SECTION 206—PLACEMENT AND COMPACTION OF EMBANKMENT AND FILL

206.1 DESCRIPTION—This work is the construction of fills, including embankments, and backfills.

206.2 MATERIAL—

(a) Fill Material. Obtain material for embankment, fill, or backfill construction from the various classes of excavation on the project, including Common Borrow Excavation, Foreign Borrow Excavation, and Selected Borrow Excavation.

1. General. Provide material meeting one of the following material classification requirements. Material of maximum size that can be placed within, and does not interfere with the proper compaction of, compacted 6-inch layers, except as specified and classified as follows:

1.a Soil. Material consisting of earth having 20% or more of the material passing the No. 200 sieve, and having a minimum dry density of 95 pounds per cubic foot oven-dried mass, determined in accordance with PTM No. 106. Material must have a maximum liquid limit of 65, determined in accordance with AASHTO T89, and a plasticity index of not less than the liquid limit minus 30, determined in accordance with AASHTO T90 for soils with liquid limits of 41 to 65.

1.b Granular Material, Type 1. Material consisting of natural or synthetic mineral aggregates having greater than 70% of the material passing the 3/8-inch sieve (less than 30% retained on the 3/8-inch sieve) and less than 20% passing the No. 200 sieve, except for AASHTO No. 8 coarse aggregate and select granular material (2RC).

1.c Granular Material, Type 2. Provide material meeting the following requirements:

• Material consisting of natural or synthetic mineral aggregates having less than or equal to 70% of the material passing the 3/8-inch sieve (greater than or equal to 30% retained on the 3/8-inch sieve) and less than 20% passing the No. 200 sieve.

• AASHTO Nos. 8 or 57 coarse aggregate, or PENNDOT Nos. 2A or OGS coarse aggregate meeting the requirements of Section 703.2.

• Select granular material (2RC) meeting the requirements of Section 703.3.

• Structure backfill

1.d Rock. Includes natural material that cannot be excavated without blasting or using rippers; also boulders, detached stones, and concrete and masonry units of a size that cannot be readily incorporated into compacted 6-inch layers and having insufficient soil to fill the voids in each layer.

1.e Shale. Includes rock-like material formed by natural consolidation of mud, clay, silt, and fine sand; usually thinly laminated, comparatively soft, and easily split.

1.f Random Material. Includes Type 1 or Type 2 granular material combined with shale, concrete, brick, stone, or masonry units that can readily be incorporated into compacted 6-inch layers.

2. Suitable Material. Provide material meeting the requirements of any of the materials listed in Section 206.2(a)1 and reasonably free of organic matter, coal, carbonaceous materials, or other objectionable matter. Wet, dry, or frozen material may be suitable when dried, wetted, or thawed, respectively.

The Contractor may waste suitable material, including wet or frozen material, after obtaining written authorization. This suitable material is subject to replacement in equivalent volume.
(b) Geotextile. Section 735, Class 4, Type A.

206.3 CONSTRUCTION—

(a) General.

1. Prepare the embankment foundation area as specified in Section 201. Backfill existing depressions in embankment or fill areas, such as gullies, old stream channels, stump holes, and areas of undercutting and topsoil or pavement removal, to the adjacent ground elevation. Backfill with material indicated. If no specific materials are indicated, backfill with suitable material, unless directed otherwise.

Where undercutting is not directed, proof roll entire embankment or fill foundation with a loaded triaxle dump truck (72,000 pounds GVW). Maintain uniform inflation pressures for all tires on the loaded triaxle between 100 and 110 pounds per square inch. When conducting proof rolling, do not exceed a speed of 1.5 feet per second (1 mile per hour). Any areas displaying permanent deformation (rutting) greater than 1/2 inch are considered unstable. Treat unstable areas by excavating material in the area to a depth of 1 foot. Dry the material and recompact or replace with compacted suitable material of the same type or other material, including Soil, Type 1 granular material, and Type 2 granular material, except having particles no greater than two inches in size, as approved by the Representative or as indicated. Perform proof rolling only in the presence of the Representative who will assess and approve or disapprove the stability of the area being investigated. In wet areas or unstable areas, the Representative may waive this requirement if other stabilization or treatment measures are indicated and/or required. The Representative may also waive this requirement in confined areas or in areas too small to be effectively proof rolled with the loaded triaxle dump truck. Proof roll the foundations of small or confined areas using the equipment that will be used to compact the fill in these areas. Treat areas identified by the Representative as unstable as specified above.

Proof rolling of constructed embankments or fills may be required by the Representative at any time during the construction when the constructed embankment or fill appears to be visually unstable. Perform proof rolling and mitigation of unstable areas as described above and at no additional cost to the Department.

Break existing pavements, more than 3 feet below the finished grade, as follows:

- break bituminous pavements to a maximum size of 1 square foot and recompact;
- break concrete pavements to a maximum size of 1 square yard; and
- scarify bituminous, surface-treated roadways to a depth of 6 inches and recompact.

Remove existing pavements, less than or equal to 3 feet below finished subgrade, in their entirety unless specified otherwise.

When constructing embankment or fill on an existing or excavated slope, bench the slope to the width and depth indicated, or as directed.

Where required for installation of transverse drainage, construct embankment as shown on the Standard Drawings.

2. Quality Control (QC) Plan. When placing and compacting materials meeting the requirements of Sections 206.3(b)1.a and 1.b, prepare a compaction control QC Plan as outlined on Form CS-206 and submit for the Representative’s review. A QC Plan is not required when placing and compacting materials meeting the requirements of Sections 206.3(b)1.c, 1.d, 1.e, and 1.f, where the compaction criteria is non-movement. QC test methods shall be in accordance with Section 206.3(a)3. The frequency of the QC testing shall be determined by the Contractor; however, at a minimum, the frequency must meet the requirements as indicated in Table A. Start-up criteria shall be used at the commencement of operations until proper control of operations has been demonstrated by passing and repeatable QC test results, as determined by the Representative. A minimum of one start-up frequency cycle must be completed before moving to production QC test frequencies. QC tests cannot be performed at the same location as an acceptance test and cannot be replaced by an acceptance test. Submit the compaction control QC Plan at the Pre-construction conference or at least 21 calendar days before placement and compaction is
scheduled to commence. If any changes are needed to the QC Plan throughout the life of the project, submit an addendum to the Representative for review before implementation.

<table>
<thead>
<tr>
<th>Material</th>
<th>Embankment or Fill</th>
<th>Subgrade*</th>
<th>Pipe Backfill</th>
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</thead>
<tbody>
<tr>
<td>Start-up Frequency</td>
<td>One QC test per lift for each 500 square yards placed; minimum six tests per lift per day.</td>
<td>One QC test per lift for each 400 square yards placed; minimum eight tests per lift per day.</td>
<td>For every pipe run conduct one QC test for every 50 cubic yards of pipe backfill; minimum two tests per lift per day.</td>
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<tr>
<td>Production Frequency</td>
<td>One QC test per lift for each 1,000 square yards placed; minimum three tests per lift per day.</td>
<td>One QC test per lift for each 800 square yards placed; minimum four tests per lift per day.</td>
<td>For every pipe run conduct one QC test for every 100 cubic yards of pipe backfill; minimum one test per lift per day.</td>
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*Subgrade consists of the top three feet of the material immediately below the pavement section subbase.

3. **Moisture, Density, and Acceptance Testing.** For materials meeting the requirements of Sections 206.3(b1), a and 1.1.b, determine the in-place moisture and density in accordance with PTM No. 402 using the direct transmission method. All other materials will be accepted based on a condition of non-movement, as determined by the Representative. Provide a Nuclear Density/Moisture Gauge calibrated according to AASHTO T 310, PTM No. 418 may be used if the gauge is manufactured by Troxler (Note: PTM No. 418 is written for Troxler manufactured gauges while AASHTO T 310 is generic to any nuclear density gauge). Gauges must be calibrated every 12 months. A sheet with the current annual calibration providing the projected monthly decay standard with upper and lower limits must be kept with every gauge. Use Form TR-4276A located in PTM No. 402 for recording daily gauge standardization and for recording the results of all nuclear gauge moisture and density test results.

At locations directed by the Representative, conduct acceptance testing for moisture and density at the frequencies specified in Table B. If the required density of the compacted material is not obtained, promptly rework, reshape and recompact or remove and replace damaged or unsatisfactory areas and perform an acceptance retest before placement or testing of another area. The extent of the unsatisfactory area is defined by the Representative using one of the following: visual inspection of the site, behavior of the material under the compaction equipment originally used to compact the material, delineation using the acceptance moisture-density gauge, or any combination of the above methods.

When an acceptance retest fails to meet the specified requirements, check standard count of the acceptance test gauge on the reference standard block in accordance with PTM No. 418 or AASHTO T 310, as appropriate. If the standard count does not meet requirements established for the gauge from the last annual calibration, or is inconsistent with the daily gauge standardization count, the gauge must be diagnosed and repaired or replaced, as necessary, before work may proceed.

If the acceptance test gauge is determined to be functioning properly, and if the required density of the compacted material, within the specified moisture limits, cannot be obtained, conduct a new moisture-density test on the material, in accordance with PTM No. 106, to determine if the moisture-density relationship of the material has changed. If the moisture-density relationship of the material has changed, the corresponding new target values for density and moisture must be established and used for QC, acceptance, and verification testing. If moisture-density testing indicates that the original target density and moisture are valid, the contractor must review their operations, make adjustments within specification requirements, and amend the QC Plan to obtain acceptable results.

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<tr>
<td>Frequency</td>
<td>One acceptance test per lift for each 4,000 square yards placed; minimum one test per lift per day.</td>
<td>One acceptance test per lift for each 3,000 square yards placed; minimum one test per lift per day.</td>
<td>For every pipe run conduct one acceptance test for every 500 cubic yards of pipe backfill; minimum one test per lift per day.</td>
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</tbody>
</table>

*Subgrade consists of the top three feet of the material immediately below the pavement section subbase.

4. **Verification Testing.** The Representative will perform verification testing, using an Independent
Nuclear Density/Moisture Gauge, on one of the first three acceptance tests and a minimum of one verification test for every 10 acceptance tests performed thereafter. Verification testing will consist of testing for density and moisture according to Section 206.3(a)3. The verification testing will take place immediately after the Contractor’s Nuclear Density/Moisture Gauge has obtained a passing acceptance test result as specified in Sections 206.3(b)1.a and 1.b. Verification tests will be run at the same location and in the same test hole as the acceptance test. Maintain a distance of at least 30 feet between gauges and from any other radioactive source when performing acceptance and verification testing. Perform testing in an area where influences affecting the gauge performance are minimized, whenever practical. In some instances, the Representative may direct an additional acceptance test based upon availability of verification testing equipment and personnel.

Verification test results will be compared to the associated acceptance test results and will not be used to determine acceptance of the in-place moisture and density. A verification test is considered acceptable if the Independent Nuclear Density/Moisture Gauge readings are within ±2.0 pounds per cubic foot for wet density (not the dry density) and within ±0.1w for moisture, where w is the moisture content in percent, when compared to the readings obtained by the Contractor’s Nuclear Density/Moisture Gauge.

When verification test results do not conform as specified, check the standard count of both the acceptance test gauge and the verification test gauge on their respective reference standard blocks in accordance with PTM No. 418 or AASHTO T 310, as appropriate, before placement and testing of another area. If the standard count for either gauge does not meet requirements established for the gauge from the last annual calibration, or is inconsistent with the daily gauge standardization count, the gauge must be diagnosed and repaired or replaced, as necessary, before work may proceed. AASHTO T 217 or AASHTO T 265 may be used to help resolve questions concerning proper functioning of gauges when determining moisture.

If both gauges are determined to be functioning properly, the Representative will immediately contact the District Materials Engineer or District Compaction Supervisor for guidance before the continuation of work. The Representative will record the acceptance test results, the verification test results, and applicable corrective measures on Form TR-4276A.

5. Compaction Control Technician. Provide, and assign to the work during placement and compaction of material, a properly trained and experienced Nuclear Equipment Operator to perform the required QC and acceptance testing. The technician must carry a valid nuclear gauge operator certification during placement and compaction of material.

(b) Placement and Compaction.

1. General. Provide uniform material from the same borrow source for the entire lift being placed, unless otherwise indicated or directed by the Representative. Compact material using the specified equipment appropriate for the material classification and placement condition. Do not operate compaction equipment at a speed exceeding 1.5 feet per second (1 mile per hour) when compacting materials. For compaction equipment other than rollers, as specified in Section 108.05(c)4, operate the equipment over the material to be compacted for a minimum duration of six seconds. Use the appropriate target moisture and density for the material being placed for QC, acceptance, and verification testing. Shape layers of the compacted embankment or fill to drain during construction. Fine grade to remove low areas and seal the final surface with a smooth drum roller to promote continuous positive drainage and reduce water infiltration. No furrows at the edges of embankments or fills that prohibit the free drainage of surface water are permitted.

1.a Soil. Place soil for the full width of the embankment or fill in uniform horizontal layers to achieve a compacted 6-inch depth. Determine the optimum moisture content and maximum dry density in accordance with PTM No. 106. Compact soil with a padfoot roller meeting the requirements of Section 108.05(c)3.g. Run all compaction equipment in static mode. Do not use vibratory compaction on soil. A single pass of a smooth drum roller in static mode may be used on soil before compaction with the padfoot roller. Maximum roller speed indicated in Section 206.3(b)1 must not be exceeded. During compaction with a padfoot roller, keep the roller drum clean and free of any soil buildup on the drum surface and between pads. When constructing embankments or fills to top of subgrade elevation with soil, overbuild by at least 3 inches in elevation. Fine grade the surface to fill any depressions left by the roller pads and to establish the final surface elevation. Compact the subgrade surface with a smooth drum roller in static mode. Finish subgrade in accordance with Section 210.
In pipe trenches, locations adjacent to structures, and locations where standard, full scale compaction equipment is prohibited, may cause damage, or is not practical due to space or other constraints, compact soil using equipment as specified in Sections 108.05(c)3.d or 108.05(c)4, as directed by the Representative. Reduce lift thickness to 4-inch compacted depth or as directed by the Representative to achieve the equivalent level of compaction as the full scale compaction equipment. Operate in a manner as to provide the required level of compaction, while producing a dense, stable soil mass that does not rut, push, or shove.

Except for the top 3 feet, compact soil for the full width of embankments to not less than 97% of the maximum dry density. Compact the top 3 feet of soil for the full width of embankments to 100% of the maximum dry density. Determine the in-place dry density of soil in accordance with PTM No. 402, using the direct transmission method. Maintain soil within minus 3% of optimum and the optimum moisture content at the time of compaction. Determine the moisture content in accordance with PTM No. 402. Compact soil to a stable condition so there is no rutting, displacement, or shear wave under compaction equipment. A shear wave is bulging of the soil surface in front of and behind the roller.

1.b Granular Material, Type 1. Place Type 1 granular material for the full width of the embankment or fill in uniform horizontal layers of not more than a compacted 6-inch depth. Compact material adjacent to structures as indicated on the Standard Drawings. Determine the optimum moisture content and maximum dry density in accordance with PTM No. 106. Except for pipe trenches, locations adjacent to structures, and locations where standard, full scale compaction equipment is prohibited, may cause damage, or is not practical due to space or other constraints, compact Type 1 granular material using a smooth drum vibratory roller as specified in Section 108.05(c)3.h. For all other areas use dynamic and/or vibratory equipment as specified in Sections 108.05(c)3.d or 108.05(c)4, as directed by the Representative. Reduce lift thickness to 4-inch compacted depth or as directed by the Representative to achieve the equivalent level of compaction as the full scale compaction equipment.

Except for the top 3 feet, compact Type 1 granular material for the full width of embankments or fills to 97% of the maximum dry density. Compact the top 3 feet of Type 1 granular material for the full width of embankments or fills to 100% of the maximum dry density. As directed by the Representative, determine the in-place dry density of Type 1 granular material in accordance with PTM No. 402 using the direct transmission method. The Representative may allow the backscatter method to be used if the material is too coarse for the direct transmission method to be conducted effectively. Conditions when the backscatter method would be appropriate include when the drive rod cannot be readily driven to the required depth to create the hole necessary to insert the nuclear gauge source rod due to coarse particles impeding or deflecting the drive rod, or when the material is too coarse to create a smooth sided, stable, open hole using the drive rod. Compact Type 1 granular material to a stable condition so there is no rutting, displacement, or shear wave under compaction equipment. A shear wave is bulging of the material surface in front of and behind the compaction equipment.

Maintain Type 1 granular material within plus or minus 2% of the optimum moisture content at the time of compaction. Determine moisture content in accordance with PTM No. 402.

1.c Granular Material, Type 2. Place Type 2 granular material for the full width of the embankment or fill in uniform horizontal layers of not more than a compacted 8-inch depth. Compact material adjacent to structures as indicated on the Standard Drawings. Except for pipe trenches, locations adjacent to structures, and locations where standard, full scale compaction equipment is prohibited, may cause damage, or is not practical due to space or other constraints, compact Type 2 granular material using a smooth drum vibratory roller as specified in Section 108.05(c)3.h. For all other areas use dynamic and/or vibratory equipment as specified in Sections 108.05(c)3.d or 108.05(c)4, as directed by the Representative. Reduce lift thickness to 4-inch compacted depth or as directed by the Representative to achieve the equivalent level of compaction as the full scale compaction equipment.

Compact Type 2 granular material for the full width of embankments or fills to a condition of non-movement under the compaction equipment. Compaction acceptance will be determined by the Representative. Non-movement under compaction equipment is defined as creating a stable condition of the compacted material. A stable condition occurs when there is no rutting, displacement, or shear wave under compaction equipment. A shear wave is bulging of the material surface in front of and behind the compaction equipment.

Maintain Type 2 granular material in a surface damp condition, but not wet (no excess moisture) at the time of compaction.
1.d Rock. Do not place rock in embankments or fills without acceptance of the planned excavation and embankment or fill operations.

When used to form the base of an embankment or fill, place rock the full cross-section width. Place rock on embankment side slopes, where indicated.

Before placing rock on other types of compacted material, slope the top of the embankment or fill from centerline to the sides, at a rate of approximately 1 inch per foot, and compact the surface.

Place rock in uniform loose layers to a depth not exceeding the approximate average size of the larger rock, but limited to a maximum depth of 36 inches. Remove oversize rock or reduce in size until it can be readily incorporated in a maximum 36-inch layer. Do not dump rock in final position, unless specified, but distribute by blading or dozing; keep voids, pockets, and bridging to a minimum. Place rock so larger pieces are evenly distributed and voids are filled as completely as possible. Compact with a smooth drum vibratory roller as specified in Section 108.05(c)3.h. Compact rock to a condition of non-movement under the compaction equipment. Compaction acceptance will be determined by the Representative.

When rock and finer material are placed adjacent to each other at the same time, place the finer material sufficiently above rock layers to allow for proper compaction of the finer material.

When the embankment or fill is to be constructed with rock, choke the surface of the rock with select granular material (2RC) of sufficient thickness to completely fill all voids in the rock and cover with a geotextile meeting the requirements as specified in Section 735, Class 4, Type A. Place an additional layer of select granular material (2RC) to reach the finished subgrade elevation and to permit fine grading as specified in Section 210.

When transitioning from rock to other types of materials, choke the rock surface with select granular material (2RC) of sufficient thickness to completely fill all voids in the rock. Place a second lift of select granular material (2RC) to a compacted thickness of 6 inches. Only one transition from rock to another type of material is permitted in an embankment or fill section.

1.e Shale. Place shale in maximum 6-inch compacted lifts so larger pieces are evenly distributed and voids are filled as completely as possible. Remove oversize shale or reduce in size until it can be readily incorporated in a maximum 6-inch compacted layer. Compact as specified in Section 206.3(b)1.e.

1.f Random Material. Place and compact random material as specified in Section 206.3(b)1.e.

2. Wet and/or Unstable Foundation Areas. Where the embankment or fill foundation is in water or swamp areas or is saturated or unstable, construct embankment or fill with rock to the indicated elevation or as directed.

3. Existing Embankment or Fill. Existing embankment or fill is defined as material placed and compacted during prior construction not associated with the current project, or material placed and compacted as part of the current project during a prior construction season and has been in place at least one winter season. When an existing embankment or fill requires additional material to bring it to the required elevation, proof roll the entire existing surface as indicated in Section 206.3(a), before placement of material.

4. Confined Areas. Do not use rock, shale, random material or any other material having a maximum size greater than 2 inches or otherwise preventing the material from being placed in a compacted 4-inch layer in confined areas. Place material in uniform, horizontal layers of not more than 4 inches in compacted depth in areas where small or hand operated compaction equipment, as specified in Sections 108.05(c)3.d and 108.05(c)4, is required for compaction. Compact material to the density and at the moisture content based on the material type as specified in Sections 206.3(b)1.a, 1.b, and 1.e. Determine the in-place dry density and moisture content based on the material type as indicated in Sections 206.3(b)1.a, 1.b, and 1.e.

5. Structure Areas. Construct structure backfill behind bridge abutments and adjacent to structures with Selected Borrow Excavation, as shown on the Standard Drawings and as specified in Section 1001.3(q)2.b. Material requirements for structure backfill are indicated on the Standard Drawings. Compact with equipment for the material classification and placement condition as specified in Section 206.3(b) and in accordance with the Standard Drawings. Do not place rock where deep foundations are to be installed.
6. **Frozen Material.** Do not place or compact frozen material. Do not place embankment or fill material on any material that is frozen. Remove frozen material, if the embankment or fill top freezes, before placing additional material.

7. **Wet Material.** Before compacting, dry material to within minus 3% of optimum and the optimum moisture content for soil, plus or minus 2% of optimum moisture content for Type 1 granular material, and surface damp for Type 2 granular material. Do not place material on embankment or fill that has become unstable from excessive moisture.

8. **Dry Material.** Before compacting, moisten material to within minus 3% of optimum and the optimum moisture content for soil, plus or minus 2% of optimum moisture content for Type 1 granular material, and surface damp for Type 2 granular material.

(c) **Stability.** Assume responsibility for the stability of embankments and fills. Replace material that, in the Representative’s judgment, has been damaged or displaced due to the following: carelessness or negligence, natural causes such as storms and floods, shrinkage of material, and all other reasons not attributable to other than movement of the natural ground upon which the material is placed.

Dry, reshape, recompact, and test material for density and moisture requirements, if construction equipment causes movement, rutting, or displacement of the material.

206.4 **MEASUREMENT AND PAYMENT**—

(a) **Embarkment.** When measurement is required, embankment will be measured in its final position as specified in Section 203.4(a)2 by the cubic yard.

Except for AASHTO Nos. 8 or 57, or PENNDOT Nos. 2A or OGS meeting the requirements of Section 703.2 and select granular material (2RC) meeting the requirements of Section 703.3, embankment construction is incidental to excavation or borrow excavation.

(b) **Select Granular Material (2RC).** Ton

(c) For fills and backfills incorporating AASHTO Nos. 8 or 57, or PENNDOT Nos. 2A or OGS meeting the requirements of Section 703.2 or structure backfill, measurement and payment are made according to the work specified.

(d) **Geotextile.** Section 735, Class 4, Type A. Square Yard