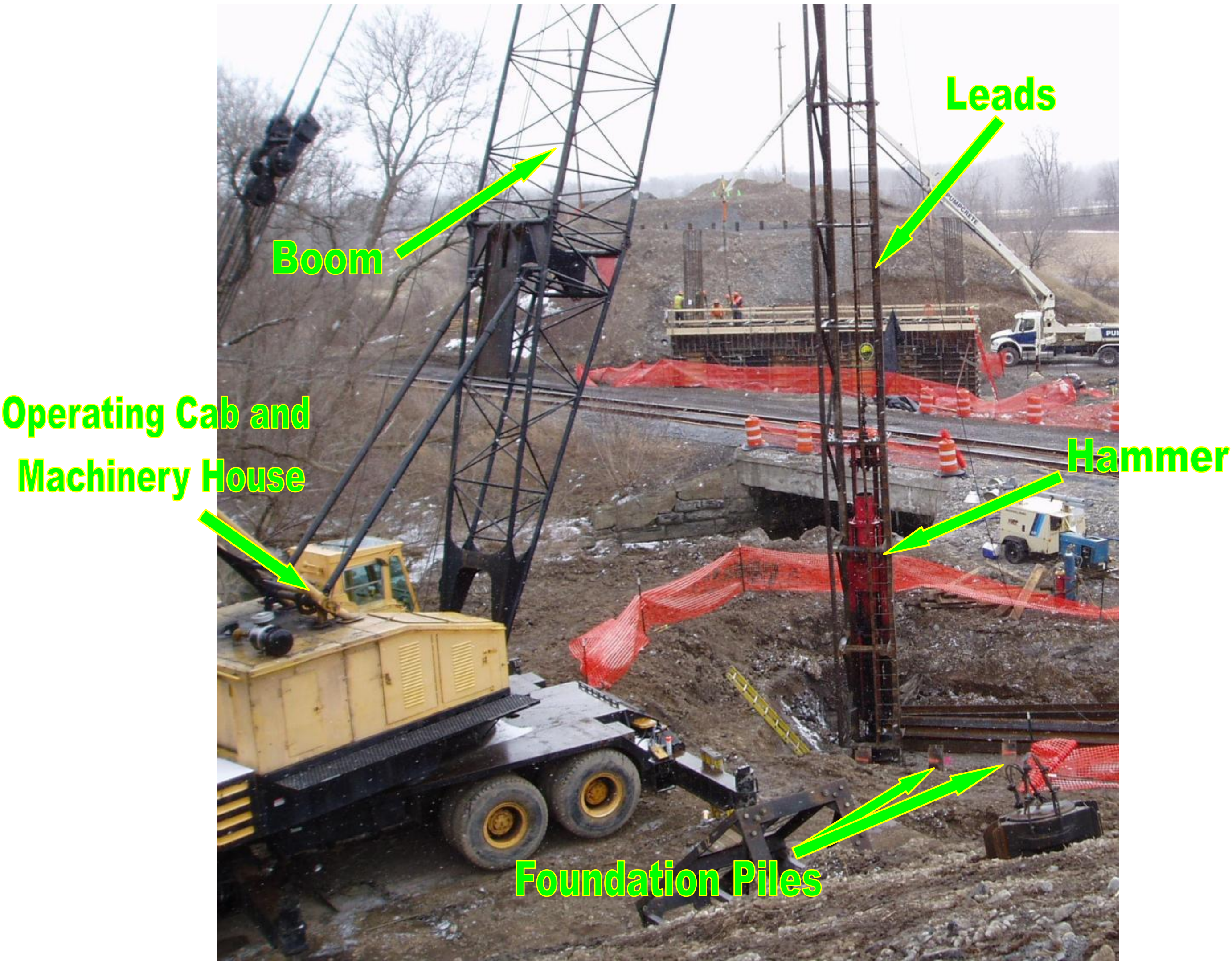
GEM-26

PILE DRIVING INSPECTION MANUAL



GEOTECHNICAL ENGINEERING MANUAL

GEM-26

Revision #1

AUGUST 2015

NEW YORK STATE OF OPPORTUNITY. | Department of Transportation | Office of Technical Services | Geotechnical Engineering Bureau

GEOTECHNICAL ENGINEERING MANUAL:
PILE DRIVING INSPECTION MANUAL

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STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

GEOTECHNICAL ENGINEERING BUREAU

AUGUST 2015

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1. INTRODUCTION

Piles are used to transfer loads to a deeper bearing strata, support structures on soil too weak for spread footings and/or protect against scour. Pile driving is unique in the construction industry, in that the machinery used to install the product is a vital part of inspecting and verifying the installation.

Piles are the starting point for the structure construction and provide the support. Therefore, piles that are installed properly are a good, sound start for making a strong and stable structure.

It is the purpose of this manual to convey to the inspector:

- A uniform method of pile inspection, including the long experience of the authors
- Information about piles and their installation
- Information about hammers and their inspection
- Use of forms and paperwork
- Methods of proper splicing
- A guide to the pile specifications

This manual also contains some background on dynamic testing and the use of the saximeter as an inspection tool.

2. PILES

Although piles are often referred to as being friction piles or end-bearing piles, it should be noted that most piles are a combination of both skin friction and end-bearing. Even an H-pile driven to rock will have some side friction, especially if the distance to rock is considerable. A pile driven in clay with no bearing layer has a small end-bearing and is primarily a friction pile. However, the vast majority of the piles that are driven into a granular soil have a distinct combination of skin friction and end-bearing.

Piles are made of steel, concrete or wood. Steel piles are accepted by certification of the materials. The latter two are inspected at the plant where the pile is fabricated, and are accepted by an on-site inspector. Copies of the certifications and inspection records must be available for verification by the installation inspector.

3. PILE TYPES

3.1 Cast-In-Place Piles

Cast-In-Place piles, or CIP's, are a pipe or shell driven into the ground primarily as a form to hold concrete. However, that casing serves as the means to transfer the loads to the soil. The distinction between a pipe and a shell is that the pipe can be driven on its own, while a shell is driven with a mandrel. Mandrel driven piles have not been used on a DOT project since 1973 therefore they will not be covered by this manual.

Figure 1 Cast-In-Place Pile Cross Section

In general practice, there are four types of pipe used for CIP's:

- Spiral welded pipe which is made by twisting a steel plate onto a cylindrical form and then welding the seam closed. Depending on the fabricator, the welding process is assisted by the use of a rod laid down on the seam.

- Butt welded or smooth pipe is fabricated by bending a plate into a tube and longitudinally welding it to itself. The weld is then ground and the pile is usually coated and looks like a smooth walled pipe.

- Monotube or fluted tapered piles are fabricated by taking a piece of sheet metal and cutting it on a bias, welding it together like a smooth wall pipe to make a cone and then putting it on a fluted mandrel and run through a press.

- Tapertube is a tapered pile. It consists of a twelve sided taper section fabricated by bending a steel plate into a series of twelve trapezoidal shapes creating a taper section. The shape is closed with one longitudinal weld. A conical tip is welded to the bottom and the top is worked into a circle to fit with a straight pipe pile.

These pipes are sized by their outside diameter, that is, as the wall becomes thicker the inside of the pile becomes smaller.

CIP's are a general purpose pile, used in all types of foundations from integral abutments to the largest of piers. They are probably the most commonly used piles in the Department.

They are used when obstacles are anticipated and the piles are not being driven to rock. They may be driven as friction piles in a clay soil, or as a combination of friction and end-bearing, or primarily end bearing on a hard bearing layer. Occasionally the end-bearing will be on a material that would not easily support an H-Pile.

3.2 H-Piles

These are hot rolled structural shapes. However, unlike most rolled shapes the webs and the flanges are the same thickness. This makes a member that can be driven without it twisting. They were originally called a Brainer Profile or BP. However, with time this was thought to stand for bearing pile. The steel industry then changed it to HP so as to promote them for other uses, such as friction piles when appropriate.

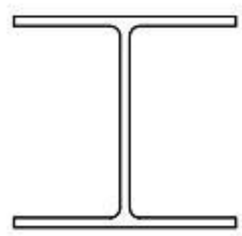

Figure 2 H-Pile Cross Section

They are primarily used as a bearing pile driven to rock. They are used when there are obstructions in the profile. When spans for an integral abutment are longer than 165 feet (50 m) then H-Piles are required for the foundation regardless of the soil profile. These piles can be designed as pure friction piles if required.

Depending on the type of material that the pile is driven into, the end bearing may be handled in one of two ways. In sands, especially in Long Island, and some silty soils, the end bearing is calculated using only the area of the steel. In other cases, the end bearing is calculated using an area defined by the product of the depth times the width. When this is used, it may be necessary to allow the pile to setup and the soil to develop a plug in the flanges.

3.3 Concrete Piles

Concrete piles in New York are precast and prestressed. The piles are cast in a pre-casting plant and then transported to the site. This creates a pile made of high quality concrete under controlled casting and curing conditions. The process is overseen by an inspector assigned to that plant.

The piles are prestressed to facilitate handling and driving. The longitudinal reinforcement is tensioned prior to the pile being cast. Typically the force is equivalent to 700 psi (4825 kPa). Once the concrete is set and the pile is ready to be moved, the force is released. This transfers this stress to the concrete as a compression force. It allows the concrete in the pile to take more tension, while being lifted, maneuvered, set and driven. The one limitation is that the concrete cannot take as much compression force during driving, since it is prestressed by 700 psi (4825 kPa).

These piles are primarily used on Long Island, along the south shore and out on the forks. There are three types of concrete piles used: Cylinders, squares and sheet piles. The first two are used where there are high moments and/or the piles will protrude out of the ground as columns. When this situation occurs, the pier is called a pile bent.

These piles require that they be handled with care, unlike the steel piles that can be dragged to the pile driver. These piles must be handled in accordance with lifting procedures in the shop drawings. The inspector should become familiar with the required procedures.

The main concern when driving these piles is not to overstress them. This can happen in tension with easy driving, where the bottom of the heavy pile wants to keep moving and tries to pull away from the rest of the pile. These problems are often taken care of by controlling the stroke and/or by proper care of the cushion. The cushion is placed between the pile and the hammer. It is typically wood, usually plywood. However, other woods have been used and laminates of wood and rubber have been fabricated for the purpose.

The cushion should be inspected after each pile is driven and replaced as necessary. Sometimes the hammer does not sit on the pile square and will deform the cushion. These cushions should be replaced immediately, as they will result in further misalignment and driving problems.

On Long Island projects it is common for these piles to be jetted into place and then set with a hammer. On upstate projects, the foundation soils are always remoldable silt or clay and the piles can be driven their whole length.

3.3.1 Cylinder Piles

The cylinder piles are commonly cast in the Bayshore yard in Maryland, and then barged and/or trucked to the site. The piles are cast in 16, 12 and 8 foot (4.8, 3.6, and 2.4 m) lengths. They have conduits cast in them to accept prestressing strands. The number of strands is determined by the loads and moments the piles must carry. Once the length of pile is established, segments are epoxied together and the strands are threaded the length of the pile, tensioned and then grouted into place.

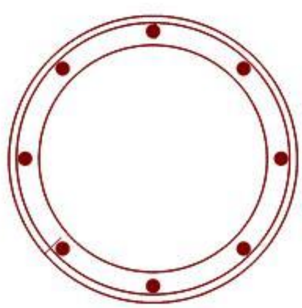

Figure 3 Cylinder Pile Cross Section

These piles have been used in upstate New York on occasion however they are more commonly used on projects along the south shore of Long Island. The cylinder piles are used as pile bents for viaducts from the mainland to the barrier islands.

3.3.2 Precast Piles

These bed cast piles are usually square in cross section. However, they can be octagonal or round. They can range in size from 12 inches (300 mm) to 24 inches (600 mm) in 2 inch (50 mm) steps. These piles can usually be fabricated by any pre-caster equipped with a large enough facility. The pile may be fabricated with an internal jet pipe. These piles typically have some form of tip treatment (see pile points). Like the cylinder pile these piles may be driven or jetted. These piles are usually cast as solid piles. However piles wider than 20 inches (500 mm) may have a void cast in the center to reduce weight.

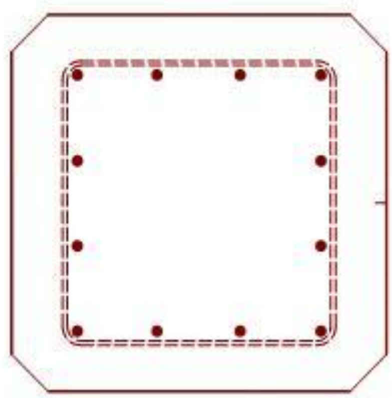

Figure 4 Precast Concrete Pile Cross Section

3.3.3 Sheet Piles

These are piles used for the same purpose as a steel sheet pile. They are used for corrosion and environmental concerns on Long Island. They are also bed cast piles, and may be fabricated with internal jet pipes. Sheet piles are used to form abutments of bridges over tidal inlets. If the opening is too large for a simple span then bed cast piles are used for bents to form the piers.

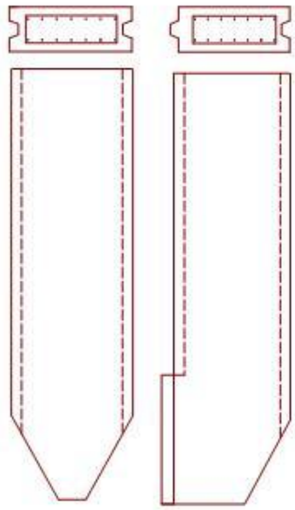

Figure 5 Sheet Pile Plan and Elevation

These piles are cast to fit together. There is a hexagonal interlock over half their length on one side and a mating groove on the other pile, creating a tongue and groove connection. The bottom of the pile has a corner cut at a 45 degree angle. The first pile placed in the center of the wall has a double bevel, and is referred to as the "king pile". The remaining piles are placed with the bevel away from the preceding pile. This causes the pile to be pushed toward the other pile and make a tight wall. They are always jetted into position and then set with a hammer, since the bevels on the bottom and the friction in the tongue and groove make driving almost impossible. These piles do not have any tip treatments.

3.4 Timber Piles

As the name implies these are wood piles. They are made from Southern Yellow pine and are treated with creosote or Cromated Copper Arsenate (CCA). The treatment is to prevent insect infestation. They are rarely used. Their primary use is in the support of various sewers and water mains across soft ground.

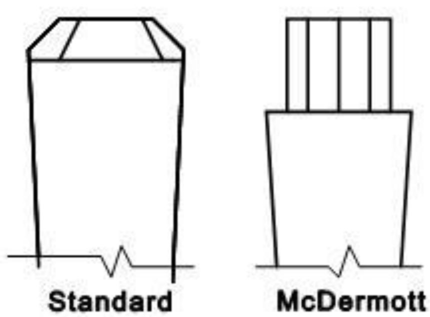

Figure 6 Timber Pile Elevation

When they are used the Contractor will drive test piles to determine a length, which becomes the ordered length for a given installation. These piles are then ordered; the timber is prepared and treated under the inspection of a Department inspector.

The biggest problems with timber piles are keeping them aligned and not overstressing them. Alignment can be handled by insisting that the Contractor use a drivehead that snugly fits the pile. The other method is if the Contractor uses what is call a McDermott base for the hammer, then the pile top is shaped to fit into the base. Overstressing of the toe is handled in part by using a shoe and sometimes by banding the bottom 5 feet (1.5 m) of the pile with steel bands. The bands restrict the expansion of the pile and restrain internal shear stresses. The bands are like the steel bands used for packing on palettes.

The toe and bands will most likely be handled in the design or when the hammer and pile are analyzed with the wave equation.

4. SPLICING PILES

Since piles are often longer than a length that is practical to handle and truck to the site, they need to be spliced. Splicing steel piles requires welding. All welding **must** be done by a NYSDOT certified Welder and performed in accordance with the NYSDOT Steel Construction Manual (NYSSCM).

The piece of the pile in the ground is referred to as the bottom. A Contractor may say "I am just driving bottoms today". The piece added onto the pile in the ground is, of course, referred to as the top.

The top of the bottom section should be cut square to the longitudinal axis of the pile. On a pipe pile, the Welder will use a strip around a round pile to make his mark and a carpenter's square to mark an H-Pile. If the bottom of a vertical pile is slightly out of plumb, do not allow it to be cut horizontally. The pile should be cut perpendicular to the longitudinal axis. Otherwise a "dog leg" or crook will be created in the pile. This reduces the transfer of energy to the toe and creates bending moments. This causes an erroneous increase in the blow count, without a commensurate increase in capacity.

4.1 Cast-In-Place Piles

Two pieces of pipe are spliced by various methods:

- The straight sided pipes are spliced by welding. The surface is then ground smooth. The bottom of the top section is beveled at 45 degrees and also ground smooth. The weld is setup using a back-up ring or chill ring, shown as option I. It is slightly spring loaded to fit different inside diameters. It has projections brazed on it, which provide space for the weld to be built-up. The ring is placed on the bottom section and then the top section is placed on the projections.

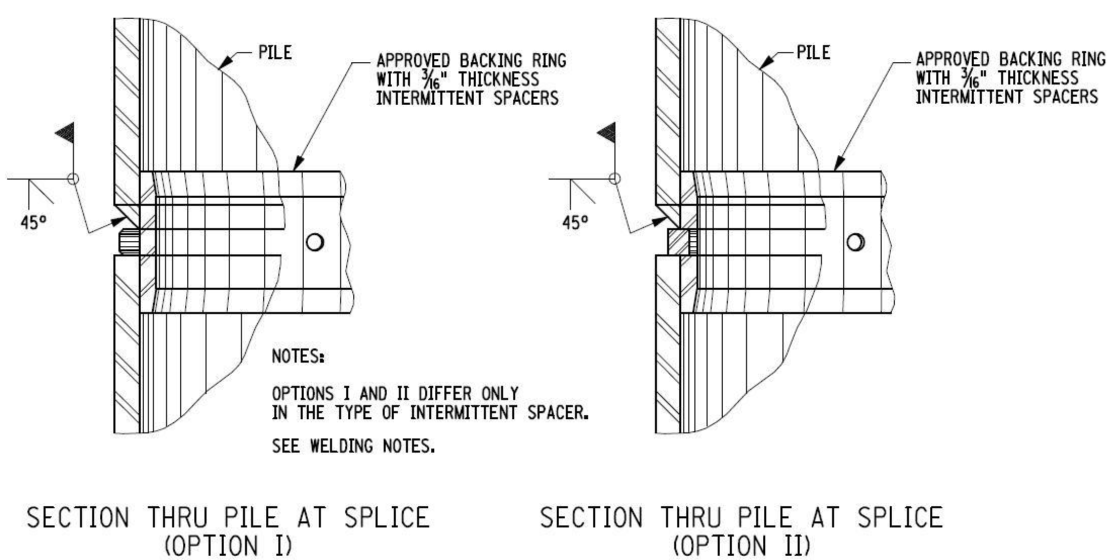

Figure 7 Cast-In-Place Pile Splice

Option II involves placing a smooth piece of sheet steel inside of the pile, then placing and tacking the spacers to the top of the bottom section. The inspector should make certain that the spacers are in place before allowing the top section to be set.

The pile is now ready to be spliced by placing as many passes of the weld as is necessary to fill the space with weldment. Care should be taken not to knock off the projections until sufficient weldment has been added to attach the two pieces. Once this is done the projections can be removed.

Diameter		**Wall Thickness**		**Prep (minutes)**	**Welding (minutes)**	**Total (minutes)**
inches	**mm**	**inches**	**mm**			
12.75	324	.188	5	1	3	4
		0.25	6	1	7	8
		0.344	9	1	10	11
		0.5	13	1	14	15
14	356	.188	5	1	4	5
		0.25	6	1	8	9
		0.344	9	1	11	12
		0.5	13	1	15	16
16	406	.188	5	2	4	6
		0.25	6	2	9	11
		0.344	9	2	13	15
		0.5	13	2	17	19

Table 1 Minimum Splicing Times for Cast-In-Place Piles

These piles may also be spliced using a splicing collar. This is a cast steel ring which tapers in from the top and bottom and has a ring in the middle to separate the top and bottom pile sections. It is designed to be a driven device, however, when they are used with spiral welded pipe a cusp develops, which causes a leak in the splice. Therefore, the Department requires that a seal weld be placed around the top and bottom of the sleeve.

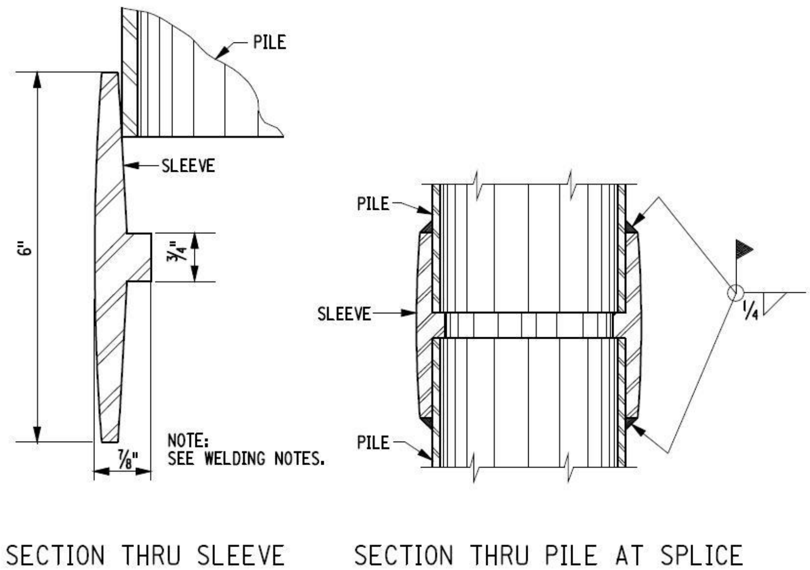

Figure 8 Cast-In-Place Pile Splice Collar

- The monotube pile is welded altogether differently. All monotube sections have a taper, even the straight sided ones. This is so that they can be nested together for transport, and it facilitates their being spliced in the field. The bottom section of the pile is prepared by cutting slits roughly 1 inch (25 mm) wide by 1 foot (0.3 m) long. These are bent out slightly to accept the top section. Once the top section is placed, fillet welds or brazing is placed along the edges of the slits.

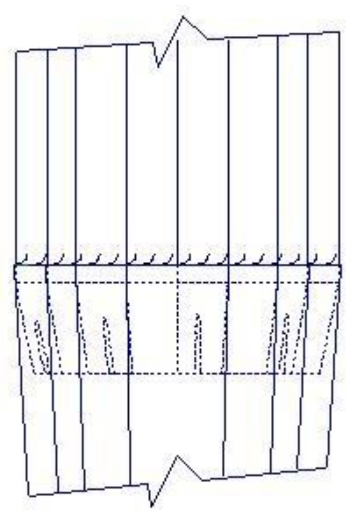

Figure 9 Monotube Pile Splice

4.2 H-Piles

These piles are spliced using a full penetration butt weld. The preparation of the piles is similar to the CIP. The top of the bottom section (in the ground) is squared and ground smooth and the bottom of the top section is bevelled at 45 degrees and ground smooth. Once the pile sections are prepared, the weldment is placed along both flanges and the web. The two access holes, or "rat holes", in the web adjacent to the flanges are left unfilled. The rat holes are needed for both methods of splicing. The splice is accomplished using one of two methods:

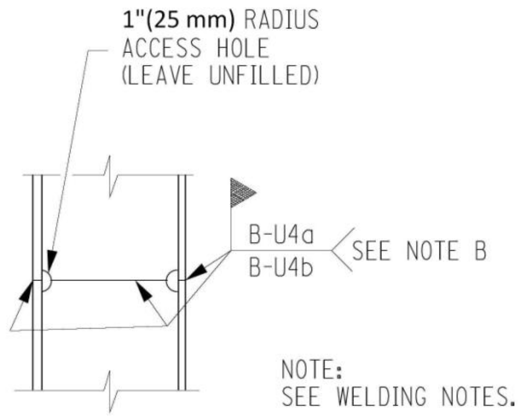

Figure 10 H-Pile Splice

- The backing plate method, shown as joint B-U4a, is performed by welding plates, usually cut from pile cut-offs on the bottom section. They are located on the sides adjacent to the point of the bevel. In addition some spacers are placed on the surface to hold the parts of the pile ¼ inch (6 mm) apart. The top is then placed and the area filled with weldment. With this method the rat holes are to allow the backing plate to be continuous along the flange.

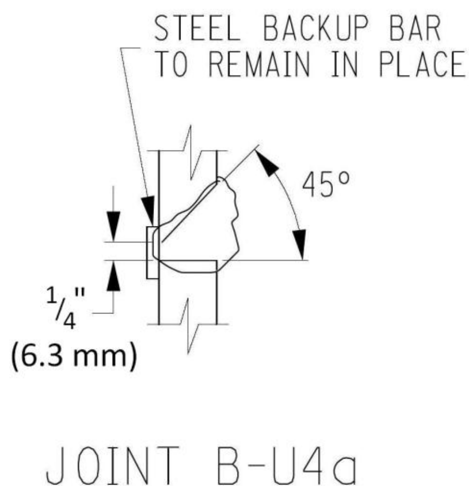

Figure 11 H-Pile Splice Backing Plate Method

Pile Size		Preparation (minutes)	Welding (minutes)	Total (minutes)
HP14x117	HP 360x174	10	65	75
HP14x73	HP360x108	10	32	42
HP12x84	HP310x125	8	36	44
HP12x53	HP310x79	8	21	29
HP10x57	HP250x85	5	25	30
HP10x42	HP250x62	5	15	20

Table 2 Minimum Splicing Times for Backing Plate Method

- The air carbon arc gouge method, shown as joint B-U4b, is performed by placing the top directly on the bottom. The area within the bevel is filled with weldment. Now the Welder changes rods and electrodes. The new rod is a hollow copper rod and the electrode is fitted with a connection to an air compressor. The work now moves to the side away from the weld. The Welder gouges out the pile material until at least ⅛ inch (3 mm) of the weldment from the other side appears. Once this is accomplished the gouged area is filled with weldment. With this method the access holes allow the completion of the weld along the entire flange.

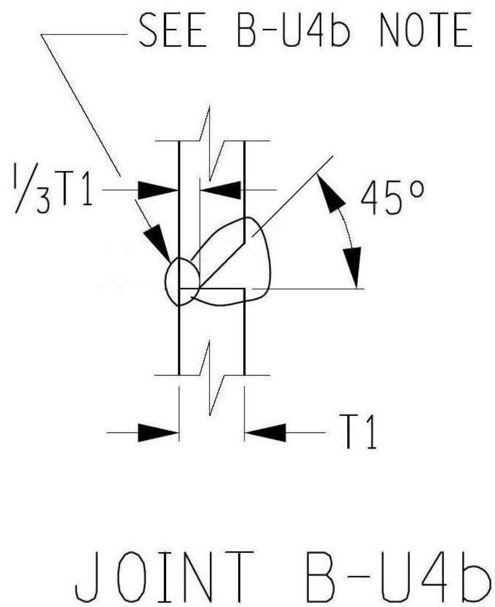

Figure 12 H-Pile Splice Air Carbon Arc Gouge Method

Pile Size		Preparation (minutes)	Welding (minutes)	Total (minutes)
HP14x117	HP 360x174	30	68	98
HP14x73	HP360x108	20	39	59
HP12x84	HP310x125	15	45	60
HP12x53	HP310x79	15	29	44
HP10x57	HP250x85	10	32	42
HP10x42	HP250x62	10	22	36

Table 3 Minimum Splicing Times for Air Carbon Arc Gouge Method

The Office of Structures allows the use of splicing sleeves for H-Piles on a case by case basis. The prefabricated sleeve consists of two U-shaped steel units with slight flares at the ends connected by a piece of steel. The piles are prepared as for the normal splice, except that the web of the top section is not beveled. A notch is cut in one piece or the other (usually the bottom section) to receive the connecting piece of metal. The sleeve is tapped in place with a sledge hammer and a fillet weld is placed along the short legs of the U adjacent to the flange. The top section is set and the weld continued along the flange of the top section. Then the two flanges are welded together filling the bevel space.

Figure 13 H-Pile Splice Sleeve

Pile Size		Preparation (minutes)	Welding (minutes)	Total (minutes)
HP14x117	HP 360x174	5	17	22
HP14x73	HP360x108	5	16	21
HP12x84	HP310x125	4	14	18
HP12x53	HP310x79	4	7	11
HP10x57	HP250x85	3	6	9
HP10x42	HP250x62	3	6	9

Table 4 Minimum Splicing Times for Splicer Sleeve Method

4.3 Precast Prestressed Concrete Piles

The only acceptable method of splicing at this time is the dowel and fluroc method. The bed cast pile is usually cast with eight 2 inch (50 mm) diameter holes in the top of the pile. These holes are 4 feet (1.2 m) long and are used to receive dowels which are cast in the bottom of the add-on section. Three of the dowels are 36 inches (900 mm), two are 42 inches (1060 mm) and three are 48 inches (1200 mm) long. The cylinder piles have a concrete plug cast into the inside of the cylinder with holes for receiving the dowels. In a like manner a plug with the dowels is cast into the cylinder of the add-on piece.

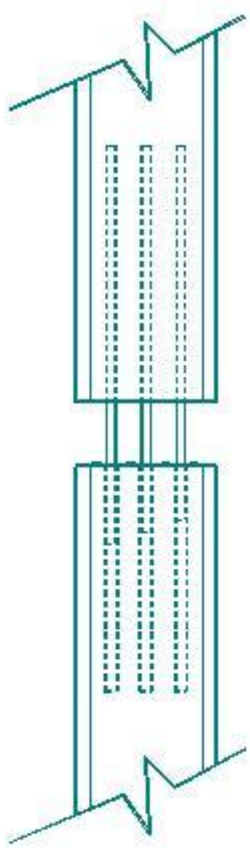

Figure 14 Precast Prestressed Concrete Pile Splice

Once the bottom is driven, the top is brought over and mated with the bottom. Often the dowels are 1 inch (25 mm) different in each of the rows. This makes the mating easier since only one dowel is being inserted at any one time. After all the dowels are in their holes spacers about ½ inch (12.5 mm) thick are placed on the top of the bottom section. This will keep the two pieces apart while the fluroc is placed.

Fluroc, or fluid rock, is like capping compound. It is heated and melted in a cauldron on the project. A form is placed around the pile and the liquid fluroc is poured into it. The fluid moves down into the holes around the dowels to bind them to the pile and then finally fill the ½ inch (12.5 mm) gap between the piles. Once the liquid is set then the pile driving is ready to resume.

4.4 Timber Piles

There is no acceptable method for splicing timber piles.

5. TOE TREATMENTS

5.1 Cast-In-Place Piles

Since these piles are designed to be a form for holding concrete they need to be closed at the end.

- Normally the toe treatment for these piles is a ¾ inch (19 mm) thick plate that is ½ inch (12.5 mm) wider than the outside diameter of the pile. These are fitted to the pile by a fillet weld around this ¼ inch (6.3 mm) shelf.

- However, in cases with occasional obstructions or when the bearing layer is dense, the toe is fitted with a conical point. These are usually cast steel and come in two types, male and female. The male type is more common and has a tapered ring around the top of the point. This can be a driven fit, but it is usually tack welded or fillet welded. The female type of point has a recess around the top that accepts the pile. The flange of the recess is then welded to the pile, much the same as a splice without the ring and spacers.

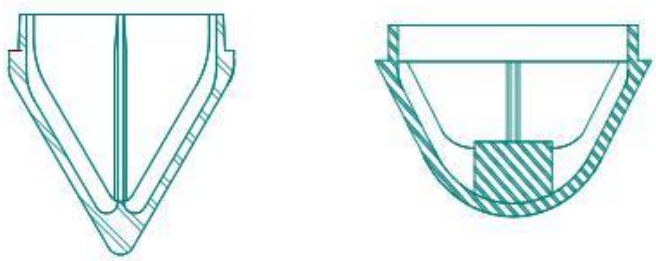

Figure 15 Cast-In-Place Pile Toe Treatments

- If the pile is being driven to rock the toe may be treated with a Buffalo Star point, which is a plate with two pieces of steel plate 2 inches (50 mm) thick fitted to it in the form of a cross.

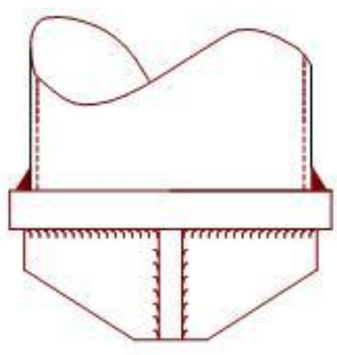

Figure 16 Cast-In-Place Pile Toe Treatment – Buffalo Star Point

5.2 Monotube Piles

These piles are fabricated with their own cast steel point, which is similar to the rounded point shown above. This is a factory applied point and will come attached to the pile. The only time that it will not be applied at the factory is if the Contractor is driving the monotube shell as a straight sided pile. This is very rare.

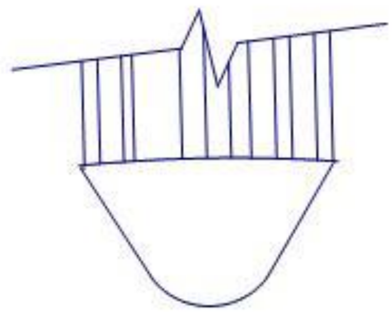

Figure 17 Monotube Pile Toe Treatment

5.3 H-Piles

Toe treatments for H-Piles can be either built-up with plates to reinforce the toe or a prefabricated cast steel toe welded on. They may range from almost flat to a 60 degree point along the flanges of the point. These are fitted to the pile by welding along the flanges. The pile flanges should be beveled at 45 degrees to accept the weldment.

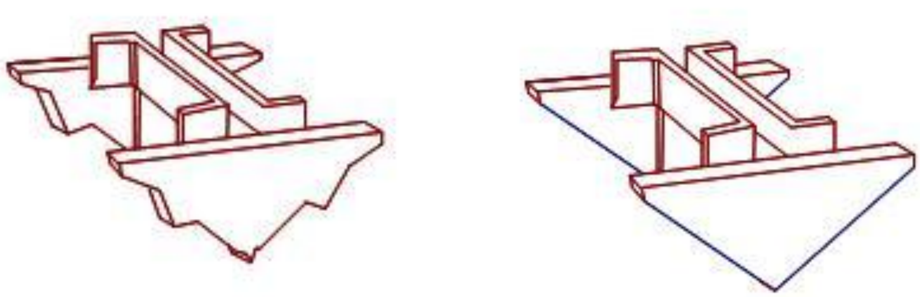

Figure 18 H-Pile Toe Treatments

5.4 Precast Prestressed Concrete Piles

The cylinder piles are driven open ended with no toe treatment used. The sheet piles are also cast with no toe treatment.

Toe treatments on the bed cast piles are either an embedded H-Pile or wide flange section. The embedded piece is called a stinger, and is there to protect the end of the pile and break up or push aside any obstructions. The end of the piece may be plain or have a tip treatment of its own.

In parts of Long Island where obstructions are unlikely and the piles are going to be jetted the pile toe is tapered over the last 4 feet (1.2 m). This helps improve the end bearing when the pile is seated by wedging the toe into the soil.

All of the bed cast piles may be cast with jet pipes inside to facilitate the jetting process.

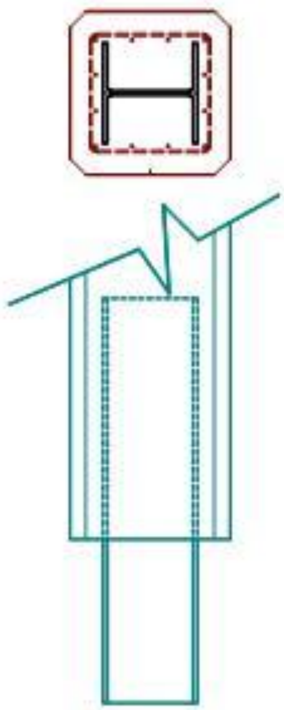

Figure 19 Precast Prestressed Concrete Pile Toe (Non)Treatment

5.5 Timber Piles

Timber piles may have either flat toes or pointed toes. In either case there are protective shoes.

Both shoes require that the toe be prepared to accept them, especially the pointed toe. The treatments are attached by spiking through the holes in the straps or the faces.

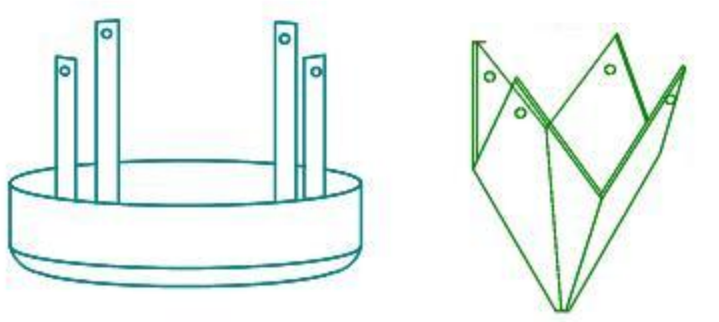

Figure 20 Timber Pile Toe Treatments

6. PILE COATINGS

Occasionally instances arise where the piles must be coated. Coatings are of two varieties: Bitumen and Epoxy.

6.1 Bitumen

The bitumen coatings are applied to the pile to mitigate downdrag on the pile. Downdrag is commonly caused by settlement of the surrounding soil. This can be common in situations where settlement takes place over a long time or where pile supported high abutments are used and the backfill settles after pile driving.

The coating is designed to create a slip layer between the settling soil and the pile material. Bitumen is used for this purpose since it has a high strain capability with little stress. The bitumen stretches between the pile and soil, like a piece of chewing gum.

The type of bitumen used will vary depending on the rate of settlement, the temperature at driving and the type of soil in the profile. All bitumens require that the pile be painted with a primer to help the bitumen stick. The type of primer will vary with the pile material.

6.2 Epoxy

Epoxies are applied usually as corrosion prevention. However they may be used on an exposed pile to enhance its visual impact. These coatings will usually be on the top parts of the piles and generally will be called for where the pile is carried out of the water as a pile bent.

6.3 Splicing with Coatings

Both coatings are often applied before the pile is driven. If the pile has to be spliced then the coatings are stopped about 1 foot (0.3 m) from the ends of the pile. These areas are then field coated after the splicing takes place.

7. PILE DRIVING HAMMERS

Hammers used in New York State are of three types: Air-Steam, Diesel and Hydraulic. The Air-Steam and Hydraulic are referred to as external combustion hammers. That is to say that their power sources are generated away from the hammer. The Air-Steam, as the name implies, is powered by either air from a compressor or by steam generated in an oil burning boiler. Hydraulic hammers are powered by hydraulic fluids that derive their power from electric pumps in an external power pack. The Diesels are internal combustion hammers, burning diesel fuel in the hammer cylinder itself.

7.1 Air-Steam Hammers

These hammers are of three different types: Single-acting, differential acting and double-acting. The air-steam hammer was an outgrowth of the steam driven rock hammer and the desire to automate the drop hammer used in pile driving.

In a single-acting hammer the ram is connected to a piston which is acted on by the fluid. When the ram rises to the proper height, the valve controlling the fluid is closed and the ram falls due to gravity. Generally this type of hammer works smoothly as long as it operates at a full stroke. However, if the stroke is shorter than specified the fluid does not evacuate the cylinder, is compressed by the falling piston and slows down the ram before impact occurs. These hammers have strokes ranging from 3 to 5.25 feet (0.9 to 1.6 m), most commonly 3 to 3.25 feet (0.9 to 1 m). They work at speeds of 60 blows per minute.

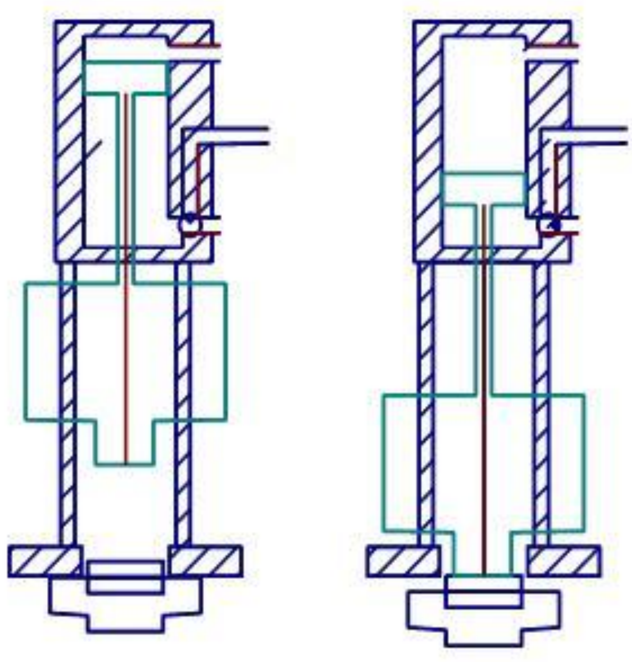

Figure 21 Single-Acting Air-Steam Hammer

The differential hammer is similar to single-acting. However, they are valved and constructed to work at half the stroke and twice the speed. The piston is constructed with the top surface larger than the bottom. The name of the hammer type comes from this difference in area. The ram is raised in the same manner. However, when the valve is tripped fluid is introduced to the top of the piston and forces the ram down with a higher velocity than a free fall. In addition the fluid from below the piston is passed to the top of the piston as it falls. In order for these hammers to work properly and deliver the correct energy they must operate at a speed close to that specified in the literature.

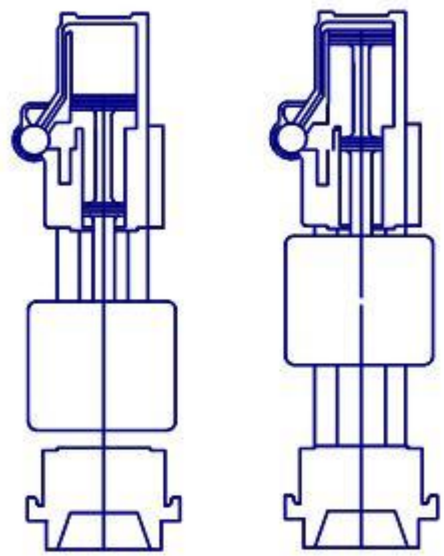

Figure 22 Differential Air-Steam Hammer

The double-acting hammer operates like the piston on a steam engine. The fluid raises the ram and then when the valve is tripped the fluid is applied to the top of the piston, while the fluid below the piston is forced out. These hammers also operate at more than twice the speed and less than half the stroke of a comparable single-acting hammer. Again these hammers must operate at their prescribed speed or they do not supply the correct energy. These hammers have a very high rate of fluid consumption. The literature specifies minimum outputs for the compressor or boiler in cubic feet per minute. It is essential that the proper size boiler or compressor is supplied for the hammer to operate properly. If they are undersized, then part way through the driving, the hammer will begin to skip or quit.

Starting these hammers is simple in that the operator opens a valve and admits the fluid to the chamber containing the piston. The piston rises and at some point a valve is tripped, which then changes or stops the flow and allows the ram to drop. In cold weather the initial raising of the ram may cause a displacement of condensation in the cylinder which will flow down on anyone below the hammer.

7.2 Diesel Hammers

These hammers also come in three types: Single-Acting, Double-Acting and Convertible. These hammers operate and generate energy in much the same way. The differences are more in the monitoring of the operation and inspection of the hammer.

The diesel hammer derives its energy from spontaneous combustion of diesel fuel in its combustion chamber. The hammer is initially started by lifting the ram between 3 and 5 feet (1 and 1.5 m) by the crane. It is then tripped, released, and allowed to fall. As it passes the exhaust port it begins compressing the air trapped in the lower part of the cylinder. It will then pass a cam, located in the side of the cylinder, which activates the fuel pump or injectors. Fuel is either dribbled or sprayed into the compressing air. As the ram strikes the impact block, the initial volume of air is compressed to a very small volume. This results in a large temperature and pressure increase. The fuel, which was vaporized on impact or was a vapor due to injection, is ignited. This creates a high pressure and a major volume expansion, which lifts the ram. This is what happens from a thermodynamic standpoint.

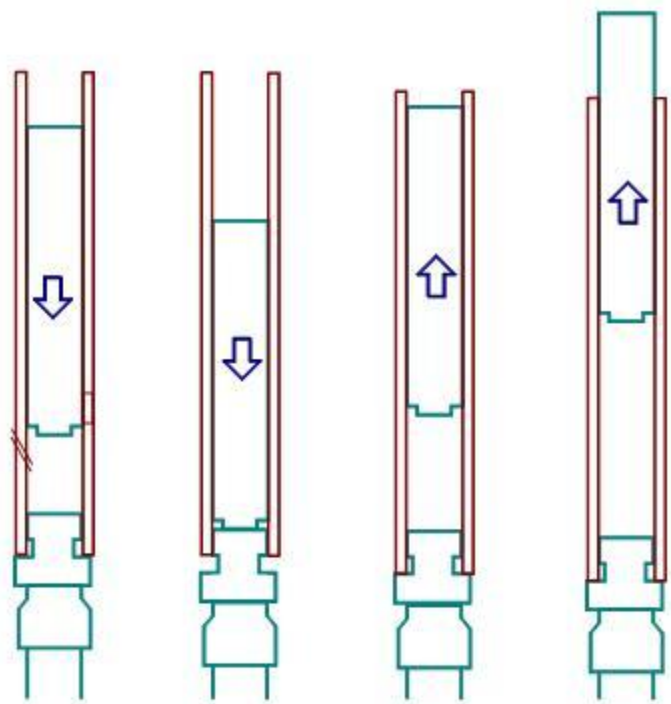

Figure 23 Diesel Hammer

Let us look at this process from the pile's point of view. The pile feels a slight unloading as the ram is raised. Then when the ram passes the exhaust ports and begins the compression of the air, the pile reacts against this pressure with a force equal to that of pressure times the area of the impact block. This generates a slight force and compression in the pile. The next event is the impact, which does the major work in moving the pile. After one or two milliseconds the explosion takes place. This helps to maintain the momentum of the movement started by the impact. The ram then begins its ascent while being pushed by the expanding gases, which produces a pressure acting on the pile and continuing to help move the pile downward.

BPM	Stroke (ft.)	BPM	Stroke (ft.)	BPM	Stroke (ft.)	BPM	Stroke (ft.)	BPM	Stroke (ft.)
31	14.73	37	10.24	43	7.51	49	5.71	55	4.46
32	13.81	38	9.71	44	7.15	50	5.48	56	4.30
33	12.96	39	9.19	45	6.82	51	5.25	57	4.13
34	12.20	40	8.73	46	6.53	52	5.05	58	4.00
35	11.48	41	8.30	47	6.23	53	4.86	59	3.81
36	10.86	42	7.87	48	5.97	54	4.66	60	3.71

Table 5 Stroke versus Blows per Minute

The height to which the ram will rise in all hammer types is a function of the amount of fuel used in the explosion and the stiffness of the pile that the hammer is driving. The stiffness is a function of the pile type, pile length and the soil into which it is being driven. The difference in the three types of hammers is what happens as the ram rebounds from the explosion. In the single-acting hammer, the ram rebounds and falls back while acting against and with gravity. The stroke of these hammers can be equated to the period, or (time it takes for a round trip), or its rate of operation in blows per minute.

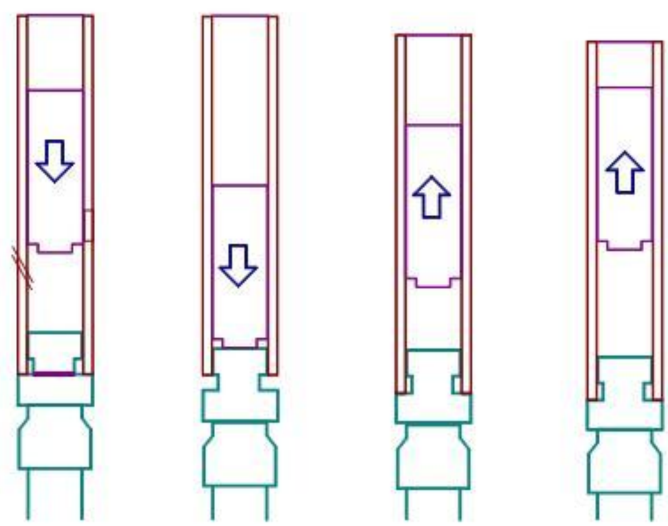

Figure 24 Rise in Ram Height

At one time MKT marketed a convertible hammer, but they are rarely used any more. Convertible hammers are similar as they began as single-acting hammers and can be used as a single-acting hammer. However, the manufacturer (MKT) added a gasketed-plate to the top of the barrel, which is equipped with a safety valve. As the ram rebounds it compresses the air trapped in the barrel. This works to slow down the ram’s ascent and generates a force to accelerate the ram back down faster than under gravity. The energy of these hammers is related to a small piston mounted on the side of the hammer, which measures the pressure of the air in

the top of the hammer. If the hammer is working near its maximum energy this will work well, however at low strokes the piston on the gage will not be activated.

The double-acting hammers work similarly to the closed convertible. However, these hammers were designed to operate in the double-acting mode. The stroke is short enough that the ram always engages the air in the bounce chamber. In fact the workings are geared in such a way that the hammer works at nearly a constant rate, regardless of the energy level. The bounce chambers of these hammers are equipped with quick connect hoses that are connected to a pressure gage on the ground. If the gage is not connected, the hammer is not complete and <u>should not be used to drive piles</u>. The gage could be as far away as the yard or as close as the cab, either way it should be connected to the hammer for your inspection and monitoring.

These hammers are typically started by the crane mechanically lifting the ram about 5 feet (1.5 m). Then a trip releases the ram to fall and start the hammer working. However, if there is not enough resistance in the pile-soil system the ram does not rebound sufficiently and the hammer will stall. In cold weather the temperatures may not be conducive to the hammer operating. If this happens then the hammer exhaust pores will be sprayed with ether, which is sucked in when the ram is raised, to promote combustion.

7.3 Hydraulic Hammers

Hydraulic hammers are becoming more popular as a more environmentally friendly hammer. These hammers also come in three types of operation: Single-Acting, Double-Acting and Double-Acting with nitrogen assist. These hammers have hydraulic fluid under pressure from an external power pack as their motive fluid.

The Single-Acting hammer uses the fluid to raise the ram and then allowing it to free fall, or as near to free fall as the escaping fluid will allow. The stroke of this hammer can be controlled, from as small as 6 inches (150 mm) to the maximum stroke. This makes them ideal for use in easy driving situations to avoid pile runs or tensile stresses. The stroke is controlled by the operator on the ground or by the crane operator in the cab. They limit the volume of the fluid supplied which limits the rise of the ram. Another advantage is the repeatability of the stroke and therefore the energy delivered.

The Double-Acting hammer works similar to the double-acting steam hammer. The fluid is used to raise the ram and then the fluid is used under pressure to accelerate the ram down faster than in a free fall. Some of these hammers are equipped with a container of nitrogen gas in a bounce chamber at the top of hammer. This works much like the double-acting diesel. As the ram is forced up by the fluid and its own inertia the gas is compressed slowing the ram and storing some of the energy. This pressure then helps in accelerating the ram back down again.

These hammers are typically closed and the ram cannot be seen. Therefore these hammers are equipped with sensor switches which measure the impact velocity. This information is used to calculate the kinetic energy. This information is sent electronically to the control panel, where it may be displayed, printed and/or stored for a final report.

The single-acting is the hammer most likely used on State jobs. The double-acting hammers are more likely to be used on off shore or near shore type projects.

These hammers are simple enough in their operation. The operator turns on the pump and the operation starts. Of course in cold weather things may be a little slow until the fluid warms up, but this is relatively quick.

7.4 Vibratory Hammers

These hammers have been used to initially drive piles on State jobs, but the piles are driven with an impact hammer to verify capacity. Work is progressing on ways to monitor these hammers for driving production piles home.

This hammer is also driven with hydraulic fluid from an external power pack. They have hydraulic motors which drive eccentrically suspended weights. These weights, as they turn, create the vibration sideways and the driving force as they come down together. The hammer is attached to the pile by hydraulically activated clamps. In addition static weights are added above and isolated from the vibrator to give the hammer mass for driving.

These hammers progress the pile by finding a frequency that excites the soil and vibrates it out of the way allowing the pile to fall under the two weights in the hammer and its own weight.

To inspect these hammers, for research purposes only until further notice, record the rate of penetration in seconds per foot (seconds per decimeter), the frequency, the horsepower and the pressure supplied to the hammer. The last three are variables obtained from the operator.

Like the hydraulic hammer this starts relatively easy. However, since the hammer must go through a vast combination of power settings and frequencies to reach the optimum operating combination, the hammer and pile can create severe ground vibrations as the hammer starts. This phenomenon cannot be avoided, but should be minimized where possible.

7.5 Capblocks

Most hammers have capblocks or hammer cushions, but some hammers are engineered so that the cushion is not needed. The capblock is there to protect the hammer during impact and to some extent protect the pile. It does this by absorbing some of the energy and lengthening the amount of time the impact takes to occur. The energy that the cushion absorbs is converted to heat. This cushion is housed in the drivehead in what is called the "fire pot". It received its name from the fact that early capblocks were wood and often caught fire. In the last thirty years or so, the cushions have evolved into an engineered material, designed both to soften the impact while at the same time transmit as much of the energy as possible. The main part of their job is to control the heat; some materials are designed to do this on their own while others are layered with materials such as aluminum to manage the heat.

Material	Description
Micarta*	Layers of canvas impregnated with a phenol resin 1 to 2 inches (25 to 50 mm) thick brown in color, smooth and shiny on top and bottom and rough on the edges.
Conbest*	Layers of canvas impregnated with a phenol resin 1 to 2 inches (25 to 50 mm) thick brown in color, smooth and shiny on top and bottom and rough on the edges.
Conbest PSH	Layers of canvas and aluminum grids with phenol resins
Conbest II	Polyamide material
Hamortex	Layers of paper and aluminum rolled tightly together, grey in color, typically 2 inches (50 mm) thick.
Force10	Braided wire rolled tightly together and bound with metal straps 1 inch (25 mm) thick.
Urethane	Typically a blue plastic with high strength and heat resistance 2 inches (50 mm) thick
Nylon	Typically a blue plastic with high strength and heat resistance 2 inches (50 mm) thick
Wire Rope Donuts	Crane cables twisted into circles - unreliable cushions and are not used.
Duracush	Asbestos impregnated with resins – not allowed because of asbestos

* Typically layered with aluminum plates for dissipating heat.

Table 6 Common Capblock Materials

8. PILE DRIVING LEADS

Leads are used in conjunction with a crane to support the hammer and the pile, helping to keep them in proper location and alignment. The crane is usually fitted with a minimum of three lines; one for the boom, one for lighter lifting that is referred to as the number one line, and one for heavier lifting that is referred to as the number two line. Traditionally, the one line is a single part line. That is, it comes off the drum on the crane up the boom and over a sheave. The two line is a two part line, it goes over the top sheave and then around another sheave either on a hook or the top of the hammer and back to the masthead.

8.1 Types of Leads

Pile driving leads come in two varieties: box leads and European or H-Pile leads. Box leads are the most common in the State. They are roughly 3 feet (1 m) square in plan. The main members are square tubular steel sections, welded together and diagonally braced with angles. They are open on one side to accept the hammer. This side is called the jaws. The width of this opening varies from 26 to 34 inches (660 to 860 mm). The hammer is fitted with guides that run in this opening. Sometimes the opening is too wide for the hammer and a hair pin follower will be placed over the hammer to make up the difference. These leads may also have a rail on the outside to allow the attachment of an auger or jetting tool.

The second type of lead is an H-Pile, also referred to as a European lead or a monkey stick. These are not necessarily for driving H-piles, but rather are often fabricated out of H-Piles or wide-flange sections. They may also be made out of round tubular steel members, of various sizes to make up the main members and cross bracing. On these leads the hammers are connected by brackets at the rear of the hammer and ride on the front of the leads. Figure 26 is configured with a European Lead.

8.2 Types of Fixity

Leads can have four types of fixity: free swinging, semi-fixed, fixed and articulated. Upstate, the most common are free swinging leads. While downstate, where there is more wharf work, the leads tend to be of the fixed variety. There are very few instances where there are semi-fixed leads.

Swinging leads are hung from the number one line of the crane. They are fitted with a tapered section at the top with an eye for attaching the line. At the bottom they are fitted with points for stabbing into the ground, to maintain their location. These leads are the shortest of the three varieties since they must fit under the crane. Sometimes the Contractor will fabricate a gate at the bottom of the leads to maintain the location of the pile. This may be an arrangement with hinges and angles, or it may be as simple as a couple of blocks. If the crane has only two lines then a short line off of the hammer is used to pick the piles. Therefore, the entire system is brought to the stack of piles. However, if the crane has a spare line then picking can be accomplished from greater distances. Regardless both methods usually involve rotating the crane.

Semi-fixed leads are connected to the masthead of the crane. This requires a special masthead section with an eye for attaching the leads and special sheaves for redirecting some of the lines. The connection allows the leads to swing in and out and from side to side. Sometimes the connection allows the leads to slide up and down relative to the connection. With this type of connection the one line is attached to the bottom of the leads. These leads can be longer or used with a shorter mast than a set of free swinging leads.

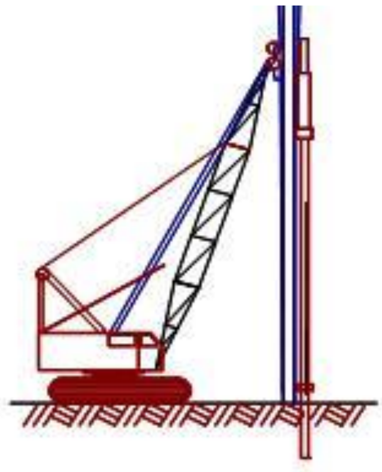

Figure 25 Semi Fixed Lead

Fixed leads are also connected at the masthead with the same kind of special section only this time the connection does not allow the movement up and down. These leads are also connected to the crane by a kicker brace or spotter. This is connected at or near the bottom of the leads and at the base of the crane. This brace has a capability to telescope depending on the length of the leads, and a system of pulleys and an endless cable wound around a winch to allow adjustments to align the leads over the pile location. The winch is usually run with the same air or steam used for the hammer. It is usually electric with diesel hammers. This type of lead frees up the one line for lifting and bringing piles to the rig.

Figure 26 Fixed Lead

The articulated rig is rare in the State. It looks like a fixed lead rig except that the connection at the masthead and the kicker allow the vertical movement of a semi-fixed lead. The kicker brace also has a certain amount of ability to move to the side, which allows driving a side batter. There are gates at the base of the leads to accept the pile and hold it in place. There is also a mechanical monkey that rides up the leads to align the pile with the hammer, without the need for a "human monkey". With these leads the Contractor achieves the fixity of fixed leads. However, with ability to slide the leads up and down he gains the mobility of swinging leads. This type of rig allows the operator to pick a pile, set it in the leads and then place the leads and pile on the peg.

Figure 27 Articulating Lead

8.3 Free Hammer

On some projects the use of leads is not practical. In these cases a template is used to locate the pile and then the pile is driven with a free hammer. A free hammer is usually set in a short length of box leads. The leads are equipped with a "mechanical monkey" or gate, this helps align the hammer with the pile.

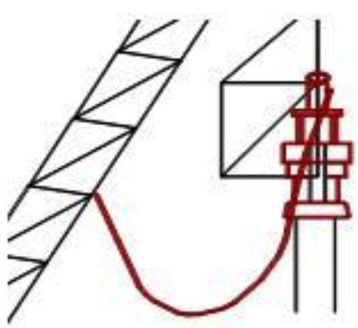

Figure 28 Free Hammer

9. METHODS OF STARTING PILES

This section could also be called dealing with obstructions. Normally piles are spotted on their location in the foundation and hammered into the ground. Occasionally, depending on the situation and the type of piles some initial work needs to be done before the driving can take place.

9.1 Spudding

This is a method of making a hole to place the pile. It is usually used where obstructions or consolidated material is impeding the proper installation of the piles. The spud can be any type of heavy section, either H-Pile or a pipe. The H-Pile is likely to have a point cut on the end and possibly some reinforcing plates. A pipe section may have a conical point or it may have a cutting edge burned onto it. The type of point is determined by the type of obstruction. If it is a boulder that might be pushed out of the way, then the conical end would be use. But if the obstruction is timber, then cutting through it would be the strategy. The pipes are usually larger in diameter and have a heavier wall than the pile being driven.

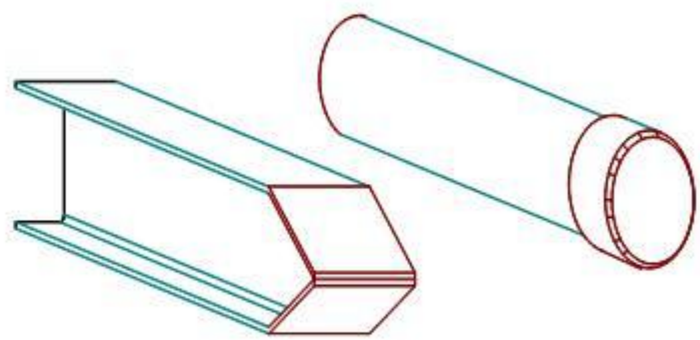

Figure 29 Spuds

It is often difficult to remove a spud once it is driven without the right kind of pile driver. If the Contractor is using a fixed lead rig then it is possible to work on the spud by pushing and pulling by working the spotter in and out, and side to side using the crane. This will work it loose. Otherwise the only solution is to extract it with a vibratory hammer or an extractor.

9.2 Augers

Augers are used to make a hole in which to put the pile. The hole may be in hard material in order to advance the pile, it may be to place loose material in the case of an integral abutment or it might be to relieve pore pressure to prevent heaving. Augers are either mounted on their own rig or they are mounted on a rail on the side of the leads. Augers can be continuous flight augers, a flight auger on a Kelly bar or they can be a bit on a Kelly bar. Most of the time they are driven by a hydraulic motor, but some larger augers, especially those on their own rig, may be driven by a diesel engine.

A continuous flight auger is as the name implies a long continuous screw. These can be single helix or double helix augers, depending on the types of soils encountered. These augers are usually run into the ground to the desired depth and then pulled out with the soil in the flights. They are fastened to the side of the leads usually by means of a rail. The auger is driven from the top using either air or hydraulic fluid to run the motor.

Figure 30 Continuous Flight Auger

A single flight is a short section of auger attached to a Kelly bar. A Kelly bar is a heavy square hollow center bar used in large scale drilling to move tools up and down the hole. These augers are used more like spoons, where the auger goes into the hole until the flight is full and then the auger is removed and cleaned and returned to the hole for another load. These augers are used in any type of soil. In granular soils a casing may have to be used to keep the hole open.

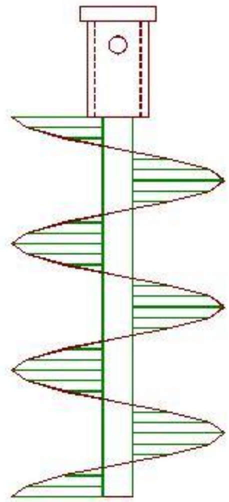

Figure 31 Single Flight Auger

The Kelly bar is usually driven by a large motor attached to the kicker brace. It turns a table that engages the square bar and acts as the guide for the bar and the auger.

Another type of auger used in more cohesive soil is a fishtail or chopping bit. It is a flat plate with the bottom edges bent out slightly. The bending is in opposite directions on either side of the Kelly bar. This bit is used with water forced through the hollow stem of the Kelly bar. The bends help chop up the soil and divert the flow of water outward. This leaves a hole full of slurry material to be displaced upward by the pile. This leads us to the use of water in the installation of a pile.

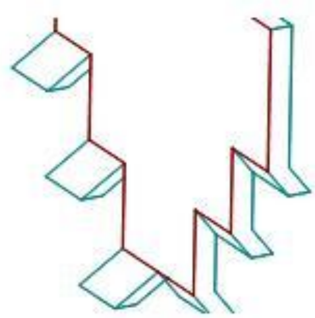

Figure 32 Fishtail Auger

9.3 Jetting

Jetting may be used in special instances <u>and only with written permission</u> to start a pile. It is used quite often while installing concrete piles. When installing cylinder piles in sand, jets are fastened to the sides of the piles in pairs and attached to a yoke for lifting. When driving square piles often the jet is cast internally and exits the center of the pile bottom. These jets are pipes

typically 2 inches (50 mm) in diameter and taper down in the last foot (0.3 m) to a diameter of 1 to 1-3/16 inches (25 to 30 mm) at the exit point to increase the pressure as the water comes out. They are typically used in sandy soils and loosen the soil causing quick condition that allows the pile to sink under its own weight. These piles are then driven 3 to 6 feet (1 to 1.8 m) in order to seat them in the soil.

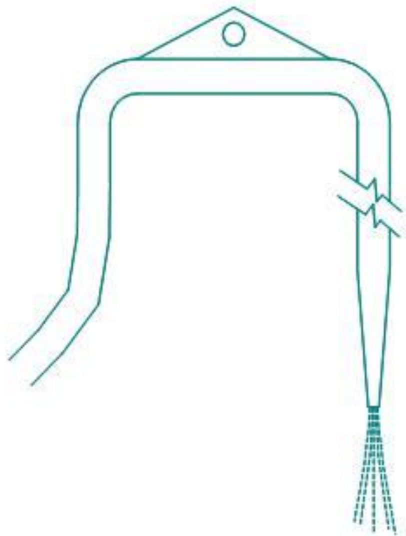

Figure 33 Jet

Another jet that is used in hard silts is about 4 inches (100 mm) in diameter and has a taper about 3 feet (1 m) long to a 2 inch (50 mm) tip diameter. Along the length of the taper are ½ inch (12.5 mm) holes that "squirt" high pressure jets of water to the side to loosen the soil and make a slurry. In other words it works like a water jet chopping bit. The pile is then placed in the loosened soil.

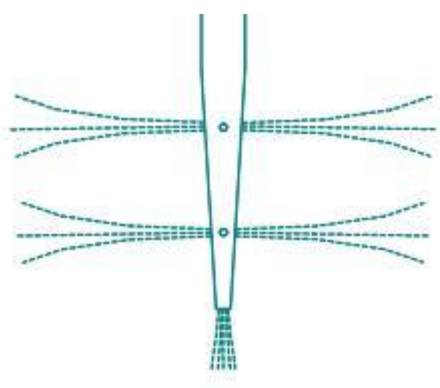

Figure 34 Jet

10. PILE TESTING

10.1 Dynamic Pile Testing

Dynamic Testing is performed by representatives from the Geotechnical Engineering Bureau in Albany. It consists of instrumenting the pile with strain transducers and accelerometers, which are bolted to the pile. The output from the strain transducers is used to calculate force in the pile. The output from the accelerometers is used to obtain velocity and displacements. These instruments are connected to a computer which reduces the data and calculates pile capacities and stresses for each impact of the pile driving hammer.

This testing can be used for determining the pile capacity, monitoring stresses, monitoring hammer performance and determining if the pile has been damaged. Some of these quantities are direct measurements, some are calculated values based on the measured quantities and others are inferred from the data.

The most common use of the test is predicting the capacity of the pile. This is the capacity at the time it is being struck. Therefore, it may be necessary to restrike the pile after a waiting period to allow the pile-soil system to setup.

Since the transducers measure strain, the force and the stress in the pile can be calculated at the point the instruments are attached. By using wave mechanics the force at the mid point of the pile and the toe of the pile may be calculated. The tensile force at the mid point of the pile is critical in the initial easy driving of concrete piles. Excessive forces at this point may require short stroking the hammer or increasing the thickness of the pile cushioning material. Forces at the toe of the pile may become a problem during hard driving on a stiff bearing layer. This is most likely during installation of high capacity CIP's.

The energy transmitted by the pile driver can be calculated. The velocity and capblock stiffness can be calculated for air/steam hammers. By monitoring the force prior to and during the impact of diesel hammers, it is possible to detect pre-ignition.

Since tensile cracks in concrete piles reflect forces transmitted down the pile, they can be detected. Damaged pile toes on a CIP will result in the signals returning to the instruments at the wrong time and with the wrong signature. Therefore, it is possible to predict that the toe is damaged.

10.2 Static Load Tests

These are tests where weights or reactions are constructed over a pile and then loading is applied with a hydraulic jack. There are two types of these tests: the maintained load test and the quick or constant-rate-of-penetration test.

The maintained load is usually a proof test to determine that the pile can safely support the design load with a safety factor. These are tests that normally take a number of days to complete depending on the specification that is used. The criteria for these tests are usually settlement

criteria. These type of tests are uncommon on DOT jobs, except in some metropolitan areas where a building code has to be satisfied.

The Quick Test or Constant-Rate-Of-Penetration Test is the more commonly performed test. These tests are performed to the failure of the pile-soil system. Although reference is made to the pile failing, it is the pile-soil system that fails. That is the support for the pile fails, not the structural element, and the system heals itself and supports the design load for the pile. The two tests are similar but are controlled in a different manner. The Quick Test is a stress controlled test in which the loads are applied in increments and the deflection are measured. The Constant-Rate-Of-Penetration Test is a strain controlled test where the rate at which the pile penetrates the soil, in millimeters per minute, is controlled. The deflection and the load to produce it are recorded. These are the more informative of the tests for the foundation engineer, since they tell them how much the pile can hold.

11. SAFETY

Safety cannot be stressed enough when it comes to pile driving, considering the weight of the equipment and piles regularly being moved around. Pile driving requires the most acute alertness. To put some of this into perspective we are including some charts of accident statistics compiled in Europe.

Figure 35 Location of Accidents

The location and causes of accidents certainly tell their own story. It is not hard to imagine that the falls on level ground are more than likely attributed to avoiding accidents in the moving machine and object categories.

Figure 36 Causes of Accidents

Safety for the inspector encompasses two areas, safety compliance by the Contractor and personal safety.

11.1 Contractor Compliance

Compliance is covered by MURK Part 1C Safety and Health Program Manual. The inspector should become familiar with this document particularly:

Section I.E.2 Construction Inspector’s Responsibilities
Section II.A.1 Comprehensive Project Specific Safety and Health Plan

Also, when applicable:

Sections II.A.3 Overhead and Underground Utility Plan
Sections II.A.4 Railroad Safety Plan
Section II.A.7 Fall Protection Plan

11.2 Personal Safety

Personal Safety is covered in the Construction Division, Health and Safety Handbook. The inspector should be familiar with this publication. They should become very familiar with:

Section I	Introduction
Section II.1	Hard Hats and High Visibility Apparel
Section II.2	Work Clothing Guidelines
Section II.3	Hearing Protection
Section II.4	Eye Protection
Section II.5e	Cold Weather Operations
Section III.6	Trenching and Excavation
Section III.9	Electrical Safety
Section III.11	Working Near Railroads
Section III.12	Working Over or Near Water

There is, of course, the obvious equipment: Hard hat, hearing protection and orange clothing. This can be a shirt, vest or coat, but the more visible you are the better. Hearing protection is available as soft plugs or "Mickey Mouse Ears" attached to your hard hat. The latter is definitely the preferred, for day in and day out operations.

Other devices to be considered for special circumstances are life jackets, for water work, and eye protection. Eye protection may be needed depending on the type of hammer, capblock and pile used. Concrete piles can spall and the cushioning material can break down throwing out particles. Air/Steam hammers are lubricated by line oilers, and therefore, the exhaust has oil drops in it. Depending on the construction of the capblocks, these hammers can spew pieces of deteriorated capblock cushion. Diesel hammers, depending upon their state of repair, can be oily and smoky. All of these situations can present a need for eye protection. Another consideration is flash reflection from welding. This is best protected against by being somewhere else or using goggles when you are unavoidably close to these operations.

Position is another consideration in the safety of the pile inspector. The pile inspector should find a location upwind from the hammer. The reason for staying upwind is rather obvious for many of the reasons outlined in the eye protection section above, not to mention the state of your paperwork.

Inspectors should not stand directly in front of the hammer. Not standing in front of the hammer is good advice on any job but especially timber pile jobs where piles can buckle in the middle and fall out of the leads. Timber piles can effectively explode. Timber piles in New York are usually creosoted and these piles can excrete the creosote and spew it into the air. Creosote will burn the skin. Concrete piles can have spalls that may fall. The hammers or the leads can have things that will come loose and they will most likely fall near the hammer.

Frozen ice and snow may be attached to the pile and become dislodged during driving. The inspector should endeavor to stand as far as practical away from the pile and still see the markings to count the penetration rate.

One of the most dangerous of times for the inspector is between piles when they are changing their paperwork; finishing one pile record and starting another pile record. This is when the rig is the most active, retrieving a new pile and setting up on the next location. This is when the inspector needs to be the most alert for their personal safety. If you can leave the area completely, that is recommended. Get out of harm’s way and if necessary have the operation stopped temporarily until you can do so. If the site is an excavation, work with one eye on the paperwork and the other on the rig and crew and what they are doing.

12. PILE INSPECTION

Knowledgeable supervision and inspection play a very important role in the proper installation of pile foundations. The inspection of pile driving operations deals not only with the pile driving equipment and properties of pile material(s) but also with the properties of soils. Inspectors assigned to pile driving operations should be able to:

- ✓ Identify the key elements of the pile installation plan;
- ✓ Identify the characteristics of the soil to be penetrated and have a working knowledge of soil classification;
- ✓ Recognize and identify pile-driving system components and tools;
- ✓ Verify tip elevations, cutoff elevations, pile penetration, and length driven for vertical and battered piles;
- ✓ Perform inspection of pile-driving operations and verify compliance with construction tolerances;
- ✓ Recognize when to stop driving based upon provided driving criteria, minimum tip or penetration, and refusal guidelines;
- ✓ Verify pile condition, labeling, and marking for compliance;
- ✓ Recognize and explain the difference between test piles and production piles and the various types of pile testing;
- ✓ Identify "driving" irregularities;
- ✓ Identify and document pay quantities.

The Inspector assigned to a pile driving operation must determine the acceptability of the pile before it is placed in the leads, observe the performance of the pile driving hammer, determine when pile damage or breakage has occurred (or is likely to occur), and must make a judgment regarding acceptable penetration and bearing capacity.

Inspection is only as good as the knowledge, experience and qualification of the Inspector. On projects where the inspection staff has limited experience with pile installation, it may be in the best interest of the Department for the Regional Construction Group to temporarily re-assign an experienced Inspector to the project to supervise, instruct, and emphasize the importance of addressing and documenting the intricacies of the pile driving operation.

12.1 Before Leaving the Office

Pile inspection begins not out on the job but in the office. The inspector should become familiar with the Contract Documents including Sections 551 and 552 of the NYSDOT *Standard Specifications*. A copy of the pile layout should be made for reference in the field. The plans should be reviewed for any notes pertaining to the pile installation. Also, look through the proposal notes for anything having to do with the foundation. Become familiar with the profile where the piles are to stop and in what material. Look over the boring logs used to produce the profile. If possible look at a copy of the foundation report and its notes.

All piles must be observed and the final blow counts recorded, along with any deviations from the normal driving. However, some piles should have blow counts recorded for the entire length. These are termed record piles. Check with the Engineer on the frequency of making record piles.

It is recommended that at least two piles per substructure per stage and one pile in every ten be a record pile. However, depending on the type of project and the piles being used, the EIC may require more piles be record piles.

Understand the criteria involved in accepting the piles. The piles may be driven to a length regardless of initial blow count, or to rated resistance or to refusal. Are the piles to be restruck after a waiting period or are they to be monitored for heave and restruck if they heave?

Digest the information on the BD-138 Pile Driving equipment and the memo from the DCES. Also, become familiar with the procedures outline on the BD-190 if welding is to be used. If the project involves precast concrete piles then the shop drawings should be reviewed. Special attention should be paid to the handling, storing and splicing of these piles.

12.2 Piles Arrive

When the piles arrive and are off-loaded the inspector's work is dependant on the type of piles on the job:

> CIP - These piles are delivered by dropping off the truck. This may be the most abuse they will ever see. If something is wrong it may show up now. They are often stencilled at the shop with their size, thickness, and weight. These should be checked with their certificates and the data contained on the BD-138 since a different size pile affects the result of the Wave Equation analysis.
>
> H-Piles - These piles are off loaded one at a time using a crane and a set of spreaders. They are stacked and often nested together. Again, these piles will be stencilled with their size, weight and length. This information should be checked against the certification from the mill that the quantity and size are correct and that they agree with the information in the BD-138.
>
> Concrete Piles - The piles are approved by an inspector at the precast plant, but things can happen in transit. Inspect the piles for cracks and breaks. The piles are to be handled as described in the shop drawings. Lifting devices are to be consistent with the handling procedures in the shop drawings. The piles are to be stacked and stored as describe in the shop drawings.
>
> Timber Piles - Creosoted piles less than 40 feet (12 m) may be unloaded by controlled roll-off. Dumping should not be permitted. Piles over that length and piles treated with CCA should be off-loaded by the derrick on the truck piece by piece. Again, watch from a safe distance and listen for cracking.

Most piles have some sort of toe treatment recommended for them. These may be fitted to the piles before shipping or they may be attached at the site. Either way, inspect the pile toes for the proper treatment as called for in the plans and called out in the BD-138.

Most pile tops are ready to be driven however, timber piles may need to be trimmed to fit the drive head being used. Most hammers will require four large cuts and four smaller cuts. If the Contractor has opted for a McDermott head then the top will have a shoulder cut about 1 foot (0.3 m) from the top and then the top will be trimmed to the diameter of the head. Watch the cutting of the shoulder cut to ensure it is no deeper than it needs to be, even to putting a keel mark on the saw blade at the correct depth. Otherwise the pile might break at the shoulder cut. H-Piles have been driven with a McDermott head. It is not recommended, but if it is done the shoulder cut should be far enough down the pile so that the McDermott plate and hammer rest on the pile top and not the shoulder.

12.3 Hammer Arrives

When the Contractor delivers the hammer to the job, it should be inspected. Does it appear to be in good repair and well maintained? Is it one of the hammers listed on the BD-138? If it is the correct make and model, do the serial numbers match? Some hammers have been dynamically tested and found to be in poor condition. These hammers will be looked for in the BD-138 process, but the inspector should make sure that the serial number is on the BD-138

The capblock should be checked. In order to check the capblock, the drivehead or fire pot should be removed and the hammer laid-down or move a safe distance away. Hammer specifications require that the capblock be topped with a penny (a 2 inch (50 mm) thick steel plate to protect the capblock material). Have the penny removed and check that the capblock material is what is specified on the BD-138 and that the thickness agrees. If the capblock is correctly constructed the penny should be just above the rim of the fire pot. It should be noted that if the penny is not close to the top, then when batter piles are driven the ram will impact the edge of the fire pot, glance off and then impact the penny. This reduces the energy assumed to be delivered to the pile. If the penny is severely recessed, then it is possible that the ram mass itself will impact the rubber cushions or donuts on the base of the hammer, instead of the nose of the ram impacting the penny and the capblock. This is definitely undesirable and should be avoided.

12.4 Pre-Driving

First check that the excavation is at grade, if it is not, have it corrected or make note of it on the logs. Then see if the pile layout appears to be correct. Check that auxiliary stakes are distinguishable from pile locations, so that additional piles are not driven.

Find out where the Contractor is going to spot the pile and confirm its location and note it on the driving log (MURK 8). Check that the pile has been marked every foot (every decimeter). Also, inch (centimeter) marks should be made near the estimated length. Once the pile is spotted, if it is an H-Pile, make sure that the orientation is correct. Look the pile over one last time for any damage that may have occurred while the pile was being handled on the site.

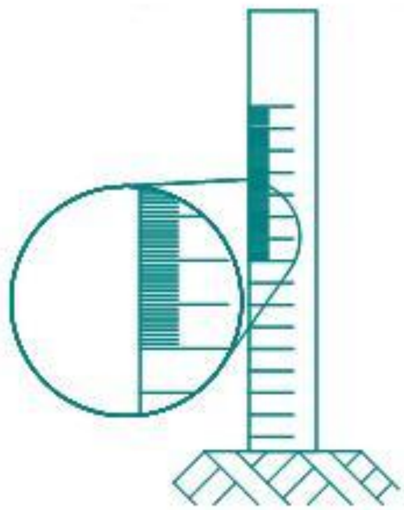

Figure 37 Marking a Pile

The foreman will now align the pile and the leads, using a long carpenter's level. If it is a batter pile, a board will be attached at the right batter. This batter should be confirmed. At this point you need to find a piece of wood or steel, to place in front of the pile and as close as practical, to be your reference for monitoring the pile penetration. You should also pick a secondary reference, in case the primary reference is kicked or obscured suddenly. This reference will probably be on the leads, a mark on the rails or a rung on the ladder.

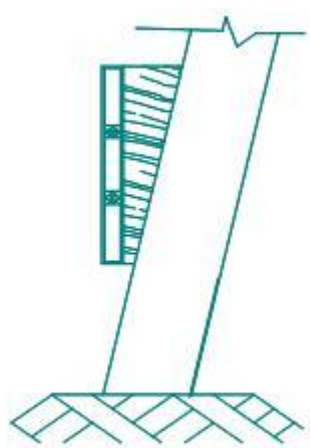

Figure 38 Identifying Proper Batter

12.5 Driving

At this point the driving will start. Make a note of the time that the pile driving started. (See various hammers for start up procedures.) Depending on the circumstances the pile may run or it may just begin to drive. After about 10 feet (3 m) the driving should stop and the alignment of the pile and leads should be checked and confirmed.

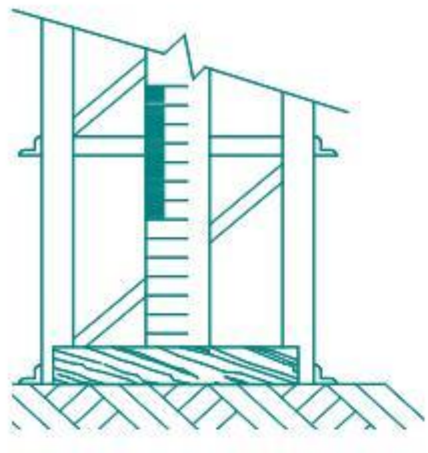

Figure 39 Checking Pile in Lead

Definition of terms for the decision making flow chart:

- **Minimum Length** - Unless specified otherwise, the minimum length for a pile is 10 feet (3 m). However, this may be modified depending upon potential depth of scour, at stream crossings. There may also be a minimum length defined in the plans that is based upon the piles having to penetrate a compressible layer.

- **Practical Refusal -** Practical refusal is defined as five blows to drive the pile a ¼ inch (or 8 blows per cm) or less.

- **Driving Criteria** - This is a criteria used for stopping the pile. It is usually defined as some number of blows to drive the pile 1 foot (3 decimeters). This should be a resistance that consistently increases over 5 feet (15 decimeters) of driving. It may also be defined as driving the pile to within 1 foot (3 decimeters) of the estimated length and stopping to allow the pile to set-up.

- **Pile Set-up** - Piles driven in fine grained soils, i.e. fine sands, silts and clays, will be subject to excess pore pressure and remoulding of the soil strength. In order to account for this the pile driving must be stopped and time allowed for the pore pressures to dissipate, this is called pile set-up. When the pile is restruck the blow count increases, hopefully to the amount required by the DCES. **It is important to count blows for each inch (centimetre) during a restrike**, since the pore pressures build up quickly and the set-up can be lost.

If this is a record pile the penetration, including any run, should be noted on the driving log. As driving continues the penetration and the blows to achieve it should be noted. The hammer rate of operation, in blows per minute, should be noted at least every 3 feet (1 m). Continue with recording the blow counts until the resistance is near the required resistance and the pile has achieved a penetration near the estimated length. At this point it may be suggested to have the pile marked off in inches (centimeters). If the pile is to be driven to a rated resistance then the

required blow count should be sustained for 18 inches (5 decimeters). There are exceptions, of course. If the pile has suddenly stopped and is obviously home then by all means stop driving. If the pile is to be driven to refusal, remember that refusal is five blows per ¼ inch (8 blows per cm). If the pile is at the end of driving and has been struck by five blows and has not moved a ¼ inch (6.3 mm), DO NOT try to drive it a full ¼ inch (6.3 mm). It is at refusal. STOP!

If the resistance begins to change from high resistance to lower resistance and high again, then the driving should stop. This type of phenomenon is associated with pile toe damage. The changes in resistance are due to the toe being overstressed on the high blows and then collapsing on the low resistance. The Inspection shall note the time that the driving stopped. If the pile is a CIP it should be sounded to check the length. For other piles the EIC and the Main Office should be contacted for direction. A dynamic load test may be needed to investigate, or the pile may need to be extracted.

Any sudden occurrences should also be noted. These could be abrupt changes in penetration rate or a change in alignment and/or location of the pile. These could be indicative of the pile having hit an obstruction.

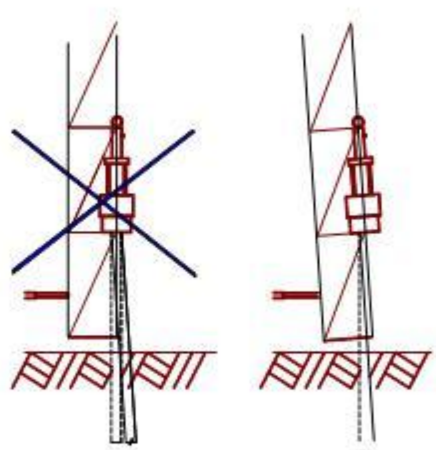

Figure 40 Identifying Changes in Alignment

If the pile has lost alignment, then the driving should be stopped and the foreman consulted on what will be done. Again, note the time that the driving stopped. There are three solutions: abandon the pile without payment and drive a replacement as near as possible; pull the pile and start at another location (this may require an additional pile depending on the location); or continue driving and decide on acceptability when the pile is finished. If the decision is to continue driving then the leads and the hammer must be aligned with the new alignment of the pile. The original alignment will result in a bad impact, resulting in poor energy transfer and possible pile damage from overstress. Note the time that driving resumed.

If steel or concrete piles need to be spliced then the procedures should be monitored for compliance with the prescribed procedure. For steel piles the procedure will be defined in an approved BD-190. For the concrete piles the splicing details will be described in the Contract Documents.

12.6 Post Driving

Record the pile length for payment, note the time that the driving stopped and mark down the resistance for the summary report. If the Contract Documents require that heave is to be monitored, then the pile top should be surveyed and the elevation noted. The Contractor may need to cut the pile; this is acceptable as long as at least 1 foot (0.3 m) is left above the cut-off elevation for restriking in case of heaving.

The following instructions are for CIP piles. After an elevation check, if required, the top should be covered to keep out water and debris. Once the dust has settled the pile should be internally inspected. The ideal way to do this requires a sunny day and a mirror, the sun is the best light source. If the day is overcast, then a trouble light should be lowered down the pile to the bottom, unless water is detected.

Once all of the piles are driven and accepted then the concreting may commence according to specifications.

13. COMMUNICATION AND FORMS

13.1 Communication

All communication should be through the EIC. The final decision on all piling issues ultimately are decided by representatives of DCES. On business days someone may be reached by calling (518) 457-7677 or if no answer (518)457-4770. These two numbers will give you answers from 7 am to at least 5 PM. Additional coverage may be arranged as needed by calling.

13.2 Forms and Paperwork

13.2.1 BD-138

The first of the pile driving forms will be the BD-138 "Pile and Driving Equipment Data". This form is typically submitted by the Contractor for the approval of his pile driving equipment. It is used by the engineers at the Geotechnical Engineering Bureau to prepare input for the Wave Equation program. The output from this program will help them determine the driving criteria, including the driving resistance, the minimum energy required to make it valid and any restrictions to avoid overstress.

It should also be the inspector's guide in determining that the hammer and pile system delivered to the project is the one described on the BD-138. The form also describes the capblock material and thickness.

The first part of the form identifies the Project. This helps the main office personnel forward the information to the proper designers for analyzing. Next the pile driving Contractor is listed. This often tells the designer something about the experience and availability of equipment, if adjustments need to be made.


BD 138
NYSDOT

PILE AND DRIVING EQUIPMENT DATA

P.I.N. ____________ Contract No.: ________ Pile Driving Contractor (Piles Driven By):
Project: ____________
County: ____________

Figure 41 BD-138: Project Information

The hammer section shows the manufacturer and model of the hammer.

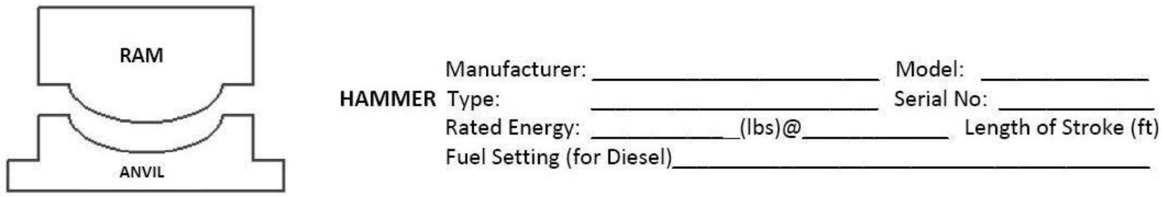

Figure 42 BD-138: Hammer Information

Often the name is enough to identify the kind of hammer, however, it helps if under Type Air/Steam, Diesel or Hydraulic is mentioned and whether it is a single-or double-acting hammer. This is especially helpful when the hammer is an MKT convertible, which can be run either way. The serial number is used to track hammers that have performed poorly on other projects.

The energy is required in kip-feet. There is no standard for this quantity. Typical values for hammers used on most DOT Projects are in the range of 15 – 25 kip-ft (20 to 34 kJ).

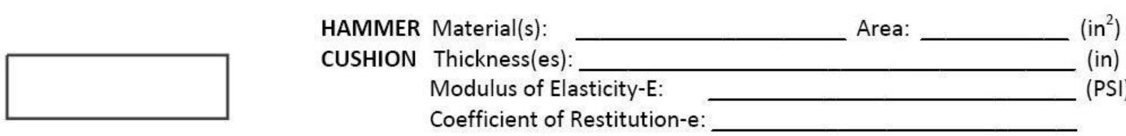

Figure 43 BD-138: Hammer Cushion Information

This section involves the hammer cushion or the capblock. The description given here should be what is seen when the capblock is exposed for your inspection. It is also an important input for the wave equation since it controls how the energy is transmitted to the pile. Common materials are listed on the back of the form. The area is called for in square inches. Common dimensions of capblocks are in the range of 100 to 250 square inches (64,500 to 161,290 mm^2). The thickness of the capblock is in inches. Typical ranges for diesel hammers are usually around 2 inches (50 mm) and for Air/Steam and Hydraulic hammers the value is 6 to 8 inches (150 to 200 mm). The modulus and coefficients are also listed on the back of the form. These values are half of the values that were originally published and Contractors are use to reporting. This is because of a change in the way the capblock stiffness is modeled in the wave equation.

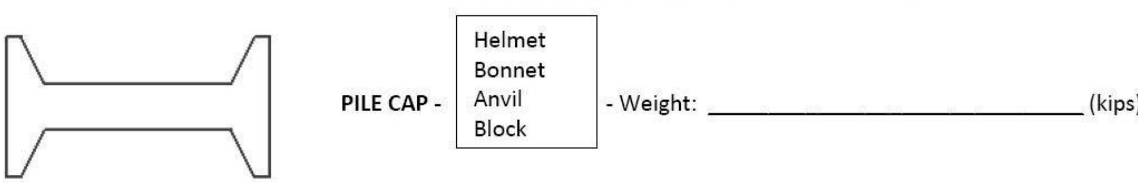

Figure 44 BD-138: Pile Cap Information

This is the weight of the helmet, which contains the firepot and the capblock. Typical values for these are 1 to 2 kips.

PILE	Material(s): ____________	Area: ________	(in^2)
CUSHION	Thickness(es): ____________		(in)
(For Concrete	Modulus of Elasticity-E: ____________		(PSI)
Piles Only)	Coefficient of Restitution-e: ____________		

Figure 45 BD-138: Pile Cushion Information

This section is used to describe the pile cushioning material. As was discussed earlier this cushion is used only with precast concrete piles. Typically these materials are woods or wood laminated with some other material. The area should be equal to or greater than the cross-section of the top of the pile. Typical thicknesses are from 4 to 10 inches (100 to 250 mm).

In an effort to reduce paperwork this form was designed so that more than one pile could be specified for the same hammer. The first couple of items are self-explanatory. The third should be a pile description like an H-Pile designation or the diameter and wall thickness of a CIP. The material might be precast concrete or steel designation like A272 or A252. The weight per foot along with the material is a good reference for confirming that the right pile has arrived at the site, since both items will be on the product stamp stenciled on the pile. The length in leads is not supposed to be the estimated length. It should be the length of pieces the Contractor intends to put in leads, i.e. an 80 foot (24 m) pile might be made up of a 60 foot (18 m) piece and half a 60 foot (18 m) piece or 90 feet (27 m). The amount that sticks out of the ground can have an effect on the blow count. Also, in some soils what happens as a pile is spliced may be a concern.

PILE	1	2	3	4	5
Structure Name:	______	______	______	______	______
Substructure (see back):	______	______	______	______	______
Pile Information (see back):	______	______	______	______	______
Material (Grade):	______	______	______	______	______
Weight/ft.:	______	______	______	______	______
Length in Leads (ft.)(see back) :	______	______	______	______	______
Nominal Resistance (ton):	______	______	______	______	______
Splice Description:	______	______	______	______	______
Toe Treatment Description:	______	______	______	______	______

NOTE: If mandrel is used to drive the pile, attach separate manufacturer's details sheet(s) including weight and dimensions.

Figure 46 BD-138: Pile Information

The last part of the form is the distribution and certification by the submitting party.

DISTRIBUTION

ONE COPY EACH TO:

- ☐ DEPUTY CHIEF ENGINEER (Structures)
- ☐ DIRECTOR, GEOTECHNICAL ENGINEERING BUREAU
- ☐ REGIONAL DIRECTOR
- ☐ ENGINEER IN CHARGE

Submitted By: ____________________ Date: __________

Phone Number: ____________________ Fax: __________

Figure 47 BD-138: Distribution

13.2.2 BD-190

The next form that is usually submitted with the BD-138 is the BD-190. This is the welding procedures that will be used for splicing the piles and attaching any toe treatment to piles. This also should act as a guide for the inspector, as to the steps involved in any of the welding processes. Prior to the start of any welding, verify that the BD-190 form has a Metals Engineering Unit stamp either "Approved" or "Approved as noted".

The first part of the form involves the materials to be used. This line should have the two materials being connected, however when it is for splicing pile sections together often only one material is shown. The next line is the welding process. Field welding is done using the Shielded Metal Arc Welding process (SMAW). There are other methods but they require additional testing and certification, refer to the NYSSCM and/or contact the Metals Engineering Unit in the Main Office.

Next is the type of welding. In the field, it is "stick" welding and is manual. The position of the welding is usually vertical or horizontal; occasionally the work will be flat.

Material specification ____________________

Welding process ____________________

Manual, semi-automatic or automatic ____________________

Position of welding ____________________

Figure 48 BD-190: Materials Used

The items in this section are commonly defined in handbooks prepared by welding machine manufacturers. Typically for our applications the filler metal would be specified as A5.1. The filler metal classification is the type of rod being used. This should be compatible with the metals and processes being used. Only the use of E7018 or E8018 rod is allowed for field welding using the SMAW process by the NYSDOT unless otherwise approved by the DCES. Again this information would be in a handbook. The electrode and manufacturer would be the company making the electrode, often this is Lincoln. The flux and manufacturer, shielding gas, dew point and flow rate refer to processes not typically used in the field to splice piles.

Filler metal specification AWS ________________________________

Filler metal classification ________________________________

Electrode and manufacturer ________________ FCM Lot # ____________

Flux and manufacturer ________________ FCM Lot # ____________

Shielding gas ______________ Dew point __________ Flow rate ________

Figure 49 BD-190: Filler Metal

This section describes how the weld will be accomplished. The number of passes will usually be "Multiple as needed for the desired weld". This type of field welding is done with a single arc. The welding current is either AC or DC. Field welds are usually DC with a reverse polarity.

Single or multiple pass ________________________________

Single or multiple arc ________________________________

Welding current ________________________________

Polarity ________________________________

Figure 50 BD-190: Accomplishment of Weld

The welding progression for field splices would be stingers. Root treatment is described in the NYSSCM. Preheat temperature is 250 degrees for field welding, check the NYSSCM Section 708. The temperature can be checked by a special stick designed to melt at a given temperature or other temperature monitoring device. Post heating is used in shop fabrication not in the field.

Welding progression ________________________________

Root treatment ________________________________

Preheat and interpass temperature ________________________________

Postheat treatment ________________________________

Figure 51 BD-190: Weld Progression

The Pass No. for field welding is usually all, and each pass is done the same way. The only exception would be the partial welds on the splice sleeve. The electrode size can be found in handbooks and in the NYSSCM. Typically it will be ⅛ inch (3mm) or 5/32 inch (4 mm) diameter rods. The amperage and voltage is typically 120-190 amperes at a constant voltage. Travel speed would be about 8-12 inches (200 to 310 mm) per minute. The joint details for toe protection will be a sketch, while splices will be a duplication of the details in the plans.

WELDING PROCEDURE

Pass No.	Electrode Size	Welding parameters		Travel Speed	Joint Detail
		Amperes	Volts		
					Sequence of weld passes shall be shown diagramatically

Procedure no. ______________________ Fabricator or Erector ______________________

Revision no. ______________________ Authorized by ______________________

Date ______________________

Figure 52 BD-190: Welding Procedure

13.2.3 Material Certifications

This is paperwork which is generated by the shop which fabricates the piles. They attest to the material used to make the pile and the dimensions of the pile. It also lists the quantities shipped and to whom. This paperwork becomes part of your project records.

13.2.4 MURK 8

This form is for recording the data for a record pile. It is fairly straight forward. The top part is for project information; most is covered by a job stamp. Then there are two areas concerning the specific pile being driven. The first involves the date, the BIN and the substructure and the amount of time involved in driving the pile. This relates to the Contractor production and a guide to any time related soil strength considerations. Additionally, any stops should be noted in the remarks area and/or the DWR. Then there is the time involved in driving the pile. These three items have become important pieces of data, when a claim is filed. The last two items in this section are the ultimate load it is being driven to and the location in the structure, i.e. which substructure. These are a quick reference for anyone reviewing the log.

JOB STAMP

DATE:____________________

B.I.N:____________________

SUBSTRUCTURE____________________

TIME START:____________________

TIME END:____________________

Figure 53 MURK 8: Project Information and Pile Driving Location

Next there is the hammer information. Since there may be four hammers submitted and accepted on the BD-138, the actual hammer the Contractor elects to use should be noted here. Also, on large projects two hammers may be working on the same project and/or bridge. They may even be the same kind of hammer with different serial numbers. This may have an impact on what driving criteria the pile is driven to. It can also have an impact on claims, such as what hammer was working where and at what time. The next item is the BIN which can be found on the plans for that structure. The next two quantities have to do with the physical pile. They are the estimated length which is in the notes on the pile layout sheet for the substructure and the lead length which was discussed earlier in the BD-138 section. The next two items concern the cut-off elevation and the elevation of the grade at the time of driving. The cut-off elevation is in the plans, but again is included here as a quick reference for anyone reviewing the logs, including the inspector. The grade should be the bottom of the pile cap or the bottom of the tremie. Under unusual circumstances, the grade may be different from these elevations and should be noted here and under remarks.

Hammer, Make, Model & Number:____

Estimated Length(ft): ____________________ Total Length Placed in Leads(ft) ____________________

Cut Off Elevation: ____________________ Ground Elevation @ Time of Driving:____________________

Figure 54 MURK 8: Hammer Information

This is followed by the table of information for recording the penetration, resistance and the hammer energy indicator. Each of the lines should represent 1 foot (1 decimeter) of penetration. The second column is self-explanatory as the number of blows for that foot (1 decimeter). The Energy Control column is used to document the hammer energy. This could be blows/minute for air/steam hammers and single-acting diesels. If the hammer is a double-acting diesel then the value to be entered here would be the bounce chamber pressure, psi (kPa). If the hammer is a single-acting diesel and a Saximeter is available then the average stroke should be recorded off of the Saximeter. See Appendix A for information regarding the use of a Saximeter

Depth(ft)	*Blows	*Energy Control

Figure 55 MURK 8: Pile Driving Information

The remarks area is, as mentioned, for recording times; when driving stopped for splicing, moving bracing or dewatering. Other remarks might be the pile was walking, the grade was not at the proper elevation, a splice did not appear to be square to the axis of the pile, etc.

At the bottom of the form is the area for the summary of the final blow counts. This self explanatory and the information will also be recorded on the MURK8-1. The total pay length is the amount of pile from toe elevation to the cut-off elevation. The length in the ground will be somewhat shorter as it is the length from bottom of pile cap or stem to the toe elevation.

NUMBER OF BLOWS:

LAST 1 ft: ______________ LAST 4 in: ______________ LAST 3 in: ______________

LAST 2 in: ______________ LAST 1 in: ______________

TOTAL LENGTH(PAY)(ft): ______________

LENGTH IN GROUND(ft): ______________

Figure 56 MURK 8: Final Blows and Length Information

When driving piles to refusal the criteria is 5 blows per ¼ inch (8 blows for the last centimeter). Sometimes the amount might be slightly more and it should be recorded here.

13.2.5 MURK 8-1

Pile Driving Record Summaries - This form summarizes all of the pile driving in addition to the Record Piles. In addition to summarizing the quantity of piles, it can also be used to gage daily production rates for a given hammer and crew.

The Job Stamp and Substructure and Total length (PAY) are self explanatory.

The pile and hammer information has been explained previously. It is recorded here for the purpose of keeping track of what hammers drove what piles. This is for those large projects where there may be more than one hammer and crew driving piles. The cut-off elevation can be found on the plans for that substructure. Since different substructures may have different types and /or sizes of piles there is an entry for the pile description.

Type and Size of Piles: ____________________

Hammer, Make, Model & Number: ____________________

Required Energy Control: Stroke(ft), Blow Rate(bpm), or Bounce Chamber Pressure (psi): __________

Cut-off Elevation (ft): __________

Figure 57 MURK 8-1: Pile and Hammer Information

As mention it can be used to gage production so it is important that the date be filled in. In addition to the date, the DWR number is included for easy cross-reference for any additional details. The length placed in leads field for total length of pile actually placed in the leads. The difference between the length in leads and the pay length or length in ground is an indication of the amount of cut-off or waste. A separate summary should be made out for each substructure driven. Therefore, there may be more than one summary report on a given day if pile driving was done at more than one substructure that day. The method and value for energy verification is to record the energy at the end of driving.

The Pile Toe Elevation can be determined by subtracting the distance from the ground to the nearest pile length mark and then subtracting that value from the grade elevation. The other method is to have the elevation of the pile top determined and subtract the length in the leads adjusted for any trimming that was done to prepare the pile for splicing. This would be the only method when driving piles in a cofferdam with a tremie seal. Once the toe elevation is established, it can be subtracted from the cut-off elevation to determine the length in the ground.

As mention before all piles need to be monitored and the blows per inch (or decimeter) for at least the last 18 inches (5 decimeter) need to be recorded. The final values would be reported here.

Also, anything of note for the non-record piles should be recorded under remarks. The piles should be listed on the summary in the order in which they were driven.

Pile No.	Date	DWR Number	Length Placed in Leads	Energy Control Recorded	Length Driven in Ground	Pile Toe Elevation	Blows for the Last				Remarks *
							4 in	3 in	2 in	1 in	

Figure 58 MURK 8-1: Pile Lengths and Blow Counts

13.2.6 Pile Layout and Number Scheme

Depending on the designer the piles may be numbered on the Contract Plans. If not, it is up to the EIC and inspection staff to number the piles. Regardless, it is helpful to mark the piles driven on any day on a copy of a numbered pile layout. This assists people reviewing this data in seeing the order in which the piles were installed.

13.2.7 Summary Tables on the Plans

Finally, as an historical record, the table in the Contract Plans should be completed to become a part of the As-Built plans. This will help future foundation engineers to make decisions when having to rehabilitate or replace the structure being built today.

14. REFERENCES

Deep Foundations Institute, *Inspectors Manual for Pile Foundations*, Inspection and Testing Committee of the Deep Foundations Institute, First Edition, 1992.

Deep Foundations Institute, *Pile Inspectors Guide to Hammer's*, Equipment Application Committee of the Deep Foundations Institute, Second Edition, 1995.

Hannigan, P.J., Goble, G.G., Thendean, G., Likins, G.E., and Rausche, F., *Design and Construction of Driven Pile Foundations*, Workshop Manual – Volume II, Federal Highway Administration, Publication No. FHWA HI 97-014, November, 1998.

New York State *Bridge Detail (BD) Sheets*, Department of Transportation, Office of Structures, https://www.dot.ny.gov/main/business-center/engineering/cadd-info/drawings/bridge-detail-sheets-usc

New York State *Steel Construction Manual (NYSSCM)*, Department of Transportation, Office of Structures, https://www.dot.ny.gov/divisions/engineering/structures/manuals/scm

APPENDIX

MEMORY SAXIMETER™

STROKE INDICATOR for Open End Diesel Hammers

BLOW COUNTER

OPERATING MANUAL

A1.0 INTRODUCTION

The SAXIMETER is an electronic instrument that (a) detects a hammer impact; (b) determines the duration between consecutive blows, Δt, and converts this to equivalent Blows Per Minute, BPM; (c) converts Δt to the corresponding stroke (H) of an open end diesel ram; (d) counts blows and (e) determines average values. The SAXIMETER detects blows by either a sound recognition circuit or manual keypad input.

The conversion from Δt to stroke for open end diesels uses an equation derived from both field observation and laboratory analysis and is based on a free fall assumption with a correction for friction and precompression. Comparisons with field results indicate a usual accuracy of ∀0.3 feet (∀0.l meters).

It must be emphasized that only open end diesel hammers have both upward and downward free fall ram motion and hence only this hammer type is compatible to the stroke computation. However, the SAXIMETER can effectively monitor other hammer types by using the blow rate. Blow rate has the dimension blows per minute (BPM). The highest blow rate measurable by the SAXIMETER is 240 BPM.

The SAXIMETER can be operated in either English or SI (metric) units as selected by the user.

A2.0 OPERATION

The SAXIMETER contains several circuits and controls as follows:

- Power
- Startup Procedure
- Microphone
- Sensitivity Adjustment

- Speed Adjustment
- Manual Trigger
- LCD Display
- Warning Signals
- Averaging
- Consistent Hammer Operation

A2.1 Power

The SAXIMETER requires a single alkaline 9v battery which should last about 50 hours (depending on temperature). A rechargeable NICAD is NOT recommended. The battery is in the bottom compartment. To conserve batteries when not in use, turn off the SAXIMETER. Remove battery when not in use for extended periods of time. Press the "POWER' key to turn on (off).

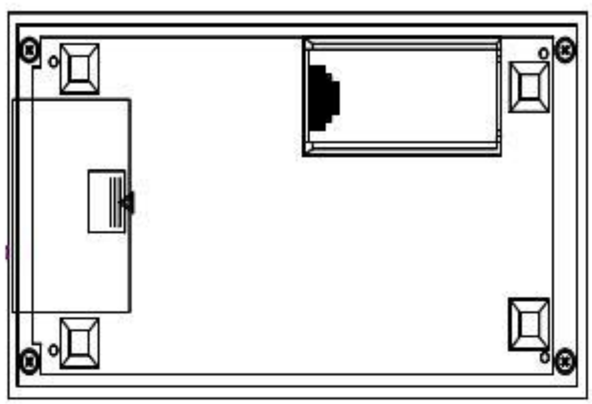

Figure A-1 Saximeter Battery Compartment

A2.2 Start-Up Procedure

When power is first turned on, a short series of instructions and questions are shown.

a) **Owner Name.** The user is first requested to enter or change the name displayed on the last line (and in all output). A 16 character limit is observed. Use "underline" for space and/or other "special characters" (i.e., "GRL-+-ASSOCIATES").

Figure A-2 Saximeter: Owner Name Input

As an example, to enter the name **"TEST",** find the key the appropriate first letter (*i.e.*, 8, RST) and press repeatedly until the correct letter **"T"** is displayed. If the next letter is on a different key, simply press the new key (3, EF+) for the next letter **"E"**. After entering the **"S"** (different key again), note that the last letter **"T"** is then on the same key as the previous "S"; press the **Enter** key **ONCE** to move to the next letter and then the (8, RST) key again for the **"T"**. Press the **Enter** key twice at the end to save this name and continue.

b) The next screen asks for further default settings.

1) **Hammer Type** can be set to either "OPEN END DIESEL" or "OTHER HAMMERS" as appropriate using the up arrow key. When correct, use the down arrow key to select the unit type.

Figure A-3 Saximeter: Hammer Type Input

2) **Unit Type** which can be in either "ENGLISH" or "SI". This only affects the stroke (H) result and produces results in feet or meters, respectively. Again use the up arrow to change. If "OTHER HAMMERS" was requested, this line also asks for the stroke in either [mm] or [inches]. This information is stored in memory for output documentation (Section 2.11). Use the down arrow to change the stroke.

3) **Alt Increment.** This value is the alternate number of increments per unit penetration. Enter the number of **integer divisions** between 1 and 100. The default values are 12 (English for 12 inches per foot) or 10 (metric for 10 cm per dm increment).

When these three inputs are correct, press the **ENTER** key to continue.

c) The next screen asks for the
  1) Pile Name (PN:)
  2) Hammer Name (HN:)
  3) Project Name (PJ:)

In all cases, the "names" are simply labels attached to all outputs. If currently correct, simply use the down arrow. If a name is wrong, use **CLEAR** or up arrow key to backspace and then enter the new name using the alphanumeric entry process as described in "Owner Name" above. An extra "Enter" will continue to data acquisition.

A2.3 Microphone

Figure A-4 Saximeter: Microphone

Normally, the internal microphone listens for the hammer blow. It is located above the battery compartment under the serial number label (please leave this label in place to prevent dirt from entering unit). A sudden increase in sound pressure level (SPL) triggers the instrument. A trigger always causes the measurement of time interval (provided a previous trigger pulse occurred). If the SPL increase is not sufficiently large, the SAXIMETER does not trigger. (see also Sections 2.4, 2.5 and 2.6).

WARNING: Ear protection is strongly recommended to prevent permanent hearing losses.

A2.4 Sensitivity Adjustment (GAIN)

Due to varying background noise (e.g., talking, machine noise, additional piling hammers working), the SAXIMETER contains an adjustment for variable sensitivity. The SAXIMETER automatically is placed in an "automatic" sensitivity mode. First, the background noise is determined and is reviewed periodically (and shown in the GAIN window when no hammer

blows are detected). When the peak sound level exceeds the background noise by a sufficient amount, the unit triggers (and displays the peak value in the GAIN window). The next trigger level self adjusts during driving. This automatic mode is also confirmed by the "A" in the LCD near the GAIN display value. Pressing the GAIN key at any time resets (or returns to) the SAXIMETER automatic sensitivity mode.

The user can override this automatic adjustment procedure. Using the up and down arrow keys will change the sensitivity to a fixed user selectable level (Press GAIN key to reset to automatic if desired).

The SAXIMETER can be placed in a completely MANUAL mode for blow detection, thus turning the microphone off completely (see Section 2.6).

If possible, the operator should not stand near other loud machines. Do not to tap the case because false triggers may occur.

A2.5 Speed Adjustment (SPEED)

A delay circuit prevents double triggers for a single blow. The operator should select a speed setting which allows one and only one trigger per hammer blow. Press "Speed' and enter the maximum blows per minute (Press SPEED and CLEAR to confirm current maximum speed) slightly higher than anticipated (for open end diesel hammers, the unit is set automatically to 68 BPM).

A2.6 Manual Trigger, PAUSE (MAN)

Sometimes it is difficult to trigger by sound; for example, two hammers operating simultaneously or very high background noise. In some cases, it could trigger erratically when the hammer is not operating. The first time MAN is pressed, the unit is placed in PAUSE mode to avoid accidental triggers. Use CLEAR or GAIN to return to sound recognition triggering. Alternatively, the next time MAN is pressed, the SAXIMETER is put into manual mode; the SAXIMETER must then be triggered manually by pressing MAN key once per every blow. The GAIN display will be set to "MAN" and will only trigger manually until the GAIN key is pressed again to reset to automatic sound detection.

A2.7 LCD Display (TIME, PEN, PI)

The SAXIMETER top line displays the last average stroke (open end diesels only), average BPM, number of blows in the last average, and total blows (TOTAL). For "open end diesels", the second line shows stroke (H), blows per minute (BPM), current blows (BN) since the last average and the GAIN. For 'other hammers', no stroke information is displayed and blows per minute have higher resolution.

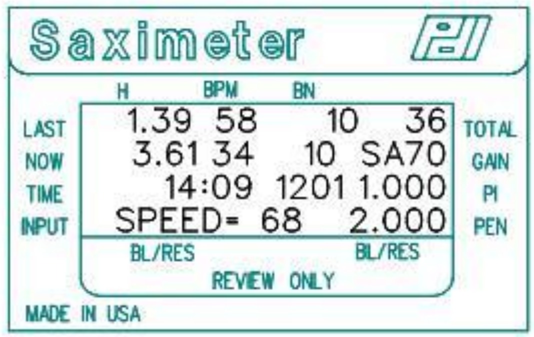

Figure A-5 Saximeter: Line Displays

The third line displays the TIME including date (which can be changed by the TIME key, entering the two digit numbers requested with CLEAR to exit the rest of the input, if correct). Enter data using a 24:00 hour clock system (*i.e.*, "14:36 1107" is 2:36 PM Nov 7).

At the end of the third and fourth lines are PI and PEN (penetration increment and penetration, respectively). To change these values use the PI and PEN keys. Enter the starting PEN. Every time the AVG key is pressed, the current PEN is automatically updated by PI. (Normally the penetration increment is the value "one" (*i.e.*, one foot, one meter). Pressing PI quickly shifts to the ALT INCREMENT (Section 2.2.b.3) number of "divisions" per unit increment (*i.e.*, for "12" inch readings per foot, the PI will then show 0.083 [ft] = 1/12).

After entering the starting PEN penetration, the SAXIMETER then keeps track of the penetration by incrementing, it each AVG. Two special cases are sometimes considered; the pile "runs" several units (feet or meters) under a single blow, or the user wants to change to the ALT INCREMENT (PI) value in the middle of a unit penetration. Both cases are handled easily. For the case of pile running, press the PEN key and then enter a new value. For the intermediate change to the ALT INCREMENT (PI), press PI first, then press PEN and enter the new value.

Located near the serial number identifier is an adjustment Potentiometer used to set the LCD contrast. Under normal conditions the LCD will not need adjustments.

A2.8 Warning Signals

During each trigger, the battery voltage is checked. If low, "L" is displayed near the GAIN window to indicate "Low Battery". Replace the battery at your earliest convenience. For alkaline batteries, the unit may operate for 30 minutes after the "L" is displayed. An "S" is displayed when the hammer stops.

A2.9 Averaging (AVG)

After depressing the "AVERAGE"(AVG) key, the calculated average values are displayed on the top line of the LCD. Pressing this key once per foot (meter, inch, centimeter) is all that is needed to easily and automatically generate the driving log. The average values are displayed until the

next "AVERAGE" and are stored in memory for later review or retrieval (Sections 2.12 and 2.13). PEN is automatically incremented by PI. Changing PEN also produces a new average (*i.e.*, used for recording "every 5 ft" logs).

For "open end diesels", the SAXIMETER does not include blows in the average calculation if the rate is less than 24.5 or greater than 70.5 blows per minute (BPM) although it does count each blow. In "other hammer" operation, all blows greater than 19.8 BPM are averaged.

A2.10 Consistent Hammer Operation

Inconsistent hammer operation or erratic triggering both result in varying BPM and stroke values displayed by the SAXIMETER. Open end diesel hammers are easily observed for whether or not the hammer strokes are inconsistent. The cause (lack of lubrication, malfunctioning fuel pump, poor hammer-pile alignment, etc.) for the varying, stroke should be determined and corrected to improve the hammer performance. An indicated stroke difference of 1 foot (0.3 m) for an open end diesel may also be caused by erratic triggering. At approximately a 7-foot stroke, a 0.10 second change of duration, Δt, causes a 1-foot (0.3 m) stroke difference. High background noise, sound reflecting from walls or other conditions may cause erratic triggering and therefore such small changes in the duration measurement. It may then be necessary to find another location where steady triggering occurs or adjust the gain and speed. For inconsistent operation of air/steam hammers, the supply source valves and hoses should be checked.

User input comments (up to 16 characters) can be inserted into the memory. To accomplish this, clear the lower left "Input" area of the LCD using the CLEAR key. Type in your message (use underline for spaces). Backspace is accomplished with the arrow key. CLEAR will delete the entire comment at any time prior to final entry. For comments longer than 10 characters the PEN will alternate with the comment. When the comment is finished, press an extra ENTER to save to memory.

The stroke for "Other Hammer" types can possibly be changed from the original value input during the setup procedure (Section 2.2.b.2). This information change can be quickly input and saved in the memory output file by pressing CLEAR (to obtain a blank Input line), followed by pressing ENTER which will prompt for the new stroke.

A2.11 Review (REVIEW)

The data in memory can be viewed on the screen using the REVIEW key. The screen then shows the percentage of memory which is "full"; the SAXIMETER should be emptied to a PC (see Section 2.13) daily (or weekly) as is convenient but must be emptied when the unit approaches 100% full.

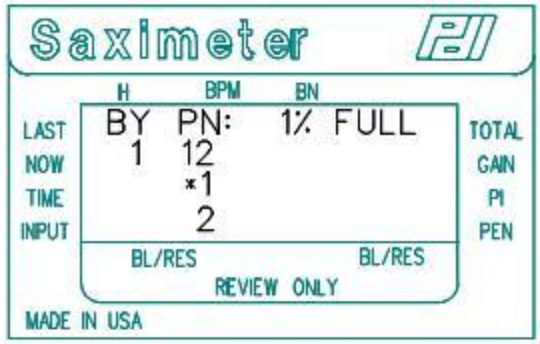

Figure A-6 Saximeter: Review

The user then selects which pile name (PN) to review using the arrow keys. The first and last piles are noted by the indicators "1" and "L", respectively. When the "*" is on the pile to review, press REVIEW again. Data is displayed in two columns; each line contains the number of blows and result (BPM or stroke as indicated in bottom right). Data is read beginning at top left, down the first column, then followed by the second column. The decimal point is dropped from the stroke to allow for more digits on the LCD. The lower right shows the penetration of the 7th data. Using down arrow scrolls to the next "page" of data. REVIEW asks for the next pile selection; CLEAR returns to data collection.

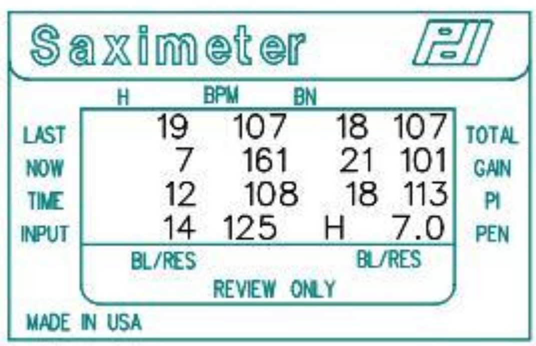

Figure A-7 Saximeter: Review of Data

A2.12 SEND (SEND)

The contents of memory can be sent to a PC or serial printer using the SEND key. The SAXIMETER must be connected to the PC using the built in RS232 connector located in the second compartment on the SAXIMETER bottom. Change the SAXIMETER BAUD rate (sending speed) using the arrow keys to match the receiving speed of the PC (SP function in the XTALK or MEMLINK program, for example). When setup is complete press SEND again. The user can choose between sending all data (press SEND a third time) or selected piles only (press ENTER) to set up separate files for each pile. Select the pile name (PN) to be sent using the arrows and then press SEND; results should be observed on PC (or directly on printer).

The MEMLINK program (from Pile Dynamics) stores the results in a file automatically and names files for user reference. XTALK (PC communications program) uses CA ON (capture on) and CA OFF (capture off) for each file save. Also note the SAXIMETER uses 8 bit, NO parity, and 1 Stop bit. The PC files can be printed, imported to spread sheets, or plotted using the SAXPLOT program also from Pile Dynamics.

A2.13 Clear (CLEAR)

After saving data (Section 2.13), the memory should be cleared using CLEAR. This request must be confirmed to prevent accidental erasure of data. The SAXIMETER has an 8000 data line memory.

A2.14 New Pile Name

After the last blow, the SAXIMETER waits one minute and then asks for a new pile name (PN?) which is entered with the alphanumeric entry process. Alternatively, the SAXIMETER can be turned off and on to reset. Power off/on is the only way to change hammer type and name, project name, owner name and units type; for most projects, these do not change and simply changing the pile name is sufficient.

A3. ADDITIONAL CONSIDERATIONS FOR OPEN-END DIESEL HAMMERS

It is not always possible to directly utilize the results of the SAXIMETER stroke. A few problem situations will be discussed and recommendations for best results given.

A3.1 Battered Pile Driving

Driving battered piles increases ram friction and reduces gravity in the axial direction. Table A-1 list correct strokes h_b. Given a SAXIMETER reading of h and a batter angle, a friction angle of 1.1 degrees was assumed but for computation has little effect on the correction. The corrected strokes, h_b can also be taken from Figure A-8. The results of Table A-1 and Figure A-8 indicate insignificant errors of the uncorrected reading for batters less than 1:5 and these corrections can therefore be ignored. For batters greater than 1:2, the results are greatly affected by the corrections. Even after correction, the SAXIMETER stroke results contain uncertainty due to the friction losses.

Batter Angle (deg.)	Batter Ratio	Stroke Reading h_b feet (m)								
0	---	4	5	6	7	8	9	10	11	12
4.8	1:12	4.0(1.22)	5.0(1.52)	6.0(1.83)	7.0(2.14)	8.0(2.44)	9.0(2.74)	10.0(3.05)	10.9(3.32)	11.9(3.63)
5.7	1:10	4.0(1.22)	5.0(1.52)	6.0(1.83)	7.0(2.14)	7.9(2.40)	8.9(2.71)	9.9(3.02)	10.9(3.32)	11.9(3.63)
7.1	1:8	4.0(1.22)	5.0(1.52)	5.9(1.80)	6.9(2.10)	7.9(2.40)	8.9(2.71)	9.9(3.02)	10.9(3.32)	11.9(3.63)
9.5	1:6	3.9(1.19)	4.9(1.49)	5.9(1.80)	6.9(2.10)	7.8(2.38)	8.9(2.71)	9.8(2.99)	10.8(3.29)	11.8(3.60)
11.3	1:5	3.9(1.19)	4.9(1.49)	5.9(1.80)	6.8(2.07)	7.8(2.38)	8.8(2.68)	9.8(2.99)	10.7(3.26)	11.7(3.57)
12.5	1:4.5	3.9(1.19)	4.8(1.46)	5.8(1.77)	6.8(2.07)	7.8(2.38)	8.7(2.65)	9.7(2.96)	10.7(3.26)	11.7(3.57)
14.0	1:4	3.8(1.16)	4.8(1.46)	5.8(1.77)	6.7(2.04)	7.7(2.35)	8.7(2.65)	9.6(2.93)	10.7(3.26)	11.6(3.54)
16.0	1:3.5	3.8(1.16)	4.8(1.46)	5.7(1.74)	6.7(2.04)	7.6(2.32)	8.6(2.62)	9.5(2.90)	10.6(3.23)	11.5(3.50)
18.4	1:3	3.7(1.13)	4.7(1.43)	5.6(1.71)	6.6(2.01)	7.3(2.23)	8.5(2.59)	9.4(2.87)	10.5(3.20)	11.3(3.44)
21.8	1:2.5	3.6(1.10)	4.6(1.40)	5.5(1.68)	6.4(1.95)	7.3(2.23)	8.2(2.50)	9.2(2.80)	10.3(3.14)	11.0(3.35)
26.4	1:2	3.5(1.07)	4.4(1.34)	5.2(1.59)	6.1(2.00)	7.0(2.14)	7.9(2.41)	8.8(2.68)	9.7(2.96)	10.4(3.17)
29.7	1:1.75	3.4(1.04)	4.2(1.28)	5.1(1.55)	5.9(1.80)	6.8(2.07)	7.6(2.32)	8.5(2.59)	9.4(2.87)	10.2(3.11)
33.7	1:1.5	3.2(0.98)	4.0(1.22)	4.8(1.46)	5.6(1.71)	6.5(1.98)	7.3(2.23)	8.1(2.47)	8.9(2.71)	9.7(2.96)
38.7	1:1.25	3.0(0.91)	3.8(1.16)	4.5(1.37)	5.3(1.62)	6.1(2.00)	6.9(2.10)	7.7(2.35)	8.4(2.56)	9.2(2.80)
45.0	1:1	2.6(0.79)	3.3(1.00)	3.9(1.19)	4.6(1.40)	5.3(1.62)	6.0(1.83)	6.7(2.04)	7.4(2.26)	8.1(2.47)

Table A-1 Corrected Stroke

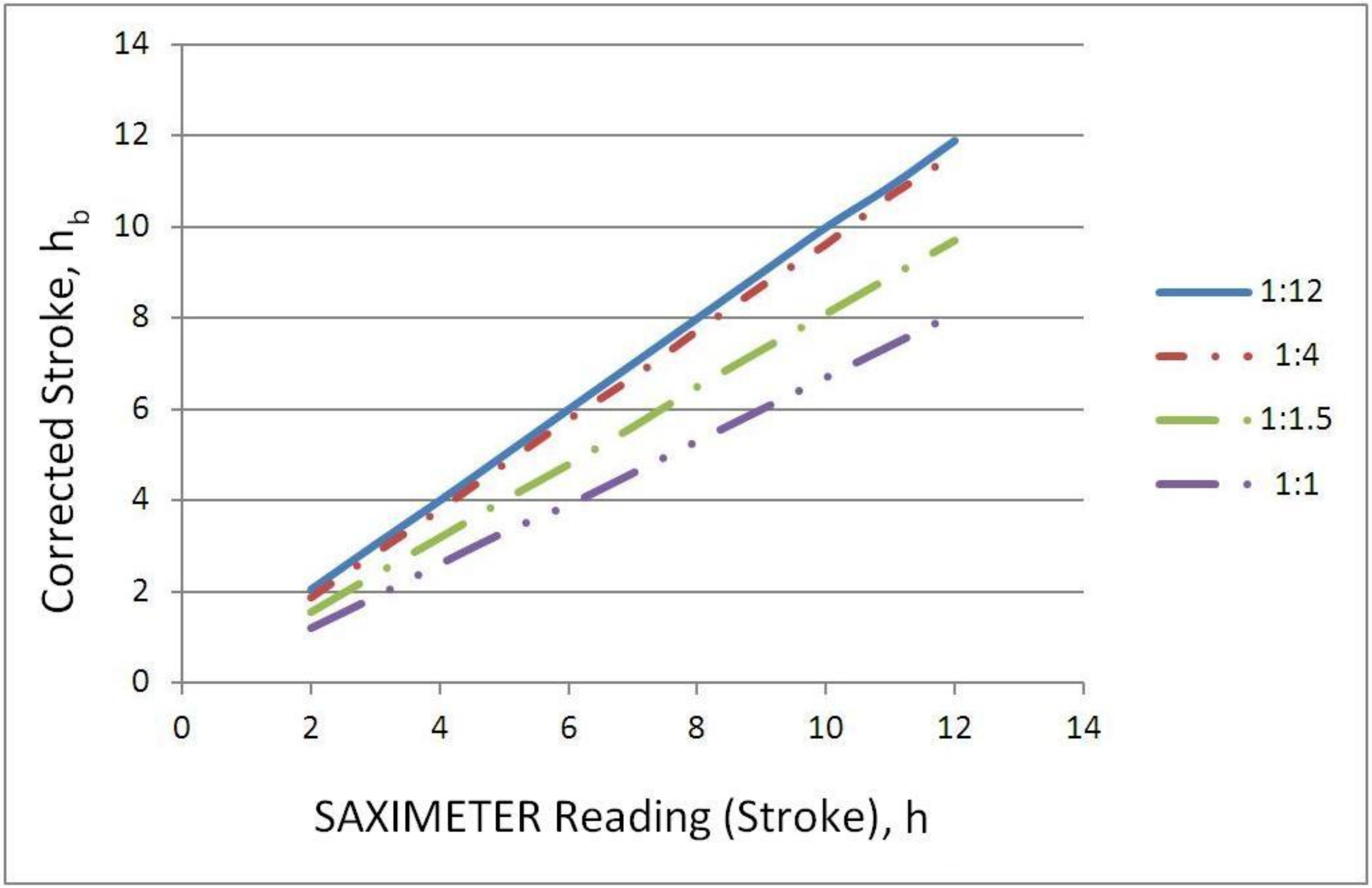

Figure A-8 Corrected Stroke

A3.2 Accuracy

SAXIMETER stroke equations assume normal (*i.e.*, minimal) ram friction. Of course, extreme friction would reduce the ram velocity and the SAXIMETER stroke reading would be too high. The SAXIMETER operator should check the hammer for signs of excessive friction. (The ram should appear moist and well lubricated. Scratches on the piston surface may indicate extreme friction or foreign matter).

The SAXIMETER calculates blows per minute to a resolution of 0.1 BPM. The stroke calculation is based on this resolution even though BPM is displayed to a 1 BPM resolution in the "open end diesel" mode.

A3.3 The Last Blow

When driving ceases, "S" (STOP) is displayed after approximately 3 seconds. The next blow causes a display "FIRST" or "1ST" for BPM. Depressing "ERASE" even after a STOP saves the current blows (or input the final PEN penetration value to record the last blows into memory). If the SAXIMETER repeatedly "stops" then either the hammer is not hitting consistently, (which should be obvious) or the SAXIMETER Gain or Speed may need adjusted (see sections 2.4, 2.5 and 2.6).

A4. NORMAL OPERATION

The SAXIMETER is versatile; however, most users monitor BPM and/or stroke for consistent hammer operation. By using the average function every unit of distance (foot, inch, meter) and recording the blow count and BPM or stroke, a driving record can be created. For open end diesel hammers, the theoretical potential energy can be calculated from the stroke and ram weight. The stroke for open end diesels can be used to confirm wave equation assumptions.

A5. MAINTENANCE

There is little maintenance needed. However, caution must be exercised to insure the displays are protected from extended exposure to direct sunlight or heat. LCD display may darken if too hot or be slow to change if too cold. Returning the SAXIMETER to normal temperatures should allow the display to operate normally.

Wipe the SAXIMETER surface occasionally with a damp cloth to clean the surface. Care should be taken not to scratch or puncture the LCD window. Keep liquids from entering the case at any time.

A6. WARRANTY

Pile Dynamics, Inc. (PDI) warranties the SAXIMETER for one year. The warranty does not include batteries, units damaged by abuse or by repairs made by unqualified persons. The customer is responsible for shipping the unit to PDI and the associated cost thereof and all customs charges (if any).

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SAXIMETER™

SAXPRINT

Users Manual

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B1.0 INTRODUCTION

The SAXPRINT program will take data files created by the SAXIMETER and allow you to edit the data records, print out the pile summary or the detailed blow count records. The SAXPRINT program will also allow you to retrieve data from the SAXIMETER (through the RS-232 serial port), to merge data files and to combine pile data.

The program initially begins with the prompt for which function you want to perform first, to load a data file or link to the SAXIMETER. If you press "F" you can enter a data file name (with proper extensions) from any directory on any drive (Fig. 1). The default file name is located in the text file SXFILE.DAT, which can be changed with a text editor. If the program cannot find the file, you will have one of three options:
1) shell to DOS, 2) exit to DOS, or 3) continue to change the present file name.

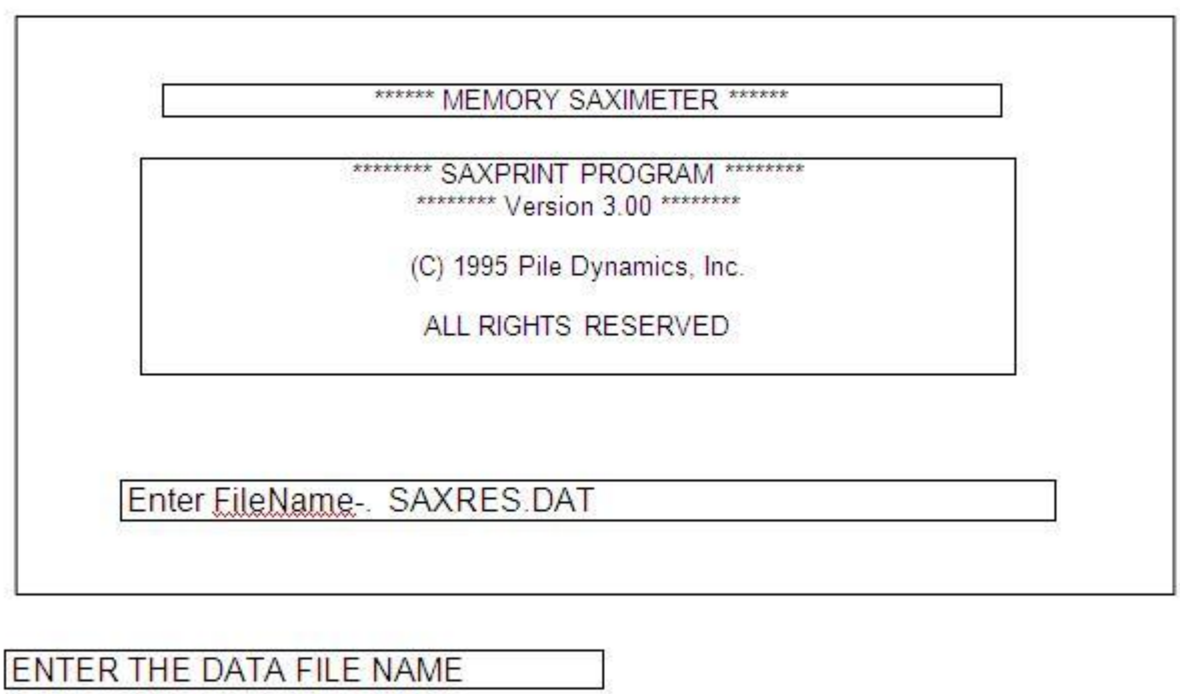


Figure B-1 Saxprint: Initial Screen

If the year is not appended to the Start and Stop dates in the SAXIMETER data, you will be asked if you would like the year appended to these dates (Fig. 2). The data is then formatted for the edit screen.

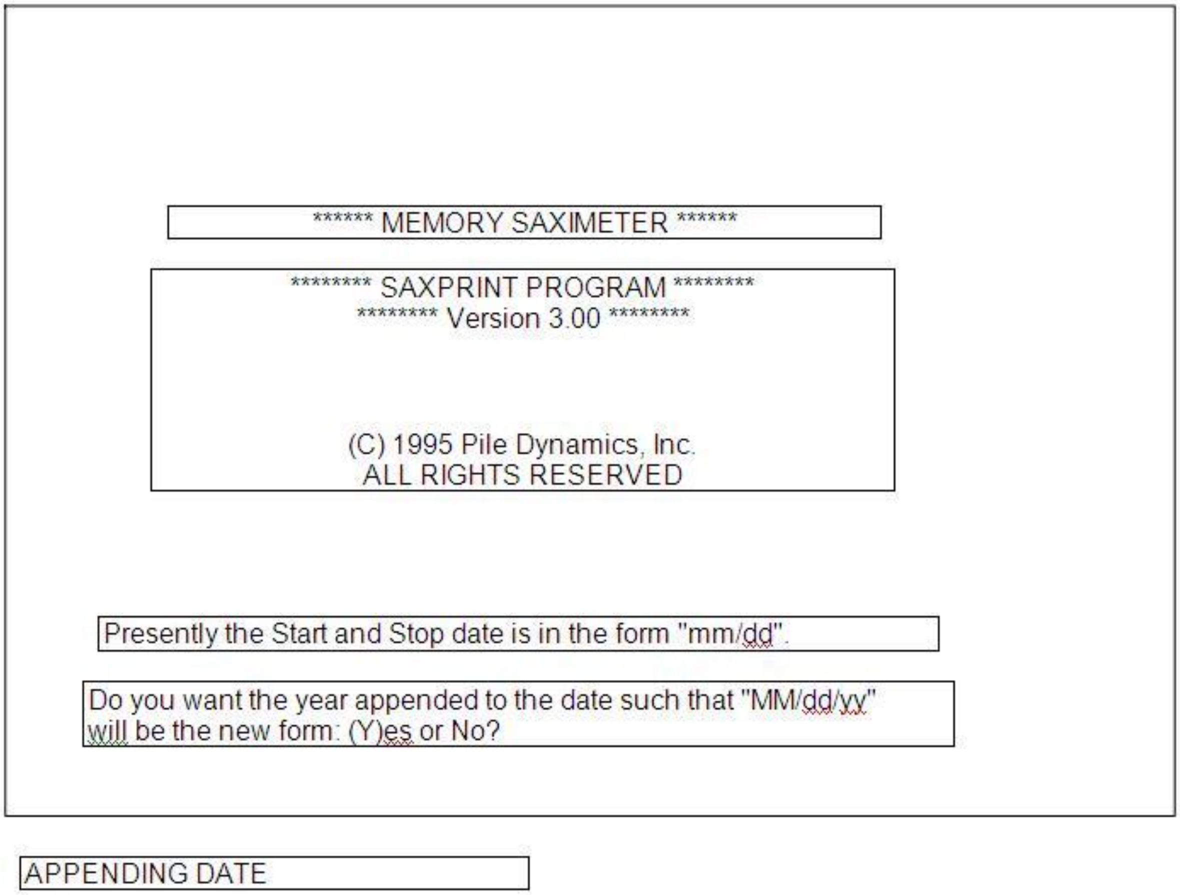


Figure B-2 Saxprint: Data Converting

B2.0 DATA EDITOR

The data editor is described as follows:

The first line displays the menu bar, which gives you the menu choices. The second line displays the column titles of the data. The third line displays the units for that column. The next 19 lines is the viewing area where the data to be printed can be viewed and edited. There is a prompt line below the data to help you through the editor and a highlighted box which indicates the current activity.

```
File          Pilename    Data          Update          Quit
LP:PEN   BCNT        BPM
 ft                  bls/min
  PILE NAME-. TP9A
  HAMMER TYPE - LB440
START:    09/21/91    10:55
LP:PEN    BCNT        BPM
20.000     194        88.8
21.000      49        88.6
22.000      56        88.7
23-000      64        88.3
24.000      80        88.2
25-000     104        88.0
26-000      58        88.5
27.000     310        88.7
28-000     293        89.1
29.000     359        89.2
30.000     434        90.3
30.500     197        90.5
STOP:    09/21/91    11:20
TOTAL BCNT:           2198

PJ: BLACK-CR-EAST PN: TP9A          HM: LB440
File => SAXRES.DAT      BROWSE (move with arrows, Home, PgUp, PgDn, End, Tab)
```

Figure B-3 Saxprint: Data Editor

The menu bar has various pull-down menus which become active when the first letter of the selection you want is pressed (i.e., press **F** or **f** for **F**ile). The choices in the pull-down menu can be activated by pressing the letter which is capitalized or by using the arrow keys to move the cursor to the desired choice, then press the **<Enter>** key.

The menu bar and its choices are described as follows:

B2.1 File

Retrieve

Allows you to open another data file. Any changes to the previous data file will be lost.

Save

Allows you to save the current data to a file. If the file already exists, a prompt will ask if you want to write over the previous file. If you overwrite the file, the previous data in the file will be lost.

Combine

Allows you to append a new file to the end of the present data file being displayed. This allows you to merge files together. When this happens, pile names contained in the new data will be added to a the Pile Name list.

Datalink

The Datalink function allows you to retrieve data from the SAXIMETER using the serial port of your computer.

B2.2 Pile Name

This option displays a list of pile names contained in the data file. To display the data related to the particular pile name, use the arrow keys to move the cursor to the pile name you wish to view, then press the **<Enter>** key. The edit screen will be updated with the data for the pile chosen.

B2.3 Data

Edit

This option allows you to edit displayed data until you activate another choice. The program only allows "COMMENT", "PILE NAME", "HAMMER TYPE" and the "COLLECT DATA" to be edited. A message will be displayed if the data line cannot be edited.

Delete

Deletes a line which the cursor is presently on. The program allows only "COMMENT" and "COLLECTED DATA" lines to be deleted. A message will be displayed if an attempt is made to delete any other data line. The deleted data is permanently lost.

Insert

Inserts a blank line at the cursor position, the blank data line can either be a comment or a number. Choose the data line to insert, then enter the data for the inserted data line. Use the arrow keys to move to the next field. At any time, you may press the **<Esc>** key to abort the insert. Press **<Enter>** when you have finished inserting a line. A window will ask if you have finished, if you have, press the **<Enter>** key.

Print

This option prints either the "SUMMARY" or the "COMPLETE" data for the present pile being edited when the option "THIS PILE" is chosen (see appendix for examples). If the "ALL PILES" option is chosen. then every pile in the data file is printed with the option of "SUMMARY" or "COMPLETE". The following data is printed during the "SUMMARY" option: "START" data, "STOP" data, and "COMMENT" data. When the "STOP" data is printed, the sum of the blows to this

point is then printed and if the hammer is an open end diesel, the weighted average of the stroke is printed. If the hammer is not an open end diesel, but the stroke has been entered manually, then this stroke value is printed. At the end of the "SUMMARY", the total blow count is given with the total driving time. If the hammer is an open end diesel, then the overall weighted average is printed. The last three lines of the "SUMMARY" are the final three blow counts for that pile.

Print To

This option allows the user to select the printer port or to print to a file. If a file is selected, then the file name is the same as that used when the file was entered into the program with the extension "POO" (filename.POO).

Combine

Allows data from different pile names to be combined. This option will display the piles to choose from. To tag the pile, you press the **<Space Bar>,** to untag, press the **<Back Space>** key. Only two piles can be combined at a time. After choosing the piles, press **<Enter>.** A prompt will ask if the penetration should be automatically updated. The pile tagged "2" will lose its "PILE NAME" and "HAMMER TYPE" and will be appended to the pile tagged "1", at which time the "TOTAL BNCT" will be recalculated. The **<Esc>** key will abort your actions. The **<Esc>** key will not abort after the point where a window will be displayed informing you that you cannot undo what you are about to do.

B2.4 Update Increment Depth

Allows you to increment or decrement a range of penetration numbers according to the given delta. To highlight a range, place the cursor on the start of the range, press **<Enter>,** Then, using the **<Arrow>, <Pgup>, <Pgdn>, <Home>,** or **<End>** keys, move the cursor to the end of the range and press the **<Enter>** key. A prompt will ask for the increment, a positive or negative value may be used. The **<Esc>** key may be used to escape backwards through this option.

B2.5 Quit

This option prompts you to exit to DOS.

B3. DATA LINK

The data link function allows you to retrieve data from the SAXIMETER using the serial port of your computer. When you first enter the function, the computer will check for an active serial port, if no serial port is active the program will tell you. The program will then clear the serial port, then wait for data from the SAXIMETER. Prepare the SAXIMETER for sending by pressing the send key (refer to SAXIMETER manual Section 2.13, page 6). The right-hand portion of the computer console will begin to fill with characters sent by the SAXIMETER. The serial port will time out when the SAXIMETER has stopped sending its data. You will then have the choice to either save the data buffer to a file or clear the buffer. After the buffer has been

saved, it will be cleared, then the serial port will be reactivated and wait for data. You may press a key to activate the menu, but doing so while collecting data will cause a window to alert you that the serial port will be deactivated if you continue.

When the first letter of the option on the menu bar is pressed, either a pull-down menu or a pop-up window will became active.

The menu bar and its choices are described as follows:

File
Allows you to change the file name of the file where the data will be saved.

Comport
Allows you to change the default setting of the serial port. The default setting can be changed by editing the file named "SXFILE.DAT".

Baud rate
Allows you to change the default setting of the serial port baud rate. The default setting can be changed by editing the file named "SXFILE.DAT".

Saxprint
Allows you to enter the SAXPRINT editor.

Quit
Allows you to exit the program.

Data Link Trouble

Every effort was made to make this serial link routine easy and trouble free. So if you are having trouble sending data, recheck the following:

a) The serial cable from the SAXIMETER is connected securely to the serial port on the computer.

b) Check serial cable for damage, especially where the serial cable storage compartment door closes.

c) Recheck which serial port you are connected to.

d) Recheck the baud rate.

e) Make sure the message in the upper left-hand corner of the console is "WAITING TO RECEIVE DATA ..." before attempting to send data from the SAXIMETER. If you are still unable to make a connection, give us a call.

B4. SETUP

In order to run the SAXPRINT PROGRAM, the following files must be present in the same directory:

SAXPRNT.EXE	The SAXPRINT PROGRAM
SXFILE.DAT	The default parameters
SAXHDS.DAT	The headings file
SAXMSG.DAT	The file containing messages for the program
PRNT.DRV	The printer driver

Figure B-4 Saxprint Program Files

The SAXPRINT requires the information from SXFILE.DAT in order to run correctly. An example of the SXFILE.DAT file is shown below.

IENG =0 1	Units identifier Default	: 0=METRIC, 1=English, 2=SI
PRTP =0 2	For printer use	: 0->Coml, 1->Com2, 2->LPT1, 3->LPT2, 4->FILE
SAXP =0 0	For Saximeter use	: 0->Coml, 1->Com2
SAXRES.DAT	PDA Temp Filename Default	
SAXRES.MDF	Data Storage Filename Default	
SAXHDS.DAT	Heading File	
SAXMSG.DAT	File containing messages for program	

Figure B-5 SXFILE.DAT Example

B5. FINAL NOTES

If the you have any suggestions for, or problems with, this program, please let us know, by letter, fax, phone or e-mail @:

Phone: (216) 831-6131
Fax: (216) 831-0916
Email: info@pile.com

Send Inquires to:

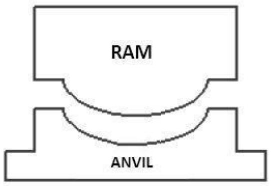
PILE DYNAMICS, INC.
30725 AURORA RD.
Cleveland, Ohio 44128

C. PILE DRIVING INSPECTION FORMS

BD 138
NYSDOT

PILE AND DRIVING EQUIPMENT DATA

P.I.N. ____________________ Contract No.: ________ Pile Driving Contractor (Piles Driven By):
Project: ____ ____
County: ____ ____
____



HAMMER Manufacturer: ____________________ Model: ____________
Type: ____________________ Serial No: ____________
Rated Energy: __________(lbs)@__________ Length of Stroke (ft)
Fuel Setting (for Diesel)________________________________

HAMMER CUSHION Material(s): ____________________ Area: __________ (in^2)
Thickness(es): ________________________________ (in)
Modulus of Elasticity-E: ________________________ (PSI)
Coefficient of Restitution-e: ________________________

PILE CAP - Helmet / Bonnet / Anvil / Block - Weight: ________________________ (kips)

PILE CUSHION (For Concrete Piles Only) Material(s): ____________________ Area: __________ (in^2)
Thickness(es): ________________________________ (in)
Modulus of Elasticity-E: ________________________ (PSI)
Coefficient of Restitution-e: ________________________

PILE

	1	2	3	4	5
Structure Name:	________	________	________	________	________
Substructure (see back):	________	________	________	________	________
Pile Information (see back):	________	________	________	________	________
Material (Grade):	________	________	________	________	________
Weight/ft.:	________	________	________	________	________
Length in Leads (ft.)(see back) :	________	________	________	________	________
Nominal Resistance (ton):	________	________	________	________	________
Splice Description:	________	________	________	________	________
Toe Treatment Description:	________	________	________	________	________

DISTRIBUTION
ONE COPY EACH TO:

- ☐ DEPUTY CHIEF ENGINEER (Structures)
- ☐ DIRECTOR, GEOTECHNICAL ENGINEERING BUREAU
- ☐ REGIONAL DIRECTOR
- ☐ ENGINEER IN CHARGE

NOTE: If mandrel is used to drive the pile, attach separate manufacturer's details sheet(s) including weight and dimensions.

Submitted By: ____________________ Date: ____________

Phone Number: ____________________ Fax: ____________

BD 138
Reverse
NYSDOT

CUSHION INFORMATION

(Data as used by NYSDOT)

Material	**Modulus of Elasticity E (ksi)**	**Coefficient of Restitution e ($\leq$1)**
Aluminum	10003	.8
Blue Nylon (MC-904)	175	.92
Conbest	280	.8
Duracush	35	.82
Forbon	400	.85
Fosterlon	380	.85
Force Ten	142	.8
Hamortex	145	.77
Micarta	225	.8
Plywood	30	.5
Urethane	175	.72
NYcast 6MPS Cast Nylon	207	.91
Ryertex	43	.93
Non-Impv. Polymer S-542/S-540	200	.90
Impv. Polymer S-539/S-530	200	.84
Oak (Parallel)	750	.50
Oak (Transverse)	60	.50
Klinger	25	.60
Bongossi Wood	290	.75
Nylon/Klinger	171	.84
MMPAC	367	.88

SUBSTRUCTURE

Give designation of corresponding abutment or pier if pile size or length varies from one substructure to another.

PILE INFORMATION

Include: Pile type, grade, size, thickness, and taper.

Length in Leads: Give the length actually used and not the estimated lengths on the plans.

MURK 8 (8/12) ◯ Metric ◉ English

PILE DRIVING RECORD

Clear Form

JOB STAMP

DATE: ________________

B.I.N: ________________

SUBSTRUCTURE ________________

TIME START: ________________

TIME END: ________________

Pile Number: ____________ Pile Type: ____________

Hammer, Make, Model & Number: ________________________

Estimated Length(ft): ____________ Total Length Placed in Leads(ft) ____________

Cut Off Elevation: ____________ Ground Elevation @ Time of Driving: ____________

Depth(ft)	*Blows	*Energy Control	Depth(ft)	*Blows	*Energy Control	Depth(ft)	*Blows	*Energy Control	Depth(ft)	*Blows	*Energy Control

Remarks:

____

____

____

NUMBER OF BLOWS:

LAST 1 ft: __________ LAST 4 in: __________ LAST 3 in: __________

LAST 2 in: __________ LAST 1 in: __________

TOTAL LENGTH(PAY)(ft): __________

LENGTH IN GROUND(ft): __________ Inspector Signature: ________________

Print Form

MURK 8-1 (8/12) ◯ Metric ◉ English

PILE DRIVING RECORD SUMMARY

Clear Form

JOB STAMP

Substructure: ______________________

Total Length (PAY) (ft): ______________________

Type and Size of Piles: ______________________

Hammer, Make, Model & Number: ______________________

Required Energy Control: Stroke(ft), Blow Rate(bpm), or Bounce Chamber Pressure (psi): ______________________

Cut-off Elevation (ft): ______________________

ABOVE MUST BE FILLED OUT COMPLETELY - SUBMIT REPORTS DAILY

Pile No.	Date	DWR Number	Length Placed in Leads	Energy Control Recorded	Length Driven in Ground	Pile Toe Elevation	Blows for the Last				Remarks *
							4 in	3 in	2 in	1 in	

Remarks:

* Bearing piles shall be given at least five blows after refusal (5 blows/ 0.25 in). Indicate number of blows under Remarks.

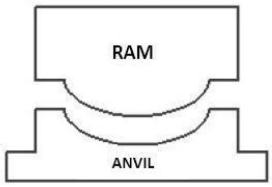
Print Form

D. PILE DRIVING INSPECTION FORMS

BD 138
NYSDOT

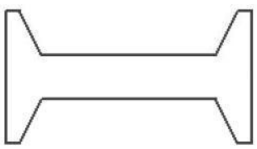
PILE AND DRIVING EQUIPMENT DATA

P.I.N. ____________________ Contract No.: _________ Pile Driving Contractor (Piles Driven By):
Project: ______________________________________ ____
County: ______________________________________ ____
____

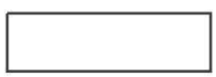


HAMMER Manufacturer: ______________________ Model: ___________
Type: ______________________ Serial No: ___________
Rated Energy: __________(kJoules) @_________ Length of Stroke (m)
Fuel Setting (for Diesel)________________________________

HAMMER CUSHION Material(s): ____________________ Area: __________ (cm^2)
Thickness(es): ________________________________ (mm)
Modulus of Elasticity-E: ________________________ (MPa)
Coefficient of Restitution-e: ____________________



PILE CAP - Helmet / Bonnet / Anvil / Block - Weight: ________________________ (kN)



PILE CUSHION (For Concrete Piles Only) Material(s): ____________________ Area: __________ (cm^2)
Thickness(es): ________________________________ (mm)
Modulus of Elasticity-E: ________________________ (MPa)
Coefficient of Restitution-e: ____________________

PILE	1	2	3	4	5
Structure Name:	________	________	________	________	________
Substructure (see back):	________	________	________	________	________
Pile Information (see back):	________	________	________	________	________
Material (Grade):	________	________	________	________	________
Weight/m :	________	________	________	________	________
Length in Leads (m) (seeback):	________	________	________	________	________
Nominal Resistance(ton):	________	________	________	________	________
Splice Description:	________	________	________	________	________
Toe Treatment Description:	________	________	________	________	________

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- ☐ DIRECTOR, GEOTECHNICAL ENGINEERING BUREAU
- ☐ REGIONAL DIRECTOR
- ☐ ENGINEER IN CHARGE

NOTE: If mandrel is used to drive the pile, attach separate manufacturer's details sheet(s) including weight and dimensions.

Submitted By: ____________________ Date: ___________

Phone Number: ____________________ Fax: ___________

CUSHION INFORMATION
(Data as used by NYSDOT)

Material	Modulus of Elasticity E (MPa)	Coefficient of Restitution e (≤1)
Aluminum	68970	.8
Blue Nylon (MC-904)	1207	.92
Conbest	1931	.8
Duracush	241	.82
Forbon	2759	.85
Fosterlon	2621	.85
Force Ten	979	.8
Hamortex	862	.77
Micarta	1552	.8
Plywood	207	.5
Urethane	1207	.72
NYcast 6MPS Cast Nylon	1428	.91
Ryertex	297	.93
Non-Impv. Polymer S-542/S-540	1379	.90
Impv. Polymer S-539/S-530	1379	.84
Oak (Parallel)	5173	.50
Oak (Transverse)	414	.50
Klinger	170	.60
Bongossi Wood	2000	.75
Nylon/Klinger	1179	.84
MMPAC	2531	.88

SUBSTRUCTURE
Give designation of corresponding abutment or pier if pile size or length varies from one substructure to another.

PILE INFORMATION
Include: Pile type, grade, size, thickness, and taper.

Length in Leads: Give the length actually used and not the estimated lengths on the plans.

MURK 8 (8/12) ◉ Metric ◯ English

PILE DRIVING RECORD

Clear Form

JOB STAMP

DATE:

B.I.N:

SUBSTRUCTURE

TIME START:

TIME END:

Pile Number: Pile Type:

Hammer, Make, Model & Number:

Estimated Length(m): Total Length Placed in Leads(m):

Cut Off Elevation: Ground Elevation @ Time of Driving:

Depth(m)	*Blows	*Energy Control	Depth(m)	*Blows	*Energy Control	Depth(m)	*Blows	*Energy Control	Depth(m)	*Blows	*Energy Control

Remarks:

NUMBER OF BLOWS:

LAST 1.0 m: LAST 100mm: LAST 75mm:

LAST 50mm: LAST 25mm:

TOTAL LENGTH (PAY)(m):

LENGTH IN GROUND(m): Inspector Signature:

Print Form

MURK 8-1 (8/12) ◉ Metric ○ English

PILE DRIVING RECORD SUMMARY

Clear Form

JOB STAMP

Substructure: ______________________

Total Length (PAY) (m): ______________________

Type and Size of Piles: ______________________

Hammer, Make, Model & Number: ______________________

Required Energy Control: Stroke (m), Blow Rate (bpm), or Bounce Chamber Pressure (kPa): ____________

Cut-off Elevation (m): ______________________

ABOVE MUST BE FILLED OUT COMPLETELY - SUBMIT REPORTS DAILY

Pile No.	Date	DWR Number	Length Placed in Leads	Energy Control Recorded	Length Driven in Ground	Pile Toe Elevation	Blows for the Last				Remarks *
							100 mm	75 mm	50 mm	25 mm	

Remarks:

____

____

____

* Bearing piles shall be given at least five blows after refusal (8 blows/10mm). Indicate number of blows under "Remarks".

Print Form

E. SUPPLEMENTAL PILE DRIVING INSPECTION FORM

BD 190 (4/81)

WELDING PROCEDURE SPECIFICATION

Material specification ____________________

Welding process ____________________

Manual, semi-automatic or automatic ____________________

Position of welding ____________________

Filler metal specification AWS ____________________

Filler metal classification ____________________

Electrode and manufacturer ____________________ FCM Lot # ____________

Flux and manufacturer ____________________ FCM Lot # ____________

Shielding gas ____________ Dew point ____________ Flow rate ____________

Single or multiple pass ____________________

Single or multiple arc ____________________

Welding current ____________________

Polarity ____________________

Welding progression ____________________

Root treatment ____________________

Preheat and interpass temperature ____________________

Postheat treatment ____________________

PQR# ____________

WELDING PROCEDURE

Pass No.	Electrode Size	Welding parameters Amperes	Welding parameters Volts	Travel Speed	Joint Detail
					Sequence of weld passes shall be shown diagramatically

Procedure no. ____________ Fabricator or Erector ____________________

Revision no. ____________ Authorized by ____________________

Date ____________________