

PennDOT Specification Changes for Materials, Equipment, Compaction, and Testing of Embankments and Fills

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Reasons for Changes

- PennDOT has worked on updating its embankment/fill compaction specifications over period of years including addressing the following issues:
 - Existing specifications did not adequately address compatibility between materials, test methods, and compaction equipment
 - Requirements for compaction equipment were inadequate and did not assure equipment was appropriate for material being compacted
 - Burden of QC/QA was on the Department, not the Contractor

Reasons for Changes

- PennDOT set out to make modifications to resolve these issues, with goals of:
 - Improve quality
 - Improve operational efficiency
 - Minimize construction problems and conflicts
 - Improve clarity of requirements for benefit of both the Department and Contractors

Proposed Changes

- Proposed changes are significant and broad
- Under development and refinement for many years
- Changes involve many interrelated standard specifications, laboratory and field test methods, manuals, and standard forms

Proposed Changes

- Revisions involve the following documents:
 - Pub. 408, Section 108 - Performance and Progress
 - Pub. 408, Section 206 - Placement and Compaction of Embankment and Fill
 - Pub. 408, Section 210 - Subgrade
 - Pub. 408, Section 350 - Subbase
 - Pub. 408, Section 601 - Pipe Culverts
 - PTM 106 - The Moisture Density Relations of Soils (Using a 5.5-lb. Rammer and a 12" Drop)
 - PTM 402 - Determining In-Place Density and Moisture Content of Construction Materials by Use of Nuclear Gauges
 - PTM 418 - Nuclear Gauge Calibration and Standard Count Verification of Troxler Moisture/Density Nuclear Gauges
 - POM - Part B, Section 6
 - Form CS-206 Minimum Quality Control Plan for Nuclear Gauge Compaction Testing
 - Form TR-4247 Method of Calculation of Moisture-Density Relationship
 - Form TR-478A Report on Compaction Density Non-Movement

Focus of Changes

- Material definitions (Soil, Granular Mat'l., Rock, Shale, Random Mat'l.)
- Proof Rolling
- Placement
- Compaction & Minimum Equipment Performance Requirements
- QC/Acceptance/Verification Testing
- Test Methods

MATERIALS

Why Changes Necessary? - Materials

- Changes necessary to better define construction materials based upon their behavior during compaction
- Needed to define materials in a way that would allow compatible laboratory and field testing to be specified for the different materials
- Revised definitions of materials allow for more compatible compaction equipment to be specified, depending on the material type

Old Specs. - Material: Soil

- Earth material with the following physical characteristics:
 - Gradation: More than 35% passing No. 200 sieve
 - Minimum dry mass density = 95 pcf
 - Maximum LL = 65
 - PI: Not less than LL minus 30 for soils with LL of 41 to 65

New Specs. - Material: Soil

- Earth material with the following physical characteristics:
 - **Gradation: More than 20% passing No. 200 sieve**
 - **Minimum dry mass density = 95 pcf**
 - **Maximum LL = 65**
 - **PI: Not less than LL minus 30 for soils with LL of 41 to 65**
- **Recognizes that fines (material passing No. 200 sieve) disproportionately control soil behavior**

Old Specs. - Material: Granular

- Natural or synthetic mineral aggregates having 35% or less passing the No. 200 sieve
- Generally, it's intended to be a non-cohesive soil

New Specs. - Material: Granular

- Granular Material - Separated into two types (Type 1 and Type 2)
- Type 1 Granular - manufactured fine aggregates and finer grained earth materials (i.e., sands)
 - Gradation - greater than 70% passing 3/8" sieve and less than 20% passing No. 200 sieve
 - Excludes AASHTO No. 8 coarse aggregate and select granular material (PennDOT 2RC)

New Specs. - Material: Granular

- Type 2 Granular - manufactured coarse aggregates and very coarse grained earth materials (i.e., gravels)
 - Gradation - less than or equal to 70% passing 3/8" sieve and less than 20% passing No. 200 sieve
 - Includes AASHTO No. 8 or 57 coarse aggregate, PennDOT Nos. 2A or OGS coarse aggregate, and Select granular material (PennDOT 2RC)
 - Also includes structure backfill

Old Specs. - Material: Rock

- Natural material that cannot be excavated without blasting or using rippers
- Boulders and detached stones of a size that cannot be readily placed and compacted in loose 8-inch layers and having insufficient soil to fill the voids in each layer

Old Specs. - Material: Shale

- Shale - "Rock-like" material formed by natural consolidation of mud, clay, silt, and fine sand; usually thinly laminated, comparatively soft, and easily split
- No other gradation requirements

Old Specs. - Material: Random

- Random Material - Any accepted combination of the above classifications and may include concrete, brick, stone, or masonry units from demolition
- No other gradation requirements

New Specs. - Material: Rock, Shale & Random

- Rock - Same as previous
- Shale - Same as previous
- Random Material - **Type 1 or Type 2 granular material** combined with shale, concrete, brick, stone, or masonry units that can be readily incorporated into compacted 6" layers

Expected Benefits - Materials

- Clear distinction relative to acceptance requirements (i.e., moisture/density vs. non-movement)
- Appropriate QC and acceptance method for material type placed and compacted
- Requires method (compaction equipment) appropriate for material to be placed and compacted

Expected Benefits - Materials

- Improved quality and effectiveness of compaction and compaction control
- Improved quality of construction for fills and pavement foundations
- **Summary: Reconciles materials with operations and control**

PROOF ROLLING

Why Changes Necessary? - Proof Rolling

- Need to refine and standardize procedure
- Clearly define when and where proof rolling required

Old Specs. - Proof Rolling

- No standard requirements when to perform proof rolling
- Section 208 - Special Rolling (50 ton pneumatic-tired equipment)
- Various special provisions

New Specs. - Proof Rolling

- Loaded triaxle dump truck (72,000 lbs. GVW)
- Speed of 1.5 fps (1 mph) maximum
- Cover entire area
- No **permanent** deformation greater than 1/2"
- Provides direction on when proof rolling required (i.e. embankment foundation, after shut-downs, before placing subbase)

Expected Benefits - Proof Rolling

- Identification of unsuitable subgrade will be done before fill placement begins resulting in less re-work
- No special equipment required (loaded triaxle dump truck)
- Improved uniformity of subgrades
- Identification of areas of subgrades, fills, and subbase that have been exposed to weather and are no longer acceptable
- Improved quality of construction

PLACEMENT

Why Changes Necessary? - Placement

- Changes necessary to provide uniformity between specifications
- Also necessary to address/control lift thickness when hand operated compaction equipment is used

Old Specs. - Placement

- **Loose lift thickness (8")** for all compaction equipment, except 4" loose lift thickness in "inaccessible areas"
- Applicable to all embankment materials except rock (which is 36" max)
- Subbase (which is Type 2 Granular Material) was 8" **compacted**

New Specs. - Placement

Compacted Lift Thickness:

- Soil, Type 1 Granular, Shale, and Random Material: 6" when compacting with full size compaction equipment
- Type 2 Granular: 8" when compacting with full size compaction equipment
 - Type 2 Granular linked to construction requirements for pavement subbase so as to avoid unnecessary spec changes
- Rock: 36" maximum (no change)

New Specs. - Placement

Compacted Lift Thickness:

- 4" when compacting with hand operated compaction equipment for all material types
- Thickness reduction accounts for lower energy of hand operated equipment

Expected Benefits - Placement

- Maintain and/or improved compaction operational efficiency
- Provide standardization and uniformity between related specifications
- Assure adequate and appropriate type energy of compaction for materials based on equipment used
- Simplified field control

COMPACTION

Why Changes Necessary? - Compaction

- Necessary to ensure appropriate equipment used for type of material being compacted
- Assure adequate energy, penetration, and pressure with depth for both full size and hand operated equipment
- **Significant changes**

Old Specs. - Compaction

- Limited equipment requirements
- No limitations by material type
- No equipment speed requirements

New Specs. - Compaction

- Equipment requirements specified by equipment type - equipment must meet minimum requirements based on factors including weight, centrifugal force, amplitude, and frequency
- Equipment rated based upon ability to provide sufficient energy to achieve required density (required compaction)

New Specs. - Compaction

- Equipment type specified according to material being placed/compacted - e.g. smooth drum vibratory roller for granular material, static padfoot roller for soil
- Maximum equipment velocity of 1.5 fps (1 mph) - assures equipment on material sufficient time for deformation response

Expected Benefits - Compaction

- Increased compaction efficiency
- Promote/increase uniformity of compaction in each lift of material
- Prevent/reduce problems with obtaining stability of compacted material (especially soil)
- Improved quality of construction

QC/ACCEPTANCE/
VERIFICATION TESTING

Why Changes Necessary? - QC/Acceptance/Verification

- Require contractor QC and acceptance testing at standard frequencies during construction
- Reduce burden of testing on the Department (limited manpower and testing policy restrictions)
- Need appropriate test methods to be used for material placed and compacted

Old Specs. - QC/Acceptance

- No specified QC requirements for Contractor
- Department does acceptance testing
- Acceptance for soil and granular material based upon moisture/density testing and use of nuclear gauge in backscatter mode (except where material too coarse - then non-movement)
- Acceptance for shale, random material, and rock based upon non-movement

New Specs. - QC/Acceptance/Verification

- Require contractor to prepare a compaction control QC Plan when placing and compacting soil or Type 1 granular material
- QC testing performed by contractor at a specified frequency
- Acceptance testing performed by contractor at a specified frequency and witnessed by the Department

New Specs. - QC/Acceptance/Verification

- Verification testing performed by the Department at a specified frequency (verification that contractor's gauge is working properly)
- Testing requirements for soil and Type 1 granular material moisture/density with nuclear gauge in direct transmission mode

New Specs. - QC/Acceptance/Verification

- Testing requirement for Type 2 granular, shale, random material, and rock non-movement with acceptance by the Department
- Modeled after QC and acceptance of other materials (e.g., concrete)

Expected Benefits - QC/Acceptance/Verification

- Contractor QC at specified frequencies will reduce the chances of non-uniform compaction and poor workmanship
- Limit potential problems and identify/resolve problem areas in more timely and effective manner
- Reduced burden on the Department and eliminate potential delays for contractor (i.e., improve operational efficiency and work flow)

Expected Benefits - QC/Acceptance/Verification

- Increased monitoring of quality of construction
- Contractor monitors own performance (with Department oversight), putting responsibility for QC/QA where it should be

TESTING METHODS

Why Changes Necessary? - Testing Methods

- Need to provide accurate and reliable testing of the materials placed and compacted when assessing compliance and acceptance
- Need to provide appropriate use of moisture/density control (i.e., use when applicable)
- Need to use nuclear density gage in manner that accurately measures in-place density and moisture

Old Specs. - Testing Methods

- Used Proctor test for determining target moisture and density for soil and granular material
 - Performed test with substitution for material retained on the **3/4" sieve**
- Department performed field testing for compliance
 - Field testing for compliance for soil and granular material was nuclear gauge in the backscatter mode
 - Use of a non-movement form for all other materials

New Specs. - Testing Methods

- Use Proctor for determining target moisture and density for soil and Type 1 Granular material
 - Perform test with substitution for material retained on the **3/8" sieve**
- Contractor to perform field testing (QC and acceptance) to monitor and assess compliance
 - Field testing for compliance for soil and Type 1 Granular material is nuclear gauge in the **direct transmission mode**
 - One hole, 3-point test (turn gauge 90°, average of 3 tests)

New Specs. - Testing Methods

- Department witnesses acceptance testing and conducts independent verification testing
- All testing (QC, acceptance, and verification) conducted at prescribed intervals based upon type of construction
- Acceptance by non-movement for all other materials (Department assesses acceptance for non-movement)

Expected Benefits - Testing Methods

- Improved confidence that the target moisture/density values are representative of the material being placed/compacted in the field
- Assure method of acceptance appropriate for material being placed and compacted
- Increased monitoring of quality when compaction controlled by moisture/density
- Improved monitoring and quality of construction

Summary

- Changes are broad and significant
- Changes will impact and benefit the Department and industry
- High expectation that changes will improve the quality of construction and reduce construction problems

Thank You!

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