

CITY OF STATESVILLE

Public Works Department

A. Scott Harrell, PE – Executive Director

The following standards are considered minimum acceptable standards for the construction of sewer lines as part of the City's collection system. Where name brands are listed for specific components, these are acceptable in all cases. Equal brands can be used only upon specific approval in writing by the Director.

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Summary of City of Statesville Pipe materials revisions.
Effective: October 2019
Scott Harrell, PE

Sewer Line Materials

SDR 21 or SDR 26 PVC pipe allowed in residential subdivisions on streets rated below collector (ultimately serving less than 100 lots) for pipe diameters of 12 inch and smaller and at a minimum depth range of 4 feet to a maximum depth of 16 feet.

NOTE

The title, *ENGINEER*, used throughout these standards refers to the *PUBLIC WORKS DIRECTOR/ CITY ENGINEER* for the City of Statesville.

SECTION 2.

GENERAL REQUIREMENTS - SEWER

A. REQUIREMENTS:

1. All materials incorporated within the city's infrastructure shall be of domestic origin.
2. The Contractor shall furnish all labor, materials, tools, equipment and all else required for and to construct the sanitary sewer system improvements complete, tested and placed into satisfactory operation, in accordance with the drawings, these Specifications, and the Engineers' requirements under them. The Contractor shall be responsible for furnishing details that are required, but not necessarily shown on the drawings, for the adequate and proper construction and operation of the sanitary sewer extensions as required by the Engineers.
3. Every item mentioned, described, specified and/or referred to in these Specifications, and all items shown, indicated or inferred by the drawings, and such items as may normally be required for the construction of the sanitary sewer extensions or the installation and operation of the equipment shall be furnished and installed complete in every respect; tested in all manners required and/or necessary; and made ready for complete and regular service, as intended. All materials and equipment of whatever nature shall be furnished by the Contractor in place in the project.
4. Insofar as possible, the existing sanitary sewer system must be kept in operation at all times. The Contractor shall so organize and schedule his work as to cause the least inconvenience to the operation of the existing system. Should it become necessary to put any part of the existing sanitary sewer system out of operation, the Contractor, without cost to the City, shall make such temporary connections, alterations, etc., as may be required to keep the existing sanitary sewer system in operation.

D. PROJECT COMPLETION:

1. The Contractor shall perform tests on all parts of the project, which he constructed, and equipment that he furnished and /or installed, under the supervision of the Engineers to demonstrate that the installed sanitary sewers and/or equipment performs in accordance with the requirements of the Specifications.
2. Upon completion of the construction work, the Contractor shall immediately remove all construction equipment, excess materials, tools, etc., from the site and leave same in a neat, orderly condition acceptable to the Engineers.
3. All equipment shall be drained and filled with new lubricants, and then thoroughly cleaned, removing all excess oil, grease, dirt, etc. All valves shall be cleaned and lubricated.
4. The Contractor shall be responsible for restoring all disturbed ground area & damaged crops, & replacing all disturbed property corners to the satisfaction of the Engineers.

5. All woods from clearing and grubbing shall be given to the Owner of the property, from which the right-of-way has been acquired.

END OF SECTION 2.

SECTION 11

CURED-IN-PLACE RESIN PIPE

TECHNICAL SPECIFICATIONS SANITARY SEWER MAIN RECONSTRUCTION

A. DESCRIPTION OF WORK:

The Contractor shall reconstruct sanitary sewer by the installation of a resin-impregnated flexible felt tube inverted into the existing sewer and cured in place. The installation shall be to the size, length, and elevations shown on the drawings or designated by the Engineer. Unless otherwise specified, all materials, equipment and labor necessary shall be furnished by the Contractor. It is the intent of this Specification for the Contractor to provide the City with a complete and operable installation on cured-in-place resin pipe.

B. RESIN PIPE

1. **MATERIALS:** Pipe shall be fiber felt impregnated with thermosetting, unsaturated polyester resin and catalyst system capable of obtaining, upon curing a minimum flexural stress of 4,500 psi and a minimum flexural modulus of elasticity of 250,000 psi, tested in accordance with ASTM D-790. Pipe shall have an impermeable plastic membrane to provide containment of the uncured resin. The Contractor shall provide certification from the resin pipe manufacturer that a sample of the installed liner will meet the specified ASTM requirement.
2. **CORROSION RESISTANCE:** Cured resin pipe shall be chemically resistant to internal exposure to domestic sewage.

The Contractor shall determine the actual length and internal circumference of sewers to be reconstructed from the plans and from actual field inspection to effectively span the distance from manhole to manhole for the extent of the project. Sections of sewer that are to be reconstructed are noted on the construction plans.

The resin pipe shall be fabricated to the thickness as recommended by resin pipe manufacturer subject to the Engineer's approval. When installed the resin pipe shall conform to the internal circumference of the existing sewer. Allowance shall be made for circumferential stretching during installation. A certified copy of the manufacturer's required thickness design criteria shall be submitted to the Engineer for approval.

C. INSTALLATION:

The Contractor shall be responsible for cleaning of the sewers to be reconstructed prior to the start of installation. Pipe shall be cleaned utilizing high-pressure jet cleaning. Cleaning shall be performed in such a manner as to not injure existing pipe. Contractor shall be responsible for damage resulting from cleaning activities. Cleaning shall include the removal of any debris, roots and other items which would interfere with the installation of the resin pipe and which can be removed by cleaning techniques not requiring open excavation. The section(s) of sanitary sewer proposed for reconstruction have been recently cleaned and internally inspected. Upon video taping the section(s), prior to resin pipe insertion, if in the opinion of the Contractor and the Engineer that cleaning of the section(s) are not required, then the City will be compensated at the unit price bid for precleaning the lines.

The Contractor shall videotape the interior of the existing sewer at the completion of cleaning. A copy of this taping and inspection log shall be delivered to the City. The Contractor shall carefully inspect the interior to determine conditions that may prevent proper installation of the resin pipe. Locations of service connections shall be noted at the time of inspection. Line obstructions (point repairs) which would prevent proper installation of the resin pipe as determined by the Engineer and the Contractor and which would require open excavation by the Contractor to repair shall be identified at the time of inspection.

The Contractor shall provide the City access to inspect materials and impregnation procedure.

Care shall be taken to transport materials to the site, free of injurious defects. Any material defects shall be the responsibility of the Contractor and shall be properly replaced.

The inversion standpipe shall be inserted through the existing manholes shown on the project drawings. All temporary scaffolding and supports shall be the responsibility of the Contractor. The uncured resin impregnated pipe shall be inserted through the standpipe and attached, and inverted into the existing sewer utilizing a hydrostatic head sufficient to fully extend it through to the next manhole, to hold the tube tightly against the interior of the existing pipe wall, to produce dimples at service connections and to produce flares at manholes. Lubrication shall be used by the Contractor as necessary.

D. BYPASSING SEWAGE:

The Contractor, when required, shall provide for the flow of sewage around the section or sections of pipe that are to be lined. The bypass shall be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow. The proposed bypassing system shall be approved in advance by the Engineer. The approval of the bypassing system in advance by the Engineer shall in no way relieve the Contractor of his responsibility and/or public liability. Under no circumstances will the dumping of raw sewage on private property, on city streets, or in storm drainage systems be allowed.

E. CURING:

1. **HOT WATER CURING:** After inversion is completed the Contractor shall supply a suitable heat source and water recirculation equipment. The equipment shall be capable of delivering hot water throughout the section by means of pre-strung hose to uniformly raise the water temperature above the temperature required to effect a cure of the resin. This temperature shall be determined as recommended by the resin manufacturer.

The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water supply. Another such gauge shall be placed between the resin pipe and the pipe invert at the remote manhole to determine the temperatures during cure. Care shall be taken during the curing process so as not to overstress the felt fiber.

Initial cure shall be considered complete when inspection of the exposed portions of resin pipe appear to be hard and sound and the remote temperature sensor indicates that the temperature is of magnitude to realize an exotherm. The cure period shall be of a duration recommended by the resin manufacturer as modified for the resin, cured-in-place, pipe process. The recirculation of the water and cycling of the heat exchanger shall be continuous in order to maintain the required temperature throughout the duration of the curing period.

2. **COOL-DOWN:** The Contractor shall cool the hardened resin pipe to a temperature below 100 degrees F. before relieving the static head in the inversion standpipe. Cool-down may be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed resin pipe.
3. **FINISH:** The finished resin pipe shall be continuous over the entire length of each inversion run and be as free as practicable from visual defects such as foreign inclusions, dry spots, pinholes and delamination. During the warranty period any defects that will affect the integrity or strength of the resin pipe shall be repaired at the Contractor's expense, in a manner mutually agreed by the Owner, Contractor and manufacturer.
4. **MANHOLE SPACING:** If installation of the resin pipe fails to make a tight seal at the manhole, the Contractor shall apply a resin mixture compatible with the resin pipe to provide a water tight seal.
5. **SERVICE CONNECTIONS:** Following curing of the resin pipe, the Contractor shall re-establish existing service connections as identified during pretaping and as directed by the Engineer. Service shall be re-established from the interior of the pipeline by means of a television camera and a cutting device. Open excavations shall not be used unless approved by the Engineer.

6. TESTING:

- a. Infiltration: The Contractor shall provide the equipment necessary to check the lines for infiltration or exfiltration as directed by the Engineer, before they are put in service. Infiltration in excess of one hundred (100) gallons per day inch-mile of sewer will result in having the Contractor go over the lines, ascertain where the leakage exists, and repair the lines to the extent necessary to bring the infiltration down within acceptable limits. No test shall exceed 900 feet.
- b. Exfiltrations: The length of sewer subject to an exfiltration test shall be the distance between two adjacent manholes as a minimum, but shall be left to the discretion of the Engineer. No test shall exceed 900 feet. The inlets of the upstream and downstream manholes shall be closed with watertight plugs and the test section filled with water until the elevation of the water in the upstream manhole is two feet above the crown of the pipe in the line being tested, or two feet above the existing ground water in the trench, whichever is higher. A standpipe may be used instead of the upstream manhole for providing the pressure head when approved by the Engineer. Exfiltration shall be measured by determining the amount of water required to maintain the initial water elevation for one hour period from the start of the test. With absorptive pipe, the one-hour period shall begin after allowing the water to stand for not more than one hour to allow for saturation of the pipe. The maximum allowable leakage, including manholes, shall be 100 gallon per inch of diameter per mile of pipe per day.

F. SITE DISRUPTION AND POINT REPAIRS:

In accordance with other applicable Sections and subject to approval by the Engineer, no more than one access excavation per 400 feet of manhole section will be allowed. Subject to this limitation are also any point repairs necessitated by line obstructions that would prevent the installation of the resin pipe.

END OF SECTION 11.

SECTION 13.

MASONRY MATERIALS, METAL FRAMES, RIP RAP, MANHOLE STEPS, ETC.

- A. MATERIALS: All materials used on this project shall be new, unused, and shall be the latest design of a standard product of a company regularly engaged in the manufacture of such items of material and/or equipment which are approved by the Engineers.
- B. MASONRY WORK: All masonry manholes, catch basins, etc., shall be constructed of clay brick, manhole block or concrete manhole brick. The manner in which they are constructed shall be in accordance with the drawings, the Proposal requirements and/or the Engineers' requirements.
- C. BRICK:
1. All subsurface brick used under these gravity-piping specifications shall be sound, hard, tough, common brick of a quality conforming to ASTM Specification C-32, latest revision, Grade MS, for Building Brick. The brick shall be made from clay or shale and shall be dark red in color. Overburned, brittle brick or brick from the benches of kilns shall not be used. Salmon, soft or underburned brick will not be accepted.
 2. The brick shall be of standard size: 2 1/4" thick, 3 3/4" wide and 8" long. Measurements shall not vary more than 1/16" in thickness, 1/8" in width and 1/4" in length.
 3. Brick used in the exposed faces of walls, both interior and exterior, where faces are not to be plastered, painted or otherwise treated, shall be selected for uniformity of size, color and texture. Such brick shall have sharp, unbroken edges, square cut, and shall be free from cracks, blisters and other blemishes on the exposed face.
 4. Before placing his order, the Contractor shall submit, for the Engineers' approval, samples of the brick he proposes to use in the work. The samples shall be representative of the brick that can be furnished and the Contractor will be required to furnish brick conforming to the approved sample.
- D. MANHOLE BLOCK: Manhole block shall consist of solid precast segmental concrete masonry units made from a mixture of Portland cement, water and suitable mineral aggregates, manufactured especially for use in the construction of catch basins and manholes. The block shall conform to the requirements of ASTM Specification C-139,

latest revision, and shall be shaped to conform to the structure within which it is to be incorporated as shown on the drawings. Before placing his order, the Contractor shall submit, for the Engineers' approval, samples of the manhole block he proposes to use in the work. The samples shall be representative of the manhole block that can be furnished and the Contractor shall be required to furnish manhole block conforming to the approved sample.

- E. CONCRETE MANHOLE BRICK: The Contractor shall submit drawings, specifications and samples of the concrete brick he proposes to use in this project to the Engineers for written approval prior to use.
- F. MORTAR FOR BRICK AND/OR MASONRY WORK:
1. Unless otherwise specified, all mortar used in brick and/or masonry work under these gravity-piping specifications shall conform to the requirements of the Standard Specifications for Mortar for Unit Masonry, C270-71. Only sufficient water to give proper density and workability shall be used.
 2. When specifically approved by the Engineers for brickwork, other than for the construction of manholes and other underground items, the Contractor may use a prepared mortar such as "Brixment." The prepared mortar shall contain a waterproofing ingredient; it shall require no soaking or slacking; it will prevent efflorescence on wall surfaces; it shall bond tightly with the brick or other masonry material; it shall have a strength equal to that of the cement sand mortar specified above; it shall stick to and not shrink away from the surface of adjacent materials with which it is used; and it shall require no further preparation for use other than mixing sand and water in accordance with the manufacturer's direction.
- G. CAST IRON MANHOLE FRAMES AND COVERS: Manhole frames and covers shall be as shown on the drawings or they shall be the City's standard, 24" diameter opening. The frames and covers shall be constructed of tough, gray cast iron and must meet the requirements of ASTM Specification A48-41, Class Twenty (20). The covers shall be machined, lie flat on the frame seat, and shall not rattle under the impact of traffic. Frames and covers shall be thoroughly cleaned and then hot-dipped in asphaltum or coal-tar varnish. Frame and cover shall weigh not less than 300 lbs. Manhole covers for sanitary sewers shall indicate "Sanitary Sewer" on the cover. Sealed manhole covers shall be furnished with four (4) brass flat head machine screws at 90° and a single polyvinyl gasket between cover and frame seat.
- H. DUCTILE IRON MANHOLE FRAMES AND COVERS: When indicated on the drawings or when approved by the City, Class 400, Designation GTS ductile iron manhole frames and covers shall be installed. Ductile iron shall comply with the requirements of ASTM A536-80. Castings shall meet the ASSHTO H-20 loading requirement and the proof load requirements of Federal Specification RR-F-621-C. Covers shall be kept from rattling under traffic impact by the use of a polyethylene gasket. Locking lid type covers are not permitted. Covers used for wastewater collection sewers shall indicate "Sanitary Sewer" on the cover.

- I. **STORM INLETS:** Furnish and install all catch basins and area inlets as shown on the drawings. They shall be of cast iron throughout. The catch basin covers, unless indicated otherwise on the drawings shall be pattern Dewey Bros. #CB-BC-73, Neenah R-3080 or equal with end frames. The area inlets shall be 24" x 24", pattern Dewey Bros. #CH-BN-3A, Neenah R-3350, or equal; drop inlets shall be pattern Dewey Bros. #MH-RCR-20, Neenah R-2650, or equal; and cast-in-place trench drain covers shall be pattern Dewey Bros. #TR-WY-10, Neenah #R-4991-D, or equal, as manufactured by Dewey Bros., Inc., Neenah Foundry Company or equal.
- J. **RUBBLE RIP RAP:**
1. Rubble rip rap shall be placed at the locations shown on the drawings and where directed by the Engineers to stabilize slopes and drainage ditches. The rubble rip rap shall be installed according to the current standards and requirements of the North Carolina Department of Transportation, Division of Highways.
 2. Rubble stone shall be sound, dense and durable, free from cracks, pyrite intrusions and other structural defects. Stone that will be used with mortar shall be free from dirt, oil or other material that might prevent good adhesion with the mortar. At least 90% of the stone shall be not less than 8" wide by 12" long by 12" deep and shall be approximately rectangular in shape.
- K. **MANHOLE STEPS:** The manhole steps shall be of coated, corrosion resistant cast iron, galvanized wrought iron, aluminum alloy conforming to Federal Specifications QQ-A-200/8 polypropylene plastic coated 3/8" steel reinforcing rods, or other approved material. Step irons shall be generally located at 90 degrees from the direction of flow on the manhole vertical wall. The steps shall be set in the wall a maximum of 12" or more on centers vertically as required by OSHA standards. All steps shall have a minimum vertical load resistance of 750 pounds with no permanent deflection and pullout resistance of 1,000 pounds. Steps shall be imbedded in the wall a minimum of 3" and project from the wall a minimum of 7" and shall be a minimum of 10" in width with lateral foot stops.

END OF SECTION 13.

SECTION 15.

DUCTILE IRON PIPE

A. DUCTILE CAST IRON PIPE:

1. Ductile cast iron pipe shall be Grade 60-42-10 centrifugally cast in accordance with ANSI Standard A21 Sectional Committee approved Specification A21.51 for 200 psi operating pressures plus surge allowance of 100 psi. Wall thickness and strength shall conform to ANSI Standard A21.50 for cover as shown on the drawings, for laying condition Type 3. Each pipe shall be hydrostatically tested, before shipment, to a minimum of 500 psi. Factory tests and basis for acceptance shall be as specified in ANSI Standard A21.51. However, when the total quantity of ductile iron pipe of all sizes exceeds 500 tons, tests shall be performed and certified by an independent laboratory, approved by the Engineers, per ANSI Standard A21.51. Unless otherwise specified, thickness class shall conform to ANSI A21.50-76.
2. Pipe for direct burial shall be cement lined inside, and coal tar coated outside, per ANSI Standard Specifications A21.4 and A21.51. The exterior surface of unburied pipe shall receive one shop applied coating of red lead primer and two coats of approved paint.
3. Standard mechanical joint and push-on joint fittings shall be rated for an operating pressure of not less than 150 psi, manufactured of gray cast iron, or ductile cast iron 80-60-03 per ASTM A339-55 as required for pressure rating. The openings from 4" to 12" may be provided with tapping saddle. Branch connection with maximum of 12" outlet on 24" and larger; 10" on 20"; 8" on 16" and 18"; 6" on 12" and 14" pipe. Joint detail and rubber gaskets shall conform to ANSI Standard Specification A21.11. Fittings shall be of the push-on joint type unless otherwise shown on the drawings, specified herein or approved by the Engineers. Flanged fittings shall be Class 125, ANSI Standard A21.11
4. When specifically called out on the drawings or in the Proposal, the Contractor shall use Class 350 ductile iron fittings, mechanical joint. Mechanical joint shall conform to ANSI/AWWA A21.11/C111. Wall and socket thicknesses shall be equal to Class 54 ductile iron pipe as specified in ANSI/AWWA A21.51/C151. Ductile iron shall be in accordance with ASTM A563 with minimum physical qualities of 70,000-psi tensile strength, 50,000-psi yield strength, and 5% elongation.

- D. LINED PIPE: Where lined pipe is shown on the drawings, the pipe shall be either saran lined or glass lined as specified herein. Glass lined pipe shall consist of cast and ductile iron pipe and fittings with a glassed coating fused to the inside metal base by placing the entire pipe or fitting into a furnace at the appropriate maturing temperature above 1,400°F. Pipe and fittings shall be held at this temperature for a period of time sufficient to develop a smooth vitreous lining. The glass shall be especially formulated with bond promoting constituents so that the high temperature will develop a strong bond between the glass and metal. This bond shall be sufficient to permit a strain in the metal of 0.001"/inch (the yield point of carbon steel) without damage to the glass. The glass coating shall average at least 0.008" and not more than 0.014" in thickness and shall have a hardness of approximately 400 on the Knopp scale or 5.5 on the Mohs scale. It shall be resistant to corrosion between pH₃ and pH₁₀ at 125°F. It shall withstand an instantaneous thermal shock of 300°F. differential. Lining shall not contain pinholes, crazing, or fishscales or any other defect that exposes the pipe metal. All material must have 401 Protecto lining on it.

END OF SECTION 15.

SECTION 16.

LINES AND GRADES

A. GENERAL REQUIREMENTS:

1. All gravity piping shall be constructed of pipe of such kinds and sizes and laid to such lines and grades as shown on the drawings and profiles and/or as directed by the Engineers. The Engineers will establish only those principal benchmarks and control points as may be required in the construction of the gravity piping. The Contractor shall provide all other lines, levels and grades required for the construction of the project. This work shall only be performed by skilled personnel who are familiar with this type of work. When deemed necessary by the Engineers, this work will be supervised and/or checked by the Engineers. The lines and grades of the gravity piping will generally be indicated by stakes parallel to the line of the piping and set at such elevations that proper batterboards or grade boards can be set. From these shall be stretched grade cords and the pipe shall be carefully set to conform to the grades indicated. The Contractor shall set all grades or batterboards from cut sheets that have been approved by the Engineers. Alternate electronic or laser beam based methods of setting lines and grades will be allowed if methods and equipment have been approved by the Engineers. When an inspector is present on the work, he shall check the position of all grades and lines, but the Contractor shall be responsible for the lines and grades of the finished piping work.
2. The Engineers will provide principal benchmarks and control points for the construction of the gravity piping one time only. The Contractor shall protect and preserve these benchmarks and control points. If the benchmarks and control points are torn out, disturbed or otherwise rendered nonusable by the Contractor's action or negligence, the Contractor shall be responsible for replacing the benchmarks and control points to the satisfaction of the Engineers without additional cost to the City. For purposes of laying piping work within the limits of a plant site, the Engineers shall provide only vertical and horizontal control benchmarks. All lines and grades within a plant site shall be the responsibility of the Contractor.

END OF SECTION 16.

SECTION 17.

EXCAVATION

A. GENERAL REQUIREMENTS:

1. All excavation under this Section shall be "Unclassified" and shall include all materials of whatever nature encountered. In general, the detail specifications set forth in Sections 17 through 22 shall apply to all types of exterior gravity piping including sanitary sewers, storm sewers and plant process piping.
2. Unless noncushioning material is encountered in trench excavation, a cushion of the type specified below and at least 8" thick shall be placed between the bottom of the pipe and the subgrade.
3. When rock or noncushioning material is encountered in trench excavation, a cushion at least 8" thick shall be placed between the rock and the bottom of the pipe. An additional 1" depth of cushioning material will be required for each additional 2' of trench depths in excess of 16' up to a maximum of 12" of cushioning material. The cushioning material shall consist of clean #57 crushed stone for pipe sizes of 27" and larger and #57 clean stone or clean, coarse sand for pipe sizes 18" to 24" and #57 clean stone or clean, coarse sand for pipe sizes 8" to 15" or other equivalent material approved by the Engineers. Rock that may be excavated from the trench shall be kept in separate storage piles away from the storage of suitable backfill material.
4. The bed for the pipe will be shaped that at least the lower quarter of the pipe shall be in continuous contact with the bottom of the trench. Bell holes shall be excavated accurately so that the barrel of the pipe supports the entire load of the pipe. In lieu of bed shaping, the Contractor, at his own expense, may provide cushioning materials in excess of that specified in Paragraphs 2 or 3, above, to attain the specified depth of contact between the pipe & cushioning material.
5. Where approved cushioning material is encountered in the trench, the excavation shall not be carried below the depth required for laying the pipe, including necessary trench excavation for cushioning material, to the grades approved by the Engineers. When the excavation is carried below the required depth, the trench shall be backfilled at the Contractor's expense, with suitable material approved by the Engineers and compacted to the density of the surrounding earth material.
6. When directed, unstable soil shall be removed for the full width of the trench and replaced with clean #57 crushed stone or other approved material. The Engineers shall determine the depth of removal of the unstable soil and the amount of backfill required. The backfill shall be thoroughly compacted and shaped to form the bed for the pipe.

7. The depth of cut shown on the drawings is from the surface grade to the invert of the pipeline. No extra compensation will be allowed for extra trench depth excavation as specified in this Section for cushioning material, the cost of which shall be included in the unit price bid for pipe as stated in the Proposal and as shown on the drawings. The alignment and grade of the pipeline may be adjusted wherever, in the opinion of the Engineers, it is necessary.

8. The minimum width of the trench at the top of the pipe when placed shall be a width which will permit the proper construction of joints and compaction of backfill around the pipe, but shall be at least equal to the largest outside diameter of the pipe plus 8" on each side of the pipe. The sides of the trenches shall be vertical unless otherwise approved by the Engineers. In no case shall vertical walls project less than 2' above the top of the pipe line laid to a grade unless the finished grade fill depth is less than 2'. The maximum allowable width of trench on each side of the pipe shall not exceed 12" for pipe 12" in diameter and smaller; 18" for pipe diameters between 14" and 36" in diameter; and 24" for pipe diameters greater than 36", unless otherwise approved by the Engineer.

END OF SECTION 17.

SECTION 18.

SUBGRADE; SPECIAL FOUNDATIONS; WATER IN TRENCHES; SHEETING AND BRACING TRENCHES; PIPE LAYING

A. SUBGRADE:

1. Care must be taken to secure a firm bearing support uniformly throughout the lengths of the pipe. A space shall be excavated under and around each bell to sufficient depth to relieve it of any load and to allow ample space for finishing the joint. The pipe when thus bedded firmly shall be on the exact grade of the completed sewer. In case the bed trimmed in the bottom of the bottom of the trench is too low, the pipe shall be completely removed from position and earth or other approved refill material shall be thrown over the bottom and thoroughly tamped into place to prepare a new foundation for the pipe. In no case shall the pipe be brought to grade by blocking up under the bell or barrel of the pipe, but a new and uniform support must be given for the full length of the pipe.
2. After the excavation is opened and to grade, it will be examined by the Engineers who will determine whether or not it is a satisfactory foundation for masonry or pipes, or if it is necessary to stabilize the subgrade, install concrete cradle or encasement. Any masonry or pipe installed in an excavation that has not been examined by the Engineers is so installed at the Contractor's own risk. Where deemed necessary by the Engineers, a soil load test shall be made to determine if the ground and the prepared foundation is firm enough to support the masonry, pipe and all superimposed loads.
3. When so designated in the drawings or ordered by the Engineers, unstable soil shall be removed for the full width of the trench, and the excavated area shall be strengthened for foundation purposes by furnishing and placing approved crushed rock or gravel refill, concrete cradle, concrete encasement, or a combination of these materials.
4. Pipe bedding must be 8 inches of #67 stone.
5. Concrete cradle or encasement shall be placed to the details shown on the drawings or as ordered by the Engineers.

B. SPECIAL FOUNDATIONS:

1. Whenever the bottom of the trench shall be of such nature as to provide an unsatisfactory foundation for the sewer or other structures, the Engineers may require the sewer to be laid on timber foundations, whether of single-plank cradle or cradle supported on piles. These foundations shall be placed as directed by the Engineers. All timber and planking for foundation shall be of good quality sawed cypress or creosoted pine lumber, sound, free from shakes, large, loose, or decayed knots and other imperfections affecting its strength and durability.
2. At creek or ditch crossings, whenever the sewer is elevated, and at such other locations as may be designated by the Engineers, the Contractor shall construct reinforced concrete piers to support the sewer lines. The pier foundation shall rest on undisturbed earth, and when located adjacent to a creek or drainage ditch the foundation bottom shall be a minimum of 3' below the channel bottom. Whenever the pier is located in the creek or drainage ditch channel it shall be supported and doweled into bed rock, or rest upon piles driven to a depth of at least 15', or as required by the Engineers to provide a sound and adequate bearing. Piles may be steel tipped creosoted timber with a minimum 8" butts.

C. WATER IN TRENCHES: Whenever ground water is encountered, the Contractor will be required to install such equipment and carry on the construction in such manner as to provide the best possible laying conditions. He shall remove all water that may accumulate or be found in the trenches or other excavations made under contract by pumping or bailing, and no pipe shall be laid until such water has been removed from the trench. The Contractor will not be permitted to drain water through the sewer within a period of 24 hours after the pipe is laid, and the open end of pipe in the trench shall be kept closed with a tight fitting plug to prevent washing of dirt or debris into the sewer line. Water so removed from the trench must be disposed of in such manner as not to cause injury to the public health nor to public or private property, nor to work completed or in progress, nor to the surface of the streets nor cause any interference with the use of the streets by the public.

D. SHEETING AND BRACING TRENCHES:

1. The Contractor will be required to keep the side of the excavation vertical, by sheeting or bracing; and to prevent movement, by slides or settling of the sides of the trench, which might injure or displace the sewer appurtenances thereof, or diminish the working space required on the sides of the pipe.
2. The Contractor shall leave in place along the trench such sheeting and bracing as the Engineers may direct. For the purpose of preventing injury to persons, corporation or property, whether public or private, the Contractor at his option may also leave in place, to be covered and embedded by the backfilling of the trench, any and all bracing, in addition to that directed by the Engineers to be left in place, provided that no sheeting or bracing shall extend closer than 2' to the finished ground or street surface; and provided, further, that no timbers shall be left in the trench so as to form pockets or cavities which cannot easily be filled during the filling and settling of the trench.

3. It is understood that the City is under no obligation to pay for sheeting left in place by the Contractor unless specific directions have been given to the Contractor by the Engineers. Failure to sheet and brace trenches or other excavations shall be at the Contractor's risk and he will be responsible for the caving thereof and all damages resulting therefrom. If the Engineers are of the opinion that at any point, sufficient or proper supports have not been provided, they may order additional supports put in at the expense of the Contractor, but compliance with such orders shall not release the Contractor from responsibility for the sufficiency of such supports.

E. PIPE LAYING:

1. No pipe shall be laid except in the presence of the Engineers or their inspector without special permission from the Engineers. The Contractor shall be expected to cooperate fully with the Engineers in regard to time and duration of pipe laying. Except in cases of emergency, where the ground is treacherous or in situations where suspension of the work would cause extra delay or damage to the sewer line, work requiring the presence of the Engineers or inspector shall be confined to the usual working hours of the day. In case noted above, work may be extended for longer periods or made continuous, provided the permission of the Engineers is first secured.
2. All pipe, previous to being lowered into the trench, shall be carefully inspected to see that each is clean, sound and free from defects. If necessary, it shall be fitted together in order to insure sufficient opening for the gasket or jointing material, and to secure a smooth inside flow line. Pipe shall be removed at any time, if broken, injured or displaced in process of laying pipe or backfilling trench.
3. Bell and spigot or tongue and groove ends of the pipe shall first be wiped clean and shall have a lubricating compound acceptable to the pipe manufacturer applied to the groove or bell before actual jointing operations are started.
4. Joints between consecutive bell and spigot or tongue and groove pipe shall be made with a rubber gasket of a type recommended by the manufacturer and must comply with ASTM Specifications C-443 for ASTM C-14 and C-76 pipe or ASTM C-361 for C-361 pipe, and shall be constructed as follows:

The gasket shall be fitted over the tongue or spigot of each pipe, and the pipe entered into the bell or groove and shoved home. The finished joint on tongue and groove type pipe shall not be greater than 1/2" in width.
5. All pipe shall be completely shoved home. On pipe of the tongue and groove type, pressure must be applied to the center of each pipe as it is laid by a winch and cable or other mechanical means properly set and operated to insure that the tongue is all the way in the groove, and that the sewer joint is of uniform size throughout the circumference of the pipe.

F. METAL PIPE:

1. Corrugated metal pipe arch culverts shall be installed in conformance to the current standards and practices of the North Carolina Department of Transportation, Division of Highways.
2. All areas of corrugated metal culverts in which the bituminous coating or spelter has been damaged shall be painted with two coats of hot asphaltic paint or otherwise repaired in a satisfactory manner.

G. PIPELINE SEPARATION: Wherever pipelines designated to carry sanitary sewage cross, or are laid less than 10' horizontally from existing or proposed potable water lines, special precautions shall be taken as follows:

1. Should conditions prevail which prevent a lateral separation of 10', the pipeline may be laid closer than 10' to a potable water line, provided the sewer is laid in a separate trench and at such an elevation that the top of the sewer is at least 18" below the bottom of the potable water line. This minimum vertical separation shall be maintained for that portion of the pipeline located within 10', horizontally, of any sewer or drain crossed, said 10' to be measured normal to the pipeline centerline to the potable water lines.
2. If it is impossible to obtain a horizontal separation of at least 10', a vertical separation of at least 18", as stipulated above, the Contractor shall suspend construction in the area in question and shall notify the Engineers. In this case the Engineers, as a minimum, may require the sewer to be constructed or reconstructed of mechanical joint, cast iron pipe, or concrete pressure pipes specified herein, and be pressure tested to assure watertightness.
3. When making crossings with less than 18" vertical separation, a full length of pipeline pipe (minimum of 16' joint) shall be centered under the water main to be crossed so that joints will be equidistant from the water main and as remote therefrom as possible.

END OF SECTION 18.

SECTION 19.

BACKFILLING

A. GENERAL REQUIREMENTS:

1. Unless otherwise directed, all trenches and excavations shall be backfilled as soon as the cementing material in the structures placed therein has acquired a suitable degree of hardness, the work shall be prosecuted expeditiously after it has been commenced.
2. The following applies in all cases where the gravity pipe is laid under streets and roadways, in municipal or urban areas or in other places where compacting of the trench throughout its depth is required. For the depth of at least 3' over the top of the pipe, the material used for backfilling trenches shall be clean earth, sand or rock dust. The space between the pipe and the bottom and sides of the trench shall be packed full by hand and thoroughly tamped with a shovel or light tamper, as fast as placed up to the level of the top of the pipe. The filling shall be carried up evenly on both sides. The pipe shall then be covered by hand to a depth of at least 18" above its top, and at least one man engaged in tamping shall be provided for each man shoveling fill in the trench. The material shall be deposited carefully in the trench to avoid injuring the pipe and to the elevation stated above, it shall be placed in layers that shall not exceed 6" in compacted thickness and each layer shall be carefully and solidly tamped with appropriate tools in such a manner as to avoid injuring or disturbing the completed sewer. The level of compaction throughout the trench shall be not less than 95% maximum density as determined by AASHO T-180.
3. Locating wire and location tape both must be used on sewer pipe. Locating tape must be located 2ft above the pipe. Locating wire must be located on the pipe. Location wire can be placed a maximum distance of 500 ft between access points in a traffic rated valve box.
4. In other areas, the trench shall be backfilled for a depth of 18" above the crown of the gravity pipe with approved material free from organic matter, no layer to be more than 1' thick and each layer to be thoroughly tamped with tampers weighing not less than 20 pounds, before another layer is deposited. Air tampering tools may be used in place of hand tamps. Surplus material shall be removed but the Contractor will be held responsible for replacing such material where required due to subsequent settlement. The level of compaction of the backfill, to a height of 18" above the top of the pipe, shall not be less than 90% as determined by AASHO T-99. Where the trench is located in outlying districts, such as across farm lands and fields, etc., no tamping shall be required above an elevation 18" higher than the crown of the gravity pipe and surplus material shall be neatly mounded over the center line of the trench. It shall be optional with the Engineers as to whether a backfilling machine shall be allowed to backfill gravity pipe trenches.

5. All pipe shall be held in place by cable and winch or other suitable method satisfactory to the Engineers during backfilling operations so that there will be no movement in the pipe joints. Excavations for manholes shall be backfilled as soon as they have developed sufficient strength of resist backfilling loads and forces.
 6. Corrugated metal pipe arch culverts and corrugated metal multiple culverts shall be backfilled in conformance to the current standards and practice of the North Carolina Department of Transportation, Division of Highways.
 7. No rock greater than 6" in any dimension shall be used in backfilling the trenches. In depositing fill material in the trench, care must be taken that it does not injure the structure. No rock shall be placed in the first 3' of backfill above the pipe laid to grade. No rock shall be in final 2' of backfill below finish grade.
 8. When sheeting is drawn, all cavities remaining in or adjoining the trench shall be solidly filled. When sheeting is left in place, all cavities behind such sheeting shall be solidly filled.
 9. Backfilling within 2' of manholes, catch basins, flush tanks and other special structures shall be of selected material free from organic matter and rocks. It shall be uniformly deposited on all sides and unless otherwise permitted, solidly tamped in such a manner as to avoid injuring the structures or producing unequal pressures on them.
- B. COMPACTION TESTING: The Engineers reserve the right to determine the quality of compaction as performed by the Contractor. If, in the opinion of the Engineers, the compaction does not meet these Specifications, the Engineers may require, at the Engineers' option, up to 10 random compaction tests to be completed by an independent testing laboratory as selected by the Engineers. If any of these tests indicate that the material has not been compacted to the required density, the Contractor shall recompact said material. The Engineers shall then have the right to require additional compaction tests to insure that this or other material is compacted to the proper density.

END OF SECTION 19.

SECTION 20.

PAVEMENTS

- A. GENERAL REQUIREMENTS: Where it is necessary to remove existing pavements, prepared road surfaces, driveways, sidewalks or curbing, these surface structures must be replaced by the Contractor to the complete satisfaction of the Engineers. Such repairing shall be done under the original specifications under which the same was done, and shall be subject to the approval of the Engineers. When gravity sewers are built in or across streets, alleys, driveways or highways that have been macadamized or graveled, the Contractor must save the gravel or stone and refill the top of the trench with such materials to bring the streets, alleys, driveways or highways to their original grade. Roadway base material, where required, is to be replaced with ABC aggregate to the depth of the existing base or to a minimum of 8", whichever is greater. Any Portland cement concrete pavement to be removed must be cut by sawing, not breaking.

END OF SECTION 20.

SECTION 21.

PRECAST CONCRETE MANHOLES

A. GENERAL REQUIREMENTS:

1. Precast concrete manholes with O-ring joints shall be used and each reducer section of the manhole shall be of the eccentric section type (including the manhole cover section) thereby producing a continuous vertical wall inside the manhole on which to place the manhole steps.
2. The Contractor shall submit drawings and specifications of precast concrete manhole sections he proposes to use to the Engineers for approval. Only the eccentric cone type precast sections which are designed for H-20 loadings and conform to ASTM Specifications C-478, latest revision, with approved rubber gasket joints conforming to ASTM Specification C-443 or C-361 or mastic joints conforming to ASTM Specification D4 (mod.) and D6 will be considered. Wall thickness shall be a minimum of 1/12 of the greatest internal diameter of each section. However, no wall thickness shall be less than 5".
3. On large diameter manholes the internal diameter may be reduced to a 4' diameter riser section at a minimum height of 24" above the top of the highest pipe crown or as provided below, whichever is greater. Either an approved reinforced concrete slab or precast reducer section will be acceptable. The reinforced concrete slab shall have the following minimum design:
 - a. 1' 0" thick minimum (3,000 psi) plus the depth of the riser groove;
 - b. Reinforced at the top with No. 4 bars at 12" o.c. EW;
 - c. Reinforced at the bottom with No. 5 bars at 6" o.c. EW for manhole depths from 22' to 32', and No. 7 bars at 6" o.c. EW for manhole depths greater than 32'; and,
 - d. Bottom half of this slab shall have the equivalent of 6 extra No. 6 bars as beam reinforcement around opening for the 4' riser section.
4. Where precast reducer sections are used, riser sections may not be reduced more than 2' in one stage unless otherwise approved by the Engineers or restricted by shallow trench depths. In the case where total base to 4' riser section reductions greater than 2' are desired or necessary, a minimum of 36" of vertical riser section shall be used between successive reducers, unless otherwise approved. Four-foot base diameters shall not be reduced further except for placement of ring and cover. Both the tongue and groove of joints shall have reinforcing steel equal in area to that of the wall sections.

5. Except where restricted by shallow cuts or otherwise shown on the drawings, minimum heights for base sections (excluding poured base thickness) shall be as follows: 46" for 4' diameter; 48" for 5' diameter; 64" for 6' diameter; 80" for 7' diameter; and 92" for 8' diameter. The base section shall not have a monolithic precast base slab. The precast base riser section shall be placed in a reinforced concrete (3,000 psi) slab to a depth equal to the length of the groove of the riser section. The slab shall have a diameter or side of at least 1" greater than the manhole base section outside diameter. The slab shall be a minimum of 1' 0" thick plus the depth of the riser groove and shall be reinforced top and bottom with a minimum of No. 4 bars at 12" o.c. EWEF for 4', 5' and 6' diameter sections and a minimum of No. 5 bars at 12" o.c. EWEF for 7', 8' and 9' sections.
6. The precast manholes shall have cast in place nonskid manhole steps of coated, corrosion resistant cast iron, galvanized wrought iron, aluminum alloy conforming to Federal Specifications QQ-A-200/8 polypropylene plastic coated 3/8" steel reinforcing rods, or other approved material. Step irons shall be generally located at 90 degrees from the direction of flow on the vertical wall. The steps shall be set in the wall a maximum of 12" and/or 16" maximum on centers vertically as required by OSHA Standards. All steps shall have a minimum vertical load resistance of 750 pounds with no permanent deflection and pullout resistance of 1,000 pounds. Steps shall be imbedded in the wall a minimum of 3" and project from the wall a minimum of 7" and shall be a minimum of 10" in width with lateral foot stops.
7. The bottom of the manholes shall be concrete, shaped to form a continuation of the invert or lower half of the entering sewers. Junction manholes shall be constructed as shown on the drawings and shall be so shaped and finished as to offer minimum resistance to the flow of sewage and avoid deposits of grit, or solid matters in the sewage. The slope of the sewer through the manhole shall be such as to void retardation of velocity. Where sewers enter and leave the manhole in a straight line, the invert of the manhole may be constructed of half-pipe with edges plastered to the bottom. For this purpose the Contractor may use suitable portions of rejected pipe.
8. Where vent pipes are called for on the drawings or in the Proposal, they shall be furnished and installed with 3/8-inch mesh galvanized screen to cover outside opening.

9. Mastic joint material shall be furnished in accordance with the following table:

Manhole Diameter (Feet)	Inches of Sealant	Sealant Size (In.)
4	170	1.25
5	208	1.25
6	252	1.50
7	290	2.00
8	334	2.00
9	372	2.00
10	410	2.00

Mastic joint material shall not be stretched to fit manhole. Mastic joint material shall be Conseal, Ram-Neck, Kent-Seal No. 2, or equal.

10. In lieu of concrete collars at pipe entrances to manholes, boots specifically made for connecting pipes to manholes may be used. Boots shall be Kor-N-Seal as manufactured by National Pollution Control Systems, Inc., Positive Seal Gasketing System (PSX) as manufactured by Press Seal Corp., or equal. A-lok connectors may be used with vitrified clay pipe, reinforced concrete pipe, and ductile iron pipe.
11. When specifically indicated, precast bottoms may be used in lieu of poured-in-place bottoms. Inverts shall be formed in the field, grouted to 0.8 times the pipe diameter and as required in item number 7. above. Prior to installation of precast bottom manholes, excavated manhole trench bottoms shall be filled with 6" minimum compacted coarse ABC stone. Manholes shall be set onto the stone base and properly backfilled to prevent tilting. If in the opinion of the Engineers, the manhole has excessive tilt, it shall be removed and reset at the Contractor's expense.

END OF SECTION 21.

SECTION 22.

INSPECTION; TESTS; RESPONSIBILITY; FINAL INSPECTION; CLEANING UP

- A. INSPECTION: Gravity mains will be checked by the Engineers to determine whether any displacement, cracking, deflections or any other damage to the pipe has occurred: (a) after the trench has been filled to 2' above the pipe and tamped as specified; and (b) upon completion of the project. The test will be physical inspection of each joint for pipe of 48" diameter and larger or, for pipes smaller than 48" diameter, by light flashed between manholes, or, if the manholes have not as yet been constructed, between the locations of the manholes by means of a flashlight or by reflecting sunlight with a mirror. If the interior or exterior of the pipe shows any misaligned pipe, displaced pipe, concrete pipe with cracks greater than 0.01", deflections greater than 5% for steel and plastic sewer pipe, or any other defects, the defects designated by the Engineers shall be remedied by the Contractor at his expense.
- B. TESTS: It is the intent of these Specifications to secure pipelines with a minimum amount of leakage. Unless otherwise approved by the Engineers, all cast iron, ductile iron and reinforced concrete pressure pipe (ASTM C-361) shall be hydrostatic pressure tested. All other gravity pipelines shall be tested for infiltration and/or for exfiltration.
- C. HYDROSTATIC PRESSURE TESTS:
1. When a stretch of pipe and appurtenances has been completed, and before the pipe or joints are covered, the Contractor shall furnish proper appliances and facilities for testing and draining the same, without injury to the work or surrounding territory. He shall test by filling the pipe with clean water under the design hydrostatic pressure designated in these Specifications. However, yard and/or process piping not subjected to hydrostatic pressure in excess of 40' by pumping or otherwise shall be hydrostatic pressure tested with water so that not less than a 15' head of water exists above the highest point of the pipeline. In no case shall there be any visible leakage, nor shall any leakage in any stretch of pipe exceed 10 gallons per 24-hour day per inch diameter per mile, as measured over a period of 2 hours in a manner satisfactory to the Engineers. Water for making tests shall be furnished by the Contractor at his expense.
 2. Any defects, cracks or leakage that may develop, or that may be discovered either in the joints or in the body of the pipe, shall be promptly made good by the Contractor, at his own expense, and to the satisfaction of the Engineers.
 3. Upon written permission of the Engineers, systems composed entirely of mechanical joints may be backfilled prior to testing, it being understood that the Contractor assumes the risk of re-excavating to the pipe in the event the system fails to meet the requirements of the pressure test.

D. INFILTRATION TEST:

1. Where ground water is encountered during construction all pipe joints for the sewer line shall be of such quality that there will be no perceptible infiltration of ground water into the sewer from any single pipe joint. The Contractor shall furnish labor, equipment and materials, including pumps, and shall assist the Engineers in making infiltration tests of the completed sewer section before it can be placed in service or connected to any other lines. The Contractor will furnish and install the measuring weirs or other approved measuring devices at locations designated by the Engineers. The length of line to be tested at any shall be subject to the approval of the Engineers. The total infiltration shall in no case exceed 40 gallons per inch of diameter, per 1,000' of pipe, per 24 hours for pipe greater than 12" diameter and not more than 30 gallons per inch diameter, per 1,000' of pipe per 24 hours for pipe diameter of 12" or less. This infiltration rate applies only to the sewer line, manholes or other structures associated with the sewer line shall not have any perceptible infiltration tributary to the sewer.
2. The test period shall be 24 hours, and if the quantity of infiltration is in excess of the maximum allowable, the leaking joints shall be re-laid if necessary or other remedial construction shall be performed by, and at the expense of the Contractor. The section of sewer shall then be retested after repairs are completed to determine compliance with the Specifications.
3. All tests shall be made in the presence of the Contractor and the Engineers.
4. Materials and construction methods called for in these Specifications are of such nature as to insure maximum protection of the sewer from infiltration. The Contractor shall be responsible for the sewer performing to the above limits for a period of one year from date of final acceptance.

E. EXFILTRATION TEST:

1. Exfiltration tests will be performed on such numbers of pipe sections and/or joints as is deemed necessary by the Engineers to insure compliance with the stated exfiltration allowances. The Contractor shall furnish all labor, materials, equipment and all else required to perform and shall assist the Engineers in performing all exfiltration tests.
2. In areas where ground water is not encountered during sewer construction, the Contractor shall furnish and install all necessary materials, equipment, supply water, etc., and shall assist the Engineers in making exfiltration test of the completed sewer section as hereinafter described before the sewer is accepted. The maximum allowable exfiltration shall be 40 gallons per inch of diameter per 1,000' of pipe per 24 hour day for pipe greater than 12" in diameter and not more than 30 gallons per inch diameter per 1,000' of pipe per 24 hours for pipe diameters of 12" or less. At the option of the Contractor, either Method A or Method B may be used to check the amount of exfiltration.

Method A: To check the amount of exfiltration by this method, the ends of each section of sewer between manholes shall be plugged with watertight bulkheads. Inserted in each bulkhead at the top of the sewer pipe shall be a 2" pipe with an elbow extending 4' vertically in the upper manhole and to the same elevation in the lower manhole. Air in the sewer pipe shall be exhausted by filling the 2" upper manhole pipe to a height of 4' of water. Using measured containers, the water shall be poured into the upper 2" pipe as needed to maintain a constant head of 4' in the upper pipe and a constant level in the lower pipe for a period of 30 minutes, not allowing the lower pipe to overflow. The volume of water added during the 30-minute period shall not exceed the allowable stated above.

Method B: To check the amount of exfiltration by this method, each individual joint shall be subjected to a water exfiltration test by means of a test apparatus especially designed for this purpose. The joint shall be isolated with an expandable steel rim equipped with rubber gaskets which fit tightly against the pipe walls on each side of the joint being tested. Through appropriate piping, water pressurized between 6 psi and 8 psi is introduced into the annular space isolated by the rim and rubber gaskets. The maximum allowable exfiltration per joint shall not exceed the allowable stated above per 1,000' of pipe per 24-hour day at anytime divided by the number of pipe joints per 1,000'.

F. RESPONSIBILITY:

1. Sewers must be built so as to remain true to line and grade. The inclining grade of the bottom of the sewer after completion shall be such that after flooding the flood water will drain off so that no remaining puddle of water will be deeper than 1/2" on pipe 36" internal diameter or smaller and 3/4" on pipe larger than 36" internal diameter. Any section of pipe that does not comply with these Specifications at any time previous to final acceptance of the work shall be replaced or re-laid at the Contractor's expense.
2. All pipe laid shall be subject to inspection for compliance with the requirements of the specifications at any time during construction and during the guarantee period. Any section of pipe that does not fully comply with these requirements shall be repaired or replaced at the Contractor's expense, as directed by the Engineers. To this end, the Contractor is advised to purchase pipe under a guarantee from the manufacturer, guaranteeing proper service of sewer pipe under conditions established by the drawings, specifications and local conditions at the site of the work.

- G. FINAL INSPECTION: The Contractor shall be required to complete the construction of each portion of the sewer, in order, as the work progresses. Upon the completion of any section of sewer line or lateral sewer line, it shall be cleaned of all debris and collections of dirt by thorough flushing. The Engineers shall then proceed to give final inspection of his portion of the contract, and the Contractor shall be required to make good any defects that may be discovered at this time or at any time within the guarantee period.

H. CLEANING UP:

1. Upon completion of the work required under this Division, the Contractor shall remove all excess materials, earth, debris, etc., and shall clean up and leave all affected property, streets, roads and highways in a neat, clean and orderly condition. All clean up work of any nature, including any required soil stabilization, debris removal, plantings and/or reseeding work, shall closely follow the actual pipe laying work. If so directed by the Engineers, the Contractor shall deposit all or part of the excess earth at such point or points as may be designated. Excess earth from trenches along State controlled highways or roads shall be disposed of in a manner satisfactory to the North Carolina Department of Transportation, Division of Highways.
2. The Contractor shall be responsible for restoring all disturbed ground area and replacing all disturbed property corners to the satisfaction of the Engineers.

END OF SECTION 22.

SECTION 25

LANDSCAPE WORK - GRASS ONLY

25-1 NOT IN USE.

25-2 EXTENT OF WORK.

The Contractor shall furnish all labor, materials, tools, equipment and all else required for, and to prepare, fertilize, seed, plant and perform other landscaping operations, complete, established, and otherwise satisfactory in accordance with these Specifications, Engineers requirements, and current NCDOT specifications.

25-3 DESCRIPTION OF WORK.

- A. The work shall consist of preparing seedbeds, furnishing and placing the specified seed mixture, compacting seedbeds, furnishing and placing a mulch covering and all other operations incidental to obtaining an acceptable stand of grass on all disturbed areas of the construction site unless otherwise specified, all in accordance with these Specifications.
- B. In addition, the work required shall include, but not be limited to, the following:
 - 1. Preparation of planting pits and beds including excavation, backfill preparation, back filling, and disposal of surplus and unsuitable excavated material.
 - 2. Maintenance of all plant material.
- C. It is the spirit and intent of these Specifications to prescribe a complete planting procedure which shall be followed in a careful, workmanlike manner and, shall be adapted to unpredictable variations in weather and soil conditions so as to assure, insofar as is humanly possible, the successful establishment and growth of grasses and/or other specified plant materials.

25-4 GENERAL LANDSCAPE REQUIREMENTS.

- A. The Contractor shall not make substitutions. If any specified plant material is not obtainable, the Contractor shall submit to the Engineers proof of non-availability and proposal(s) for the use of equivalent material.
- B. The Contractor shall submit a planting schedule to the Engineers showing the coordination of normal planting times with the construction schedule for other related work.
- C. Plant all plant material during normal seasons for such work in the location of the project.

- D. Plant all plant material after final grades are established and prior to the planting of lawns, unless otherwise acceptable to the Engineers. If planting of plant material occurs after lawn work, the Contractor shall protect lawn areas and promptly repair any and all damage to lawns resulting from planting operations.
- E. Plant frost-tender plant material only after the danger of frost is past or sufficiently before the frost season to allow for establishment before the first frost. Do not plant in frozen ground.
- F. Submit the seed vendor's certified statement for each grass seed mixture required, stating the botanical and common name, the percentage by weight, and the percentages of purity, germination, and weed seed for each grass seed species.
- G. Provide fresh, clean, new-crop seed complying with the tolerance for purity and germination established by the Official Seed Analysts of North America. Provide seed of the grass species, proportions, and minimum percentages of purity, germination, and maximum percentage of weed seed specified in the "Schedule of Grass Seed Requirements."
- H. Seed shall have been approved by the North Carolina Agriculture Department before being sown. No seed will be accepted with a date of test more than nine (9) months prior to the date of sowing, excluding the month in which the test was completed. Such testing, however, will not relieve the Contractor from any responsibility for furnishing and sowing seed that meets these Specifications.
- I. The Contractor shall seed all disturbed areas not intended to be paved, graveled, or otherwise planted, within 30 days of completing any portion of the grading operations. Seeding is to be performed in a manner consistent with these Specifications for materials and methods specified.
- J. The Contractor shall restore at his own expense to a condition equal or similar to and as approved by the Engineers, that existing before damage or injury by repairing, rebuilding, or replacing damaged items. All trees, designated to remain on the site by the Engineers, shall be protected as required to protect them from damage or injury during construction operations. Barricades shall be constructed when required, and as directed by the Engineers. Where cuts expose or affect root systems of trees, the exposed roots shall be cut off cleanly, and such areas shall be backfilled with topsoil and seeded as soon as is practicable, according to the methods specified herein.
- K. Any tree removed erroneously, or damaged beyond repair, shall be replaced with the same species, 5 inches in caliper.

25-5 EXCAVATION, FILLING AND GRADING:

- A. The excavation, filling and grading required to establish the elevations shown on the drawings are specified herein and under other sections of these Specifications. The Contractor for this Section of the work shall verify all subgrade elevations and notify the Engineers in writing of any discrepancies. The Contractor shall not proceed with the landscape work until the discrepancies have been corrected in a manner acceptable to the Engineers.

- B. Determine the location(s) of underground utilities and perform all work in a manner which will avoid possible damage. Hand excavate, as required, to minimize the possibility of damage to any underground utilities. Maintain the grade stakes set by others until their removal is mutually agreed by all parties concerned.
- C. All areas to be planted in grass shall be cultivated to a minimum depth of 6" as specified below.
- D. Cultivate bare and/or compacted areas thoroughly to provide a good, deep planting bed.
- E. Within lawn areas where the topsoil has not been stripped, cultivate to a depth of 6", mix in the specified soil amendments, and till the surface to a level, fine texture, creating a satisfactory seed or sod bed free of clods and other extraneous matter.
- F. Within lawn areas where topsoil has been stripped the Contractor shall loosen subgrade to a depth of 6", spread a 3" depth of topsoil, till to mix the topsoil with the subsoil, spread additional 3" depth of topsoil and till the surface to a level, fine texture. The top 4" shall then be mixed with the specified soil amendments, and worked into a satisfactory seed or sod bed free of clods and other extraneous matter.
- G. Within all lawn areas, removal all stones over 1 1/2" in any dimension and all sticks, roots, rubbish and other extraneous matter to a depth of 6".
- H. After grading the lawn areas to a smooth, even surface with a loose, uniformly fine texture, the Contractor shall roll, rake, remove ridges, and fill depressions, as required, to meet finished grades. Limit fine grading to areas which can be planted immediately after grading.
- I. Restore lawn areas to the specified condition if eroded or otherwise disturbed after fine grading, and prior to planting.
- J. When fine grading, allow for sod thickness in areas to be sodded.
- K. Dispose of subsoil removed from landscape excavations. Do not mix it with prepared backfill or use as backfill.
- L. Prior to the preparation of unchanged areas (areas that have not been altered or disturbed by excavating, grading, or stripping operations), remove all existing grass, vegetation and turf. Dispose of such material outside of the Owner's property; do not turn it over into the soil being prepared for lawns.
- M. After removing the objectionable material mentioned above, prepare the soil for lawn planting as follows: Till to a depth of not less than 6"; apply the soil amendments and initial fertilizers as specified; remove high areas and fill in depressions; till the soil to a homogenous mixture of fine texture, free of lumps, clods, stones, roots and other extraneous matter. Upon completion of the fine grading, follow the lawn planting operations and requirements specified herein.

25-6 TOPSOIL.

- A. Topsoil for all areas to be grassed or otherwise planted shall be stockpiled for reuse in landscape work. If the quantity of stockpiled topsoil is insufficient, the Contractor shall provide additional approved topsoil as required to provide a minimum 4" depth of topsoil over all disturbed areas, and to complete the landscape work.
- B. Provide new topsoil which is fertile, friable, natural loam, surface soil, reasonably free of subsoil, clay lumps, brush, weeds and other litter, and free of roots, stumps, stones larger than 1 1/2" in any dimension, and any other extraneous or toxic matter harmful to plant growth.
- C. Obtain topsoil from local sources or from areas having similar soil characteristics to that found at the project site. Obtain topsoil only from naturally, well-drained sites where the topsoil occurs in a depth of not less than 4"; do not obtain the topsoil from bogs or marshes.

25-7 INSTALLATION OF PLANT MATERIALS.

- A. In addition to all other landscape requirements and operations specified herein, grass seed shall be sown as follows:
 - 1. All areas to be seeded shall be restored to the specified condition if eroded or otherwise disturbed after fine grading and prior to planting.
 - 2. Sowing of seed shall be done only after the prepared topsoil, to which the specified soil amendments have been added, has been thoroughly settled by rainfall or artificial watering. Sow only when the moisture content of the soil is suitable for sowing grass seed. Keep the soil in a moist condition until the seed has germinated and the grass is actively growing.
 - 3. Immediately before any seed is sown, the ground surface shall be scarified as necessary to a depth of not over 1" and shall be raked until the surface is smooth, friable and of a uniformly fine texture.
 - 4. Sow the seed using a spreader or seeding machine. Do not seed when the wind velocity exceeds 5 mi. per hr. Distribute the seed evenly over the entire area. The method of seeding may be varied at the discretion of the Contractor on his own responsibility to establish a smooth, uniformly grassed lawn.
 - 5. Sow not less than the quantity of seed specified or scheduled.
 - 6. On banks or slopes greater than or equal to 5:1 the rate of seeding shall be increased by 50%.
 - 7. Rake the seed lightly into the top 1/8" of the prepared topsoil, roll lightly, and water with a fine spray.
 - 8. Recondition existing lawn areas damaged by Contractor's operations (including storage of materials and equipment, and movement of vehicles), and all lawn areas where minor regrading is required, by cultivating bare and compacted areas thoroughly to provide a satisfactory planting bed.

9. Provide the fertilizer, seed and/or sod, and soil amendments specified for new lawns and as required to provide a satisfactorily reconditioned lawn. Provide new topsoil as required to fill all low spots and to meet the new finished grades.
10. Remove all diseased and/or other unsatisfactory lawn areas; do not bury any of the grass, vegetation, or turf into the soil. In addition remove all topsoil containing any foreign materials resulting from any Contractor's operations, including oil drippings, stone, gravel and other loose building materials.
11. Where substantial lawn remains (but is thin), mow, rake, aerate (if compacted), fill all low spots, remove humps, cultivate the soil, fertilize, and seed. Remove all weeds before seeding, or if extensive, apply selective chemical weed killers as required. Apply a seedbed mulch, if required, to maintain a moist condition. Water newly planted areas and keep them moist until the new grass is established and actively growing.
12. All seeded non-slope areas, and all seeded slope areas less than 3:1, shall be mulched with clean, seed-free, threshed grain straw of wheat, rye, oats, barley, or other satisfactory material as approved by the Engineers. Spread uniformly to form a continuous blanket of not less than 1-1/2" loose measurement over all seeded areas. The straw shall be tacked with asphalt at a minimum rate of 200 gallons per acre or more if required to satisfactorily hold the straw. Emulsified asphalt shall be used April through October and rapid curing asphalt shall be substituted during the winter months. Take precautions to prevent the damage or staining of construction or other plantings adjacent to the mulched areas.
13. On seeded slopes greater than or equal to 3:1, the Contractor shall stabilize the slopes with either the use of polypropylene netting installed over the asphalt-tacked straw mulch, or a short-life erosion control fabric. Netting shall be polypropylene extruded plastic net, with approximately 1" square openings or smaller and weighing a minimum of 2.5 pounds per 1,000 square feet, and shall be placed over the straw mulch immediately after the seeding, mulching, and asphalt tacking operations are complete in order to further stabilize the slope. Netting shall be held in place by a sufficient number of #11 gauge new-steel wire staples formed into a "U" shape; having a length of not less than 6" and a throat of not less than 1" in width. In lieu of using tacked straw and polypropylene netting the Contractor may use a two to four-week-life erosion control fabric of plastic and paper. Installation of this plastic and paper fabric shall be in strict conformance to the manufacturer's recommendation.
14. All ditches, swales and channels, where so indicated on the drawings, shall be stabilized within 24 hours after seeding to the extent indicated, with anti-erosion matting, which shall be jute or excelsior matting, or fiberglass roving. Other acceptable material manufactured especially for erosion control may be used when approved by the Engineers in writing before being used. Anti-erosion matting for erosion control shall not be dyed, bleached, or otherwise treated in a manner that will result in toxicity to vegetation. The seedbed shall be smooth and free from stones, clods or debris, etc. as specified, which will prevent the contact of the matting with the soil. Care shall be taken to preserve the required line, grade and cross section of the area treated.

15. Jute matting shall be a uniform open plain weave of single jute yarn, 48" in width plus or minus 1". The yarn shall be of a loosely twisted construction and shall not vary in thickness by more than one-half its normal diameter. There shall be 78 warp ends, plus or minus 2, per width of the matting; 41 weft ends, plus or minus 1, per linear yard; and the weight shall average 1.22 pounds per linear yard of the matting, with a tolerance of plus or minus 5%. Jute matting shall be secured with metal staples.
16. Excelsior matting shall be wood excelsior 48" in width, plus or minus 1", shall have a minimum thickness of 1/4"; and the weight shall average 1.07 pounds per linear yard of the matting, with a tolerance of plus or minus 5%. The excelsior matting shall be covered on one side with a woven fabric consisting of either twisted paper cord or cotton cord having a minimum mesh size of 1" x 1", and a maximum mesh size of 1 1/2" x 3". When excelsior matting is used, the matting shall be installed with the fabric on the top side. Excelsior matting shall be secured with polypropylene netting and metal staples as specified.
17. Excelsior or jute matting shall be unrolled in the direction of the flow of water, and shall be applied without stretching, so that it will lie smoothly but loosely on the soil surface. The up-channel, or top of slope end, of each piece of matting shall be buried in a narrow trench at least 5" deep and tamped firmly. Where one roll of matting ends and a second roll begins, the end of the upper roll shall be brought over the buried end of the second roll so that there will be a 6" overlap. Check slots shall be constructed at 50' intervals longitudinally in the matting or as directed by the Engineers. These slots shall be narrow trenches at least 5" deep. The matting shall be folded over and buried to the full depth of the trench, after which the trench shall be closed and firmly tamped. Where two or more widths of matting are laid side by side, the overlap shall be at least 4".
18. Staples shall be placed across all jute and excelsior matting at ends, junctions and check slots, and shall be spaced approximately 10" apart. In addition, staples shall be placed along the outer edges and down the center of each strip of jute and excelsior matting, and shall be spaced no more than 3' apart. Staples shall also be placed along all lapped edges a maximum of 3' apart.
19. After the excelsior or jute matting has been placed and stapled completely, the matting shall be rolled with an approved roller to assure that it is in proper contact with the soil.
20. The fiberglass material shall be formed from continuous fibers drawn from molten glass; coated with a chrome-complex sizing compound; collected into strands; and lightly bound together into a roving without the use of a binding agent or other deleterious substance. The roving shall be wound into a cylindrical package to allow the material to be continuously withdrawn from the center using a compressed air ejector so that the roving expands into a mat of glass fibers on the soil surface.

The fiberglass roving shall conform to the following detailed requirements:

PROPERTY	LIMIT	TEST METHOD
Strands/Rove	55-70	End Count
Fiber Diameter, In. (Trade Designation - G)	0.00035-.0004	ASTM D 578
Yards/lb. of Rove	210-230	ASTM D 578
Package Weight, lbs.	30-35	ASTM D 578

21. Equipment necessary for the application of fiberglass roving shall include: One pneumatic ejector or nozzle, capable of applying glass roving at a rate of two pounds or 8 square yards per minute; an air compressor, capable of supplying 40 cfm at 80 to 100 psi; sufficient air hoses for supplying air to inaccessible places; and an approved asphaltic material distributor with necessary hoses and hand spray bar for working in areas not accessible to the distributor.
22. Fiberglass roving shall be spread uniformly over the designated area to form a random mat of continuous glass fibers at the rate of .25 to .35 pounds per square yard. Immediately after the roving has been placed, it shall be anchored to the ground with an approved asphaltic material applied uniformly over the glass fibers, at not less than the rate of 1200 gallons per acre.
23. At the upgrade end and at maximum intervals of 50' longitudinally along ditches, the roving shall be buried to a depth of one foot to prevent undermining and tension failures.
24. In the installation of anti-erosion matting on cut or fill slopes, the Engineers may require adjustments in the trenching or stapling requirements to fit individual slope conditions.

25-8 MAINTENANCE.

- A. Begin maintenance immediately after planting.
- B. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and replanting for at least 90 days, and as much longer as is necessary, until acceptance, to establish a uniform stand of the specified grass.
- C. If seeding occurs in the fall and is not given a full 90 days of maintenance, or if it is not considered acceptable at the time, continue the maintenance the following spring until an acceptable lawn is established.
- D. Scattered bare spots, none of which is larger than one square foot, will be allowed up to a maximum of 3% of any lawn areas. When lawn areas are ready for final inspection, the grass shall be neatly mowed to the uniform height of approximately 1 1/2". The lawns shall be considered established only when the specified grass is vigorous and growing well in addition to meeting the other requirements specified.

- E. Maintain all plant material by pruning, cultivating and weeding as required for healthy growth. Restore planting saucers. Tighten and repair stake and guy supports and reset trees and shrubs to proper grades or vertical position as required. Restore or replace damaged wrappings. Spray as required to keep all plant material free of insects and disease.
- F. All plant material shall be maintained until final acceptance, but in no case less than 90 days.
- G. Prior to the expiration of the required maintenance period(s), submit to the Engineers 2 copies of typewritten instructions recommending procedures to be established by the City for the maintenance of landscape work for one full year.
- H. Protect all landscape work and materials from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain the protection during the installation and maintenance periods, until final acceptance.

25-9 SCHEDULE OF GRASS SEED REQUIREMENTS.

- A. Provide the grass seed mixtures corresponding to the conditions of slope, soil and maintenance that apply to each location, using the Index shown below:

Low Maintenance	Table*
Steep slopes of stony, shallow or dry soils	I
Gentle slopes with average or better soils	II
High Maintenance (slopes less than 3:1)	
Cool sites; soils with average or better moisture retention	III
Warm sites; dry, poor soils	IV
Grass Lined Channels	
Soils with average or better moisture retention	V
Full sun, drought-prone soils	VI

*TABLES ARE PAGES 25-11 THROUGH 25-16.

- B. The specific time periods established in seeding dates may vary due to the climatic conditions existing, at the time of sowing the seed. It shall be the responsibility of the Contractor to request and receive verification from the Engineers concerning the appropriate seed mixture to be used.

25-10 SCHEDULE OF PREPARED TOP SOIL MIXTURE REQUIREMENTS:

- A. For all areas to be grassed the Contractor shall provide not less than the following quantities of specified soil amendments:
 - 1. 70 lbs. of lime per 1,000 sq. ft. for soils with a pH less than 5.5,
 - 45 lbs. of lime per 1,000 sq. ft. for soils with a pH between 5.5 and 6.5, or
 - 25 lbs. of lime per 1,000 sq. ft. for soils with a pH greater than 6.5.

2. 5 lbs. of bonemeal per 1,000 sq. ft.
 3. 10 lbs. of super phosphate per 1,000 sq. ft.
 4. 23 lbs. of commercial 8-8-8 fertilizer per 1,000 sq. ft.
- B. Lime shall be agricultural grade natural limestone containing not less than 85% of the combined calcium and magnesium carbonates, ground so that 100% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve. During handling and storing, the limestone shall be cared for in such a manner that it will be protected against hardening and/or caking. Any hardened and/or caked limestone shall be pulverized to its original condition before being used.
 - C. Peat Humus shall be FS Q-P166, with the texture and pH range suitable for the intended use.
 - D. Bonemeal shall be commercial, raw, finely ground bonemeal containing 4% nitrogen and 20% phosphoric acid.
 - E. Superphosphate shall be a soluble mixture of treated minerals containing 20% available phosphoric acid.
 - F. Commercial fertilizer shall be a complete fertilizer, with some elements derived from organic sources. During handling and storing the fertilizer shall be cared for in such a manner that it will be protected against hardening, caking, or loss of plant food values. Any hardened and/or caked fertilizer shall be pulverized to its original condition before being used.

25-11 CLEAN-UP AND COMPLETION.

- A. Any soil, fertilizer, peat or similar material which has been brought onto paved areas by hauling operations or otherwise, shall be removed within the same working day and not be allowed to remain overnight, keeping these areas clean at all times. Upon completion of the planting, all excess soil, stones and debris which has not previously been cleaned up shall be removed and legally disposed of away from the property. All damage to existing lawns and plantings caused by the construction operations shall be repaired to the satisfaction of the Engineers at the Contractor's expense. All lawns and planting areas shall be prepared for final inspection.
- B. When the landscape work is completed, including maintenance, the Engineers will, upon request, make an inspection to determine acceptability.
- C. The landscape work may be inspected for acceptance in parts agreeable to the Engineers, provided that the work offered for inspection is complete, including maintenance, and that the area comprises one complete unit or area of substantial size.
- D. Where inspected landscape work does not comply with the requirements, the Contractor shall, at no additional cost to the Owner, replace all rejected work and continue the specified maintenance until it is reinspected and found to be acceptable by the Engineers. Remove rejected plants and materials promptly from the project site.

- E. Failure by the Engineers to approve or disapprove work, in the course of operations or during the inspection of the work, shall not be interpreted as acceptance of work not in conformance with this specification. Improper work and/or materials shall be corrected wherever and whenever discovered.

25-12 GUARANTEE.

- A. The Contractor shall guarantee a good uniform stand of grass as specified.
- B. The Contractor shall guarantee all plant material for a period of one year after acceptance by the Owner against death and unhealthy condition, except as may result from neglect by the Owner or damage by others.
- C. The Contractor shall remove and replace all plant material found to be dead or in an unhealthy condition during the guarantee period. The Contractor shall plant missing plant material and make replacements during the growth season following the end of the guarantee period. Furnish and plant replacements that comply with the requirements shown and specified. Also, replace all plant material that is in doubtful condition at the end of the guarantee periods, unless, in the opinion of Engineers, it is advisable to extend the guarantee period for a full growing season. The Engineers will make another inspection at the end of the extended guarantee period, if any, to determine acceptance or rejection. Only one replacement will be required at the end of the guarantee period, except for losses or replacements due to failure to comply with all specified requirements.

Continued to the following tables

TABLE I

SEEDING FOR: STEEP SLOPES OR POOR SOILS; LOW MAINTENANCE

Seeding Mixture:

Species	Rate (lb./acre)
Tall fescue	100
Sericea lespedeza	30
Kobe lespedeza	10

Seeding Notes:

1. In Eastern Piedmont add 25 lb./acre Pensacola Bahiagrass or 10 lb./acre common Bermudagrass. Use common Bermudagrass only where it is unlikely to become a pest.
2. After Aug. 15 use unscarified sericea seed.
3. Where a neat appearance is desired, omit sericea and substitute 40 lb./acre Bahiagrass or 15 lb./acre Bermudagrass.
4. To extend spring seeding dates into June, add 15 lb./acre hulled Bermudagrass. However, it is preferable to seed temporary cover and seed fescue is Sept.

Nurse Plants: Between May 1 and August 15, add 10 lb./acre German millet or 15 lb./acre Sudangrass. Prior to May 1 or after August 15, add 40 lb./acre rye (grain).

Seeding Dates:

	Best	Possible
Fall:	Aug. 25 - Sept. 15	Aug. 20 - Oct. 25
Late Winter:	Feb. 15 - Mar. 21	Feb. 01 - Apr. 15

Fall is best for tall fescue and late winter for lespedezas. Overseeding of Kobe lespedeza over fall-seeded tall fescue is very effective. Use unhulled Bermudagrass seed in fall.

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 4,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

Mulch: Apply 4,000-5,000 lb./acre grain straw, or equivalent cover of another suitable mulching material. Anchor mulch by tacking with asphalt, roving, or netting. Netting is the preferred anchoring method on steep slopes.

Maintenance: Refertilize in the second year unless growth is fully adequate. May be mowed once or twice a year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

TABLE II

SEEDING FOR: GENTLE SLOPES, AVERAGE SOIL; LOW MAINTENANCE

Seeding Mixture:

Species	Rate (lb./acre)
Tall fescue	80
Sericea lespedeza	20
Kobe lespedeza	10

Seeding Notes:

1. After Aug. 15 use unscarified sericea seed.
2. Where periodic mowing is planned or a neat appearance is desired, omit sericea and increase Kobe lespedeza to 40 lb./acre.
3. To extend spring seeding dates into June, add 15 lb./acre hulled Bermudagrass. However, after mid-April it is preferable to seed temporary cover.

Nurse Plants: Between May 1 and August 15, add 10 lb./acre German millet or 15 lb./acre Sudangrass. Prior to May 1 or after August 15, add 40 lb./acre rye (grain).

Seeding Dates:

	Best	Possible
Fall:	Aug. 25 - Sept. 15	Aug. 20 - Oct. 25
Late Winter:	Feb. 15 - Mar. 21	Feb. 01 - Apr. 15

Fall is best for tall fescue and late winter for lespedezas. Overseeding of Kobe lespedeza over fall-seeded tall fescue is very effective.

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 4,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

Mulch: Apply 4,000 lb./acre grain straw, or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt, netting, roving or by crimping with a mulch-anchoring tool. A disk with blades set nearly straight can be used as a mulch-anchoring tool.

Maintenance: Refertilize in the second year unless growth is fully adequate. May be mowed once or twice a year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

TABLE III

SEEDING FOR: GENTLE SLOPES, SOILS WITH AVERAGE OR BETTER MOISTURE RETENTION, COOLER SITES; HIGH MAINTENANCE

Seeding Mixture:

Species	Rate (lb./acre)
Blend of two turf-type tall fescues (90%) and two or more improved Kentucky bluegrass varieties (10%)	200 - 250

Seeding Dates:

	Best	Possible
Fall:	Aug. 25 - Sept. 15	Aug. 20 - Oct. 25
Winter:		Feb. 01 - Mar. 31

For quality turf avoid spring seeding. Where grading is completed during late winter or spring, an alternative is to seed 30 lb./acre Kobe lespedeza, keep mowed, prepare seedbed, and seed a permanent mixture in early fall.

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 4,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

Mulch: Apply 4,000 lb./acre small grain straw or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt, netting, or by roving or crimping with a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch-anchoring tool.

Maintenance: Fertilize according to soil tests or apply 40 lb./acre nitrogen in January or February, 40 lb. in September, and 40 lb. in November, from a 12-4-8, 16-4-8, or similar turf fertilizer. Avoid fertilizer applications during warm weather, as these increases stand losses to disease. Mow to a height of 2.5-3.5 inches as needed. Reseed, fertilize, and mulch damaged areas immediately.

TABLE IV

SEEDING FOR: GENTLE SLOPES, SOILS SOMEWHAT WARMER OR DRIER THAN 3P, OR WITH PHYSICAL LIMITATION; HIGH MAINTENANCE

Seeding Mixture:

Species	Rate (lb./acre)
Blend of 50% KY-31 tall fescue and 50% mixture of two or more turf-type tall fescues	200 - 250
or	
Blend of three or more turf-type tall fescues	200 - 250

Seeding Dates:

	Best	Possible
Fall:	Aug. 25 - Sept. 15	Aug. 20 - Oct. 25
Winter:		Feb. 01 - Mar. 31

For quality turf avoid spring seeding. Where grading is completed during late winter or spring, an alternative is to seed 30 lb./acre Kobe lespedeza, keep mowed, prepare seedbed, and seed permanent mixture between August 25 and September 15.

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 4,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

Mulch: Apply 4,000 lb./acre small grain straw or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt, roving, or netting or by crimping with a mulch-anchoring tool. A disk with blades set nearly straight can be used as a mulch-anchoring tool.

Maintenance: Fertilize according to soil tests or apply 40 lb./acre nitrogen in January or February, 40 lb. in September, and 40 lb. in November, from a 12-4-8, 16-4-8, or similar turf fertilizer. Avoid fertilizer applications during warm weather, as these increases stand losses to disease. Reseed, fertilize, and mulch damaged areas immediately. Mow to a height of 2.5-3.5 inches as needed.

TABLE V

SEEDING FOR: GRASS-LINED CHANNELS

Seeding Mixture:

Species	Rate (lb./acre)
Tall fescue	200 (4-5 lb./1,000 ft ²)

Nurse Plants: Between May 1 and August 15 add 15 lb./acre Sudangrass or 10 lb./acre German millet. Before May 1, or after August 15, add 40 lb./acre rye (grain).

Seeding Dates:

Best:	Aug. 25 - Oct.
Possible:	Feb. - April 15

Avoid seeding from November to January. If seeding must be done at this time, add 40 lb./acre rye grain and use a channel lining that offers maximum protection.

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 4,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer. Operate tillage equipment across the waterway.

Mulch: Use jute, excelsior matting, or other effective channel lining, material to cover the bottom of channels and ditches, and staple securely. The lining should extend above the highest calculated depth of flow. On channel side slopes above this height, and in drainages not requiring temporary linings, apply 4,000 lb./acre grain straw and anchor straw by stapling netting over the top.

Mulch and anchoring materials must not be allowed to wash down slopes where they can clog drainage devices.

Maintenance: Inspect and repair mulch frequently. Refertilize in late winter of the following year; use soil tests or apply 150 lb./acre 10-10-10. Mow regularly to a height of 2-4 inches.

TABLE VI

SEEDING FOR: GRASS-LINED CHANNELS; COASTAL PLAIN, LOWER PIEDMONT, AND DRY SOILS IN THE CENTRAL PIEDMONT

Seeding Mixture:

Species	Rate (lb./acre)
Common Bermudagrass	40-80 (1-2 lb./1,000 ft ²)

Seeding Dates:

Coastal Plain:	April - July
Piedmont:	April 15 - June 30

Soil Amendments: Apply lime and fertilizer according to soil tests, or apply 3,000 lb./acre ground agricultural limestone and 500 lb./acre 10-10-10 fertilizer.

Mulch: Use jute, excelsior matting, or other effective channel lining, material to cover the bottom of channels and ditches, and staple securely. The lining should extend above the highest calculated depth of flow. On channel side slopes above this height, and in drainages not requiring temporary linings, apply 4,000 lb./acre grain straw and anchor straw by stapling netting over the top.

Mulch and anchoring materials must not be allowed to wash down slopes where they can clog drainage devices.

Maintenance: A minimum of 3 weeks is required for establishment. Inspect and repair mulch frequently. Refertilize the following April with 50 lb./acre nitrogen.

END OF SECTION 25.

SECTION 26

CONCRETE FORM WORK

PART I - GENERAL

26-1 REQUIREMENTS.

- A. The Contractor shall provide all labor, materials, equipment and services necessary for the proper completion of all formwork for cast in place concrete work indicated on the drawings and specified herein.
- B. The Contractor shall refer to the drawings for required size and location of cast in place concrete members.

26-2 REFERENCE SPECIFICATIONS.

Unless otherwise altered, amended, supplemented or deleted by "Part II, Products" and "Part III, Execution" which follow, all concrete formwork shall conform to the following:

- A. American Concrete Institute Standard ACI 347, "Recommended Practice for Concrete Formwork."
- B. The American Concrete Institute "Specifications for Structural Concrete for Buildings," ACI 301-72. A copy of "Specifications for Structural Concrete for Buildings, ACI 301-72, With Selected ACI and ASTM References," ACI Publication SP-15, shall be purchased by the Contractor and shall be maintained in good condition at the job site at all times during construction. This reference may be purchased from the American Concrete Institute, P.O. Box 4754, Redford Station, Detroit, Michigan, 48219. This reference is referred to hereafter in these Specifications as the ACI Specifications.
- C. The American Concrete Institute "Manual of Standard Practice for Detailing Reinforced Concrete Structures," ACI 315-80, hereafter referred to as the ACI Detailing Manual.
- D. The Concrete Reinforcing Steel Institute "Manual of Standard Practice," latest edition, hereafter referred to as the CRSI Manual.

26-3 SUBMITTALS.

- A. Complete erection plans shall be prepared for removable forms in accordance with the ACI Detailing Manual, the CRSI Manual, and the Manual of Recommended Practice for Concrete Formwork.
- B. The review of erection drawings will be for size and arrangement of the concrete members. The Contractor shall verify dimensions and any errors in dimensions shown on the erection drawings shall be the responsibility of the Contractor.

- C. Review by the Engineers shall not be construed as a waiver of construction responsibilities unless the Contractor has requested a deviation from the Contract Documents in writing and the Engineers have granted such deviation in writing. Fabrication or delivery of materials prior to review of submittals shall be entirely at the risk of the Contractor.

PART II - PRODUCTS

26-4 MATERIALS.

- A. Removable Metal Pan Forms: Unless otherwise noted, the metal pan joists shall be constructed in accordance with the "Code of Standard Practice for the Use of Removable Forms for Concrete Joist Floor and Roof Construction," of the CRSI Manual. It is essential to the load capacity of concrete joists that the dimensions for all standard and special filler forms be in accordance with the "Standard Dimensions of Forms for One-Way Joist Construction" of the U. S. Department of Commerce Simplified Practice Recommendation R87-32.
1. Longform Type - Where concrete joists will be permanently exposed to view (see drawings), the joist forms shall be of the "long form" type constructed to the full length of each segment of joists between distribution ribs or beams. End closures may be of the removable type or may be permanently attached to the forms.
 2. Standard Type - Where concrete joists will be concealed by ceiling construction, and in mechanical equipment rooms, the joist forms shall be "standard" type. End closures and laps shall be sufficiently tight to prevent the leakage of concrete.
 3. Removable metal pan forms shall be new, or practically so. Forms displaying excessive dents, holes or other signs of excessive use or abuse shall not be used. Forms shall be cleaned and properly oiled before each use.
 4. Special width filler forms shall be used to fill in odd spaces. Openings and ends shall be properly headed.
 5. Products of equivalent quality and dimensions constructed of molded fiber, reinforced fiberglass or plastic may be used in lieu of steel forms, at the option of the Contractor.
- B. Forms for As-Cast Architectural Concrete: Concrete to be left permanently exposed to view shall be considered "As-Cast Architectural Finishes" and shall conform to the requirements of Chapter 13 of the ACI Specifications.
- C. Forms for Pile Caps and Grade Beams: Earth cuts shall not be used to form vertical surfaces for pile caps, grade beams and other vertical concrete surfaces in contact with earth. These surfaces shall be formed with wood or metal forming materials to the required dimensions.

- D. Forms for Footings: Earth cuts may be used for forms for vertical surfaces for footings where the workmanship and soil permit accurate excavation to size and shape shown on the drawings. Sloping sides, rounded corners and irregular bottoms will not be accepted. Where these requirements cannot be met, form the vertical surfaces with wood or metal forming materials to the required dimensions.
- E. Grade Stakes: Where earth cuts are used for forms, the footing excavations shall be provided with grade stakes set to correct elevations prior to ordering concrete. Grade stakes shall be #3 or larger steel bars, may be new or scrap material and may remain in the concrete.
- F. Wood Forms: Wood forming materials shall conform to the requirements of Chapter 4 of the ACI Specifications.
- G. Corrugated Steel Sheet Forms: The Contractor shall furnish and install galvanized corrugated steel sheet forms for all concrete slabs over joist beams, as shown on the drawings and directed by the Engineers. The steel sheet forms shall be corrugated form low temper, low carbon, cold reduced steel with a minimum yield strength of 95,000 psi by 0.1% offset method to a nominal corrugation pattern of 2-3/8" x 9/16". Sheets shall be galvanized conforming to ASTM Specification A446-60T, Grade E steel, 1.25 oz. per square foot coating class. Minimum physical properties shall be as follows:

<u>DESCRIPTION</u>	<u>CHARACTERISTICS</u>
Weight-galvanized per cover width	0.88 lbs./sq. ft.
Moment of Inertia per foot width	0.010 inches 4
Section of modulus per foot width	0.036 inches 3
Corrugation (pitch x depth)	2-3/8" x 9/16"
Nominal cover width	24 inches
Nominal overall width	25-1/16 inches

26-5 DESIGN OF FORMS.

Forms shall conform to shapes, lines and dimensions of the members as called for on the drawings, and shall be sufficiently tight to prevent leakage of mortar. They shall be properly braced or tied together so as to maintain position and shape.

26-6 FORMS COATINGS.

Provide commercial formulation form coating compounds that will not bond with, stain nor adversely affect concrete surfaces, and will no impair subsequent treatment of concrete surfaces requiring bond or adhesion, not impede the wetting of surfaces to be cured with water or curing compounds.

26-7 TIGHTENING FORMS.

Immediately prior to the commencement of concrete placement all joints in the formwork shall be tightened to prevent the leakage of concrete.

26-8 ERECTION CORRUGATED STEEL SHEET FORMS.

- A. The corrugated sheet steel forms shall be placed with corrugation edges up and with corrugations perpendicular to supports. Sheet shall be placed end-to-end along one side of the building. Adjacent rows will be placed in like manner, side lapping one corrugation with previously placed row. End laps shall always occur over supporting joists, beams or purlins and should be centered over the support. Minimum end lap is 2" for welded attachment shall not extend beyond edge of support flange. Sheets shall be attached to supports by plug welding through curved washers to supporting top chords.
- B. The welded attachments shall have the following minimum welding requirements:
 - 1. End Laps - Weld top sheets in the valley of the side lap through four (4) sheet thicknesses and again at the middle of the sheet.
 - 2. Intermediate Supports - Weld in X pattern; that is, weld in valley of side lap on every other joist and in the valley of the center corrugation of the remaining joist.

26-9 REMOVAL OF FORMS.

- A. Formwork for joists, slabs, beams and other parts supporting the weight of concrete, shall remain in place until the concrete has reached its specified 28-day strength, but in no case less than 14 days. Other formwork may be removed in accordance with "Recommended Practice for Concrete Formwork," ACI 347-78, unless otherwise specified in these specifications.
- B. Forms shall be removed in such a manner as to ensure the complete safety of the structure. Where the structure is supported on shores, the removable floor forms, beams and girder sides, and column and similar vertical forms may be removed after 48 hours, providing the concrete will not be injured.

26-10 REUSE OF FORMS.

Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable. Apply new form coating compound material to concrete contact surfaces as specified for new formwork.

When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance and tighten forms to close all joints. Align and secure joints to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to the Engineers.

END OF SECTION 26.

SECTION 27

CONCRETE REINFORCEMENT

PART I - GENERAL

27-1 REQUIREMENTS.

- A. The Contractor shall provide all labor, materials, equipment and services necessary for the proper completion of all reinforcement for cast in place concrete work indicated on the drawings and specified herein.
- B. The Contractor shall refer to the drawings for required size, type and location of concrete reinforcement.

27-2 REFERENCE SPECIFICATIONS.

- A. Unless otherwise altered, amended, supplemented or deleted by Part II - Products and Part III - Execution, which follow, all reinforcement for concrete work shall conform to the following:
- B. The American Concrete Institute "Specifications for Structural Concrete for Buildings," ACI 301-72. A copy of "Specifications for Structural Concrete for Buildings, ACI 301-72, with Selected ACI and ASTM References," ACI Publication SP-15, shall be purchased by the Contractor and shall be maintained in good condition at the job site at all times during construction. This reference may be purchased from the American Concrete Institute, P. O. Box 4754, Redford Station, Detroit, Michigan 48219. This reference is referred to hereafter in these Specifications as the ACI Specifications.
- C. The American Concrete Institute "Manual of Standard Practice for Detailing Reinforced Concrete Structures," ACI 315-80, hereafter referred to as the ACI Detailing Manual.
- D. The Concrete Reinforcing Steel Institute "Manual of Standard Practice," latest edition, hereafter referred to as the CRSI Manual.

27-3 QUALIFICATIONS.

- A. Reinforcing Steel Fabricator:
 - 1. The fabricator shall have not less than 5 years experience in the fabrication of reinforcing steel and shall have previously fabricated not less than 5 projects similar in scope to this project.
 - 2. When directed by the Engineers, the fabricator shall submit a written description of fabrication ability including facilities, personnel and list of similar completed projects.
- B. Reinforcing Steel Erector:
 - 1. The erector shall have not less than 3 years experience in the erection of reinforcing steel and shall have previously erected not less than 3 projects similar in scope to this project.

2. When directed by the Engineers, the erector shall submit a written description of reinforcing steel erection ability including equipment, personnel and a list of similar completed projects.

27-4 SUBMITTALS.

A. Shop and Erection Drawings:

1. Complete shop and erection drawings shall be prepared for reinforcement in accordance with the ACI Detailing Manual and the CRSI Manual. Erection drawings shall show sufficient detail to illustrate the reinforcing steel erection procedure, including placement of accessories.
2. Preliminary and final erection drawings shall be submitted to the Engineers for their approval before any reinforcement may be placed.
3. The review of shop and erection drawings will be for size and arrangement of the reinforcement. The Contractor shall verify quantities and dimensions and any errors shown on the shop and erection drawings shall be the responsibility of the Contractor.

B. Certifications of Materials: Furnish to the Engineers for review the following:

1. Certified mill test reports of ladle analysis, tensile properties and bend tests of each grade of steel from which reinforcement is fabricated.
2. Certificates of conformance of stainless steel accessories.

C. Review: Review by the Engineers shall not be construed as a waiver of construction responsibilities unless the Contractor has requested a deviation from the specifications in writing and the Engineers have granted such deviation in writing. Fabrication or delivery of materials prior to the review of the shop and erection drawings shall be entirely at the risk of the Contractor.

27-5 PRODUCT HANDLING.

- A. Reinforcement shall not be carelessly unloaded from delivery vehicles in such a manner as to alter the configuration of the individual pieces.
- B. Reinforcement shall be stored in an orderly manner to avoid mixing bars of different marks.
- C. Reinforcement and accessories which are stored at the project site shall be at least 2' above the ground on platforms, skids or other supports, and be covered to protect it from the weather. It shall be free from oil, mud, dirt or excessive corrosion when placed in the formwork.
- D. Accessories and other packaged materials shall be stored in their original unbroken package until ready for use in the work.

PART II - PRODUCTS

27-6 MATERIALS.

A. Metal Reinforcement:

1. All reinforcing bars shall be deformed and shall conform to one of the following:
 - a. Specifications for Billet-Steel Bars for Concrete Reinforcement, ASTM A615, Grade 40.
 - b. Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement, ASTM A615, Grade 60.
 - c. Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement, ASTM A615, Grade 75.
 - d. Specifications for Minimum Requirements for Deformations of Deformed Steel Bars for Concrete Reinforcement (ASTM A408).
 - e. Specifications for Special Large-Size Deformed Billet-Steel Bars for Concrete Reinforcement (ASTM A408).
 - f. Bar and rod mats for concrete reinforcement shall conform to Specifications for Fabricated Steel Bar or Rod Mats for Concrete Reinforcement (ASTM A184).
 - g. Wire for concrete reinforcement shall conform to Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (ASTM A82).
2. Welded wire fabric for concrete reinforcement shall conform to Specifications for Welded Steel Wire Fabric for Concrete Reinforcement (ASTM A185) except that the weld shear strength requirement shall be extended to include a wire size differential up to and including six gauges.
3. The clear distance between parallel bars shall be not less than the nominal diameter of the bar, $1 \frac{1}{3}$ times the maximum size of the coarse aggregate, nor less than 1".
4. Structural steel shall conform to Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings of the American Institute for Steel Construction adopted April 17, 1963, as amended to date.
5. Steel pipe for concrete-filled pipe columns shall conform to Grade B of Specifications for Welded and Seamless Steel Pipe (ASTM A53).
6. Cast iron pipe for composite columns shall conform to Specifications for Cast Iron Pressure Pipe (ASTM A377).

B. Metal Accessories:

1. High chairs with sand plates (HCP) shall be used to support reinforcing steel in footings and other members in contact with the earth. Wire shall not be less than #4 and plate shall not be less than 20 gauge. HCP shall be constructed with one, approximately square, sand plate.
2. CRSI "Class E, Special Stainless" bar supports shall be provided to support all reinforcing steel in members to be left permanently exposed to view. Such supports shall be constructed of stainless steel containing not less than 16% chromium.
3. CRSI "Class A, Bright Basic" bar supports shall be provided to support reinforcing steel for all other concrete members.

PART III - EXECUTION

27-7 PLACING REINFORCEMENT.

Metal reinforcement shall be accurately placed according to the drawings and adequately secured in position by concrete, metal or other approved chairs, spacers or ties.

27-8 CLEANING AND BENDING.

At the time concrete is placed, metal reinforcement shall be free from rust, scale or other coatings that will destroy or reduce the bond. All bars shall be bent cold, unless otherwise permitted by the Engineers. No bars partially embedded in concrete shall be field bent except as shown on drawings or as specifically permitted by the Engineers.

27-9 SPLICES IN REINFORCEMENT.

- A. Welded wire fabric shall be considered as load carrying reinforcement and shall be lapped in accordance with 505(b) of the ACI Specifications, except at slabs on grade, which shall be considered as nonload carrying and shall be lapped in accordance with 505(c) of the ACI Specifications.
- B. No splices of reinforcement shall be made except as shown on the drawings, as specified, or as authorized by the Engineers. All welding shall conform to the American Welding Society's Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction (AWS-D-12.1), unless otherwise authorized by the Engineers. Where lapped splices are used the minimum amount of lap shall be not less than 40 bar diameters.

END OF SECTION 27.

SECTION 28

CONCRETE - GENERAL

PART I - GENERAL

28-1 REQUIREMENTS.

- A. The Contractor shall furnish all labor, materials, tools, equipment and all else required to construct the concrete work, test and place the structures into satisfactory operation as required by the drawings, these Specifications, and the Engineers' requirements under them.
- B. All concrete shall be composed of Portland cement, fine and coarse aggregate and water proportionally mixed.
- C. All concrete shall be mixed, tested, transported, formed, placed, vibrated, finished and cured as shown on the drawings and as hereinafter specified.

28-2 REFERENCE SPECIFICATIONS.

Unless otherwise altered, amended, supplemented or deleted by "Part II - Products," and "Part III - Execution," which follow, all concrete work shall conform to the American Concrete Institute "Specifications for Structural Concrete for Buildings," ACI 301-66. A copy of "Specifications for Structural Concrete for Buildings, ACI 301-66, with Selected ACI and ASTM References," ACI Publication SP-15, shall be purchased by the Contractor and shall be maintained in good condition at the job site at all times during construction. This reference may be purchased from the American Concrete Institute, P. O. Box 4754, Redford Station, Detroit, Michigan, 48219. This reference is referred to hereafter in these Specifications as the ACI Specifications.

28-3 TESTING.

The Contractor shall be responsible for all testing of concrete. He shall be responsible for preparing, transporting, storing, curing, testing and reporting test sample cylinders for compressive strength. He shall also perform slump tests when required by the Engineers. All tests and the manner in which they are conducted shall be satisfactory to the Engineers. The testing laboratory shall be satisfactory to the Engineers.

- A. SLUMP TEST AND AIR ENTRAINMENT TEST OF PORTLAND CEMENT CONCRETE:
 - 1. Test specimen shall be formed in a standard 16-gauge, galvanized metal slump cone 12" in height, as described by ASTM C143-52.
 - 2. Air entrainment test shall conform to ASTM C-175 and C-595.

B. SAMPLING:

1. Samples of concrete for test specimens shall be taken at the mixer, or from the truck mixer in the case of ready-mixed and transit-mixed concrete, during discharge. Obtain such samples by passing a receptacle completely through the stream of concrete, at three or more regular intervals throughout the discharge of the entire batch except that samples shall not be taken at the beginning or end of discharge. The sample shall then be transported in a wheelbarrow or some other suitable conveyance to the place of molding.
2. Mix the specimen with a shovel until the specimen is uniform in appearance. Note location of batch where the sample is taken for future reference.

C. MOLDING:

1. Dampen the cone and place it on a flat, moist, nonabsorbent surface. From the sample, immediately fill the cone in three layers, each approximately 1/3 of the volume of the cone. In placing, move the scoop around the top edge of the cone in order to insure symmetrical distribution of the concrete. Rod each layer with 25 strokes of a 5/8" standard rod. (See equipment list.)
2. Distribute the strokes across the cross section of the cone, penetrating the underlying layer. Rod the bottom layer throughout its depth. After the top layer has been rodded, strike off surface of the concrete with a trowel so that the cone is exactly filled. Remove the cone by raising it carefully in a vertical direction. The slump shall then be measured by determining the difference between the height of the cone and the height of the specimen.

D. PREPARATION OF STORAGE OF CONCRETE TEST CYLINDERS IN THE FIELD (Reference ASTM C31-57; ASTM C172-54):

1. Sampling:
 - a. The sampling shall be representative of the batch. (The word batch as here employed shall be understood to refer to one day's pour rather than the contents of one mixer load.) It shall consist of portions from different points in the batch. A sample shall be taken for each fifty (50) C.Y. or portion thereof of each pour.
 - b. When taken from truck mixers or agitators, the samples shall be taken in three or more regular increments throughout the discharge of the entire batch.
 - c. The composite sample shall be mixed with a shovel sufficiently to insure homogeneity & immediately molded into test specimens.

- d. The place of molding shall be such that the cylinders will not have to be moved during the first 24 hours. Molding shall be done on a platform or some other firm, level base not subject to vibration.
2. Size of Specimens: Cylinders shall be 6" in diameter and 12" deep. The mold shall be metal or other nonabsorptive material such as paraffined cardboard. If a metal mold is used it must have a machined base which can be secured to the mold and be watertight.
 3. Molding: Place the concrete into the mold in three layers of approximately equal volume. Move the scoop around the top edge in placing in order to achieve symmetrical distribution of the concrete. Distribute the concrete further by a circular motion of the tamping rod. Rod each layer with 25 strokes of a 5/8" diameter standard rod. (See equipment list.) Distribute strokes uniformly over the cross section of the mold, penetrating into the immediate underlying layer. Bottom layer shall be rodded throughout its depth. Where voids are left by the tamping rod, tap sides of the mold to close the voids. After the top layer has been rodded, strike off the surface of the concrete with a trowel and cover with a glass or metal plate to prevent evaporation. Mark number and date on top of cylinder with a nail or similar object.
 4. Curing:
 - a. Test specimens shall be removed from the molds at the end of 24 hours and stored in a location such that they will be protected from damage. At the end of 48 hours they shall be moved to the laboratory where they shall be placed in a moist room or in a lime saturated water bath until time for testing. The temperature of the moist room or water bath must be controlled between the limits of 60° F. and 80° F. All other conditions of curing shall conform to Paragraph 7(c) ASTM C31-57. The test specimens cured as above specified shall be the ones used for the standard 7-day and 28-day reports.
 - b. Should the Contractor desire to remove shoring and forms before the time stipulated in the Specifications and to subject the concrete to loads of any kind, he will be required to provide an extra set of test cylinders for testing at an agreed upon time to determine whether the structure has actually acquired sufficient strength to carry the loads. These test cylinders shall receive, insofar as practicable, the same protection that they represent, and shall be stored on the site. They shall be moved to the laboratory not more than two days prior to the date of testing.

5. Shipping Instructions: When cylinders are moved to a laboratory they shall be packed in boxes having inside dimensions of 7" x 21" x 13" to contain three cylinders. The box shall be made of 1/2" plywood with a separation partition between the cylinders and equipped with a hinged lid, hasp and carrying handle. The cylinders shall be packed completely with excelsior, straw or sawdust and kept damp. In the top of the box, place a list showing the data listed in Paragraph 1 of "Data to be Reported." Fasten the lid securely and tag with a shipping ticket.

E. EQUIPMENT TO BE FURNISHED BY CONTRACTOR FOR CONCRETE TESTING:

1. Slump Cone.
2. Platform.
3. Concrete molds for cylinders, including machined base if metal molds are used.
4. 5/8" round smooth rod approximately 24" long, one end rounded to a hemispherical tip diameter that is 5/8".
5. Shovel and wheelbarrow for sampling and transporting of samples.
6. Metal or glass covers for protecting cylinders.
7. Small scoop for use in filling slump cone and cylinder molds.

F. DATA TO BE REPORTED:

1. The following data shall be reported by the Contractor to the testing laboratory for each group of cylinders.
 - a. Mix, including amounts and brands of materials used.
 - b. Specified 28-day compressive strength.
 - c. Atmospheric temperature at time of pour.
 - d. Slump.
 - e. Type and amount of admixtures used.
 - f. Location of concrete in the structure. (In sufficient detail to definitely identify the pour at any later date.)

2. The following data shall be reported by the laboratory to the Engineers and to the Contractor.
 - a. Data listed in Paragraph 1, above.
 - b. Unit weight of the cylinder (lbs./cubic foot).
 - c. Type of break.
 - d. Percentage of aggregate broken.
 - e. Breaking load (lbs.).
 - f. Breaking stress (lbs./square inch).

28-4 QUALIFICATIONS.

A. CONCRETE PRODUCER:

1. The concrete producer shall have not less than 5 years experience in the production of structural concrete and shall have previously supplied concrete for not less than 5 projects similar in scope to this project.
2. All concrete mixers, stationary or transit-mix, shall be equipped with revolution counters in proper working order.
3. When directed by the Engineers, the concrete producer shall submit a written description of production ability, including facilities, personnel and list of similar completed projects.

- B. TESTING AGENCY: The testing agency shall provide evidence to the Engineers that an inspection of its facilities within the previous 24 months was made by the Cement and Concrete Reference Laboratory of the National Bureau of Standards and that any deficiencies noted in the report of that inspection have been corrected.

28-5 SUBMITTALS.

- A. For review, the Contractor shall prepare and submit to the Engineers data for the following items specified in this Section:
- B. Concrete mix designs.
- C. Certificates of analysis for concrete aggregates.
- D. Cement mill reports.

- E. Proposed method of concrete curing and trade names of proposed curing methods.
- F. Trade names of other proprietary items if different than those specified.
- G. Trade name and physical data of proposed nonslip aggregate.

28-6 PRODUCT HANDLING.

- A. Revolution counters shall be in operation for all concrete discharged for use on this project.
- B. All concrete shall be discharged from the mixer within one hour after the introduction of water into the mix or before the drum has been revolved 300 revolutions, whichever comes first. To insure mixing at the job site, the drum must be revolved 20 revolutions at mixing speed just before pouring.

PART II - PRODUCTS

28-7 CLASS OF CONCRETE.

Unless otherwise provided herein, or noted on the drawings, all structural concrete used in this project shall be Class "D" concrete having a minimum compressive strength of not less than 3,000 pounds per square inch at 28 days and all plain concrete shall be Class "F" having a minimum compressive strength of not less than 2,500 pounds per square inch at 28 days.

28-8 MATERIALS.

Unless otherwise provided herein, noted on drawings or approved in writing by the Engineers, all material used in concrete work shall conform to the following specifications.

- A. **CEMENT:**
 - 1. Portland cement shall conform to Specifications for Portland Cement ASTM C-150 and shall be Type I.
 - 2. When high early strength concrete is called for, use Type III.
- B. **ADMIXTURES:**
 - 1. Except as noted on the drawings, all structural and plain concrete to be used on this project shall contain an approved air entraining agent conforming to "Specifications for Air Entraining Admixtures for Concrete" (ASTM C-260). The admixture shall be used and dispensed according to the recommendations of the manufacturer.

2. Except as noted on the drawings, all structural and plain concrete to be used on this project shall contain an approved water-reducing admixture. The water-reducing admixture shall be composed essentially of water soluble reacting products of an amine and an organic acid or a hydroxylated polymer, and shall not contain lignosulfonic acid, its derivatives or calcium chloride. The admixture shall be supplied in liquid, ready-to-use form and shall be used and dispensed according to the recommendations of the manufacturer. The water reducing admixture shall meet the performance requirements of ASTM C-494, "Standard Specifications for Chemical Admixtures for Concrete."

3. Due to special construction conditions, the Contractor may request permission from the Engineers to use a retarding agent in his concrete. Such request shall be made in writing and approval received from the Engineers in writing before any retarding agents are used. Such approval shall not relieve the Contractor from any responsibility under the Contract. The retarding admixture shall be composed essentially of a complex amine salts of hydroxylated carboxylic acid or a hydroxylated polymer and shall not contain lignosulfonic acid, its derivatives or calcium chloride. The admixture shall be supplied in liquid, ready-to-use form and shall be used and dispensed according to the recommendations of the manufacturer.

4. Other admixtures, if approved by the Engineers, shall conform to appropriate ASTM Standards.

C. AGGREGATES:

1. Concrete aggregates shall conform to Specifications for Concrete Aggregates (ASTM C-33). Aggregates failing to meet these requirements but producing concrete of required quality as shown by special test or actual service may be used where authorized by the Engineers. (See Table 1, Grading of Fine and Coarse Aggregate for Concrete.)

2. The maximum size of the aggregate shall be not larger than $1/5$ of the narrowest dimension between sides of the forms within which the concrete is to be cast nor larger than $3/4$ of the minimum clear spacing between reinforcing bars, or between reinforcing bars and forms. For unreinforced slabs, the maximum size of aggregate shall not be larger than $1/3$ of the slab thickness.

D. MIXING WATER: Preferably, water used in mixing concrete shall be fresh, clean and potable. Nonpotable water may be used if mortar cubes made with the water in question have 7 and 28-day strengths equal to those of companion specimens in which potable water was used.

28-9 CONCRETE QUALITY.

- A. ALLOWABLE STRESSES: The allowable stresses for the design of the structures are based on the specified 28-day compressive strength of the concrete, or on the specified compressive strength at the earlier age on which the concrete may be expected to receive its full load. The strength of concrete, at 28 days, for which all parts of the structures were designed, unless shown otherwise on the drawings, is 3,000 psi.
- B. WATER-CEMENT RATIO: The proportioning of materials shall be based on requirements for a plastic and workable mix. When no preliminary tests of the materials to be used are made, the water-cement ratio shall not exceed, nor shall the cement content be less than that given in Table 2 for the class of concrete specified. The water in the aggregate must be included in the quantity specified and subtracted from the amount added to the mixture. It shall be measured by methods satisfactory to the Engineers which will give results within one (1) pound for each one hundred (100) pounds of aggregate. Moisture determination shall be made on representative samples at least once each day and at such other times as the appearance of the aggregate of the mixed concrete indicates a change in moisture content.
- C. PROPORTIONS FOR CONCRETE MIX: The determination of the proportions of cement, aggregate and water to attain the required strengths shall be made by one of the following methods:
1. Method 1 - Without Preliminary Tests: When no preliminary strength tests of the concrete to be used are made, the water cement ratio shall not exceed the values in Table 2.
 2. Method 2 - With Preliminary Tests and/or Field Data: Water cement ratios other than those shown in Table 2 may be used when the strength of the concrete is to be established by tests. Test specimens shall be made before beginning operations, using the consistencies suitable for the work and in accordance with ASTM Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory (ASTM C-192). Tests shall be conducted according to ASTM Method of Test for Compressive Strength of Molded Concrete Cylinders (ASTM C-39). A curve shall be established to represent the relationship between the water cement ratio and the minimum 28-day compressive strength or earlier strength at which the concrete is to receive its full working load. The range of values on the curve shall include all the compressive strengths called for on the drawings. The curve shall be established by at least three points, each point denoting average values from at least four test specimens. The water cement ratio shall correspond to a strength sufficiently high as to ensure that none of the strength tests shall have values less than the specified strength. Method 3-ACI 318-71 coefficient of variation report with appropriate over design.

- D. CONCRETE CONSISTENCY: The proportions of the concrete shall produce a mixture that will work readily, with the placement method used, into the corners and angles of the forms and around reinforcement. Segregation of materials in the mixture shall not be permitted nor the collection of excess free water on the surface.

28-10 CONCRETE TOPPINGS.

- A. FLOOR TOPPING: The floor topping indicated on the drawings shall be proportioned in accordance with Paragraph 1140 (f), "Two-Course Heavy-Duty Topping (deferred placement)" of the ACI Specifications.
- B. ROOF TOPPING: The roof topping indicated on the drawings shall be proportioned to produce a minimum compressive strength of 3,000 psi at 28 days, and shall be of a consistency to permit placement to the slopes required for drainage of the roof.

28-11 EXPANSION JOINT FILLER FOR 1/2" EXPANSION JOINT W/O WATERSTOPS.

Use bituminous impregnated, preformed type conforming to ASTM D-994. Provide joint filler between all horizontal concrete surfaces and vertical surfaces, unless otherwise noted on the drawings. Joints shall be sealed with 3/4" depth of sealer acceptable to the Engineer.

28-12 DUSTPROOFING HARDENER.

- A. For all interior concrete floor surfaces to be left permanently exposed to view, apply a two-coat treatment of "Clearbond" manufactured by Guardian Chemical Company, "Lapidolith" manufactured by A. C. Horn Co., or equal. Remove all foreign materials, including mortar, paint, etc., to prevent any foreign materials from showing through the finished surface.
- B. One coat shall be applied upon completion of curing of the slab and one coat applied after final painting and other finishes are complete. The final result shall be a transparent appearance which, when subjected to an abrasion test made with a stiff wire brush, shall not dust but shall polish without showing abrasion.

28-13 CONCRETE CURING

Use Opeic Poly (5 mils thick or greater) or curing paper, as directed by the Engineer.

Where curing paper is selected for final curing of flatwork, Sisalkraft "Orange Label," Ludlow Papers, Inc., "Scuf-Champ," "Glas-Kraft" Grade A, or equivalent concrete curing paper conforming to ASTM C-171, Type I, shall be used.

28-14 MEMBRANE-FORMING CURING COMPOUND.

Liquid membrane-forming curing compounds shall be wax free resin type capable of retaining 95% of the moisture for the specified curing period and shall conform to ASTM C-309, Type I, and shall contain a red fugitive dye. Curing compound applied to surfaces to be

left permanently exposed to view shall not cause permanent discoloration or otherwise adversely affect the appearance of these surfaces. Curing compounds shall not be used on surfaces to receive hardeners or other finishes.

28-15 NONSHRINK GROUT.

- A. All column base plates and all equipment base plates shall be grouted with nonshrink grout, whether called for or not on the drawings.
- B. Nonshrink grout used for grouting column base plates and equipment base plates shall be non-catalyzed metallic aggregate grout capable of developing full strength without vertical confinement, and requiring no cutting or capping of shoulders. It also shall be used at a self-leveling (fluid) consistency.
- C. If nonmetallic nonshrink grout is required by the Engineers for special applications, it must be capable of developing full strength without vertical confinement and require no cutting or capping of shoulders. It also shall be used at a self-leveling (fluid) consistency.

28-16 NONSLIP AGGREGATE:

Concrete surfaces to receive a "Nonslip Finish" shall receive a "dry shake" application of crushed ceramically bonded aluminum oxide abrasive particles. The material shall be pre-mixed by the manufacturer and applied as recommended by the manufacturer.

28-17 STONE FILL UNDER SLABS-ON-GRADE.

A minimum thickness of 4" of N.C. Department of Transportation, Division of Highways Standard Size No. 5 stone shall be provided under all slabs on grade within the building lines and at other locations noted on the drawings.

28-18 VAPOR BARRIER UNDER SLABS-ON-GRADE.

"Moistop," manufactured by American Sisalkraft Corporation, "Ply-Bar Plus" manufactured by Glas-Kraft, Inc., "Sealtight Premoulded Membrane" by W. R. Meadows, Inc., or equal conforming to the requirements of ASTM E-154, shall be provided under all slabs on grade within the building lines and at other locations noted on the drawings.

PART III - EXECUTION

28-19 PREPARATION OF EQUIPMENT.

- A. Before placement, all equipment for mixing and transporting the concrete shall be cleaned and all debris and ice shall be removed from the places to be occupied by the concrete. Forms shall be thoroughly wetted (except in freezing weather) or oiled, and masonry filler units that will be in contact with concrete shall be well drenched (except in freezing weather). The reinforcement shall be thoroughly cleaned of ice, dirt, rust, scale or other coatings.

- B. Water shall be removed from place of deposit before concrete is placed unless otherwise permitted by the Engineers. All laitance and other unsound material shall be removed from hardened concrete by sand blasting, chipping or wire brushing before additional concrete is added.

28-20 INSPECTION.

After the reinforcing steel is in place and all formwork completed, and at least 24 hours before placing concrete, the Contractor shall notify the Engineers that the work is ready for his inspection. The Engineers will then inspect the work. The Contractor shall have capable men on the job who shall assist the Engineers in inspecting the work and who shall make all changes in the work required by the Engineers prior to placing concrete. No concrete shall be placed except when the Engineers are on the job and have approved the work and authorized the placing of the concrete.

28-21 STORAGE OF MATERIALS.

Cement and aggregates shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter. Liquid admixtures shall be protected from freezing and from settling out of solution. Any deteriorated or damaged material shall not be used for concrete.

28-22 MIXING.

- A. Ready-mixed concrete shall be mixed and delivered in accordance with Specifications for Ready-Mixed Concrete (ASTM C-94).
- B. For job-mixed concrete, the mixer shall be rotated at a speed recommended by the manufacturer. Each batch of one cubic yard or less shall be mixed for at least one minute after all materials are in the mixer. The mixing time shall be increased 15 seconds for each additional cubic yard or fraction thereof. The entire batch shall be discharged before the mixer is recharged. If job-mixed concrete is used, all equipment and methods of mixing employed must be approved by the Engineers.

28-23 CONVEYING.

- A. Concrete shall be conveyed from the mixer to the place of final deposit by methods that will prevent separation or loss of materials.
- B. Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete at the delivery end without separation of materials.

28-24 PLACING.

- A. Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. Unless approval is granted by the Engineers, concrete shall not be dropped more than 3'. Chutes or "elephant trunks" shall be used to deposit concrete for drops greater than 3'. The

placing of concrete shall be carried on at such a rate that concrete is at all times plastic and flows readily into the spaces between the bars. No concrete that has been contaminated by foreign material shall be used, nor shall retempered concrete be used unless approved in writing by the Engineers.

- B. When placing is once started, it shall be carried on as a continuous operation until placement of the panel or section is completed. When construction joints are necessary, they shall be made in accordance with "Construction and Expansion Joints," as hereinafter specified.
- C. All concrete shall be thoroughly consolidated by suitable means during placement. It shall be thoroughly worked around reinforcement and embedded fixtures and into the corners of the forms.

28-25 WATERTIGHT STRUCTURES.

All concrete structures shall be made watertight. The Contractor shall use all means necessary to produce structures that are absolutely watertight against hydraulic pressure both from inside and from outside. Concrete walls, etc. that show seepage or damp spots will not be accepted until this condition is corrected. No waterproofing ingredients shall be added to the concrete mix unless approved by the Engineers. Should contraction cracks occur in the concrete work, the Contractor shall make such repairs as necessary to produce a watertight structure. The Contractor shall lap all splice bars in temperature and structural reinforcement not less than 40 diameters.

28-26 COLD WEATHER REQUIREMENTS.

- A. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near freezing weather. No frozen materials or materials containing snow or ice shall be used.
- B. All reinforcement, form, fillers and ground with which the concrete is to come in contact shall be free from snow and ice. Whenever the temperature of the surrounding air is below 40°F, all concrete placed in the forms shall have a temperature of 40°F or higher after placement. Adequate means shall be provided for maintaining this temperature for 4 days. When high early strength concrete is used, a temperature of at least 45°F shall be maintained for 3 days. In either case, any additional time necessary to ensure proper curing of the concrete shall be provided as directed by the Engineers. The housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heating is discontinued. No salt or other devices shall be used for the prevention of freezing.

28-27 HOT WEATHER REQUIREMENTS.

- A. In hot weather, suitable precautions shall be taken to avoid drying of the concrete prior to finishing operations. Use of windbreaks, sunshades, fog sprays or other devices shall be provided as directed by the Engineers.

- B. Concrete deposited in hot weather shall not have a placing temperature that will cause difficulty from loss of slump, flash set, or cold joints. Concrete temperature shall be less than 90°F unless higher temperatures are permitted by the Engineers.

28-28 CONDUIT, PIPES, ETC., EMBEDDED IN CONCRETE.

- A. Conduits, pipes, sleeves, etc., with the outside diameter not exceeding 1/3 the thickness of concrete and spaced not closer than 3 diameters on center may be placed in the center of slabs, walls, beams, columns, etc., unless approved by the Engineers. Concrete covering shall be not less than 1" and preferably 2".
- B. Piping carrying liquid, air, gas, etc., shall be tested immediately prior to placing concrete and again after concrete has attained its designed strength.

28-29 CONCRETE PROTECTION FOR REINFORCEMENT.

- A. The reinforcement shall be protected by the thickness of concrete indicated in the drawings. Where not otherwise shown, the thickness of concrete over the reinforcement shall be as follows:
 - 1. Where concrete is deposited against the ground without the use of forms - not less than 3".
 - 2. Where concrete is exposed to weather or to the ground but placed in forms - not less than 2".
 - 3. In slabs and walls not exposed to the ground or to the weather - not less than 3/4".
 - 4. In beams, girders and columns not exposed to the ground or to the weather - not less than 1 1/2".
 - 5. In all cases - at least equal to the diameter of the bars.
- B. Exposed reinforcing bars intended for bonding with future extensions shall be protected from corrosion by concrete or other adequate covering.

28-30 CONSOLIDATION.

- A. All concrete shall be consolidated by the use of mechanical vibrators operated by experienced workmen under competent supervision. Supplement vibrating by spading and rodding. No forking or raking shall be permitted. Vibrators and consolidation shall conform to the requirements of ACI-609.
- B. Where the drawings require concrete fill to be placed in concrete masonry units, cavity walls or other similar locations where proper placement and consolidation cannot be made, the concrete may be proportioned with 3/8" maximum aggregate size and the maximum slump increased to 8", provided the minimum strength requirements are maintained.

28-31 GROUTING.

- A. In concrete columns, walls and where conditions impair consolidation of concrete, or where reinforcement is congested, the Contractor shall first deposit in the forms, batches of grout containing proportions of one part cement to two parts of concrete sand with sufficient water for workability to a depth of at least 3".
- B. The Contractor shall provide nonshrink grout under all column bases and beam bearings on masonry or concrete, whether or not called for on the drawings.

28-32 SLABS-ON GRADE WITHIN BUILDING LINES.

- A. Prior to placing reinforcement, the grade shall be prepared, the fill and stone base materials compacted and the vapor barrier, keyways, joint material and other imbedded items placed as required by the drawings and other Sections of the Specifications.
- B. The vapor barrier shall be placed by lapping all edges a minimum of 4" and sealing continuously with an approved roofing mastic, waterproof tape or equivalent material. Seal around all piping and other openings through the vapor barrier and turn up edges 2" minimum at the walls and other vertical surfaces.
- C. Screed chairs or other objects shall not be permitted to damage or penetrate the vapor barrier or waterproofing membrane. Buggy runways shall be used where concrete is required to be transported over the vapor barrier or waterproofing membrane. Screeds may be set in mounded concrete in lieu of screed chairs.

28-33 CONSTRUCTION JOINTS AND 1" EXPANSION JOINTS.

- A. Joints not indicated on the drawings shall be so made and located as to impair least the strength of the structure. Where a joint is to be made, the surface of the concrete shall be thoroughly cleaned and all laitance removed by sweeping the top of the joint with a stiff broom just before the concrete becomes thoroughly hard. No such joints shall be made without first obtaining the permission of the Engineers in writing.
- B. A delay until the concrete is no longer plastic in columns or walls (generally, at least 2 hours) must occur before concrete is placed in the beams, girders or slabs to be supported. Beams, girders, brackets, column capitals and haunches shall be considered as part of the floor system and shall be placed integrally with it.
- C. Construction joints in floors shall be located near the middle of the spans of slabs, beams or girders. If a beam intersects a girder at this point, the joint in the girder shall be offset a distance equal to twice the beam width and adequate shear reinforcement provided.

- D. Provision shall be made at expansion and construction joints to prevent water leakage. All construction joints shall have a minimum 1/8" by 8" wide steel plate waterstops continuous for the full length of the joint, embedded on each side of the joint as required by the drawings. When the waterstop exceeds 15" in width, it shall be 3/16" steel plate. A construction joint keyway shall have a width of at least 1/3 of the wall width. The ratio of depth to width of a construction joint keyway shall be at least 1/2. Joints at intersection and at ends of steps shall be welded to form continuous waterstop. Expansion joints shall have a continuous strip of 3/8" polyvinyl plastic or synthetic rubber (SBR), 9" wide, embedded 4" into the concrete on each side of the joint and having a 3/4" bulb to form a bellows in the center such as Type 7C as manufactured by Serviced Products Corporation, type SS.7 large "O" as manufactured by Saf-T-Grip Specialties or equal.
- E. Each piece of waterstop shall be of maximum practicable length in order that the number of end joints will be held to a minimum.
- F. Joints at intersections at ends of pieces shall be made in the manner most appropriate to the material being used. Joints shall develop effective watertightness fully equal to that of the continuous waterstop material and shall develop not less than 50% of the mechanical strength of the parent section.
- G. In expansion joint construction, in connection with the waterstop, use an approved premolded expansion joint filler 1" thick conforming to ASTM D-1752-67, Type I. In expansion joint construction, the outermost 1/2" of the joint shall be filled with an approved two component polyurethane joint sealing compound for horizontal joints. Caulk vertical joints with an approved nonsag two component polysulfide that shall be suitable for use in potable water supplies with EPA and State approval. Expansion joints shall be provided as shown on the drawings and as approved by the Engineers.

28-34 PATCHING CONCRETE.

A. PATCHING:

1. If any concrete work is not formed as shown on the drawings or if, for any reason, is out of alignment or level or shows a defective surface, it shall be considered as not conforming with the intent of these Specifications and shall be removed from the job by the Contractor at his expense, unless the Engineers grant permission to patch the defective area. Permission to patch any such areas shall not be considered a waiver of the Engineers' right to require complete removal of the defective work if the patching does not, in their opinion, satisfactorily restore the quality and appearance of the surface.
2. Immediately after removing forms, all concrete surfaces shall be inspected and any poor joints, voids, stone pockets or other defective areas permitted by the Engineers to be patched and all the holes shall at once be patched before the concrete is thoroughly dry. Defective areas shall be chipped away to a depth of not less than 1" with the edges

perpendicular to the surface. Such areas are to be patched and a space at least 6" wide entirely surrounding them shall be wetted to prevent absorption of water from the patching mortar. The defective areas shall be patched with a mortar containing a special bonding agent mixed and applied in accordance with the manufacturer's instructions. The mortar shall be made of the same material and of the same proportions as used for the concrete except that the coarse aggregate shall be omitted. The amount of water used in mixing the mortar shall be as little as consistent with the requirements of handling and placing.

3. The mortar shall be thoroughly compacted into place and screeded off so as to leave the patch slightly higher than the surrounding surface. It shall then be left undisturbed for a period of one to two hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface.

28-35 PROPRIETARY PATCHES.

If approved or required, proprietary compounds for adhesion or as patching ingredients may be used in lieu of or in addition to the foregoing patching procedures. Such compounds shall be used in accordance with the manufacturer's recommendations.

28-36 FINISHES.

The finishing of concrete work shall be in accordance with Chapters 10 and 11 of the ACI Specifications.

- A. At the completion of consolidation of the concrete, the tops of all footings, pile caps and grade beams shall be floated to a level and plane surface with wood or metal floats.
- B. Exterior formed surfaces to be left permanently exposed to view shall receive a "Smooth Rubbed Finish."
- C. Exterior flatwork shall receive a "Broom Finish."
- D. Exterior and interior concrete steps except those with abrasive nosing, exterior slabs, platforms and landings and interior and exterior ramps shall receive a "Non-slip Finish" of approved ceramically bonded aluminum oxide abrasive particles.
- E. Interior flatwork to receive terrazzo, concrete topping or other cementitious finish applications shall receive a "Scratched Finish."
- F. The floor topping indicated on the drawings shall be placed in accordance with Paragraph 1104(f), "Two Course Heavy Duty Topping (deferred placement)" of the ACI Specifications.
- G. All other interior flatwork shall receive a "troweled finish."

28-37 CURING AND PROTECTION.

- A. Provisions shall be made for maintaining concrete in a moist condition for a period of at least 7 days after placement. For high early strength concretes, however, moist curing shall be provided for at least the first 3 days when concrete and air temperatures are above 50°F; longer periods of curing shall be required when temperatures are below 50°F.
- B. All concrete shall be cured by one or more methods specified in Chapter 12 of the ACI Specifications. Membrane forming curing compounds shall not be used on any surfaces against which additional concrete or other cementitious finishing materials are to be bonded.
- C. Waterproof curing paper shall be used for final curing of flatwork only. When selected for final curing, the paper shall be placed as follows:
 - 1. Unroll curing paper over the entire surface to be cured. Lap ends and edges a minimum of 4" and seal continuously with masking or pressure sensitive tape and provide sufficient weights over paper to prevent separation from concrete surface.
 - 2. Curing paper shall be used for curing purposes only one time.
- D. Additional care shall be exercised in protecting and curing the concrete topping to prevent rapid loss of moisture at any time during and immediately after the curing period.

28-38 FIELD QUALITY CONTROL.

A. TESTING:

- 1. Routine testing of materials and concrete for compliance with the Specifications shall be the responsibility of the Contractor. The Contractor shall be responsible for taking, handling, transporting and curing of concrete samples.
- 2. Six cylinders shall be molded from each sample of concrete for compressive strength tests. Two specimens shall be tested at 7 days and two specimens tested at 28 days, and two spares to be tested in case of low 28-day breaks.

B. FAILURE TO MEET STRENGTH REQUIREMENTS:

- 1. If strength tests fail to meet the minimum requirements of the Engineers, the concrete represented by such tests shall be considered questionable and shall be subject to further testing at the expense of the Contractor.
- 2. Additional tests of questionable concrete shall be conducted at the expense of the Contractor in accordance with "Methods of Securing, Preparing and Testing Specimens from Hardened Concrete for Compressive and Flexural Strengths" (ASTM C-42).

3. Additional tests of the hardened concrete may be required by the Engineers even though the requirements of the Specifications are met when, in their opinion, there is cause for concern over the adequacy of the structure.
4. If core tests fail to demonstrate strengths adequate for the intended purpose of the member or members in question, as determined by the Engineers, or if the failure to meet specified strength requirements occurred in members from which it is impracticable to secure test specimens by the method of ASTM C-42, load tests shall be conducted and their results evaluated in accordance with Chapter 2 of "Building Code Requirements for Reinforced Concrete" (ACI-318).

C. FIELD REVIEW BY THE ENGINEERS:

1. The Contractor shall give ample notice to the Engineers prior to placing concrete to permit field review of the general construction work as well as mechanical, electrical and other work to be incorporated in the concrete.
2. The Contractor shall afford the Engineers whatever casual labor, platforms, ladders or other access as may be required for proper field observation of the concrete work.
3. Field review of the work by the Engineers shall in no way relieve the Contractor of his responsibility to furnish materials and workmanship in full compliance with the drawings and Specifications.

END OF SECTION 28.

SECTION 37

HORIZONTAL DIRECTIONAL DRILLING (HDD)

A. DEFINITIONS:

1. Annular Space: the space between the HDD final reamed bore diameter and the product pipe or cable.
2. Bent Sub: A section of drill pipe behind the cutting tools that is inclined at an angle at one to three degrees from the axis of the bore in the desired direction of steering. The bent sub allows steering while rotating the cutting tools.
3. Drilling Fluid/Mud: A mixture of water, bentonite, and/or polymers continuously pumped to the drilling tools to facilitate the removal of soil cuttings, and stabilization of the bore. These fluids also cool the cutting tools and lubricate the drill pipe and product pipe string.
4. Drill String: The total length of the drill pipe in the borehole.
5. Drilling Tool/Bit: Any tool or system of tools which excavates at the face of a bore.
6. Entry Pit: The location where the pilot bore initially penetrates the ground surface and where the HDD rig is positioned.
7. Exit pit: The location where the pilot bore exits the ground surface.

8. Horizontal Directional Drilling (HDD): A surface-launched, guided, steerable drilling system used for the trenchless installation of pipes, conduits, and cables. A pilot bore path is excavated in a shallow arc from a surface-launched drill rig. Excavation takes place with fluid assisted cutting from a drilling tool on the drill string. The pilot bore is directed by the positioning of a bent sub. Tracking of the drill string is achieved by using a downhole wireline survey tool which shall be augmented by using an energized wire grid at the surface. The bore is filled with drilling fluid/mud for stabilization, to cool the cutting tools, and to mix the cuttings into a slurry, which is circulated to the entry point where solids are removed before the drilling fluids are returned to the bore. The bore path is enlarged with subsequent reaming passes until the desired diameter is achieved. The product pipe, conduit, or cable is then pulled into the fluid-stabilized bore hole.

9. HDD Work Plan: Written descriptions, together with sketches, profile drawings, schedules, and other documents defining Contractor's plans and procedures for horizontal directional drilling. This HDD Work Plan also includes a detailed inadvertent return and subsidence analysis and any changes proposed to the boring lengths, depths, entry/exit pit locations or angles.

10. Inadvertent Return: Uncontrolled flow of drilling fluid/mud to the surface at a location other than the entry or exit pit.

11. Obstruction: Any hard object lying completely or partially within the design pathway of the bore and pipe that prevents further advancement of the drill pipe, pre-reamer, reamer, and/or pipe, after all reasonable Contractor attempts to advance past the object or re-drill around the object have failed.

12. Pilot Bore: The action of creating the first guided pass of the HDD process which is then reamed in one or more passes to the size required to allow pullback of the pipe.

13. Pullback: The part of a horizontal directional drilling process in which the drill pipe, swivel, and product pipe or cable is pulled back through the bore to the entry.

14. Pullback Loads: The loads (forces) applied to a drill string and product pipe during the pullback process. In addition to the tensile pullback loads, bending, buckling and combination loads must be considered in design.
15. Reamer: A cutting tool pushed or pulled through the borehole in order to enlarge the pilot bore hole to a diameter sufficient for the installation of the product pipe.
16. Tracer Wire: Wire used to track the drill string, achieved by using a downhole wireline survey tool. An energized wire grid at the surface augments the tracer wire.
17. Settlement Point: A point with elevation and spatial location established by survey prior to construction. The point is re-surveyed periodically to monitor ground movements. The point may be a nail, pin, subsurface settlement rod, borehole extensometer, or other device that can be readily located and surveyed.

B. REFERENCE STANDARDS:

1. Horizontal Directional Drilling Good Practices Guidelines, Latest Edition, HDD Industry Consortium, 300pp.
2. Pipeline Design for Installation by Horizontal Directional Drilling, ASCE Manuals and reports on Engineering Practice No. 108, 2005.

C. SUBMITTALS:

1. Submittals shall provide sufficient detail to allow the Engineer to judge whether or not the proposed equipment, materials, and procedures will meet the Contract requirements. The Engineer's review of submittal details and data will be based on considerations for the completed Work, utilities, and the possibility of necessary delays in the execution of the Work to be constructed under the Contract. Review and acceptance of the Contractor's submittals by the Engineer shall not be construed in any way as relieving the Contractor of its responsibilities under the Contract.
2. The following is the summary of information to be included in shop drawing submittals required for the HDD Work. All submittals shall be signed and sealed by a licensed Professional Engineer registered in the State of North Carolina.

- a. Qualifications: The Contractor shall submit written documentation of HDD superintendent and key personnel experience.

- b. Schedule: No later than fifteen (15) working days prior to mobilization for HDD operations, the Contractor shall submit a detailed schedule for the HDD installation showing all major construction activities and durations, with beginning and completion dates shown. The schedule shall be updated at least every and shall include:
 - i. Utility locate requests and visual confirmation of all crossing utilities and all parallel utilities within the vicinity of the bore centerline.
 - ii. Risk Mitigation Meeting.
 - iii. Rig mobilization and setup.
 - iv. Pilot bore drilling.
 - v. Pre-reaming and reaming.
 - vi. Layout and fusing/welding/assembly of pipe.
 - vii. Final reaming and pullback of pipe.
 - viii. Pressure testing of pipe after installation.
 - ix. Mandrel/pig test to confirm deformations of pipe are within allowable tolerances.
 - x. Cleanup, surface restoration, and demobilization.

- c. Safety Plan: The Contractor shall submit a Safety Plan, including the name of the Contractor's Site Safety Representative, emergency telephone numbers for medical facilities, and precautions for handling and disposal of any hazardous or flammable materials. The Safety Plan shall include a code of safe practices and an emergency plan in accordance with OSHA requirements.

- d. Methods, Equipment, and Materials Description Plan: The Contractor shall submit detailed description of methods, equipment, and materials to be used for the pipeline installation. Descriptions of drilling fluid additives shall be accompanied by Materials Safety Data Sheets (MSDS) and Manufacturers' descriptions and warranties. Descriptions of equipment shall include Manufacturers' specifications, calibrations, appropriate drawing, photographs, and descriptions of any modifications since manufacture.

- e. Surveying Equipment and Procedures: The Contractor shall submit records of equipment calibrations and certifications for all equipment used for downhole surveys and tracking of the drill head. Procedures for operating the downhole survey tools shall be described, including measures to verify the accuracy of the equipment readings.

- f. Protection of Adjacent Structures and Facilities Plan: The Contractor shall submit a plan that provides details on measures to be taken to monitor and protect adjacent utilities, structures, roadways and sidewalks, and provide details on monitoring equipment and provisions, including the layout of all settlement points and other monitoring points. Provide two (2) copies of preconstruction survey of adjacent structures and photographs with captions to document preconstruction conditions prior to beginning HDD construction.

- g. Contingency Plan for Remediation of Potential Problems: The Contractor shall submit a Contingency Plan for Remediation of Potential Problems that may be encountered during the drilling operations. The contingency plans shall address the observations that would lead to the discovery of the problem and the methods that would be used to mitigate the problem. Items to be discussed in the plan include, but is not limited to, the following:
 - i. Loss of returns/loss of circulation of drilling fluids.
 - ii. Inadvertent returns/hydrofracture or surface spills resulting in drilling fluids entering surface waters or reaching the ground surface.
 - iii. Encountering obstruction during pilot bore or reaming/pullback.

- iv. Drill pipe or product pipe cannot be advanced.
 - v. Deviations from design line and grade exceed allowable tolerances.
 - vi. Drill pipe or product pipe broken off in borehole.
 - vii. Product pipe collapse or excessive deformation.
 - viii. Utility strike.
 - ix. Deviation from planned bore path.
 - x. Hydrolock occurs or is suspected.
 - xi. Excessive ground settlement or heave.
- h. Disposal of Spoils and Drilling Fluids Plan: The Contractor shall submit plans for disposal of waste materials resulting from the pipeline construction, including drilling fluids, cuttings, waste oil, fuel, discharge water, etc. Identify the disposal site(s) and submit a letter indicating willingness and legal authority to accept the described and anticipated waste products.
- i. Equipment Layout Plan: The Contractor shall submit a plan which provides sketches depicting the layout and locations of equipment within the rig side work area and pipe side work area, including any proposed drilling fluid containment and recirculation pits. The Contractor shall confirm that all operations shall be completely contained within the permanent and temporary construction easements shown on the Contract Documents.
- j. Inadvertent Return and Surface Spill Contingency Plan: An Inadvertent Return and Surface Spill Contingency Plan shall be prepared and the Contractor shall be capable of implementing the plan immediately should an Inadvertent Return or Surface Spill occur during the HDD work. The Contractor shall submit letter signed by an authorized representative of the Contractor confirming that the Plan will be followed. If required by permit conditions, the Contractor shall revise the Plan as necessary to satisfy the associated regulatory agency.

- k. Horizontal Directional Drilling Work Plan: The Contractor shall submit a HDD Work Plan complete with drawings and written description identifying details of the proposed method of construction and the sequence of operations to be performed during construction including placement and method of attachment. The plan shall include:
 - i. A detailed plan and profile of the bore, showing utilities and structures and plotted at a scale no smaller than one inch equals 40 feet horizontal and one inch equals four feet vertical. Proposed deviations from the Contract Documents shall be shown; and,
 - ii. Details of the planned bore path and the method for monitoring and controlling the speed, line, grade and rate of fluids delivery. Include the sequence, size, and description of each reamer and capabilities of each through anticipated geologic formation. Include details on the swabbing of the borehole prior to pullback of the pipe.

- l. Soil Separation Plan: The Contractor shall submit details on the pump and soil separation plan. Include dimensions, manufacturer's specifications, pump capacity, etc. on the system.
 - i. Pump capacity shall be specified for water at sea level elevation and adjusted for actual elevation and fluid viscosity.
 - ii. Provide details on the generator, including dimensions, noise ratings at 25 feet, etc. Confirm that the generator meets any applicable regulatory requirements.

- m. Maximum Allowable Drilling Fluid Pressure Calculations: The Contractor shall submit calculations identifying the critical downhole pressure that would cause hydrofracture or inadvertent return of drilling fluid. The calculations shall identify the critical points in the alignment and near the exit point where the soil cover above the bore is low. The calculations shall identify all parameters used and state all assumptions made in the calculations. The calculations shall be signed and sealed a licensed Professional Engineer registered in the State of North Carolina.

- n. Pipe Filling Methods and Testing: Submit methods and procedures for filling the pipe with water during pull back and testing.
- o. Pipe Stress Calculations: Submit calculations for pipe stresses expected to result from the pullback, bending, buckling loads, earth loads, groundwater loads, and other installation and service loads expected to be exerted on the pipe. The calculations shall identify parameters and state the assumptions made in the calculations including: the radius of curvature; assumed drilling fluid weights; whether or not the pipe is assumed to be filled or empty during pullback; and temperature. The calculations shall be signed and sealed by a licensed Professional Engineer registered in the State of North Carolina.
- p. Pullback Calculations: The Contractor shall submit calculations for pullback loads for the conditions and operating practices anticipated. In addition to the tensile pullback loads, bending, buckling and combination loads must be considered in design. The calculations shall identify all parameters used and the state all assumptions made in the calculations. The calculations shall be signed and sealed by a licensed Professional Engineer registered in the State of North Carolina.
- q. Radius of Curvature Confirmation: Confirm that the bore can be completed using the radius of curvature and geometry shown on the Contract Drawings along with the calculations showing that installation stresses do not exceed allowable pipe stresses.
- r. Rig Capacity Plan: Submit a plan which provides details on the capacity of the drill rig verifying that the pullback capacity is greater than the calculated required pullback.
- s. Contact Grouting Plan: The Contractor shall submit descriptions of methods, equipment, and materials to be used for contact grouting any areas where over-excavation, aborted bores, voids, or cavities are created or encountered during construction.

3. Construction Records: The following shall be submitted as construction progresses and at the completion of construction.
 - a. Daily Logs and Records: The Contractor shall submit complete, legible, written daily logs and records by noon of the following day to which the records correspond.
 - b. Drilling and Reaming Rates: The Contractor shall submit maximum drilling speeds and reaming rates for pilot bore and each reaming pass and confirm that the pump capacity is adequate for these anticipated drilling rates for the mud and/or drilling fluid weights and viscosities anticipated. These shall be submitted to the Engineer on a daily basis.
 - c. Drilling Fluid Viscosity and Density (Mud Weight): The Contractor shall submit measured mud and/or drilling fluid weights used during pilot boring and reaming of the bore measured at a minimum of three times per shift or at least once per 200 feet of drilled or reamed length, whichever is more frequent, with at least two (2) hours between readings.
 - d. Pilot Bore As-Built Profile: The Contractor shall submit an as-built profile of the pilot bore within 24 hours of completion of the pilot bore.
 - e. Pressure Test Records: The Contractor shall submit all pressure test records for post installation tests. These shall be submitted within 24 hours of completion of such tests.
 - f. Variations in Plan and Profile: The Contractor shall document any variations between the actual Contract Drawings and profile of the bore path and the location shown on the Contract Drawings. The Contractor shall notify in writing and by telephone the Engineer immediately upon discovery of any deviations.

4. Risk Mitigation Meetings: At least 15 working days prior to the specified HDD segment of the work, the Contractor and HDD superintendent shall attend a risk mitigation meeting (or conference call) with representatives of the Engineer and Owner for the HDD crossing to discuss major operations milestones. Specific risk mitigation meetings shall be held and include a discussion of the following as a minimum:
 - a. Drilling of pilot-hole.

- b. Pre-reaming and reaming.
- c. Layout of pipe.
- d. Pressure testing of pipe prior to pullback.
- e. Final reaming and pullback of pipe.
- f. Pressure testing of pipe after installation.
- g. Pig test.
- h. Protection and monitoring of adjacent and/or overlying structures, roadways, sidewalks and utilities.

D. PERFORMANCE REQUIREMENTS:

1. The Contractor shall provide all equipment, materials, and personnel necessary for completing the installation as shown on the Contract Drawing and specified herein. The equipment and materials shall include but are not limited to:
 - a. Directional drilling rig with all ancillary equipment, including drill pipe, drilling fluid, cutting tools, reaming bits, swivels, expanders, motors, pumps, hoses, mixing equipment, drilling fluid processing equipment (cuttings separation equipment), downhole survey equipment, energized surface grid tracking system, fluid pressure and flow rate monitoring equipment, spare parts, pipe handling equipment (cranes, backhoes, rollers, side boom tractors) control equipment, and office equipment.
 - b. Drilling fluids, water, fuel, lubricant, polymers, or other additives. Any other expendable or reusable materials, supplies, and equipment needed for the installation.
2. The drilling equipment shall be capable of advancing through the geologic conditions to be encountered at the site, as encountered in the applicable test boring logs.

3. The drilling fluid shall be designed for the geologic conditions to be encountered at the site, as described in the test borings and as anticipated by the Contractor.
4. The drilling system shall include a fluid pump and separation plant that can achieve the rates of drilling fluid pumping, spoil separation, and slurry cleaning required by the Contractor to achieve planned production rates for the soils as anticipated by the Contractor. Shaker screens and hydrocyclones may be required for efficient separation of spoils.
5. All spoil and slurry must be contained in trucks, tanks, approved recirculation pits, or other containers at all times. Dumping of spoil or slurry on the ground, discharge into sewers, or discharge into the water bodies will not be permitted. All spoils will be transported and disposed of off-site at an approved disposal facility that meets all State of North Carolina and local requirements.
6. Perform all Work within Work areas shown on the Contract Drawings or in areas obtained by the Contractor with written approval from the affected property owner.
7. The pipeline shall be installed using the radii of curvatures and entry and exit angles as specified herein, or as shown otherwise on the Contract Drawings, unless deviations are approved in writing by the Engineer.
8. For sections of pipe that are to be fused/welded, pipe rollers and lifters will be required to help the transition of the carrier pipe into the bore and to minimize the pull force. The number of pipe rollers and lifters shall be determined by the Contractor in accordance with the pipe supplier's recommendations. Location and spacing of the rollers and lifters will be done in accordance with the pipe manufacturer's recommendations based on bend radius and to protect pipe during pullback over hard or sharp surfaces. All pipe rollers and lifters will be in a condition so as not to damage the pipe during construction activities.
9. It shall be the Contractor's sole responsibility that all Work is done in conformance with all applicable federal, state, and local safety requirements. Required safety equipment and procedures shall be employed by the Contractor at all times.
10. The Contractor shall allow access to the Owner and/or Engineer and shall furnish necessary assistance and cooperation to aid the Engineer in observations and data and sample collection, including, but not limited to the following:

- a. The Owner and/or Engineer shall have full access to the operator control container prior to, during, and following all HDD operations. This shall include, but not be limited to, providing visual access to real-time operator control screens, gauges, and indicators.
 - b. The Owner and/or Engineer shall have full access to the slurry separation plant prior to, during, and following all HDD operations. This shall include, but not be limited to, full access to shaker screens, hydrocyclones, conveyor belts, and slurry and spoil holding tanks. The Engineer shall be allowed to collect soil samples from the shaker screens and/or spoil holding tanks on the slurry separation plant a minimum of once per installed pipe section, and whenever changes in conditions are observed or suspected. If requested, the Contractor shall assist in the collection of these samples as directed by the Engineer.
11. Contractor shall comply with all local noise ordinances. Sound levels in excess of these values are sufficient cause to have the Work halted until equipment can be quieted to these levels. Work stoppage for excessive noise shall not relieve the Contractor of the portions of this Specification including, but not limited to completion of all Work within specified Contract Time and Contract Price. The Contractor shall submit a Plan prior to construction identifying all noise reduction/abatement procedures. The Plan will be reviewed by the Engineer prior to construction. If mufflers cannot achieve the necessary noise reduction, noise abatement shall be accomplished by the Contractor's installation of baffles (or other acceptable means) positioned to break line-of-sight from the noise source to affected residences and/or commercial structures. Minimum noise abatement measures shall consist of equipping all engines with hospital grade mufflers or silencers.

E. QUALITY ASSURANCE:

1. Contractor Qualifications and Experience: The Contractor shall meet the following minimum qualifications:
 - a. Contractor must be licensed in the State of North Carolina as an underground utility Contractor for a minimum of five (5) years.
 - b. The Contractor shall have at least five (5) years of demonstrated successful experience installing pipelines by the means of HDD.

- c. The Contractor must have successfully completed three (3) water projects where the carrier pipe was installed with HDD techniques.
 - d. Contractor shall provide the following for each project:
 - Project Description
 - Pipe Size, Length, Material, DR
 - Bore Length
 - Soil Types
 - Owners' contact information
 - Engineer's contact information
 - Change Orders
 - Scheduled Completion Date and Actual Completion Date
2. The Contractor will be required to employ skilled, experienced superintendent(s), equipment operator(s) and personnel throughout the project. The superintendent shall have at least five (5) years of successful experience using the HDD process.
 3. The HDD equipment operator for this project shall have at least three (3) years of successful experience using the HDD process.
 4. The Contractor shall furnish resumes of the superintendent(s) and key personnel. Personnel experience records should include project names, locations, project description, project owner, Engineer, and references with names, addresses, and telephone numbers.
 5. The superintendent listed in the submittal shall be on site during all construction related activities required for the HDD installation for this project.
 6. The Contractor shall not be allowed to alter their personnel assigned to the project without prior written approval from the Engineer and owner.

7. Daily Logs and Records: Daily logs and records shall be maintained by the Contractor and shall include the following:
 - a. Drilling lengths.
 - b. Location of drill head.
 - c. Drilling fluid pressures and flow rates.
 - d. Drilling fluid losses.
 - e. Inadvertent returns.
 - f. Drilling times required for each pipe joint.
 - g. Any instances of retraction and re-drilling of the pilot bore or segments thereof
 - h. Any other relevant observations, including any observed settlement, heave, frac-outs, or surface spills.
 - i. The downhole annular drilling fluid pressures shall be measured and recorded throughout the pilot hole drilling. These records shall be maintained and provided daily to the Engineer. The position of the drill head shall be continuously tracked and recorded. A plot of actual locations of the bore path shall be maintained and updated daily.
8. Advance Notices and Inspections: The Contractor shall provide at least 72 hours advance written notice to the Engineer of the major drilling activities, including pilot bore launch, pre-reaming, reaming, and pipe pullback. The Contractor shall immediately notify the Engineer, in writing, when any significant problems are encountered or if ground conditions are considered by the Contractor to be materially and significantly different than those represented within the test boring logs. All Work by the Contractor shall be performed in the presence of the Engineer, unless Engineer grants prior written approval to perform such Work in Engineer's absence.
9. Surveying Equipment and Procedures: All surveying equipment used for downhole surveying and tracking of the bore path and drill head shall be inspected and calibrated by the equipment manufacturer prior to use. Proof of this inspection and calibration shall be provided to the Engineer prior to commencement of drilling operations.

F. PRODUCTS:

1. Drilling fluids: The Contractor shall select drilling fluid mixture proportions to ensure continuous circulation, bore stability, reduce drag on the pipe, and completely fill the annular space between the bore and the pipe to control settlement. Management and disposal of drilling fluids shall be the Contractor's responsibility. Drilling fluids shall not be disposed of on-site or discharged to sanitary or storm sewers, or the waterways or adjacent wetlands.

2. Drill pipe: The Contractor shall provide high quality drill pipes that have been inspected and determined to be adequate for the project requirements. Bent, racked, or fatigued drill pipes shall not be used. Threads must be in good condition. The length of each drill pipe shall be measured and recorded.
3. Carrier pipe: The Contractor shall pipe which conforms to the most conservative design with respect to design calculations for the critical combination of internal and external pressure, pullback and bending.
4. Water: The Contractor shall secure a suitable source of water, and shall be responsible for transporting, storing and disposing of water required.
5. Cement grout: Cement grout shall consist of one part cement to six parts sand. The quantity of cement may be increased or decreased as necessary and as permitted by the Engineer to provide good flowing characteristics.

G. EXECUTION:

1. General:

- a. The Contractor shall provide adequate control of surface water and drilling fluids drainage and runoff, and provide silt fences, hay bales, and wattles to prevent surface water or drilling fluids from being transported off-site.
- b. The Contractor shall not initiate HDD until all submittals are received, reviewed, and approved by the Engineer.
- c. The Contractor shall not initiate HDD until all required permits are obtained. Copies of all permits shall be provided to the Engineer prior to construction.
- d. It is the Contractor's responsibility to provide barricades, fencing, or other safety measures to prevent public access into Work and staging areas.

2. Protection of underground utilities:

- a. The Contract Drawings show existing buried utilities that are believed to be near the directional drill alignment. There is no guarantee that these utilities are located as shown or that other utilities are not present. It will be the Contractor's responsibility to field locate all nearby utilities or other potential subsurface obstructions that may interfere with the Work.

- b. The Contractor shall notify the “North Carolina 811 System” to request marking of utilities that subscribe to the System, and shall individually notify all other known or suspected utilities to request marking of these utilities. The Contractor shall confirm that all requested locates are made prior to commencing drilling operations. Contractor shall make all diligent efforts to locate any unmarked or abandoned utilities using all available information, maps, and drawings. The Contractor shall visually confirm and stake all existing lines, cables, or other underground facilities including exposing all crossing utilities and utilities within twenty (20) feet laterally of the centerline of designed drilled path.

3. Work staging area:

- a. Barricades, Warning Signs, and Lights: The Contractor shall, in accordance with approved Traffic and Safety Plans, erect appropriate barriers, warning lights, and signs, painted with approved colors, warnings, and graphics to ensure adequate warnings to personnel and the public.
- b. Combustible Materials: Combustible materials (fuel, oil, lubricants, etc.) shall be stored off-site or in a well-ventilated storage facility removed from the immediate vicinity of the drilling area by at least twenty (20) feet.
- c. Construction Impacts: The Contractor shall maintain the Work area in a manner that shall minimize adverse impacts on other public use activities. The Contractor shall proceed with Work in a safe, orderly manner, while maintaining the Work site free of debris and unnecessary equipment and materials.
- d. Control of Drilling Fluids: The Contractor shall follow all requirements of the Inadvertent Return and Surface Spill Contingency Plan as submitted and approved and shall control operational pressures, drilling mud weights, drilling speeds, and any other operational factors required to avoid hydrofracture fluid losses to formations, and control drilling fluid spillage. This includes any spillages or returns at entry and exit locations or at any intermediate point. All inadvertent returns or spills shall be promptly contained and cleaned up by the Contractor.

The Contractor shall maintain on-site mobile spoil removal equipment during all drilling, pre-reaming, reaming, and pullback operations and shall be capable of quickly removing spoils. The Contractor shall immediately notify Engineer of any inadvertent returns or spills and immediately contain and clean up the return or spill.

- e. Removal of Temporary Facilities: At the completion of construction, the Contractor shall remove all temporary facilities installed by the Contractor. Unused soil, aggregate, and other materials shall be removed and disposed of at approved sites in accordance with Federal, State, and Local regulations. Any damage to streets, lawns, common areas, and sidewalks shall be restored to original or better conditions at no additional cost to the Owner. All disturbed areas shall be revegetated.
- f. Site Security: The Contractor shall install an enclosure fence around the Work area. The enclosure fence shall be adequate to prevent entry of unauthorized persons. The Contractor is completely responsible for their own site security throughout the entire duration of construction.
- g. Temporary Lighting: The Contractor shall procure and maintain all temporary lighting needed for Contractor's operations, safety, testing, and inspection. Temporary lighting shall be removed immediately after completion of construction.
- h. Work Staging: The Contractor shall be responsible for obtaining staging areas and all necessary approvals and permits for storage of equipment and materials, parking, drilling and other Work.
- i. Pipe Layout Staging Areas: The Contractor shall:
 - i. Obtain a pipe layout area if not otherwise provided by the owner as part of project easements, etc. shown on the contract drawings;
 - ii. Limit the pipe layout to the pipe staging area;
 - iii. Visit the proposed areas prior to submitting a bid for this work;
 - iv. Not conduct excavation or earthwork activities in the pipe staging area without prior acceptance by the Engineer; and
 - v. Be responsible for securing necessary permits and approvals for the use of the temporary staging area layout of the pipe.

H. MOBILIZATION:

1. The Contractor shall mobilize all equipment, materials, and personnel necessary to construct the carrier pipeline using the HDD process at the locations shown in the Contract Drawings.
 - a. Entry Area: The Contractor shall set up temporary workspace within the areas delineated on the Contract Drawings. Appropriate precautions and measures shall be employed by the Contractor to prevent erosion, surface drainage, and spillage of drilling fluids or other materials that could adversely impact the environmental quality of the site. Silt fences, hay wattles, and hay bales shall be used to line the Work area to minimize erosion and contain any spillage or runoff. Shovels, brooms, buckets, and barrels shall be kept on-site to facilitate containment and cleanup. A vacuum truck or trailer unit will be on standby and capable of responding within one hour to any spill or inadvertent return incident.
 - b. Exit Area: the exit area shall have appropriate precautions and measures for containing drilling fluids and cuttings. The Contractor shall use appropriate methods to minimize erosion and runoff. Containment and cleanup equipment shall be available to contain and clean up any surface spills and inadvertent returns.
 - c. Pipe Layout Area: Layout area shall be free of stones, wood, debris, and obstructions. Pipe rollers shall be provided by the Contractor during the assembly process to facilitate pipe joining and pullback. Pipe rollers and all pipe handling shall be non-abrasive and cushioned using special devices and methods to prevent damage. Pipe rollers that are uncushioned, unsteady or in any way pose a possibility of damaging or scratching the pipe shall not be used. The pipe layout area may not allow the entire length to be joined in a single length before start of pull-in. Contractor will plan work accordingly. The Contractor shall maintain access to all properties unless written permission has been granted by the individual property owners.

I. HORIZONTAL DIRECTIONAL DRILLING:

1. Drill Rig Capacity: The capacity of the directional drilling system used by the Contractor shall be adequate to install the specified pipeline.

2. Pump Capacity: The pumps used by the Contractor shall be adequate to supply the required flow rate and pressures at the anticipated drilling fluid viscosity at all times. Drilling speeds shall not exceed pump capacity. Drilling speeds shall be monitored continuously during HDD operations.
3. Bore Tracking and Monitoring: At all times during the pilot bore the Contractor shall provide and maintain a bore tracking system that is capable of accurately locating the position of the drill head in the x, y, and z axes. The Contractor shall record these data at least once per drill pipe length or every twenty (20) feet, whichever is less.
 - i. Tracking System: Monitor and record the x, y, and z coordinates relative to an established surface survey benchmark. Where the pilot hole is greater than 10 feet from the surface, a downhole wire line tracking locator system shall be installed between the entry point and the exit point. The coordinates of the surface wire grid system shall be surveyed and recorded. The grids shall be surveyed to establish horizontal and vertical position to 0.1 foot accuracy.
 - ii. Deviations between the recorded and design bore path shall be calculated and reported on the daily log. If the deviations exceed tolerances specified, such occurrences shall be reported immediately to the Engineer. The Contractor shall undertake all necessary measures to correct deviations and return to design line and grade.
 - iii. Drilling Fluid Pressures and Flow Rates: Drilling fluid pressures and flow rates shall be continuously monitored and recorded by the Contractor. The pressure shall be monitored at the pump. These measurements shall be made during pilot bore drilling, reaming, and pullback operations.
 - iv. Drilling Speeds: Maximum allowable drilling speeds shall be calculated by the Contractor for pilot boring and each reaming pass and shall not be exceeded for pilot boring or reaming passes. Measurements shall be taken every twenty (20) feet or thirty (30) minutes, whichever is more frequent.
 - v. Drilling Fluid Viscosity and Density (Mud Weight): The Contractor shall measure and record drilling fluid viscosity and density at least three (3) times per shift or at least once per 200 feet of drilled and reamed length, whichever is more frequent with at least two (2) hours between readings, using calibrated Marsh funnel and mud balance. These measurements shall be included in daily logs submitted to the Engineer.

The Contractor shall document modifications to the drilling fluids, by noting the types and quantities of drilling fluid additives and the dates and times when introduced. The reason for the addition of drilling fluid additives or other modifications shall be documented and reported.

4. Location of Entry and Exit Points: Entry and exit points shall be as shown on the Contract Drawings, unless otherwise approved in writing by the Engineer. The Contractor shall employ experienced licensed surveyors registered in the State of North Carolina to locate the entry and exit points, and to establish horizontal and vertical datum for the bore and the pipe layout and fabrication areas.
5. Entry and Exit Angles: Drill entrance and exit angles shall be as shown on the Contract Drawings or unless otherwise approved in writing by the Engineer.
6. Pilot Bore: The pilot bore shall follow the design path of the bore shown on the Contract Drawings.
 - a. Horizontal and Vertical Tolerances: Horizontal and vertical deviations shall be less than plus or minus two (2) feet from the design path centerline. The Contractor shall continuously monitor horizontal and vertical position and record the position at least once per drill pipe length, or every twenty (20) feet, whichever is less.
 - b. Radius of Curvature: The radius of curvature shall not be less than that shown on the Contract Drawings.
 - c. Entry and Exit Tolerances: The location of the entry and exit points shall be in accordance with the approved HDD Work Plan. The Contractor shall be solely responsible for all Work necessary to correct excessive deviations from line and grade, including re-drilling, redesigning connections, and acquiring additional easement, at no additional cost to the Owner and without schedule extension.
7. Pre-reaming and Reaming: The pilot bore shall be pre-reamed and reamed using equipment and methods submitted by the Contractor. The Contractor shall completely pre-ream the bore to the final diameter prior to pullback.
8. Pipe Pullback:
 - a. A final swabbing of the bore path prior to pullback of the carrier pipe is required.
 - b. The pipe shall be installed by pulling it into the reamed bore path in a continuous operation, behind a final reaming tool selected by the Contractor. Consideration shall be given that the carrier pipe may not be able to be pulled into the bore path in a continuous operation and that pulling may need to be temporarily suspended during intermediate fusing/welding of the carrier pipe.

- c. The pipes shall be isolated from excessive torsional and axial stresses by a swivel device.
 - d. All measurements shall be made, recorded, and submitted on the daily logs during final reaming and pipe pullback.
 - e. Pulling Loads: The maximum pull (axial tension force) exerted on the carrier pipeline shall be measured continuously and limited to the maximum allowed by the pipe Manufacturer so that the pipe or joints are not overstressed. A factor of safety over the maximum allowable is not required.
 - f. Pipeline Support: The pipelines shall be adequately supported during installation so as to prevent overstressing or buckling. The Contractor shall provide adequate support/rollers along the stringing area to support the required length of the carrier pipe for each bore. Such support/rollers shall be spaced according to the pipe supplier, and the rollers shall be comprised of a non-abrasive material arranged in a manner to provide support to the bottom and bottom quarter points of the pipeline allowing for free movement of the pipeline during pullback. The pipe layout area shall be cleared of all large stones, construction debris, or other foreign objects that could damage the piping during pullback.
 - h. The leading end of the pipe shall be closed during the pullback operation, in accordance with the pipe supplier's recommendations. A pulling head shall be used that is rated at the allowable pull force capability of the pipe section being installed, in accordance with the pipe supplier's recommendations.
 - i. Each length of pipe shall be inspected and cleaned as necessary to be free of debris immediately before joining.
9. The Contractor shall at all times handle the carrier pipe in a manner that does not overstress or otherwise damage the pipe. Vertical and horizontal curves shall be limited to manufacturer's recommended bend radius so that wall stresses do not exceed the allowable bending radius as recommended by the pipe supplier. If the pipe is buckled or otherwise damaged due to Contractor's acts or omissions, the damaged section shall be removed and replaced by the Contractor at his expense. The Contractor shall take appropriate steps during pullback to ensure that the carrier pipe and tracer wires will be installed without damage.
10. If the pull has mid-welds, the Contractor shall engage the pipe Manufacturer to provide a Welding Technician to ensure Quality Assurance and Quality Control (QA/QC) of the midwelds during the Pullback operation.
11. The Contractor shall monitor and inspect pipe rollers and method for suspending pipe at entry during the pullback operation to avoid damage to the pipe.

12. The Contractor shall cease operations if the carrier pipe is damaged and shall remove the pipe from the bore and repair the pipe using the Manufacturer's recommended procedure or replace the damaged pipe before resuming installation.
13. Damage to the pipe resulting from installation or contact grouting is the responsibility of the Contractor, including costs for replacement and labor and materials at no cost to the Owner.
14. After the carrier pipe is completely installed, a sufficient period as recommended by the pipe Manufacturer shall be provided before the final pipe tie-in.
15. Upon completion of pullback and grouting, perform the following cleaning on the completed pipeline.
 - a. After the installation of the carrier pipe, swab inside of pipe with a flexible polyurethane foam swab complete with rear polyurethane drive seal.
 - b. In tandem, swap with a one to two pounds per cubic foot pig for proving, sweeping and sealing and a five to seven pounds per cubic foot pig for wiping.
 - c. The tandem swabs shall make a minimum of two passes through the entire pipeline.
 - d. Cleaning and flushing shall be accomplished by propelling the swab down the pipeline to the exit point with potable water. Flushing shall continue until the water is complete clear.
16. Final Hydrostatic Test: The Contractor shall conduct a final hydrostatic test of the installed pipeline. The Contractor shall repair any defects discovered during the test, and repeat until the pipe passes the test.
17. Flushing: The Contractor shall be responsible for flushing prior to startup.

J. ANNULAR SPACE AND CONTACT GROUTING:

1. The Contractor shall be prepared to grout the annular space between the bore and the outer diameter of the carrier pipe prior to the mandrel or pig test.

2. Grouting shall be completed within 48 hours of completion of the final hydrostatic test. Grouting procedures shall be in accordance with approved submittals. The grouting operations shall ensure that the both annulus are filled with grout for at least 100 feet from entry point and the last 100 feet before exit point. Grouting may be accomplished using one or more of the methods described below, or an alternative submitted by the Contractor, subject to Engineer's approval. The Contractor shall ensure that the annulus does not provide a preferential pathway for seepage regardless of the method(s) used and shall ensure that settlements shall not cause damage to existing utilities, roadways or structures.
3. Tremie pipe: Tremie pipes shall be inserted into the borehole, for at least 100 feet from both entry and exit ends after the carrier pipe pullback is completed to grout the annular space between borehole and carrier pipe, or any other voids created or encountered above the borehole. Tremie grout pipes shall be not less than 1-1/4 inch, Schedule 40 PVC, and shall be inserted at the crown and at two locations 60 degrees from the crown. Grout will be injected in sufficient volume to completely fill the annulus as the tremie pipes are withdrawn. Grouting pressures shall be carefully controlled and monitored to avoid applying excessive pressure to the pipe and to avoid heave or hydrofracture. The pipes shall be filled with water during grouting to counterbalance grouting pressures and to avoid excessive heat of hydration as the grout sets that could damage the pipes. Mix grout into drilling fluids and inject with drilling fluid as pipe is pulled back 100 feet to grout annulus at entry side. Grout shall be mixed into drilling fluid recirculation/distribution system and shall be injected as drilling fluid as the tremie pipe is pulled back. The grout mixture shall satisfy performance requirements of drilling fluid before set and requirements of annulus grout after set. Retarding agents may be incorporated into grout mixture to allow sufficient time to complete pipe pullback before initial grout set. The exit side annulus shall be grouted by inserting a tremie pipe(s) into the bore annulus and pipe annulus for at least 100 feet from the exit end as described in 1 above. Grout/drilling fluid injection pressures shall be less than pressures that could result in collapse of the pipe or hydrofracture of the surrounding soil.

K. OBSTRUCTIONS:

1. The Contractor shall notify the Engineer immediately in the event that any obstruction is encountered that prevents further advancement of the drill pipe, or pullback of the pre-reamer, reamer, and/or pipe.
2. The Contractor shall make all diligent and reasonable efforts to advance past the object by drilling slowly through the object, pulling back, and drilling along a new bore path that avoids the object, or excavating and exposing and removing the object, and all other reasonable attempts to continue the bore.

3. The Contractor shall notify the Engineer of proposed measures to attempt to advance past the object, prior to initiating the attempt. If the Contractor attempts to pullback and re-drill, the Contractor shall adhere to line and grade tolerances established in this Specification section, unless the Engineer approves variance, in writing, prior to the Contractor's attempt to re-drill.
4. The Contractor and Engineer shall investigate the cause and together determine an appropriate response. Appropriate response may include revisions to equipment or methods, retraction and re-drilling of a portion of the bore, or abandonment of the hole.
5. If abandonment is deemed necessary, the Contractor shall recover, to the extent practicable, any drill pipe, product pipe, and tools in the bore, and properly abandon the bore by contact grouting unless otherwise directed in writing by the Engineer. If the bore is abandoned, the Contractor shall be allowed to begin a second attempt to install the pipeline at an alternate location subject to approval, in writing, by the Engineer. The Contractor shall take all reasonable actions to complete the installation with minimal delays.

L. SITE RESTORATION AND DEMOBILIZATION:

1. The Contractor shall remove all equipment, materials, drilling fluids, muck, waste, and debris from the site and restore the site to its original condition upon completion of the installation. Restoration and demobilization shall be completed by the Contractor within seven (7) calendar days of the completion of the pipeline installation.
2. Settlement Monitoring: The Contractor shall visually monitor for settlement or heave before and during drilling and grouting operation at the locations shown on the plans and/or as determined during the pre-construction survey. The settlement monitoring locations shall be surveyed to the nearest 0.01 foot and recorded prior to drilling operations and each day drilling operations are ongoing. A final record of spot elevations shall be recorded two weeks after pipe installation is complete and presented with the record drawings. Areas found to have significantly settled or heaved will require restoration. The Engineer will determine what constitutes significant settlement or heave. The Contractor will restore these areas at no cost to the Owner.

END OF SECTION 37.