

Type of sampling equipment, their advantages and disadvantages are fully discussed in most standard references, and the various manufacturer's catalogues.

The soils engineer shall specify, in the Boring Contract, the type of sampling equipment most suitable for recovering the type of materials expected to be encountered. If there is a possibility that a special type of sampling equipment may be needed, this provision should be included in the contract with a minimal proposal quantity, so as to avoid having to negotiate a price for its use during the boring operation.

Ordinary dry samples for identification purposes shall be obtained by using the split spoon sampler with the standard penetration test on the spoon. Undisturbed samples may be obtained using either the thin walled tube sampler, the piston samples or the Dennison sampler. Rock cores are obtained using the swivel type, double tube core barrel or the N&N Drilling Supply Core barrel part no. 39-108. Special types of sampling devices are available for extraordinary conditions and these should be investigated whenever the need arises. The Burmister Method of Soil Identification outlined in the Inspector's Manual (Section 12, Appendix C) shall be used.

The details governing each type of sampler and the methods for using them to recover samples shall be stated in the Contract Specifications so that the Contractor is fully aware of his responsibilities when submitting his bid.

e. Ground Water

Ground water levels are measured in each bore hole during the boring program. It is recommended that the ground water level be measured each morning before beginning work in a hole, and twenty-four hours after the hole is completed and the casing withdrawn. At selected locations, especially in cut sections, a perforated plastic pipe, referred to as an observation well, shall be inserted into the hole to keep it open, and the water level measured each day by the Engineer until it stabilizes. The method of installing the observation wells shall be described in the Contract Specifications and a typical detail shown on the Contract Plans. Refer to Section 12, Appendix A – Subsection 2.15 for additional direction on the installation and handling of observation wells.

f. In Situ Shear Tests

split spoon sampler and observe the jarring and labeling of representative samples for future identification checking or index testing. The jars shall be kept in a safe place away from open sunlight. The soil descriptions to be used by the Boring Inspectors is the Burmister Soil Identification System (Ref. 2) which is noted in Appendix B. Undisturbed samples shall be properly sealed in accordance with the Specifications, by the driller in the presence of the Inspector, and placed in the required sample tube container. The Inspector shall keep them safely, guarding them against sunlight, impact or vibration, and carefully transport them to the laboratory.

The Inspector shall verify that ground water levels are taken at each hole by the driller. Ground water levels shall be taken each morning before work begins at a hole, on completion of the boring after removal of the casing, and twenty-four hours later.

The Inspector shall assure that all borings are grouted up at the completion of the borings.

A manual for the use of the Boring Inspectors is provided in Appendix C. The boring log forms to be used are given in Figures 1A and 1B. A sample boring log is given in Figures 2A and 2B.

6. Soils Report (for a more detailed description, see III.E.3 this Section)

At the conclusion of the boring program, the Engineer shall prepare a revised list of borings showing the “as-built” boring station and offset, actual type and depth of each boring (the Engineer shall maintain a record of boring coordinates). This revised list is to be utilized in locating the borings on the construction contract plans.

The soils report for the testing program has been outlined previously in Section II, under Testing Program.

The Inspector’s field boring logs shall be edited by the soils engineer for consistency and completeness and then typed on a stable reproducible base for record. The forms to be used for the boring logs are shown in Figures 1A and 1B. A sample boring log is given in Figures 2A and 2B. A layout of the boring logs applicable to each construction contract shall be made on standard size sheets and incorporated in the construction plans as reference drawings.

It is the Engineer's responsibility to provide storage for the samples obtained during the boring program. All samples shall be carefully stored so that they are readily available until such time as all borings and testing contracts are completed and all claims satisfactorily settled. When the Engineer no longer has need for the samples and cores, he will contact the Authority for direction on the disposition of the samples.

III. SOILS AND FOUNDATION STUDIES

A. General

The purpose of the boring and testing programs is to obtain adequate information relating to the subsurface conditions and the behavior of the soils, in order to facilitate the design of satisfactory and economic foundations. The adequacy of the foundation will, in large measure, be reflected by the behavior of the structure.

The boring and testing programs shall be completed in sufficient time to allow the engineer to complete the soil studies and make the foundation recommendations prior to the Phase B construction plan submittal. These soil studies and foundation recommendations shall be incorporated in a Soils Report, with all relevant back-up information, and shall be submitted to the Authority with the Phase B submittal for review.

The boring program is designed to provide information from which the soil profile can be constructed, and the testing program is to provide the soil properties from which the behavior can be predicted. The analysis of the results of both of these programs requires a great deal of thought and judgement on the part of the soils engineer.

In spite of extensive research in the field, soils analysis is still as much an art as it is a science, and there is no substitute for experience and sound judgement. In view of this, all soils exploration and analysis is to be performed under the supervision of, and reviewed by, an Engineer, licensed by the State of New Jersey, who has had at least five (5) years experience in the field of soils engineering.

B. Subsurface Soil Profile

A majority of the subsurface soil profiles encountered in nature is considerably varied and complex. The simply, uniform

soil profile is more the exception than the rule. The borings provide the soils engineer with the general characteristics of the subsurface materials and, hopefully, the location of potential sources of trouble. With this information, the soils engineer is faced with the task of constructing idealized soil profiles outlining the boundaries of potential trouble zones. An estimate of performance based on these profiles can furnish the designer with knowledge which would aid him in avoiding the undesirable consequences of these potential trouble zones by the use of appropriate design methods.

Subsurface soil profiles shall be constructed for the mainline roadways and ramps under embankments. Profiles shall also be constructed at each foundation unit for each structure. The purpose of these subsurface soil profiles is to ascertain variations in the soil boundaries, which shall be taken into consideration in design. The soils profiles shall contain Standard Penetration Test (SPT) data, generalized soil descriptions with boundaries, and ground water levels. The soils profile shall be prepared in such a manner that it can be included in a Soils Report. The preliminary investigations shall evaluate stability and settlements, their effects on the proposed construction schedule, the effects of the proposed construction on adjacent structures and embankments, and any other considerations that could effect the performance of existing or proposed structures. This step in the design procedure is very important and can lead to the avoidance of problems during and after construction.

C. Soil Properties

The laboratory testing program provides the data from which the properties of the soils are computed. These properties may be classified as index properties and behavioral properties. The index properties are used essentially in classifying the soils and, on minor projects, may be used to predict behavior by comparing them with the behavior of similar soils. Minor projects shall refer to sign structures, simple span bridges and noise barriers. On important projects (all projects not covered by "minor projects" or as directed by the Authority), the soil is tested under conditions similar to those expected during and after construction so that the behavioral properties under similar conditions may be determined. These properties are then utilized to predict the behavior of the soils which, in turn, will control the performance of the foundation.

The soil properties to be used for design are the same as those derived from the laboratory reports in Section II, Division B - Test Results. Therefore, it is important that the laboratory testing program be based on conditions similar to those expected in design.

Soils with high acidic properties are not suitable for the growing of grasses and shrubs. Areas containing these soils shall be identified and delineated as part of the soils testing program, so that remedial measures may be incorporated into the grading plans.

The purpose of the test is to determine the acidity level of all the various types of soils that will be located within the top three feet of the final ground. The location of the tests will vary with the proposed grading. If acidic soils are encountered within the top three feet of the final ground, these soils shall either be removed and replaced with non-acidic soils or shall be treated to neutralize the acidity for the full three feet. The above treatment shall take place for soils with pH values of 3.0 or less within the construction limits only.

Areas containing soils, within the top three feet of the final grading, with pH values between 3.0 and 6.5, within the construction limits, shall be tabulated by stations, and this tabulation sent to the Authority as early as possible after the tests are completed. A complete list of all pH tests, listed by Station and Offset, shall be included in the Soils Testing Report.

As a general guide, the following is suggested:

1. In proposed cut sections, test the jar samples obtained from the borings within the three feet below the final ground elevation.
2. In proposed fill sections, the borrow material to be used within the final three feet should be tested. If the material is to be obtained from cut sections, it may be necessary to test all the jar samples within the cut area to ascertain if any acidic soils are present. If the borrow material is to be obtained from sources outside the construction limits, this borrow material should be tested.

It is recommended that any electro-chemical device, such as the "Chemtrix" unit, be used since the readout is obtained directly from a meter, which eliminates a common operator error. The colormetric kits, such as the "Sudbury" unit, are acceptable; but they are subject to operator error in color comparison to determine the pH value. The results obtained from either device are only as good as the sample used; therefore it is important that the operator choose a good representative sample for all types of material tested.

The hand-held, direct contact instrument is not recommended but may be used if it is properly calibrated and used. It has the disadvantage in that it can only obtain spot

Journal, SM2, March 1970, p. 760. The Schmartzmann Procedure which is based on the results of displacement measurements within sand masses loaded by model footings, as well as finite element analyses and deformations of materials with non-linear stress-strain behavior, may also be used. These methods are only approximate but may be used to predict the relative magnitude of settlement under a foundation.

4. Time-Consolidation

In clays and silts with low permeabilities, the time rate of consolidation becomes important. The coefficient of vertical consolidation is determined from the time rate data obtained during the consolidation test. The data is plotted using the Taylor Method of square root of time vs. strain or log of time vs. strain to determine the coefficient of vertical consolidation.

Vertical permeability tests can be performed in conjunction with the consolidation test at specified load increments. By turning the sample horizontally and trimming it to fit the consolidometer, the horizontal permeability may also be obtained in the same manner. In addition to these, vertical and horizontal permeability tests can also be performed using the triaxial apparatus with specified chamber pressures. These results are utilized in computing vertical and horizontal coefficients of consolidation.

The time rate calculation is based on Terzaghi's one dimensional theory of consolidation. It is used to predict the time required for settlement to occur and the necessity of special treatment for accelerating the consolidation. It can also be used to predict the excess pore pressure within the foundation soils. The excess pore pressure measured during construction is compared with the predicted, and may be used to control the rate of placement of the embankments.

5. Stability

Whenever poor foundation conditions are encountered, the stability of the embankments becomes critical and the safety factor against failure must be determined. A minimum safety factor of 1.2 is desired during construction. Whenever the safety of existing facilities may be endangered by a failure, this safety factor shall be increased to a minimum of 1.5 or higher. The safety factor may be achieved either by using toe berms, or relying on shear strength gain from consolidation within the foundation soils or a combination of both. This judgement is left to the soils engineer who will consider, among other factors, time scheduling, rate of shear strength gain and economy.

The Authority recommends the use of computers for performing the stability analyses. A large number of failure circles can be analyzed by this method in a short period of time, giving the soils engineer a certain degree of flexibility in his analysis. There are several computer firms and universities with programs designed for stability analysis. Most of the programs use the Fellenius' Method or Ordinary Method of Slices without pore pressures. The Integrated Civil Engineering System uses the Slope Subsystem for stability analysis. This program uses the Fellenius' Method or Ordinary Method of Slices, the Simplified Bishop and the Morgenstern-Price Methods of analysis with pore pressures.

6. Lateral Pressure

In the design of earth retaining structures, lateral earth pressures are computed either by the Rankine Method, which uses the Plastic Equilibrium Theory or, by the Coulomb Method, which used the Wedge Theory. In both cases, the soil is considered to be at the point of incipient failure.

A retaining structure must yield a minimum of $0.001H$ in order for the soil to develop the full active pressure condition. Before specifying the lateral pressures to be used in design, the soils engineer shall consult with the design engineer to determine the type of structure that will be used and whether it can yield enough to develop the active pressure condition. If not, some value intermediate between the active and the at rest condition shall be specified.

The strain required to develop the full passive pressure is greater than that required to develop the active pressure condition. Whenever the passive pressure is used in design, consideration shall be given to the possible movement of the structure, and a suitable safety factor applied. The passive pressure shall be ignored in the calculations if the possibility of scour exists.

In designing sheet pile cofferdams, consideration shall be given to seepage pressure that may apply. Leakage between the interlocks usually is not large enough to completely relieve these pressures.

When designing temporary cofferdams, the above theories shall be used in the sheeting design. However, the struts shall be designed using the earth pressure distributions given by Terzaghi and Peck in "Soil Mechanics in Engineering Practice, Second Edition, Article 48".

Compaction below water level is required. Typical excavation sections are shown in Figure 4.

b. Special Man Made Foundation Problems

Problems for roadway cuts and embankments can be caused by a number of manmade features, such as uncompacted fills, dumps, sanitary landfills, and old buried foundations. Usually these conditions cause roadway settlement problems. Often, sanitary landfills can cause a problem involving methane gas.

If these conditions are encountered, or suspected, then test pits should be utilized so that the contents can be disclosed. The test pit logs should give a complete verbal description and include photographs.

A controlled sanitary landfill is one in which the refuse is placed in spread lifts not exceeding five feet, with a one or two foot layer of either sand or silt placed over each lift and rolled. If it can be determined that the sanitary landfill was built under conditions similar to those outlined above, it is sometimes possible to place low embankments, in the magnitude of five feet, on this material. An overload shall be placed above the profile grade and left in place until most of the settlement has occurred, to precompress the material. Before constructing the pavement, the overload is removed and the embankment is proof-rolled using a 50-ton roller with minimum tire pressures of 100 pounds per square inch. Soft or weaving areas shall be removed and replaced with a select granular backfill.

Uncontrolled sanitary landfill is not desirable as a foundation material even for low embankments. These materials shall be excavated for their entire thickness and replaced with select granular materials. Typical excavation sections are shown in Figure 4.

In view of the recent emphasis on toxicity, excavation methods may be frowned upon because of the disposal problem. If satisfactory methods of disposal cannot be found, the Engineer may be forced to examine alternative methods of design. One such method is Dynamic Deep Compaction where a heavy weight is dropped, repeatedly, three to eight times at the same spot from a 30- to 120-foot height. In this event, the post-construction settlement shall be estimated and the degree of future maintenance brought to the Authority's attention.

Soil bearing foundations may be considered unyielding if the allowable bearing pressure is 3.0 tons per square foot or greater, provided that there are no compressible layers below the footing level that will cause unacceptable settlement. The settlement shall be computed so that the structure designer can take it into consideration if he is planning to use continuous spans.

When embankments are placed on stabilized foundation soils, post-construction settlement may occur. This settlement may consist of primary and secondary consolidation or secondary consolidation only, depending on the treatment time available. Since the magnitude of this post-construction settlement may affect the type of structure to be chosen, it shall be computed and if necessary, later verified using actual settlement data.

The embankment post-construction settlement will cause an abutment (soil bearing or pile supported) to rotate backwards. (A rule of thumb used to estimate the amount of lateral movement into the embankment is one-third to one-quarter of the post-construction embankment vertical settlement.) The abutment shall be designed so that the bearing shoes can be adjusted for this lateral shift.

Piles for pile supported footings shall be designed according to the procedures outlined in this Section, Division D - Design Considerations. The foundation recommendation shall state the type of pile, the design load in tons and the minimum and/or estimated pile tip elevation. Any special treatment required for the piles (e.g. coating for corrosion protection, creosoting wood piles, pile shoes, special pile tips or points, etc.), shall be stated in the foundation recommendations in the remarks section.

Table 1 is a list of alternate recommended pile types and design loads that are based upon past experience on the New Jersey Turnpike and other sources. There may be cases where other types of piles or design loads would be more appropriate.

Piles driven through stabilized foundation soils that are expected to continue to settle after construction will experience drag forces due to the consolidation of these soils. These drag forces can be severe in some cases and may overload piles that have not been designed for this additional load. The foundation recommendations shall also state, in the remarks section, the estimated magnitude of the drag forces, so that the designer can take them into consideration.

3. Engineering Soils Reports

The Section Engineer is to prepare an Engineering Soils Report on all the proposed construction that he will design. This report is to facilitate the review of contract plans and specifications and to provide a documentation of all potential problems for future reference.

The Engineering Soils Report can consist of one or more letter reports or formal reports that cover all the proposed construction for bridges, retaining walls, major culverts, roadway embankments and roadway cuts, and other significant structures.

The Engineering Soils Report is to be submitted to the General Consultant with the Phase B plan submittal. Three copies of the report will be submitted, the Section Engineer will retain the fourth copy.

This soils report should contain the following items:

1. A brief description of the structure or structures.
2. A brief description of the soils and foundation conditions.
3. A soils profile showing SPT data, ground water elevations, soil strata and a generalized description of the soils and bedrock encountered.
4. A table of undisturbed soil properties.
5. A brief description of any potential foundation problems and the proposed treatments.
6. Any required criteria necessary for the use of construction instrumentation.
7. For all bridges, retaining walls and major culverts documentation of recommended AASHTO Group I allowable loads using a foundation recommendation form (Figure 3).

IV. CONSTRUCTION CONTROL

Control of normal methods of construction are covered by the standard specifications (Ref. 3), the construction contract specifications and are discussed in the Construction Manual (Ref. 4). The earthwork and structure items noted in these references include compaction, select material gradations, pile load tests and pile driving.

Construction of embankments on soft foundations often requires treatments that need special construction control methods with which most Contractors and Field Engineers are not familiar. Consequently, the methods of construction and construction control have to be clearly stated in the plans, specifications and directives to the Field

shall be based on stability calculations of the embankment.

There are several types of piezometers available from various manufacturers. The Authority has found the hydraulic heavy liquid piezometer, manufactured by the Piezometer Research and Development Corporation, to be satisfactory in response to pressures and for ease of maintenance.

C. Slope Indicators

These devices are essentially early warning devices for measuring horizontal displacements in the weak subsoil strata. They are especially useful in monitoring unstable conditions in cuts or fills.

Essentially, these devices consist of a specially designed aluminum or plastic casing installed into the ground with wash boring equipment. The bottom of the casing is anchored in rock or in a very dense soil stratum. If large settlements are anticipated, the sections shall be of the telescoping type to prevent buckling.

A specially designed torpedo is inserted into the casing and the angle of inclination at selected depths measured. The inclination angles are translated into displacement measurements which, by integrating from the bottom to the top produces the displacement profile. The magnitude and rate of displacement are monitored and provide the basis for determining a possible failure condition.

D. Observation Wells

These are open perforated pipes placed in the ground to monitor the ground water level. They shall be used wherever the ground water level is critical to construction progress.

V. REFERENCES

1. "Engineering Soil Survey of New Jersey", Rutgers University College of Engineering Research Bulletins - Nos. 15 through 36.
2. D.M. Burmister, "Principals and Techniques of Soil Identification," Proceedings of the Highway Research Board, December, 1949.
3. New Jersey Turnpike Standard Turnpike Specifications.
4. Construction Manual.

Acknowledgement is hereby made of the following Addenda received since the issuance of the Plans and Specifications:

Accompanying this Proposal is a certified check or bid bond made payable to _____ (engineer) _____ in the amount of not less than five percent of the Total Price bid, which the undersigned agrees is to be forfeited as liquidated damages, and not as a penalty, if the Contract is awarded to the undersigned and the undersigned shall fail to execute and deliver the Contract Agreement and the Contract Bond and furnish satisfactory evidence of all required insurance coverage, all within the stipulated time; otherwise, the check will be returned to the undersigned.

(an Individual)
The undersigned is (a Partnership) under the laws of the State
(a Corporation)

of _____, having its principal office
at _____.

Name of Firm Bidding: _____

Address of Firm: _____

Witness or Attest:

Bidder's Signature: _____

Title: _____

Date Signed: _____, 20____

(Corporate Seal)

BORING CONTRACT NO. _____

* * * * *

CONTRACT AGREEMENT

THIS AGREEMENT, made this _____ day of _____ in the year of our Lord Two Thousand and _____, between _____ (engineer) _____, party of the first part, hereinafter called the Engineer, _____, party of the second part, hereinafter called the Contractor.

WITNESSETH, that the said Contractor, for and in consideration of the payments hereinafter specified and agreed to be made by the Engineer, hereby covenants and agrees to furnish and deliver all materials necessary, and to perform all the work required to be performed, including all work incidental thereto, for the making of boring for _____

_____ and to complete this Contract in strict and entire conformity with the attached Specifications and accompanying boring location Plans, which said Plans and Specifications and other Contract documents are hereby made a part of this agreement as fully and with the same effect as if the same had been set forth at length in the body of this Agreement.

The Contractor agrees to make payment of all proper charges for labor and materials required in the aforementioned work, and to defend, indemnify and save harmless the Engineer, the New Jersey Turnpike Authority, their officers, employees, agents and servants, and each and every one of them, against and from all suits and costs of every name and description, and from all damages to which the said parties may be put, by reason of injury to the person or property of others resulting from the performance of said work, or through the negligence of the Contractor, or through any improper or defective machinery, implements or appliances used by the Contractor in the aforesaid work, or through any act or omission on the part of the Contractor, or his agent or agents, employees or servants.

It is also agreed and understood that the acceptance of the final payment by the Contractor shall be considered as a release in full of all claims against the Engineer, the New Jersey Turnpike Authority or any of their officers, employees, agents and servants, arising out of, or by reason of, the work done and materials furnished under this Contract.

In consideration of the premises, the Engineer hereby agrees to pay to the Contractor for the said work, when fully completed, the sum of _____ Dollars and _____ Cents (\$ _____) (Estimated), payments

BORING CONTRACT NO. _____

* * * * *

CONTRACT BOND

KNOW ALL MEN BY THESE PRESENTS that we, the undersigned, _____

_____ as PRINCIPAL, and _____

a Corporation organized and existing under the laws of the State of _____, and duly authorized to do business in the State of New Jersey, as SURETY, are hereby held and firmly bound unto _____ (engineer), their successor or successors, in the penal sum of _____ Dollars and Cents (\$ _____), for the payment of which well and truly to be made, we hereby jointly and severally bind ourselves, our heirs, executors, administrators, successors and assigns.

Signed this _____ day of _____, A.D. two thousand and _____.

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH that whereas the above-named Principal is about to enter into a contract with _____ engineer, their successor or successors, which said contract, for the making of borings for _____ is hereby made a part of this bond as if set forth herein at length.

NOW, THEREFORE, if the said Principal shall well and faithfully do and perform the things agreed by _____ to be done and performed according to the terms of the said Contract, or any changes or modifications therein made as therein provided, and shall pay all lawful claims and judgements of subcontractors, materialmen, laborers, persons, firms or corporations, for labor performed or materials, provisions, provender or other supplies, or teams, fuels, oils, implements or machinery furnished, used or consumed in the carrying forward, performing or completing of said Contract, we agreeing and assenting that this undertaking shall be for the benefit of any subcontractor, materialmen, laborer, person, firm or corporation having a just claim, or judgement against the Principal, as well as for the obligee herein, and shall defend, indemnify and save harmless the party of the first part mentioned in the Contract aforesaid, the New Jersey Turnpike Authority, their employees, agents and servants, and each and every one of them against and from all suits and costs of every kind and description, and from all damages to which the said parties or any of their officers, agents, or servants may be put by reason of injury to the person or property of others resulting from the

apprising the owners that the Authority's personnel and contractors may be performing work on their property. These letters do not constitute a request for a right of entry to the property. It is the responsibility of the Contractor to secure, at his own expense, the owner's permission before entering onto the property. The Contractor shall ascertain from the Engineer whether these letters have been sent before requesting such permission.

The Engineer will provide a list of all known property owners.

Temporary crossings of railroad property will not be permitted without written permission from the railroad company. The Engineer will offer all possible assistance to the Contractor in securing permission to enter upon such private property for his work. The Contractor shall at all times carry out his operations so as not to inconvenience residents at or near the working area. The Contractor shall make clear to all his personnel the importance of proper public relations.

In gaining access to and from boring sites along roadways, the Contractor shall observe all applicable traffic regulations regarding the movements of his vehicles, equipment and personnel. Vehicles shall travel on roadways only in the direction of normal traffic flow and at no time shall they cross the traffic stream.

Permission to work on the railroad property should be obtained.

The Engineer will provide location plans to submit with the Contractor's application and permit fees where applicable.

The Contractor will be responsible for the securing of wash water supply and for the proper disposition of its discharge at all boring locations.

The location of all stationary and mobile equipment shall be subject to the approval of the Engineer.

The Contractor may occupy during his operations only those portions of public places at the boring locations for which he has obtained the required permission, subject to the approval of the Engineer.

1.18 Jurisdiction and Authority of the State Police

Traffic on the Turnpike is under the direct supervision and control of the New Jersey State Police who will enforce all statutory laws including the Authority's established "Regulations Relating to the Control of Traffic on the New Jersey Turnpike", as they pertain to the Contractor as well as to the

employed on the Project, the materials or equipment used, or the conduct of the work.

In the hiring of laborers, workmen and mechanics for the performance of work under this Contract or any subcontract hereunder, no Contractor, nor any person acting on behalf of such Contractor or subcontractor, shall, by reason of race, creed or color, discriminate against any person who is qualified and available to perform the work to which the employment relates.

No Contractor, subcontractor, nor any person on his behalf, shall in any manner, discriminate against or intimidate any employee hired for the performance of work under this Contract on account of race, creed or color. All people employed by the Contractor on this project are subject to the prevailing New Jersey wage rates.

1.27 Drilling Permit

The Contractor shall procure a drilling permit prior to the start of any boring work from the Division of Water Resources, New Jersey Department of Environmental Protection.

1.28 Permits and Licenses

The Contractor shall procure all required permits and licenses, pay all charges and fees therefor, and shall give all notices necessary and incident to the due and lawful prosecution of the Project.

The Contractor shall furnish at his own expense the water supply necessary for carrying out the work, and shall secure all permits and licenses required to maintain such supply.

The cost thereof shall be included in the prices bid for the various items scheduled in the Proposal.

1.29 Public Utilities and Property Damage

The Plans indicate the locations of some subsurface structures within the vicinity of the proposed borings. The Contractor shall not proceed with his work at any one boring location until he has made diligent inquiry at the office of the Engineer, utilities and private companies and municipal authorities, to determine the existence and exact locations of subsurface structures. The Contractor shall also comply with the State's Underground Facility Protection Act and notify the State's One Call System before performing any work. The Contractor shall exercise extreme care in accurately locating all utilities and in carrying out his operations, and shall be solely responsible for any damages caused to utilities and to the facilities affected by such utility damage, whether such utilities are shown on any available plan or not.

The Contractor shall fill all holes caused by his operations and shall take every precaution against injuring paving, utilities, or private or public property, and shall promptly repair, at his own expense and to the satisfaction of the Engineer and the owners, any damage to such paving, utilities and property caused by his operations. This shall also include sodding of any areas where the grass is damaged.

Upon completion of the Contractor's operations at each site, he shall remove his equipment therefrom, including pulling all casing and shall clear the area of all debris and restore it to the condition existing before the start of his operations.

The policy required under subparagraph (d) above shall include an endorsement requiring ten days prior notice to _____ Railroad _____, before any change or cancellation is made effective.

The Railroad Protective Insurance policy shall be maintained until all work on railroad property is completed. All other policies required under this Contract shall be maintained until completion of all work.

As an alternate to the Contractor's furnishing a separate policy for the Railroad Protective Insurance, the railroad company may wish to extend its present protective insurance policy to cover the Contractor's operations on railroad property. If this alternate arrangement is proposed by the railroad company, the Contractor shall comply with this request and shall reimburse the company for the benefit of such extended coverage on the basis of the company's established fees therefor.

No separate payment will be made for the cost of the insurance herein specified but the Contractor shall include the cost of such insurance in the prices bid for the various items scheduled in the Proposal.

1.31 Commencement and Prosecution of Work

The Contractor shall have a complete crew or crews and fully-equipped rig or rigs actually at work upon the site within three calendar days from the date of written notice to proceed.

The Contractor shall notify the Engineer of his intention to start work or to add extra crews and rigs at least two calendar days in advance of such work.

The sequence in which the individual borings are to be made shall be as directed by the Engineer. The Engineer reserves the right to order the borings made at such locations and in such sequence as will provide the maximum amount of preliminary information as the work progresses.

The Contractor shall so conduct the work as to give the Engineer every facility to obtain his own records, including ground water level and note every detail of the work and to obtain a correct record of the material passed through.

Each boring shall be sunk and drilled entirely by a single crew.

No drilling shall be done on Sundays, nor before sunrise or after sunset on Mondays to Saturdays, inclusive, except with the express approval of the Engineer.

No materials or plant used in the making of any borings shall be removed until the Engineer has given permission therefor.

1.32 Sealing of Bore Holes

At the completion of each boring or abandoned boring, the holes are to be sealed in accordance with New Jersey Department of Environmental Protection requirements.

Since the number, types and sizes of borings are subject to change in the field, the quantities of the various scheduled items of work stated in the Proposal, may be substantially increased or decreased as directed by the Engineer as the work progresses, without change in the unit prices bid by the Contractor for any of the scheduled items in the Proposal, except as provided in Article 1.36 of these Specifications.

2.5 Depth of Borings

All borings are to be carried to the depths ordered by the Engineer. In general, 2½-inch casing borings shall be carried into firm bearing material or to rock, and when ordered by the Engineer, the boring continued into rock with 1 -inch core borings for a minimum depth of five feet. Four inch casing borings are to be made primarily to sample all soft or highly compressible strata and shall generally be carried slightly below the lowest known soft or highly compressible stratum when soil sampling but may be of more shallow depths when driven exclusively for in-place shear testing of the soils.

In general, borings should be carried into rock under structures and under embankments. Borings should be through varved clays.

2.6 Driving of Casings

Casings shall be extra strong steel pipe or flush-coupled casing with nominal inside diameter of 2½" or 4", as required.

Casings shall be sunk vertically through earth and other materials, including boulders and rock veins, to rock, or if not to rock, to such depth below ground as the Engineer may direct. They shall be driven down without washing to the depth at which a sample is to be taken or shear test performed, after which the material shall be cleaned out to the bottom of the casing and the sample or shear test vane driven or pushed below the bottom of the cleaned casing. After sampling and/or shear testing, casing driving shall be resumed.

The use of water for cleaning out the casing between sample elevations will be required. The Contractor shall make suitable arrangements satisfactory to the Engineer and other interested parties, for the procuring and disposition of washwater.

The weight of hammer to be used in driving the casing shall be 300 pounds with a 24-inch height of free fall. The hammer shall be raised by means of a rope having one end wrapped (not more than three loops) around a winch head. A continuous record of the blows per foot required for the driving of the casing shall be kept by the driller except when the casing is being driven exclusively for performing in-place shear tests.

Simultaneous washing and driving of the casing will not be permitted except in the case of difficult driving which, in the opinion of the Engineer, requires the use of water. Where such use of water is permitted, a record must be kept by the Inspector and the driller of the elevations between which simultaneous washing and driving occurred.

When ready to take an undisturbed dry sample, all loose and disturbed material shall be removed by washing to the bottom of the casing except that final cleaning of a four-inch casing shall be done with an M.P.F.M. clean-out jet auger having an outside diameter of 3/4" (NN Drilling Supply's Part No. 71789 or approved equal). Cleaning out with the auger shall be done in such a manner that the soil immediately below the bottom of casing shall be as nearly undisturbed as possible.

The sampler shall then be lowered slowly to the bottom of the casing, and pressed either manually or by hydraulic jack, if necessary, into the soil a distance sufficient to fill the sampler to within three or four inches of its capacity. In no case shall the sampler be driven with a hammer; however, the sampler may be forced downward under the weight of the hammer. The sampler shall be pushed or jacked downward into the soil at a rate of 20 or 25 inches in approximately five seconds, as this is about the rate at which water can be vented through the ball valve without creating excessive pressure on the top of the sample.

When using the piston type sampler, the sampler, with the piston set flush with the cutting edge at the bottom, shall be carefully lowered to rest on the soil at the bottom of the cleaned casing. The rod supporting the piston shall then be clamped to the top of the casing so as to be immovable, after which the sampling tube shall be forced down as previously described to the proper depth. Then, the two rods shall be locked together at the top and the entire assembly slowly withdrawn from the hole.

After the sampler (either type) has been carefully removed from the hole, the tube section containing the soil sample shall be detached. The ends of the sample shall be carefully squared up not less than one-half inch back of each end, and the end spaces of the tube shall be completely filled with hot "Petrowax A", as manufactured by the Gulf Oil Company, or approved equal. The tubes shall then be closed at both ends with snug fitting metal or plastic caps which shall be secured in place with masking tape, after which the ends of the tube shall be dipped in hot "Petrowax A", or approved equal, to provide airtight seals.

Samplers shall not be pressed more than three feet below the bottom of casing. Where continuous sampling is ordered, driving of the casing shall be resumed before the bottom of sampler penetrates beyond this three-foot limit.

Undisturbed dry samples shall be clearly labeled showing the name of the Project, boring number, sample number, depths between which the sample was taken and the top of the sample tube. Special care shall be taken to indicate the top end of the sample tube.

The Contractor shall provide the sample tube containers. He shall carefully preserve these samples and deliver them to the Inspector as hereinafter specified. Extreme care must be taken in handling undisturbed samples to avoid shock or jarring which may affect the character of the sample.

2.10. In-Place Vane Shear Tests

Vane shear tests shall be performed directly in strata of soft soils encountered in boring operations in order to determine the shearing resistances of various saturated fine-grained material.

The test consists basically of sinking a four-bladed vane in the undisturbed soil beneath a casing and rotating the vane through the soil by means of a turning apparatus mounted on the top of casing above ground. The torsional force required to rotate the vane and cause a cylindrical surface in the soil to fail, is read on a gage attached to the turning mechanism, which readings can be converted to shearing resistance.

Vanes shall be of two sizes - two inches in diameter by four inches in length and three inches in diameter by six inches in length. Unless specifically directed by the Engineer to use the two-inch diameter vane; the three-inch diameter vane shall be used for shear testing.

The calibrated torque assembly for rotating the vane and measuring the turning force, shall be equal to NN Drilling Supply's Part No. 10136, complete with base plate. A conversion chart shall be provided to enable the Inspector or driller to convert the gage readings to shear strength.

The vane shall be connected to the torque assembly by means of coupled rods. Whenever a casing is being used, at least one ball bearing guide shall be mounted on the rod shaft to fit snugly against the inside of the casing. The casing may be eliminated when the depth of hole does not exceed six feet.

When ready to perform a shear test, the casing shall be washed clean to the bottom of the casing. The vane and rod shaft shall be inserted in the casing until the vane reaches the bottom of the casing. If the test is being performed in a boring being made primarily for soil sampling, the test will generally be ordered after the securing of the undisturbed dry sample; in these instances, the vane is to be lowered to the deepest point penetrated by the sampler.

The vane shall then be slowly pressed, not driven, into the undisturbed soil beneath the bottom of the hole for a distance of 15 inches.

The torque assembly shall be mounted on the rod shaft and casing and braced against any possible accidental rotation of the casing or assembly during the test.

The crank shall be turned slightly to remove any slack or play, and the initial gage reading recorded. The crank shall then be turned at a uniform rate corresponding to a one-degree rotation of the vane in ten seconds. Gage readings shall be recorded by the driller every five degrees of vane rotation, and also at the point of maximum torque. The turning of the crank shall not be stopped to take the readings. Vane rotation and gage readings shall continue until the second reading beyond the maximum reading (to ensure that the maximum is not a false peak of resistance). For each reading, the driller shall record the angle of rotation, the gage reading and the converted value of shear strength. Each data sheet shall be identified as to Project, boring number, station, offset, ground line elevation, vane size, and elevation of the bottom of the vane at time of shear test.

Retractable Plug Borings

Elevation at the top and bottom of each run.

Elevation at the top and bottom of each six-inch tube sample preserved.

Soil represented in each end of each six-inch tube sample, including those ordered discarded.

Length of sample retained in each six-inch tube.

Distance from ends of tube of ends of sample when the tube is not completely filled with soil.

Percentage of recovery of the run.

Core Borings

Elevation of bottom of casing when seated on bedrock.

Type of core drill, including size of core.

Length of core recovered for each length drilled, with resulting percentage of recovery.

Elevation of each change in type of bedrock.

Elevation of bottom of hole.

Rate at which each section was cored in minutes per foot.

The bedrock shall be described in accordance with the following classifications:

- (a) Type: Shale, schist, slate, limestone, granite, sandstone, etc.
- (b) Condition: Broken, fissured, laminated, solid, etc.
- (c) Hardness: Soft, medium, hard, very hard, etc.

The driller's logs of all borings, containing the information specified above, shall be transferred onto the Contractor's standard log forms, at least 8½" x 11". The necessary data shall be recorded on the forms in ink or pencil or may be typewritten.

No separate payment will be made for preparing such boring records, but the cost thereof shall be included in the prices bid for the various items scheduled in the Proposal.

2.15. Observation Wells

Observation wells, consisting of plastic pipe, shall be installed in borings designated by the Engineer. Borings in which observation wells are to be installed will be determined as the work proceeds. Notice to install an observation well will be given prior to time of completion of the selected borings. The well shall be installed immediately after completion of the boring.

Pipe for observation wells shall be rigid plastic or PVC, Schedule 40 minimum, 1¼" I.D., as approved by the Engineer. The installation shall be protected in a manner acceptable to the Engineer, so that water and

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	-	surfaces that are slick and glossy in appearance or polished.
Fissured	-	an extensive crack or cracks.
Sensitive	-	pertaining to cohesive soils that are subject to appreciable loss of strength when remolded.
Varved	-	alternating thin layers of silt (or fine sand) and clay.
Laminated	-	composed of thin layers and texture, 1cm, or less, in thickness.
Interlayered	-	composed of alternate layers of different soil types.
Parting	-	a very thin layer one or two grains thick.
Calcareous	-	containing appreciable quantities of calcium carbonate.

DRY SAMPLE BORINGS

The borings are to be advanced using ordinary boring techniques. Cased holes shall use driven casings not less than 2½" in diameter to the extent needed to maintain an open hole without loss of ground. Cleaning out the hole, where casing is used, or advancing the hole, if casing is not needed, shall not be done by washing through a sampling spoon or open-ended drill rod unless prior approval is obtained from the Resident Geotechnical Engineer. The use of rotary drilling techniques with weighted drilling mud, hollow stem augers or other methods to advance and maintain a stabilized hole may be permitted depending upon field conditions and the design of the drilling program. Any changes in the drilling program should have the approval of the Resident Geotechnical Engineer. Casing, where used, shall be driven down without washing in stages of not more than five feet, after which the material shall be cleaned out to the depth of the bottom of the casing. At every change in soil formation and at vertical intervals not to exceed five feet, hole advancement should be stopped, the loose material should be removed from the hole and an ordinary dry sample of the material should be taken. These samples should be taken in accordance with the provisions of the Standard Penetration Test. The samples should be removed from the hole in an unwashed condition in such a manner as to provide a true sample of the soil formation from which they are recovered. Requirements of the Standard Penetration Test (ASTM D1586) specifications for the sampler and guidelines for soil sampling are as follows:

1. A two-inch O.D. split-barrel sampler similar to Ackers' Sampler No. 22017-9 may be used, provided a full I.D. open split-barrel at least 26-inches long is incorporated in the sampler. The beveled edge of the drive should be maintained in good condition and if excessively worn, should be reshaped to the satisfaction of the Engineer. The drive shoe of the sampler should be replaced, if damaged in such a manner as to cause projections within the interior surface of the shoe.

CONTINUOUS SAMPLING

Continuous sampling in certain borings or through certain soil strata may be requested by the Resident Geotechnical Engineer based upon information disclosed by the borings. Continuous sampling shall mean the securing of successive samples in sampling devices without intervening drilling or washing except for cleanout operations, as specified.

UNDISTURBED SAMPLE BORINGS

At the request of the Resident Geotechnical Engineer, or his representative, the driller may be required to take samples in a three-inch O.D. open-type "Shelby" tube undisturbed sample with sample tubes 30 inches long and provided with a positive ball check valve in its head. For obtaining undisturbed samples, the casing shall be at least 3½" in diameter. Undisturbed samples are normally required in soft clay or organic soils. Such samples shall be obtained by pushing or jacking the sampler into undisturbed soil at the bottom of the hole. Wherever possible, the equipment for advancing the sampler shall measure the force required to penetrate the soil. The Boring Inspector shall record the force required to penetrate the soil. The Boring Inspector shall record this force, depth of penetration and length of sample recovered. These samples shall be sealed in the tubes in which they are obtained and carefully labeled to show location and depth of sample (i.e.: S1, S2, ST3, S4). When there are problems with obtaining undisturbed samples using Shelby tubes, then undisturbed soil samples shall be recovered by means of special piston-type samplers.

When ready to take Shelby or piston-type samples, all loose and disturbed materials shall be removed to the bottom of the casing or of the open hole. This final cleaning should be accomplished with a device in which washwater is fully deflected in an upward direction. No washing with downward directed jets should be permitted within four inches of the intended top of the undisturbed sample unless otherwise directed by the Resident Geotechnical Engineer or his representative. Cleaning out of the last four inches of the intended top of the sample should be accomplished with shield jet auger such as a "Clean-Out Jet Auger", (Ackers Catalogue 320396 for 3½" pipe of 320397 for 4" pipe), or equivalent device subject to the approval of the project engineer. Cleaning out should be done in such a manner that the soil immediately below the bottom of the casing is as nearly undisturbed as possible. The sampling device connected to the drilling rod should then be lowered slowly to the bottom of the hole and the sampler forced into the soil for a distance of not less than 24 inches or more than 27 inches.

In the operation of securing the undisturbed samples, the samplers should be forced into the soil at a rate of four to five inches per second. The samplers should be pushed or jacked downward, and not to be driven unless the character of the soil is such that driving with the hammer is absolutely necessary and is approved by the project engineer.

The sampler with its contained soil sample should be rotated, then carefully removed from the hole. The thin-walled tube containing the sample should be detached from the driving head. A portion of the undisturbed sample should always be carefully removed from both ends of a tube (a minimum of ½" thickness) and squared and preserved whether the sample is sealed in the tube

or extruded in the field and preserved in cartons. The removed samples from the top and tip of the tube should then be described on the boring log. At the request of the Resident Geotechnical Engineer, it may be necessary to perform Pocket Penetrometer and field Torvane tests on the bottom of the recovered undisturbed sample. It may, however, be necessary, if requested by the Resident Geotechnical Engineer, to extrude the samples in the field and preserve them in quart cartons; when samples are handled in this manner, extra time and care must be taken.

If the soil sample is not extruded, the ends of the tube are wiped clean and the end spaces filled with hot paraffin or hot melted beeswax. The ends of the tube should then be sealed with snug-fitting metal or plastic caps and secured in place with friction tape, after which the ends of the tube should be dipped in hot paraffin/beeswax to provide airtight seals.

Undisturbed soil samples should be clearly and permanently marked on the tube to show the project contract number, the number of the hole, the sample number, the depth from which the sample was taken, the measured recovery, and the top and bottom of the tube, and any other information which may be helpful in determining subsurface conditions. Whenever possible, a measurement of the force required to push the undisturbed sampler tube into the soil should be obtained and recorded.

Undisturbed samples, designated by a "U" and "Shelby Tubes" designated by "ST", should be numbered according to their occurrence in the boring sequence: i.e., S1, S2, U3, S4, ST5, S6, S6A, etc. Undisturbed samples should be handled and transported in a cushioned rack with the top of the sample always upright. It should be delivered to the laboratory with extreme care in order to minimize disturbance effects which may render laboratory test results useless.

During the winter months, precautions must be taken to prevent undisturbed samples from freezing during handling and shipping; if allowed to freeze, the samples will be worthless for strength or consolidation testing.

Tubes for undisturbed samples are to be provided by the driller, and should be of steel, seamless brass or hard aluminum. Sample tubes should have a machine-prepared sharp cutting edge with a flat beveled to the outside wall of the tube. The cutting edge shall be drawn in to provide an inside clearance beyond the cutting edge of $0.015'' \pm - 0.005''$.

When recovery of samples by use of Shelby tubes is poor, then undisturbed soil samples are to be recovered by means of a thin-wall piston-type sampling device, similar to Acker's No. 22041-7 in which piston rods extend to the ground surface, or a self-contained hydraulically-operated piston sampler, such as the "Osterberg" sampler, or a casing-actuated piston sampler, such as the "Hong" sampler. The sampler selected should be designed to utilize sample tubes with a three-inch outside diameter. When samplers utilizing piston rods extending to the ground surface are used, positive locking of the piston rods with respect to the surface of the ground must be provided to prevent upward or downward motion of the piston during the advance of the sampling tube and the piston rods must be positively locked to the drill pipe at the surface during removal of the sampler for the depth to which it penetrated undisturbed soil. If the piston rods are locked to the mast of a truck-mounted drill rig, the rig should be blocked and

anchored to the ground in such a manner as to prevent motion of the rig during the sampling operations.

If specifically approved in advance by the Resident Geotechnical Engineer, samples may be recovered in hard soils by an open-type, thin-wall sampling device, similar to Acker's No. 22012-14 or No. 22058-4.

In very soft soils, a weighted drilling mud may be required, whether or not casing is used, in order to maintain a pressure on the soil as nearly equal as possible to that existing before the drilling operations.

Under certain conditions, continuous sampling with three-inch diameter "Shelby" tubes may be required in cohesionless materials encountered in 3½" undisturbed sample borings.

BORING TERMINATION

In general, a specific completion depth, or depth criterion should be assigned to each boring location for the design of the drilling program. Unless otherwise instructed by the Resident Geotechnical Engineer, it is expected that the design completion depth will be adhered to. Because the sample depths are generally at five-foot intervals and the completion depths are generally in multiples of five feet (i.e. 25, 30, 40, 65 feet, etc.), the last sample should begin before and terminate at the design completion depth. Similarly with rock coring, the last run does not have to be a complete five-foot run, but may be stopped early at the design completion depth.

There are occasions when borings might not be terminated at the designated completion depths. Such occasions might be:

1. The boring is in soft clays or organic silts or some compressible stratum;
2. Sampling blow counts have been decreasing significantly or are very low to begin with (i.e. fewer than 10 to 20 blows per foot);
3. A void is encountered just before or at the design completion depth;
4. Unanticipated subsurface conditions have been encountered;
5. Minimum criteria for terminating a boring as established by the Resident Geotechnical Engineer have not been met (i.e. blow count, core recovery, R.Q.D., particular stratum, etc.)

Before proceeding further with the boring, the Boring Inspector should consult with the Resident Geotechnical Engineer for further instructions. If the Resident Geotechnical Engineer is unavailable, then consult the person next above in the chain of command, such as another engineer, the project manager or principal-in-charge.