FOUNDATIONS
5-393.100

5-393.101 GENERAL

Before starting excavation, and after staking the substructure units, a visual inspection should be made in order to compare the work with the layout shown on the plans. Actual measurement checks should be made to features such as railroad tracks, or to other construction, which may have an influence on the location of the structure. Structures over navigable waters should receive special attention in this respect.

Cross sections and levels should be taken for the purpose of determining excavation quantities, when they are required. Place cut stakes at convenient locations for the contractor, so as to properly guide the excavation operations.

The excavation limits defined in the specifications are for the purpose of measurement for payment, and are not intended to confine the contractor's operations to these limits or warrant a stable slope. Any excavation outside of the defined limits must not interfere with or endanger other work or property. If solid rock is encountered, the excavation must conform to specified limits as closely as practical, since any over excavation must be backfilled with concrete.

In the case of rock excavation it is often necessary to remove overburden before elevations for computing rock quantities can be obtained. The contractor should be informed that rock excavation should not start until the engineer has had an opportunity to obtain these elevations.

A comprehensive record should be kept of the types of soil encountered, water table elevation, and soil stability. The Bridge Office will appreciate receiving such information for its files at the completion of each structure, or after completion of substructure work. (Notations on copies of the plan sheets containing soil boring logs is a good way to send in this information). It may also be required when a decision is to be rendered on whether or not additional soil borings will be required.

5-393.102 COFFERDAMS

Cofferdams provide a watertight enclosure for the excavation and construction of structure foundations below the prevailing water surface. To ensure a safe and satisfactory cofferdam, it must be built in accordance with the plans and/or drawings submitted by the Contractor and approved by the Engineer before construction is started. Bracing and other supports cannot extend into the substructure concrete without written approval of the Engineer. See Figure A 5-393.102 for an example of a cofferdam.

Loose, permeable or water-saturated soils, water, and the need for protecting adjacent work or structures all dictate the needs for cofferdams. Since our prime concern at all times should be for the safety of the employees and the public, every possible precaution should be taken to avoid accidents. For that reason, it is advisable to check the cofferdam plans. Assistance in checking plans may be obtained from the Bridge Office. Observe the action of the members during the time it is in service, and report any indications of distress to the Contractor and the Engineer.

The adequacy of cofferdams is, in general, the responsibility of the contractor, since they ordinarily are not a permanent part of the structure. The purpose of the cofferdams is to provide a supported opening within which the contractor can perform work, which is required by the contract. Cofferdams must be removed to specified limits after they have served their purpose (See Mn/DOT Specification 2451.3A3a). The Special Provisions may contain limitations on cofferdam construction or removal and should be checked prior to any work.

Cofferdams must be large enough to provide room for footing forms and to allow for drainage between the forms and the sheeting. For proper drainage, sump holes are necessary outside the forms at the end of the cofferdam. In laying out the size of the cofferdam, allowance should be made for possible vertical deviation of the sheeting while driving and for the sump at the end.

Cofferdams and excavations adjacent to railroads should receive added attention, because any movement or overloading of members here could immediately reflect to the tracks. A slight change in either the vertical or horizontal alignment of a railroad track could result in a serious accident, particularly on a high speed track.

Cofferdam plans are usually required by the Railroad when substructure units are to be constructed adjacent to their tracks, and their approval of these plans is necessary. Also, if legal clearance requirements are encroached upon, it will be necessary to get approval of the Mn/DOT Railroad Administration Section, Office of Freight & Commercial Vehicle Operations. Read the Special Provisions to determine whether or not plans are required.

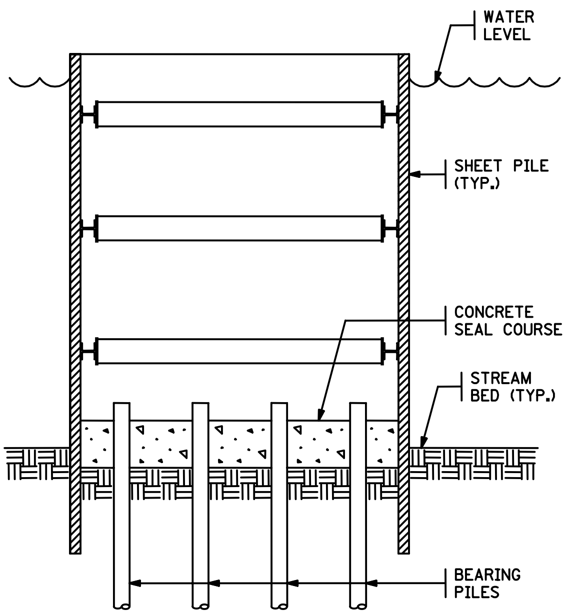
In order to satisfy the requirements of the various agencies when excavation is performed adjacent to railroad tracks, it is necessary to submit ten sets of cofferdam plans to the Mn/DOT Railroad Administration Section. Approval by the Railroad Company, and by the Mn/DOT Railroad Administration Section when required, will be obtained, and approved prints returned to the Project Engineer for the contractor and Project Engineer. It sometimes requires two weeks or more to obtain the necessary approvals; therefore the contractor should be encouraged to prepare the plans well in advance of the time they will be needed.

In order to serve the purpose for which they are intended, cofferdams in water should be reasonably tight to keep pumping requirements to a minimum. They should be sufficiently large to provide for driving batter piles in the outer rows, the construction of forms, and to provide a waterway outside of the footing area. The length of the sheeting should allow for lowering the plan footing elevation at least 1 meter (3 feet), as provided for in the Mn/DOT Specification 2451.3A3a. The sheeting should also be long enough to obtain sufficient toe so that water is not forced below the sheets and up through the soils below the excavation. Insufficient depth of sheeting creates conditions that could cause complete failure of the dam when it is pumped out. To avoid failure due to water pressure often requires that the sheets be driven to a depth below the footing equal to one half the distance, or more, from the bottom of the footing to the water level (referred to as head).

Do not permit employees under your supervision to work within cofferdams which are considered questionable or unsafe. In such cases notify the engineer, so that appropriate action can be taken to correct the situation.

Struts and braces should be located so as to minimize interference with pile driving, formwork, reinforcement bars, and placement of concrete. They should be tightly secured and adequately supported. Timber should be sound, and should be free of deep cuts, large holes, or other damaging characteristics.

For more information on cofferdams refer to "Concrete Placement in Cofferdams" in Section 5-393.354 of this manual.



COFFER DAM

FIGURE A 5-393.102

5-393.103 CONCRETE SEALS

Plans for substructure units which must be constructed in water within a cofferdam may require that a concrete seal be placed directly over the bottom of the excavation before pumping the water out of the cofferdam. The purpose of the seal is two fold; it serves to act as a barrier against inflow of water and saturated soils caused by hydrostatic pressure of the water outside of the dam and as a bottom frame for the cofferdam. An example of a seal placement is shown in Figure A 5-393.103.

Theoretically, the thickness of a foundation seal must be such as to balance the uplift forces and the forces counteracting uplift. Practically, the thickness is indeterminate because of the variable value of all the factors except the mass (weight) of the concrete and the sheet piling. The character of the underlying soil or rock and the number and penetration of the foundation piles affect the seal design as does the water level during construction or the type of penetration of the sheet piling.

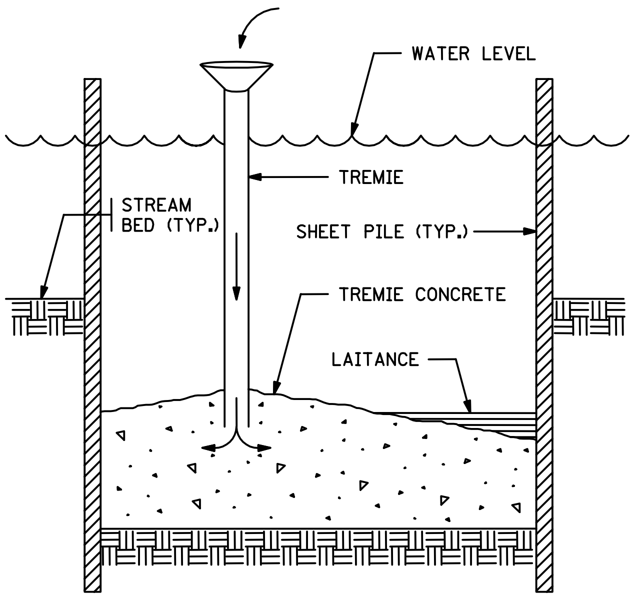
When the depth of the water (head) and the character of the soil is such that the designer anticipates that a concrete seal is necessary, or that it will be less costly to provide the seal than to drive sheet piling to adequate depth, a seal will be shown in the plans. When this is done, a pay item is generally included to cover the special concrete required for this purpose. The concrete specified is usually a type with a high cement content, because it is likely that some loss of cement will be encountered during placement, and also because early strength is desirable for the progress of subsequent operations.

When the plans do not require a concrete cofferdam seal, but the contractor requests permission to place a seal in lieu of providing and driving cofferdam sheets of a length that will prevent dewatering problems, the seal will be placed at the contractor’s expense. No payment will be made for the additional excavation nor for equipment or material made necessary by such a change, since it is merely a change in the contractor’s method of operation.

It is, of course, expected that the contractor’s supervisors will have had previous experience in cofferdam and seal construction. It is also expected that adequate cofferdam material, as well as pumping and driving equipment, will be supplied. A properly constructed cofferdam with a properly constructed seal will require a minimum of continuous pumping.

Before the contractor is permitted to start concrete placement for a cofferdam seal, a thorough inspection should be made to make certain that the excavation has been properly completed to specified grade. Some failures have occurred in the past due to mounds of dirt left in the excavation which have resulted in water spouts through the seal. These mounds of dirt were left under the struts and wales where it is difficult to perform the excavation and inspection. Repairing this type of failure is very difficult, costly and time-consuming.

For more information regarding placement of concrete seals refer to "Tremis" on page 5-393.352(3) and "Concrete Placement in Cofferdams", section 5-393.354 of this manual.



TREMIE CONCRETE SEAL

FIGURE A 5-393.103

5-393.104 EXCAVATION

In determining excavation quantities, it is imperative that cross sections or levels be taken at the top of the ground before excavation is started.

Excavation, regardless of whether it is with or without cofferdam protection, should be conducted carefully to avoid endangering adjacent work or structures. OSHA requires the contractor to designate a competent person to be responsible for excavation safety. State personnel should have sufficient training to recognize hazardous situations, particularly as applies to worker safety.

When excavating for a footing where piling will not be used, extra care will be required to avoid excavating below the bottom of the footing. The final stages of excavation must generally be accomplished by hand work in order to prevent such over-excavation. If excavation is carried too deeply in a natural foundation, the contractor is required by the specifications to remove all disturbed material, and to backfill the entire extra depth with concrete at the contractor's expense. (The exception to this is when a sand-gravel subfoundation is required.) The concrete mix to be used for this purpose should be obtained from the Concrete Engineer, unless the contractor elects to use the same mix as provided for the remainder of the footing. When excavation is performed within a cofferdam where a substantial number of tubular or timber foundation piles are to be driven, it is usually good practice to over-excavate, perhaps as much as a foot or more in some cases. When a large number of such piles are driven within an enclosure, particularly in spongy soils, the tendency is for the ground to heave due to the displacement by the piles. It is generally easier and less expensive for the contractor to backfill to grade if the excavation is low, than it is to excavate in water after piling have been driven. This is, of course, the contractor's choice, but it is prudent to discuss the matter with the contractor in advance of performing the work.

Over-excavation for pile foundations should be backfilled with granular material, or with concrete, at the contractor's expense.

After excavation has been completed for an underwater foundation, and before pile driving is started, check the elevation of the bottom of the excavation thoroughly. Make certain that mounds of dirt have not been left under the struts, walers, or bracing. A similar check should be made after pile driving operations have been completed.

Should the bottom of an underwater foundation excavation be too high after the piles have been driven, excess material can sometimes be removed by scouring the area with a water jet and pumping while the material is still in suspension.

5-393.105 DISPOSAL OF MATERIALS

Unless otherwise noted in the contract, all excavation for substructure units should be used for backfilling to the grade and cross section existing before the excavation was started. When such materials are unsuitable for backfill they should be replaced with suitable material, furnished and paid for as Extra Work, unless other provisions are indicated. All surplus or unsuitable material should be disposed of as provided for in Plans, Special Provisions and Specifications 1701, 1702 and 2104.

When the contract requires stock piling of suitable materials removed from abutment areas for use as sand-gravel fill behind the abutment, care should be exercised so as not to contaminate such material during removal operations, or subsequently.

Excavations for substructure units located in streams or other waters should also be backfilled to the grade and cross section existing before the work was started, unless a channel change is involved, or unless some other grade is indicated in the plans. Excess materials should be removed and disposed of outside of the stream bed.

It is advisable, particularly in navigable waters, to obtain cross sections over the entire area which may be affected by the work. This should be done prior to starting such operations. Cross sections should be repeated on the same pattern after the work has been completed and before the contractor removes his or her equipment from the site. Then it will not be necessary to require the contractor to return the equipment at a later date. The Corps of Engineers has jurisdiction over navigable water, and they are very strict about maintaining uniform flow lines for such waters. They "sweep" the bottom intermittently to determine whether or not the required channel depth is available to navigation, and will require that corrections be made whenever and wherever necessary.

5-393.106 DRILLED SHAFTS

A drilled shaft foundation is a cylindrical excavation in soil or rock that is filled with concrete with the primary purpose of structural support. Reinforcing steel is installed in the excavation prior to placing the concrete. Drilled shafts are circular in cross section and may be belled at the base to provide greater bearing area.

Vertical load is resisted by the drilled shaft in base bearing or side friction or a combination of both. Horizontal load is resisted by the shaft in horizontal bearing against the surrounding soil or rock.

Other terminology commonly used to describe a drilled shaft includes drilled pier, drilled caisson, or auger-cast pile. Excavation of a "drilled" shaft may not utilize a drill or auger. Extraction of the soil or rock may be done by almost any method. For large diameter shafts, extraction is often done by clam shell. Drilled shafts are used because of their very high load capacities. Drilled shafts are becoming more common for river crossing bridges as they can be constructed to depths below predicted scour elevations, even in very dense soils or bedrock. The attention to detail in the construction of drilled shafts is critical to ensure a successful foundation. If proper procedures are used by an experienced contractor, drilled shafts can be installed successfully in a wide variety of subsurface conditions.

Certain limitations exist with regard to the geometry of a drilled shaft. Diameters of 300 to 360 millimeters (12 to 14.5 inches) can be used if the length of the shaft is no more than 2.5 to 3.0 meters (8 to 10 feet). Such small foundations are commonly used to support sign structures and high tower lighting.

As the depth of the excavation becomes greater, the diameter normally must increase. Several factors that influence the ratio of depth to diameter are: the nature of the soil profile, the position of the water table, whether or not a rebar cage is required, the design of the concrete mix, and the need to support lateral loading. The concrete may be placed by free fall in shafts if the mix is carefully designed to ensure that the excavation is filled and segregation is minimized. Free fall is defined as concrete falling through air. Therefore, the concrete must not fall through the rebar cage or strike the sides of the excavation.

Heavy, rotary-drilling equipment is available for large drilled-shaft excavations. Cylindrical holes can be drilled with diameters of up to 6 meters (20 feet) to depths of up to 60 meters (200 feet) and with under reamed bells up to 10 meters (33 feet) in diameter. Percussion equipment can make excavations of almost any size and depth. Typical sizes of shafts for bridge foundations have diameters in the range of 1 to 2 meters (3-6.5 feet).

The drilled shaft is most commonly constructed by employing rotary drilling equipment to drill a cylindrical hole. Auger methods are used in earth and soft rock and coring methods in hard rock. Three methods of keeping the excavated hole open are in general use: the dry method, the casing method and the slurry-displacement method. The dry method is generally used if the excavation can be made with little or no caving, squeezing or sloughing, and with little or no water collecting in the excavation. If the excavation will not maintain its dimensions, or if excessive water collects, the use of temporary or permanent casing may be required. An alternative to the use of casing is to drill the hole using a slurry to prevent caving or sloughing (the slurry-displacement method). After the cylindrical hole is excavated by augers, core barrels, or drilling buckets, an under reaming tool can be used to enlarge the base of the drilled shaft. A rebar cage is placed and the excavation is filled with concrete. Temporary casing, if used, is recovered as the concrete is placed. A concrete mix with a high workability (slump) is frequently required.

During placement of concrete into the shaft the inspector should carefully monitor the volume to determine if voids are present or if the walls are uncased, to determine if sloughing of the walls has occurred. To aid in monitoring the concrete volume a form has been developed (see figures A 5-393.106 and B 5-393.106). This form allows the inspector to compare the predicted volume with the actual volume at specific elevations during the placement. Large overruns or underruns in concrete volume may indicate large voids or sloughing of the walls.

After completion of *each* drilled shaft the Contractor is responsible for compiling an initial data report in a standard format furnished by the Engineer (see figure C 5-393.106). The report shall be furnished to the Engineer within 24 hours after concreting has been completed for that shaft. Upon completion and acceptance of all shafts by the Engineer, a final report for each shaft--in the same standard format--containing any additional data shall be furnished to the Engineer.

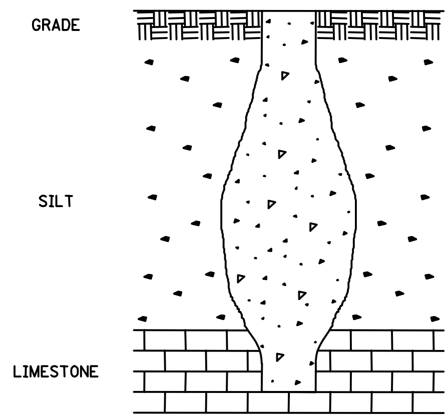
As there are many variations in the equipment and methods of excavation and construction for drilled shafts, this manual does not discuss detailed procedures. Personnel that are to be involved with projects having drilled shafts should carefully review the special provisions and obtain the following references available from the Federal Highway Administration and the International Association of Foundation Drilling which describe the detailed methods of construction that are used in a variety of subsurface and surface conditions:

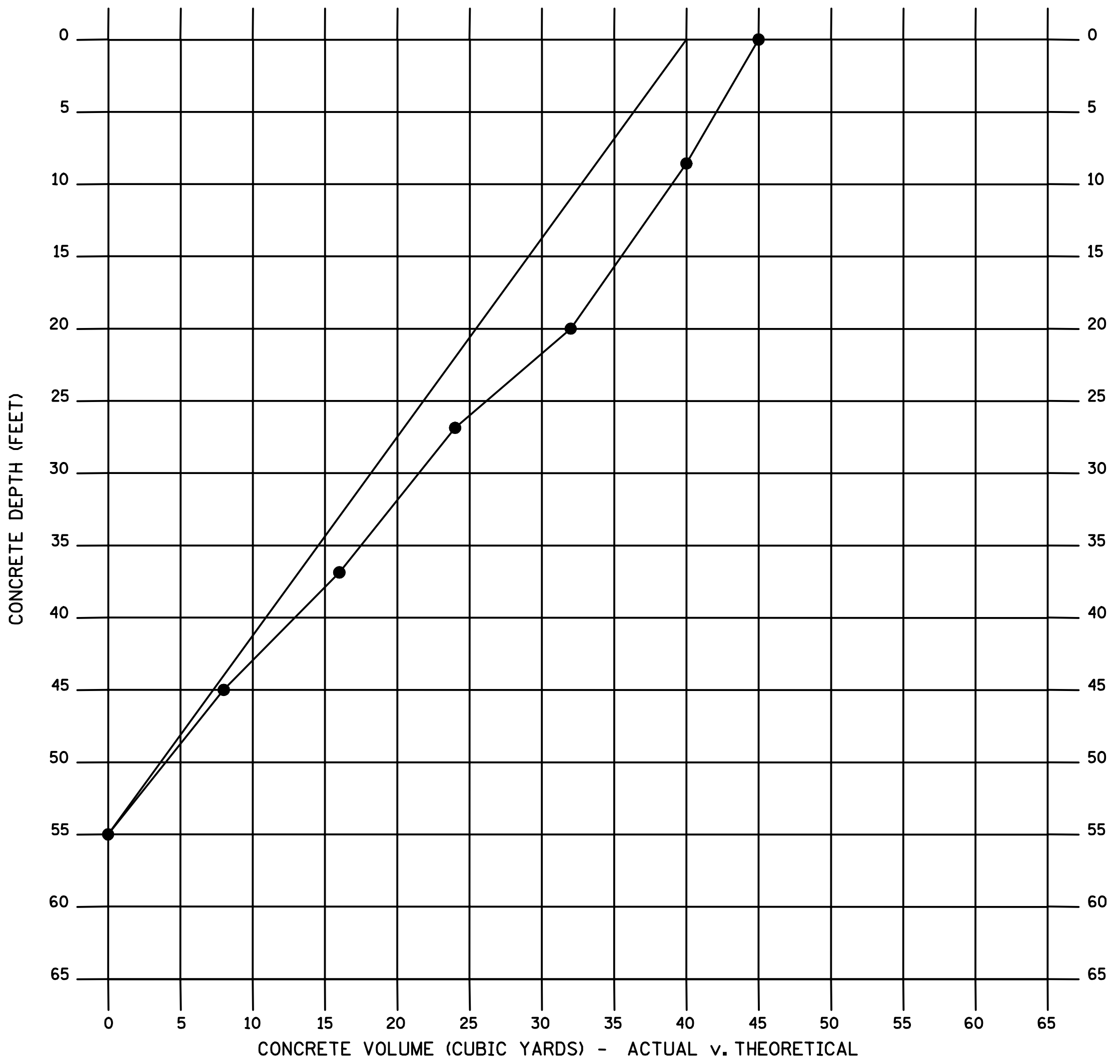
Drilled Shaft Inspectors Manual
Published by: The International Association of
Foundation Drilling
PO Box 280379, Dallas, Texas 75228 (214) 681-5994

SPTC/SLURRY PANEL SUMMARY REPORT

CONCRETE PLACEMENT DETAILS

LOAD NO.	CU. YDS. PER LOAD	CUMULATIVE CU. YDS.	TREMIE TIP DEPTH	CONCRETE DEPTH
1	8	8	53	45
2	8	16	46	37
3	8	24	38	27
4	8	32	30	20
5	8	40	23	8
6	5	45	15	0
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				





SPTC/SLURRY PANEL SUMMARY REPORT

CONCRETE PLACEMENT DETAILS

LOAD NO.	CU. YDS. PER LOAD	CUMULATIVE CU. YDS.	TREMIE TIP DEPTH	CONCRETE DEPTH
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

DRILLED SHAFT REPORT

BRIDGE NO. ____________ S.P. NO. ____________________

ABUTMENT/PIER NO. ___________ SHAFT NO. ___________

PRIME CONTRACTOR ________________________________

SHAFT CONTRACTOR ________________________________

MN/DOT INSPECTOR ________________________________

TIME CONCRETE PLACEMENT STARTED _________________

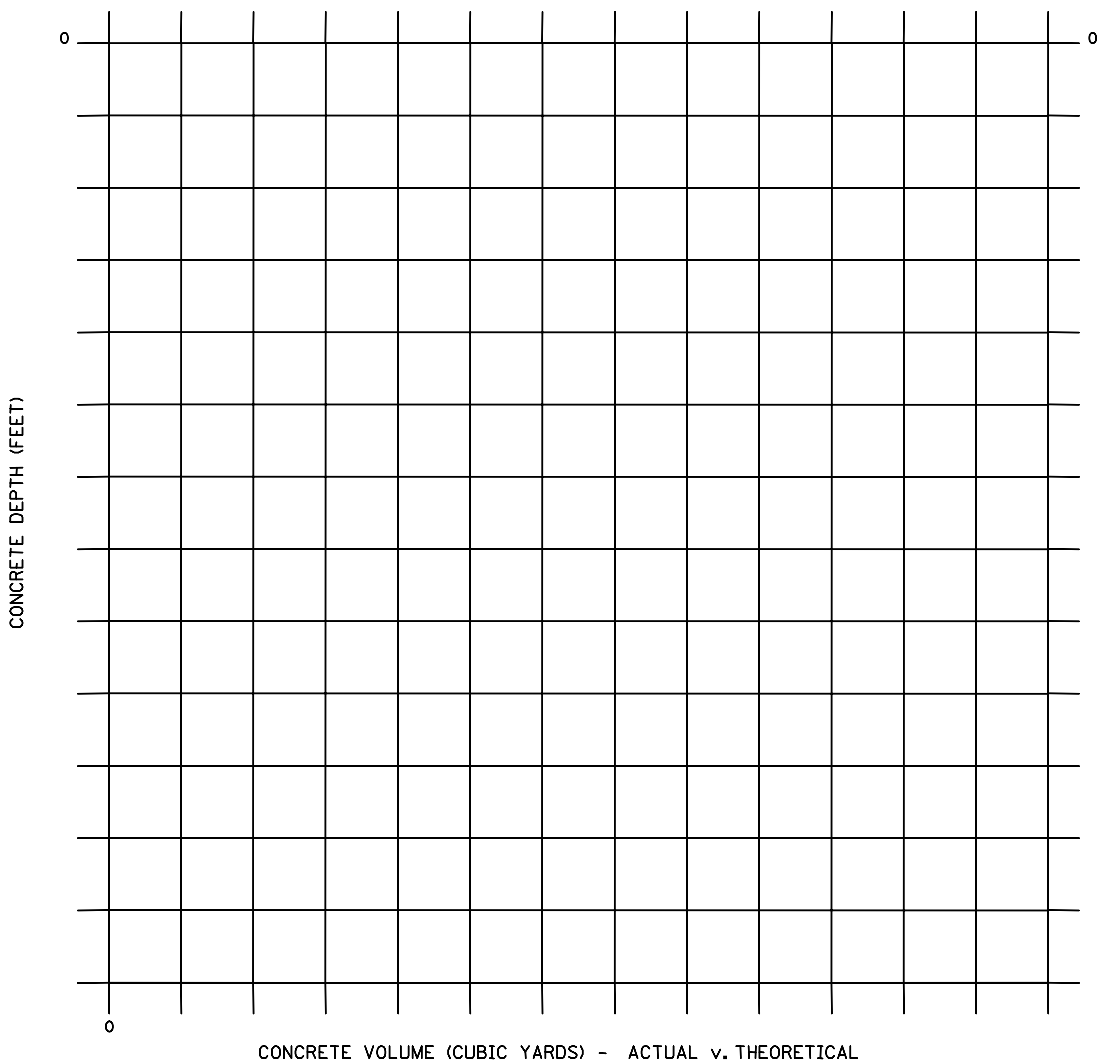
TIME CONCRETE PLACEMENT COMPLETED ________________

SHAFT DIAMETER(S): ______________________________

SHAFT LENGTH(S): ________________________________

PLANNED VOLUME (CY): _____________________________

ACTUAL FINAL VOLUME (CY): _________________________



MINNESOTA DEPARTMENT OF TRANSPORTATION

DRILLED SHAFT REPORT

Bridge No. ________ S.P. No. ________ Pier No. ________ Shaft No. ________

Prime Contractor ________

Drilled Shaft Contractor ________ Mn/DOT Inspector ________

GENERAL INFORMATION

Date Shaft Construction Started ________

Date Shaft Construction Completed ________

River Pool Elev. ________ Water Temp. ________

Construction Method: Wet ________ Dry ________

SHAFT INFORMATION

Permanent Casing Dia.: Plan________ mm

As-built ________ mm

Date Permanent Casing Set ________

Bottom Elev. of Permanent Casing ________

Top Elev. of Finished Shaft: Plan ________

As-built ________

Elev. of Initial Contact of Rock ________

Bottom Elev. of Drilled Shaft ________

Rock Shaft Dia. Plan ________mm, As-built ________ mm

DRILLING INFORMATION

Drill Rig Make and Mdl.________

____

Drilling Tools Used:________

____

____

Excavation Tools Used: ________

____

____

Earth Drilling Start Date ________ , Finish Date ________

Rock Drilling Start Date ________ , Finish Date ________

Excavation Finished Date ________

Location and Extent of Rock Cavities or Shaft Caving:

____

____

____

OBSTRUCTIONS

Description of Obstructions Encountered in Earth Shaft

____

____

Removal Methods and Tools Used ________

____

____

ROCK SHAFT CLEANOUT PROCEDURE

Method ________

____

Estimated Thickness of Sediment at Bottom of Shaft at Time of Concreting________

CONCRETE PLACEMENT OBSERVATIONS

Concrete Mix No. ________

Placement Date ________

Ambient Temperature________

Placement Method ________

Total Placement Time ________

Water Elev. in Shaft at Time of Conc. Placement ________

VARIATION OF SHAFT FROM PLUMB AND PLAN LOCATIONS

Plumb ________

Lateral ________

REMARKS/COMMENTS/NOTES

____

____

____

____

____

Drilled Shafts, Publication No. FHWA HI-88-042
Published by: U.S. Dept of Transportation
Federal Highway Administration
Office of Implementation, McLean, VA 22101

5-393.107 FOOTINGS

The design of substructure units is, in part, based on information contained on the survey sheet. The borings will indicate soil types encountered and the approximate vertical limits of each type; the blow counts will give an indication of soil densities.

When foundation conditions are found to be quite different than shown on the survey sheet, the Engineer should be notified. Depending on the situation, it may necessitate lowering or raising the footings, eliminating or introducing piling, changing pile types, or lengths increasing the size of the footings, or any of several other alternatives. If the Bridge Office is to be notified of the change in conditions, be sure to submit complete and detailed information of the findings, including additional borings below the footing elevations.

When a substructure footing is to be placed on a natural foundation, without the use of piling, it is very important that the material encountered at the bottom of the footing be uniform, and that it be capable of supporting the design load. It is also important that uniformity exists for some distance below the bottom of the footing; and again, it would be prudent to obtain additional soils information when there is any reason for doubt.

When the footing is to be placed on a recently constructed fill of considerable height, special provisions may require a waiting period, overload or particular sequence of construction. Settlement plates may be required and construction of a substructure may be dependent on analysis of settlement readings. Information regarding installation and monitoring of settlement plates and additional information is available from the Mn/DOT Foundations Unit.

In some cases, the plans specify that soil load bearing tests be made on foundations to determine whether or not piling will be required. When necessary, the special provisions will outline the procedure and sequence of loading in detail.

When materials encountered at the established footing elevation are such that they are likely to flow into and contaminate the concrete when it is deposited, correction should be made by one of the methods outlined in Specification 2451.3. The contractor should be cautioned that any contamination of foundation areas due to careless operations by his or her forces, must be corrected at his or her expense.

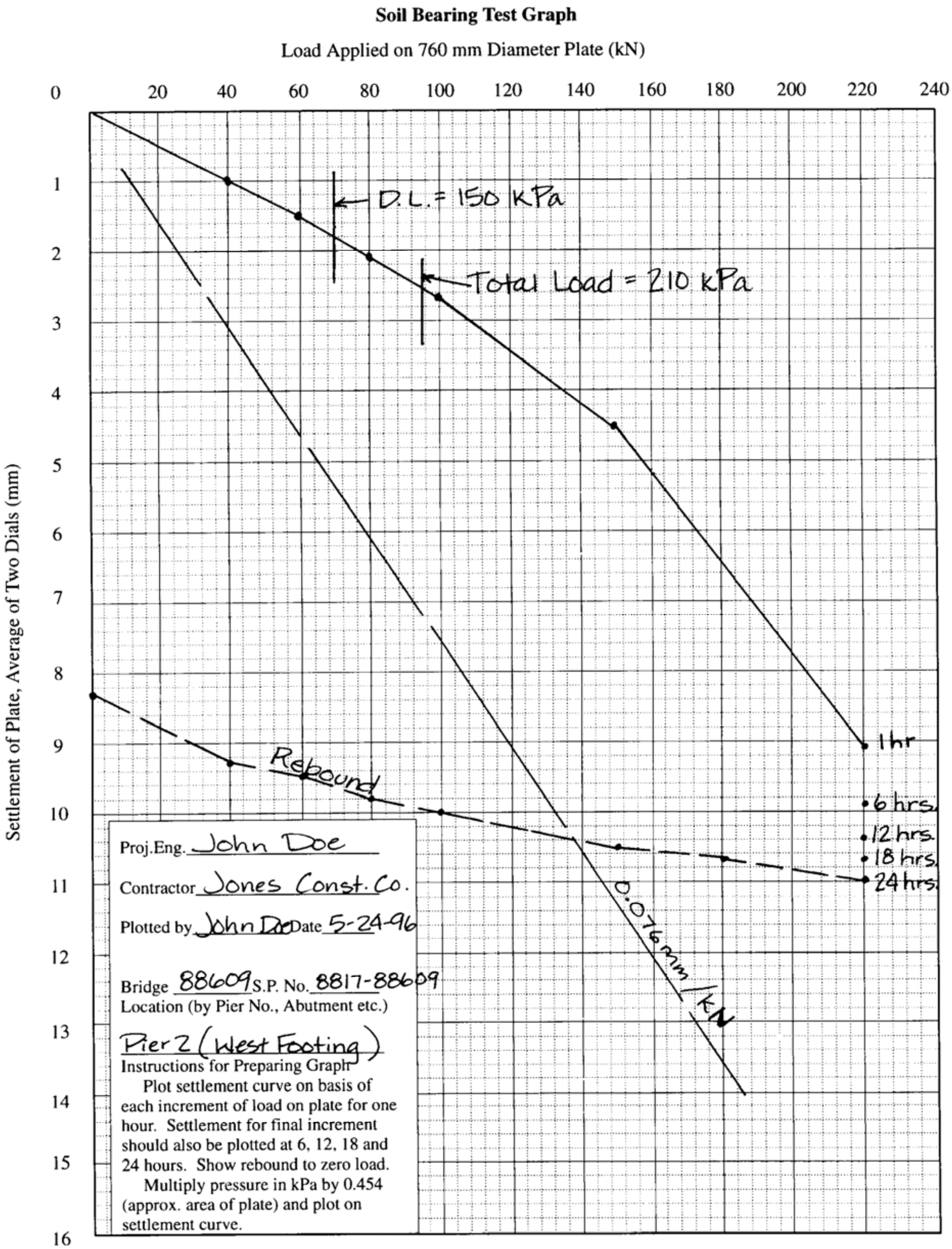
If troublesome springs or boils occur in the footing area of an excavation, run-off water should be diverted before placing concrete. This can usually be accomplished by means of an inverted trough placed below grade. If several smaller springs occur, the flow can be controlled or diverted by means of a canvas placed over the area. Holes made in the canvas to permit piling to project through it should be sealed by wire wraps just above the ground line. Edges of the canvas inside the footing area should be buried, and drainage should be provided under the forms into the outer waterway. Well point systems may be necessary for excavations below the water table. The contractor is required to provide a dry excavation for structure construction at own expense.

5-393.108 FOUNDATION SOILS EXAMINATION AND SOIL BEARING TESTS

When the plans indicate that footings are to be founded on undisturbed natural soils, without the use of piling, a thorough visual examination should be made of the foundation soils as soon as excavation operations have been completed for a unit. Even when it seems apparent that the material at the bottom of the excavation is the same as shown in boring logs, a sufficient number of hand borings should be taken to establish the uniformity of the material to adequate depths. The assistance of the District Soils Engineer should be obtained whenever there is any question regarding the quality of the material encountered during this examination.

If the above investigation discloses questionable materials a determination should be made as to whether or not a soil bearing test would serve any useful purpose, taking into account the costs for such tests. There is, of course, nothing to be gained from making a soil bearing test if it is evident from visual examination and hand soundings that the foundation material is definitely unsuitable. Also, the presence of rocks and boulders, or of a water table above the bottom of the footing, would generally preclude obtaining reliable information from soil bearing tests. Bear in mind that soil bearing tests do not, by themselves, constitute a basis for evaluation of the capacity of a foundation material to sustain high loads over an extended period of time, but are only an additional tool to be considered along with all other available information.

When it has been determined that a soil bearing test is desirable, the test should be made in accordance with instructions from the Mn/DOT Foundations Unit and any special provisions applying thereto. A record should be kept of all dial readings taken, and the information plotted on a graph on as shown on Figure A 5-393.108. A separate sheet, or sheets, showing the results of the visual examination and the borings should be included with the above reports, and two complete sets of the complete report forwarded to the Bridge Construction and Maintenance Engineer, along with the Project Engineer's recommendations. Final determination regarding the foundation design will then be made by the Bridge Office and appropriate notification made. When expediency is essential, the results of the test, along with other pertinent information and recommendations, may be telephoned to the Bridge Construction Unit, but the required reports should follow immediately as a means of documentation.


Soil Bearing Test Graph
Load Applied on 760 mm Diameter Plate (kN)
0
20
40
60
80
100
120
140
160
180
200
220
240
Settlement of Plate, Average of Two Dials (mm)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
D.L. = 150 kPa
Total Load = 210 kPa
Rebound
1 hr
6 hrs.
12 hrs.
18 hrs.
24 hrs.
0.076 mm / kN
Proj.Eng. John Doe
Contractor Jones Const. Co.
Plotted by John Doe Date 5-24-96
Bridge 88609 S.P. No. 8817-88609
Location (by Pier No., Abutment etc.)
Pier 2 (West Footing)
Instructions for Preparing Graph
Plot settlement curve on basis of each increment of load on plate for one hour. Settlement for final increment should also be plotted at 6, 12, 18 and 24 hours. Show rebound to zero load.
Multiply pressure in kPa by 0.454 (approx. area of plate) and plot on settlement curve.

An intelligent determination regarding the adequacy of the supporting soils to support design loads can only be made when complete and accurate information is available from the field. The type of design and the cost of changing to a pile foundation may further influence the final decision. In some cases the dimensions of the footings may be increased to reduce the square-foot loading rather than change to a pile foundation design.

The general specifications permit the Engineer to delay all construction, except for foundation excavation, until test conclusions have been determined for all tests which may have an influence on the type of construction to be used. Discretion should be exercised in the application of this specification, however, so as to not unduly delay the work.

Substructure units constructed on spread footings, except when founded on rock or other unyielding materials, should be checked for settlement or movement subsequent to construction. In the case of abutments which are to be constructed on high embankments, movement checks should be started as soon as the footings have been completed. The results of these follow-up checks should be forwarded to the Bridge Construction Engineer, so that the Bridge Office may be kept fully informed of the success or failure of this type of foundation design, and so that this information can be used as a guide for future design.

5-393.109 BACKFILL - GENERAL

Too much emphasis cannot be made on the importance of properly constructed backfills. This work calls for careful inspection and requires a constant presence during the entire operation. Particular attention must be paid to tamping the areas next to the structure and areas which cannot be reached with the motorized equipment. When the backfill material is too wet, it should be dried before placing it in back of closed abutments or walls.

Pneumatic tampers or portable vibratory compactors should be used to compact backfill immediately adjacent to structures, when it is impossible or impractical to use heavy compaction equipment. Vibratory compactors are particularly effective in granular materials. Hand tamping is unsatisfactory where high densities are required and should generally be discouraged.

On bridge abutments, the entire excavation behind the abutment must be backfilled using approved granular material. It may not be necessary to excavate to the lines shown as the limit for granular backfill if the embankment is granular as originally constructed.

Backfill should be brought up evenly to the elevation shown on the plans. Granular material must be placed in not more than 200 mm (8 inches) layers (lifts) and should have sufficient moisture to facilitate compaction. The amount of fine material is limited by specification to assure that material will drain freely into subdrains.

Backfilling as discussed in this article includes not only the backfill up to the original ground line but also the embankment material that is placed on one or both sides of the structure and immediately adjacent to it above the original ground line. It includes that part of the approach fill which lies next to the structure.

The Specifications provide that backfill behind an abutment or wall shall not be placed above the backfill in front of the wall for a specified number of days after the concrete is poured. In addition, it is required that abutments that are designed as beams rather than as cantilevers (such as in slab and rigid frame bridges) may not be backfilled until the superstructure is completed and the falsework removed.

5-393.110 BACKFILL - CULVERTS

When backfilling culverts, the material used must have sufficient moisture to permit required compaction. Loose layers must not exceed 200 mm (8 inches). Rollers may be used, but hand operated mechanical tampers must be used to secure proper compaction in the area immediately adjacent to the culvert which the roller cannot reach.

Backfill should be placed and compacted on both sides of the culvert to approximately the same elevation. Backfilling on one side to a considerable depth before placing material on the opposite side should not be permitted.