31 23 00 – Trenching, Backfilling, and Compaction of Utilities

1. General

   A. The Contractor shall furnish all labor, materials, tools, equipment, and perform all work and services necessary for or incidental to the furnishing and installation, complete, of all operations in connection with excavation, trenching, and backfilling of underground utilities as shown on drawings and as specified, in accordance with provisions of the Contract Documents, and completely coordinated with work of all other trades.

   B. Work included in the project consists of, but is not limited to, methods of installation of the following:

      1. Wastewater piping.

      2. Sanitary sewers and foundation drains.

      3. Water piping.

      4. Chilled Water Piping.

      5. Steam Piping.

      6. Drainage pipes.

      7. Relocation of existing piping.

      8. Surface drainage conduits and piping.

   C. Although such work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure, complete and compatible installation.

2. Quality Standards

   A. Refer to following standards and include as part of these design guidelines.

      1. American Society for Testing and Materials

         a. ASTM C33-16$^{\varepsilon 1}$ .....Standard Specification for Concrete Aggregates

         b. ASTM D4253-16 .....Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

         c. ASTM D2487-11 .....Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

         d. ASTM D698-12$^{\varepsilon 2}$ .....Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb./ft.) (Standard Proctor)

e. ASTM D1557-12$^{\varepsilon 1}$ …….Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb./ft.) (Modified Proctor)

f. ASTM D4318-17…..Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

g. ASTM D6913-17…..Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

h. ASTM D7928-17….Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

2. American Association of State Highway & Transportation Officials

a. AASHTO T99-17 …….The Moisture-Density Relations of Soils using a 5.5 - pound Rammer and a 12 inch drop

b. AASHTO T180-17 …...The Moisture Density Relations of Soils using a 10 pound Rammer and an 18 inch drop

3. North Carolina Department of Transportation

a. Standard Specifications for Roads and Structures, Current Revision

3. Pipe Bedding and Backfill

A. Pipe Bedding

1. Earth, loam, sandy clay, sand and gravel, soft shale, or other acceptable materials which are free from organic matter and large clods of earth or stone, may be used for fill. Material shall be moistened as required to facilitate backfilling. Duke Standard is that all pipe bedding shall be undercut a minimum of four inches below the pipe and filled above the pipe to a depth not less than four inches with approved backfill material. Material shall be in accordance with NCDOT specifications.

2. Stabilization of Trench Bottom: When the trench bottom is unstable due to wet conditions, it shall be stabilized with the gravel or crushed rock. Some instances may require the installation of underdrains. The contractor shall coordinate with the Geotechnical Engineer when wet conditions are present for proper bedding material and underdrain installation.

B. Backfill Material

1. Prior to trench backfill, the condition of the trench and laying of pipe must be inspected and approved by the Geotechnical Engineer.

2. Backfill material shall be free from construction material, frozen material, organic material, or unstable material. Backfill with a high clay content or high shrink-swell potential (i.e. highly plastic fat clays) that cannot meet compaction requirements shall be deemed unsuitable and replaced.

3. Backfill materials that have been allowed to become saturated or with moisture contents non-conducive to meeting compaction requirements shall be deemed unsuitable and replaced.

4. When original excavated materials have been deemed unsuitable, granular material must be imported to the site to backfill utility trenches and meet compaction requirements. The following materials shall be acceptable forms of granular backfill: aggregate base course, soil type base course, select backfill material, sand in accordance with NCDOT specifications.

5. In all open utility trenches, the following percentages of maximum dry densities in a range of +/- 3% of optimum moisture content, as determined by ASTM D698 Standard Proctor, shall be achieved for each lift in fill materials:

    a. Under-structures, footings, paved surfaces, drainage piping, utilities, and other improvements:

        1. All fill 98%

        2. Top 12 inches of sub-grade in cut 98%

    b. Within lawn or planting area:

        3. All fills to within 18 inches of finished grade.....90%

        4. Top 18 inches to finished grade 90%

6. Backfill for utility trenches shall be placed in 8-inch lifts or less and brought up uniformly on both sides of the pipe to avoid bending or distortional stress.

7. In some circumstances the Contractor shall backfill trenches or undercut with flowable fill as directed by the Engineer. Verbal approval must be obtained by Duke utilities department prior to placing flowable fill.

8. Topsoil shall be replaced to at least 6 inches in areas to be seeded; topsoil shall be placed so as to produce a smooth, even, well-draining slope.

4. Submittals

A. Submit test reports to the Project Manager and fully document each with specific location or stationing information, date and other pertinent information.

B. Submit respective pipe or conduit manufacturer's data regarding methods of installation, jointing and general recommendations.

5. Protection of Existing Utilities

   A. Verify location and existence of underground utilities. Coordinate all excavation with the Duke locator prior to any digging operations. Verify the location of the project to ensure if Risk Mitigation approval is necessary.

   B. Take necessary precautions to protect existing utilities from damage due to any construction activity. Repair damages to utility items at contractors expense. Assess no cost to Duke University for any damages.

   C. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to the University property.

   D. Provide full access to public and private premises, to fire hydrants, at street crossings, sidewalks and other points as designated by Duke to prevent serious interruption of travel. Maintain access to all vaults, junction boxes, manholes, etc…to the full satisfaction of the Duke inspector.

   E. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Duke University.

   F. Procedures:

      1. Unless shown to be removed, protect active utility lines shown on the drawings or otherwise made known to the Contractor prior to trenching. If damaged, repair or replace at no additional cost to Duke University.

      2. If active utility lines are encountered, and are not shown on the Drawings or otherwise made known to the Contractor, promptly take necessary steps to assure that service is not interrupted to the University or Medical Center.

      3. If service is interrupted as a result of work under this Section, immediately contact Duke Project Manager or Duke Representative responsible for the project to coordinate emergency communication efforts.

      4. If existing utilities are found to interfere with the permanent facilities being constructed under this Section, immediately notify the Engineer and secure his instructions.

6. Protection of University Interest:

   A. Barricade open holes and depressions occurring as part of the Work, and post warning lights on property adjacent to or with public access.

B. Operate warning lights during hours from dusk to dawn each day and as otherwise required.

C. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, washout, and other hazards created by operations under this Section.

7. Unclassified Trench Excavation

A. General:

1. Remove all material of whatever nature, including but not limited to clay, silt, gravel, and partially weathered rock, as directed by the Geotechnical Engineer and dispose of unsuitable material in either a NC DENR permitted demolition land fill or a site which legally can accept earthen fill (i.e. meeting all applicable laws such as erosion control, zoning, etc.). Material, of a compactible nature, that can be re-used as trench backfill shall be replaced and re-compacted to the requirements set forth in these specifications.

2. The cost of excavation is to include all costs for equipment, personnel, trenching, shoring, de-watering, well-pointing, removal and replacement of material, compaction, testing, or disposal if material is deemed unsuitable by the testing agency.

8. Trench Excavations

A. Unless given permission to do otherwise or shown as a bore, all excavation of trenches is to be by the open cut method to depth shown on drawings and as necessary to accommodate work.

B. Do not open greater length of trench than can be effectively utilized and maintained under existing conditions and with the forces at hand. Once trench is opened, proceed immediately and with dispatch to place specified materials in trench, or to otherwise utilize trench for intended purpose. Schedule work and order materials so that trenches are not left open for a longer period than is reasonably necessary. Any trench or portion of trench, which is opened and remains idle for seven calendar days, or longer, as determined by the Duke representative, may be directed to be immediately refilled, without completion of work, at no additional cost to Duke. Said trench may not be reopened until Duke is satisfied that work associated with trench will be prosecuted with dispatch.

C. Observe following trenching criteria:

1. Trench size: Excavate only sufficient width to accommodate free working space. In no case shall trench width at top of pipe or conduit exceed outside diameter of utility service by following dimensions:

Overall Diameter of Utility Service	Excess Dimension

a. 24 inches and less ……..18 inches - However, the minimum trench width is generally 36-inches in order to accommodate a “Rammax” tamp.

b. More than 24 inches……. 24 inches

2. For pipe diameters greater than 3”, the free working space on each side of the pipe barrel shall not be less than 12 inches.

3. Cut trench walls vertically from bottom of trench to one foot above top of pipe, conduit, or utility service.

4. De-watering: Keep trenches free of water. Include cost of de-watering in original proposal.

5. Sheeting and Bracing: Brace and sheet trenches as soil conditions dictate and in full observation of OSHA requirements. Do not remove sheeting until backfilling has progressed to stage that no damage to piping, utility service, or conduit will result due to removal.

6. Brace trenches running near walls or columns, to prevent any settlement or other disturbance of walls or columns. Make trench excavation that runs parallel to footing bottom with maximum slope of one to one.

7. Trench walls may have vertical sides up to a maximum height of 5 feet above subgrade elevation. Beyond this depth the entire sides must be laid back or a trench box, certified for the depths being used, must be used. Contractor is responsible for determining the proper and applicable slope based on type soil in order to meet OSHA subpart P latest requirements. Laying back slopes also applies for areas where the top of the trench box is lower than the top of the bank. Contractor shall employ the services of a Geotechnical engineer for direction and guidance if unstable or difficult soils are encountered. In any event, the Contractor shall hold Duke University harmless for injuries and/or damages resulting from failure to properly adhere to trench protection regulations/requirements in force at the time of a failure or mishap.

9. Backfilling (Materials and Methods)

A. Backfilling

1. General:

a. Do not completely backfill trenches until required pressure and leakage tests have been performed, and until the utilities systems as installed conform to the requirements specified in the pertinent Sections of these Specifications.

b. Except as otherwise specified or directed for special conditions, backfill trenches to the ground surface with selected material approved by the Engineer.

c. Reopen trenches that have been improperly backfilled, to a depth as required for proper compaction. Refill and compact as specified, or otherwise correct to the approval of the Engineer.

d. Do not allow or cause any of the Work performed or installed to be covered up or enclosed by work of this Section prior to required inspections, tests, and approvals.

e. Should any of the Work be so enclosed or covered up before it has been approved, uncover all such Work and , after approvals have been made, refill and compact as specified, all at no additional cost to Duke.

B. Flowable Fill Concrete Backfill

1. When directed by the Engineer, the Contractor shall backfill trenches or undercut areas with flowable fill (Controlled Low Strength Material – CLSM) concrete plant mix. CLSM strength shall be as specified by the Engineer. However, unless directed otherwise, the ultimate compressive strength shall be between 50 and 150 psi to allow for future re-excavation of filled area. Except for structural applications, traffic can be placed on mixture once sufficient strength is achieved, generally within two to four hours after placement. Final surfacing of pavements; however, should be delayed if possible at least 24 hours to allow for strength gain, shrinkage and hydration of the mixture. Settlement on the order of ¼" per foot of depth placed is to be expected.

2. The option to use flowable fill is open to the Contractor to reduce delay and inconvenience to traffic. However, payment for flowable fill backfill is considered incidental to the cost of construction unless either a pay item has been provided in the proposal, a change order has been approved or the Contractor is ordered by the Engineer to place flowable fill concrete as an emergency measure.

C. Special Method Requirements.

1. Water flushing for consolidation is permitted with permission of Engineer only.

D. Pipe Cover

1. Provide minimum trench depth indicated below to maintain a minimum cover over the top of the installed item below the finish grade or subgrade:

Table A			
Pipe Diameter/Cushioning/Bedding for Gravity Pipe			
Utility	**Pipe Material**	**Bedding Material**	**Minimum Depth**
Domestic Water	DIP, K Copper K Copper	67 or 78M Sand	36"

Sanitary Sewer	DIP, SDR	67 or 78M	36”
Storm Sewer	DIP, SDR, RCP, HDPE	67 or 78M	24”
Chilled Water	DIP	67 or 78M	36”
Steam/Heating Hot Water	Steel	Sand	48”
High Voltage/OIT	Ductbank	Natural Soil	24”

2. Exceptions to be approved by DUES.

10. Testing

A. Density testing shall be performed by a recognized independent testing laboratory approved by Duke University to insure trench backfill complies with specified minimum compaction and moisture content requirements.

B. Where backfill compaction is suspect and questionable, the material shall be removed as directed by Duke representative or testing agency and the area tested. If the suspect area fails to meet the prescribed minimum moisture density test requirements, the soil shall be removed, replaced, compacted and re-tested, as directed by the Duke representative or Engineer until the backfill meets or exceeds the minimum density requirements. The Contractor shall pay for all costs associated with re-testing.

C. Testing Frequency:

1. Structural Areas ……Density tests of one per 2500 SF per lift of fill not to exceed 12 inches

2. Trench areas ……One test per 100 feet per 12 inches/1 foot of fill thickness

D. Insure Duke has at all times immediate access for the testing of all soils related work. Insure excavations are in a safe condition for testing personnel.

11. Sheeting and Wellpointing

A. Shoring or sheeting or well-pointing will be used where and as required, in order to prevent damage to existing facilities or structures, or as a matter of safety, or as directed by Duke representative.

12. Tree and utility separation:

A. Prior to conceptual design, all projects that involve landscaping and/or utilities will perform a site assessment that will investigate the existing trees and the existing utilities. The site assessment should include size and species of existing trees as well as depth and age of the existing utilities. The site assessment should be provided to the Duke Landscape Architect and the Duke Civil Engineer.

B. Existing trees: no construction or maintenance project may perform excavation within the canopy of any existing tree without written consent from the Duke Landscape Architect.

C. New utilities: utilities shall be installed in such a way that the utility will not encroach within 5 feet of the future mature tree trunk of any new or existing tree unless mitigation efforts are made. For deep utilities (greater than 10 ft deep), utilities shall be installed in such a way that the utility will not encroach within 10 ft tree trunk. Shrubs and general ground cover are allowed to be planted on top of all utilities.

D. The Landscape Architect and Civil Engineer shall work together during design of such projects phase to shift new utilities or new tree locations to the extent practicable.

E. In areas where a conflict occurs, the Architect/Engineer shall work with the University to develop mitigation efforts, which may include the use of root barriers or installing a sleeve around the utility in the area where the utility pipe is under the mature tree's canopy

13. Pavement Repairs

A. In general, the repair standard when working within paved area on campus will be a "T-patch", which includes a minimum bench (or key) of 12 inches beyond the edges of the excavation.

B. All pavement saw cut edges must be straight and clean.

C. All street striping impacted with trenching/utility work must be replaced to Duke standards.

D. All repairs shall be full lane width. When utility work crosses over multiple lanes of travel, then pavement repairs shall account for the full lane width of all lanes impacted.

E. A patch within a patch is not allowed. All repairs shall be full lane width.

F. When cutting pavement for a series of utility service lines perpendicular to the street, repair the pavement area impacted by service lines on large repair area when utility service lines is less than 10 feet.

G. All street repairs shall provide a smooth transition between existing pavement and repaired pavement. Repaired area shall be at least as good as, if not better than, the pavement prior to repairs.

H. Surface tolerances for street repairs shall be tested with a ten (10) foot straightedge parallel to the centerline or perpendicular across joints. Surface variations between the straightedge to the surface of the street repair shall not exceed one-quarter (1/4) inch.

I. Any scarring, gouging, or other damaged pavement adjacent to utility work shall be repaired to the satisfaction of Duke Representative.