

SECTION 145

RAILROAD AND HIGHWAY CROSSINGS TUNNEL METHOD

PART 1 - GENERAL

1.01 SCOPE

The Contractor shall, under this item, furnish all of the necessary labor, materials, equipment and services for mining the tunnels and furnishing and installing the carrier pipe including necessary shafts and sumps for the proper installation of the pipe lines including furnishing and placing of concrete, liner plates, pressure grout, cradles, bases, fills, wood blocking, horizontal alignment and settlement monitoring equipment, and all other appurtenances required for the proper completion of the sewer construction in tunnels as shown on the contract drawings and as specified herein.

It is understood that a diversity of materials may be encountered in sinking the shafts and excavating the tunnels, including clay, quicksand, rock, and debris from previous construction, etc. It will be the Contractor's responsibility for safety within the tunnel and completing the tunnel installation for any and all conditions for the price bid in the Bid Schedule.

1.02 SHOP DRAWINGS AND SPECIFICATIONS

Complete specifications and product information shall be submitted to the Engineer in accordance with the requirements of the section.

A. Shop drawing shall include the following:

1. Tunnel linings showing sizes, shapes, methods of attachment, and connection details with location and details of grout holes.
2. Design mix of concrete grout.
3. Tunnel method of construction:
 - a. The contractor has the option to select the exact method of excavation used in the tunneling method, including ground water control.
 - b. The contractor shall submit working drawings and written procedure describing in detail the proposed tunnel method and entire

operation for conformity and compliance with the Specifications. This shall include but not be limited to tunnel shafts, tunnel support, dewatering, ground stabilization if proposed, excavation procedures, support of tunnel face and initial supports, grouting procedures, detection of surface movement, procedure for installing pipe, supports, and anchors, and placement of grout between pipe and tunnel liner. If, in the opinion of the Contractor, modifications to the methods are required during construction, working drawings shall be submitted which delineate such modifications and reasons for said modifications.

- c. The Contractor is required to submit for approval the method he proposes for monitoring settlement and horizontal alignment prior to the start of construction.

B. Certified test reports shall be submitted for the following:

1. Liner plate segments for tunnel linings.
2. Tunnel liner plate connectors.

1.03 STORAGE AND DELIVERY

All materials shall be stored and protected with strict conformance to the manufacturer's recommendations and as approved by the Engineer.

1.04 GUARANTEES

The Contractor shall provide a guarantee against defective equipment and workmanship in accordance with the requirements of the section entitled "Guarantees and Warranties", of these Specifications.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Cement, sand, concrete, grouting material and steel reinforcing shall conform to the requirements of the applicable items of these Specifications.
- B. Structural steel liner plates shall be as manufactured by Armco Drainage and Metal Products Company, Republic Steel Corporation, Commercial Pantex-Sika, or approved equal. Liner plates shall conform to ASTM Specification A 569 and shall be of the thickness shown on the Drawings. Liner plates shall be of the two-flange, lap-joint or the four-flange type. Bolts and nuts used shall be a minimum of 1/2-inch in diameter for plate thickness equal to or greater than

0.179 inch; bolts and nuts shall also conform to the latest revision of ASTM A 307. Each liner plate ring shall have three 1-1/2-inch or 2-inch-diameter grout holes with plug for grouting in each ring. Rings shall be installed with holes set to allow complete filling of voids with grout. Liner plates used for railroad crossings shall be hot dipped galvanized in accordance with AREA 1-4-25 or ASSHTO M167.

- C. All plates shall be of uniform fabrication and those intended for one size tunnel shall be interchangeable.
- D. The material used for the construction of these plates shall be new, unused and suitable for the purpose intended. Workmanship shall be first class in every respect.
- E. Carrier pipe shall be push-on joint ductile iron pipe conforming to the Section of these Specifications entitled "Ductile Iron Pipe, Ductile Iron and Cast Iron Fittings".
- F. Grout fill between the tunnel liner and carrier pipe shall consist of a sand-cement grout with one part portland cement and three parts fine aggregate. The water-cement ratio shall be 0.62 by weight.
- G. The void behind the liner plates shall be filled with sand-cement pressure grout. The sand-cement content shall be one part portland cement to 3 parts fine aggregate. The water-cement ratio shall be 0.62 by weight.
- H. The minimum liner plate thickness shall be the thicker of that shown on the Drawings or listed in the Bid Schedule. At the Contractor's option, a heavier gauge liner plate material may be used at no increase in cost to the Owner.

PART 3 - EXECUTION

3.01 GENERAL

- A. The Contractor or Subcontractor must be fully equipped and experienced in the installation of large diameter structures by tunneling. As evidence of his experience in this type of work, the Contractor shall submit to the Engineer specific information covering the successful installation by his company of at least six similar structures.
- B. The Contractor shall inspect the location where the tunnel is to be installed and familiarize himself with the conditions under which the work will be performed and with all necessary detail as to the orderly prosecution of the work. The omission of any details for the satisfactory installation of the work in its entirety,

which may not appear herein, shall not relieve the Contractor of full responsibility.

- C. Construction of the tunnel shall be carried on in such a manner that settlement of the ground surface above the tunnel shall be held to an absolute minimum. Where ground conditions are unstable, a suitable shoring method must be implemented, as approved by the Engineer, and shall be used to prevent caving of material above the tunnel before the liner plates can be installed.
- D. Mining for tunnels and all classes and types of excavation, the removal of rock, muck, debris, the excavation of all working pits backfill, requirements of Section 20, "Earthwork," are included under this section.
- E. Tunnel construction shall be performed so as not to interfere with, interrupt, or endanger surface and activity thereon, and minimize subsidence of the surface, structures, and utilities above and in the vicinity of the tunnel. Support the ground continuously in a manner which will prevent the loss of ground and keep the perimeters and face of the tunnel, passages, and shafts stable.

The Contractor shall be responsible for all settlement resulting from tunnel operations and shall repair and restore damaged property to its condition prior to being disturbed at no cost to the Owner.

Rock, voids, unstable materials, debris, and/or water, if encountered, shall not entitle the Contractor to additional compensation.

F. Tunnel Operations

1. Control the tunnel face using such support procedures as breasting, poling plates, face jacks, sliding tables, either singly or in combination, spaced as required.
2. When using liner plates, advance excavation in increments, sufficient for the placement of one ring of liners and install liner plates immediately after each increment of excavation. Excavate in such a manner that voids behind the liner plates are held to a minimum. Completely fill such voids with grout placed under pressure.
3. Whenever the tunnel operation is suspended, support the tunnel face by positive means and keep dewatering system operating. Have qualified personnel periodically check conditions that might threaten the stability of the tunnel.

3.02 EXCAVATION METHODS

- A. Underground excavation shall be performed by methods best suited to the local conditions and which do not induce damage to adjacent surface or underground structures and/or utilities. Excavation shall be performed to the size, shape, and within the tolerances shown on the contract drawings, or herein specified, for the type of lining to be installed, and to accommodate all of the necessary tunnel supports and other components as indicated on the contract drawings, as directed or approved by the Engineer, according to conditions encountered.
- B. Prior to the start of excavation in any area, the Contractor shall submit to the Engineer a detailed plan showing pertinent data in detail for each stage of excavation including equipment to be used in accomplishing the work to be performed.
- C. Adequate sheeting, shoring and bracing for embankments, operating pits, and as elsewhere required shall be placed and maintained in order that work may proceed safely and expeditiously. Upon completion of the work, the sheeting, shoring and bracing shall be left in place, cut off, or removed as designated by the Engineer.
- D. Any solidifications of embankments or unstable soil in the heading or sides of the tunnel shall be the Contractor's responsibility and shall be done at his expense.
- E. All excavation for the entire length of the tunnel shall be done by tunneling from one end of the tunnel. The periphery of the tunnel shall be trimmed smooth to fit the outside of the steel liner plate as nearly as is practical.

3.03 SAFETY AND INTEGRITY OF STRUCTURES

- A. The Contractor shall assume full responsibility for the safety of all excavations performed under this section, as well as for the safety and integrity of all existing structures, equipment, and personnel that may be affected by his work, until the completion and acceptance of the work. In fulfillment of his responsibility, the Contractor, subject to the provisions of these Specifications, shall adopt any and all measures that he may consider necessary to avoid damage to excavations and structures.
- B. All drilling, blasting, barring down of loose rock, mucking-out and removal of material shall be performed, and surrounding rock supported, in a manner that will insure the safety of the personnel and the work.

3.04 BLASTING

- A. Blasting shall be permitted only after the proper precautions have been taken for the protection of all persons, work and property. Blasting within 50 feet of cured

concrete, except shotcrete, will be permitted only after submission by the Contractor of a plan showing the relative positions of the concrete, the area to be blasted and blasting technique to be employed. In any event, all concrete work shall be protected by limiting the size of blasts, covering blasts, and by other means until it is certain that there is no danger of damage caused by either shock waves or fly rock.

3.05 BLASTING TECHNIQUES

- A. The Contractor shall exercise all possible care in his drilling and blasting operations to ensure the stability of the remaining rock and to keep overbreak and overdrilling to a minimum. All excavated surfaces shall be as smooth and sound as the nature of the rock permits. It shall be the Contractor's responsibility to produce the most satisfactory surface utilizing the rock failure process of blasting, by determining the proper relationships of the factors of burden, spacing, depth of charge, amount and type of explosive, hole size and delay pattern, as well as well as other necessary considerations to achieve the required results.
- B. For the surfaces of all walls and arches, controlled perimeter blasting techniques involving the positioning of closely spaced, uniformly loaded perimeter holes, shall be used to produce smooth excavated surfaces. Modifications to the controlled blasting methods shall be made as required to achieve the best obtainable results and to keep the vibrations within limits acceptable to the Engineer.

3.06 BLASTING INFORMATION TO BE FURNISHED BY THE CONTRACTOR

The service of at least one person thoroughly qualified in the use of explosives shall be provided by the Contractor to design the blasts and implement their execution. Prior to the start of work, the Contractor shall submit qualifications of such person or persons to the Engineer for approval and will be responsible for all blasting and field supervision aspects of the project and his position will not be substituted without approval by the Engineer.

3.07 TEMPORARY VENTILATION

The Contractor shall provide temporary ventilation of the underground work areas in a manner that will ensure the supply of fresh air in adequate quantities at all times.

3.08 DUST CONTROL

All drilling and tunneling operations shall be conducted by methods and with equipment which shall positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities.

3.09 TEMPORARY DRAINAGE FACILITIES

- A. The Contractor shall furnish, operate and maintain temporary drainage to remove all water entering the excavation. Water bearing seams in the rock tunnel shall be drained as directed by the Engineer. The Contractor shall furnish and place approved or directed by the Engineer, and shall connect them to the drainage system in order to prevent the water flowing into the tunnel from interfering with or damaging the work. The pans and shields are to be properly supported. The cost of furnishing, maintaining and removing such temporary pans and shields is deemed to be included in the unit prices for tunneling.
- B. The Contractor shall maintain and operate pumps, well points, drainage system and equipment to keep the work dewatered at all times, as may be necessary.
- C. When water is encountered, provide and maintain a dewatering system of sufficient capacity to remove water on a 24-hour basis keeping excavation free of water until the backfill operation is in progress. Methods of dewatering shall be at the option and responsibility of the Contractor. Maintain close observation to detect settlement or displacement of surface facilities due to dewatering. Should settlement or displacement be detected, notify the Engineer immediately and take such action as necessary to maintain safe conditions and prevent damage.

3.10 DISPOSAL OF EXCAVATED MATERIAL

The disposal of all excavated material or spoil shall be the responsibility of the Contractor. He shall remove all spoil from the site of the work and dispose of the same, at his own expense, at sites secured by him, unless specified disposal areas are provided.

3.11 INSTALLATION OF LINER PLATES

- A. Steel liner plates shall be installed in excavated tunnels. The liner plates shall be installed progressively as excavation proceeds. Excavation shall not continue more than 24 inches past the end of the liner plate already in place. At this time an additional section of liner shall be installed before excavation shall continue.

Grout shall be placed under pressure in the annular void as the excavation proceeds. Grouting shall be done continuously after each ring is installed.

When work is interrupted for any reason, no ring shall be left ungrouted. Grouting shall follow progressively with each adjacent set of holes. Grout should be continuously placed as close to the heading as possible, using grout stops if necessary. Grout shall be injected in the lower holes first, moving upward as the back space is filled. Threaded plugs shall be installed after filling each grout hole. The water-cement ratio and cement sand content of the grout shall be as

specified previously in this section and as approved by the Engineer. All grout shall be placed under pressure sufficient to fill all voids entirely by pumps and/or other equipment manufactured for the purpose and operated in accordance with the manufacturer's instructions.

- B. Steel liner plates shall be installed in accordance with manufacturer's instructions to lines and grades as shown on the contract plans.
- C. As liner plate rings are installed, the Contractor shall consecutively number the rings, using a method which will remain legible while the work progresses. The number shall be placed at the three or nine o'clock position and carried at that location through the entire length of tunnel. Furthermore, the distance from the tunnel entrance shall be labeled at even 10-foot increments.

3.12 INSTALLATION OF CARRIER PIPE

- A. After the tunnel liner is installed, the carrier pipe shall be installed exercising care at all times to protect the interior of the tunnel liner and to maintain tight, fullseated joints in the carrier pipe. The carrier pipe shall be installed at the proper line and grade without any sags or high spots.
- B. The carrier pipe shall be held in place in the tunnel liner by the use of hardwood blocks spaced radially around the pipe and secured together so that they remain firmly in place. The spacing of such blocks longitudinally in the casing pipe shall not be greater than 10 feet.

3.13 FILL BETWEEN TUNNEL LINER AND CARRIER PIPE

- A. After each joint of the carrier pipe has been installed properly and secured as described above, the annular space between carrier pipe and the tunnel liner shall be filled using sand-cement grout as described previously in this section. The grout shall be installed beginning at the end of each piece of pipe and shall completely fill the space to the other end before the next joint of pipe is installed. Care shall be exercised at all times to maintain the carrier pipe at its proper line and grade.

3.14 SETTLEMENT

- A. The Contractor shall take appropriate measures to monitor surface and subsurface settlement on a daily basis at no additional cost to the Owner.
- B. The Contractor shall report any settlement or horizontal movement to the Engineer and to the Agent of the highway or railroad immediately and confirm the

report in writing as soon as practical after discovery of the settlement or movement, and take immediate remedial action at no cost to the Owner.

- C. In the event that settlement or heave becomes apparent, the Contractor shall immediately cease work and take immediate required action to prevent further settlement or heave. The Contractor shall also restore surface elevations to the levels existing prior to the start of tunnel operations.
- D. Whenever the tunnel operation is suspended, support the tunnel face by positive means and keep dewatering system operating. Have qualified personnel periodically check conditions which might threaten the stability of the tunnel.

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