HIGHWAY CERTIFIED TECHNICIAN PROGRAM

TRAINING MANUAL

Construction

Earthworks
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This material is to be used for training purposes only. Some of the procedures, field tests, and other operating procedures as described within these pages may be different than actual on-site procedures. Therefore, application should not be made without consideration of specific circumstances and current INDOT standards and policies.
1 Right-of-Way Preparation

Preliminary Investigation

Clearing and Grubbing

Removal of Structures and Obstructions

Building and Foundation Removal

Inspection and Removal of Asbestos

Bridge Removal

Pipe and Sewer Removal

Pavement and Miscellaneous Removal
CHAPTER ONE:

RIGHT-OF-WAY PREPARATION

Whether the work requires widening of an existing pavement section or the construction of a new roadway section through a new undisturbed right of way, certain preliminary investigations are required. The PE/PS obtains right of way grants for all parcels of property purchased for the new work. These also include grants for temporary right of ways. From the construction plans, all right of way is staked so that the limits of ownership are clearly visible and areas of temporary ownership for construction are known. All INDOT employees and the Contractor are required to be aware of the limits so that no disputes arise over work activities outside our property or destroying or disturbing private property. Any work on the right of way has some involvement with public or private utilities.

PRELIMINARY INVESTIGATION

During the completion of the plans, INDOT has already notified all public utilities and all pipe line owners or other parties affected so that they may plan to move and relocate their existing facilities. Delays caused to the Contractor by public utility companies are reason for time extension and may cause contracts to be extended into another construction season.

Existing survey section corners and other survey controlled points and bench marks are required to be referenced for establishment when the contract is completed. The County Surveyor is contacted to obtain the proper location of all section survey references.

Another area of importance is the investigation of existing underground drainage. Farm field tiles placed by farmers are required to be outletted or
continued across the project limits so the drainage is uninterrupted. Legal county tiles and ditches are required to be maintained and preserved. The PE/PS coordinates with the County Surveyor or County Engineer to assure that all legal county drainage has been located.

If the Contractor is required to assist in the investigation of underground drainage by excavation, this excavation is paid for as set out in Section 203.
CLEARING AND GRUBBING

When the Contractor arrives at the job-site, one of the first orders of business is to clear the right-of-way in preparation for construction. This work consists of the removal and disposal of all vegetation and debris within the limits of construction which is in the way of the construction work. Any items within the right-of-way that are designated to remain in place are not to be disturbed or damaged by the Contractor.

Trees that are encountered within the construction limits may be removed. If the tree stump is cut off level with the ground and is a minimum of 3 ft below the final subgrade, the stump may be left in place. If trees are completely removed, the roots from the stump are required to be grubbed from the ground around the old stump. Any holes created in the embankment area are required to be backfilled satisfactorily up to the level of the existing ground prior to starting the new embankment. Burning perishable items may only be done if local laws, ordinances, and the contract permit burning. Perishable materials such as brush, stumps, and sod are removed from the right-of-way and disposed of at a location approved in advance by INDOT. This approval includes a plan for site restoration after the contract, and a plan for prevention of stream sedimentation. Written permission to dispose of perishable materials is required to also be obtained from the property owner before beginning the disposal operation (Section 201.03).

The measurement and payment of clearing of right of way is a somewhat complicated process. Payment may be by the acre, by a lump sum, by length, or by individual units. If tree removal is paid for by an individual unit, the tree is measured at a height of 24 in. above the ground. Any tree less than 4 in. in diameter is classified as brush and no payment is made.

REMOVAL OF STRUCTURES AND OBSTRUCTIONS

Most contracts require removal of structures and obstructions. This includes the removal and disposal of buildings, fences, structures, old pavement, abandoned pipe lines, and any other obstructions that are not designated in the contract to remain in place.
BUILDING AND FOUNDATION REMOVAL

A Contractor is not allowed to begin removing a building without written authority from INDOT. For buildings or houses that are
required to be removed, the Contractor removes the buildings and the foundations or basement walls to an elevation 1 ft below original ground. All debris and trash that is accumulated in a basement or foundation is removed. Any floor drains encountered are plugged, and any basement floors are broken. All public utilities into the building are to be shut off prior to beginning of demolition. The Contractor is responsible for notifying the utility companies involved. Basements are backfilled with B Borrow in accordance with Section 203.

Wells, cisterns, septic tanks, and other tanks are cleaned and backfilled in an approved manner. Cisterns, septic tanks, and other tanks that cannot be satisfactorily backfilled are removed. All abandoned wells are sealed and backfilled in accordance with Indiana code.

**INSPECTION AND REMOVAL OF ASBESTOS**

The contract documents will contain information on if the building contains asbestos. All State, Federal and Local regulations are required to be followed in cleaning up the hazardous materials.

**BRIDGE REMOVAL**

Clearing of the right-of-way may include the removal of bridges, culverts, and other drainage structures. Bridge foundations are removed to the existing stream bed, and those portions outside the stream bed are removed 1 ft below the original ground. The removal of a reinforced concrete arch includes the removal of all of the pavement and backfill of the arch.

Blasting should only be used in the demolition of bridges if allowed by Local ordinances. When a portion of a bridge structure is removed to widen an existing structure, care is taken not to damage the portion of the existing structure to remain in place. If specified, broken up concrete from bridge removal may be used as riprap on the contract.
PIPE AND SEWER REMOVAL

Materials not specified to be salvaged become the property of the Contractor. Sanitary and storm sewers no longer in use are removed from under the roadway and shoulders.
When the removal includes concrete pavement, sidewalks, curbs, and other miscellaneous concrete items, this concrete may be broken into pieces and used as riprap on the contract or disposed of off the right-of-way. Pavement removal includes the concrete pavement and all HMA overlay courses on existing public roads, streets, and alley pavements. Parking lots and driveways are not considered pavement removal. When a portion of pavement is removed, the limits of removal are marked and sawed along these limits to assure a smooth line of removal. Any portion that is damaged outside the removal lines is replaced at the Contractor’s expense. Sawing of pavement to be removed is not paid for directly, but is included in the cost of pavement removal.
2 Materials

Materials

Soil Composition and Texture

Soil Classification

Field Identification and Classification of Soils

Rock and Shale Embankment

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Indiana Geology

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Shale, Shale and Soft Rock Mixtures, or Soft Rock

Other Embankment and Fill Materials

Borrow

B Borrow

Structural Backfill

Rock Backfill
Aggregate Materials

Aggregate Base

Subbase

Aggregate Pavements or Shoulders

Synthetic Materials

Coal Combustion By-Products

 Crushed Glass

Recycled Concrete Pavement

Recycled Foundry Sand
CHAPTER TWO:

MATERIALS

All materials used in the construction of highway embankments, fills, subgrades, and subbases originate from the Earth. Most of these materials are natural in origin, i.e. they are the result of geologic processes that occur naturally as opposed to synthetic materials which are the result of industrial processes (i.e. slag, flyash). This chapter focuses on the natural earth materials.

Earth materials consist of two types: soil and rock. **AASHTO M 146** defines soil as, “*sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.*” Soil may also be defined as all unconsolidated materials overlying bedrock. The key word in these definitions is "unconsolidated". Soil is essentially natural material that is not indurated (hardened, cemented) into a cohesive mass. Soil exists in a loose, unbound condition and therefore may be easily excavated with construction equipment.

**AASHTO M 146** defines rock as, “*natural solid mineral matter occurring in large masses or fragments.*” Rock may be composed of hardened or cemented soil. The process of converting soil into rock is called lithification. Since lithification takes time and may be incomplete, the distinction between rock and soil may be unclear. For example, soil hardpans have been indurated by chemical action and may be quite hard, but are not considered to be rock. Shale is another example. Shale is considered to be rock by Geologists and soil by Engineers.

Soil and rock may be processed into aggregates by excavating, blasting, dredging, crushing, washing, and screening. These aggregates are considered natural aggregates since the chemical and mineralogical composition of the individual fragments or grains has not been altered.
Natural aggregates are used extensively as materials for highway construction and are discussed in this chapter as well.
The following references are required to be reviewed in detail:

INDOT Standard Specifications

1) Section 101

2) Sections 203.03, 203.08 and 203.20

3) Section 211.02

4) Sections 301.02, 302.02 and 303.02

5) Section 903

6) Section 904

SOIL COMPOSITION AND TEXTURE

Soil is made up of the following components:

1) Boulders

2) Gravel
3) Sand
4) Silt

5) Clay

6) Colloids

7) Organic material

With the exception of organic material, the components listed denote grain size and not origin or chemical/mineralogical composition. Organic materials are largely decayed plant matter and may be found in any state of decay.

Soil texture refers to the size and distribution of the components that comprise the soil. This is commonly referred to as the gradation of the soil.

SOIL CLASSIFICATION

Section 903 and AASHTO M 145 detail the classification system INDOT uses for all soils. Section 903 is strictly a textural classification system. AASHTO M 145 has a textural component as well as an engineering property component. The liquid limit (AASHTO T 89) and plasticity index (AASHTO T 90) parameters are included in the classification system. When classification of a soil is required, a sample is submitted to the Office of Geotechnical Engineering or the District Testing Laboratory if the District is capable of conducting the tests.

Organic and Marly Soils

When discussing organic and marly soils, peat, marl, and muck are required to be understood. Peat is a highly organic substance composed of decaying plant matter. Marl is calcareous (calcium carbonate, calcium or lime) clay
that commonly has shell fragments. Muck is an organic soil with dark, decomposed organic material intermixed with high amounts of silt.

Organic soils are classified in accordance with AASHTO T 267 and Section 903.05. AASHTO T 267 is used to determine the amount of organic matter in the soil and Section 903.05 classifies the soil based on the percentage of organic matter.

Marly soils are classified in accordance with Section 903.06.
FIELD IDENTIFICATION AND CLASSIFICATION OF SOILS

Field classifications are generally conducted by the Office of Geotechnical Engineering or Consultant Geotechnical Companies. Though procedures for field classification are outlined herein, the Technician is required to interpret soil-boring descriptions as opposed to actually describing and classifying soils. Soil boring logs from the geotechnical investigation accompany the contract proposal and plan sheets. These logs provide vital information concerning the soil types and potential material problems. Therefore, the Technician is required to read and interpret the soil descriptions, understand how the soil descriptions are written, and interpret what the terms mean.

Soil identification and classification in the field is based on visual inspection and simple field tests. The identification contains the following descriptions in this order:

1) Color

2) Moisture

3) Consistency or density

4) Textural classification

5) Modifying terms

Color

The color of the soil is described in a wet condition. Use of the Munsell Soil Color Chart may be helpful.
### Moisture

The soil moisture condition is described as:

1) Wet
2) Very moist
3) Moist
4) Slightly moist
5) Dry
Consistency or Density

The relative consistency of silt-clay material is described as:

1) Very soft -- easily penetrated several inches by thumb. Exudes between thumb and fingers when squeezed in hand.

2) Soft -- easily penetrated 1 in. by thumb. Molded by light finger pressure

3) Medium stiff -- may be penetrated over 1/4 in. by thumb with moderate effort. Molded by strong finger pressure

4) Stiff -- indented about 1/4 in. by thumb but penetrated only with great effort

5) Very stiff -- readily indented by thumbnail

6) Hard -- indented with difficulty by thumbnail

The relative density of granular material is described as:

1) Very loose -- easily penetrated with 1/2 in. rebar pushed by hand

2) Loose -- easily penetrated with 1/2 in. rebar pushed by hand

3) Medium dense -- penetrated 1 ft with 1/2 in. rebar driven with 5 lb hammer

4) Dense -- penetrated 1 ft with 1/2 in. rebar driven with 5 lb hammer
5) Very dense -- penetrated only a few inches with 1/2 in. rebar driven with 5 lb hammer

*Textural Classification*

Textural classification is determined by estimating the amounts of gravel, sand, silt, and clay in the soil and then classifying the material in accordance with Section 903. Since laboratory testing for particle size is not conducted, a few simple techniques for distinguishing fines are as follows:
1) Fine sand when rubbed between the fingers feels gritty and does not stain the fingers, whereas, silt and clay materials feel smooth and leave a stain.

2) Silt does not stick to your teeth when a piece of the soil is bit but clay tends to stick. Also, small amounts of sand may be detected this way, as the sand has a gritty texture against the teeth.

3) Silt, when rinsed lightly with water, tends to wash off hands while clay sticks to hands

The following methods may be used in the field to estimate the soil texture, which is defined as the relative size and distribution of the individual soil particles or grains.

1) Visual Examination. By carefully looking at the soil, the material may be divided into at least the gravel, sand, and fines (silt and clay combined) components. Since the naked eye only distinguishes particle sizes down to about 0.05 millimeters, silt and clay sized particles cannot be separated without further magnification.

The examination is done by drying a sample, spreading the material on a flat surface, segregating the material into various components, and estimating the relative percentage of each. The percentage refers to the dry weight of each soil fraction, as compared to the dry weight of the original sample. Figure 2-1 provides the defined particle sizes for each component and a common reference to aid in identifying the various particle sizes.

2) Sedimentation/Dispersion. This test is done by shaking a portion of the sample into a jar of water and allowing the material to settle. The material settles in layers. The gravel and coarse sand settle almost immediately, the fine sand within about a minute, the silt requiring as much as about an
hour, and the clay remaining in suspension indefinitely. The percentage of each component is estimated by comparing the relative thickness of each of the layers in the bottom of the jar. The larger size particles typically settle into a denser mass than the fines.
<table>
<thead>
<tr>
<th>Classification</th>
<th>Measured</th>
<th>Sieve</th>
<th>Comparison Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders and Cobbles</td>
<td>Over 3 in.</td>
<td>&gt; 3 in.</td>
<td>Grapefruit size</td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>3 in. to 1 in.</td>
<td>3 in. to 1 in.</td>
<td>Lemon</td>
</tr>
<tr>
<td>Medium</td>
<td>1 in. to 3/8 in.</td>
<td>1 in. to 3/8 in.</td>
<td>Diameter of penny</td>
</tr>
<tr>
<td>Fine</td>
<td>3/8 in. to 2.0 mm</td>
<td>3/8 in. to 2.0 mm</td>
<td>Pencil diameter to pea or rock salt</td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>2.0 mm to 0.42 mm</td>
<td>No. 10 to No. 200</td>
<td>Broom straw diameter to sugar or table salt</td>
</tr>
<tr>
<td>Fine</td>
<td>0.42 mm to 0.075 mm</td>
<td>No. 40 to No. 200</td>
<td>Human hair to powdered sugar</td>
</tr>
<tr>
<td>Silt</td>
<td>.075 mm to 0.002 mm</td>
<td>&lt; No. 200</td>
<td>Cannot be discerned with naked eye</td>
</tr>
<tr>
<td>Clay</td>
<td>&lt; 0.002 mm</td>
<td>&lt; No. 200</td>
<td>Cannot be discerned with naked eye</td>
</tr>
</tbody>
</table>

Figure 2-1. Visual Grain Size Identification

Granular Materials
Granular materials per AASHTO M 145 have 35% or less passing the No. 200 sieve. These materials are sand and gravels with or without an appreciable amount of fines. These limits do not apply in field classification. Since texture is based on visually estimating percentages of the components, granular materials are more loosely defined in the field as materials that are composed predominantly (≥ 50%) of sand size or larger material. The general character of the soil is more granular than cohesive. The following are guidelines for properly describing and classifying granular materials:

1) Estimate the largest particle in sample

2) Remove any gravel in the sample if present and estimate the amount.

3) Determine if the gravel or sand is clean or dirty

4) If the sample contains appreciable fines, determine if the fines are silty or clayey as outlined in Silt-Clay Material
Determination of clean verses dirty may be made by two simple field tests as follows:

1) Settlement Rate Test -- Place a small amount of the material in a container filled with water. The water clears in 30 seconds for clean sands and remains cloudy for dirty sands.

2) Dust Formation Test -- Dry out the granular material if moist. Sift the dry, granular material through your fingers and let the material fall on a hard, clean surface. If large amounts of silt and clay are present, the material that strikes the hard surface is dust.

Silt-Clay Materials

Silt-clay soils are composed predominantly of grains that visually cannot be distinguished in size. Besides the general techniques described earlier, several field tests may be used to distinguish silty from clayey soils as follows:

1) Plasticity Test -- The ability to be molded within a certain range of moisture contents is termed plasticity. Plasticity is dependent upon the percentage and type of clay component, and therefore requires differentiation between silt (non-plastic fines) and clay (plastic fines).

For the ribbon/thread test, a roll of soil moist enough to have workability, approximately 1/2 in. to 3/4 in. in diameter and about 3 in. to 5 in. in length, is pressed between the thumb and index finger into a ribbon of about 1/8 in. thick. The longer the ribbon may be formed before the soil breaks under the soil’s weight, the higher the plasticity of the soil. Highly plastic clays may be ribboned to 4 in. longer than the original material. Clay of low plasticity may be ribboned only with some difficulty into short lengths. Predominately silty soils do not ribbon or have ribbons that are delicate, softer,
and easily crumbled. Non-plastic materials cannot be ribboned.
<table>
<thead>
<tr>
<th>Plasticity</th>
<th>Length of Ribbon (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non Plastic</td>
<td>0</td>
</tr>
<tr>
<td>Slightly Plastic to Plastic</td>
<td>0 - ½</td>
</tr>
<tr>
<td></td>
<td>½ - 1</td>
</tr>
<tr>
<td></td>
<td>¾ - 1</td>
</tr>
<tr>
<td></td>
<td>0 - 1</td>
</tr>
<tr>
<td>Plastic to Highly Plastic</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Highly Plastic</td>
<td>&gt; 2</td>
</tr>
</tbody>
</table>

2) Dry Strength / Breaking Test -- The dry strength/breaking test is normally made on a dry pat of soil about 1/2 in. thick and about 1 1/4 in. in diameter that has been allowed to air dry completely. Attempts are made to break the pat between the thumb and fingers. Very highly plastic clays are resistant to breakage and highly plastic clays are broken with great effort. Caution is exercised with highly plastic clays to distinguish between shrinkage cracks, which are common in such soils, and a fresh break. Clays of low plasticity may be broken with ease, therefore, clayey soils have medium to very high dry strength. Silty soils break readily and have no strength (non-plastic) to medium strength (slightly plastic). Non-plastic soils have very little dry strength, crumbling on being picked up by the hands.

3) Shaking / Dilatency Test -- In the shaking / dilatency test, a pat of soil about 3/4 in. in diameter is moistened to a putty-like state and placed in the palm of the hand. The hand is then shaken vigorously or jarred on a table or other firm object. If the surface of the sample begins to glisten, this is an indication that moisture within the sample has risen to the surface. When this does not occur, the soil is probably clayey. Where this occurs sluggishly or slowly, the soil is predominately silty, perhaps with a small amount of clay. For silts or very fine sands, the moisture rises to the surface rapidly, and the test may be repeated over and over by
simply remolding and then reshaking the pat. This test is not generally done by INDOT.
Marl and Peat

Marl and peat may be identified by visual inspection, color, smell, density, and compressibility. Peat is a highly organic soil characterized by undecayed to decaying plant matter, which gives the material a fibrous texture. Marl tends to have animal remains, predominantly shells. Organic soils are dull brown to black in color, spongy, and have a slight to strong odor of decay.

Modifying Terms

When describing soils in the field, modifiers are used and included in the description, when appropriate. These modifiers are either textural or general.

Textural modifiers are used to indicate components that were not considered in the textural classification of the material. These include such materials as rock fragments, gravel particles, pieces of shale, etc. and are indicated as follows:

1) Trace amounts -- component comprises 0-10 % of soil
2) Little -- component comprises 11-19 % of soil
3) Some -- component comprises 20-35 % of soil
4) And -- component comprises 36-50 % of soil
General modifiers may be very helpful and accompany the soil description whenever possible. They are noted in parenthesis after the usual soil classification.

Some examples of general modifiers are:

1) Fill material
2) Apparently natural ground
3) Peat
4) Marl
5) Till
6) Old lake bed (lacustrine)
Examples and Interpretations of Field Descriptions

All soil descriptions follow the same format. The color is described first, then the moisture, followed by consistency or density, and finally the textural classification, which is in all capital letters. The following is an example from an actual soil-boring log:

1) Topsoil (visual)

2) Brown, moist, very loose to medium dense, LOAM

3) Brown, moist, very loose, SANDY LOAM

4) Gray, moist, medium dense to loose, LOAM with little organic matter (LOI = 8.5%)

5) Gray, moist, very soft to medium stiff, SILTY CLAY LOAM

6) Brown and gray, weathered SHALE with interbedded layers of sandstone (visual), % recovery, and Rock Quality Description.

Number 1 is the topsoil.

Number 2 is a granular material. Granular soils have the density described, not the consistency. A range of densities may be used to describe the soil.

Section 903.02 defines a loam as having as much as 50% sand and gravel. Therefore, since loam was considered granular, the sand-sized material probably was around 50%. Since the material obviously had large amounts of fines (≈ 50%), the material was classified as a loam as opposed to a sandy loam. Obviously, the sand was dirty.
Number 3 is a granular material. Sandy loams have between 50-80 % sand and gravel. This material was obviously granular to be classified as a sandy loam. Since the density was described as very loose, the material had considerably fewer fines than the sample above; however, there was enough to classify the sand as dirty and consequently the material is a sandy loam as opposed to sand.
Number 4 is a granular material. Again, the material was composed predominantly of sand. The sample had a textural modifier, concerning the organic matter (LOI = 8.5 %). The LOI is the "loss on ignition" of organic material (AASHTO T 267). The sample was tested in the laboratory for organic content and had obvious organic material in the material.

Number 5 is a silt-clay material. The consistency of the material was described as opposed to the density. Again, a range of consistencies was given as opposed to a single consistency. The material obviously had considerably less sand than the previous samples and the fines were predominantly silt, not clay.

Number 6 is the top of bedrock.

The granular soils were apparently not gravelly. If they were gravelly (≥ 20 %), the textural modifiers “with some gravel” or “and gravel” would have been used. No gravel was found in the soils at all since no textural modifiers were used.

Based on visual classifications and laboratory testing, Geotechnical Engineers refine the field boring logs.
<table>
<thead>
<tr>
<th>Classification</th>
<th>% Sand &amp; Gravel</th>
<th>% Silt</th>
<th>% Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>80 - 100</td>
<td>0 - 20</td>
<td>0 – 20</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>50 – 80</td>
<td>0 – 50</td>
<td>0 – 20</td>
</tr>
<tr>
<td>Loam</td>
<td>30 – 50</td>
<td>30 – 50</td>
<td>0 – 20</td>
</tr>
<tr>
<td>Silty Loam</td>
<td>0 – 50</td>
<td>50 - 80</td>
<td>0 - 20</td>
</tr>
<tr>
<td>Silt</td>
<td>0 – 20</td>
<td>80 – 100</td>
<td>0 – 20</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>50 – 80</td>
<td>0 – 30</td>
<td>20 – 30</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>20 – 50</td>
<td>20 – 50</td>
<td>20 – 30</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>0 - 30</td>
<td>50 - 80</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>50 – 70</td>
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<tr>
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<td>0 – 20</td>
<td>50 – 70</td>
<td>30 – 50</td>
</tr>
<tr>
<td>Clay</td>
<td>0 - 50</td>
<td>0 - 50</td>
<td>30 - 100</td>
</tr>
</tbody>
</table>
Fig. 2-1. Soil Classification
ROCK AND SHALE EMBANKMENT

Rock and shale embankment is covered in Section 203.20. INDOT considers three categories of rock and shale as follows:

1) Rock

2) Shale, Shale and Soft Rock Mixtures, or Soft Rock

3) Shale and Thinly Layered Limestone

In order to understand the differences in the materials, a greater understanding of rocks, Indiana geology, and the INDOT specifications is required.

PRINCIPAL ROCK TYPES

There are three general classes of rock: Igneous, Sedimentary, and Metamorphic. All of the rocks on earth fit into one of these classes.

Igneous rocks are rocks that were formed from cooled molten rock material called magma and are considered the original rock type. The rate of cooling and chemical composition of the magma determined the type of igneous rock. Examples of igneous rocks are granite and basalt.

Sedimentary rocks are rocks that were formed from the accumulation, compaction, and cementation of fragmented earth materials, organic remains, and or chemical precipitates. These materials are collectively called sediments, hence the name. Sedimentary rocks are derived rock types that require the weathering and erosion of existing rocks for their formation. Examples of sedimentary rock are sandstone, limestone, and shale.
Metamorphic rocks are rocks that were formed from existing rocks that have been subjected to heat and/or pressure. This process metamorphoses or changes the rock mineralogical, texturally, and structurally. An existing metamorphic rock may be metamorphosed again by the geologic conditions. Examples of metamorphic rocks are marble (metamorphosed limestone), slate (metamorphosed shale), and gneiss (metamorphosed granite).

**ROCK**

Rock, as defined in AASHTO M 146, does not distinguish between soft rock and hard or durable rock. Section 203.03 defines what materials would classify as rock. Generally, materials meeting 203.03 are to be treated in accordance with section 203.20(a) rock embankment. This is not always the case, however, since some shale requires blasting as opposed to ripping with a bulldozer and all shale is covered under Section 203.20(b) unless written permission is obtained to incorporate shale in accordance with Section 203.20(a). Therefore, careful consideration of the type of rock material in question is required before incorporating the material in embankments. When in doubt as to which section applies to the material, the Area Engineer, District Construction Engineer, Testing Engineer, or the Office of Geotechnical Engineering is consulted.

**SHALE, SHALE AND SOFT ROCK MIXTURES, OR SOFT ROCK**

Shale is a sedimentary rock composed of clay, silt, or mud that is finely laminated. Shale appears in a variety of colors and may be highly variable in hardness. Shale belongs to a class of sedimentary rocks termed mud rocks.

The problem with mud rocks is that this material has an affinity for water. Because of the high clay content in mud rocks, they readily absorb water; however, these types of rocks are impermeable and do not allow the water to leave. This absorption of water results in a significant volume change in the material, causing the material to slake. Slaking is defined as the crumbling and disintegration of clay-rich materials when exposed to water. Clay-rich rocks, or argillaceous rocks, readily slake under alternate cycles of wetting and drying.
Therefore, all mud rocks are properly treated in accordance with Section 203.20 (b).

Because of the propensity of shale or soft rock to slake, embankments constructed with these materials may experience problems as follows:

1) Settlement

2) Heaving, either from frost or alternating cycles of wetting and drying

3) Slope instability

4) Surface and subsurface erosion

Large pieces of unslaked material produce large voids when they eventually slake. The large voids cause settlement and possible eventual failure of the fill or embankment.

Heaving may also induce embankment failure. Shale and soft rock have a tendency to heave when an increase in moisture occurs or during freeze-thaw conditions. Heaving loosens the material, thereby decreasing the compaction of the lifts so the material no longer has the proper density. Again, settlement and failure of the fill may happen.

**SHALE AND THINLY LAYERED LIMESTONE**

Shale and thinly layered limestone may be common in some geographical areas in Indiana. When two rock types such as shale and limestone are found mixed together, they are termed interbedded.

Interbedded shale and limestone is essentially shale as defined in Section 203.20(b) and rock as defined in Section 203.20(a) intermixed. Therefore, the
potential for slaking is present. Section 203.20 (c) describes the construction requirements for these materials.

OTHER EMBANKMENT AND FILL MATERIALS

Embankment and fill materials may or may not be aggregates and therefore are not required to originate from a Certified Aggregate Producer (CAP). In the case of borrow, there is no testing requirement for acceptance; however, the top 2 ft below the pavement is required to meet the requirements of the Section 207.03.

BORROW

Borrow is defined in Section 203.08

B-BORROW

B-borrow is defined in Section 211.02.

STRUCTURE BACKFILL

Structure backfill is defined in Section 904.05.

AGGREGATE MATERIALS

Aggregate materials are required to originate from a Certified Aggregate Producer in accordance with Section 917. Since these materials are certified, no testing for gradation by INDOT is required.
**AGGREGATE BASE**

The requirements for this material are listed in Section 301.02.

**SUBBASE**

The requirements for these materials are listed in Section 302.02.

**AGGREGATE PAVEMENTS OR SHOULDERS**

The requirements for these materials are listed in Section 303.02.

**SYNTHETIC MATERIALS**

Synthetic materials are by-products or waste materials that have been reclaimed and/or processed to be used in highway construction. Generally their usage is very limited and restricted.

**COAL COMBUSTION BY-PRODUCTS.**

Coal combustion by-products are recovered from coal-fired power plants and include fly ash, bottom ash, and boiler slag. The requirements for these materials are included in Recurring Special Provision 203-R-360.

**CRUSHED GLASS**

Crushed glass is recycled glass containers processed to meet specific gradation requirements and are used for bedding beneath pipes and storm sewers. The material requirements are listed in Recurring Special Provision 211-R-415.
Recycled concrete pavement may be used in the embankment on that project. Sometimes the concrete pavement will be processed and used in the sub base. The requirements for this are found in Recurring Special Provision 202-R-544 and 202-R-545.
3 Excavation

Common Excavation
- Submitting Samples
- Preparing the IT 530

Rock Excavation
- Exploration Drilling
- Rock Pre-Splitting
- Explosives
- Primary Blasting
- Restrictions
- Finished Grade

Unclassified Excavation
- Waterway Excavation
- Class Y Excavation
- Class X Excavation
- Wet Excavation
- Dry Excavation
- Foundation Excavation, Unclassified

Disposal of Excavated Material
- Suitable Material
- Unsuitable Material
- Excess Material

Borrow

Contractor Responsibilities
Preparing a Borrow Pit

Peat Excavation

- Treatment of Existing Fills
- Treatment by Removal
- Treatment by Displacement
- Peat Disposal
CHAPTER THREE: EXCAVATION

During the construction of a highway or bridge, existing materials may be required to be removed. These materials occupy the space in which a new highway or bridge is planned. Therefore, they are removed or "excavated." The types of excavation are:

1) Common

2) Rock

3) Unclassified

Some materials excavated may be suitable for use in construction of embankment. Some are not and are disposed of completely.

COMMON EXCAVATION

Common excavation is the most frequently encountered type of excavation. The Specifications state that, "Common excavation shall consist of all excavation not included as rock excavation or excavation which is otherwise classified and paid for, including asphalt type pavement and all rippable materials".

Common excavation is the excavation of soil materials from within the contract limits; however, this excavation is not limited to soil materials and may include existing HMA pavement. If the material is indicated on the plans and is not a concrete pavement or another defined excavation, then the material is considered common excavation.

Section 203 further defines embankment construction as the excavation, hauling, and disposal or compaction of all material. Because compaction of the material is included in common excavation, soil samples are required to be obtained. These samples are submitted to the appropriate testing laboratory for determining compaction requirements and moistures.

SUBMITTING SAMPLES

The manner of sampling and the number and the size of samples required depends upon two conditions:
1) The number of different soil types used on the contract. The submitter investigates each cut and borrow pit to determine the soil types. Only samples of the different types encountered are submitted.

2) The method the Contractor expects to use in the removal and placing of the soil. If each type is worked separately, the soil is required to be sampled separately. However, if the Contractor expects to blend soil types, the soils are sampled accordingly. Blending may occur during excavating or placing. Therefore, communication with the Contractor is essential.

If relatively few samples are to be secured, a 5 in. auger is a satisfactory tool for securing samples. Three foot extension sections of pipe may be required to reach the desired depth. The grading Contractor is required to supply a backhoe with an operator for securing a large number of samples or samples at depths greater than 5 ft.

The grade Technician may be required to determine where the samples are to be taken, obtain the samples, and submit the samples. Each soil sample is required to be a minimum of 25 lb and each granular material a minimum of 65 lb. A small portion of each sample is required to be retained for later reference.

**PREPARING THE IT 530**

When the samples are submitted to the District laboratory, they are accompanied by an IT 530 for each sample. The following special information for each sample is reported on the IT 530:

1) Centerline station and offset
2) Centerline station and offset for adjacent borrow pits
3) Elevation
4) Field office telephone number
5) Copies of applicable special provision sheets
6) Referenced specifications
7) Intended use
8) Description of soil as to texture, color, visual classification, moisture content, etc.
The appropriate laboratory determines the maximum density and optimum moisture content. These results are sent to the PE/PS for use in determining in-place soil densities.

**ROCK EXCAVATION**

Rock excavation consists of the excavation of igneous, metamorphic, and sedimentary rock and boulders or detached stones having a volume of 1/2 yd³ or greater. The material for this type of excavation is removed by blasting, by power shovel with a bucket that has a minimum capacity of 1 yd³, or by other equivalent powered equipment. Unless otherwise specified or directed, the following criteria is used in excavating the material.

**EXPLORATORY DRILLING**

Exploratory drilling may be required to determine the existence of cavities and possible sink holes in cut sections. These holes are 1 1/2 in. in diameter, and drilled on centerline at 100 ft intervals to a point which is 7 ft below the proposed grade. If a cavity or sink hole is found then additional holes are drilled along the edges of the pavement at 25 ft intervals. These holes are also drilled to 7 ft below the proposed grade. If the cavity has less than 5 ft of cover, then the cover is removed and the cavity treated as set out in the plans or as directed.

**ROCK PRE-SPLITTING**

The rock is pre-split by the use of drilling and explosives. The work is done in such a manner that minimum breakage occurs outside the neat lines of the typical cross section. The holes for this operation are from 2 in. - 4 in. in diameter, spaced 3 ft apart, and drilled 2 ft below the established grade of the cut or the predetermined bench elevation. The maximum depth of a pre-split lift is 30 ft. If a cut section requires more than one lift, the holes are drilled in such a manner that the specified offset for each succeeding lift is obtained. A horizontal distance of 2 ft off the back side of the paved side ditch line is required.

The pre-split face shall deviate no more than 6 in. from the front line and 1 ft from the back line of holes. The pre-splitting operation is kept well in advance of the regular blasting operations. The line holes are to be fired before the main excavation is blasted. There is no direct payment for pre-splitting because the cost is included in the cost of excavation.
EXPLOSIVES

The explosives to be used and the method of loading depends on the type of material to be blasted. A single strand of detonating chord or a solid column of dynamite may be used. The type used is required to be capable of pre-splitting the material with a minimum breakage outside the excavation area.

PRIMARY BLASTING

The holes for the primary blasting are drilled at least 6 ft away from the pre-split face. If additional charges are required, the holes are placed at half the distance of the full depth holes. These holes are drilled to a depth 2 ft above the pre-split face.

RESTRICTIONS

The Contractor is required to restrict the amount of explosives used near structures, rock formations, or other property that may be damaged. Adequate seismograph readings should be taken during blasting operations to document the impact on nearby buildings. The contractor should also document the existing condition nearby buildings prior to blasting operations.

FINISHED GRADE

The final breakage of rock is required to conform to or closely approximate the slope lines indicated on the plans. The final slopes are required to be left reasonably smooth and uniform with all loose and overhanging rock removed. Unless otherwise permitted, no rock is allowed to project more than 1 ft beyond the established slopes. If a natural seam intersects an established slope, permission may be granted to follow the seam face for an approved distance. If the Contractor provides a finished slope which is equal or superior to that which is obtained by pre-splitting, machine methods to establish final slopes may be used. The rock is excavated to the required elevation for the full width of the roadway as indicated on the plans or as directed. The final surface of the rock excavation is required to have proper drainage. If the rock is excavated below the required elevation, the rock excavation is backfilled to the subgrade elevation with crushed stone, spalls, subbase material, or other granular material.
UNCLASSIFIED EXCAVATION

Unclassified excavation consists of the excavation of and proper disposal of any type of material that is encountered during the progress of the work.

WATERWAY EXCAVATION

Waterway excavation consists of excavation and the proper disposal of material encountered in the clearing of the waterways, making channel changes, or a combination of the two. The excavation does not include Class Y excavation or the excavation made for a structure as set out in Section 206. Waterways are cleared between the right-of-way lines unless otherwise specified. Surface objects, trees, stumps, and roots are cleared and grubbed.

CLASS Y EXCAVATION

While conducting normal waterway excavation, material may be encountered such as rock or material which consists of hard ledge rock, hard shale, conglomerate, concrete, masonry, or any similar material which is not part of the existing structure as indicated on the plans. If the material cannot be reasonably removed by any other method, the material is removed by blasting. This excavated material is defined as Class Y excavation. Section 203.07 defines material that may not be considered Class Y excavation.

CLASS X EXCAVATION

One or more of the following materials encountered within the limits of foundation excavation are defined as Class X excavation.

1) Solid rock, hard ledge rock, slate, hard shale, or conglomerate. Because the material cannot be reasonably removed by any other method, blasting or pneumatic or equivalent tools are required for removal.

2) Loose stones or boulders which are greater than 1/2 yd³ in volume.

3) Concrete, masonry, or similar materials which are parts of an old buried structure that was not shown on the plans.

4) Timber grillages, old foundation piling, buried logs, stumps, or similar material that extend beyond the limits of excavation and are required to be cut off to be removed. These materials are removed back to the cofferdam limits and paid as Class X excavation.
Hard pan is not considered as Class X excavation. The limits of Class X excavation are the neat lines of the footer unless the excavation lies above another type of excavation whose limits are different. In this case, Class X excavation is paid to the limits of the underlying material.

**WET EXCAVATION**

Wet excavation is that portion of the foundation excavation, except Class X, which is below a horizontal plane designated on the plans as the upper limit of wet excavation and above the bottom of the footing. If the elevation of the upper limit of wet excavation is not indicated on the plans, an elevation of 1 ft above the elevation of low water level is used.

**DRY EXCAVATION**

Dry excavation is that portion of foundation excavation, except Class X, which is above the upper limit of the wet excavation.

**FOUNDATION EXCAVATION, UNCLASSIFIED**

Foundation excavation, unclassified includes all the work for wet excavation or dry excavation if no pay item is included for these items, regardless of whether or not water is encountered. Class X is not included in foundation excavation, unclassified.

If no upper limit of foundation excavation, unclassified is shown on the plans, the upper limit is the original ground, except where waterway excavation, common excavation, or other classified excavation overlaps the area of foundation excavation.

**DISPOSAL OF EXCAVATED MATERIAL**

Excavated material may be classified as follows:

**SUITABLE MATERIAL**

If the material removed is suitable, then the material may be used for construction of embankments, shoulders, special fills, or other places as specified or directed depending on the nature of the fill.

** UNSUITABLE MATERIAL**

If the material is unsuitable for use in the embankment, the material is removed from the right-of-way. To place unsuitable material on private property, the Contractor is required to have written permission from the property owner.
**EXCESS MATERIAL**

Any excess excavated material that cannot be constructively used within the contract limits may be disposed of off the right-of-way, or used as directed to widen embankments or flatten fill slopes.

Excavation obtained from within the right-of-way and planned to be used in the embankment may be wasted and replaced with borrow if permission is obtained. However, the borrow is not paid for.

**BORROW**

Borrow is a material obtained by the Contractor from locations outside of the right-of-way to complete the planned grading section. Frequently this material is obtained from properties adjacent to the right-of-way. Many of the areas that are "borrowed" from become ponds or small lakes. Hence the term "borrow pit".

Material such as river or lake deposit, cinders, or a soil mixture with a high organic content are not allowed. Borrow material is required to be free of substances that:

1) Form putrefying (rotting) deposits
2) Form deleterious (harmful) deposits
3) Produce toxic concentrations or combinations that may be harmful to human, animal, plant, or aquatic life

The following borrow materials that are not suitable for the growth of vegetation may be used:

1) Recycled materials such as coal combustion products, recycled foundry sand, granulated slag, etc.
2) Dune sand
3) B-Borrow
4) Other granular material

When these materials are used they may not be placed within 1 ft of the required finished grade of the shoulders and slopes. The final 1 ft is required to be material suitable for the growth of vegetation. This material is required to be free from clods, debris, and stones.
CONTRACTOR RESPONSIBILITIES

When borrow is necessary or the disposal of excavated material, the Contractor is required to comply with the requirements spelled out in Recurring Special Provision **203-R-550**, Approval of Borrow and Disposal Site. The plan should include the following:

1) A detailed sketch showing limits relative to property and right-of-way lines
2) The grade of all slopes
3) The encasement, finishing grade, and seeding procedures
4) An erosion control plan for the borrow pit in accordance with 327-IAC 15-5.

4) An archeological clearance. The archeological report is required to be conducted by a qualified archeologist. A record check and an intensive field survey is conducted. Prior to the excavating of any material, a written report of the results is furnished to the PE/PS. If any archeological sites are identified, the archeologist establishes the limits along with a reasonable border, and the Contractor is required to remain clear of the site unless the archeological site is cleared by established procedures and written authority has been issued by the PE/PS. Under no circumstances does an employee of the Contractor or INDOT share in the ownership or profit from the sale of any archeological artifacts that may be salvaged.
5) A wetland survey. The wetland survey needs to be performed by a certified wetland professional approved by the department.

The Contractor will need to request approval of the borrow or disposal site at least 14 days prior to when it will be used. Additional requirements for the contractor request are in RSP **205-R-550**.

PREPARING A BORROW PIT

Section **203** places limits on the location, planned excavation, and control of the drainage of the borrow pit. Upon approval of the site by all parties involved the Contractor may proceed with clearing the borrow pit site. Soil samples of the pit are taken and forwarded to the District Testing Department. Before any borrow material is removed from the pit, a base line is required to be established and the original cross-sections taken. The base line is established through or near the proposed borrow pit with
the extremities of the line referenced outside of the excavated area. Sections should be taken well outside of the expected excavation area so the quantity can be determined if the amount of borrow is overrun. The reference line will need to be reproduced after the borrow material is removed. The quantity of borrow paid to the contractor will be the difference from the original section and the final sections after the material is removed.

Precautions are to be taken to ensure that the references are not disturbed. In establishing a base line, consideration is given to the topography, the line of the cross sections, and the possibility of extending sections, if necessary. If the borrow pit includes a large area, an auxiliary line is run parallel to the base line to properly align the cross sections. Unless written permission is granted, there is no excavation below the elevation of the adjacent properties in a borrow pit within 150 ft of the nearest right-of-way line of an existing highway. A sketch is required to be made of the borrow pit layout in the permanent field notes. A description of the location of the borrow pit is placed on the sketch, such as, the number of feet right or left of a roadway station. The name of the property owner is also placed on the sketch.

**PEAT EXCAVATION**

Peat is partly decayed plant matter that has collected in swamps and marshes over long periods of time and is generally the first stage in the formation of coal. Dried peat varies from a light yellow-brown substance to deeper layers of dark brown, compact material which looks like brown coal. Peat is not suitable for foundations of roadways because the material is unstable and subject to settlement when additional embankment is placed upon the deposit. Therefore, peat is required to be removed from under the roadway.

Peat excavation is the removal and satisfactory disposal of peat, marl, or any other unsuitable material and any overlaying material. Extremely soft organic silt is found in lake bottoms and in static areas along river bottoms (flood plains). Marl is a water-deposited sand, silt, or clay containing calcium carbonate. Marl is sometimes found immediately below peat.

In rolling country where the ground rises sharply from the peat deposit, soils have often been washed over the edge of the original peat deposit. Some peat may therefore be trapped under what appears to be the soil perimeter of the peat deposit. This also is considered to be peat excavation.

Removal of peat deposits may be done in several ways. Methods of treatment may be shown on the plans, as directed, or by other methods outlined in the Specifications. Because treatments detailed on the plans,
or as directed, are not all uniform in application, only the methods outlined in the Specifications are discussed.

The Specifications detail three methods for treatment:

1) Treatment of existing fills
2) Treatment by removal
3) Treatment by displacement

**TREATMENT OF EXISTING FILLS**

Treatment of existing fills is a method used to change a fill over an existing peat deposit. The change may be in height and/or width. Treatment of existing fills may be done by several means and is usually predetermined and outlined in the contract plans.

**TREATMENT BY REMOVAL**

The method of treatment by removal consists of completely removing the objectionable material by machine operations. This method is usually used when the following conditions exist:

1) The peat deposit is small in size
2) The peat deposit is shallow in depth
3) The peat deposit limits are completely within the construction limits or right-of-way

The following takes place during the method of treatment by removal:

1) New original cross-sections are taken. The entire area may have settled since the original survey.
2) The width of excavation is to be the full toe of slope to toe of slope width of the proposed embankment.
3) Final cross-sections are taken after the excavation is completed.
4) Backfilling of the peat excavation follows as soon as possible to minimize the occurrence of slides.
5) If water is not present, the excavation may be backfilled with borrow or common excavation.
6) If water is present, the backfill is required to be B Borrow placed by end-dumping to an established grade of approximately 2 ft above free water level.

**TREATMENT BY DISPLACEMENT**

Treatment by displacement is the most commonly used procedure for excavation of peat. This procedure is frequently used under the following conditions:

1) The peat deposit is large in size
2) The peat deposit is deeper than 10 ft
3) Water is present at all times
4) The free water level is high

The following steps are usually followed during this method of treatment, if conditions permit:

1) Each end of the deposit is removed until the depth of the peat excavation is greater than 10 ft. This may be subject to change as directed. If conditions permit, the upper portion of peat is excavated across the remainder of the deposit. Excavation of this upper level begins at one end and continues ahead of the displacement-backfill operation. The free water level usually controls the depth of this operation. Displacement-backfill operation is also known as "surcharge".

2) After the completion of the excavation, cased test holes are placed. These test holes determine the extent of peat displacement and are also used to determine final measurement of the excavation.

The surcharge operation is the most difficult portion of the treatment to control. The weight of the surcharge literally pushes or squeezes the peat from the deposited area. A crane(s) with a drag line assists the surcharge procedure by removing the peat from in front of the surcharge. Since a properly constructed surcharge is very important, several guidelines are followed during the construction of the surcharge:

1) The surcharge is constructed of B Borrow.
2) The top of the surcharge is constructed and maintained to a width equal to the full shoulder width of the embankment.
3) The height of the surcharge is the same as the depth of peat being excavated. The original ground is the reference elevation for measuring the peat depths and the surcharge heights.

4) The top of the surcharge is approximately level.

5) The length on the top of the surcharge is at least 2 times the depth of the peat being treated.

6) The surcharge is maintained and pushed forward as directed.

7) The crane operation is coordinated with the rate of placing the surcharge.

**PEAT DISPOSAL**

Once the peat deposit is excavated, by either removal or displacement, the excavated peat may be disposed of by one of the following methods:

1) Uniformly spread between the toes of fill slopes and the swamp ditch lines and beyond.

2) According to Section 203.08 and 205-R-550 (Disposal Sites).
4 Excavation Construction Requirements

- General Preparation
- General Requirements
- Erosion Control
- Lifts

Equipment

- Hauling
- Spreading
- Compacting
CHAPTER FOUR:
EXCAVATION CONSTRUCTION
REQUIREMENTS

GENERAL PREPARATION

Prior to beginning excavation, grading, or embankment operations in any area, the following items are required to be completed:

1) Clearing and grubbing is conducted. This includes the removal of all perishable material such as tree roots, stumps, sod, weeds, agricultural debris, etc.

2) Check sections are taken and checked satisfactorily with those on the plans. On contracts with construction engineering, the Contractor is responsible for securing check sections. The method of checking original cross sections is outlined in the General Instructions to Field Employees.

3) After the previous items have been completed, the Contractor proceeds with scalping in areas where excavations are to be made, or embankments are to be placed. Another common term for scalping is stripping. Scalping is the removal of the upper 4 in. of the soils. Removal is necessary to ensure that decayable vegetation is not incorporated into an embankment. Although 4 in. is the maximum depth, top soils containing large quantities of humus to a depth greater than 4 in. are removed until suitable materials are exposed. Scalping is completed to the limits the area where excavations are to be made or embankments are to be placed. The grading operations is inspected closely for unsuitable material. Roots and other large perishable objects are removed and stockpiled outside of the construction limits for later disposal.

4) All pronounced depressions left in the original ground surface by removal of objectionable material from within embankment limits are filled with acceptable material and compacted to the density required for the embankment. The upper 6 in. of the original ground is compacted with a roller weighing no less than 10 t, or with other approved compacting equipment.
5) The final step before embankment placement is proofrolling. This work is done with a pneumatic tire roller (Figure 2-1) with a minimum tire size of 7:50 by 15 in accordance with Section 409. Other approved equipment, such as a fully loaded tri-axle dump truck, may be substituted for the pneumatic tire roller. One or two complete coverages is required, as directed. This procedure also reveals all spongy and yielding materials which are not compacted. If soft areas are identified that will result in soft areas under the embankment they should be removed. The volume removed should be measured and paid in the common excavation item as undercutting. Judgment should be used in identifying these areas considering the height of embankment to be placed at that location. Identified areas within the proposed embankment are removed. The locations of spongy and yielding material may be detected visually.

After proofrolling has been completed and all soft or unstable areas have been corrected, the area is ready for placement of the new embankment.
GENERAL REQUIREMENTS

Excavated material that is suitable for embankment construction is placed in the embankment before placing any borrow material. This means that ditches are excavated first, since much of common excavation is derived from ditch cuts. The construction of ditches first also provides drainage for the embankment area. The roadway embankments are maintained higher at the center to promote drainage of the roadway.

TEMPORARY EROSION CONTROL

Once the ditches have been completed, the Contractor begins placement of temporary erosion control devices as soon as possible. Failure to do so may cause pollution to drainage ditches, streams, and rivers adjacent to the project and is a violation of 327 IAC. Some different types of temporary erosion and sediment control devices may include:

1) Perimeter protection
2) Drainage barrier at swale
3) Slope protection – interceptor ditches and slope drains
4) Sediment control in side ditches – straw bale ditch check, riprap ditch check, ditch sediment trap, or culvert pipe protection
5) Sediment basin
6) Inlet protection – curb inlet protection and drop inlet protection

These erosion control features are maintained until permanent erosion control features are placed. The need for erosion control devices is determined in the planning stages of the project, and erosion control devices are outlined and detailed on the construction plans. An amended Erosion Control Plan shall be submitted in accordance with 327 IAC 15-5 for those areas not included in the plans or as necessary for changes initiated by the Contractor. Items to include consist of sequencing of operations, stockpile sites, equipment storage sites, plant sites, borrow and disposal areas, and haul roads as well as any revision to the features shown in the plans. All appropriate erosion control items shall be in place prior to disturbing the project site. A copy of the amended plan should be provided to the PE/S. The Technician is responsible for ensuring that these devices are being maintained. Inspection of control devices is especially important during and after periods of rainfall which may cause damage to the devices. Sediment basins are required to be cleaned, dikes or dams
reconstructed, and straw bales replaced, if damage has reduced the effectiveness of these devices.

**LIFTS**

During the construction of an embankment, each lift being placed has certain factors which are required to be considered:

1) Lifts are required to extend transversely over the entire embankment area between slope stakes. Doing this ensures that the outside slopes of the embankment are compacted as well as the middle of the embankment. The higher the fill, the more critical this becomes.

2) The fill width is required to be checked as the fill progresses. Failure to do so may cause fat or bellied slopes.

Fat slopes are slopes which contain excess material or exceed the planned slope. Bellied slopes are slopes that do not contain enough material and these slopes are detected by viewing the slopes longitudinally. Bellied slopes are required to be corrected as the embankment is being built. Sidecasting is avoided as a solution since this usually develops a fill slough or slide at a future date.

**EQUIPMENT**

Equipment required for placing embankment consists of four categories;

1) Hauling equipment

2) Spreading equipment

3) Compacting equipment

4) Moisture control equipment

**HAULING**

The method of hauling embankment material is determined by the Contractor and is based upon the following construction factors.

1) Type of material

2) Source of material
3) Conditions or obstacles between the source and area of placement

4) Availability of equipment

The equipment used for hauling includes:

1) Dump trucks

2) Earthmovers

3) Quarry trucks

Earthmovers (Figure 2-2) are frequently used for hauling embankment material. There are various sizes and models of earthmovers. Earthmovers are used in excavating, hauling, and placement of soil materials that are adjacent to or on the contract. When common excavation is required to be hauled across a bridge structure or when borrow material is obtained from a remote source, or hauling takes place over a road that is open to the public, dump trucks are used. Quarry trucks are used only in rock excavation.

Figure 4-2. Earthmover

SPREADING

Because embankments are to be constructed in uniform layers, spreading equipment is necessary. Placing uniform layers may be done with several types of equipment or groups of equipment. The most common are the
motor grader and the bulldozer. If soil conditions are suitable, earthmovers may also be considered as spreading equipment. This is done by the earthmover operator controlling the discharge of the materials in such a manner to create a uniform layer. Because soil conditions may change dramatically, the earthmover is not the only spreading device necessary.

Another method of leveling layers uses a sheepsfoot compactor with a blade (Figure 2-3). This equipment may be used instead of a motor grader. This is especially true on small grading projects.

![Sheepsfoot Compactor with Blade](image)

**Figure 4-3. Sheepsfoot Compactor with Blade**

A piece of equipment that may also be used during the spreading operation is the disk (Figure 2-4). Although the disc does not level the soil, this equipment is helpful in creating a uniform layer. The disc is used for:

1) Breaking up lumps, slabs, and clods
2) Aerating material to remove excess moisture
3) Incorporating water to increase moisture
COMPACTING

Compacting equipment requirements vary from contract to contract. A list of the types of compactors which are most commonly used include:

1) Three wheel roller
2) Smooth drum vibrator roller
3) Vibratory tamping roller (Figure 2-5)
4) Static tamping roller or sheepsfoot
5) Crawler-tread equipment or bulldozer
6) Mechanical tamps or vibrators
The compactor to be used is determined by the Contractor and is dependent upon several factors:

1) Size of embankment
2) Type of materials being compacted
3) Conditions of materials being compacted
4) Availability of equipment
5) Contractor's preference

For placement of granular embankment material, three wheel and smooth drum vibrator rollers are preferred over tamping rollers. A dozer may be used in areas not accessible to conventional rollers, in building surcharges for peat excavation, or for rock embankments. Tamping vibratory rollers are preferable for shale embankment.
For placement of a clay soil embankment material, large slabs, lumps, or clods are required to be broken up before compacting. Breaking may be done by disking, but often a sheepsfoot roller is required to break up clods and low moisture lumps.

The following chart is helpful in determining which compactors may be used for different materials.

<table>
<thead>
<tr>
<th>Compactor Type</th>
<th>Material</th>
<th>Lift Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Wheel</td>
<td>all soils</td>
<td>8 in. maximum</td>
</tr>
<tr>
<td>Smooth Drum Vibratory</td>
<td>all soils</td>
<td>8 in. maximum</td>
</tr>
<tr>
<td>Tamping-Foot</td>
<td>soil or shale</td>
<td>Length of tamping foot</td>
</tr>
<tr>
<td>Crawler-Tread</td>
<td>rock</td>
<td>see Specifications</td>
</tr>
<tr>
<td>Crawler-Tread</td>
<td>aggregates*</td>
<td>6 in. maximum</td>
</tr>
<tr>
<td>Smooth Drum Vibratory</td>
<td>aggregates*</td>
<td>6 in. maximum</td>
</tr>
<tr>
<td>Mechanical Tamp or Vibratory</td>
<td>soils</td>
<td>6 in. maximum</td>
</tr>
<tr>
<td>Mechanical Tamp or Vibratory</td>
<td>aggregates</td>
<td>4 in. maximum</td>
</tr>
</tbody>
</table>

*Where impractical to conduct density tests.

Whatever equipment is used for compacting, the goal is a uniform dense embankment.
5 Embankment Construction

Rock Embankment

Lift Requirements

Compaction Methods

Shale and Soft Rock Embankments

Lift and Compaction Requirements

Embankments on Hillsides and Slopes

Embankments over Existing Roads

Treatment of Existing Roadbeds

Compaction Control
Settlement Control
CHAPTER FIVE:

EMBANKMENT CONSTRUCTION

The purpose of this chapter is to teach the Technician how to properly inspect embankment construction. The knowledge acquired will enable the Technician to implement the skills necessary to insure a good, solid, and lasting embankment which is absolutely necessary for a durable and safe highway. Different classifications of materials encountered, lift requirements, compaction methods, benching, density tests, moisture content, earthwork calculations, and Specifications relating to each particular area of embankment of construction will be discussed.

ROCK EMBANKMENT

Rock excavation consists of removing rock which cannot be excavated without blasting. This material includes all boulders or other detached stones each having a volume of 1/2 yd³ or more.

In a rock fill, the lifts are thick and the voids between the rock chunks are large. Although these voids are filled with fines at the top and sides of the embankment, inside the embankment many large voids remain. If these rock pieces remain intact, deformations are small within the embankment because of the friction and interlocking between pieces.

LIFT REQUIREMENTS

The requirements for a rock embankment are:
1) No large stones are allowed to nest and are distributed over the area to avoid pockets. Voids are filled with small stones.

2) The final 2 ft of the embankment just below the subgrade elevation is required to be composed of suitable material placed in layers not exceeding 8 in. loose measurement and compacted to the required density.

3) Shale or shale-like materials are not permitted in the upper 2 ft of embankment.

4) Where the depth of an embankment is greater than 5 ft and consists entirely of rock, the rock is deposited in lifts not to exceed the top size of the material being placed, but in no case exceeding 4 ft.
5) Where the depth of an embankment is 5 ft or less, or where the material being placed does not consist entirely of rock, the material is placed in lifts not to exceed the top size of the rock being placed, but in no case exceeding 2 ft.

6) The rock for any particular lift is required to be deposited on and pushed over the end of the lift being constructed. If the voids of the last lift are not closed sufficiently, they are required to be choked with small broken stones or other suitable material and compacted as directed.

7) Where a rock fill is to be placed over a structure, the structure is first covered with 2 to 4 ft of earth or other approved material, and properly compacted before the rock is placed.

8) Shale is not incorporated as rock embankment unless written permission is obtained.

**COMPACTION METHODS**

When rock is used for embankment construction and has such a large top size as to make the material impractical to conduct density tests, such material may be compacted with crawler-tread equipment or with approved vibratory equipment, or both. Each lift is compacted thoroughly by successive passes back and forth with the tread areas overlapping enough on each trip so that all portions are compacted uniformly.

**SHALE AND SOFT ROCK EMBANKMENTS**

If a rock fill were built of rocks which weathered rapidly in the fill, the rock pieces would become soil, which could in turn fall down into the rock voids. The cumulative result of this would be considerable settlement of the embankment and subsequent slope failure. Shales are a good example of this type of failure, since large pieces may degrade (slake) into soil which squeeze down into the
large voids. The net result is that large settlements, and even slope instability, may occur.

**LIFT AND COMPACTION REQUIREMENTS**

The requirements for lift placement and compaction include:

1) Shale, shale and soft rock mixtures, or soft rock are placed in 8 in. maximum loose lifts.

2) The compaction is required to be done with an approved vibratory tamping-foot roller in conjunction with a static tamping-foot roller. Each tamping foot on the static roller
is required to project from the drum a minimum of 6 in. Each tamping foot on the vibratory roller is required to project from the drum a minimum of 4 in.

3) Shale, shale and soft rock mixtures, or soft rock are required to be compacted to at least 95% of maximum dry density.

4) The moisture content is required to be controlled within -2 and +1 percentage points of optimum moisture content.

5) The compaction is measured with a Light Weight Deflectometer.

6) Water is required to be applied to the shale in the cut to accelerate the slaking action and again prior to diskng and compaction. Water is paid for on a volume basis.

7) The water is required to be uniformly incorporated throughout the entire lift by a multiple gang disk with a minimum disk wheel diameter of 24 in.

8) Unless otherwise approved in writing, each embankment lift is required to receive a minimum of three passes with the vibratory roller. A roller pass is defined as being one complete coverage of a given area. The material is required to be bladed before using the vibratory roller.

**EMBANKMENTS ON HILLSIDES AND SLOPES**

Before an embankment is placed on natural soil slopes or existing fill slopes steeper than 4:1, benches a minimum of 10 ft wide, unless otherwise specified, are cut into the slopes prior to the placement of embankment fill. Before placing embankment on natural soil slopes of 4:1 or flatter, the existing ground surfaces are plowed or deeply scarified.
If benches are cut, the excavation is paid for at the contract unit price per \( \text{yd}^3 \) for the class or classes of excavation encountered. No direct payment is made for plowing or scarifying.

**EMBANKMENT OVER EXISTING ROADS**

Whenever constructing an embankment over an existing roadway, certain precautions are required to be taken.
TREATMENT OF EXISTING ROADBEDS

1) If embankments for new pavement are to be placed over an area where a rigid pavement is in place and the upper surface of the existing pavement is 12 in. below the subgrade elevation of the proposed new pavement, the existing pavement is required to be removed.

2) If embankment for new pavement is to be placed over an area where an existing rigid pavement is in place and the upper surface of the existing pavement is more than 12 in. but less than 3 ft below the subgrade elevation of the proposed new pavement, the existing pavement is required to be broken. The pavement is broken so that the area of any individual piece does not exceed 1 yd$^2$.

3) If embankment for new pavement is to be placed over an area where a hot mix asphalt surface on a concrete base is in place, and such existing surface is more than 12 in. but less than 3 ft below the subgrade elevation of the proposed new pavement, the hot mix asphalt is required to be removed and the concrete base is broken.

4) If embankment for new pavement is to be placed over an area where a hot mix asphalt pavement is in place, the top of which is set at the approximate elevation of 12 in. or less above or below the required subgrade elevation of the proposed new pavement, the existing pavement is broken and removed to the depth directed, but no less than 12 in.

5) If embankment for new pavement is to be placed over any existing pavement, the top of which is greater than 3 ft below the required subgrade elevation, the existing pavement is left in place.
6) If an embankment is to be widened, precautions are taken to ensure a firm foundation. After all perishable material has been removed, the existing shoulders are plowed down 2 ft out from the existing pavement. This material is used for widening. Benches, a minimum of 4 ft wide, are cut into slopes of the old embankment unless otherwise directed. No direct payment is made for plowing or benching, the cost thereof to be included in the various pay items of the contract.
The following compaction control requirements are included in the duties of the grade Technician:

1) Unless otherwise specified, all embankments are compacted to the target density provided by the Geotech lab results or from a test strip.

2) The moisture content is controlled within -2 and +1 percentage points of optimum moisture content.

3) If the embankment material is too wet, the material is aerated to remove excess moisture.

4) If the embankment material is too dry, the material is watered and disked to increase the moisture content.

5) The embankment material is placed in uniform level layers, and compacted with approved compacting equipment. Compacting equipment is required to include at least a three-wheel roller or other compacting equipment capable of providing a smooth and even surface.

6) Each lift is disked or treated by some other mechanical means which ensure the breaking up of any existing lumps and clods.

7) The loose depth of each lift is required to be such that the required compaction may be obtained, but in no case exceed 8 in.
8) Where a tamping roller is used, the loose depth of lift is required to not exceed the length of the tamper feet. The surface area of the end of each foot of the tamping roller is required to be no less than 5 in².

9) When silts, silty loams, or loessial type soils are encountered and used in embankment construction, the moisture content is controlled within -3 percent of optimum and the optimum moisture content.

10) Field compaction tests are required to be conducted on each lift, and the required compaction obtained on each lift before the next lift is placed.
11) The moisture content for sandy soil or a sand and gravel soil, having at least 80% sand and gravel size particles, is required to be such that the soils may be compacted to the specified density, which is normally several percentage points below optimum or as directed.

SETTLEMENT CONTROL

Preliminary investigation sometimes finds that the existing soil below the embankment settles over time when a heavy embankment is constructed. Therefore, settlement control is necessary to measure this settlement and to ensure that the settlement has slowed to an acceptable rate. The locations requiring settlement plates will be shown in the plans. This work consists of providing, installing, maintaining, and reading various types of geotechnical instrumentation at locations indicated on the plans or as directed as follows:

1) Prior to the beginning of embankment operations in any area, 1/2 in. by 3 ft by 3 ft settlement plates equipped with sections of 3/4 in. and 2 in. galvanized threaded pipe and couplings for a cover are installed at locations as indicated in the plans.

2) The 3/4 in. pipe sections for the settlement plates are required to be 4 ft. Such pipe sections may be extended vertically from the center of the plates up through the new embankment as the embankment increases in height. The pipe sections are spot welded at the joints. A cover of pipe of 2 in. is slipped over the pipe and not welded to the plate. The 3/4 in. steel pipe and 2 in. cover extend 2 ft or more above the grade of the new embankment at all times during grading operations and the settlement period.

3) In addition to the settlement plates, lateral stakes are installed, if indicated on the plans. The stakes are required to be 3/4 in. by 4 ft steel rods and are driven to at least 12 in. into the ground.
4) B Borrow is used as embankment material around settlement plates and pipe to protect this equipment during construction.

5) After the embankment has been constructed to subgrade elevation, settlement stakes are installed at the locations as set out in the plans. The stakes are required to be 3/4 in. by 4 ft steel rods.
6) During the construction of the embankment, elevation readings are taken on all settlement plate extension pipes and settlement stakes at the end of each 7-day period, or more frequently if the conditions warrant.

7) After the embankment has been constructed to subgrade elevation, readings are taken on the settlement stakes, in addition to the settlement plate extension pipes. Lateral stakes are used to monitor horizontal movement of the ground or new fill. If lateral movement is observed during construction of the fill, the work is suspended and corrective measures are taken as directed.

8) Unless otherwise directed, the new embankment, after being constructed to subgrade elevation, is allowed to settle for a period of 3 months.

9) After the embankment is constructed to the subgrade elevation, a reading is taken every seven days until the settlement rate is 1/4 in. or less for four consecutive weeks. The monitoring period may be reduced as directed by the Office of Geotechnical Engineering. If the results of any readings indicate that the new embankment has a settlement greater than 1/4 in., the monitoring period is extended until the settlement requirements are met.

10) In the event that serious settlement develops during the construction of the embankment or within the required settlement period, the work is required to be suspended and corrective measures taken as directed.
6 Measurement and Earthwork Calculations

- Contract Quality Payment
- Measured Quantity Payment
- Measurement and Earthwork Calculations
- Cross Sections
- Volumes
An important part of the discussion of earthwork is the determination of pay quantities. In this section the following items are discussed:

1) Contract quantity payment

2) Measured quantity to include cross sections, computations of volumes, and terms.

**CONTRACT QUANTITY PAYMENT**

According to the Specifications, if the plan quantity of borrow, common and unclassified excavation is less than 15,000 CYD the plan quantity will be paid, unless either the Contractor or INDOT disagrees and can provide documentation showing another quantity was placed. When paying plan quantities for excavation, the following procedures are to be followed:

1) New original cross-sections are to be taken at 500 ft intervals and plotted to check the accuracy of the original sections.

2) Final cross-sections are to be taken at 500 ft intervals. Cross-sections are required to be complete sections in cuts and from the shoulder break to the right-of-way in fills. These final sections indicate substantial conformance with the planned cut slopes and ditches and are used to determine if earthwork deductions are required.

3) Spot checks are made of the cross-section areas indicated in the plans. The number of spot checks is required to average one for each 2000 ft with the locations concentrated in areas of the major excavation. Additional area checks are made to determine whether the plan quantity needs to be adjusted for areas varying more than 10 % from the area indicated on the plans. If the average deviation of all the areas checked varies from the planned areas at the corresponding locations by more than 2 %, a more detailed check is required on those areas or balances showing the highest deviation.
4) The computation of the volume from the planned areas of one balance is required to be checked. In general, this balance is the largest balance in the contract. Any other questionable balances are required to be checked for volume computations.

5) Any other pertinent facts which would justify using plan quantity or indicating the need for adjustments is required to be considered.

MEASURED QUANTITY PAYMENT

Where measured quantities are specified or found necessary by the check of plan quantities, the excavated quantities in each balance are computed on Form IC 401. If "excess cut" or "waste" deductions, as described later, are applicable to the roadway excavation, they are deducted from the balance totals.

MEASUREMENT AND EARTHWORK CALCULATIONS

Payment for grade construction is usually based on a bid price per yd³ for excavation measured in-place as computed from survey notes. The unit price generally includes the following:

1) Hauling excavated material (cut) from within the limits of the roadway or bringing in other material from outside areas (borrow)

2) Building the embankments (fill) to specified form

3) Disposing of surplus material (waste)

4) Conducting such operations as forming earth shoulders, trimming slopes, and preparing the subgrade for pavement

CROSS SECTIONS

The determination of earthwork quantities is based upon field cross-sections taken in a specified manner before and after excavation. Cross-sections are vertical profiles taken at right angles to the survey centerline. Every section is an area formed by the subgrade, the sideslopes, and the original ground surface.
VOLUMES

Volumes are computed from cross-section measurements by the average end area method.

Volume (english) (yd³) = \[ \frac{[L \times (A_1 + A_2)]}{(2 \times 27)} \]

L is in feet

A₁ and A₂ are in square feet

Volume (metric) (m³) = \[ \frac{[L \times (A_1 + A_2)]}{2} \]

L is in meters

A₁ and A₂ are in square meters

These formulas are used to compute earthwork quantities because the Specifications require this calculation. All the plans and bidding for the project have been completed using this method.

The formula for average end areas is accurate only when the end areas are equal. For other cases, the formula generally gives volumes slightly larger than their true values. If applied to a pyramid, for example, the error would be the maximum and would be equal to 50 % of the correct volume. In practice, however, the total error over the long run is seldom more than 2 %.

Also, where not practical to measure material by the cross-section method due to erratic location of isolated deposits, acceptable methods involving three dimensional measurements may be used to measure material in the original position. Equations for these measurements are:

Volume (yd³) = \( \frac{(Length \times Width \times Depth)}{27} \)

Volume (m³) = Length x Width x Depth

Earthwork may also be measured on a linear basis. For linear grading items in a contract, the measurement for payment is based on the actual length of roadway mileage constructed. This includes all classes of excavation on both sides of the roadway.

Small quantities of excavation may also be measured on a weight basis in accordance with Section 203.27.
Embankment fills are not paid for directly. The cost is to be included in the other pay items of the contract. In certain contracts, fills are paid for directly.

Borrow is measured and paid for by the yd$^3$. In most cases, borrow is cross-sectioned in the original position of the borrow before excavation begins and after excavation is completed. The volumes are computed by the average end area method.

Excavation may also be measured on a lump sum basis. When this occurs, no individual measurements are required.

There are many other special cases for different types of measurements and classes of excavation which may be encountered on a construction contract. The plans, Special Provisions, Specifications, General Instructions To Field Employees, and the PE/PS are required to be consulted when starting an operation on a contract.
7 Subgrade Construction

Construction Requirements

Fine Grading

Density Testing

Proofrolling

Subgrade Treatments

Chemical Modification of Soils

Moisture Control

Drainage

Measurement and Payment

Summary
CHAPTER SEVEN:
SUBGRADE CONSTRUCTION

Subgrade is that portion of the earth roadbed which after having been constructed to reasonably close conformance with the lines, grades, and cross-sections indicated on the plans, receives the base or surface material. In a fill section, the subgrade is the top of the embankment or the fill. In a cut section the subgrade is the bottom of the cut (Figure 1-1). The subgrade supports the subbase and/or the pavement section. To ensure a stable, long-lasting, and maintenance free roadway, the subgrade is required to be constructed using certain proven procedures that provide satisfactory results.

After the rough grading is completed, the fine grade stakes are set and the final processing of the subgrade may begin. The rough grade is the top grade of the embankment as built using the information provided on the grade sheets. The grade is normally within 2 in. at this point. The finish grading operation consists of trimming the excess material down to the final grade. Filling any low spots with thin lifts of materials tends to slide these lifts around if not properly worked into the underlying materials.

Figure 1-1. Typical Roadway Cross Sections
The subgrade is the base the pavement is built upon. As the upper surface, special consideration is given prior to the pavement construction. Subgrade treatment is constructed uniformly transversely across the width of the pavement including 2 ft outside the edge of shoulders or curbs, unless indicated otherwise on the plans, by one of the following methods.

1) Chemical modification in accordance with Section 215

2) Aggregate No. 53 in accordance with Section 301

3) Geogrid in accordance with Section 214 placed under aggregate No. 53 in accordance with Section 301

4) Soil compaction to 100 % of maximum dry density

Longitudinally, the treatment may vary depending on the method of construction.

CONSTRUCTION REQUIREMENTS

Soils containing greater than 3 % by dry weight calcium, magnesium carbonate, or organic material, or with a maximum dry density of less than 100 lb/ft³, or with liquid limit of greater than 50, are not allowed within the specified thickness of the subgrade. Density is determined in accordance with AASHTO T 99 and loss of ignition is determined in accordance with AASHTO T 267. Liquid limit is determined in accordance with AASHTO T 89.

Coal within the specified thickness of the subgrade is excavated, if directed, and disposed of in accordance with Section 202.05. Coal or coal blossoms that are allowed to remain are mixed thoroughly with subgrade soils and compacted in accordance with Section 207.04.

During subgrade preparation, adequate drainage is required to be provided at all times to prevent water from standing on the subgrade.

The final goal is to have a subgrade that meets the cross section and finish grade requirements as well as satisfying the density and proof rolling Specification prior to placing the initial subbase material. Even though the proof rolling is the last operation to be conducted, most of the potential soft spots are required to be detected and treated before the final grading is completed.

FINE GRADING

Fine grade is required to be provided for the final trimming and checking of the cross section and grade. Most contractors are now using GPS control on their grading equipment. This allows the grading to be
accurately controlled. However the final grade still needs to be held to within ½ inch of the plan elevation. Adequate stakes are needed so the finish grade can be checked to assure that the grade is correct. The appropriate corrections for a crown in the typical cross section are used in calculating the correct offset distance. The tolerance for finishing the earth subgrade is ½ in. from the true grade. Any low areas in the grade requiring less than 3 in. additional fill material are scarified prior to placing the fill material so the thin layer of fill is tied into the previous layer when compacted.

Fine Grading (Figure 1-2) the subgrade for aggregate or asphalt base courses is usually conducted with a motorgrader with GPS control. The automatic grading machine is required to be used for preparing the subgrade for concrete base and pavement. When underdrains are specified, special care is required to be taken to ensure that there is no damage to the drains and that the aggregate backfill does not become contaminated with soil.

Figure 1-2. Fine Grading

DENSITY TESTING

Where the density and moisture control option is used, compaction of the embankment areas is required to be in accordance with Section 203.23. The minimum number of tests required is outlined in the Frequency Manual. For mainline and shoulders, one test for each 1500 ft for each lift is required. For widening trenches ≤ 5 ft, one test each 1500 ft is required. Any failing tests require additional work on the subgrade in that area to obtain the required density. Soil compaction at the optimum moisture content requires the least amount of compactive effort to obtain 100 % maximum dry density. Therefore, drying excess moisture or adding water to a dry subgrade may be necessary to obtain this required density.
PROOFROLLING

Even though the subgrade has been previously accepted, the condition of the subgrade at the time paving material is placed is required to be in accordance with Section 105.03 and Section 207.04. Prior to placing the base course on the subgrade, proofrolling in accordance with Section 203.26 is completed. Undue distortion of the subgrade is avoided. If limits of the work make mechanical preparation of the subgrade impractical, appropriate hand methods may be used. Two complete coverages with the proofroller are required to verify the condition of the subgrade. All roller marks, irregularities, or failures are required to be corrected. Any depressions in the subgrade that hold water are required to be eliminated.

Preparing the subgrade well ahead of the paving operation helps insure a more uniform subgrade with fewer paving delays.

SUBGRADE TREATMENTS

The subgrade treatment type is required to be as specified on the contract plans.

Within each of the following subgrade treatment types, the Contractor may choose from the listed options for each type.

Type I 14 in. chemical soil modification, 12 in. of the subgrade excavated and replaced with No. 53 aggregate, or by 24 in. of soil compacted to density and moisture requirements.

Type IA 14 in chemical soil modification or 12 in. of the subgrade excavated and replaced with No. 53 aggregate.

Type IB 14 in chemical soil modification.

Type IC 12 in. of the subgrade excavated and replaced with No. 53 aggregate.

Type II 8 in. chemical soil modification, 6 in. of the subgrade excavated and replaced with No. 53 aggregate, or 12 in. of soil compacted to density and moisture requirements.
Type IIA 8 in. chemical soil modification or 6 in. of the subgrade excavated and replaced with No. 53 aggregate.

Type III 6 in. of soil compacted to the density and moisture requirements, or 6 in. of subgrade excavated and replaced with No. 53 aggregate.

Type IIIA 6 in. of subgrade excavated and replaced with No. 53 aggregate.

Type IV 9 in. of the subgrade excavated and replaced with No. 53 aggregate on geogrid.

CHEMICAL MODIFICATION OF SOILS

Chemical modification of soils consists of uniformly mixing dry Portland cement, fly ash, lime, or a combination of the materials with soil. This has the effect of raising the optimum moisture content allowing the compaction to take place when the soil is wetter. For the purpose of aiding in compaction the lime or cement product is added at a rate of from 1% to 2%. When used for subgrade treatment the lime or cement product is added at around 4.5%, depending the recommendations from the soil report.

The Contractor is responsible for all tests required to determine the optimum chemical modifier content for modification of the soils. The modifier selection, laboratory testing, and mix design are conducted by an approved geotechnical consultant in accordance with the Department's Design Procedures for Soil Modification or Stabilization. The test results, recommendations, and type A certifications are submitted to the PE/PS and Office of Geotechnical Engineering for approval at least 5 days prior to use. Based on the test results the quantity of chemical modifier may be adjusted from that shown in the specifications for different soil types. The source or type of chemical modifier may not be changed during the progress of the work without approval, and any change in source requires a new mix design.

Chemical soil modification is conducted when the soil has a minimum temperature of 45° F, 4 in. below the surface, and with the air temperature rising. The modifier is not allowed to be mixed with frozen soils.

The soil is scarified to a planned depth prior to placement of the chemical modifier when type A-6 or A-7 soils are used or encountered. The modifier is uniformly distributed by a cyclone, screw-type, or pressure manifold distributor. Spreading of the modifier is limited to an amount
which may be placed into the soil within the same work day and during acceptable wind conditions.

The chemical modifier, soil, and possibly water are thoroughly mixed by rotary speed mixers until a homogenous layer of the required thickness has been obtained. Compaction of the mixture begins as soon as possible, but is required to be started within:

1) For cement modified soils, mixing is required to be completed within 30 min of cement placement, and compaction completed within 3 h after mixing.

2) Fly ash modified soils are required to be compacted within 4 h

3) Lime modified soils are required to be compacted within 24 h

The compaction effort is required to be in accordance with recommendations provided in the mix design. The moisture content of the mixture is required to be between optimum moisture and optimum plus 2 %.

The compaction of the subgrade treatment is accepted based on the Dynamic Cone Penetrometer, DCP. For a 14 inch lift the required DCP blow count is 17 for the top 6 inches and 16 for the bottom 8 inches of the lift. For an 8 inch lift the required blow count is 20. One passing DCP test is required every 1,500 feet for a 2 lane pavement.

Construction traffic is not allowed on the treated soils within 72 h of compaction.

When selected by the Contractor, subgrade construction may be done by excavation and replacement with No. 53 aggregate in accordance with Section 301.

When specified in the plans, subgrade construction may be constructed with geogrid and No. 53 aggregate in accordance with Sections 214 and 301.

**MOISTURE CONTROL**

The moisture content is required to be controlled during the special subgrade treatment operations. Fine grain or clay type soils are placed at a moisture content within -2 and +1 percentage points of the optimum. Silts, silty loams, or loessial type soils are required to be within -3 percent
of the optimum. Soils composed primarily of sand or sand and gravel may
normally be compacted to the specified blow count at a moisture content
several percentage points below optimum. Careful monitoring and control
of the moisture content of the soil during the special subgrade treatment
process is essential for attaining a uniformly dense and stable subgrade.

DRAINAGE

Providing surface drainage for the undercut areas is usually not possible.
The size of the undercut areas is limited, and the undercutting schedule
regulated so that an area is not left open when rain is likely. Water
ponding in the undercut area would likely worsen the excess moisture
problems that the undercut was designed to alleviate. The final moisture
and density testing, and proofrolling are conducted on the top 8 in. of the
completed subgrade near the beginning of the paving operation.

MEASUREMENT AND PAYMENT

Subgrade treatment is measured in both cut and fill areas by the square
yard. The cost of subgrade treatments including testing, sampling,
aggregates, modifiers, geogrid materials, water, or the excavation required
for the methods selected by the Contractor is included in the cost of the
pay item for subgrade treatment. The under cutting of rock, where
encountered, is measured in accordance with Section 203.27(b). Where
conditions exist below the specified subgrade compaction depth that
prevent achieving the specified compaction, payment for correcting such
conditions is based on the directed method of treatment. The accepted
quantity of chemically modified soils is paid for by the square yard,
complete in place.

SUMMARY

Proper subgrade construction and treatment is one more step toward the
completion of a good roadway. The specified moisture and stability
requirements are required when the subgrade is covered by any subsequent
courses. Through careful schedule planning and construction, the
Contractor may attain these results in the most economical way possible
while providing a good, stable, subgrade.
8 Finishing

Shoulders

Ditches

Slopes

Earth Graded Roads

Final Trimming and Cleaning

Measurement and Payment
CHAPTER EIGHT:  
FINISHING

Finishing consists of the final shaping and dressing of shoulders, ditches, and slopes by machine or by hand methods to the required smoothness, elevation, and cross section as indicated on the plans, or as directed. Finish work is usually undertaken after the paving has been completed. If the initial grading was not checked for reasonable conformance to the planned cross sections, the finishing operation may produce an excess or deficiency of material.

SHOULders

The subgrade is constructed uniformly transversely across the width of the pavement including 2 ft outside the edge of shoulders or curbs. The shoulders are constructed with earth or other approved material which contains no sod, weeds, sticks, roots, or other perishable matter. The inside edges are built up above the surface of the adjoining pavement and compacted with a roller weighing no less than 5t. Rolling and shaping continues until the desired cross section and compaction is obtained. Shoulder areas that are not accessible to the roller are compacted with some other mechanical means that produce satisfactory results. Unless otherwise allowed, the outside edge of shoulder is required to be parallel to the pavement edges and be compacted the full width. The grade and slope of the shoulders may vary through super-elevated curves but in no case is water allowed to pond at the edge of the pavement or anywhere on the shoulder surface.

DITCHes

Ditches are required to be constructed and finished to the grades and cross section as indicated on the plans, or as directed. All ditches are constructed so that they drain and are free from water pockets. Abrupt changes in grade and alignment of side ditches may cause erosion and are avoided.

SLOPES

All cut and fill slopes are constructed to the cross sections as indicated on the plans, or as revised. Cut and fill slopes are finished to the degree ordinarily obtained by a grader blade. Slopes are required to be uniform without bulges and or dips. The length of transition for a slope change is required to be long enough to avoid the appearance of an abrupt change.
A slight roll back of the slope at the ends of a cut section is desirable for a more pleasing appearance. When finishing rock cuts, the rock face is carefully inspected for loose or overhanging rock that might fall on the roadway. All loose or overhanging material is required to be removed.

EARTH GRADED ROADS

Earth graded roads are required to be finish graded to a reasonably smooth, uniform grade to at least within +/- 0.1 ft of the required profile and cross section as indicated on the plans. Shaping and compacting is required to be conducted with approved equipment capable of providing a well drained, finished roadway.

FINAL TRIMMING AND CLEANING

Final trimming and cleaning consists of trimming and cleaning the otherwise completed highway between right-of-way lines for the entire contract length. At the time of acceptance of the contract, the following conditions are required for the entire length and right-of-way width of the contract.

1) All debris and rubbish removed and properly disposed of off of the right-of-way

2) All cut and fill slopes and any other areas that were disturbed left reasonably smooth and uniform

3) Any loose and overhanging rock removed

4) Weeds, brush, and stumps cut close to the ground and properly disposed of as directed

5) Waterways left unobstructed

6) Bridges cleaned of all rubbish, sand, stone, gravel, and dirt including the floors, roadways, railings, bottom chords, shoes, and seats

7) Culverts and other drainage structures left clean for their entire length
These provisions apply for all new construction contracts, including construction of pregrading contracts and paving contracts on pregraded contracts. For new construction of the second lane of a divided highway, the final trimming and cleaning requirement applies only to those areas of the right-of-way that were disturbed by the new construction. Unless otherwise specified for any contract built under traffic, the final trimming and cleaning provisions apply only to that portion of the right-of-way disturbed by the construction operations.

**MEASUREMENT AND PAYMENT**

Finishing shoulders, ditches, slopes, earth graded roads, and final trimming and cleaning is not measured for payment unless otherwise provided. The cost of these items is included in the various pay items of the contract.
B Borrow Fill and Backfill

Materials

Flowable Backfill Substitution

Construction Requirements

Mechanical Compaction

Embankment for Bridges

B Borrow Around Bents

Aggregate for End Bent Backfill

Unbalanced Backfill

Spandrell Filling

Method of Measurement

Basis of Payment

Flowable Backfill

Proportioning

Flow
Average Penetration Resistance

Mixing Equipment

Placement

Limitation of Operations

Method of Measurement

Basis of Payment
CHAPTER NINE:  
SPECIAL FILL AND BACKFILL

Special backfills play an important role in highway construction. Many times weak subgrades require special backfill to correct problems. Special backfill may also be necessary to facilitate good compaction around structures, such as catch basins, manholes, pipes, or bridge end bents.

The Technician is required to have a good knowledge of how special backfill is used for best highway performance. This chapter discusses materials, compaction, placement, and measurement of special fill and backfill.

B BORROW AND STRUCTURE BACKFILL

Placing B Borrow and structure backfill consists of backfilling excavated or displaced peat deposits; filling up to designated elevations of spaces excavated for structures and not occupied by permanent work; constructing bridge approach embankment; and filling over structures and over arches between spandrel walls, all with special materials.

MATERIALS

B Borrow used for special filling is required to be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. Sand, gravel, crushed stone, air cooled blast furnace slag, granulated blast furnace slag, or other approved materials are used for B Borrow. The material is required to contain no more than 10% passing the No. 200 sieve and be otherwise suitably graded. The use of an essentially one-size material is not allowed, unless approved.

The Contractor has the option of either providing B borrow or structure backfill from a CAPP source or supplying the material from another source. The Contractor has the following options for supplying B borrow or structure backfill from a local site:

1) The establishment of a CAPP Producer Yard at the local site in accordance with 917; or
2) Use a CAPP Certified Aggregate Technician or a Consultant on the Department's list of approved Geotechnical Consultants for gradation control testing.
The frequency of gradation control testing is required to be one test per 2000 t based on production samples into a stockpile or by over the scales measurement, with a minimum of two tests per contract (one in the beginning and one near the mid-point). The sampling and testing of these materials is required to be in accordance with the applicable requirements of Section 904 for fine and coarse aggregates. The Contractor is required to indicate in writing the plan to measure the material to the PE/PS and the District Testing Engineer.

**FLOWABLE BACKFILL SUBSTITUTION**

When B borrow for structure backfill is specified, the Contractor may substitute flowable backfill in accordance with Section 213. However, flowable backfill is not allowed to be placed into or through standing water, unless approved in writing.

**CONSTRUCTION REQUIREMENTS**

If B borrow or structure backfill is obtained from borrow pits, the locations, depths, drainage, and final finish of the pits are required to comply with the provisions for these items in accordance with Section 203.

If B Borrow or structure backfill is within embankment limits and if the entire fill or backfill is not required to be of B borrow and placed as such, then that portion above free-water level is required to be placed in accordance with applicable provisions of Section 203 and compacted to the required density.

If borrow is required outside the specified limits of B borrow, material in accordance with the Specifications for B borrow may be furnished at the contract unit price for borrow; however, the quantity of borrow measured for payment outside the limits of structure backfill may not exceed the theoretical quantity of B borrow furnished.

Unless otherwise specified, all spaces excavated for and not occupied by bridge abutments and piers, if within embankment limits, are required to be backfilled to the original ground line with B borrow and placed in accordance with Section 211.04.

Where B borrow or structure backfill is required as backfill at culverts, retaining walls, sewers, manholes, catch basins, and other miscellaneous structures, the material is required to be compacted in accordance with Section 211.04.
MECHANICAL COMPACTION

Where B borrow or structure backfill is placed by mechanical compaction, the material, unless otherwise specified, is required to be placed in accordance with the applicable provisions of Section 203.23. If mechanical tamps or vibrators are used, the material is required to be deposited in approximately 6 in. horizontal layers, loose measurement, and each layer compacted to density requirements.

EMBANKMENT FOR BRIDGES

When special filling is required, the embankment for bridges are constructed using B borrow within the specified limits shown on the plans. All embankment construction details specifically set out in this Specification for embankment for bridges are required to be in accordance with the applicable requirements of Section 203.

At the time B borrow is being placed for approach embankment, an earth, watertight, well-compacted dam is required to be constructed in level lifts, the details of which are shown on the plans. Except as hereinafter specified for material to be used in constructing the enclosing dam, and for growing vegetation, and unless otherwise provided, the material for constructing bridge approach embankment is required to be B borrow compacted by mechanical methods. If approach embankment or shoulders are constructed of material not suitable for growing seed or sod, then such areas are required, unless otherwise specified, to be covered with a layer of clay, loam, or other approved material which is suitable. This layer is required to be approximately 1 ft thick after being compacted into place.

B BORROW AROUND BENTS

When specified, B borrow is required to be placed around all bents falling within the limits of the approach grade as shown on the plans. Before placing, the surface of the ground on which the material is placed is scarified or plowed. The embankment slope is required to be 2:1 on the sides and beneath the structure and 6:1 from the end of the bridge down to the average ground line, or may be required to complete the approaches back to the existing grade. The enclosing dam and provisions for growing vegetation are required to be in accordance with Section 211.05.
When specified, coarse aggregate in accordance with Section 211.07 is placed behind the end bents as indicated on the plans. The material is required to be deposited in lifts not to exceed 12 in. loose measurement. Each layer is mechanically compacted with two passes using a hand held vibratory plate compactor having a plate width of 17 in. or larger that delivers 3000 to 9000 lb per blow.

Prior to placing the aggregate, a geotextile in accordance with Section 918.03 is required to be installed in accordance with Section 616.11.
**UNBALANCED BACKFILL**

Unbalanced backfill is not allowed until the concrete required to resist the backfill is at least 10 days old or a flexural strength of 440 lb/in\(^2\) for third point loading has been attained. The unbalanced height may not exceed 10 ft until the concrete is at least 15 days old or a flexural strength of 480 lb/in\(^2\) for third point loading has been attained.

**SPANDRELL FILLING**

Unless otherwise specified, spandrel fills for arch structures are required to be composed of B borrow. The fill is carried up symmetrically in horizontal layers from haunch to crown and simultaneously over all piers, abutments, and arch rings. Compaction is required to be in accordance with Section 211.04.

**METHOD OF MEASUREMENT**

B borrow, structure backfill, and aggregate for end bent backfill is measured by the cubic yard as computed from the neat line limits indicated on the plans, or as adjusted. If cubic yards are set out as the pay unit for B borrow or structure backfill in the Schedule of Pay Items and if neat line limits are not specified for measurement of volume for the material, measurement is made by the cubic yard at the loading point in truck beds which have been measured, stenciled, and approved. The B borrow may be weighed and converted to cubic yards by assuming the weight per cubic foot to be 90% of the standard maximum wet density determined in accordance with AASHTO T 99. The material may be cross-sectioned in the original position and again after excavation is complete, and the volume computed by the average end area method. If B borrow is used for backfill in areas where unsuitable material is present or peat excavation has been conducted, the B borrow is cross-sectioned and the volume is computed by the average end area method.

If the material is to be paid for by the ton, the material is weighed in accordance with Section 109.01 (b).

If the material is obtained from a wet source such as below water or a washing plant and weighing is the method of measurement, there is required to be a 12 h drainage period prior to the weighing.
Geotextiles are required to be measured in accordance with Section 616.12.

**BASIS OF PAYMENT**

The accepted quantities of B borrow are paid for at the contract unit price per cubic yard or per ton as specified, complete in place.
Structure backfill is paid for at the contract unit price per cubic yard, based on the neat line limits indicated on the plans or as adjusted for authorized changes, provided the material is obtained from outside the permanent right-of-way. If the schedule of pay items does not contain a pay item for structure backfill and this material is required to backfill pipes or culverts within the contract limits, a change order is generated to establish a unit price.

B borrow material placed outside the neat lines is paid for as borrow when such B borrow eliminates required borrow material. Otherwise, no payment is made for backfill material placed outside the neat lines.

If material which is in accordance with the requirements for B borrow is obtained within the excavation limits of the contract and is used as such, this material is paid for at $5.00/yd$^3$ for B borrow/structural backfill handling. No further payment is made.

Aggregate for end bent backfill is paid for at the contract unit price per cubic yard, based on the neat line limits indicated on the plans or as adjusted by authorized changes.

Geotextiles are paid for in accordance with Section 616.13.

Flowable mortar, which is substituted for B borrow or structure backfill, is paid for as B borrow or structure backfill, respectively.

If topsoil, loam, or other suitable material in accordance with Section 211.05 is used for expediting the growth of seed or sod, this material is paid for at the contract unit price per cubic yard for borrow, or for salvaged stockpiled selected materials as shown on the Schedule of Pay Items, unless otherwise provided.

**FLOWABLE BACKFILL**

Flowable backfill is used to fill trenches for pipe structures, culverts, utility cuts and other work extending under pavement locations, to fill cavities beneath slopewalls and other locations in accordance with Section 105.03.

If fly ash is used as a filler and not as a pozzolanic material, this material is required to be in accordance with the applicable requirements of Section 904.
The Contractor is required to submit a mix design and arrange for a trial batch demonstration to ensure compliance in accordance with the requirements listed herein. The mix design includes a list of all ingredients, the source of all materials, the gradation of all aggregates, the names of all admixtures and dosage rates, and the batch weights. Except
for adjustments to compensate for routine moisture fluctuations, mix design changes after the trial batch verification are required to be documented and justified prior to implementation by the Contractor. A change in the source of materials or addition or deletion of admixtures or cementitious materials requires a new mix design.

Only the materials listed in Section 213.02 may be used in the flowable backfill mix designs. The proposed mix design materials and proportions are submitted to the District Testing Engineer. Final proportioning is determined based on the approved mix design.

FLOW

The test (ASTM D 6103) for flow consists of filling a 3 in. diameter by 6 in. high open-ended cylinder placed on a smooth level surface to the top with the flowable backfill. If necessary, the cylinder is struck off so that the mixture is level. The cylinder is pulled straight up within 5s. The spread of the material is then measured. The diameter of the spread is required to be at least 8 in. Flow adjustments may be made by making minor adjustments in the water or fly ash filler content in the mixture.

AVERAGE PENETRATION RESISTANCE

The Contractor is required to determine the penetration resistance of the flowable backfill during the trial batch in accordance with ITM 213 at one, three, seven, and fourteen days.

MIXING EQUIPMENT

The mixing equipment is required to be in accordance with the applicable requirements of Section 702 or Section 722, except that instead of the calibration requirements of Section 722.11, the mixer operator is required to make delivery in a properly calibrated continuous mixer.

PLACEMENT

The mixture is discharged from the mixing equipment by a reasonable means into the spaces to be filled. The flowable backfill is brought up uniformly to the fill line as indicated on the plans or as directed. Placing of material over the flowable backfill may commence as specified herein or as directed.
Voids beneath a reinforced concrete bridge approach pavement are filled as directed. Holes are to be drilled at locations as directed and in accordance with Section 612.04. The flowable backfill is placed until the bridge approach pavement has uniform support by means of completely filling all voids. During the filling operation, plugs may be required. plugs are installed to confine the backfill as directed. The bridge approach pavement is required to not lift off the bridge seat.
LIMITATION OF OPERATIONS

Flowable backfill may not be placed on frozen ground and is required to be protected from freezing until the material has set.

The flowable backfill is not subject to any load nor disturbed by construction activities until the penetration resistance testing has been completed. Penetration resistance is determined in accordance with ITM 213.

METHOD OF MEASUREMENT

Flowable backfill is measured by the cubic yard as computed from the neat line limits shown on the plans, or as adjusted. If neat line limits are not shown on the plans, the volume in cubic yards of flowable backfill furnished and placed is computed from the nominal volume of each batch and a count of the batches. Unused and wasted flowable backfill is estimated and deducted. Drilled holes are measured by the number of holes drilled.

BASIS OF PAYMENT

The accepted quantities of flowable backfill are paid for at the contract unit price per cubic yard furnished and placed.

Filling voids beneath a concrete bridge approach pavement is paid for at the contract unit price per cubic yard for flowable backfill. Holes drilled in the pavement are paid for at the contract unit price per cubic yard.
10 Aggregate Bases

Aggregate Base

Preparation of Subgrade

Temperature Limitations

Spreading

Compacting

Checking and Correcting Base

 Priming

Method of Measurement

Basis of Payment

Subbase

Preparation of Subgrade

Temperature Limitations

Spreading

Compacting

Checking and Correcting Subbase

Method of Measurement
Basis of Payment

Aggregate Pavements or Shoulders

Preparation of Subgrade

Temperature Limitations

Spreading

Compacting

Checking and Correcting Base and Surface

Dust Palative

Method of Measurement

Basis of Payment
 CHAPTER TEN:  
AGGREGATE BASES

Uncoated aggregate bases are classified as compacted aggregate bases or subbases. In general, subbase has a small amount of material passing the No. 200 sieve making the material a well drained material. Compacted aggregate is more dense than subbase. Aggregate bases provide additional strength for pavement sections and allow less capillary rise of moisture from paving subgrades, making them less susceptible to "frost heave" and "pumping". The location, width, and depths of aggregate bases are found in the typical cross-section sheets of the plans.

AGGREGATE BASE

An aggregate base is a dense-graded compacted aggregate that is normally placed on a prepared subgrade in accordance with Section 105.03.

Materials used for aggregate bases are required to be size No. 53, Class D or Higher in accordance with Section 904.

PREPARATION OF SUBGRADE

Subgrade is required to be compacted in accordance with Section 207.04. In areas of 500 ft or less in length, or for temporary runarounds, proofrolling is not required. Proofrolling is also not required in trench sections where proofrolling equipment cannot be used.

TEMPERATURE LIMITATIONS
Aggregate is not placed when the air temperature is less than 35° F or on a frozen subgrade. Frozen aggregates may not be used.

**SPREADING**

The aggregate is required to be spread in uniform lifts with a spreading and leveling device approved by the PE/PS. The spreading and leveling device is required to be capable of placing aggregate to the depth, width, and slope specified. The compacted depth of each lift is required to be a minimum of 3 in. and a maximum of 6 in. The aggregate is handled and transported to minimize segregation and the loss of moisture. In areas inaccessible to mechanical equipment, approved hand spreading methods may be used.
COMPACTING

Aggregates are required to be compacted according to the current specifications. Compaction is tested using a Light Weight Deflectometer. The aggregate is required to meet the compaction requirements at the time subsequent courses are placed. In areas inaccessible to compaction equipment, such as private drives, mailbox approaches, and temporary runarounds, the compaction requirements may be accepted by visual inspection. All displacement or rutting of the aggregate is repaired prior to placing subsequent material.

CHECKING AND CORRECTING BASE

The top of each aggregate course is checked transversely to the cross section and all deviations in excess of 1/2 in. are corrected. If additional aggregate is required, the course is remixed and re-compacted.

PRIMING

A prime coat, when required, is required to be in accordance with Section 405.

METHOD OF MEASUREMENT

Compacted aggregate base is measured by the ton in accordance with Section 109.01(b).

BASIS OF PAYMENT

The accepted quantities of compacted aggregate base are paid for at the contract unit price per ton, complete in place. The cost of placing, compacting, water, and necessary incidentals is included in the costs of the pay item. Payment is not made for material placed outside of a one to one slope from the
planned typical section. Replacement of pavement damaged by the Contractor's operations is done at no additional payment. If the aggregate is placed as a subgrade treatment it is not paid as aggregate but the cost is paid as subgrade treatment.

**SUBBASE**

Subbase is a foundation course of selected materials, placed and compacted on a prepared subgrade in accordance with Section 105.03.

Subbase for PCCP consists of 3 in. of coarse aggregate No. 8 as the aggregate drainage layer placed over a 6 in. coarse aggregate No. 53 as the separation layer. Dense graded subbase consists of a 6 in. of coarse aggregate No. 53.
Coarse aggregate No. 8 used as an aggregate drainage layer is required to consist of 100 % crushed stone or air cooled blast furnace slag and meet the requirements of Section 904.

**PREPARATION OF SUBGRADE**

Subgrade is required to be prepared in accordance with Section 207.

**TEMPERATURE LIMITATIONS**

Aggregate may not be placed when the air temperature is less than 35° F or on a frozen subgrade. Frozen aggregates may not be used.

**SPREADING**

The aggregate is required to be spread in uniform lifts with a spreading and leveling device approved by the PE/PS. The spreading and leveling device is required to be capable of placing aggregate to the depth, width, and slope specified. The compacted depth of each lift is a minimum of 3 in. and a maximum of 6 in. The aggregate is handled and transported to minimize segregation and the loss of moisture. In areas inaccessible to mechanical equipment, approved hand spreading methods may be used.

**COMPACTING**

Subbases are required to be compacted as follows:

1) Aggregate Separation Layers and Dense Graded Subbase. Compaction is required to be in accordance with Section 301.06.
2) Aggregate Drainage Layers. Compaction consists of two passes with a vibratory roller before trimming, and one pass with the same roller in static mode after trimming. A vibratory roller is required to be equipped with a variable amplitude system, a speed control device, and have a minimum vibration frequency of 1000 vibrations per min. A roller in accordance with Section 409.03(d)4 may be used.

All displacement or rutting of the aggregate drainage layers is required to be repaired prior to placing subsequent material.

In areas inaccessible to standard size compacting equipment, a specialty roller/compactor in accordance with Section 409.03(d) 6 may be used.
CHECKING AND CORRECTING SUBBASE

The top of each aggregate course is checked transversely, and all deviations in excess of 1/2 in. are corrected. If additional aggregate is required, the course is remixed and re-compacted.

METHOD OF MEASUREMENT

Subbase for PCCP or dense graded subbase is measured by the cubic yard based on the theoretical volume to the neat lines as indicated on the plans. The quantity indicated in the Schedule of Pay Items is adjusted if the quantity is different by more than 2 % of the measured quantity.

BASIS OF PAYMENT

The accepted quantities of subbase for PCCP or dense graded subbase are paid for at the contract price per cubic yard, complete in place. The cost of compacting, water, aggregates placed outside neat lines as indicated on the plans, and necessary incidentals is included in the cost of the subbase.

AGGREGATE PAVEMENTS OR SHOULDERS

Aggregate pavements or shoulder require a dense-graded compacted aggregate which is placed on a prepared subgrade in accordance with Section 105.03.

Materials for this use are required to be No. 53 or No. 73 in accordance with Section 904.

PREPARATION OF SUBGRADE
Subgrade is required to be compacted in accordance with Section 207.04. In areas of 500 ft or less in length, or for temporary runarounds, proofrolling is not required. Proofrolling is also not required in trench sections where proofrolling equipment cannot be used.

**TEMPERATURE LIMITATIONS**

Aggregate is not placed when the air temperature is less than 35° F or on a frozen subgrade. Frozen aggregates may not be used.

**SPREADING**

The aggregate is required to be spread in uniform lifts with a spreading and leveling device approved by the PE/PS. The spreading and leveling device is required to be capable of placing aggregate to the depth, width, and slope specified. The compacted depth of each lift is a minimum of 3 in. and a maximum of 6 in. The aggregate is handled and transported to
minimize segregation and the loss of moisture. In areas inaccessible to mechanical equipment, approved hand spreading methods may be used.

**COMPACTING**

Aggregates are required to be compacted according to the current specifications. Compaction is tested using a Light Weight Deflectometer. The aggregate is required to meet the compaction requirements at the time subsequent courses are placed. In areas inaccessible to compaction equipment, such as private drives, mailbox approaches, and temporary runarounds, the compaction requirements may be accepted by visual inspection. All displacement or rutting of the compacted aggregate is repaired prior to placing subsequent material.

**CHECKING AND CORRECTING BASE AND SURFACE**

The top of each aggregate course is checked transversely and all deviations in excess of 1/2 in. are corrected. If additional aggregate is required, the course is remixed and re-compacted.

**DUST PALATIVE**

A dust palative, if required, is required to be in accordance with Section 407.

**METHOD OF MEASUREMENT**

Compacted aggregate is measured by the ton in accordance with Section 109.01(b) for the type specified.
The accepted quantities of compacted aggregate are paid for at the contract unit price per ton, for the type specified, complete in place. The cost of placing, compacting, water, and necessary incidentals is included in the costs of the compacted aggregate. Payment is not made for material placed outside of a one to one slope from the planned typical section. Replacement or repair of pavement or shoulders damaged by the Contractor's operations does not require additional payment.
11 Light Weight Deflectometer

Overview

Using the Light Weight Deflectometer
CHAPTER ELEVEN:

LIGHT WEIGHT DEFLECTOMETER

OVERVIEW

Acceptance of the compaction of aggregate bases is determined by testing with a Light Weight Deflectometer, LWD. The LWD is used to determine the surface deflection resulting from an application of an impulse load. The resulting deflections are used to determine the stiffness of granular materials placed in embankments and aggregate subgrades.

The test procedure is described in ITM 508. The contractor is required to keep the moisture content within -3 and -1 percentage points of the optimum moisture content determined in accordance with AASHTO T 99 Method C. The district testing lab determines the compaction criteria from samples submitted to the lab. The lab results will include, optimum moisture, maximum density, and gradation in accordance with AASHTO T 99 Method C, T11, and T 27 respectively. The minimum deflection required will be determined based on a test section for each material type. Test sections are constructed in the presence of the Engineer and determine the roller type, pattern, and number of passes required to obtain the minimum required deflection.

Prior to construction of the test area, the subgrade should be proof rolled in accordance with 203.26. See the contract documents for detailed instructions on the test strip.

Once production starts the contractor will need to keep the moisture content within -3 and -1 percentage points of the optimum moisture content.
USING THE LIGHT WEIGHT DEFLECTOMETER

Instructions for using an LWD are found in ITM No. 508.
In general the LWD test proceeds as follows:

1. The test area shall be leveled so that the entire undersurface of the load plate is in contact with the material being tested.
2. Any loose and protruding material should be removed. If required, any unevenness should be filled with fine sand.
3. The test should not be conducted if the temperature is below freezing.
4. The test area should be at least 1.5 times larger than the loading plate.
5. The loading plate should be seated in place by rotating it back and forth through about 45 degrees.
6. Hold the guide rod plumb.

The control box is not shown in this illustration.

(1) grip  
(2) top fix and release mechanism  
(3) guide rod  
(4) 10 kg - falling weight  
(5) lock pin  
(6) set of steel springs  
(7) loading plate diameter (300 mm)
7. Lift the weight to the release mechanism. Release the weight and catch it when it rebounds after striking the loading plate. Repeat this step 3 times to seat the plate.
8. Turn on the control box and press start.
9. The test will require 3 drops as prompted by the control box. Record the data for each drop in mm. The test is considered invalid if you fail to catch the rebounding weight or the plate moves laterally. If that happens, move the plate at least 2 feet away and repeat the full test sequence.
10. If the results vary by more than 10% for 2 consecutive drops the area will need additional compaction or additional drying. This will need to be done by the contractor and the location retested.
11. The results should be recorded on the test form. Also, copy the results to the data card in the control box.
12. Calculate the average deflection of the 3 drops.
13. The average deflection will be recorded in mm.
Overview
Components
Use of the DCP
CHAPTER TWELVE:

DYNAMIC CONE PENETROMETER

OVERVIEW

The compaction of a cohesive soil is accepted based on strength of the soil as measured by a Dynamic Cone Penetrometer, DCP. The test is conducted in accordance with ASTM D 6951, using the 17.6 pound hammer. Currently the requirements for use of the DCP are in RSP 203-R-562. During the compaction of the fill and testing the moisture content is required to be within -3 and +2 percentage points of the optimum moisture content as determined by the district lab.

The Department will establish the criteria for DCP acceptance of the compaction by performing the sieve analysis, liquid limit, plastic limit, and optimum moisture and maximum density testing in accordance with AASHTO T 88, T 89, T 90, and T 99, respectively, on representative samples of the soils to be used. The required blow counts is determined based on the laboratory tests for each soil type.

Test sections are constructed in the presence of a Geotechnical representative using the equipment the Contractor intends to use for compaction. The test section will determine the roller type, pattern, and the number of passes to verify the blow counts for the 6 in. lift. The Office of Geotechnical Services should be contacted prior to construction of the test sections to determine the number of test sections required for the evaluation of the DCP process. The test section site should be chosen at a location where at least 2 lifts are to be constructed. The test section in the second lift should be approximately in the same location as the test section in the first lift. The soil immediately below the test section in the first lift needs to be proof rolled in accordance with 203.26 prior to construction of the lift. Moisture tests will be performed in accordance with ITM 506 at 2 random locations and DCP testing will be performed at 4 random locations in each lift. The locations will be determined in accordance with ITM 802. The moisture content during compaction and testing should be held to within -3 and +2 percentage points of the optimum moisture content. Blow counts greater than 10 or less than 4 are
reason to choose a new random test location. If all of the test section blow counts are outside of the range of 10 to 4, the Office of Geotechnical Services should be contacted.

COMPONENTS

The DCP consists of the following components:
The DCP showing the disposable tip. OMM recommends using the disposable tips to reduce damage to the DCP with it is removed from the embankment after the test is taken. Additional tips are available from the district office or OMM.
Since the DCP test procedure counts the blows required for a given penetration, the easiest way to do this is by monitoring the depth with a series of marks along the stem of the DCP.
USE OF THE DCP

1. The DCP is held vertical by the handle.
2. The weight is lifted to the top of the DCP and cleanly dropped.
3. The number of blows required for a given penetration is the test result.

Care should be taken not to bump the handle too hard and displace the disposable tip from the bottom of the stem.
A few things to remember when performing the DCP test:

- Representative samples of the soil from the jobsite or borrow pit needs to be taken and submitted to the district for sieve analysis and determination liquid limit, plastic limit, optimum moisture content and maximum density. You will also get a target blow count.
- If the DCP is bouncing and does not appear to be penetrating, the point may be bearing on a rock. If necessary move to a nearby location and conduct another test.
- For most tests the disposable cone points are recommended. The disposable cones cause less wear and tear on the DCP when it is being removed from the ground.
- If necessary a 1-Point Proctor can be performed to determine the optimum moisture content if soil conditions change.
13 Family of Curves and One-Point Proctor Procedures

Maximum Dry Density

Family of Curves

One-Point Proctor

Example Problem
CHAPTER THIRTEEN:

FAMILY OF CURVES AND THE ONE-POINT PROCTOR PROCEDURES

Highway embankments are composed of soil and/or aggregates placed in layers and compacted to an acceptable level. The purpose of a highway embankment is to provide adequate support of the overlying roadway and applied traffic loads. Section 203.23 discusses the methods of compaction control for embankment construction using most types of soils and aggregates. Section 215.09 addresses the maximum dry density and optimum moisture of chemically modified soils when the density option is used. Subgrade compaction with density and moisture control requires compaction to 100% of the maximum dry density. If the contractor chooses the density and moisture control option for subgrade treatment the District Testing Engineer will need to be consulted for the proper testing procedures for acceptance. Embankment compaction is accepted using the LWD and DCP rather than percentage of density. The family of curves and the one-point proctor procedure can be used for the determination of the optimum moisture content as well as the maximum density for a soil sample.

MAXIMUM DRY DENSITY

Maximum dry density refers to the soil or aggregate density as determined in accordance with AASHTO T 99. AASHTO T 99 sets forth a method of determining the density of a sample placed in layers in a certain size mold and compacted with a specified weight dropped from a specified height. The process is repeated on the same sample at various moisture contents. The resultant points are plotted on a chart of moisture content versus density. The maximum dry density and optimum moisture are found at the peak of the curve formed by joining the points.
FAMILY OF CURVES

Repeating the compaction process for several different types of cohesive soils yields graphs (i.e. curves) of similar shape and geometry. These similar graphs plotted on one sheet are called the Family of Curves (see AASHTO T 272). A copy of the INDOT developed Family of Curves is kept on file in each District Testing Department. The Family of Curves may be used to estimate the maximum dry density and optimum moisture content of a cohesive soil sample in the field. AASHTO T 99 is used to determine the values in a laboratory process.
Each layer of soil is required to be tested for compaction using either the LWD or DCP depending on the soil type, and moisture during embankment construction. In preparation for testing the soil, samples are taken from the job-site cut areas or from proposed "borrow areas". By carefully observing the soil layers or horizons in a cut, the Technician may obtain samples of each soil type and submit those samples to District Testing. The samples are processed in accordance with AASHTO T 99 and the maximum dry density and optimum moisture content of each sample is reported to the project in the form of a lab report.

The testing process works well if the embankment is constructed from just one soil type in each lift of embankment. However, the normal process is not nearly as well defined. Each embankment layer being placed may contain different portions of two or more types of the soils as sampled. Which optimum moisture content that is most representative of that specific lift of embankment may be difficult to determine.

ONE-POINT PROCTOR

If the soil is cohesive in nature, the INDOT Family of Curves may be used. After the Technician has conducted a DCP test to determine the in place compaction of an embankment layer, a representative sample of soil, approximately 7 pounds, is removed from the area around the test site. The maximum dry density and optimum moisture of the soil sample is determined using the one point proctor method, AASHTO T 272 Method A. The process involved is similar to that required in AASHTO T 99. The moisture of the sample is determined in accordance with ITM 506. The resulting wet density and actual field moisture content are plotted on the Family of Curves to determine which curve fits the point as plotted. The curve number is recorded and the data from the box in the upper right corner of the chart is used for maximum dry density and optimum moisture content.

The following example illustrates the use of the INDOT Family of Curves to select a maximum dry density and optimum moisture content for a density test.
EXAMPLE PROBLEM

A sample of the soil is obtained from the area immediately surrounding the DCP test site. The sample size is required to exceed 7 pounds. A minimum of 2.2 pounds is required for the moisture test in accordance with ITM 506 and approximately 4 to 5 pounds is necessary to produce the molded soil sample for the one-point proctor. This sample need not be protected from drying.

From the one-point proctor test, the following information was obtained.

A. Weight of prepared sample in the mold          9.60 lb

B. Weight of the one-point mold                   5.40 lb

C. Net weight of Soil (A-B)                      4.20 lb

D. C x 30 = Weight of one cubic foot             126.00 lb

E. ITM 506 moisture content                      16.6 %

By plotting 126.0 lb/ft$^3$ on the vertical axis of the chart and 16.6 % on the horizontal axis, Curve 6 is selected (Figure 3-1). The box on the upper right hand side of the chart lists the maximum dry density of Curve 6 as 108.3 lb/ft$^3$ at an optimum moisture content of 16.8 %. These values then become the target dry density and moisture content for the soil mixture being tested.
As previously mentioned, RSP 203-R-562 requires that the moisture content during compaction be within -2% and +3% of the optimum moisture content.

The points plotted on the Family of Curves do not always plot directly onto one curve. For example, if the one point proctor revealed a wet density of 131.0 lb/ft³ and the moisture content results was 14.0 %, plotting this pair of points on the chart would locate a point between Curve 9 and Curve 10. For this situation, the average of the curve data may be obtained to select the maximum dry density and optimum moisture content. For these values, the dry density target would be 115.4 lb/ft³ and the optimum moisture target would be 13.7 %, the average of the data from the two curves.

The moisture content used to plot on the Family of Curves is required to be between the optimum moisture and minus two percent of optimum moisture. If the plotted points fall outside of these limits, water may be added to the sample or the sample may be dried to allow the moisture to fall within the prescribed limits. The soil sample would then be recompacted in the one-point mold and a new wet density calculated and moisture obtained.
## Typical Moisture Density Curves

**Division of Materials & Tests**  
**Indiana Department of Transportation**

<table>
<thead>
<tr>
<th>Curve No.</th>
<th>MAX. Dry Dens. (lbs. per cu. ft)</th>
<th>Optimum Moisture</th>
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<td>8.3</td>
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</table>

**Wet Density - Pounds per Cubic Foot**

**Moisture Content - Percent of Dry Weight**
Figure 3-1. Typical Moisture Density C