SECTION 02315
TUNNELING - EXCAVATION AND LINING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: The loosening, loading, removing and disposing in the specified manner of all materials, wet or dry, necessary to be removed for purposes of tunnel construction; and furnishing, placing and maintaining of all sheeting, bracing and lining; dewatering; the protection of existing structures and utilities from injury; the protection and repair of street surfaces and sidewalks; and all incidental work necessary for completion.

B. Related Work Specified in Other Sections Includes:

1. Section 02222 - Excavation - Earth and Rock
2. Section 02223 - Backfilling
3. Section 03311 – Concrete for Non-Plant Work

C. Unit Prices:

1. Unauthorized Excavation: Wherever excavation is performed outside of the specified outside dimensions of the lining section to allow the placing of the sheeting, bracing or lining and whenever excavation if performed beyond the lines of the finished work for convenience, and whenever material outside of the specified outside dimensions of the section, caves or breaks into the tunnel, fill the remaining space, outside of the lines of the finished work, with grout of the quality specified in Section 03311 with no addition to the Contract Price.

2. Dispose of excavated material with no addition to the Contract Price.

3. Include all work required to construct, maintain, operate and backfill the shafts, line and construct the tunnel to be built under this Contract, including costs resulting from the use of compressed air for construction.

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM A 36/36M - Specification for Carbon Structural Steel

2. ASTM A 307 - Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
3. ASTM B 8 - Specification for Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft

4. ASTM B 33 - Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

1.3 SUBMITTALS

NOTE: Provide a list of required submittals.

A. Provide all submittals, including the following, as specified in Division 1.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PREPARATION

A. Make all arrangements necessary for the construction and operation. Design and carefully construct shafts so as to preclude the loss or movement of ground that may damage nearby utilities and structures, and to comply with the requirements of the U.S. Department of Labor Safety and Health Regulations for Construction promulgated under the Occupational Safety and Health Act of 1970 (PL-91-596). Before commencing excavation for shafts and tunnels, submit, for the record, four copies of complete design calculations and working drawings for the proposed shafts, and tunnel lining, including liner plates and all bracing arrangements, signed and sealed by a Professional Engineer registered in the State of Florida. Submission of design calculations and drawings, however, does not relieve the CONTRACTOR of responsibility to provide and install adequate and safe shafts, tunnel lining and bracing. Repair and restore any damage to nearby utilities or structures resulting from the design or construction of the shaft or tunnel lining.

3.2 INSTALLATION

A. Shafts: Construct shafts of proper size and shape, and equip suitably to allow the work to be carried on expeditiously.

1. Provide cages, wells, or safety devices where ladders are used for a total length of climb exceeding 20 feet but not exceeding 30 feet. For a total
length of climb exceeding 30 feet, provide landing platforms for each 30 feet of climb or fraction thereof together with cages, wells or safety devices wherever the length of climb to or from a platform exceeds 20 feet. Install suitable protection at the bottom of the shaft to properly protect the workers.

2. Provide shafts with an adequate guardrail with a toeboard around the periphery of each shaft.

3. Upon the completion of the work, completely backfill all shafts, drifts and tunnels which are not part of the finished work.

4. Backfill as specified in Section 02223 unless otherwise shown or noted.

B. Tunnel Construction: Construct tunnels with mechanical excavating machines with protective shields, or by other approved methods.

1. Perform hauling in tunnels by means of electric locomotives with totally enclosed controllers, motors, resistors and batteries. Use signal lights to indicate when a locomotive is energized.

2. Use fireproof materials in all above-ground tunnel plant structures, within 100 feet of the shaft. Use driven steel sheet piling, steel bracing and tight wood or steel lagging or steel liner plates on all shafts. In tunnel construction, use steel ribs and wood lagging and concrete, steel liner plates or other approved material. Construct electrical service buildings of wood, steel or other approved materials.

3. Provide a ventilation system to properly ventilate all sections of the tunnel. Provide a minimum of 200 cfm of air for each worker in the tunnel.

4. Hoisting in shafts may be done by means of a crane. Keep the crane at least 20 feet away from the shaft with the exhaust at least 30 feet away to prevent contamination of shaft area air. In the event performing construction operations out of a single central shaft is desired, use cages exclusively for hoisting workers and materials during construction of the tunnel, except during the construction of the shaft. Provide hoisting equipment with all safety devices, including landing dogs at all landings, effective devices to prevent overwinding, and down speed regulators. Make cages of metal, fitted to metal guide bars running from top to bottom, constructed and equipped with strong metal covers, screens and automatic devices for the protection of persons riding in them.

C. Excavation: Excavate tunnel and trim to such size and shape as will allow the placing of the full masonry section after all lining is in place.

NOTE: Consult geotechnical engineer to determine allowable unsupported tunnel length.
1. Excavate the tunnel and place support against the surrounding earth so that no movement of the earth over or adjacent to the work can occur at any time. At no time allow more than ___ feet unsupported by bracing, measured horizontally.

2. Grout all voids between the excavation and the liner plates immediately after setting ribs and lagging or setting and bolting liner plates. Use grout as specified in Section 03311.

3. In case any movement of the earth over or adjacent to the work occurs, due to unforeseen conditions or otherwise, suspend all work except that which assists in making the work secure and in preventing further movement of the ground over or adjacent to the work. Resume tunnelling at the place at which movement of the earth over or adjacent to the work has occurred only after all necessary precautions to prevent further movement have been taken.

4. Keep a record of the elevation of all adjacent sewer, water and utility lines to detect any settlement of or damage to such utilities. Immediately perform such work or make such arrangements as will restore any damaged utilities and will protect against further settlement or damage.

5. Be responsible for any after settlement of the ground over or adjacent to the work throughout the 1 year warranty period.

D. Tunnel Lining and Bracing: Line and brace shaft excavation with steel ribs and steel spreaders with wood or steel lagging, or with bolted steel liner plates. Line tunnel excavation with steel ribs and steel or wood lagging or concrete or steel bolted liner plates.

1. Design and arrange the tunnel lining for expansion against the tunnel wall immediately after placing. Fully place the lining around the periphery of the tunnel section.

2. Use steel ribs having a section not less than W4x13 meeting the requirements of ASTM A 36/36M.

3. Arrange steel lagging plates or wood lagging for installation behind the ribs with steel spreaders between the ribs. Size the steel spreaders no less than the minimum specified for the rib section. Use steel lagging not less than 1/8-inch thick. Use wood lagging a minimum thickness of three inches.

**NOTE:** For soil conditions that contain fine sands and silts that tend to flow under pressure add, "All liner plates shall include neoprene gaskets adhered to each flange face." to the end of Item 4 below.

4. Design bolted steel liner plates to carry an overburden pressure (pounds per linear foot) not less than 2500 x D (where "D" is the diameter of the tunnel in
feet). Fabricate the liner plates from hot rolled carbon steel plates or sheets having a minimum yield strength of 28,000 psi and a minimum ultimate strength of 45,000 psi. Use liner plate sections not less than 1/8-inch thick. Provide a minimum of one liner plate per ring with 2-inch diameter coupling for grouting.

5. Design the steel tunnel liner plates for insertion of filler pieces, or other method of closure subject to approval, to prevent material from entering the tunnel when the lining is expanded.

6. Where the tunnel is constructed on a curve, use tapered lagging or liner plates so as to provide a uniformly curved alignment.


8. Exercise special care to ensure that full bearing is obtained between the tunnel lining and the earth.

E. Breasting: At all times keep sufficient breasting and bracing available near each heading to secure the heading against soil movement.

F. Disposal of Excavated Material: Remove and dispose of all excavated material from the site of the work as soon as it is excavated. Dispose of material excavated from under State Highways in areas designated. Obtain a place of disposal and convey other surplus excavated material not required at other locations in the work to this place of disposal.

G. Electrical Work: Comply with latest NEC, National Electrical Safety Code, ANSI, State and local Codes. Use all equipment and materials listed as approved by the Underwriters’ Laboratories, Inc., for the particular application wherever approval of such equipment or materials is available. Conform conduit and equipment in or through hazardous areas as well as other electrical appurtenances installed therein to Chapter 5 of the NEC, Hazardous Locations.

1. Use electrical power of 480 volts or less in shafts and tunnels.

2. Properly ground electrical equipment.

3. If compressed air is used, carry all wiring terminating in the tunnels in conduits to a point inside the air locks. Seal all conduits running through the air locks to prevent the leakage of air.

H. Telephone Systems: Install a separate tunnel telephone system at each shaft with one telephone in each heading and one at the top of the shaft, interconnected to a telephone in the CONTRACTOR's office. Provide telephone systems operating independently of the tunnel power supply. Contain telephones in damp places in cast-iron enclosures.
1. Maintain and operate the telephone system until such time as all work has been accepted and the plant has been dismantled and removed. Remove telephone equipment, switchboard, and wiring at the conclusion of the work. Telephone equipment remains the CONTRACTOR's property.

I. Lighting: Use lighting fixtures in all tunnel headings, air locks, shafts and stairwells of heavy-duty vapor-tight fixtures of not less than 50 watt size, equipped with suitable guards.

1. Place fixtures along one of the tunnel sidewalls at intervals of not more than 50 feet. Install sufficient additional lights in all other locations as necessary.

2. Install all necessary red and yellow designation lights marking emergency manholes, air locks, and fire extinguishers as required by applicable safety codes.

3. Furnish suitable outlets and extension cords and light boxes for running line and grade.

4. Furnish and install 300 to 500 watt floodlights of an approved make for the illumination of the yards and ground adjacent to shafts.

3.3 SAFETY

A. Safety Engineer: Employ and assign a qualified competent safety engineer to the Work. Assign the safety engineer to perform work or duties only related to the safety of workers, and others engaged upon or connected with the work being done under this Contract.

B. Safety Equipment and Tests:

1. Follow the requirements of the health and safety rules of the State of Florida pertaining to tunnel construction, whether or not such construction is under compressed air, and Subpart S, Part 1926 - Safety and Health Regulations for Construction, Chapter XVII - Occupational Safety and Health Administration, U. S. Department of Labor.

2. If compressed air is used, provide the rates for compression and decompression to be used when any person is in the air lock in accordance with the requirements of Subpart S, Section 1926.803 of the Department of Labor Safety and Health Regulations for Construction. Properly post and strictly adhere to such rates. Keep a complete record of all physical examinations, re-examinations, injuries, cases of air sickness, and other data concerning each worker. In the event air pressure greater than normal atmospheric is used in the tunnel, keep a daily record of each worker indicating the length of time of compression upon entering the tunnel, the
length of time and the air pressure while working in the tunnel, and the length of time of decompression upon leaving the tunnel.

3.4 COMPRESSED AIR TUNNELING

A. General: If work is to be done under compressed air, furnish complete information concerning all compressed air equipment to be installed. Include all compressor units, air receivers, piping, controlling valves, air locks, main and emergency locks, bulkhead walls, gauges, and all other appurtenances.

1. Provide a system of capacity to maintain sufficient air pressure to prevent movement of the ground, and capable of supplying the normal demand of air.

2. Furnish two sources of power for the construction plant. Install and maintain necessary protective equipment in satisfactory operating condition.

3. If diesel or gasoline power is used for air compressors, locate the air intake at the proper elevation to ensure pure, clean air.

4. Equip the pipe line supplying air to the working chamber with a pressure reducing valve of an approved type. Equip each working chamber with a sufficient number of relief valves, pressure recording gauges and other appurtenances to ensure a constant pressure in the chamber. Equip air locks with proper valves so that the lock may be operated from within and without. Employ competent lock tenders for each of the main locks 24 hours a day during operations. In no case permit the operator to leave his post in the lock unless relieved. Equip each lock door with a glass bull's-eye not less than 6 inches in diameter. Install adequate signaling devices for the operation of the lock at each lock. Furnish and install a signal system for the compressor house, composed of a siren operated from a mercoid switch on each of the pressure reducing valves. Supply air to the working chamber at proper temperature and containing no objectional substance.

5. Do not allow the use of any combustible material for preventing leakage of the compressed air.

6. If air pressure greater than normal atmospheric is used, furnish all necessary safeguards including a medical lock, with a physician on call day and night at all times when persons are working, stage decompression facilities, and all other items necessary for the safety of the workers.

7. Where used or secondhand equipment is provided, demonstrate by suitable tests that the equipment is in proper operating condition. Should any equipment prove defective after being installed, replace it with suitable equipment.
8. Do not use secondhand pressure reducing valves unless such equipment has been overhauled and reconditioned by the original manufacturer and guaranteed to be in good working order.

B. Emergency Locks or Escape Manholes: Provide and install emergency locks with escape shafts and exits to the surface of the ground or escape manholes equipped with air locks and devices in each heading which allow passage to or from the tunnel at all times. Install each emergency lock or escape manhole as soon as the heading advances past a cleanout. Move the emergency lock and escape manhole forward as the heading is advanced.

1. Move the emergency locks or escape manholes forward prior to advancing the main air locks so that at no time is there a heading which is not served by an emergency lock or escape manhole.

2. Allow passage to or from the tunnel through each emergency lock at all times. Submit drawings of emergency locks or escape manholes proposed for approval at least thirty days before they are required on the work. If the work is performed from cleanout to cleanout, make the emergency locks or escape manholes large enough to allow the exit of all workers in the heading at any time, but in any case provide a capacity of at least five persons. If the work is performed from a central shaft, provide emergency locks or escape manholes having a capacity of at least fifteen persons.

3. Provide the escape shaft to the surface of at least 3 feet in diameter, of fireproof construction. After the escape shafts are no longer required in the openings in the tunnel fill the shafts with concrete. Remove the shaft lining to a point at least 3 feet below the top of the ground and backfill the shafts with sluiced sand. Cleanouts may be used as escape shafts.

C. Signal Systems: Where the construction work is performed in tunnel under air, provide the following signal systems.

1. Install an adequate signal system for the operation of the shaft hoists. Provide an individual system for each hoist. Arrange each system so that the actual operation of signal of operation is made by a person stationed at the bottom of the shaft. If the operation is manual from a remote location, provide approved lights and bells at the operating location.

2. Provide limit switches to prevent overtravel of the hoist at both extremes of travel. Mount a chart showing the signals in a convenient place at both top and bottom of the shaft.

3. If a crane is used for hoisting, station a signaler at the top of the shaft to direct the crane operator at all times.
4. Provide a signal system indicating both high and low pressure in the feeder line to each heading in the compressor room. Use a bell or siren in the compressor room actuated by pressure stats in each heading feeder which is under air pressure.

5. If concrete is forced into the tunnel by air or other mechanical equipment from ground level or from a device located more than 100 feet from the heading, install an approved signal system for signaling between the heading and the concrete placing device.

6. Provide all switches, sirens, bells, lights, push buttons and pressure stats of an approved watertight type.

END OF SECTION