INSPECTION PROCEDURE 45053

GEOTECHNICAL/FOUNDATION ACTIVITIES WORK OBSERVATION

PROGRAM APPLICABILITY: 2512

45053-01 INSPECTION OBJECTIVES

01.01 To determine by direct observation and independent evaluation whether work and inspection performance relative to geotechnical/foundation activities are being accomplished in accordance with specifications and procedures.

01.02 To determine whether inadequacies in work activities associated with geotechnical/foundation activities indicate a management control problem or generic weaknesses.

Inspection Schedule

May Be Started	Must Be Started	Must Be Completed
After geotechnical/foundation work starts	No later than six months after geotechnical/foundation work starts	Before all geotechnical/foundation work is completed

45053-02 INSPECTION REQUIREMENTS

02.01 Review the results of the inspection performed under Inspection Procedure (IP) 45051.

02.02 Review the specifications, drawings, and QA/QC and construction procedures applicable to the ultimate heat sink and material supporting seismic Category I structures.

02.03 By direct observation of work in progress on the ultimate heat sink and material supporting seismic Category I structures, ascertain whether the following applicable geotechnical/foundation activities are being controlled and accomplished in accordance with the requirements of the documents reviewed in 02.02, above (items in this procedure may not apply to all facilities):

a. Subgrade Preparation. The following items should be verified semiannually when inspecting the exploration, excavation, and preparation of the foundation subgrade.

1. For subgrade explorations, determine whether the borings, cores, soil samples, test pits, or other explorations are properly collected, handled, boxed, identified, protected, and recorded as required by the specifications and procedures. Verify that required testing on samples or in-place testing has been completed in accordance with the soil exploration program. The acceptance criteria should be specified by the designated geotechnical expert. The results of testing and analysis of test specimens should be properly factored into the design of the foundation.

2. The excavation methods and sequence of operations should not be detrimental to the final foundation subgrade materials. Determine whether blasting restrictions and controls are adequately implemented. Blasting should not be detrimental to adjacent natural foundations or safety-related structures. Blast monitoring should be performed.

3. Unusual or changed conditions encountered during excavation, i.e., cavities, faults, pockets of unsuitable material, springs, seeps, boils, protrusions, etc., are noted, investigated, evaluated, and taken into consideration.

4. For soil foundations, the foundation subgrade should be free of organic or soft unsuitable material. Depressions or holes left by grubbing and stripping or excavation should be backfilled with suitable materials compacted to the specified density and moisture content. Soil classification at the depth excavated for foundations should be verified and compared with the soil profile determined during subgrade explorations (bore holes, soundings, exploratory excavations, etc.). The occurrence of extraneous detrimental or unexpected soil may necessitate further investigation or evaluation/redesign. The finished grade should be as specified, meet compaction and density requirements, be protected from the elements, and be inspected.

5. For rock foundations, the subgrade should be excavated to the proper grade, cleaned, inspected, mapped, and approved by a geotechnical engineer. The rock subgrade should be free of water, loose rock, highly weathered rock, and other defects. Tests should be performed on the foundation materials to assure that the specified design requirements are met.

6. Determine whether the stockpiling and segregation of excavated materials which are to be used as seismic Category I fill material are in accordance with specifications.

7. The foundation subgrade treatment such as compaction, grouting, installation of foundation drains, or other methods (vibration) should be properly controlled. Where grouting is required, determine whether procedures are being followed and the required records kept. The injection pressure, types of mixes, the changes of mixes, sequence of grouting operations, and grout completion should be as specified and controlled.

8. Determine whether QC inspections are adequate with regard to scope, frequency, and inspector qualifications.

9. The recordkeeping activities should reflect the actual conditions in the field and provide adequate documentation of work and inspections. Determine whether records are being maintained, reviewed, and approved as specified.

b. Fill Materials and Compaction Control. At least quarterly while backfill, engineered fill, or compaction activities are in progress, ascertain that:

1. Specified lift thicknesses are adhered to and specified equipment is being used with the correct number of passes.

2. Material being used is identified as and traceable to an approved source. The approved source should meet design and specification requirements and have been properly qualified by the soils laboratory.

3. Engineered fill is placed at the proper location and on approved foundation materials.

4. In-place density tests are being performed at the required frequency with properly calibrated instruments (including moisture content tests if applicable).

5. Samples for laboratory tests are being taken at the required frequency and are adequately identified. Review the results of the required tests and compare results to design specification requirements.

6. Inspection activities (QA and QC) are being performed as required by qualified personnel. Review inspection documentation and verify that the records quantitatively define actual construction conditions and testing results.

7. Verify that geotechnical engineering direction is available on site.

c. Embankments. In addition to the inspection attributes listed for compaction control, ascertain on a quarterly basis while the embankment is being constructed, that:

1. Individual material types are placed to the dimensions of the zones required by design drawings.

2. Care is being taken to avoid material contamination in filter zones.

3. Subsequent layers of impervious material are adequately tied together to avoid separation of layers.

4. Instrumentation is protected from construction activities.

5. Rip-rap for erosion control is properly designed and placed.

d. Dewatering Systems. The following items should be reviewed semi-annually (permanent safety-related dewatering systems will necessitate a more extensive review). Note that 1 and 2 below represent good practice, but are not requirements unless specified in the site specifications.

1. Emergency power supply to ensure continuous dewatering system operation is being maintained and tested.

2. Open excavations are protected from flooding by an adequate sump pump system.

3. Piezometric surfaces are being defined by monitoring performed at the required frequency.

4. Inspection and testing of system discharge should assure that sediment material is not being removed from the foundation.

5. For safety-related dewatering systems, review the following items:

   (a) Materials meet specifications and design requirements.

   (b) The system was installed as specified.

e. Piers and Piling. The following items should be verified semi-annually when inspecting the installation of either drilled piers or piling. Note that 1 below represents good practice, but is not a requirement unless specified in the site specifications (referencing ANSI/ASME N45.2.5-1978).

   1. Pile driving tests and pile or pier load tests should be completed and the results evaluated before their installation for seismic Category I structures.

   2. Location, type, and depth of piers or pilings are in agreement with design drawings.

   3. Driving of piles is being monitored according to the required formula for adequate load (either blows per inch for last foot, in accordance with empirical formulas or driven to a specific depth in accordance with load tests). Installation techniques (including splicing) and the equipment used are in accordance with the construction procedures and specifications.

   4. For drilled piers, ascertain that reinforcing steel will have adequate concrete cover and that concrete is placed so as to avoid segregation and contamination by surrounding materials.

   5. QA/QC activities are being performed as required by qualified personnel. Changes, deviations, and problems should be documented, evaluated, and adequately corrected.

f. Concrete Foundations (Unreinforced and Reinforced). Unreinforced concrete foundations include mudmats and fill concrete if the mudmats or fill concrete significantly affect the foundation properties. Reinforced concrete includes footings and mats. Verify the following items semi-annually when concrete foundation activities (except the basemat for the containment structure) are being performed:

   1. Grade and dimensions are as specified in the design drawings.

   2. Control and placement of reinforcement and concrete are in accordance with the construction specifications and procedures. Additional concrete inspection details are in IP 46053.

   3. Drainage, embedments, or tiedowns are installed where required.

   4. Unreinforced porous concrete should be controlled to meet specifications and samples should be tested for required permeability.

   5. Inspection and testing activities meet scope, frequency, and qualification requirements.

   6. Changes, deviations, or unusual problems are documented, evaluated, and adequately corrected.

   7. Records accurately reflect the actual conditions and an adequate records system is in force.

g. Testing Laboratory. The onsite laboratory should be inspected at least semi-annually while tests (primarily soils) are being performed on seismic Category I material. The following items should be verified during the inspection:

1. Personnel qualifications (education and experience) of testing and inspection personnel have been verified by the employing organization. Verification must be supported by documentation.

2. Test results are being evaluated at an appropriate level and evaluation includes trending analysis.

3. Observed testing conforms to the procedures specified in the ASTM standards.

4. Testing apparatus is being calibrated at the required frequency.

5. Records reflect the results of inspections, the actual field conditions, testing frequency requirements, and that data calculations are checked.

h. Instrumentation and Monitoring System. The following items should be verified during the inspection:

1. If specific instrumentation or monitoring systems are not reviewed as part of the other sections of this procedure, review these systems at least annually. The items to be reviewed:

   (a) Number, location, and type.

   (b) Instrumentation and monitoring systems installed before start of activity being monitored.

   (c) Installation: as specified, functioning properly, and protected against construction hazards.

   (d) Operation and monitoring: monitored at specified frequency to assure that construction activities have not made the instrumentation inoperable.

   (e) Calibration of measuring and testing equipment.

   (f) Recordkeeping activities: records reflect specified frequency of monitoring, data checked, and evaluated. This is important in activities such as settlement monitoring. A comparison of the actual settlement data with those predicted can reveal problems at an early stage, enable the cause to be determined relatively early in the construction phase, or can cause design changes to be incorporated before the completion of extensive construction work.

2. Surveying activities should be reviewed annually to assure that the instruments are properly calibrated and calculations are checked to assure accurate results.

i. Personnel Interviews. Informal interviews with field craft and inspection personnel should be randomly conducted to determine how well employees know of their work activity. Also, obtain a sense for the degree of the adversary or intimidating relationship with the construction forces. Perceived management support should be identified. Any adverse trend should be identified to regional management. Ascertain whether a sufficient number of adequately qualified QA and inspection

(QC) personnel are at the construction site, commensurate with the work in progress, and adequately performing their assigned duties through the established organizational structure.

02.04 Additional inspections, as determined by Regional management, may be conducted in the inspection areas covered above when licensee performance is classified as Category 3 by the SALP program, or if Regional management concludes that recent findings will likely result in a SALP Category 3 rating. In these cases, particular consideration should be given to an expanded sample of items to be inspected under Section 02.03b, 02.03e, and 02.03g, above.

45053-03 INSPECTION GUIDANCE

General Guidance. Before observing the activities in 02, above, review the pertinent specifications, drawings, and procedures (including QC) as well as applicable codes, standards, and Regulatory Guides. The inspector should use judgment in determining sample selection during inspection activities. Sample selection should reflect the importance of the activity to safety. Observations of work and independent verification of critical dimensions, locations, etc. should be performed at various stages of completion, especially for engineered fill and structural foundations. The inspector should be aware of the compaction and backfill materials problems identified at several sites and described in IE Circular 81-08.

The inspector may not be able to directly observe all facets of all activities identified in 02, above. However, direct observation, on a sampling basis, of important activities should be made. In some cases it will be necessary to observe a completed activity rather than work in progress. Moreover, it may be more appropriate, for example, to observe the effects of blasting rather than the actual blasting operation. The intent is to determine whether the activities and/or the end product meet requirements.

The basemat of a concrete containment structure is not covered in this procedure because it is covered in the IP 46000 series procedures.

Findings from this inspection activity should address each element as being satisfactory, being unresolved and requiring resolution, or being in violation and requiring correction. When significant inadequacies are identified in specifications or procedures indicating weakness within the preparing technical organization, the inspector should inform cognizant regional supervision. The issue should be addressed at the appropriate level of licensee management.

03.01 Specific Guidance

Note: The numbering of the guidance below refers to specific subsections of 02, above.

02.03a1 The soils exploratory program may call for standard penetration resistance testing as defined by ASTM D 1586. The operator technique must be observed and verified to assure that the free fall and height of the 140-lb. drop weight is always maintained. Additionally, an accurate count of the number of blows per foot must be recorded, starting after an initial penetration of six inches is obtained. Standard penetration testing should be supervised by a qualified geotechnical engineer.

02.03a2 Blasting activities should be supervised by a designated and qualified specialist. Precautions to prevent overblast and damage to the remaining natural foundation or adjacent safety-related structures are of primary importance and should be considered and treated in an adequate manner. Determine whether blast monitors are specified and properly used.

Determine whether use of a geotechnical expert to inspect and monitor excavation activities is required.

02.03b Continuous licensee/contractor inspection may be required during fill operations.

02.03b2 If select fill is used, the inspector should determine before use whether the materials satisfy the prescribed gradation specifications and tests.

02.03b4 By a selective review of test results, the inspector should determine whether adequate corrective action is being taken when density or moisture test results are not within acceptance criteria.

02.03c The inspector should be aware that the design of the dewatering system may have to be modified when excavation or testing identify such a need, e.g., more pumping capacity may be required after evaluation of existing conditions.

02.03e Pile installation and installation techniques should not have a detrimental effect on adjacent structures and subgrade.

02.03e5 Continuous inspection by qualified personnel may be required during pile installation.

02.03f If safety-related structural concrete is first used at the site during construction of foundations, the inspection requirements of IP 46053 should be accomplished in conjunction with this inspection procedure (IP 45053). The intent is to observe structural concrete activities important to safety during initial use at the construction site. However, if the same personnel/organizations, specifications, and procedures are utilized for these activities as for previous or present safety-related structural concrete activities, the inspection requirements IP 46053 021 and 022 need not be repeated as part of this procedure.

02.03g5 A sample of data calculations should be reviewed for accuracy and conformance to design requirements.

02.03h Examples of typical instrumentation are monuments for settlement monitoring and piezometers or well points for monitoring groundwater surface and pore pressure.

02.03i In determining the adequacy of QA/QC staffing, the effectiveness of their activities must be considered. Insufficient or unqualified personnel, or inadequate QA management, indicate inadequate staffing. Capabilities and effectiveness, rather than only the number of personnel, are the principal criteria to be used.

03.03 Background Information. This information is to be used as reference material, however, the site specifications govern. The information may be valuable in discussions concerning the adequacy of the specifications.

a. Foundation Subgrade

1. Excavation. Unexpected conditions are frequently encountered ranging from unfavorable deposits of materials not found in the exploratory program to problems not identified in previous site studies.

   Where unfavorable conditions are encountered, further exploration by test pits, borings, or other means are necessary to define the extent and nature of conditions. The effect of the unexpected conditions must be evaluated in relation to the original design. Examples of common unfavorable conditions frequently encountered are:

- Highly compressible and low strength soils
- Clay shales - slake rapidly on wetting and drying
- Collapsible soils - low density soils that collapse when saturated
- Old river channels
- Weathered rock
- Faults, open joints, and fractures
- Cavities and solution features
- Overhangs and surface depressions
- Springs or artesian conditions
- Unstable excavation slopes because of unanticipated conditions

Standard methods of subsurface explorations, their applicability, and limitations are listed in Appendix B of Regulatory Guide 1.132.

If blasting is to be used during site preparation, the inspector should consider whether there is a potential for structural damage to the unblasted rock and to adjacent facilities important to safety. Because of the magnitude and intensity of energy application, blasting must be used with care. Blasting can cause widespread shattering of the bulk of the rock and more than usual care is required to minimize overbreak. Efficient fragmentation of rock, without excessive use of explosives, overbreak, or damage to adjacent facilities, may be obtained by conducting a test program to establish selection of explosives with appropriate detonation rates. If blasting and concrete placement activities are simultaneously in progress (e.g., concrete is placed for Unit 1 while Unit 2 is being blasted), the inspector should determine whether the specified permissible particle velocities from blasting have not been exceeded.

If the likelihood of damage exists, the inspector should determine whether: the licensee/contractor has an appropriate blasting plan to protect against damage; competent personnel have been engaged to supervise the implementation of the plan; and equipment to monitor the effect on adjacent structures and unblasted rock is used and is adequate.

Excavation materials are frequently used as engineered fill or backfill around and under seismic Category I structures. The inspector should determine whether these materials have been qualified through explorations and testing by a soils testing laboratory and whether they are stockpiled in designated areas. Excavated materials to be used as seismic Category I borrow, should be excavated in layers so that widely varying soil classes are not mixed. Some of the more common tests used for qualifying soils materials and their associated standards are:

- Moisture density relationships, ASTM D-698 or D-1557

- Soil classification tests, ASTM D-2487
- Grain size analysis, ASTM D-422
- Test for plastic limit and plasticity index, ASTM D-424

Acceptance and qualification of excavated rock materials should be controlled by an engineering geologist or geotechnical engineer. Acceptable methods for qualifying and testing soil and rock materials are listed in ANSI/ASME N45.2.20, Supplementary Quality Assurance Requirements for Subsurface Investigations for Nuclear Power Plants.

2. Undisturbed Soil. Soil subgrades should be approved by a geotechnical engineer before placement of engineered fill, mudmats, or structural concrete. Compaction is the usual method to treat or stabilize loose, disturbed, or unsuitable areas in soil subgrades. In some instances, soil stabilization methods such as chemical grouting may be used in lieu of or in conjunction with soil compaction. Methods such as chemical grouting are difficult to control and should be given a careful review by the inspector. The inspector should determine whether appropriate sampling and testing procedures are included to verify the material in place is as specified.

   Common tests used to verify that foundation subgrades meet design specifications are listed in Appendix B, Methods of Subsurface Exploration, of Regulatory Guide 1.132, Site Investigations for Foundations of Nuclear Power Plants.

3. Rock. Rock subgrades should be mapped, inspected, and approved by a geologist before placing of fill, mudmats, or structural concrete. Geologic mapping should include features such as rock types, bedding, joints, faults, cleavage, cavities, orientation of these features, and weathering characteristics. Foundation treatment usually consists of removing loose rock and weathered materials, and excavating soft weathered materials from large open joints and cavities or depressions to specified depths and backfilling with concrete. Cement or chemical grouting requires close control and, where used, the inspector should carefully review procedures, work in progress, and records to satisfy himself that specification requirements are met. General and specific guidance and methods of testing rock are presented in Regulatory Guide 1.132 and ANSI/ASME N45.2.20.

b. Engineered Fill. In some instances, preparation for foundations may consist merely of excavation and grading to appropriate dimensions. However, in many locations, the top layer of native site material may be too soft, or otherwise unsuitable, to properly support the structures. In this case, some special compactive effort may be required. Occasionally, adequate compaction may be achieved on the native material in place in conjunction with careful control of groundwater level. More typically, it will be necessary to remove the native material and fill the resultant excavation under carefully controlled procedures, in relatively thin layers, sequentially compacted.

   Before placing engineered fills, materials and compaction requirements should be qualified by laboratory tests and test fills. Required moisture/density relationships for each material should be determined in accordance with either ASTM D-698 or ASTM D-1557. The inspector should be assured that the specified method is being used. Where impervious materials are used, qualification tests should include determination of the Atterberg Limits (Liquid Limit, ASTM D-423; Plastic Limit and

Plasticity Index, ASTM D-424). Grain size analysis should also be made as specified by test methods in ASTM D-422 and ASTM D-1140.

Test fills for each material type should be made to determine lift thickness, type of compaction equipment, and number of passes to be used in compacting fills to specified densities.

In-process testing used to control fill placement for the most part, will be density tests and moisture tests. Acceptance will be in terms of some percentage of the maximum dry density (usually 95%) and a moisture content within some percentage of optimum (usually ±2%) as determined by ASTM D-698 or ASTM D-1557. Density tests may be made by test methods ASTM D-1556 (most common method used), ASTM D-2167, ASTM D-2922, or ASTM D-2937. Test method ASTM D-2922, the nuclear method, must be calibrated against a reliable direct method. Test method ASTM D-2049, Relative Density of Cohesionless Soils, is another method sometimes used to control compaction. However, this method should be limited to materials having less than 12% by weight, passing a No. 200 sieve.

Control of moisture content at time of compaction is extremely important, especially with materials having more than 12% passing a No. 200 sieve. Testing and research has demonstrated that variation of the moisture content of a material at time of compaction, even though it has been compacted to the same dry density, has a wide effect on the shear strength, permeability, and consolidation characteristics of the material. Ultimate control of moisture should be by test method ASTM D-2216, Laboratory Determination of Moisture Content of Soil. Rapid methods such as the "Speedie" and field stoves are sometimes used to expedite operations because of the time required for test method ASTM D-2216. Where rapid methods are used, they should be calibrated against ASTM D-2216 and their variation taken into consideration in controlling moisture content of the fill. For example, if the specified moisture control is ±2% of optimum and calibration checks show that the rapid method varies by ±1% from ASTM D-2216, then field control using the rapid method should be held to ±1% of optimum. Field stove methods should be limited to granular materials with little or no fines since experience shows results with impervious materials are erratic (probably due to driving off the water of hydration).

Minimum acceptable test frequencies and other recommended in-process testing controls are listed in Table B of ANSI/ASME N45.2.5.

c. Dewatering Systems. In most locations, some degree of groundwater control will be required, at least during site preparation and foundation placement. In some instances it may merely represent a construction convenience; in others, groundwater removal may be required in order to properly compact the soilbearing area. It may be necessary to maintain the groundwater level below the level of the structure foundations until the structures are sufficiently loaded so that they will not float. Occasionally, the design may require that groundwater be permanently maintained below some specified elevation.

Excavations and placement of fill and foundations must be in the dry state. The inspector should determine whether surface and subsurface erosion of excavation slopes and foundation subgrades is harmful. Discharge outlets of dewatering systems should be monitored for sediment content to assure that subgrades are not being undermined. Dewatering systems, if not properly designed, installed and operated, can have an adverse effect on foundations, especially those founded on earth materials. Improper design and operation can and has resulted in undermining of foundations through removal of sediment with the discharge water.

The inspector should assure himself that careful consideration has been given to the impact that the installation, operation, shutting down, and decommissioning of the system will have on foundation design. Through observations the inspector should satisfy himself that the system has been installed and is being monitored as specified. Piezometric or observation wells should be used in conjunction with the dewatering system to monitor the groundwater surface and pore pressure beneath the subgrade and adjacent ground.

Acceptable methods for installation and maintenance of piezometers and observation wells are presented in the U.S. Army Corps of Engineers Manual, EM 1110-2-1908, 1972.

d. Piers and Piling

1. Drilled Piers and Caissons

(a) Load testing will generally be required to confirm design assumptions. The inspector should be assured that the method of load test selected, interpretation of the test results, and the safety factors applied in selection of the safe bearing capacity of the pier or caisson are adequate. Load testing must be completed before installation of permanent seismic Category I piers and caissons. If there are no provisions for load testing on the project, the inspector may refer this to NRR, as appropriate.

(b) The inspector should verify that equipment being used to drill holes for piers or caissons is of sufficient size and capacity to drill to the required bearing layer.

(c) The inspector should verify that side walls of holes are either cased or stabilized to prevent them from caving or collapsing. The caving or collapse of the side walls could result in loss of lateral stability of the pier or adjacent piers, and damage to adjacent structures.

(d) The inspector should verify that the elevation of the bottom of the hole is accurately determined and documented. After cleaning, the bottom of the hole should be inspected and approved by a qualified geotechnical engineer or engineering geologist to verify that pier or caisson will be founded on proper bearing stratum, and not on compressible materials, cavities, or other unacceptable features.

(e) Following drilling or excavation of the hole, the inspector should verify that the hole location, plumbness or batter, and diameter are being checked. The inspector should verify that the shape at the bottom of the hole is as specified.

(f) Proof testing of materials at the bottom of the hole generally consists of drilling a 2-inch-diameter exploratory hole to verify that materials below the bottom of the hole are competent enough to support the pier or caisson.

(g) Dewatering of the hole is generally necessary for cleaning and inspecting the hole and for placing of concrete. If holes cannot be dewatered, special construction techniques are required for cleaning, inspection, and concreting.

(h) One of the most common causes of defects in piers and caissons is inadequate concrete strength caused by segregation during placement or contamination of the concrete by collapse of the walls of the hole, and "hanging-up" of the concrete in the casing while the casing is being pulled.

(i) Other recommended inspection practices for piers and caissons are contained in ANSI N45.2.5.

2. Piles

(a) Piles may be fabricated either on site or off site. The inspector should be assured that the materials used in fabrication of piles meet specification requirements by observation of pile fabrication activities (if being accomplished on site), by review of records such as certified material test reports, shop fabrication reports, concrete test reports, etc., and visual examination of the fabricated piles (if fabricated off site). Storage, handling, and onsite transportation of piles should also be examined to verify that piles are not being damaged (e.g., cracking of concrete pile or mechanical damage to steel piles) before driving. Considerations such as location of lift points, location of support points in storage areas and on transporting equipment, and type of lifting equipment should be addressed by the project specifications and drawings. Concrete piles are very sensitive to damage from improper lifting and/or handling.

(b) Pile load tests are made to determine the ultimate bearing capacity of the piles. The method of pile installation, type of installation (driving) equipment, the minimum depth of pile installation, and minimum pile penetration resistance are determined on the basis of results of the pile load tests.

Since the purpose of the pile load test is to determine the safe load-carrying capacity of the piles, the pile load test must be completed before installation of seismic Category I piles. The method and equipment used to install load test piles must be the same as those used for the permanent piling. In the pile load test, the piles are loaded in increments to at least twice the maximum design load that will be imposed on the pile during the life of the project. The measurements of the pile under the various loads are recorded, plotted, and analyzed to determine the safe load-carrying capacity and for purposes of determining the minimum penetration resistance of the pile. The inspector should assure himself that the equipment used in the pile load test was properly calibrated, that load test data were recorded accurately, and that the subsurface conditions at the location of the pile load test are typical of those that will be encountered on the project site. Pile load tests are generally done in accordance with ASTM D-1143, Method of Test for Load-Settlement Relationships for Individual Piles Under Vertical Axial Load.

In addition to load test piles, some projects may also have requirements for test drive piles. The purpose of the test drive piles generally is to determine pile type, the optimum pile installation technique, and for assistance in estimating pile lengths.

On some projects, there may be no provision for performance of pile load tests. In these cases, the safe load-carrying capacity of the piles will be established by use of pile-driving formulas such as the Engineering News Formula. If there are no provisions for pile load tests on a project, the inspector may refer this to NRR, as appropriate.

(c) Piles may be installed by predrilling, jetting, driving, or combinations of these methods, depending on subsurface conditions. The inspector should verify that the pile installation method, installation equipment, depth of installation, and resistance to penetration (blows/inch) is as established from the load test results. The inspector should assure that permanent piling is installed using the same size and type of hammer operating with the same effective energy and efficiency as used to install the load test piles.

Piles should be driven without interruption from the first blow of the hammer until the required penetration is reached, the pile should be driven a minimum of 12 inches upon resumption of driving before taking the record of penetration for purposes of determining if minimum penetration resistance has been obtained.

Precautions must be taken during driving in order to avoid damaging the piles. During driving, piles should be watched for indication of breaking or splitting below ground. If the driving suddenly becomes easier, it is possible the pile may have failed. The inspector should ensure that the piles were not damaged during driving and that precautions, such as use of cushion blocks on the pile heads, driving shoes on pile tips, and refraining from overdriving, are followed during installation of the piles.

(d) Examples of detrimental effects that pile installation may have on adjacent structures or subgrade are as follows:

(1) When displacement piles are installed in large groups at close spacing, the soil may heave. This may disturb adjacent structures, or raise or weave (lateral displacement) previously driven piles.

(2) Pile hammer vibration during pile driving may affect adjacent structures. Precautions similar to those observed during blasting may have to be taken to avoid damaging adjacent structures. Attention must be paid to the effect of pile driving on nearby plastic or fresh concrete.

(3) Jetting results in loosening of some types of soils.

(e) Pile heads often tend to twist or move horizontally during pile installation. The inspector should verify that the location and batter of piles is accurately determined following completion of installation, and that the location and batter are within the specified tolerances.

(f) Pile splicing is generally accomplished by welding or bolting of steel piles, and grouting or use of epoxy cements in concrete piles. Specially designed mechanical connections may also be used on precast concrete piles. The inspector should verify that splices meet design requirements, that splice locations are being accurately determined and recorded, and that if grout or epoxy cement is used in the splice, it is allowed adequate time to set and cure before resumption of driving.

(g) Hollow steel piles, either thin or thick walled, are generally filled with plain or reinforced concrete. The inspector should verify that concrete to be placed in piles meets specification requirements; that piles are cleaned, dewatered, and inspected prior to placement of the concrete; that freefall drop height of concrete is as specified; and that concrete is properly consolidated after placement. On some projects, some types of piles may be filled with sands or gravels. The inspector should verify that fill material meets specification requirement, that piles are properly cleaned and inspected before filling, and that fill materials are properly compacted.

(h) Pile cap construction should be as specified. Refer to guidance in IP 46053 for additional information on structural concrete.

(i) The inspector should verify that changes, deviations and problems encountered during pile installations are being documented, evaluated, and adequately corrected. NRR should be made aware of major problems or changes encountered during pile installation.

(j) For additional guidance for inspection of fabrication and installation of piles, see ANSI/ASME N45.2.5.

e. <u>Concrete Foundations</u>

1. <u>Unreinforced Concrete</u>. Unreinforced concrete, such as mudmats and fill concrete, should be controlled as specified. Mudmats and fill concrete may form an integral part of the foundation for a structure.

2. <u>Reinforced Concrete</u>. Reinforced concrete, such as footings and mats, should be adequately controlled. Refer to IP 46053-03 for additional information.

f. <u>Testing Laboratory</u>. Acceptance of all earthwork onsite including verification of soil foundations, engineered fill and backfill, for the most part, will be based on testing done by the site soils laboratory. The inspector should routinely check the soils laboratory during independent inspection efforts as well as during programmatic inspections. The inspector should ensure that work is being done in accordance with specified methods and with specified equipment that is periodically calibrated for accuracy. Data calculations should be checked by testing personnel for accuracy and spot checked by the inspector.

Qualifications of testing personnel should be checked by personal interviews, examination of certification records, as well as licensee's procedures and records to verify contractor's qualification records. Refer to ANSI/ASME N45.2.20 for specific guidance on laboratory testing.

g. <u>Instrumentation and Monitoring Systems</u>. Instrumentation will, for the most part, consist of settlement monuments for monitoring settlement and piezometers or well points for monitoring the groundwater surface and pore pressure. Specific guidance regarding their use, installation, and maintenance is presented in the U.S. Army Corps of Engineers Manual EM 1110-2-1908. The inspector should ensure that the instrumentation is installed as specified, is adequate for the intended use, and that accuracy of the data recorded is sufficient to provide needed information. The instruments should be monitored periodically throughout construction and, if needed, post-construction.

45053-04 REFERENCES

SAR, Chapters 1, 2, 3, and 17, including pertinent codes and standards referenced in these chapters.

IE Circular No. 81-08, Foundation Materials, May 29, 1981.

Regulatory Guide 1.58, Qualification of Nuclear Power Plant Inspection, Examination and Testing Personnel.

Regulatory Guide 1.94, Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete, Structural Steel, Soils and Foundations During the Construction Phase of Nuclear Power Plants.

Regulatory Guide 1.132, Site Investigation for Foundations of Nuclear Power Plants.

Regulatory Guide 1.138, Laboratory Investigation of Soils for Engineering Analysis and Design of Nuclear Power Plants.

ANSI/ASME N45.2.5-1978, Supplementary Quality Assurance Requirements for Installation, Inspection and Testing of Structural Concrete, Structural Steel, Soils and Foundations.

ANSI/ASME N45.2.20-1979, Supplementary Quality Assurance Requirements for Subsurface Investigations for Nuclear Power Plants.

U.S. Army Corps of Engineers, Instrumentation of Earth and Rock-Fill Dams (Groundwater and Pore Pressure Observations), Engineer Manual EM 1110-2-1908.

U.S. Army Corps of Engineers, Soil Sampling, Engineer Manual EM 1110-2-1907.

U.S. Army Corps of Engineers, Foundation Grouting and Planning, Engineer Manual EM 1110-2-3501.

U.S. Army Corps of Engineers, Foundation Grouting and Field Technique and Inspection, Engineer Manual EM 1110-2-3503.

Department of the Army, Dewatering and Groundwater Control for Deep Excavations, Technical Manual TM 5-818-5.

Department of the Army, Grouting Methods and Equipment, Technical TM 5-818-6.

<u>American Society for Testing and Materials</u>

ASTM D-422, Particle Size Analysis of Soils.

ASTM D-423, Test for Liquid Limit of Soils.

ASTM D-424, Test for Plastic Limit and Plasticity Index of Soils.

ASTM D-698, Moisture-Density Relations of Soils.

ASTM D-1140, Test for Amount of Material in Soils Finer than No. 200 Sieve.

ASTM D-1143, Testing Piles Under Axial Compressive Load.

ASTM D-1556, Test for Density of Soil in Place by the Sand-Cone Method.

ASTM D-1557, Moisture-Density Relations of Soils.

ASTM D-1586, Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2049, Test for Relative Density of Cohesionless Soils.

ASTM D-2167, Test for Density of Soil Inplace by the Rubber-Balloon Method.

ASTM D-2216, Laboratory Moisture Content of Soil.

ASTM D-2487, Classification of Soils for Engineering Purposes.

ASTM D-2922, Tests for Density of Soil and Soil-Aggregate Inplace by Nuclear Methods (Shallow Depth).

ASTM D-2937, Test for Density of Soil Inplace by the Drive-Cylinder Method.

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