SECTION 02221
TRENCHING, BACKFILLING, COMPACTING

PART 1 - GENERAL

1.1 SUMMARY:

A. Section Includes:

1. Trenching, backfilling and compacting in connection with the construction of underground utilities and appurtenances for work outside of building lines including the following:

   a. Water lines.
   b. Sanitary sewer lines.
   c. Storm sewer lines.
   d. Natural gas systems.
   e. Direct-bury steam systems.
   f. Direct-bury chilled water systems.
   g. Direct-bury compressed air systems.
   h. Direct-bury electric lines.
   i. Direct-bury telephone and data lines.
   j. Other utilities as shown in the Contract Documents.
   k. Utility tunnels.

2. Pavement removal and replacement.

B. Related Sections:

1. Section 01400 - Quality Control.
2. Section 02010 - Subsurface Exploration.
3. Section 02110 - Site Clearing.
4. Section 0211 – Tree and Plant Protection
5. Section 02200 - Earthwork.
7. Section 02513 - Asphaltic Concrete Paving.
8. Section 02520 - Portland Cement Concrete Paving.
10. Section 02667 - Chilled Water Systems.
12. Section 02695 - Steam Distribution Systems.
13. Section 02722 - Drainage Structures and Piping.
15. Section 02785 - Electric Power Transmission.
16. Section 02790 - Communication Transmission.
17. Section 02795 - Compressed Air Systems.
18. Division 15 - Mechanical: Additional requirements for mechanical work.
19. Division 16 - Electrical: Additional requirements for electrical work.
1.2 QUALITY ASSURANCE:

A. Requirements of Regulatory Agencies:

1. Perform excavation work in conformance to the requirements herein specified. Refer to the City of Boulder, Colorado Design and Construction Standards, Oct. 17, 2000 edition, for work not covered in this specification. The University of Colorado at Boulder Utilities Engineer shall approve the use of particular City of Boulder standards.
2. Supply, install, and remove all shoring as may be required to comply with all OSHA and EPA safety regulations and to maintain earth banks until backfill is placed.
3. Backfilling and construction of fills and embankments during freezing weather shall not be done except by permission of the Owner’s Representative. No backfill, fill, or embankment materials shall be installed on frozen surfaces, nor shall frozen materials, snow or ice be placed in any backfill, fill, or embankment.

B. Testing and Inspection:

1. Conform testing and inspection of backfill to the requirements of Section 02200. Make in place density tests at intervals and locations as directed by the Owner’s Representative.
2. All tests required for preliminary review of materials shall be made by an acceptable independent testing laboratory at the expense of the contractor. Two(2) initial gradation tests shall be made for each type of pipe bedding, fill or backfill material, and one (1) additional gradation test shall be made for each additional 500 tons of each material. Retests of samples failing initial tests shall be at the expense of the contractor. Initial moisture density (Proctor) tests and relative density tests on the materials, and all in-place field density tests shall be made at the expense of the Owner.

1.3 SUBMITTALS:

A. Submit six copies of a report from a testing laboratory verifying that material conforms to the specified gradations or characteristics.
B. Submit method of compaction in pipe zone including removal sequence of shoring where used.

1.4 PROJECT/SITE CONDITIONS:

A. Protection:

1. Protect existing utilities, adjacent property, and utility excavations, including hand excavation, in accordance with the requirements of Section 02200.

B. Sleeving:

1. Verify all required utility sleeving is installed and properly located and supported prior to backfilling.

PART 2 - MATERIALS
2.1 GENERAL:

A. All bedding and backfill material shall have the approval of the Owner’s Representative, and shall be free of frozen material, organic material and debris.

B. Bedding materials shall contain no cinders or other material which may cause pipe corrosion.

C. Squeegee sand conforming to the gradation for RCP Sewer Pipe may be used as bedding material for other types of pipes, subject to approval by Owners Representative’s.

D. Reuse of on-site material is subject to Owner Representative’s approval.

2.2 BEDDING AND BACKFILL:

A. Fill and Backfill Materials

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.

2. If the job excavated material proves to be unsuitable for backfill, the contractor may, if approved by Owner’s Representative, use a pit-run material consisting of rocks less than three (3) inches in diameter and a maximum of 20% passing a No. 200 sieve.

B. Select Backfill:

1. Suitable material with no stones greater than 1” diameter for concrete pipe and 0.75” diameter for all other pipe. Excavated material which meets the grading requirement may be used for select backfill.

C. Granular Bedding Materials for Ductile Iron Pipe and PVC Pressure Pipe.

1. This material shall consist of washed chips, nominal size 3/8”, meeting the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing By Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2-inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8-inch</td>
<td>85-100</td>
</tr>
<tr>
<td>No. 4</td>
<td>10-30</td>
</tr>
<tr>
<td>No. 8</td>
<td>0-10</td>
</tr>
<tr>
<td>No. 16</td>
<td>0-5</td>
</tr>
</tbody>
</table>

D. Granular Bedding Material for PVC and HDPE Sewer Pipe.

1. This material shall be imported, crushed, angular quarry rock and meet the following
gradation (ASTM D448, No. 67):

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing By Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4-inch</td>
<td>100</td>
</tr>
<tr>
<td>3/8-inch</td>
<td>20-55</td>
</tr>
<tr>
<td>No. 8</td>
<td>0-10</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-5</td>
</tr>
</tbody>
</table>

E. Granular Bedding Material for RCP Sewer Pipe and Manholes.

1. This material shall be squeegee sand meeting the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing By Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-5</td>
</tr>
</tbody>
</table>

F. Bedding Material Within Building Lines.

1. The pipe shall be carefully bedded in accordance to the above gradations except within building lines where 6” pea gravel shall be used to surround the pipe. Pea gravel shall be rounded gravel, graded with less than 10% passing a No. 200 sieve, less than 50% passing a No. 4 sieve, and having a maximum particle size as follows:

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Max. Particle Size (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductile iron</td>
<td>3/4</td>
</tr>
<tr>
<td>Concrete or concrete cylinder</td>
<td>3/4</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>3/4</td>
</tr>
<tr>
<td>VCP</td>
<td>3/4</td>
</tr>
<tr>
<td>Steel pipe 3 inches and smaller</td>
<td>1/4</td>
</tr>
<tr>
<td>Steel pipe larger than 3 inches</td>
<td>3/4</td>
</tr>
</tbody>
</table>

G. Stabilization Material.

1. Stabilization material shall be placed on suitably prepared subgrades and compacted by vibration. Stabilization material shall be crushed rock or gravel; shall be free from dust, clay, or trash; and shall be graded 1-1/2 inch to No. 4 as defined in ASTM C33 and shall be compacted to not less than 70% relative density as determined by ASTM D253 and D4254.

H. Flow Fill

1. Low Strength Concrete (LSC) is defined as Flow Fill in these standards.
2. Materials, batching, mixing and delivery shall be in accordance with the Colorado
Department of Highways Standard Specifications for Road and Bridge Construction and shall meet the following specific requirements:

<table>
<thead>
<tr>
<th>INGREDIENTS</th>
<th>POUNDS per CUBIC YARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>50.0</td>
</tr>
<tr>
<td>Coarse Aggregate (AASHTO No. 57 or 67)</td>
<td>1700.0</td>
</tr>
<tr>
<td>Fine Aggregate (AASHTO M 6)</td>
<td>1845.0</td>
</tr>
<tr>
<td>Water (39.0 gallons)</td>
<td>325.0 (or as needed)</td>
</tr>
</tbody>
</table>

3. The amount of water shall be such that the flow fill flows into place properly without excessive segregation. Approximately 29 gallons of water per cubic yard of flow fill is normally needed.

4. The Contractor may use aggregate which does not meet the above specifications if the cement is increased to 100 lbs/CY and the aggregate conforms to the following gradation:

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>% PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-10</td>
</tr>
</tbody>
</table>

5. The Contractor may substitute 30 lbs/CY of cement and 30 lbs/CY of fly ash for 50 lbs/CY of cement or may substitute 60 lbs/CY of cement and 60 lbs/CY of fly ash for 100 lbs/CY of cement.

6. The maximum desired 28-day compressive strength is 100 PSI (not a specification requirement).

7. Compaction of flow fill will not be required. The above combination of material or an equivalent, as approved by the Owner’s Representative, may be used to obtain the desired flow fill.

I. Unsuitable Material:

1. Highly organic soil; ASTM D2487 Group PT, topsoil, roots, vegetable matter, trash and debris will not be used for any bedding, backfill or structural fill.

PART 3 - EXECUTION

3.1 SHORING AND BRACING:

A. Provide materials for shoring and bracing, such as sheet piling, up rights, stringers and cross-braces, in good serviceable condition. Provide shoring as required for safety and by governing authorities.

B. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses. Arrange shoring and bracing so as not to place stress on completed work.

C. Exercise care in removal of shoring and bracing to prevent collapse or caving of excavation...
D. Any damage to pipes or structures resulting from settlements, heaving, water or earth pressures, slides, caving, or other causes, due to lack of shoring, sheeting, or bracing, or due to failure of shoring, or due to improper shoring, or due to any other negligence on the part of the contractor, shall be repaired at the contractor’s expense.

3.2 DEWATERING:

A. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding areas.

B. Do not allow water to accumulate in excavations. Remove water to prevent softening of trench bottoms, and soil changes detrimental to stability of subgrades and foundations.

C. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

D. Convey water removed from excavations and rainwater directly to storm sewer lines only, subject to approval by owner.

E. Do not use pipe or pipe trench excavations as temporary drainage ditches.

F. Refer to Section 02200 Part 3.5.

3.3 INSTALLATION OF PIPE BEDDING:

A. Pipe bedding material shall consist of the material as specified in this section. Bedding material shall be placed to the required elevation of the pipe invert. Tamping equipment shall be used to thoroughly tamp the bedding material. The moisture content of the material shall be within two (2) percent of optimum.

B. After bedding material has been placed and has been approved and after the pipe has been installed and approved the granular bedding material shall be installed to an elevation 12 inches above the top of the pipe. The granular bedding material shall be placed and compacted in distinct, separate lifts not to exceed six inches of loose depth; except that the first loose lift shall not be higher than the pipe centerline (springline). Compaction shall meet the above requirements utilizing T-bars or mechanical tamping equipment.

C. Set all pipe on compacted granular material supporting the lower half of the pipe barrel. Place compacted granular material around and on top of pipe to not less than 12" deep from top of pipe.

3.4 INSTALLATION OF TRENCH BACKFILL:

A. The compaction requirements shall conform to maximum dry density according to ASTM D698, Moisture-Density Relations of Soils (Standard Proctor). When the ASTM D698 test is not applicable, the percentage compaction requirements shall conform to ASTM D2049 Test for Relative Density of Cohesionless Soils.
B. All backfill above the bedding installation shall be carefully placed and compacted. Compaction shall be by mechanical tamping in eight-inch maximum loose lifts using mechanical or hand tampers, suitable for material being compacted, or vibratory rollers. All backfill shall be compacted to 95% of maximum laboratory dry density or 70% relative density. The material shall be within two (2) percent of optimum moisture content.

C. The contractor may request approval of alternate means of compaction. Such request must be submitted to the Owner’s Representative in writing and the approval will be made by the Owner’s Representative in writing. Use of specified or approved compaction methods does not relieve the contractor from providing a complete project meeting the intent of the Design and Construction Standards.

D. When directed by the Owner’s Representative, the contractor shall excavate backfilled trenches for purposes to perform compaction tests at locations and depths determined by the Owner’s Representative. The contractor shall be responsible for reinstalling and compacting the test excavations at no additional cost to the Owner.

E. Do not backfill any pipe trenches until pipe is inspected by University Engineer and owning utilities (if any).

3.5 PLACEMENT OF FLOW FILL

A. Sufficient mixing capacity shall be provided to permit the flow fill to be placed continuously, without interruption.

B. Flow fill shall be thoroughly mixed prior to discharging to ensure a uniform product. Agitation is required during transportation and waiting time to ensure that the material is in suspension when placed.

C. Flow fill shall be discharged from the mixer truck into the trench to be filled, or by other methods approved by the Owner’s Representative.

D. The flow fill shall be placed continuously and brought up uniformly to a point a minimum of 1-inch above adjacent surfaces (trench walls) to ensure proper drainage of bleed water away from the trench.

E. Flow fill shall be vibrated during and after placement to accelerate the bleeding and evaporation of water and to improve consolidation of the material.

F. Flow fill shall not be placed on frozen ground.

G. Flow fill shall be protected from freezing until it has hardened.

H. When the bleed water subsides, the fill material shall be struck off level with the adjacent pavement and the surface finished with a wood float. After the fill material has sufficiently cured to support anticipated traffic loads, the roadway may be temporarily reopened to normal traffic. It shall be the Contractor’s responsibility to maintain the finished surface of the cured fill material in a safe and driveable condition, until such time that the roadway pavement section is permanently replaced. Alternatively, the Contractor may opt to remove the cured fill material to a depth equal to the bottom of the existing pavement, and install a temporary
asphalt concrete patch. The foregoing does not preclude permanent pavement restoration immediately after the fill material has sufficiently cured to support anticipated traffic loads, should construction scheduling so permit. Permanent pavement restoration shall be in accordance with these specifications.

I. Flow fill mixing and placement may be started if weather conditions are favorable, when the air temperature in the shade and away from artificial heat is at least 34 degrees Fahrenheit and rising. Mixing and placing shall stop when the air temperature in the shade and away from artificial heat is 38 degrees Fahrenheit or less and falling, and in no case shall flow fill be placed when the air temperature is lower than 34 degrees Fahrenheit.

J. It shall be the Contractor’s responsibility to ensure that the backfilled trench is not exposed to vehicular traffic loads until such time that the fill material has sufficiently cured to support the anticipated vehicle loads. Prior to reopening the roadway to normal traffic, the Contractor shall subject the fill material to a vehicular test load that is reasonably representative of the ultimate loading anticipated. When the fill material supports such vehicular test load without apparent deformation, said fill material shall be deemed sufficiently cured to permit reopening of the roadway to normal traffic.

K. Should it be necessary to reopen the roadway to normal vehicular traffic, before the fill material has sufficiently cured to support the anticipated traffic loads, it shall be the Contractor’s responsibility to provide and install steel plates to bridge over the trench.

3.6 PAVEMENT REMOVAL AND REPLACEMENT:

A. Asphalt Pavement:
   1. Score existing surface with a cutting wheel to create clean break line. Leave 6" undisturbed subgrade lip on each side of trench.
   2. Compact aggregate base course to 95% per AASHTO T180. Replace pavement in accordance with permit requirements or minimum thickness specified in Section 02513. Compact asphalt to 95% per ASTM D1559.

B. Concrete Pavement:
   1. Sawcut existing concrete. Leave 6" undisturbed subgrade lip on each side of trench.
   2. Compact aggregate base course to 95% per AASHTO T180. Replace pavement in accordance with permit requirements or minimum thickness specified in Section 02520.

C. Sidewalk and Curb Removal
   1. Cut curbs and sidewalks prior to excavation of the trenches with a pavement saw or pavement cutter. Leave 6” undisturbed subgrade lip on each side of the trench. Haul concrete materials from the site. Do not use for trench backfill.

3.7 FIELD QUALITY CONTROL:
A. Comply with Section 02200 requirements.

END OF SECTION 02221