S

Soils Technician Course

Tennessee Department of Transportation

2020 Manual

Soils Technician Course

Tennessee Department of Transportation

2020 Manual

Table of Contents

TN TDOT Department of Transportation

WELCOME!

Soils Technician Course

TN

Who Are We?

- Headquarters Materials and Tests Division
- Field Operations
- Concrete and Aggregate Section
- We want to provide each student with the best ONLINE training program possible

- Jason Mellons – Michael.J.Mellons@tn.gov

TN

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- Trans. Proj. Spec. SR
- Areas of Expertise:
  - Prestressed Products
  - Aggregate
- Several years of experience with both performing and teaching these test methods
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- Trans. Proj. Spec.
- Areas of Expertise:
  - Ready Mix
    - Mix Design
  - Producer List
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  - Precast Products
  - Volumetric Concrete
  - Retaining Walls
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Seth Gilliland

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  - Precast Products
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Purpose of Certification

- To ensure proper performance of tests
- To improve reliability of results
- For quality control
- To comply with federal requirements

Course Highlights

- Originally part of the aggregate technician course and formally known as the Soils and Aggregate Technician Course
- The Soils part of this class has been consolidated into this online learning module
- Slide Presentations
- No certification or exam will be provided

TN

Resources

- Course materials
  - Presentation slides
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
  - HQMT website: https://www.tn.gov/tdot/materials-and-tests.html

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ADA Notice of Requirements

- Can be found at the following website:
  - https://www.tn.gov/tdot/government/g/ada-office0.html
- To be in compliance with TDOTs requirements listed on the website above, it is our goal to provide reasonable accommodations to those who identify themselves as having a disability and request such accommodations
- Please feel free to bring it to any of the course instructors and accommodations will be administered as discretely as possible

TN

Questions

TN TDOT.MaterialsTests@tn.gov

1

Soils Classification

AASHTO M1245

ASTM D2487

Standard Method of Test for

Soils Classification

References

AASHTO M1245

ASTM D2487

TN

Identification, Description, and Classification

- Identification, Description, and Classification are the three terms used by geotechnical specialist to describe geo-material.

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Identification

- Identification is the process of determining which components exist in a particular soil sample.
  - Gravel?
  - Sand?
  - Silt?
  - Clay?

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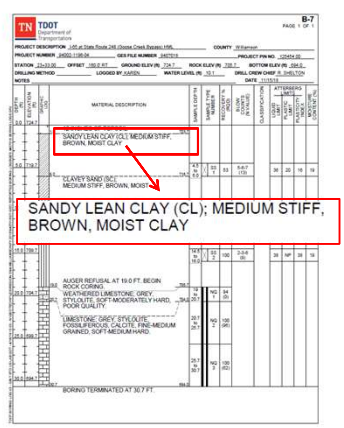
Description

- The process of estimating the relative percentage of each component to prepare a word picture of the sample.

- Most common process in the field for determining the soil type. It is accomplished by visual examination and the feel of the sample.



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Classification

- Laboratory confirmation of the field determination.
- Two major soil classification systems used in the US.
  - Unified Soil Classification
  - AASHTO Classification

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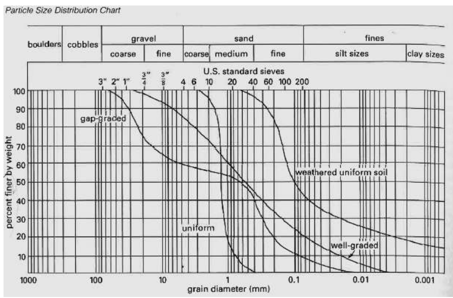
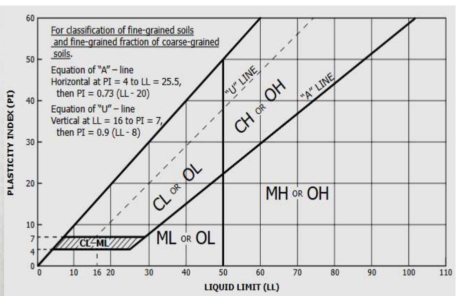
Classification

- The Unified Soil and AASHTO classification systems are both based on gradation and the Atterberg Limit tests.





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Unified Soil Classification

Soil classification chart (laboratory method) (after ASTM D 2487)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[a] COARSE-GRAINED SOILS (Sands and Gravels) - more than 50% retained on No. 200 (0.075 mm) sieve FINE-GRAINED (Silts and Clays) - 50% or more passes the No. 200 (0.075 mm) sieve			Soil Classification: Group Symbol	Soil Classification: Group Name[b]
GRAVELS More than 50% of coarse Fraction retained on No. 4 Sieve	CLEAN GRAVELS < 5% fines	$C_u \geq 4$ and $1 \leq C_c \leq 3$[e]	GW	Well-graded gravel[f]
		$C_u < 4$ and/or $1 > C_c > 3$[e]	GP	Poorly-graded gravel[f]
	GRAVELS WITH FINES > 12% of fines[c]	Fines classify as ML or MH	GM	Silty gravel[f,g,h]
		Fines classify as CL or CH	GC	Clayey gravel[f,g,h]
SANDS 50% or more of coarse fraction passes No. 4 Sieve	CLEAN SANDS < 5% fines[d]	$C_u \geq 6$ and $1 \leq C_c \leq 3$[e]	SW	Well-graded Sand[i]
		$C_u < 6$ and/or $1 > C_c > 3$[e]	SP	Poorly-graded sand[i]
	SANDS WITH FINES > 12% fines[d]	Fines classify as ML or MH	SM	Silty sand[g,h,i]
		Fines classify as CL or CH	SC	Clayey sand[g,h,i]
SILTS AND CLAYS Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[j]	CL	Lean clay[k,l,m]
		PI < 4 or plots below "A" line[j]	ML	Silt[k,l,m]
	Organic	$\frac{\text{Liquid limit - overdried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[k,l,m,n] Organic silt[k,l,m,o]
SILTS AND CLAYS Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[k,l,m]
		PI plots below "A" line	MH	Elastic silt[k,l,m]
	Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[k,l,m,p] Organic silt[k,l,m,q]
Highly fibrous organic soils	Primary organic matter, dark in color, and organic odor		Pt	Peat

- **Coarse-grained Soils**
  - G - gravel
  - S - sand
- **Fine-grained Soils**
  - M - inorganic silts
  - C - inorganic clays
  - O - organic clays and silts
- **Subcategories**
  - W - well graded, fairly clean
  - C - significant amounts of clay
  - P - poorly graded, fairly clean
  - M - significant amounts of silt
  - L - low Compressibility
  - H - high Compressibility

AASHTO Soil Classification

AASHTO Soil Classification System (from AASHTO M 145 or ASTM D3282)

General Classification	Granular Materials (35% or less passing the 0.075 mm sieve)							Silt-Clay Materials (>35% passing the 0.075 mm sieve)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, % passing											
2.00 mm (No. 10)	50 max	...	...	...	...	...	...	...	...	...	...
0.425 (No. 40)	30 max	50 max	51 min	...	...	...	...	...	...	...	...
0.075 (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid Limit	...		...	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[1]
Usual types of significant constituent materials	stone fragments, gravel and sand		fine sand	silty or clayey gravel and sand				silty soils		clayey soils	
General rating as a subgrade	excellent to good							fair to poor			

Note (1): Plasticity index of A-7-5 subgroup is equal to or less than the LL - 30. Plasticity index of A-7-6 subgroup is greater than LL - 30

Comparable Soil Groups

Soil Group in AASHTO System	Comparable Soil Groups in Unified System		
	Most Probable	Possible	Possible but Improbable
A-1-a	GW, GP	SW, SP	GM, SM
A-1-b	SW, SP, GM, SM	GP	—
A-3	SP	—	SW, GP
A-2-4	GM, SM	GC, SC	GW, GP SW, SP
A-2-5	GM, SM	—	GW, GP, SW, SP
A-2-6	GC, SC	GM, SM	GW, GP SW, SP
A-2-7	GM, GC, SM, SC	—	GW, GP, SW, SP
A-4	ML, OL	CL, SM, SC	GM, GC
A-5	OH, MH, ML, OL	—	SM, GM
A-6	CL	ML, OL, SC	GC, GM, SM
A-7-5	OH, MH	ML, OL, CH	GM, SM, GC, SC
A-7-6	CH, CL	ML, OL, SC	OH, MH, GC, GM, SM

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Why classify a soil?

- Identifies and groups soils of similar engineering characteristics.
- Provides a "common language" to describe soils.
- In a limited manner, soil classifications can provide approximate values of engineering characteristics.

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Questions

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Engineering Characteristics

Engineering Characteristics

References

Geotechnical Engineering Textbooks

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Sand and Gravels

- Great foundation material for supporting structures and roads.
- Great embankment material.
- Best backfill material for retaining walls.
- Susceptible to settlement under vibratory loads or blasting.
- Generally not frost susceptible.

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Clays

- Low Shear Strength
- Plastic and Compressible
- Loses shear strength with wetting and disturbance.
- Poor material for backfill and embankments.
- Clay slopes are prone to landslides.

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Silts

- Low shear strength.
- High capillarity and frost susceptibility.
- Relatively low permeability.
- Frost heaving susceptibility.
- Difficult to compact.

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Questions

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Embankment Construction

TDOT Standard Specifications

(Section 205)

Embankment Construction

References
TDOT Standard Specifications
(Section 205)

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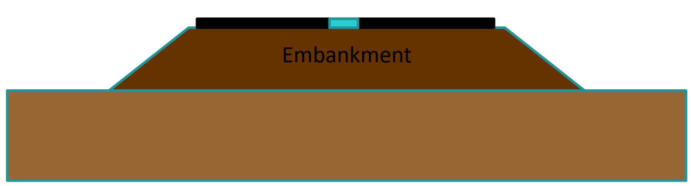
What is an embankment?

- An embankment refers to a volume of earth that is placed and compacted for the purpose of raising the level of a roadway above the ground level.



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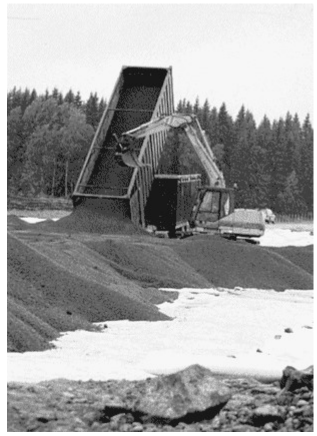
Major Embankment Materials

- Rock fragments
- Gravel
- Sand
- Silt
- Clay



Organic Materials

- Topsoil or other organic material should never be used as embankment material.

Graded Solid Rock (Item 203-02.01)

- Sometimes embankments are constructed out of rock to bridge soft soils or to provide a steeper slope than permitted by conventional fill.
- Graded Solid Rock is typical and is defined in the spec book as follows:
  - Max Particle Size of 3 Feet in any direction.
  - Particle size distribution in which at least 50%
    of the rock is uniformly distributed between 1
    foot and 3 feet in diameter, and no more than
    10% is less than 2 inches in diameter.
  - Roughly equi-dimensional in shape.
  - No thin, slabby material.

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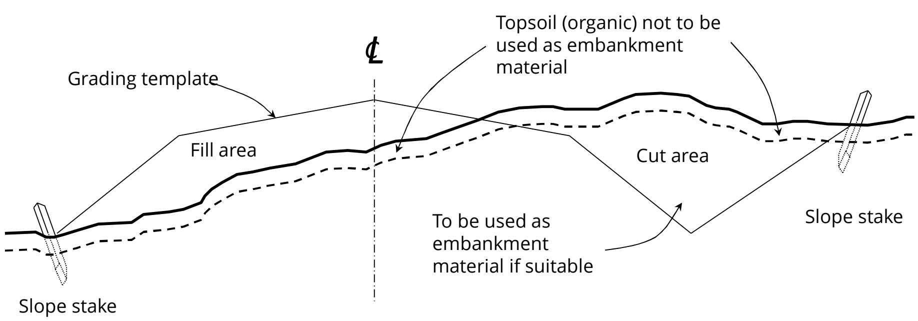
Sources of Embankment Materials



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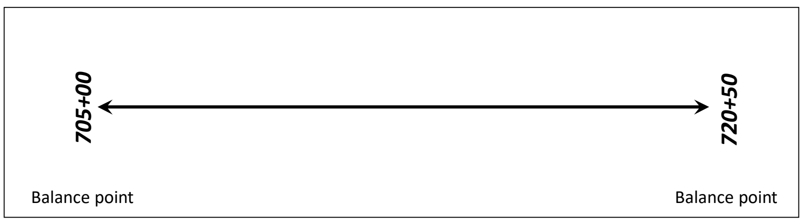
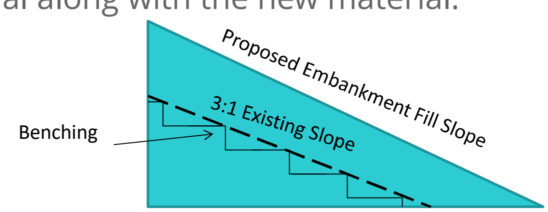
Earthwork Balances

- Earthmoving is typically designed to achieve earthwork balances at intervals along the project.
- The contractor is expected to haul within the balances shown on the plans or as adjusted by the project supervisor.



Pre-Embankment Construction

- Before beginning embankment construction in any area, complete Clearing and Grubbing, Removal of Structures and Obstructions, and fill in all depressions or holes with suitable material and compact.
- When placing embankment material on or against slopes that are steeper than 4:1, cut benches into the existing slope while bringing up the new embankment materials in layers. Re-compact the cut material along with the new material.



Formation of Embankments

- Construct embankments so as to provide adequate surface drainage at all times.
- Keep placing and compacting area separate.
- Compact each layer of embankment to the required density.
- Obtain engineers approval before proceeding with each succeeding layer.
- Do not incorporate or bury any perishable materials or obstructions.
- Embankments must be built up in uniform, well-mixed layers for the full width of the roadway.

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Embankment Placement Equipment and Procedures

- The equipment and procedures involved in the dumping and spreading of the embankment material will depend on the type of equipment available and material used.

- The contractor must have enough equipment and use procedures that will enable proper moisture and compaction requirements to be met.

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Questions

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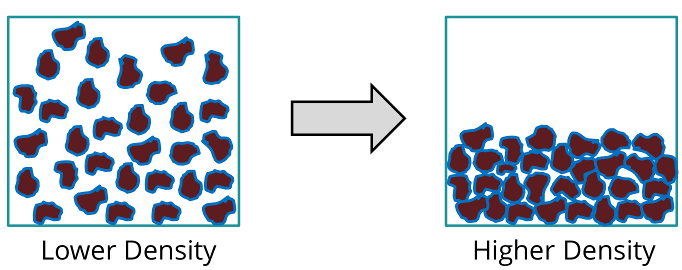
Compaction

Compaction

What is Compaction?

- Compaction is the process of mechanically densifying a soil.



Why Do We Compact?

- To improve the engineering properties of the soil mass, which in turn will:
  - Increase the strength and stiffness of t he embankment
  - Increase the bearing capacity of foundations
  - Decrease the settlement of the roadway embankment
  - Reduce movement of water
  - Increase the stability of slopes and embankments
  - Provide uniformity

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Factors Affecting Compaction

- Soil Type – Material and Gradation
- Compactive Effort – Equipment and Passes
- Moisture Content – At time of compaction
- Lift Thickness – Limits Compaction Depth

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Questions

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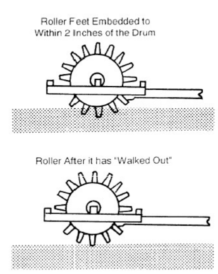
Compaction Equipment

Compaction Equipment

Sheepsfoot Roller

- Compacts all fine-grained materials
- Will not compact cohesionless granular materials
- Compacts from the bottom up and is used especially for plastic materials
- The lift thickness for sheepsfoot rollers is limited to 6 inches in compacted depth
- If the required densities are not being obtained, it is often necessary to change to a thinner lift to ensure that the specified density is obtained



Tamping-Foot Roller

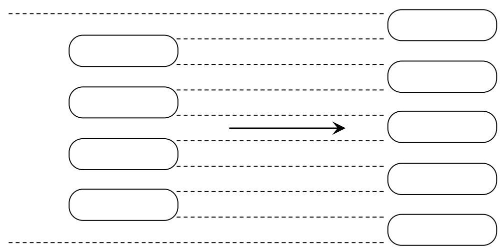
- A tamping-foot roller is a modification of the sheepsfoot roller
- The tamping feet are trapezoidal pads attached to a drum
- Tamping-foot rollers are normally self-propelled, and the drum may be capable of vibrating
- The tamping-foot roller is suitable for use with a wide range of soil types

Pneumatic Rollers

- Variants include: pneumatic-tired roller & self-propelled pneumatic-tired roller
- Suitable for granular materials; however, it is not recommended for fine-grained clay soils except as necessary for sealing the surface after a sheepsfoot roller has "walked out"
- It compacts from the top down and is used for finishing all types of materials, following immediately behind the blade and water truck

Pneumatic Rollers

- Pneumatic rollers have an uneven number of wheels and should never have fewer than 7 wheels. The tires are arranged so that the gaps between the tires of one axle will be covered by the tires of the other.



Steel-Wheeled Roller

- The steel-wheeled roller is much less versatile than the pneumatic roller.
- The steel-wheeled roller is used for compacting granular materials in thin lifts
- Although extensively used, it is normally operated in conjunction with one of the other types of compaction rollers
- Probably its most effective use in subgrade work is in the final finish of a surface, following immediately behind the blade, forming a dense and watertight surface

Self-Propelled, Smooth-Drum Vibratory Roller

- Compacts with a vibratory action that rearranges the soil particles into a denser mass
- The best results are obtained on cohesionless sands and gravels
- Compaction efficiency is impacted by the ground speed of the roller and the frequency and amplitude of the vibrating drum

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Questions

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Proctor Density Testing

AASHTO T99

AASHTO T180

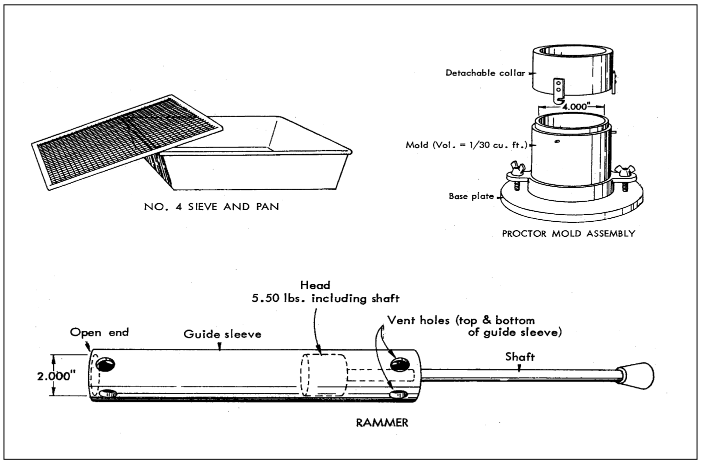
Proctor Density Testing

References
AASHTO T99 Standard Proctor Test
AASHTO T180 Modified Proctor Test

Proctor Density Test Methods

- TDOT uses the Proctor density test to determine the densities to which a soil can be compacted with various moisture contents
- AASHTO T99 Standard Proctor Test
- AASHTO T180 Modified Proctor Test

Proctor Density Test Equipment



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AASHTO T99 & T180

Test Method	Mold Diam (in)	Mold Height (in)	Mold Vol. (ft^3)	Rammer Wt. (lbs.)	Rammer Drop Height (in)	No of Layers	Blows/ Layer	Energy (ft-lbs/ft^3)
AASHTO T99 - Standard Proctor	4	4.5	1/30	5.5	12	3	25	12375
AASHTO T180 - Modified Proctor	4	4.5	1/30	10	18	5	25	56250

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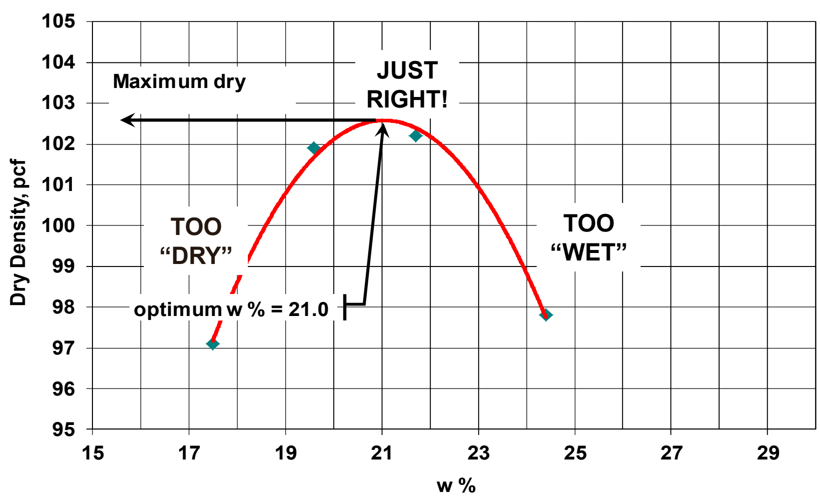
Standard Proctor Density Test

TN

Moisture-Density Curve



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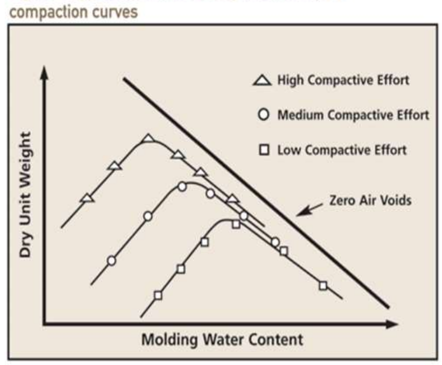
Density/Moisture Ranges

- High maximum densities are 125 - 145 pcf (oven-dry weight)
  - Low optimum moisture (~8%) corresponds to high maximum density
- Low maximum densities are 85 - 100 pcf (oven-dry weight)
  - High optimum moisture (~30%) corresponds to low maximum density

Figure 1. Typical moisture density relationships or compaction curves



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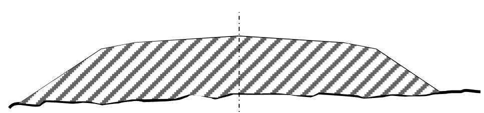
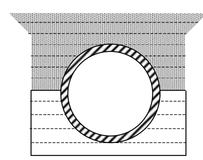
Earthwork Requiring Proctor Tests

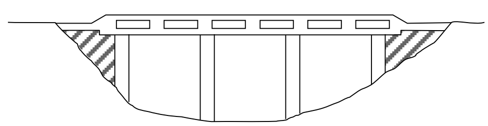
Embankments



Pipe backfill



Structure backfill



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Questions

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Nuclear Density Testing

SOP 7-1

AASHTO T310

Nuclear Density Testing

References

SOP 7-1 (Nuclear Density Testing)

AASHTO T 310 – Standard Method of Test for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods

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Nuclear Density/Moisture Testing

- SAFETY FIRST!!!!
- You must have attended a Radiation Safety Course prior to using a Nuclear Gauge!
- Never handle a nuclear gauge without wearing your own personal radiation dosimeter.
- Never leave a nuclear gauge unattended on a job site.

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Soils and Aggregate Technician Certification

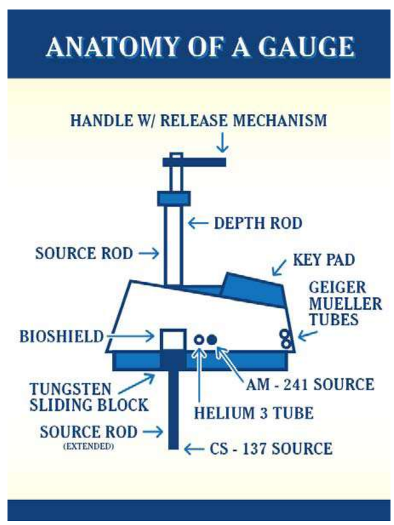
TDOT Certification

- In order to perform Nuclear Density testing on a TDOT project. The individual performing the test must take the Nuclear Gauge Field Technician Course.
- This half-day course is designed to cover TDOT policy on the proper testing procedure for Nuclear Density Gauges as well as covering random testing for density on a project site.

TN

Nuclear Density/Moisture Testing

- Regardless of gauge manufacturer (Troxler, Humbolt, Instrotek, etc.), all gauges utilize the same basic components.
- All tests performed on soil and aggregate will be using the Direct Transmission method.



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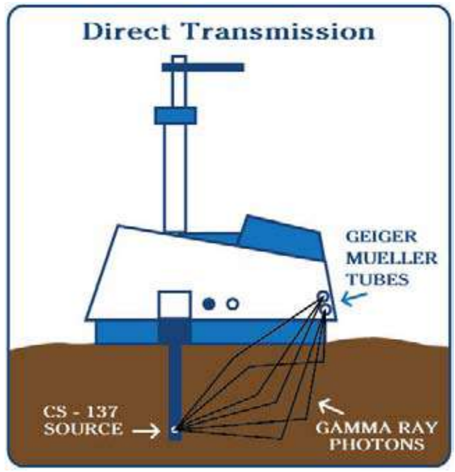
Nuclear Density/Moisture Testing

- When taking a test the gauge measures the amount of radiation detected over a predetermined timeframe, such as one minute.
- The detector tubes count the radiation that is able to pass through the material between the bottom of the source rod and the detector tubes.
- The denser the material, the lower the amount of radiation that is able to reach the detector tubes to be counted.



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Nuclear Density

- Report test results on TDOT Form no. DT-0314
- This form can be found on the Materials and Test Division website, under the Forms tab.
- https://www.tn.gov/tdot/materials-and-tests/field-operations/forms.html

SAMPLE

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360
DENSITY WORKSHEET - NUCLEAR METHOD

Project Reference No. SP
Project No.
Nuclear gauge no. 456
County Montgomery
Contract No. 5678
Date
Region 3

Lot No.	4				
Test No.	1	2	1	2	3
Station	40+77	39+50	40+77	39+50	40+77
Offset (ft.)	12'R	24'R	12'R	24'L	12'L
Feet Below Grade	9	10	8	9	7
Moisture Standard Count	587	587	587	587	587
Moisture Count Ratio	—	—	—	—	—
Probe Depth	6"	6"	6"	6"	6"
Density Standard Count	2769	2769	2769	2769	2769
Density Count	2460	2397	2542	2541	2491
Density Count Ratio	—	—	—	—	—
Unit Weight Wet (pcf)	123.0	124.1	121.4	121.4	122.3
Moisture (pcf)	23.7	23.9	27.3	27.5	26.2
Unit Weight Dry (pcf)	99.3	100.1	94.1	93.9	96.2
Percent Moisture	23.9	23.9	29.0	29.3	27.2
Cut Station	43+00	43+00	43+00	43+00	43+00
Sample Number	66	66	66	66	66
Proctor Density	96.2	96.2	96.2	96.2	96.2
Optimum Moisture	22.3	22.3	22.3	22.3	22.3
Percent +4	26.3	26.3	26.3	26.3	26.3
Corrected Proctor Density					
Corrected Optimum Moisture					
Percent Compaction	103.2	104.1	97.8	97.6	96.7

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Questions

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Quality Acceptance Testing

SOP 1-1

Quality Acceptance Testing

References

SOP 1-1 (Sampling and Testing Guide)

TN

Quality Acceptance Testing

- Generally, a quality-acceptance plan consists of breaking the total job down into lots.
- A lot is accepted or rejected depending on the test results obtained through random sampling that represent the lot.
- By handling the acceptance procedure in this way, the project engineer is able to determine the quality of the job on a lot-by-lot basis.
- This benefits the construction unit and project engineer by identifying the lots that will be accepted and the lots that will be rejected.

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Quality Acceptance Testing: Procedure

- Identify Density/Moisture Requirements
  - Based on type of material being placed
  - Target values are determined by Materials and Tests and submitted to Project Supervisor.
  - These values may change during the course of the project, so be sure to make sure you have the most current numbers.
- Determine Required Lot Size/Number of Tests
- Determine Test Locations
- Perform Test(s)
- Report Results

Determine Required: Lot Size/Number of Tests/Test Locations

- S.O.P. 1-1: Sampling and Testing Guide
  - Describes the testing frequency for all materials
  - Lists the person responsible for either obtaining the sample or performing the test.
  - Available in PDF format at:
  - https://www.tn.gov/tdot/materials-and-tests/standard-operating-procedures.html

Quality Acceptance Testing: Soil Best Practices

- Use a "test strip" to determine the approximate number of passes needed to attain proper densities
- Test every lift as soon as compaction is completed
- Test obvious weak spots
- Remove all oversized materials
- Remove any pockets of organic or unsuitable soil material

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Questions

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TDOT Requirements

TDOT Standard Specifications for Road and Bridge Construction (2015)

TDOT Requirements

References

TDOT Standard Specifications for Road and Bridge Construction (2015)

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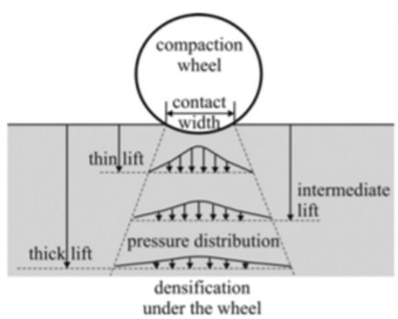
Soil Lift Thickness Standard Specifications Section 205.04

- Embankments that consist of predominantly soil must be placed in horizontal lifts not thicker than 10 inches before compaction (loose).



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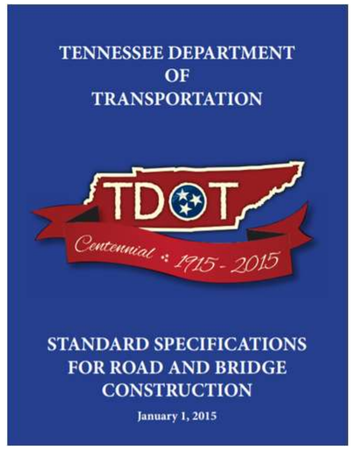
TDOT Requirements

- TDOT requires that a certain percentage of the maximum dry density (“relative compaction”) be obtained while the moisture content of the soils is held within certain limits.



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Relating Laboratory Tests to Field Test Results

- Relative Compaction (RC) is used to express laboratory-measured compaction parameters in terms of field compaction.

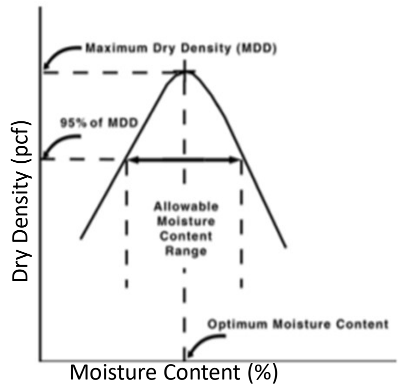
- RC is simply the ratio of the desired field dry unit weight to the maximum dry density measured in the laboratory.

$$RC = \frac{\gamma_{d\,field}}{\gamma_{d\,max}} \times 100\%$$

TN

Minimum 95% Max Density Standard Specifications Section 205.04

- Compact each layer to a minimum of 95% maximum density.
- When a minimum of 95 percent maximum density is required, the moisture content of the material must be within the range of values at which this density can be obtained



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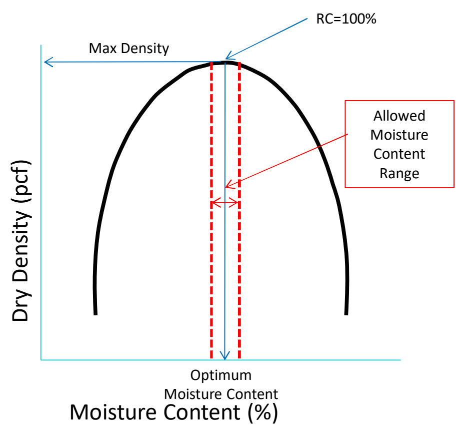
Top Six Inches Specifications Standard Specifications Subsection 205.04

- In both cut and fill sections, the top six inches of roadbed must be compacted to 100 percent of maximum density
- When a 100 percent maximum density is required, the moisture content of the material must not vary from optimum moisture by more than 3 percentage points



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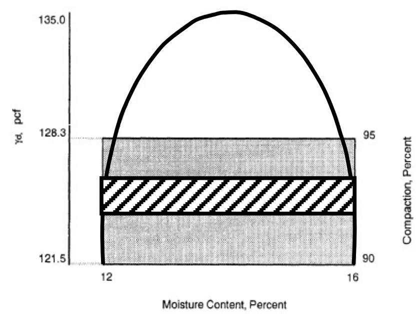
Appropriate Limits Standard Specifications Section 205.04

- The contractor is required to aerate the material or distribute and incorporate water uniformly to control moisture content within appropriate limits
- If the moisture is within the appropriate limits but the density is not, additional compaction is necessary



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Questions

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Corrective Actions

Corrective Actions

Too Wet

- Soils that are to wet when compacted are susceptible to shearing and strength loss.

- Corrective Action:
- Scarify
- Aerate
- Retest Moisture Content
- Re-Compact, if moisture content is within specified range
- Retest for both moisture and density.

Too Dry

- Soils that are too dry when compacted do not achieve the specified degree of densification as do properly moistened soils.

- Corrective Action:
- Scarify
- Add Water
- Mix Thoroughly
- Retest Moisture Content
- Re-Compact, if moisture content is within specified range
- Retest for both moisture and density.

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Over Compaction

- Occurs when material is densified in excess of specified range.
- Wasted construction effort and time.

- Causes:
- Too many passes with construction equipment.
- Change in soil type.

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Under Compaction

- Occurs when material is not densified sufficiently.
- Could be localized or throughout entire layer, depending on the cause.

- Causes:
- A missed roller pass.
- Insufficient roller weight.
- A change in operating frequency or amplitude.
- A defective roller drum.
- Improper type of compaction equipment.
- Change in soil type.

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Questions

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Pipe Installation

TDOT Standard Specifications

TDOT Standard Drawings

Pipe Installation

References
TDOT Standard Specifications
TDOT Standard Drawings

Learning Outcomes

- Installation Procedure
- Trench Installation
- How should the trench be compacted
- Different types of pipe used
- Alternative ways to install pipe

General Pipe Installation Procedure

- Locate Utilities
- Excavate trench
- Explore foundation
- Place loose bedding under pipe
- Install pipe
- Compact bedding
- Backfill

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Trench Installation

- Common in-situ soils for trench installation are clays, silts, and sands
- Sandy soils may be encountered in West Tennessee
  - Must be braced or installed by other methods

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Trenching Best Practices

- When installing your trench, make sure to keep in mind the following:
  - Safety First: follow all applicable OSHA requirements
  - For trenches with in-situ soils walls, the soil shall be firm and able to stand up on its own
  - Don't over or under excavate trench
  - Ensure the proper width of trench is dug as it relates to the pipe diameter
  - Brace as needed and don't get too far ahead of installation

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Compaction

- It is important to get the same amount of compaction across the entire area of soil
- If one part of the foundation is hard and another is soft, the pipe will settle unevenly

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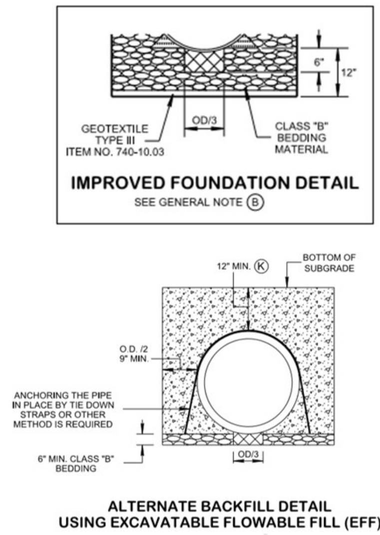
Foundation Corrective Actions

- If the foundation is found unacceptable or the water table is found to be high during excavation:
  - Improved foundation or excavatable flowable fill may be used at the engineers discretion



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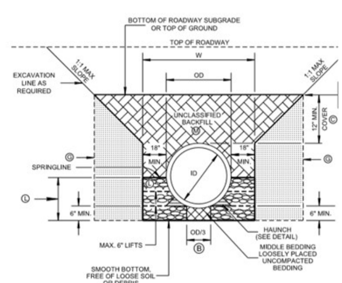
Reinforced Concrete Pipe

- Pipe shall be installed in accordance with the TDOT standard drawing for concrete pipe installation as shown



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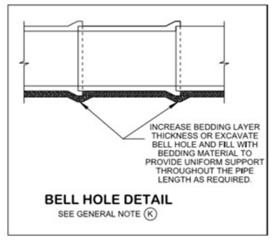
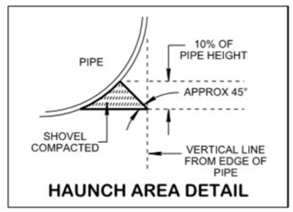
Pipe Bedding

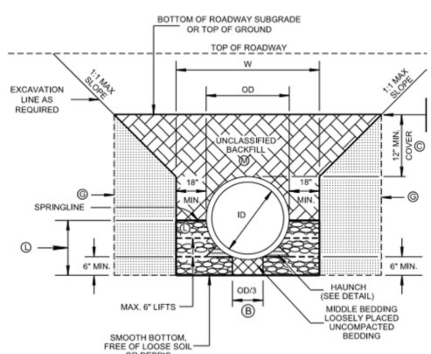
- Pipe must be uniformly supported throughout length required
  - Haunch area must be properly excavated and backfilled by shovel





Bedding and Backfill Requirements

- Place 6 inches minimum of Class "B" bedding material, along with sufficient additional class "B" bedding material accurately as shown in Haunch Area Detail
- Class "B" bedding material meeting the requirements of construction specifications shall be placed at a minimum of 6 inches to the pipe spring line
  - Not to exceed 6 inches

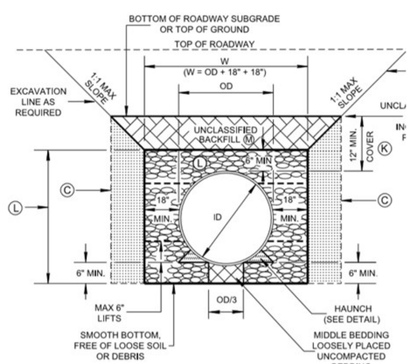


Unclassified Backfill Requirements

- Unclassified backfill shall be placed and compacted in layers not exceeding a 6 inch loose lift thickness and brought up evenly and simultaneously on both sides of the pipe to an elevation not less than one foot above the top of the pipe

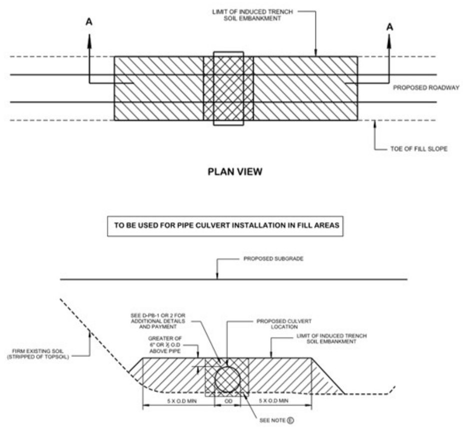
Flexible Pipe Materials

- The main difference between concrete pipe and flexible pipe is that the material above the springline to at least 6 inches above the pipe is also bedding material
- Flexible pipe relies on backfill and bedding to carry the majority of the load
- A minimum compaction level of 90% of the standard proctor density is required
- Plastic is most common material



Pipes in Fill Sections

- Where pipes must be placed in fill sections it is not necessary that the entire embankment be constructed before cutting the trench, but the embankment must be built up in the immediate vicinity of the pipe
- This is known as the induced trench method



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Trenchless Technologies

- A progressive civil engineering process for the installation, replacement, or renewal of underground utilities with little to no excavation and surface disruption
  - Can reduce noise and air pollution
  - Workers are exposed to less hazards
  - Traffic congestion is reduced
  - Can be used to install utility lines

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Trenchless Technology Installation Applications

- New Installations:
  - Jack and Bore
  - Pipe Ramming
  - Moles and Small Rammers
  - Pipe Jacking
  - Microtunneling
  - Horizontal Directional Drilling (HDD)

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Questions

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