Grading Field Inspection

TECHNICAL TRAINING & CERTIFICATION PROGRAM

2024 Edition

IOWA DOT

SMARTER | SIMPLER | CUSTOMER DRIVEN

TABLE OF CONTENTS

INTRODUCTION

I. Introduction

Grading work is the foundation building project for the highway. This foundation is usually built only once. Hence, it is very important to build it properly. The foundation must be strong enough to assure that (1) the pavement will perform; (2) the highway can carry a certain number of traffic loads; (3) the unnecessary cost and construction delay due to failure are minimized. Just as when a person is building a dream home, he or she does not want to see a tilted floor and cracks all over the walls. It is certainly not desirable to have too many bumps and cracks on the highways. Unfortunately, the soils formation is seldom uniform. There are many different layers and kinds of soil a person would have to deal with during a grading project. One may have to ask many questions during a grading project:

- How can a person recognize what soil he or she is dealing with?
- Why do these soils have different colors but are still the same classification?
- Where should a certain soil be used -- under the mainline or should it be out on the slope?
- Should a sheepsfoot roller be used to compact this soil?
- How can a person tell if adequate compaction is achieved or over-compaction has happened?

Course & Manual Objectives

An inspector may have many questions in regard to the earthwork. There is nothing wrong with asking questions. There is only one “stupid” question, which is the one that could not be answered because it was never asked. The intent of the training is to provide the inspector (1) a chance to ask questions; (2) a chance to learn, understand, and be ready; (3) an opportunity to make work more enjoyable. Please do not hesitate to express concerns or comments.

This training manual has been prepared to provide guidance and instruction to inspectors involved in grading construction. The important tasks involved in this work are explained and proper procedures are described. The material is targeted for those who have not had experience in grading construction.

The Soils Certification class is also available through the Iowa Department of Transportation that will provide more information on the moisture-density relationship of soil and the Standard Proctor Test.

This manual is intended for use in any of three ways:

- a text for a training class
- a self-training manual
- a reference to be used in the field

The manual is intended to help the inspector learn the various aspects of what is involved in grading operations and also to become familiar with the duties that are a part of the grading inspection responsibility.

At the beginning of each section, references (when applicable) are given to:

- Iowa Department of Transportation Standard Specification with the Specification Article listed
- Materials Instructional Memorandums (I.M.)
- Standard Road Plans
- Construction Manual Chapters

These references will enable the inspector to refer to those documents for more detailed information.

Most of the actual documents are not included in this material because they are continually being updated. Different versions may be applicable to different projects being constructed in the same construction season. The project letting date will determine which Specification Article, I.M., Standard Road Plan, or Construction Manual Chapter is applicable.

Inspection worksheets available online at:
https://iowadot.gov/construction_materials/Inspection-tool

Specifications, Materials IMs, Road Standards, and Construction Manual available online at:
http://www.iowadot.gov/erl/index.html

Iowa DOT standard forms available online at:

https://iowadot.seamlessdocs.com/sc/

SOILS INFO

II. Soils

In order to achieve a quality embankment, it is very important to understand the soils behavior and their best uses for the project. There is a lot of preliminary work before the grading project actually starts. Soil boring and testing are the typical requirements. This section will provide some information on the soil classification, behavior, and compaction.

A. Soils Classifications

There are several systems of soil classification. In order to simplify this training, only three systems the Iowa DOT uses will be presented: the American Association of State Highway and Transportation Officials (AASHTO), the U.S. Department of Agriculture (USDA) textural, and the Unified classifications. The Iowa DOT material requirements will also be discussed.

Table 2-1: Soil classification systems used at the Iowa DOT.

Soil Classification System	Example	What is it used for?
AASHTO	"A-7-6(15)"	DOT Mainline Profiles and DOT Borrows
USDA Textural	"Clay Loam"	DOT Mainline Profiles and DOT Borrows
Unified	"CL" and "Sandy Clay"	Bridge Soundings

1. AASHTO Classification

This system requires information on sieve analysis, liquid limit, and plasticity index. Before a soil can be classified, these properties must be determined first. Figure 2-1 shows the AASHTO classifications.

Soil particle sizes and particle size distribution (percentage of gravel, sand, silt, and clay) of a soil sample can be measured in a laboratory and can also be estimated in the field. Laboratory methods used to determine particle size distribution of a soil sample include sieves and a hydrometer.

A mechanical sieve analysis is used for the sand and gravel fractions (Figure 2-2).

A hydrometer is used for the finer particles in which the settling velocity of the particles (spheres) in liquid is determined by distance of the hydrometer in the liquid and time. Particles with larger diameters will settle more quickly than those with smaller ones.

TABLE 1 Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

General Classification	Granular Materials (35% or less passing No. 200)							Silt-Clay Materials (More than 35% passing No. 200)			
	A-1			A-2							A-7
											A-7-5
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-6
Sieve analysis, percent passing:											
No. 10	50 max.										
No. 40	30 max.	50 max.	51 min.								
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit				40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*Classification procedure: With required test data available, proceed from left to right on above chart and correct group will be found by the process of elimination. The first group from the left into which the test data will fit is the correct classification.

*Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30 (see Fig. 14.1).

Figure 2-1: AASHTO Classification Table

From this settling velocity, the particle diameter is calculated. Please see Figure 2-3.

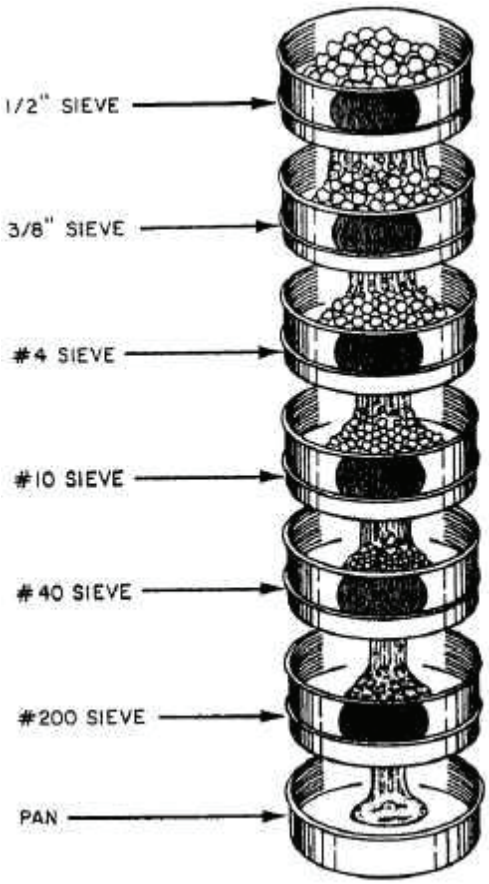


Figure 2-2: Sieves used in sieve analysis to determine gradation of soil

Figure 2-3: Hydrometer used to determine gradation of particles passing No. 200 sieve

Definitions:

- Gravel: Material passing sieve with 3-in square openings and retained on the No. 10 sieve.
- Coarse sand: Material passing the No. 10 sieve and retained on the No. 40 sieve.
- Fine sand: Material passing the No. 40 sieve and retained on the No. 200 sieve.
- Silt-clay: Material passing No. 200 sieve.

The different types of soil, their characteristics, size, and identifying information are shown in Table 2-2.

The relative sizes of coarse sand, coarse silt, and clay is illustrated in Figure 2-4.

Table 2-2 summarizes the characteristics and size of each of the soil mineral matter types, and includes information on how to identify each type.

Mineral Matter	Characteristics	Size	Identifying
Clay	Individual clay particles are not visible; plate-like; resembles pieces of paper; stacks like deck of cards; can be expansive (shrink/swell); high dry strength; low strength when wet	<0.002 mm	• When dry: hard, cannot brush or dust off hands • When moist: extremely sticky with slight grittiness • When wet: very soft and sticky; can roll into ribbon; can mold into ball; shines when cut, if right moisture (very shiny surface)
Silt	Large silt particles can barely be seen with naked eye; small silt particles are not visible to the naked eye; lower dry strength (compared to clay) and much more difficult to roll into threads	0.002 mm to 0.074 mm	• When dry: fairly hard, but "brittle" • When moist: feels velvety • When wet: soft, but not sticky; feels smooth • When saturated: "Jello-like" or "Quivery" • Feels similar to talcum powder
Sand	Fine to coarse; Can see individual particles; good characteristics when confined, but generally will be mixed with silt and clay (this can be problematic); ruts from traffic loadings	0.074 mm to 2 mm	• Feels very gritty when moist
Gravel	Rounded to angular, hard, rock particle	>2 mm	
Boulders	Rounded to angular, hard, rock particle	>12 inches in diameter	

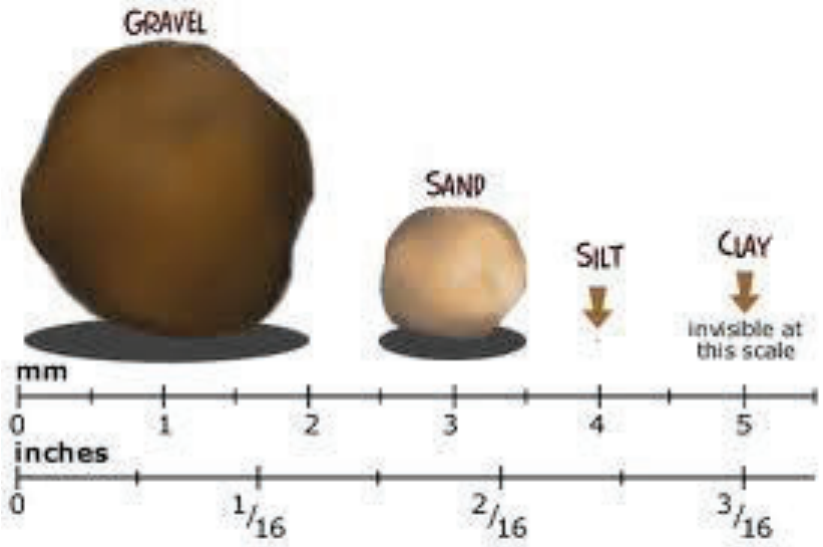


Figure 2-4: Relative particle sizes of gravel, sand, silt, and clay

Identifying sand, silt, and clay can be difficult. Below are several identification problems and proposed solutions (Coduto 1999):

- Problem: Clay and silt often clump together and can sometimes be mistaken for sand.
  Solution: Wet the soil. The clay and silt clumps will dissolve when wet. Sand will not.

- Problem: Clay and silt are usually mixed together. Fine sand can be easy to miss if mixed with silt and clay.
  Solution: Wet the soil and feel for grittiness.

- Problem: Cementing agents (e.g., calcium carbonate) are sometimes present in sandy or silty soils. In Iowa, cementing agents can be found in the loess, glacial, alluvial, and sand and gravel deposits. Cementing agents will give the soil a high dry strength, even in the absence of clay.
  Solution: Wet the soil. Cemented soils will retain dry strength, while clayey soils will soften.

Liquid Limit:

Liquid limit (LL) is the moisture content above which a soil readily becomes a liquid. In general, the higher the liquid limit, the more compressible the soil may be and the more volume changes may occur. To run this test, a small amount (250 grams) of soil passing the Number 40 sieve is mixed with water to a paste consistency. It is then placed in a round-bottomed brass cup and the surface is struck off with a spatula so that the maximum thickness is 10 mm. The soil is next divided into two segments by means of a grooving tool.

The cup is then raised and dropped onto a hard rubber block causing the divided soil to flow together. The moisture content at which it takes 25 blows to close the groove is the liquid limit. Please see Figure 2-5.

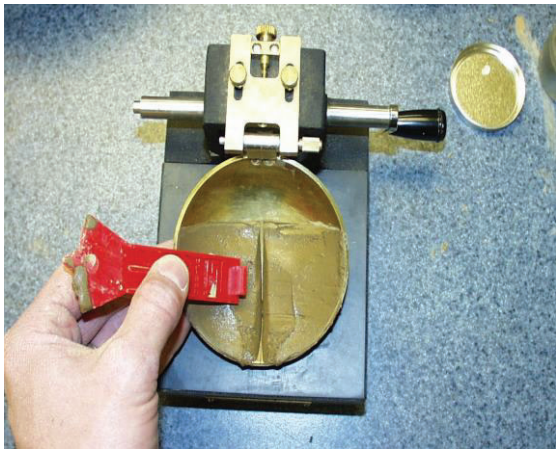


Figure 2-5: Liquid Limit test equipment

Plastic Limit:

In order to determine the plasticity index, the plastic limit (PL) must be obtained. Plastic limit is the minimum moisture content at which the soil acts as a plastic solid. To run this test, a small soil-water mixture (soil particles passing No. 40) is rolled out with the palm of the hand on a glass plate until a thread of soil is formed. When the thread is rolled to a diameter of ⅛ of an inch, it is balled up and rolled out again. The mixture gradually loses moisture in the process. Finally the sample dries out to an extent that it becomes brittle and will no longer hold together in a continuous thread. This moisture content is the plastic limit. See Figure 2-6.

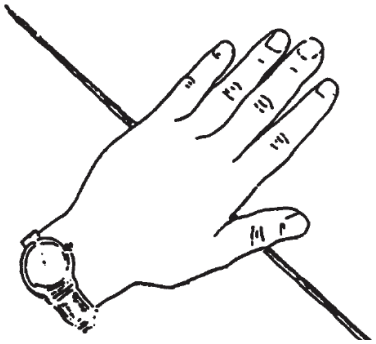


Figure 2-6: Test to determine plastic limit of soil.

Plasticity Index: Plasticity index (PI) is the numerical difference between the liquid limit and the plastic limit.

$$PI = LL - PL$$

The plasticity index is a measure of the cohesive property of the soil. In general, the higher the PI, the softer the soil tends to get in wet weather.

Based on the sieve analysis and the Atterberg Limit tests, soils are classified in groups from A-1 to A-7.

Group A-1: The typical material of this group is a well-graded mixture of stone fragments or gravel, coarse sand, fine sand, and a non plastic or slightly plastic soil binder.

Group A-2: This group includes a wide variety of granular materials which are at the borderline between materials falling in groups A-1 and A-3 and silt-clay materials of groups A-4 through A-7. This group contains the materials with 35 percent or less passing No. 200 sieve.

Group A-3: The typical material of this group is fine beach sand or fine desert blown sand without silty or clayey fine, or very small amount of nonplastic silt. The group also includes stream-deposited mixtures of poorly graded fine sand and limited amounts of coarse sand and gravel.

Group A-4: The typical material of this group is a nonplastic or moderately plastic silty soil having 75% or more passing the No. 200 sieve.

Group A-5: The typical material of this group is similar to that of group A-4except the liquid limit for this group is higher.

Group A-6: The typical material of this group is a plastic clay soil usually having 75percent or more passing the No. 200 sieve. This group also includes mixtures of fine clayey soils and up to 64% of sand and gravel retained on the No. 200 sieve. 19

Group A-7: The typical material of this group is similar to that of group A-6 except the liquid limit is higher.

The original classification had an A-8 group. This A-8 group is mainly a peat or muck soil. It is characterized by low density, high water content, high organic matter, and high compressibility. It is very unstable material.

The following equation is used to calculate the group index:

Group Index = GI = (F-35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10)

Where:

F: Percentage passing No. 200 sieve
LL: Liquid limit
PI: Plasticity index

When the group index determined by the 1991 method is 30 or higher, the soil is considered unsuitable. However, Soils Design may make project-specific exceptions to this general rule (typically raising it above 30). Thus, some Soils Design sheets may show soils with a GI above 30 that is still marked as suitable, and feasibly soils with a GI below that are marked unsuitable.

2. Textural Classification

Another classification that the IDOT uses is the USDA textural classification. The textural triangle is divided into 12 textural classes, and each class has a minimum and a maximum percentage of sand, silt, and clay. From this method, the soil will be described as loam, silty loam, clay loam, etc. These descriptions are frequently abbreviated on the soil sheets as L, S. L., C.L., etc.

Before classifying the soil, the soil gradation is first determined. From the gradation, different classes are defined. This method does not consider the gravel portion or content. Thus, the sand, silt, and clay contents are prorated so the sum is 100 percent. In addition, if the gravel content is 10% or more, the term “gravelly” will be put in front.

Example:

The gradation analysis shows the gravel, sand, silt, and clay contents are 4, 31, 44, and 21 respectively. What is the textural class of this soil?

Since the gravel content is not considered in this method, the sand, silt, and clay contents must be prorated. The prorated contents are:

Sand = 31 * (100/96) = 32%
Silt = 44 * (100/96) = 46%
Clay = 21 * (100/96) = 22%

Figure 2-7 gives the textural class as loam.

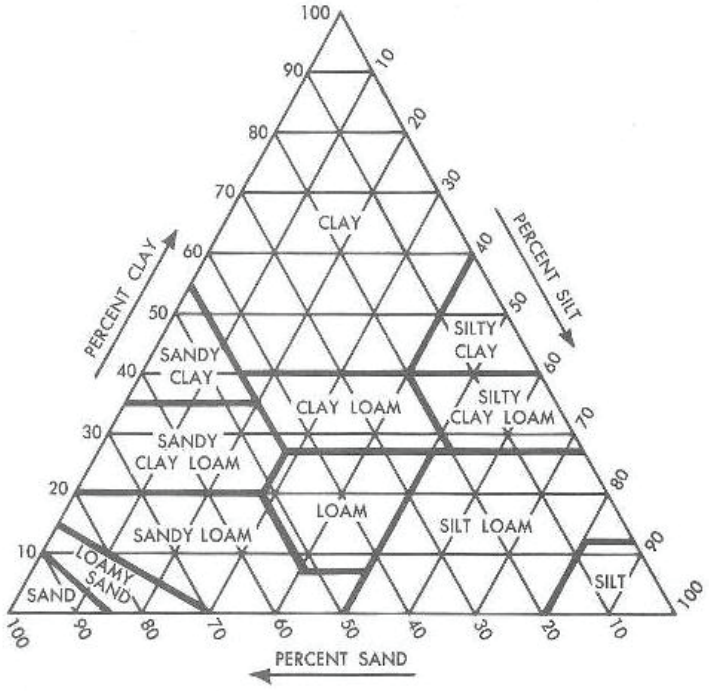


Figure 2-7: USDA textural classification triangle.

Table 2-3: Textural Classification of Soil Based on Composition

	Composition (%)		
Textural Class	**Sand**	**Silt**	**Clay**
Sand	80–100	0–20	0–20
Sandy loam	50–80	0–50	0–20
Loam	30–50	30–50	0–20
Silt loam	0–50	50–100	0–20
Sandy clay loam	50–80	0–30	20–30
Clay loam	20–50	20–50	20–30
Silty clay loam	0–30	50–80	20–30
Sandy clay	55–70	0–15	30–45
Silty clay	0–15	55–70	30–45
Clay	0–55	0–55	30–100

The sand, silt, and clay content can also be estimated in the field using the 'Texture by Feel' method. The 'Texture by Feel' method is shown in Figure 2-8.

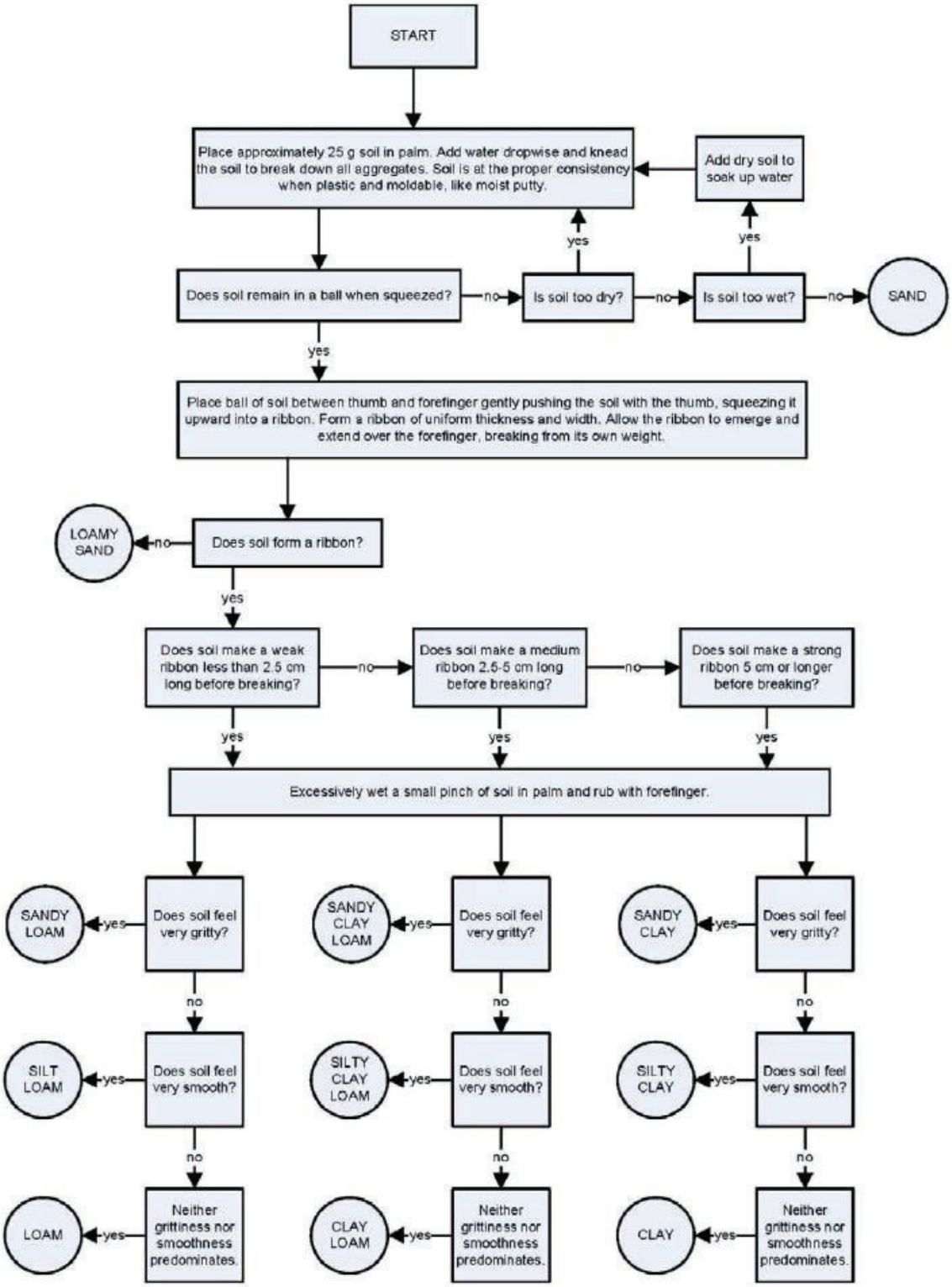


Figure 2-8: Texture by Feel Method

3. Unified Classification

The Unified soil classification system identifies soils based on their textural and plasticity qualities, and their grouping is based on their suitability as engineering construction materials. Soils are identified based on 1) percentages of gravel, sand, and fines (fraction passing the No. 200 sieve), 2) shape of the grain-size distribution curve, and 3) plasticity and compressibility characteristics. The soil is given a descriptive name and a letter symbol based on its characteristics.

Table 2-4 shows the Unified Soil classification and engineering use of the various materials.

Table 2-4: Unified soil classification and engineering use

Typical Names of Soil Groups	Group Symbols	Permeability when compacted	Shearing Strength when Compacted and Saturated	Compressibility when Compacted and Saturated	Workability as a Construction Material	Foundations	Foundations	Roadways	Roadways	Roadways
						Seepage Important	Seepage not Important	Fills Frost Heave not Possible	Fills Frost Heave Possible	Surfacing
Well-graded gravels, gravel-sand mixtures, little or no fines	GW	pervious	excellent	negligible	excellent	——	1	1	1	3
Poorly-graded gravels, gravel-sand mixtures, little or no fines	GP	very pervious	good	negligible	good	——	3	3	3	——
Silty gravels, poorly graded gravel-sand-silt mixtures	GM	semipervious to impervious	good	negligible	good	1	4	4	9	5
Clayey gravels, poorly graded gravel-sand-clay mixtures	GC	impervious	good to fair	very low	good	2	6	5	5	1
Well-graded sands, gravelly sands, little or no fines	SW	pervious	excellent	negligible	excellent	——	2	2	2	4
Poorly graded sands, gravelly sands, little or no fines	SP	pervious	good	very low	fair	——	5	6	4	——
Silty sands, poorly graded sand-silt mixtures	SM	semipervious to impervious	good	low	fair	3	7	8	10	6
Clayey sands, poorly graded sand-clay mixtures	SC	impervious	good to fair	low	good	4	8	7	6	2
Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	semipervious to impervious	fair	medium	fair	6	9	10	11	——
Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL	impervious	fair	medium	good to fair	5	10	9	7	7
Organic silts and organic silt-clays of low plasticity	OL	semipervious to impervious	poor	medium	fair	7	11	11	12	——
Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	semipervious to impervious	fair to poor	high	poor	8	12	12	13	——
Inorganic clays of high plasticity, fat clays	CH	impervious	poor	high	poor	9	13	13	8	——
Organic clays of medium to high plasticity	OH	impervious	poor	high	poor	10	14	14	14	——
Peat and other highly organic soils	Pt	——	——	——	——	——	——	——	——	——

Note: Modified from Wagner, 1957.

4. Iowa DOT Material Requirements

Specification Section 2102.02, D

The specifications include material requirements for Select, Suitable, and Unsuitable material based on soil characteristics such as Proctor density, silt content, AASHTO classification, and plasticity index.

The following table shows various material types and their suitability:

Table 2-5: Material type and suitability.

Material Type	**Suitability**
Cohesive Soil	• If moisture is right, OK to work with. • If not unsuitable, performs OK to Well.
Granular Soil	• Usually easy to work with, and performs well.
Glacial Till	• Usually good Suitable. • Frequently Select.
Loess	• Good Suitable, not Select.
Sand/Gravel	• Good Suitable. • Good Select.
Gumbotil	• Always Unsuitable. • Usually Type B disposal.
Claypan	• Always Unsuitable. • Usually Type C disposal.
Alluvium	• Silty alluvium hard to work with if wet (usually is). Sand/Gravel (see above).
Shale	• Always Unsuitable. • Usually Type A disposal. • Can consider Type B disposal with Moisture Control, or Waste.
Residuum	• Type B Disposal. • Always Unsuitable.

B. Engineering Properties of Soils

The small particles of the available soils throughout the project may be structured differently. This difference includes composition, texture, shape, size, structure, etc. One should know the differences and the engineering properties of each type.

Following is the discussion of some materials that are encountered during a grading project:

Figure 2-8: Sand, silt, and clay

1. Granular Soils (Sands and Gravels)

Granular soils are those containing high percentages of sand, gravel, cobbles, or mixtures of them. Fine sand is an exception because its engineering properties are on the borderline between the granular and the fine-grained soils. A granular soil has the following significant engineering properties:

- It is generally excellent foundation material for supporting structures and roads. The bearing capacity is large and the settlement is small. Settlement occurs quickly.
- It is the best material for embankment, because it has high shear strength. It is easy to compact and it is not susceptible to frost action.
- It is the best backfill material for retaining walls due to good drainage and low lateral pressure.
- It is very permeable.

2. Cohesive Soils (Silts, Clays, and Loess)

Clay is the soil that has a particle size of less than 2 microns. Its shear strength is largely or entirely derived from cohesion. A clayey soil may have the following significant engineering properties:

- It often possesses low shear strength.
- It is often plastic and compressible.
- It loses part of its shear strength upon wetting or disturbance.
- It is very impervious.

Silt is the material with grain size between the No. 200 sieve and 2 microns in size. It possesses little cohesion and plasticity. Because it is so fine, silt may have the following undesirable properties:

- It may be very difficult to compact.
- It has a high capillary potential.
- It is susceptible to frost action.
- It possesses low shear strength.
- It is highly erodible.

Loess is a silt material but is differentiated because it is the wind-blown deposited material with grain size of silt. Loess may have the following properties:

- It has a relatively low unit weight.
- It does contain some cementitious material if undisturbed in its natural condition. Thus, it may be capable of standing nearly on a vertical cut bank in some instances, but not in an embankment fill. However, the Iowa DOT currently does not allow or design for vertical cuts in loess.
- It may subside upon saturation due to loss of cementation.

3. Organic Soils

Soil is primarily composed of mineral matter. Mineral matter is the sand, silt, clay, and occasional gravel and rocks that make up the soil. However, any soil that contains a sufficient amount of organic matter to influence the engineering properties is called organic soil. Organic matter is essentially decomposed plant material and is what gives soil a black or dark color. The organic soil has the following properties:

- It may have a low shear strength.
- It may be highly compressible.
- It can be very difficult to compact.

Figure 2-9: Dark brown or black color in soil usually indicates the soil has high organic content.

C. Soil Color

As soil moisture content varies, so does its color. Color determinations are done with soil in a moist condition.

Color indicates certain soil characteristics as well as the presence of certain compounds.

- Dark brown to black colors usually indicate organic content.
- Reddish soils indicate the presence or iron oxides and are usually well drained.
- Yellow to yellowish-brown soils indicate a presence of iron and are poorly drained. Grey to grayish-blue and yellow mottled colors are usually an indication of poor drainage.
- White indicates considerable silica or lime.

D. Soil Compaction

Material IMs 309 & 335

Figure 2-10 shows that soil is made up of solids (soil particles), liquid (water) and gas (air). Compaction is the act of densifying the soil by pressing soil particles together into close contact. As a result, the air is removed from the soil body. This increases the strength of the soil and reduces the permeability.

The four most important factors when it comes to soil compaction are:

- Moisture content
- Soil type
- Equipment
- Lift thickness

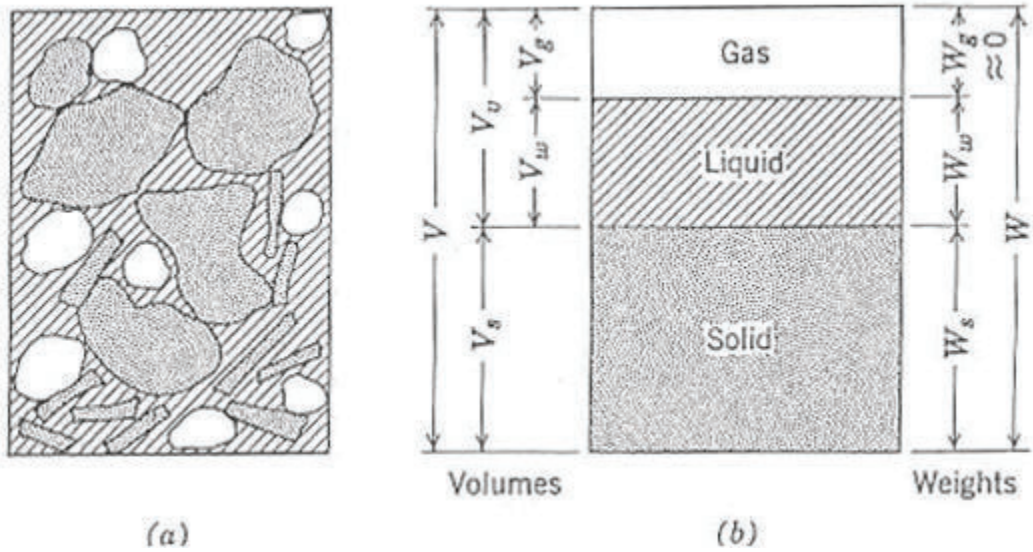


Figure 2-10: Illustration showing composition of soil. Compaction primarily drives air out of this mixture.

Moisture Content and Proctor Density

For moisture content information, a Proctor density relationship should be established.

R. R. Proctor, the Los Angeles County Engineer, discovered an important relationship between soil density and moisture content. Proctor found that by molding a series of specimens with different moisture contents, using the same compactive effort for each specimen, the density on a dry-weight basis would peak out as shown in Figure 2-11. A Proctor density curve or test should be done when there are some questions about the soil. The method of running a proctor density is in Materials IM 309.

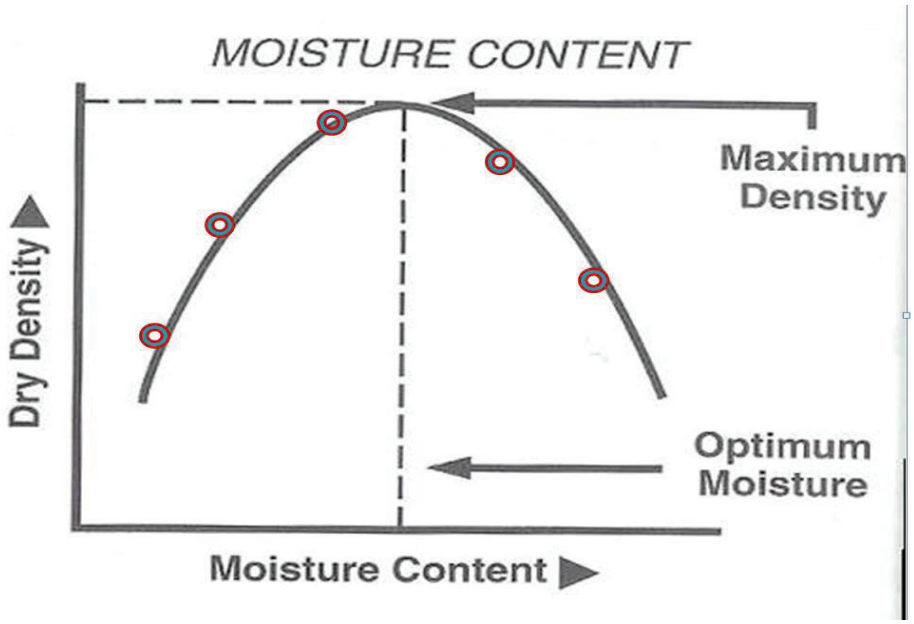


Figure 2-11: Proctor curve showing the moisture-density relationship of soil

The theory behind this relationship is that during compaction, moisture or water is needed to provide the lubrication between soil particles and hence improve compaction. However, it is not good to compact soil too far away from the optimum moisture content. When the moisture is too low, soil particles are prevented from sliding. Thus, good compaction would be hard to obtain. On the other hand, when moisture is too high, soil particles cannot come in contact with each other. Unlike gases, water is an incompressible material. Consequently the compactive effort will rework the soil, shearing it, and reducing its strength.

Over-compaction is a condition which occurs when a large compactive effort is put into soil which is too wet for proper compaction. The compactive effort causes the wet soil particles to slide over/across each other into such a configuration where they have a “preferred orientation”, which in turn produces “weak zones” which, along with low density, produce a soft, weak, unstable embankment. For this reason, the hauling pattern must be considered. If it is possible, the trucks should be running on the shoulder. If it is not possible, the wheel tracks should spread out across the grade instead of one location, i.e., not driving in the same wheelpath. When the top of the grade is used for traffic hauling for a while, it is highly recommended that the top layer be scarified and recompacted.

At the present time, the moisture-density requirement is seldom specified during Iowa DOT grading projects. Rather, “Compaction with Moisture Control” is performed. This will be discussed in a later section.

E. Shrink/Swell

The volume of soil will shrink or swell depending on its stage in the excavation process.

- Bank Measure (or bank volume): The volume of earth material in its in-ground natural state
- Loose-Measure (or loose volume): The volume of earth material that is excavated and transported (i.e. dump truck, scraper, Etc.)
- Compacted Measure (or compacted volume): The volume of earth material after it is compacted

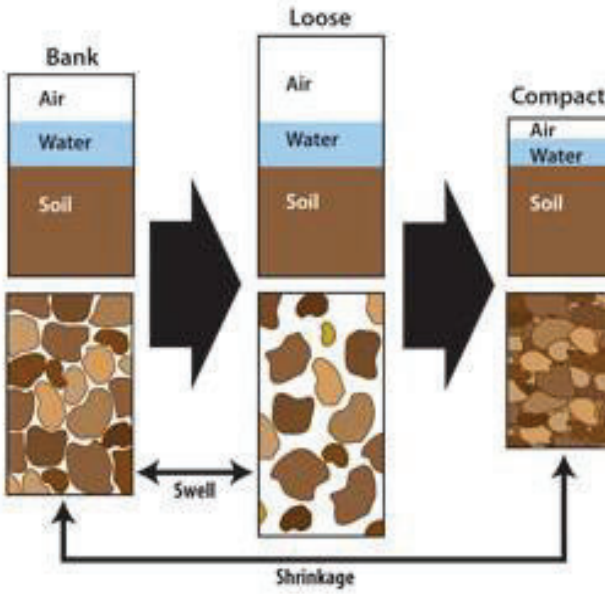


Figure 2-12: Shrink-swell of soil depending on stage in excavation process

The change in volume described above is mainly due to the amount of air (i.e. the amount of compaction). However, some expansive clay soils have a high shrink-swell capacity depending on its water content. These soils will expand when water is absorbed and contract when water dries up.

F. Shear Strength

Shear strength has been mentioned several times in the previous section. What is the shear strength of a soil? It is mainly the ability of a soil to resist shear failure along a certain rupture plane or zone. The shear strength of a soil comes from the cohesion, friction, or combination of both. There are a variety of factors that would affect the shear strength of a given soil. They include the size, the shape, and the gradation of the particles making up the soils, density or void ratio of the material, and moisture content.

The shear strength of a soil may be expressed by the following equation:

$$s = c + \sigma' \tan \Phi$$

Where:

s: Shear strength
c: Cohesion
σ': Effective stress
Φ: Angle of internal friction of the soil.

Sand and gravel have no real cohesion. A cohesive soil, on the other hand, obtains the shear strength mainly from cohesion. In some instances when a new embankment is constructed, part of the "load" will be carried by the water held within a saturated soil. However, as time goes by, the water escapes from the soil which means that the friction between the particles is more effective. Thus, the shear strength can increase with time.

Because the effective stress is the difference between the total pressure and the pore pressure, the effective stress decreases as the pore pressure increases. Water has no cohesion or internal friction angle, and water possesses no shear strength. Hence, when the soil is saturated with water and part of the load is carried by this water, the actual benefit of friction in the soil is lower. In other words, the beneficial effects of friction cannot be fully utilized until the pore pressures dissipate. Thus, it is very important to keep the water table as low as possible to prevent loss of shear strength.

SOILS

PLAN SHEETS

III. Soil Sheets

A. Introduction

The soil sheets are very important to a grading inspector. These sheets should provide the key to building a quality project. There is a lot of information on the soil sheets. The typical information includes cut moisture, cut density, plastic limit, Shelby tube core data, AASHTO classification and group index, color and textural classification, the abbreviated color and description, proctor density and optimum moisture content, water table, etc. The following are some general descriptions and discussions of each term:

Cut Moisture: Moisture of in-place soil at location indicated for "core" in the boring. This information should be compared to the proctor density information so that the inspector would have some idea how wet the soil is and how much disking would need to be done. It may provide some information on whether or not a backslope subdrain is needed at the cut area.

Cut Density: Density of in-place soil at location indicated for "core" in the boring. Similar to the cut moisture, the cut density may provide some information on shrinkage. For example, the cut density is 95 pcf and the Proctor density is 105 pcf. Thus, there should be at least 10% shrinkage if compacted to 100% Proctor. However, the current practice without any actual testing, this guide is not applicable.

Plastic Limit: This term was defined earlier on Page 2-6.

Shelby Tube Core Data: This is an undisturbed Shelby Tube sample. It is usually taken in an area where a fill is proposed or the soil investigation indicates that there may be a soft layer that may experience some settlement upon loading. A triaxial test is run on this sample to determine the cohesion, internal friction angle, consolidation coefficient, etc. The results are used for slope stability analysis, settlement prediction, etc. which will determine whether berms, blankets, core-outs, etc. are necessary.

AASHTO and Group Index: These terms were also defined earlier on Page 2-1.

Color and Textural Classification: The color and textural description are the preliminary remarks described by the soil crew during the drilling. Sometimes they are not the same as the abbreviated textural classification.

Abbreviated Color and Textural Classification: The textural classification was defined earlier. However, the color of the soil was not discussed. Soil color is a function of surface coatings which constitute only a small percentage of the soil. For example, an intense rusty red-brown signifies iron oxide coating. On the other hand, a white crusty appearance indicates calcium carbonate coating. The water table and air have a lot to do with the color of the soils. Dark gray or green or blue hues indicate conditions or greying, which occurs below a permanent water table. Once, they are exposed to the air, the color will change.

Proctor Density and Optimum Moisture Content: These two terms were defined in more detail in “Soil Compaction” section. Proctor density is the maximum density that a given soil can be compacted at the proper or optimum moisture content. This moisture content provides important information on what moisture content the soil should be during compaction to obtain adequate compaction.

Water Table: The water table is indicated as the little dash-line with the symbol H_2O. This is what was found during the soil investigation. This water table should give some good indication on how wet the soil is and whether or not a backslope subdrain is needed.

Subgrade Treatment: Subgrade treatments are used to provide the best possible support for the subbase (if needed) and the pavement. The type of subgrade treatment used depends on the type and quality and quantity of natural soils available on the project.

B. Soil Testing Results

The information on the soil sheets is a visual presentation of the soils present along the general centerline of the proposed roads as well as the soil design features that apply to the construction of the road. The report on the soil testing from the Central Laboratory or consultant provides further information. This report is sometimes referred to as the "VanDyke Sheets". The inspector should get this report as soon as possible. It should be available online with the bidding documents, but the inspector may contact the Earthwork Field Engineer for assistance.

The report includes the station, location from the centerline, depth of the sample, liquid limit, plastic limit, plasticity index, gravel content, sand content, silt content, clay content, Proctor density, optimum moisture content, carbon content, textural classification, AASHTO and USDA classifications, color, and sieve analysis.

Even though the distance between the samples could be two or three hundred feet, the testing information is very useful. The following are some typical examples that the inspector can use:

Example 1:

Due to the additional cost for hauling, a contractor approaches the inspector to use the Class 10 with the following information for select. AASHTO classification is A-7-6; the unit weight is 110 pcf.

Does this material meet all of the requirements in Specification 2102.02, D, for select material? No, it does not.

The information on the soil sheet does not mention the silt content of the soil. When the inspector looks it up in the report, the silt content is 50%. This is Class 10 soil, not select because the silt content limit for select is 45% according to the specification.

A similar example could be used with plasticity index.

Example 2:

From looking at the test report, the inspector may recognize there is a close relationship between the optimum moisture content and plastic limit. Most of the time the optimum moisture content is a few percentage points lower than the plastic limit. Thus, the inspector should be able to tell whether the moisture content is good for compaction or whether some disking is needed by running the plastic limit at the site.

The plastic limit was discussed earlier. For a quick and easy method in the field, the following brief discussion may be useful:

Since the optimum moisture content is lower than the plastic limit, rolling a soil thread would give some information on moisture content. Thus, obtain a small piece of the soil. Roll the soil in the palms until a thread of soil is formed. When the thread is rolled to a diameter of c

inch and not broken, the moisture content is too high. The inspector should work with the contractor to get some disking done.

Some other information that the inspector could use would be liquid limit, plasticity index, and silt content, etc. to determine whether the soil is select soil or Class 10. In addition, the information may provide some good indication about the soils' behavior. For example, the soil with high liquid limit indicates that the soil can take in a lot of water. It also means that the soil may be compressible or the soil can experience volume changes.

A high plasticity index indicates the soil could get very soft when it is wet and volume change may happen.

The soil testing report will not indicate whether shale is encountered. From experience, it appears when the clay content is in the 30's or 40's but the plasticity index is in the 10's or low 20's, it is a good indication the soil is shale. The numerical difference between the two values is more than 20. For example, the clay content is 43 but the plasticity index is only 15. When it comes to shale, the inspector should look at the soil profile and compare it with the site condition.

For more information on soils uses and classes, please see Specification Section 2102.

EQUIPMENT

IV. Equipment

The following are common types of equipment used in earthwork.

A. Scraper

The scraper is designed to remove a layer of soil from the ground surface and transport it to another location where it is deposited in a thin layer or stockpiled.

There are basically two types of scrapers; the tractor drawn and self propelled units. There are variations of these basic units presently in use. Some self propelled scrapers have tractor units with four-wheel drive. Others may have a two-engine drive, one pulling and one pushing the scraper.

Figure 4-1: Tractor drawn scraper

Scrapers are rated according to the cubic yards of material that the scraper bowl will hold. These may range in size from a few to 30 or more cubic yards. Scraper units usually lack sufficient traction when loading, particularly when the material in the cut is hard. It might be necessary for additional power to be provided to the scraper unit. The pusher plate at the rear of the unit enables other tractors to push the scraper and assist in the loading process. Under normal conditions only one “pusher-tractor” is used but when the material is very hard, the Contractor may need to use two “pusher tractors”.

B. Bulldozer

The bulldozer is probably one of the most versatile of the various equipment designed for earthwork. The wide crawler tracks provide stability and traction not usually available on other equipment. It may be used to pull scrapers, rollers, and discs as well as used as a surface-grading unit by spreading and leveling unloaded material with the bulldozer blade.

The bulldozer blade consists of a large curved steel blade held at a fixed distance in front of the tractor by arms secured on a pivot or shaft near the horizontal center of the tractor. The blade can be raised or lowered or tilted vertically. This blade has many uses such as backfilling, spreading, leveling, etc.

Figure 4-2: Dozer equipped with GPS

C. Disk/Disc

A large disk is used to aerate or dry out wet spots, break down lumps of soil, mix the soil and help to get moisture into the soil evenly.

Figure 4-3: Disk

D. Excavator

An excavator is a tractor with a bucket used to load material. It is used to load material into truck or scrapers or to remove topsoil or other material from areas in which a scraper cannot operate. It is used to dig trenches for pipe and box culverts.

Figure 4-4: Excavator (backhoe) loading a truck

E. Water Truck

The water truck is used to apply water to the soil in order to obtain optimum moisture or to apply water to a haul road to reduce dust. It may be a truck with a tank mounted on the back or a water wagon as shown.

Figure 4-5: Water truck applying water to reduce dust

F. Motor Grader

The motor grader is a four or six-wheeled self-propelled grader. It has a long wheelbase, which will allow it to travel over uneven ground and to level it to an even grade. The blade of the motor grader can be raised or lowered, rotated in a wide angle and tilted to different positions. Motor graders (also called motor patrols) are used to level and spread the material as it's unloaded from the scraper, shape the slopes, cut ditches, perform the final grading, and maintain haul roads.

Figure 4-6: Motor grader (motor patrol)

G. Haul Trucks

A Haul Truck is a large pneumatic wheeled truck with a large box used to haul soils or aggregate from location to location. The size of the trucks and boxes vary greatly, depending on its use and haul distance.

Figure 4-7: Haul truck

H. Compactors

There are different types of compactors with different compaction methods.

- Manipulation: kneading
- Vibration: rearranges particles
- Pressure: downward force
- Impact: blows

Sheepsfoot rollers are drums with a large number of "sheepsfoot" projections that use kneading action to compact soil. They may be pulled along by a tractor unit or they may be self-propelled. The drum is hollow and closed but may be filled with water to increase the compactive effort. The feet attached to the drum do the compacting.

Sheepsfoot rollers are especially useful in compacting cohesive materials.

The initial pass of a sheepsfoot roller compacts the lower portion of the lift. Subsequent passes compact the middle and upper portions. The roller is said to "walk out" as the soil is compacted, and the feet do not penetrate as deeply as the initial pass.

Figure 4-8: Sheepsfoot roller pulled by tractor

Vibratory Rollers work well in compacting granular soils.

The vibratory action sets the soil particles in motion, which rearranges them into a denser packing. Vibratory compactors may have smooth or pad-foot drums.

Figure 4-9: Pad-foot vibratory roller compacting granular soils.

Pneumatic or rubber-tired rollers have a series of rubber tires side-by-side. They generally work from the top of the lift down, and compaction is achieved by a combination of weight and kneading action. These rollers are usually self-propelled units. The rubber tires are staggered so that the spaces between one set of wheels are covered by the wheels of the other axle.

Figure 4-10: Pneumatic roller

Smooth wheel rollers are typically used for finishing operations. If an area is properly shaped and rolled with a smooth wheel roller, most rain will run off and will not harm the top of subgrade. Depending on the use, the roller may use vibration, pressure, or impact.

Figure 4-11: Smooth wheel roller

I. GPS Equipment

Specifications Article 1105.16

Machine control or automated grade guidance uses Global Positioning System (GPS) and a three-dimensional computer model of the road design to guide equipment to place, level, and compact materials for road construction.

GPS provides near exact position of the equipment in “real time”, and the position of the cutting edge (blade, bucket, etc.) is computed.

With machine control, the equipment operator is provided a visual indicator of the position of the cutting edge relative to the surface as designed. The equipment’s hydraulics moves the cutting edge accordingly to match the design surface.

Machine control on grading work is allowed by the Standard Specifications on any project.

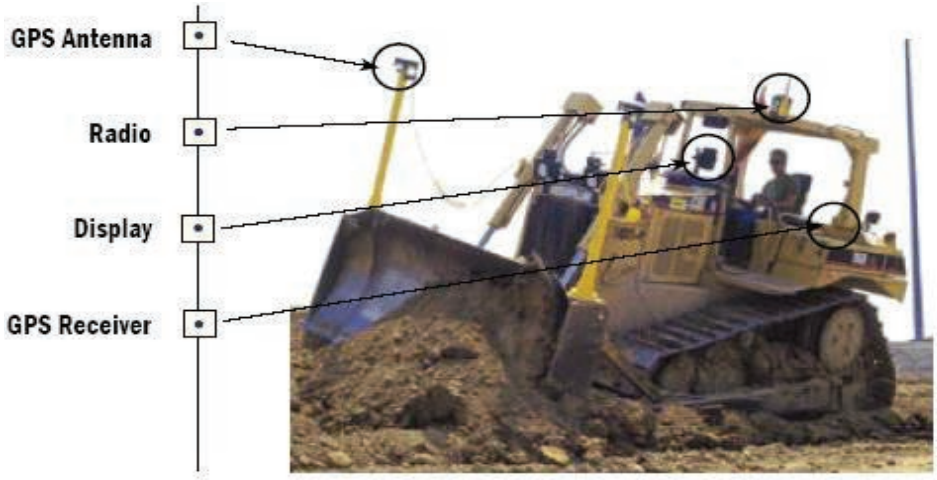


Figure 4-12: Dozer equipped with GPS.

J. Intelligent Compaction

Intelligent Compaction (IC) refers to the compaction of road materials, such as soils or aggregate, using modern vibratory rollers equipped with a measurement and computer reporting system and GPS based mapping.

IC rollers also maintain a continuous record of color-coded plots, allowing the user to view plots of the precise location of the roller, the number of roller passes, and material stiffness measurements.

Some potential benefits of using IC are:

- Improved density
- Increased productivity
- Reduction of highway repair costs
- Continuous record of material stiffness values
- Identification of non-compactable areas

The Iowa DOT has used IC on pilot/demonstration projects.

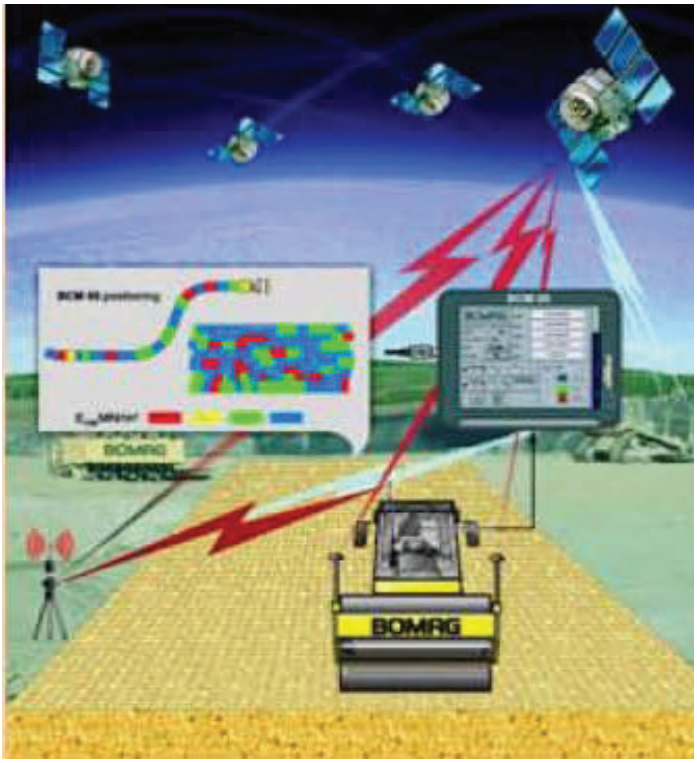


Figure 4-13: Illustration of IC components – roller, operating panel, and map

PRELIMINARY

WORK

V. Preliminary Work

There are things that should be reviewed before the grading work begins so that the inspector can become familiar with the project. Following are some items the inspector should be looking at:

A. Plan Review

The plans are the instruction and direction on what work is to be done. The plans are loaded with information. It is extremely important the inspector review and understand the plans. The Department has an excellent plan reading course available to the inspector. Thus, no attempt will be made here to duplicate this course.

The index sheet on the front will list by page number the description of the work. The individual plan sheets will give the exact location of the work. Please study the general notes, standard road plans, and typicals.

Tabulations will give information on size and location of different items such as pipe, silt fence, silt basin, subgrade treatment, etc.

Grading plans will also include soil information sheets that show various types of soil and rock formations found in a soil survey. This information is very important to the grade inspector. The main hope of this training is to provide the inspector with the knowledge to recognize what may be coming before the work actually begins. Please keep in mind the site conditions may have changed. Therefore, use these soils sheets for information.

The inspector should also have cross-sections. These cross-sections will give additional information on design, estimates, and survey. Therefore, please study the cross-sections.

B. Proposal Review

When the contract is ready to be let, the Department publicly posts the proposal form and plans. Contractors use this form for estimating and determining their final bid price. On the letting date, the contractor with the lowest bid generally is typically awarded the contract.

The proposal form shows the project number, type of work, and location. Information on starting date, working days, liquidated damages, site completion dates etc. is included in this proposal.

Each proposal lists supplemental specifications and special provisions that apply to the contract. Special notes are also included.

C. Right of Way (ROW) Contract Review

The ROW contract is the agreement between the State and the property owner. The inspector on the project and the survey party chief each should have a copy of this document. This contract gives specific information describing land acquired by the State. Items such as driveways and field entrances are shown on a plat in the back and must be constructed as stated.

The office copy of this contract includes a tabulation (a red breakdown) of what was included in the total amount paid. This can be very useful in dealing with the property owner on what was included and what may have to be preserved.

Property owners should be contacted to discuss construction staging and effects on temporary access. These visits may eliminate many complaints during the project.
It is important to compare the ROW contracts with the plans for the type and location of entrances.

D. Preconstruction Meeting

Construction Manual 2.10

The preconstruction meeting may be the most important meeting to having a successful and enjoyable project. The main purpose of the preconstruction meeting is to evaluate the contractor's schedule and discuss potential problems that may occur on the project. It is very important that all the involved parties have a chance to present any questions or concerns on staging, weekly meeting, communications, etc. It must be made clear what is expected of the contractor, subcontractors, utility companies, etc. Everyone should be aware of the sequences so that no unnecessary delay will occur. Minutes of the meeting and the attendance list and phone numbers are available for information.

The topics that need to be discussed are listed in Chapter 2 of the Construction Manual.

E. Utility Companies

Construction Manual, Chapter 12

For a grading project, there are many utility companies existing within the project boundaries. These companies are notified of the preconstruction meeting. However, it must be understood that it is the contractor's responsibility to notify the utility company when working near any type of utility that may be damaged due to the construction.

There may also be Utility Relocation Agreements. These are for the areas where the utility was located on private property prior to the highway construction. There is information on documenting these agreements in Chapter 12 of the Construction Manual.

Figure 5-1: Grading may occur around existing utilities.

F. Asbestos Inspection and Removal

Construction Manual 10.62

Make sure that asbestos inspection and removal are done before building demolition work.

Asbestos inspection is normally done by the Central Materials staff prior to letting. Once the inspection is done, the information is forwarded to the Asbestos Coordinator in the Location and Environment Bureau. If asbestos is present, the Asbestos Coordinator will contact an asbestos removal contractor under contract to remove the asbestos before demolition. The Resident Office is expected to get the "Certification of Completion" from the asbestos removal contractor, sign off, and send the paperwork to the Asbestos Coordinator so payment can be initiated.

G. Demolition /Underground Tank Removal/Contaminated Soil/Land Farming

1. Demolition

Construction Manual 10.61

Before the demolition can begin, the Asbestos Coordinator needs to send a "Notice of Demolition" to the Iowa Department of Natural Resources. This notification must be filed at least 14 calendar days in advance of commencing work. The specification requires a 25-day notice from the contractor to the RCE, so project engineers have 7 calendar days to provide this information to the Location & Environment Bureau.

The Demolition Notice is parcel specific. If an extra work order is created for another parcel or parcels, another notice must be requested.

The Demolition Notice is required for demolition of structures and structural components, i.e., house, garage, barn, sheds, etc. The contractor is allowed to start removing non-structural items such as sidewalks, driveways, fences, etc.

Demolition by burning is not allowed by specification.

If the local Fire Department would like to use the building for training purposes, please contact the Construction and Materials Bureau.

2. Underground Storage Tank Removal

Construction Manual 10.22

Underground Storage Tank (UST) is defined as a tank and associated piping with 10% or more of its volume below the ground which has stored or is storing a regulated substance.

It is important to check the registration of the tank. Please contact the Location and Environment Bureau for assistance. ***Do not remove nonregistered tanks.***

All the liquids in the tank must be removed and disposed of in accordance with the Iowa DNR regulations. ***Do not release the liquids on the ground.***

The Location and Environment Bureau will have the tank removed utilizing a statewide service agreement contract.

3. Contaminated Soil

Construction Manual 10.22

If the site is contaminated, the contaminated soil must be excavated and treated or disposed of properly. There are two ways to dispose of contaminated soil. First is taking the material to a state permitted sanitary landfill. Second involves removing the soil and spreading it out on the surface. This method is called “Land Application” or “Land Farming”.

Please call the Location and Environment Bureau for more information and assistance.

More information on the above subjects is available in Chapter 10 of the Construction Manual.

H. Stormwater Permit

Construction Manual 10.30
Erosion & Sediment Control Field Guide available at:
https://iowadot.gov/construction_materials/Earthwork-and-erosion-control
Pollution Prevention Plan in C, CE, or R sheets

Stormwater permit coverage is required for projects in which more than 1 acre of land is being disturbed. The paperwork is typically started before the letting. One newspaper notice is published by the Construction and Materials Bureau. Also, a Notice of Intent form and fee are sent from the Construction and Materials Bureau to the Iowa Department of Natural Resources to obtain coverage under NPDES General Permit #2. All the prime contractors of all the projects within the permit boundaries are required to sign as the co-permittee of the permit at the time the contracts are signed. The permit and signed co-permittee certification will be sent to the corresponding RCE office as soon as they are available. Please make sure that all the prime contractors have signed the co-permittee certification.

Also, all affected subcontractors must sign the co-permittee certification statements. The signed certifications should be kept on DocExpress.

This permit coverage needs to remain active until 70% of permanent vegetation is established. When the project(s) have reached this point, the RCE is to submit the Notice of Discontinuation to the Construction and Materials Bureau (Earthwork Engineer).

I. Erosion and Sediment Control

Construction Manual, Chapter 7
Specification Sections 2601 & 2602
Erosion & Sediment Control Field Guide available at:
https://iowadot.gov/construction_materials/Earthwork-and-erosion-control

Unprotected soil is susceptible to erosion, and the contractor should take measures to reduce erosion and limit the amount of sedimentation that is created. Erosion controls, such as seed or mulch, help keep soil in place. Sediment controls, such as silt fence or basins, collect or allow soil to settle to prevent it from traveling offsite.

Erosion and sediment control is the vital requirement for stormwater regulations. Prior to beginning the grading or clearing and grubbing operations, silt fences must be installed. Silt fence must be placed along the perimeter of the area to be disturbed at locations where the runoff can move off site. Vegetation in areas not needed for construction shall be preserved.

Extra attention should be given to areas near a waterway. This includes the disturbed areas at the ends of a culvert or a ditch before the water gets to the creek or drainage way. Silt fences, silt basins, or rock checks should be installed at these locations to prevent siltation from getting into the water. Areas with a steep slope may need to be protected with rock flumes.

Contractors should not be allowed to disturb several areas without trying to do some finishing work, i.e., seeding or mulching. If cooperation is not obtained from the contractor, a letter of warning should be sent. Withholding payment and shutting down the project are the next steps.

Inspection of the erosion and sediment control devices will be made every seven calendar days. The inspection and the findings will be documented as the record for inspection and compliance with the storm water permit requirements. These inspections must continue over the winter for sites that haven't achieved vegetative growth.

The silt fences that have lost 50% of their capacity will be cleaned or replaced.

Maintenance of the erosion and sediment control devices is required throughout the contract period.

The inspector should work closely with the contractor to make sure that the appropriate actions in regard to erosion and sediment control devices are done as soon as possible.

J. Clearing and Grubbing/Tree Disposal

Specification Section 2101, Clearing & Grubbing
Construction Manual 6.10

The process of removing and disposing of trees is described as clearing. Grubbing is defined as removal and disposal of stumps and roots. Clearing and grubbing is generally performed concurrently in order to ready the site for topsoil stripping and excavation.

The work may also include the following work:

- Removal of logs and down timber
- Hedge removal
- Brush & shrub removal
- Removal of growing corn
- Vegetation and rubbish removal
- Field fence removal

The limits for clearing and grubbing are generally noted on the plans.

Figure 5-1: Clearing of trees

There are many ways to dispose of the clearing and grubbing waste. Following are the allowable ones:

- Open Burning: Iowa Administrative Code 567-23.2 allows open burning of the clearing and grubbing waste, unless prohibited by local ordinances or regulations. The Administrative Code prohibits burning in Cedar Rapids, Marion, Hiawatha, Council Bluffs, Carter Lake, Des Moines, West Des Moines, Clive, Windsor Heights, Urbandale, and Pleasant Hill. In locations where burning is allowed, the burning of the waste must be located at least one quarter mile away from any inhabited building. Rubber tires shall not be used to ignite the wastes. Wind direction and ash pollution should be kept in mind so that complaints from the public are avoided.

- Chipping: Where feasible, brush should be chipped for subsequent use as mulch.

- Firewood: Where feasible, the logs should be salvaged for firewood.

- Landfill: The waste can be disposed at a “yard waste” landfill.

- Burial on Project: The stumps can be buried within the State of Iowa Right-of-Way at locations approved by the RCE.

K. Topsoil Removal

Specification Section 2105, Stripping, Salvaging, and Spreading Topsoil
Construction Manual 6.21

Topsoil in the area of cuts is usually unsuitable for use as fill. It is normally stripped and stockpiled for later use as topsoil. The limits and depths of topsoil removal are usually included in the plans.

Methods of monitoring topsoil removal include:

- Setting stakes at regular intervals at ground elevation as a reference for depth of removal
- Removing a scraper width strip at periodic intervals or leaving a narrow strip between scraper paths, thereby obtaining a reference for depth of removal.

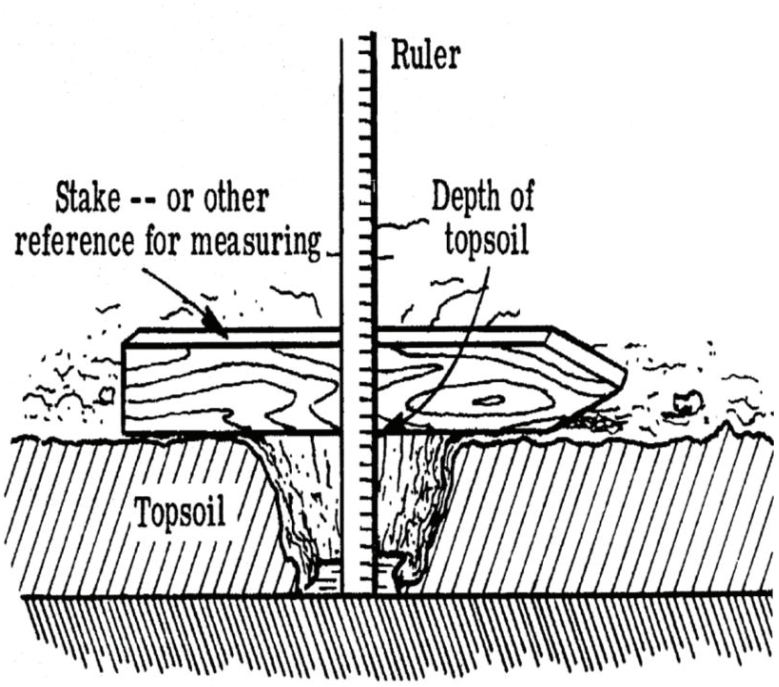


Figure 5-2: Method of monitoring removal of topsoil.

The method of measurement is noted in the specifications. However, it would be a good idea to discuss this at the preconstruction conference.

The Iowa DOT typically prefers a final topsoil depth of 8-inches to allow for better vegetation growth. However, refer to Tab 103-4, the T-sheets, or the plan notes for project specific requirements.

L. Traffic Control

Construction Manual Chapter 5

Traffic control shall be checked and documented at least once a day and should be done twice; once in the morning and once in the afternoon. This is an important contract item, which requires constant monitoring. Traffic control will be shown on the plans and referenced to standards and typicals. Many times, modifications have to be made because of sight distance or unforeseen hazards. Before modifications are made, check with the Resident Engineer for approval.

M. Survey

Construction Manual Chapter 4
Construction Surveying Handbook available at:
http://www.iowadot.gov/Construction_Materials/inspection_tools/survey_fundamentals.pdf

There are two very important fundamentals in construction survey that relate to grading.

1. Elevation: Elevation is determined by using an established elevation point, which is called a bench mark. A rod reading is taken to determine how high the instrument is above the bench mark. The reading, added to the elevation of the bench mark, gives the elevation of the hair line. This elevation is called the height of instrument (H.I.). Any ground reading, subtracted from the H.I., gives the ground elevation at the place where the reading was taken.

2. Horizontal Distance: Horizontal distance is obtained by measuring from the base line to the point where a ground reading is taken.

Some common stakings that the inspector should be aware of are:

Slope Stakes for Fills: Slope stakes for fills are the means by which the information from the plans is transferred to the ground for the contractor to do the cut excavation and embankment construction. Slope stakes for the fill section are the stakes set at the toe of the slope to show the height of the fill, measured from the shoulder grade to the ground where the stake is driven. These stakes are set for grades and width of road bed as shown on plans.

Slope Stakes for Cuts: Slope stakes for cuts are the stakes set at the top of the backslope to show the depth of cut from a point on the ground where the stake is driven to grade at the bottom of the side ditch or, if no side ditches are planned, to the point where the floor of the proposed cut meets the plane of the backslope.

Blue Tops: Blue tops are finish stakes set on centerline and shoulder line. These are a distinct help in securing neat lines and smooth grades.

Roadway Pipe: One important thing to remember about roadway pipe is the inlet and outlet elevations. The direction of the flow must be recognized before the installation of the pipe. The elevations of the inlet and outlet must be checked so proper flow is achieved. Also, pipe elevation for the inlet and outlet should be

checked against the existing ground elevations, as conditions often change between design and construction. Pipe alignment should be checked so flow will fit existing water ways.

The grade inspector should have good communication with the survey party (private or DOT) to make sure the method of staking is understood.

Lastly, there are some basic points the inspector should know about the survey during the grading project. The following survey checklist should be kept in mind:

a. Reset control points on centerline to include:
   - Mainline
   - Interchanges
   - Sideroads

b. Set all Right of Way pins with markers.

c. Establish a permanent bench mark list. This list should include a bench mark in every bridge and concrete box culvert.

d. Temporary references should be set on all control points as required in Item (a).

N. Tile Exploration

Specification Article 2102.02, H, 3
Construction Manual 6.61

The best procedure for locating tile is to go through and find all existing lines shown on the plans. It is also a good idea to look near cut areas where a draw is located outside the ROW or to talk to the land owners in the area. Trench a minimum of five feet deep inside the ROW line, perpendicular to the tile. Watch closely for evidence of tile lines and record the following: location, depth, size, whether it is dry or running, and direction of flow. Make a rough drawing, in the field, as soon as possible. Make sure the lines are properly spliced to keep them working until they can be replaced. Tiles shown on the plans and not found by trenching may require deeper excavation.

After the tiles are found in an area, a plan for running the lines under the new highway should be made. This may require extra prospecting and elevation shots. Approval shall be made with the project inspector for any work not listed in the plans. Grades should be established for new tile lines when possible. Check the surface for possible intakes and outlets not listed on the plans. Locations and dimensions of subdrains on the plans do not necessarily have to be followed. However, any changes made in the plans should be for a good reason. The best and least expensive methods of keeping the water flowing should be the main consideration.

O. Documentation

There is no doubt that documentation should a priority. For a grading project, there may be more than one diary for documentation.

These could include:

- *Project Diary* which the project inspector is responsible for. This diary may include: summary of contractors' work; conversations with RCE, contractors' superintendents, local property owners, visitors; changes to plans or specifications, documentation of traffic control; work on contract items, etc. In this diary, please indicate the date, time started, time stopped, and whether there was a work day charged. The weather and the average temperature of the day should be recorded

- *Spread Diary* which the grade inspector is responsible for. This diary may include: activity of one or more grading spreads. This diary should consist of superintendent's name, crew number, location of all work done each day. It also should contain the list of each separate contract item the crew is working on. The estimated quantities of contract items for each day should be recorded. In addition, conversations with a foreman, property owners, RCE, project inspector, visitors should be recorded. An equipment log should certainly be a part of this diary.

- *Pipe Diary* which the pipe inspector is responsible for. Similar information as the spread diary should be recorded.

The point of the daily diary is to provide accurate records of daily activities. In many cases, this record has provided the Department with enough information to resolve disputes. A log of equipment used by the contractor can show if a contractor is making a serious effort to complete the project. The inspector is required to keep track of all contract items. Daily quantity of each item should be recorded for payment purposes.

Copies of various inspection forms are located in the Appendix.

P. Preservation of Cultural Resources

Specification Article 2102.03, J
Construction Manual 6.35

Cultural resources are archaeological and historic/architectural resources in an area. A common cultural resource site is a burial ground. If unusual things such as bones, pottery, etc. are found, work should be stopped immediately. Please contact the Construction and Materials Bureau and the Location and Environment Bureau for assistance.

EXCAVATION &
EMBANKMENT CONST

VI. Excavation & Embankment Construction

A. General

To build an embankment, materials are taken from cut areas or borrows and placed in fill areas.

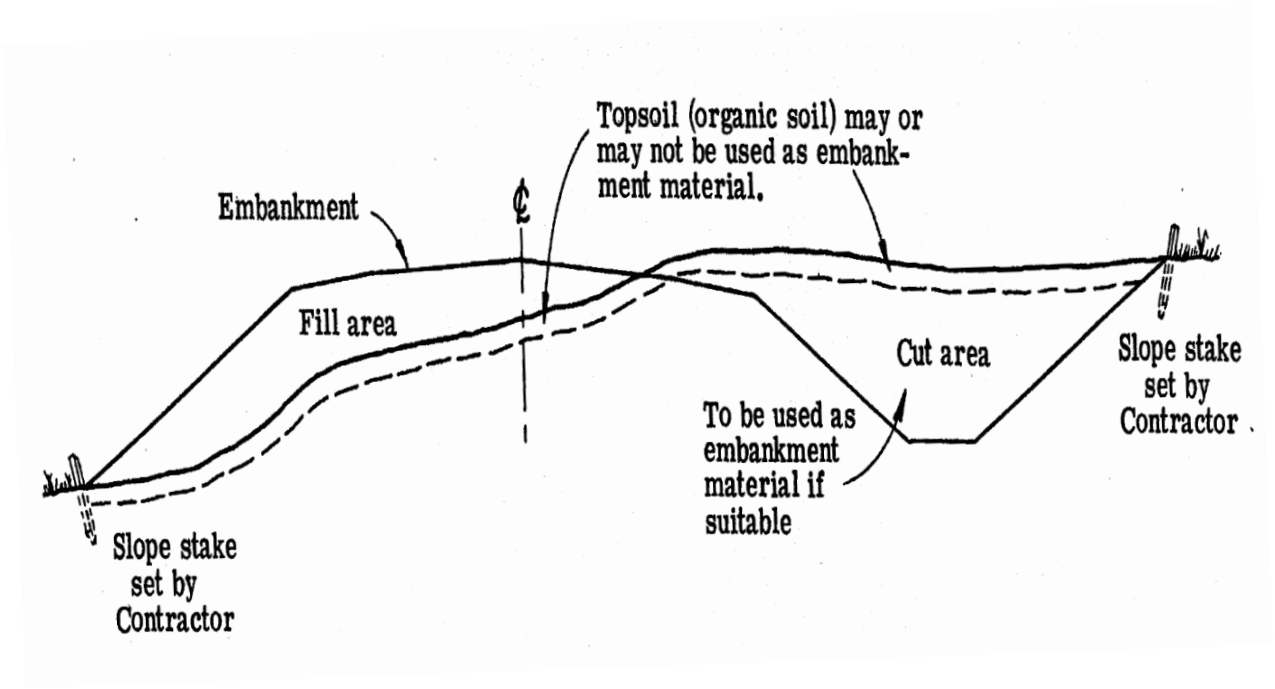


Figure 6-1: Cut and fill areas showing excavation and embankment construction.

B. Classes of Excavation

Specification Section 2102, Roadway & Borrow Excavation

Specification Section 2102 defines three classes of roadway and borrow excavation. They are:

Class 10:

- Normal earth materials such as loam, silt, gumbo, peat, clay, soft shale, sand, and gravel.
- Fragmentary rock or boulders handled in the manner normal to Class 10 excavation.
- Any combination of the above described materials and any other material not classified as Class 12 or Class 13.

Class 12:

- Granite, trap (any fine-grained igneous rock), quartzite, chert, limestone, sandstone, hard shale, or slate in natural ledges or displaced masses.
- Rock fragments or boulders which occur on the surface or in subsurface deposits mixed with earth, sand, or gravel when their size, number, or location prevents them from being handled in a manner normal to Class 10 excavation.

Class 13:

- All Class 10 material plus Class 12 material.
- Any other material encountered

Class 10 material is also used as a term referring to “general fill” or “between select and unsuitable”.

Table 2-5 shows material type and its typical suitability

Other classes of excavation for structures (Class 20, 21, 22, 23, and 24) are in Specification Section 2402.04, J.

C. Subgrade Preparation

Specification Article 2107.03, C, Preparation of the Site

When the height of the proposed embankment is 5 feet or less, sod should be removed after a thorough disking from the area. Sod should then only be placed on the outer portion of the embankment.

Depressions or holes below the original ground should be filled and compacted with suitable material before any lifts are placed. Also, pavements and bases should be broken up and removed.

D. General Embankment

Specification 2107.03, D, Depositing Embankment Material

The key to a successful earthwork operation is uniformity. As an inspector, you should understand that non-uniform operations -- particularly uneven placement -- may cause the embankments to have failing densities or non-uniform settlement.

The equipment and procedures involved in the dumping and spreading of the embankment material will depend largely on the type of equipment the Contractor has on the project and the type of material being used.

Embankment material is spread and leveled in layers or "lifts." As the material is dumped, it is typically spread to the full width of the embankment. Each lift must be compacted before the next lift is placed.

An inspector should closely observe the Contractor's spreading and leveling operations to see that the layers are uniform and that they are not thicker than the maximum loose thickness of 8-inches per Specification 2107.03, D. When it appears that the Contractor is not meeting these requirements, you should check the thicknesses being placed.

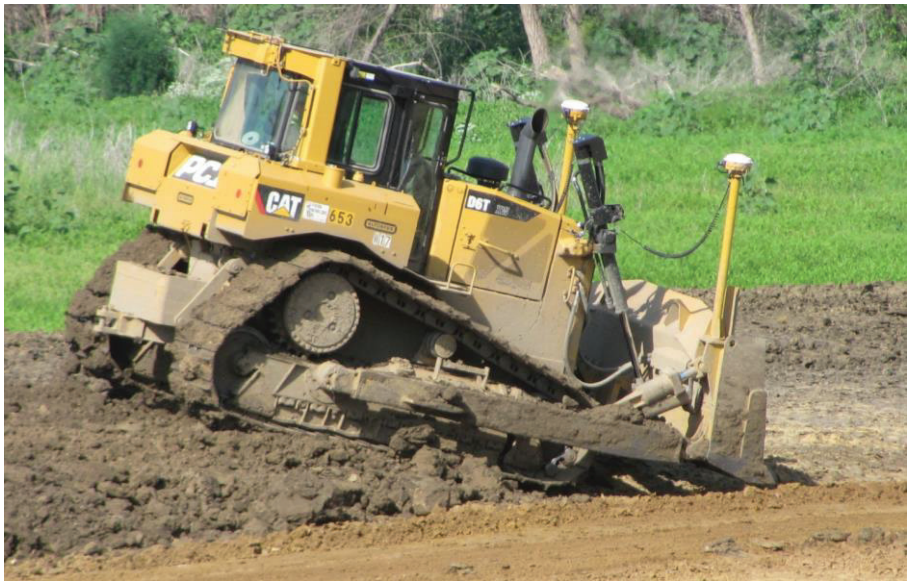


Figure 6-2: The Contractor must construct embankments uniformly and in lifts not to exceed 8-inches in loose thickness.

The Contractor must also use the procedures and equipment necessary to meet moisture or moisture-density requirements (if required by the contract). This will be discussed in a later section.

Embankments should not be constructed using frozen materials or on frozen ground. Compaction of soil during cold weather is very difficult. Water acts as a lubricant aiding in compaction. As the temperature decreases, the water becomes more viscous (less slippery) and inhibits efforts to pack the soil particles together. Eventually, the water becomes ice, at which point compaction is impossible. Figure 6-3 shows the effect of freezing temperatures on the proctor curve of a soil.

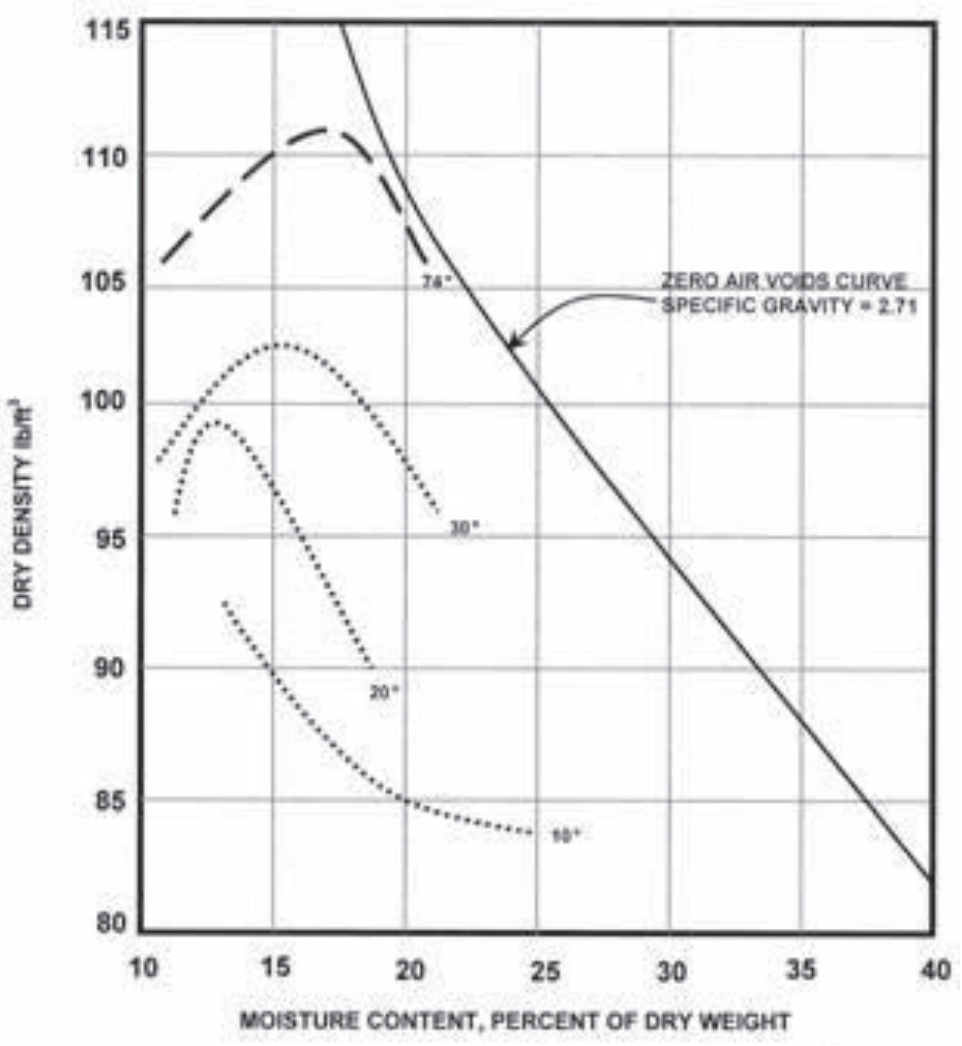


Figure 6-3: Proctors curves shown for the same soil compacted at Different Temperatures

Embankments should not be constructed of materials containing muck, stumps, or other material that will not compact into a strong and stable roadbed. All materials designated as undesirable (by the specifications or the Engineer) must be removed and disposed. Soils containing roots, sods, or other vegetable matter may be placed in the embankment outside of the shoulder line and within the outer 3 feet of the embankment.

The specifications don't allow the contractor to place rocks in the area from grade line to two feet below the finished grade line. The photo below shows a subgrade that was trimmed prior to paving and rocks that were placed too high in the embankment that required removal.

Figure 6-4: Rocks that required removal prior to paving

Disking is required if deposited material contains an average of more than 1 lump per square yard large enough to have at least one dimension greater than 12-inches. The disk used needs to cut and stir the full depth of the layer.

Figure 6-5: Disking helps break up clods that would prevent uniform compaction.

E. Placement of Unsuitable Material

Specification Article 2107.04, N, Use of Unsuitable Soils
Specification Article 2102.03, D, Removal of Unsuitable or Unstable Soil and Placement of Selected or Special Backfill Material

Unsuitable soils may be used in embankments according to Standard Road Plan EW-102. Peat and muck are not allowed in to be placed in embankments. They are very low in strength, and if placed in the embankment could cause settlement issues due to their high compressibility.

Be aware that even if these unsuitable materials are shown in the plans, it is often difficult to quantify. The area extent and depth may be different then that was assumed in the plans.

If unsuitable or unstable material is removed, in most cases, select or suitable material or special backfill may be used as backfill material.

F. Type of Compaction

Specification 2107.03, E Type A Compaction

If a type of compaction is not specified, Type A compaction will be required. Type A compaction required a minimum of one rolling per inch lift depth. Roller walk-out is also a requirement. This means that the roller is supported entirely on its feet and the feet penetrate no more than 3 inches into an 8 inch lift.

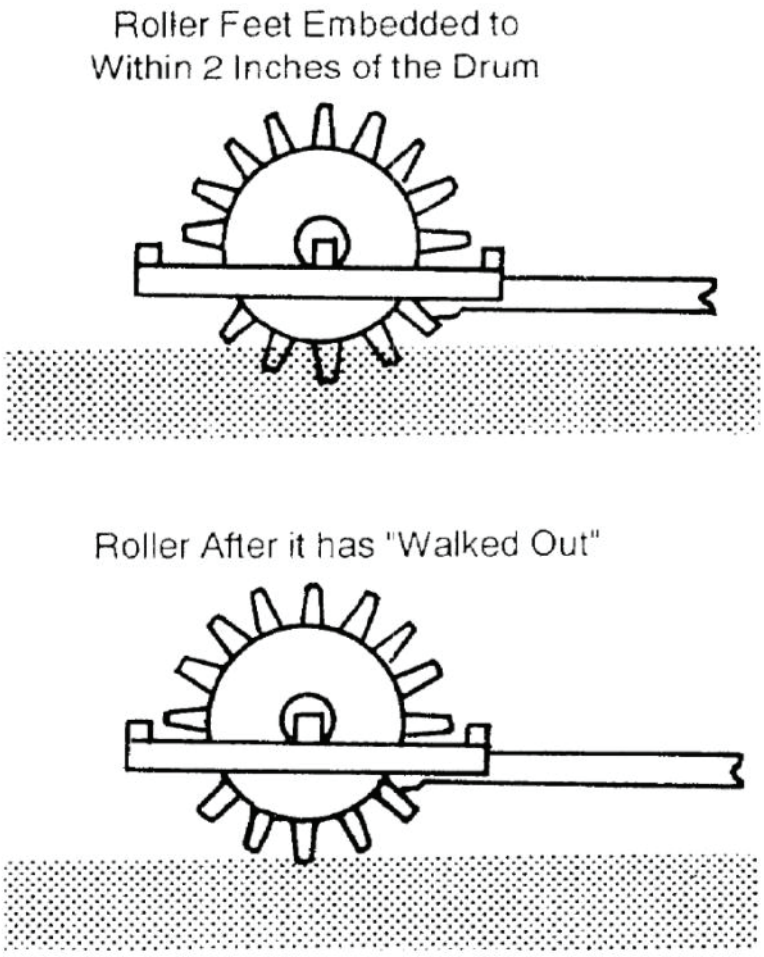


Figure 6-6: Illustration of Roller Walk-out

For cohesive soils, a sheepsfoot roller should be used. However, for granular soils, a sheepsfoot is not appropriate and a vibratory roller is the preferred equipment. Section 6.41 of the Construction Manual has more detailed information on equipment and how to determine the roller pressure.

Since different soils behave differently, the same pattern and same equipment for all soils may not be appropriate. For example, with the proper moisture content, the compactive effort to get good density should be lower. The specifications allow for other compaction methods to be used f the contractor demonstrates that suitable compaction is achieved. This means that some density be taken at the beginning using methods such as nuclear density, etc. The test procedure for density testing is included in a later section. Some information to keep in mind is the lift thickness should not be more than two inches thicker than the length of the tamping feet.

The contract may also require Compaction with Moisture Control or Compaction with Moisture & Density Control. These will be discussed in a later section.

G. Equipment

Specification Article 2001.05, A, Soil Compaction Rollers
Specification Article 2107.03, B Equipment

The specification requires soil compaction rollers to be sheepsfoot-type rollers with feet projecting no less than 6 ½ inches from the surface of the drum. The roller also needs to be loaded so that no less than 200 psi is exerted on a single row of feet parallel to the axle of the drum. It is important to check the pressure of the roller.

Figure 6-7: Sheepsfoot roller feet should project no less than 6 ½ inches

The specifications also require a different type of roller in the compaction of sand or granular material. In these cases, a self-propelled vibratory or pneumatic roller should be used.

H. Compaction with Moisture Control and Compaction with Moisture & Density Control

Specification Sections 2107.03, H & I Compaction with Moisture & Density Control & Compaction with Moisture Control, and P Quality Control Program (Embankment Construction)
IM 540

As discussed in Chapter 2, proper moisture content and uniformity of moisture is essential to proper compaction. You may encounter moisture content variance depending on location, topography, soil type, climate and depth of excavation. If material is too wet or too dry, it will require moisture conditioning, such as:

- Too Dry: Watering via trucks and mixing into soil – disking
- Too Wet: Disking, ripping, blading, blending, sun and wind

Check your project's bid items to determine whether compaction with moisture control or compaction with moisture and density control are required. On projects where the DOT is the Contracting Authority, quality control (QC) testing is the contractor's responsibility. If it is a local agency project, also check the plan notes to see if the QC testing has been assigned to the contractor.

If your project has "Compaction with Moisture Control", the plans will typically include a tab (Tab 103-6) regarding moisture requirements. Specification Article 2107.03, I also provides moisture content range (plus and minus % of optimum moisture content). If your project has "Compaction with Moisture and Density Control", the plans will typically include a tab (103-1) or plan notes regarding moisture and density requirements. Specifications Section 2107.03, H also provides density requirements and moisture content range for embankments.

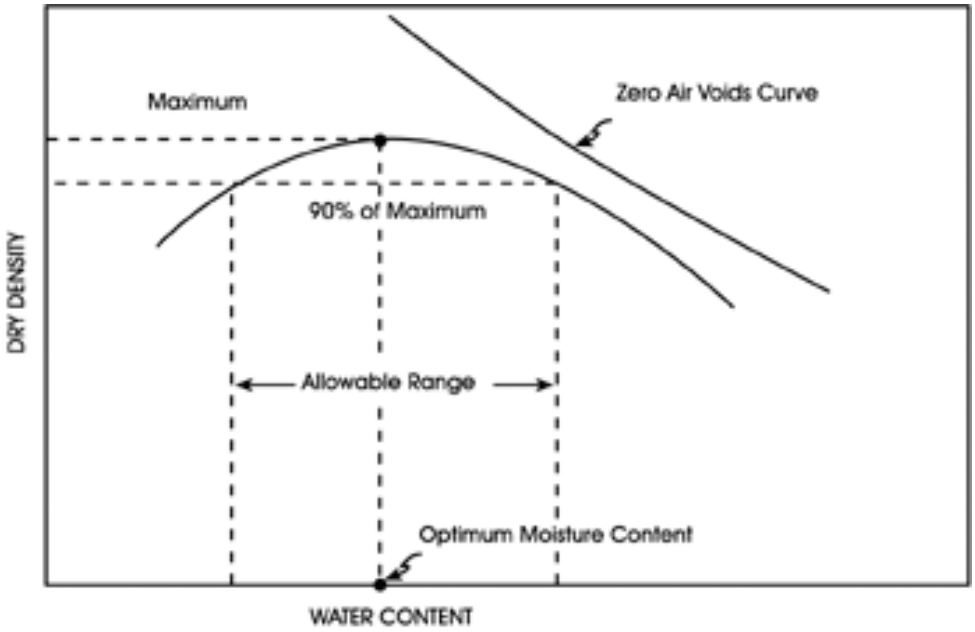


Figure 6-8: Proctor curve showing allowable range for moisture content and a requirement for 90% compaction.

I. Density Testing

IM 334: Determining Moisture Content & Density of Soils, Bases, Subbases with a Nuclear Gauge
IM 204, Appendix A: Sampling & Testing Guide-Minimum Frequency: Roadway & Borrow Excavation & Embankments

If required by the contract, density tests must be performed as embankment lifts are placed and compacted. The tests are performed according to frequencies in IM 204, Appendix A. In addition to the moisture-density tests, samples of embankment materials must be obtained

to perform proctor tests, which determine maximum dry density and optimum moisture content.

Whenever the result of a density test fails, you should immediately run another test close to the first one. It may be that an error was made in running the first test and the result was incorrect. If the result of the second test also fails, you can likely conclude that the density is insufficient. Once corrective action has been taken, retest the area. The area must meet the minimum density requirement before accepting it.

As an inspector, you should not tell the Contractor HOW to correct the situation. Rather, the Contractor is responsible for deciding how to correct it.

Each layer must be compacted as required before successive lifts are placed.

Figure 6-9: Nuclear gauge test used to determine in-place density of a compacted lift.

A nuclear density gauge consists of a radiation source that emits a directed beam of particles and a sensor that counts the received particles that are either reflected by the test material or pass through it.

The nuclear gauge determines moisture by releasing “fast” neutrons that are slowed down, or thermalized, when they interact with the nucleus of hydrogen, a key ingredient of moisture.

Nuclear density gauges are typically operated in one of two modes:

1. “Direct transmission" is based on the amount of radiation that passes through the material and is measured by drilling a hole in the material and lowering the retractable rod into the ground.

2. "Backscatter" is based on the amount of radiation that is deflected by the material and is measured by placing the gauge on the surface of the material.

IM 334 provides the test procedure for using a nuclear gauge to test for moisture and in-place density of soils and bases. The procedure for density requires the use of direct transmission, the more accurate mode.

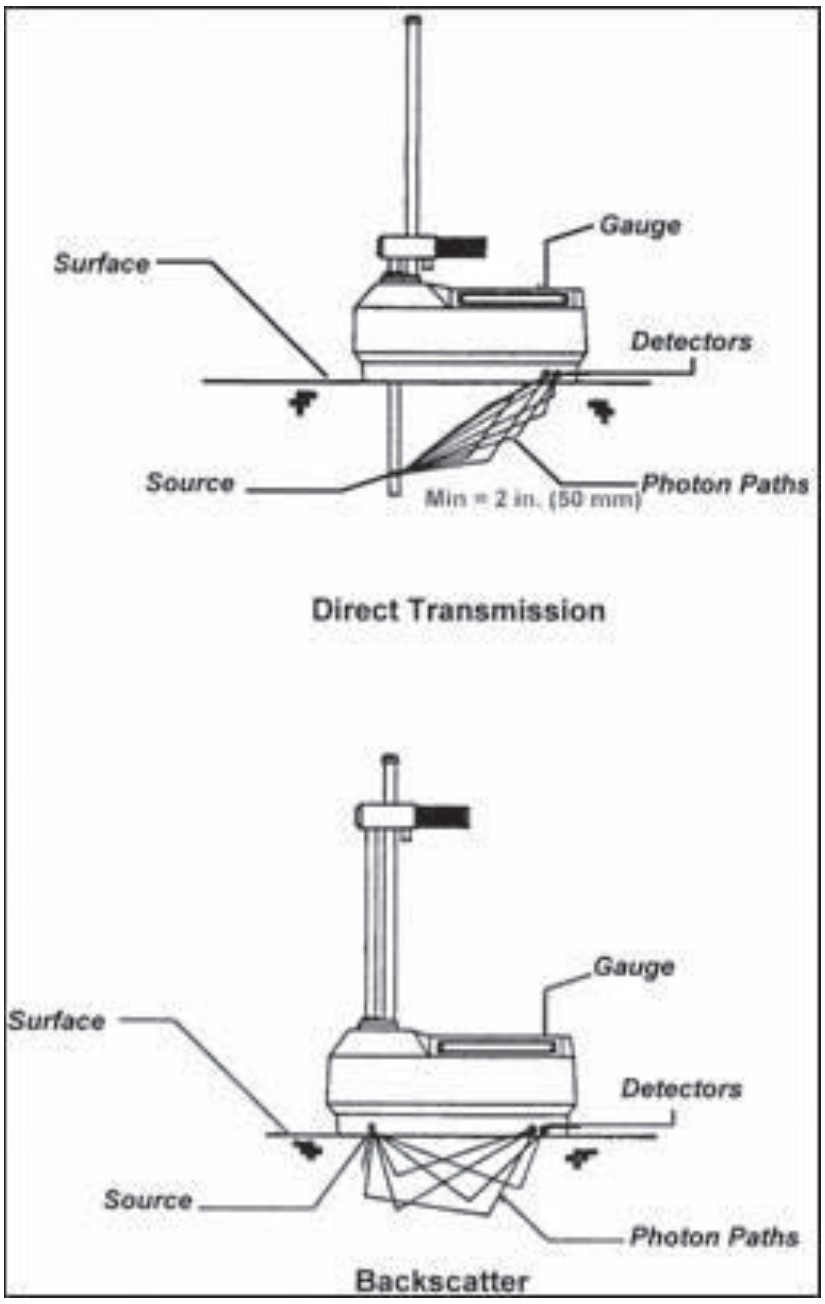


Figure 6-10: Direct Transmission and Backscatter uses of nuclear gauge

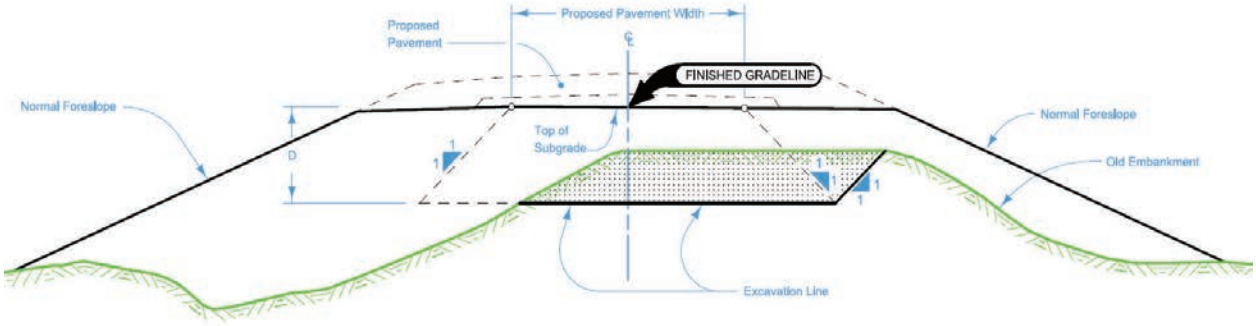
A disadvantage of this instrument is the safety precautions that have to be taken into account. If you are to use a gauge, you must follow your agency's training and safety requirements.

The Iowa DOT's Soils Technician course provides additional instruction on moisture and density tests.

J. Rebuilding Embankment

Specification Article 2107.03, L, Rebuilding Embankments

Plowing and shaping is required when constructing a road partly over a new embankment and partly over and old. Standard Road Plan EW-101 illustrates the portion of the existing embankment that is required to be rebuilt. The plans should include Tab 107-31 that provides the location of this work.



TYPICAL CROSS SECTION REBUILDING EMBANKMENT
(Plowing and Shaping)

107-31
04-19-11

PLOWING AND SHAPING

Refer to Standard Road Plan EW-101

Station to Station	D FT	Remarks

Figure 6-11: EW-101 and Tab. 107-31 for Plowing and Shaping

K. Step/Bench Cutting Procedure

Specification Article 2107.03, C, Preparation of Site

When an embankment is placed on or against an existing slope which is steeper than 3:1 and is more than 10 feet high, the Contractor is required to cut the slope into steps or benches to key the new fill into the existing slope. Without benching, the sloping original ground surface creates a natural plane of weakness. Benching breaks up the potential failure plane, thus increasing the stability of the entire slope.

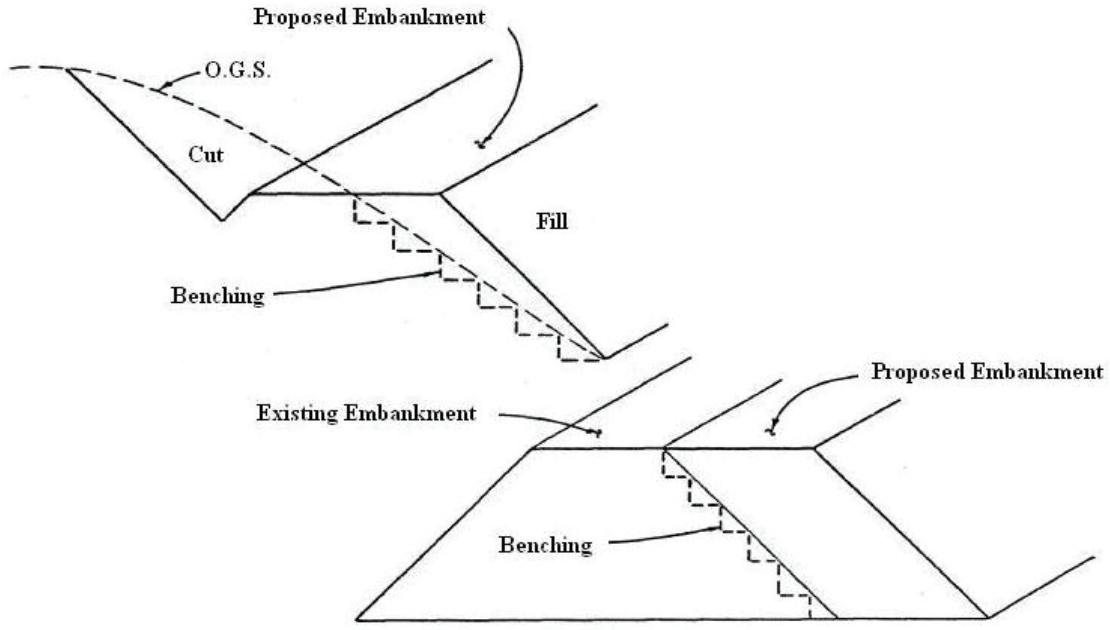


Figure 6-12: Benching breaks up the potential failure plane, thus increasing the stability.

In some cases (such as if there is a shallow bedrock surface), it might be necessary to key into the bedrock to improve the stability of the slope by intercepting the failure surface at the soil-bedrock interface.

L. Surface Drainage

Specification Article 2107.03, D, Depositing Embankment Material

When construction will be suspended for a period during which rain is likely to occur, the Contractor is required to smooth the surface to produce a smooth and compact surface to shed water. This will allow adequate drainage on the embankment surface.

It is to the contractor's advantage to control surface runoff so that damage to completed work will be minimized and their operations will not be hindered.

Ditches are designed to collect surface runoff that otherwise would flow down the slope and pond in low areas. This water can cause erosion, problems with cut-slope stability, and saturate areas that are to be excavated. By delaying ditch work, the Contractor will create problems that are not only costly to correct but may also delay operations.

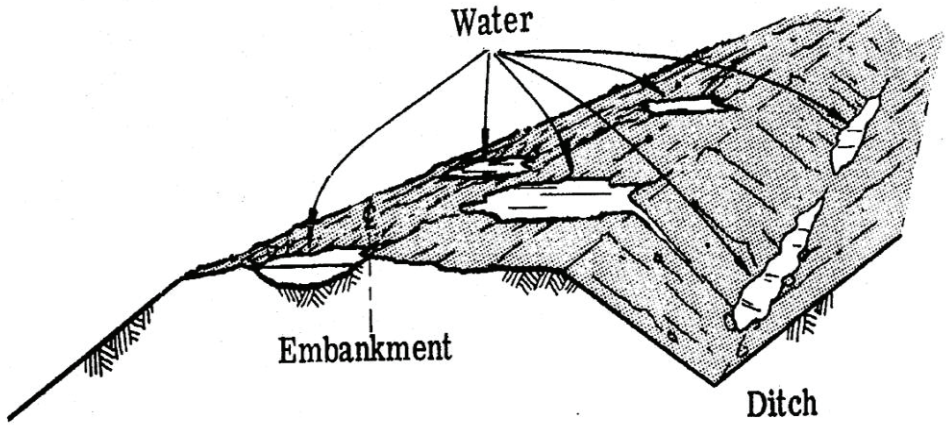


Figure 6-13: Improper drainage from work areas may delay the Contractor.

M. Finishing

Specification Articles 2102.04, K, Finishing and L, Grading for Paving

The contractor shall finish the excavation to the specified or designed grade and cross section. This means the excavation should be reasonably smooth and uniform to the lines, grades, and cross-sections shown in the plans. When grading work is done before a separate paving project, the grading contractor is required to build the roadbed so that it is not lower at any point than the designed subgrade elevation and so that is it not above the designed subgrade elevation by more than 3-inches.

N. Borrow Requirements

Specification Article 2102.03, F, Borrow
Construction Manual 6.34 & 6.35
IM 545

Borrow excavation consists of excavating suitable materials obtained from borrow locations furnished by the Contracting Authority or the contractor and transporting the materials to various locations throughout the limits of the contract.

For onsite borrows, the contractor shall excavate the area so that it is sufficiently regular in cross section to allow for accurate measurements. The borrow site surface shall also be

bladed so that it is shaped to be consistent with the existing natural drainage conditions or as shown in the plans.

Unless a mandatory onsite borrow is required, the contractor is allowed to furnish equivalent material from an alternate borrow. The contractor is then required to submit a plan for alternate borrows or designated borrows to be used in a manner different than that shown in the plans. Plan includes expected quantity and type of material available and test sample reports – similar to what is provided for borrows provided within right-of-way.

For contractor furnished borrow quantities greater than 10,000 cubic yards, the Contractor is required to sample and test according to Materials I.M. 545. Processing and approval of these submittals is detailed at the end of the I.M.

For contractor furnished borrow quantities less than 10,000 cubic yards, the Contractor is required to provide verification samples to the Engineer.

For alternate borrows or contractor furnished borrows, the Contractor is responsible for obtaining the necessary permits and clearances for the sites. Construction Manual 6.34 provides a list and contact information to help the contractor determine impacts.

"FAQ's for Environmental Considerations, Permits, & Clearances" also provides information regarding permits and clearances (available at https://iowadot.gov/construction_materials/FAQs/Environmental).

O. Settlement Plates

Standard Road Plan EW-212
Specification Section 2106, Settlement Plates.

When a proposed fill is built over a layer of compressible soil, a settlement plate may be required if the time rate of settlement is critical for any reason. This plate is used to determine whether or not the predicted settlement has occurred. It is also used to determine whether or not the consolidated strength at a certain time is enough to allow the additional fill on top. Tab 103-5 in the plans will show locations where settlement plates are to be installed. Elevations of the settlement plates are normally taken every week during the construction. There is a form to record elevations available at: http://www.iowadot.gov/Construction_Materials/earthwork_erosion/Settlement_Plate_Data_Form.xls

The elevation readings are forwarded to Soils Design for monitoring purposes. It would be very helpful to Soils Design to have the exact elevation of the plate on the report.

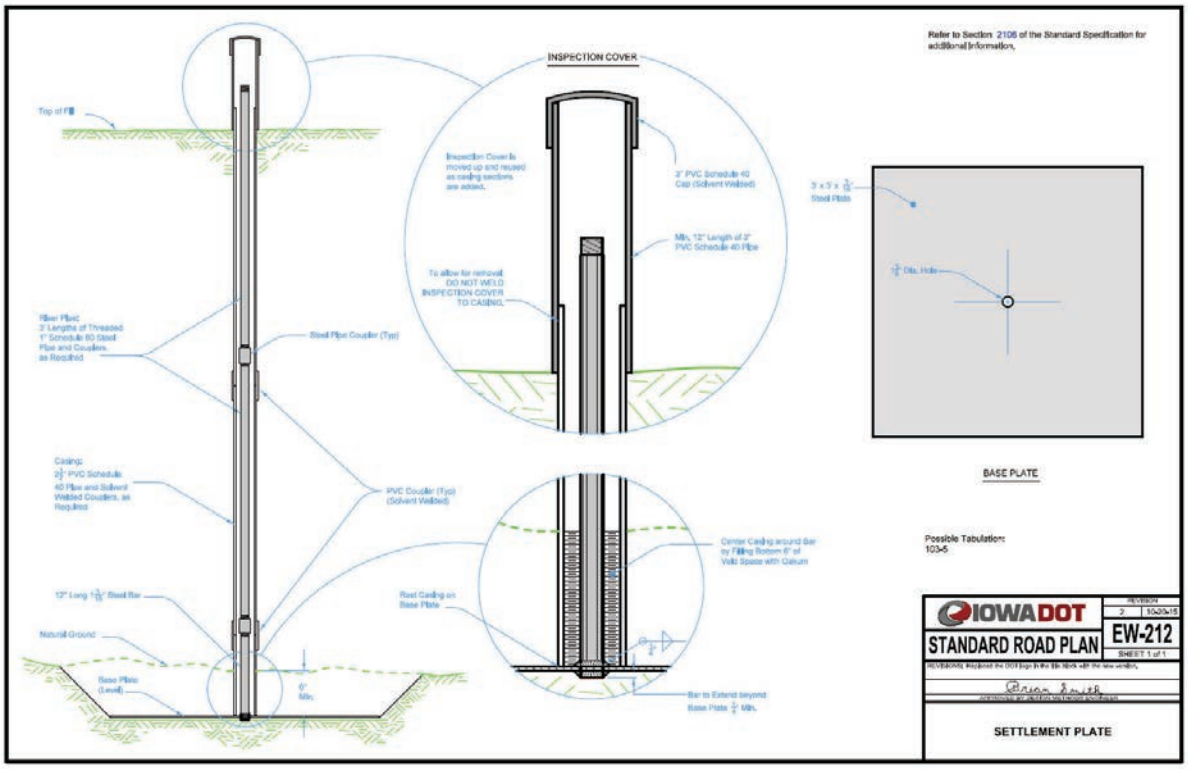


Figure 6-14: Standard Road Plan EW-212

Figure 6-15: Photo of an installed settlement plate prior to placement of embankment

P. Structure Excavation

Specification Section 2402, Excavation for Structures

To provide room for structure construction, it is common to over-excavate the soil from the sides of the structure. Whenever an open excavation is needed, the contractor is responsible to excavate a safe slope or use temporary shoring. The contractor is also responsible for complying with Occupations Safety and Health Administration (OSHA) requirements.

Contractor should not place fill against or over new abutments, wingwalls, piers, or box culverts until at least 14 calendar days to elapse after concrete has been placed.

The Structures Field Inspection course provides more information on excavating and placing backfill at structures.

Figure 6-16: Contractor should not place backfill at box culverts until at least 14 days after concrete has been placed.

Q. Quantities

Specification Article 2102.04

Payment for Class 10 is made for the quantity as shown in the contract documents. However, the specifications allow for the contractor to request actual measurement or for changes that come up during construction.

Measurements will be made by cross sectioning of the area excavated before and after excavation for Class 12 and 13. Quantities will be computed from the cross section measurements by the average end area method. Preliminary cross sections shown in the contract documents will be used.

Average end area method is as follows:

$$V = \frac{A_1 + A_2}{2} L$$

Where:

- V= Volume
- A_1= Cross section area of first side
- A_2= Cross section area of second side
- L= Length between the two areas

R. Other Fill Material

1. Expanded Polystyrene (EPS)

EPS (Expanded Polystyrene) or geofoam is a lightweight material that can be used as embankment materials. EPS is typically about 1% of the weight of natural soil materials and about 10% the weight of most other lightweight fills.

EPS blocks can be cut to size and placed like Legos to construct an embankment. The surface of the EPS embankment typically requires a geo-membrane liner to prevent contact with fuel, which will disintegrate the material.

EPS blocks should not be placed near water structures as they will float.

In non-paved areas, the EPS embankment is topped off with soil to allow for vegetation. In paved areas, a thick base course is required (usually a thickness of frost-depth) to ensure the EPS is not damaged and to avoid early freezing of roadways during winter.

2. Lightweight Foamed Concrete Fill (LFCF)

Lightweight foamed concrete fill (LFCF) (also called cellular concrete) is a low density material made by the injection of a foam into a cement-based slurry. Based on design, the density can be from 15 to 120 pcf. The material has a greater bearing capacity than natural soils. It is pumped like concrete and self-levels. No compaction is required.

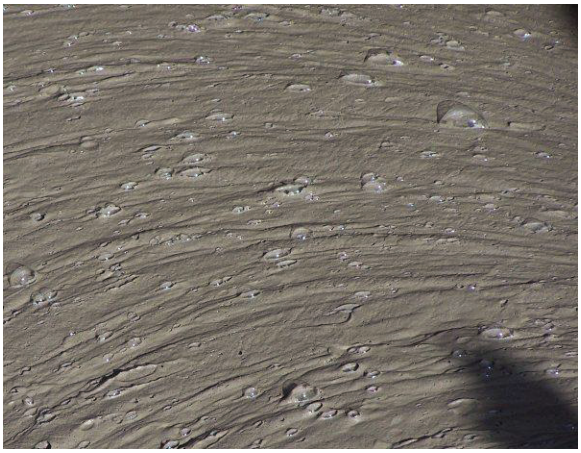


Figure 6-17: Close-up view of LFCF

S. Slide Repair Procedures

Sometimes the water table is high on the backslope. This could potentially cause backslope failures. Other times when wet material is used, foreslope failure may occur. This failure sometimes happens because the excess water in the fill material has prohibited proper compaction. When failure like this happens, some sort of drainage with porous backfill and/or a stone key is frequently recommended. If the problem is extreme, a toe berm is also sometimes added.

Please keep in mind since the slope is already failing, minor mistakes would cause severe problems. Following are some recommended procedures to follow:

For Bench Cutting to Install a Subdrain
Benches and drains are common on an unstable backslope. Keep in mind the slope is already failing. The only thing in this situation that would keep this slope from complete failure is the resistant weight at the toe. The higher the backslope, the more critical it would be. The best thing to do is to give the Construction and Materials Bureau or Soils Design a call to let them know there is a problem. A field visit may be necessary.

If a backslope subdrain is proposed, this *does not mean let's excavate the toe open for some time to see what would happen.* Care must be taken to remove a small portion at the toe and install the subdrain before moving to the next portion. A stone key is not normally required. However, if one is called for, please ask for a specific design and procedure.

For Bench Cutting to Install a Stone Key and an Additional Berm

This procedure is normally done when the embankment experiences some failure on the foreslope. Reworking the foreslope by making some benches and adding a stone key at the toe usually are recommended. If the failure is significant, a toe berm may be needed. As previously mentioned, the slope is already in an unstable condition and the resistant weight at the toe or lower portion of the slope is very important. The best thing to do is to ask for help from Soils Design and the Construction and Materials Bureau. In most cases, a specific design and procedure must be followed.

In some instances, the weight at the top may have to be moved down to the toe first. A portion of the berm may have to be built before installing the stone key or cutting any benches. The soil from the upper portion may be brought down to build the lowest bench. From there, a step by step procedure is followed for every bench. Once again, please follow the given design and procedure.

T. Safety

The leading cause of highway construction worker injuries and fatalities is contact with construction vehicles, objects, and equipment. Being aware of the equipment around you and understanding the blind spots can help you avoid runovers/backovers.

Figure 6-18 shows the blind area diagram of a one manufacturer's haul truck. The orange area is the blind area and the blue-lined areas are only viewable by the driver using the mirror.

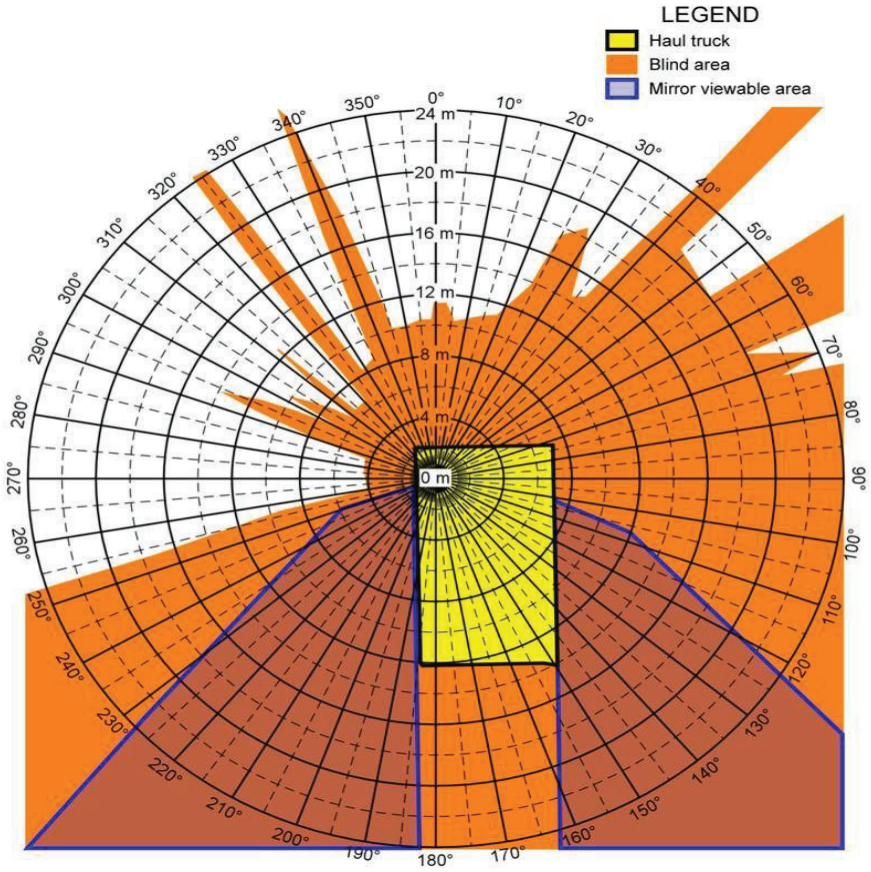


Figure 6-18: Haul truck blind area diagram.

U. Dust Control

Construction Manual 2.12

"Fugitive Dust" is defined as that dust which drifts beyond the lot line of property on which dust is raised (for example, beyond the ROW line). Fugitive dust must be controlled when it creates a nuisance. Whoever is responsible for raising dust is responsible for controlling it. A nuisance must bother a person.

Specification 1107.07 requires the contractor to control fugitive dust raised on the project or in contractor's plant area. Contractor is to be paid for watering construction

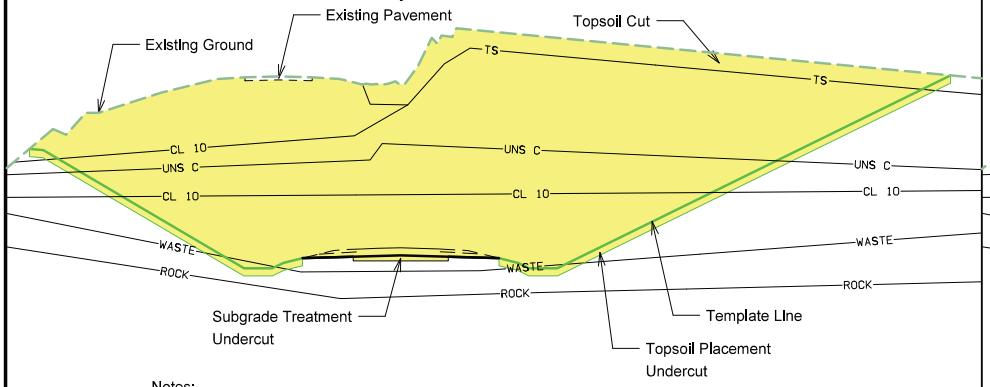
areas adjacent to primary and interstate roads on which traffic is maintained.

If the Iowa Department of Transportation designates a haul road or return route over a gravel county road, the DOT is responsible only for dust in excess of that caused by ordinary traffic.

Figure 6-19: Haul roads or the project site may require application of water for dust control.

T SHEETS

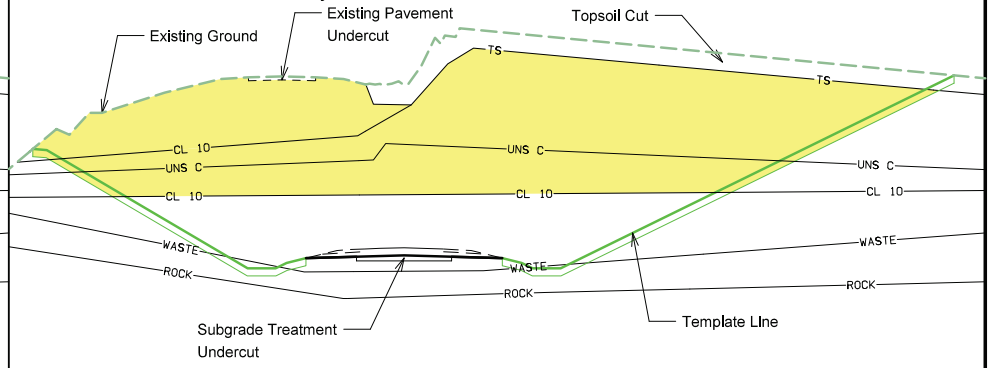
CUT SIDE Total Cut Unadjusted — RURAL



Notes:

1. "Total Cut Unadjusted" Column Includes all cut values In the Station Range based on Typical, Topsoil and Subgrade Treatment needs.
2. "Total Cut Unadjusted" does not include and Existing Pavement values inside or outside the cut template as shown on cross sections.
3. Tabulated Plowing and Shaping operations are included in the "Total Cut Unadjusted" values.

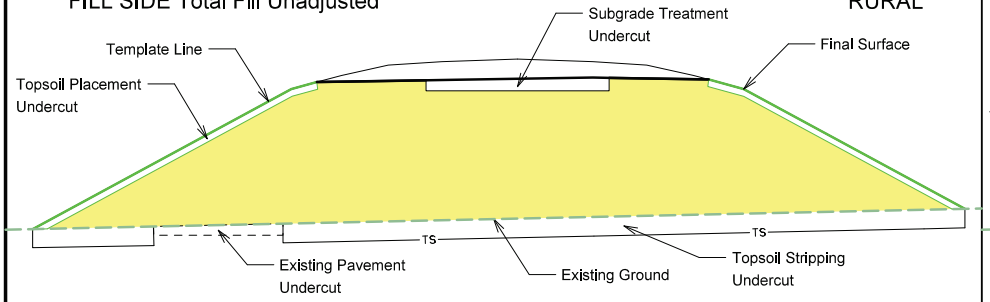
CUT SIDE Total Cut Adjusted



Notes:

1. "Total Cut Adjusted" Column Includes all cut values usable as Class 10 material.
2. "Total Cut Adjusted" does not include and Existing Pavement , Existing Topsoil, or material to be wasted.

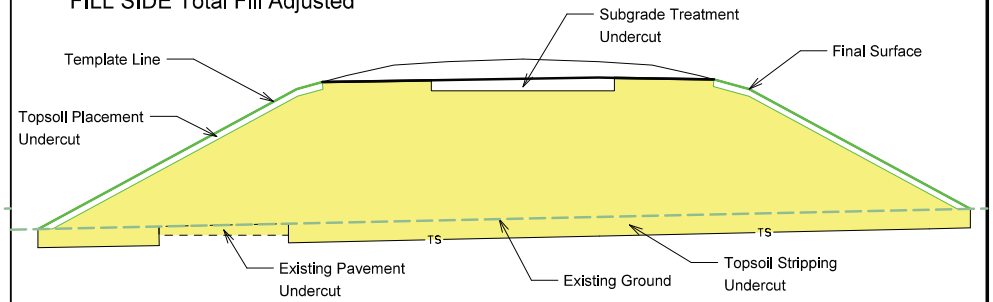
FILL SIDE Total Fill Unadjusted — RURAL



Notes:

1. "Total Fill Unadjusted" Column includes all Class 10, 12, and 13 fill. This excludes the topsoil, subgrade treatment, subbase, new pavement, and shoulder fill needs in that station range.
2. "Total Fill Unadjusted" Column does not include adjustments for additional fill from cuts such as existing pavement removed, plowing and shaping operations, entrances, dikes, or topsoil stripping.

FILL SIDE Total Fill Adjusted

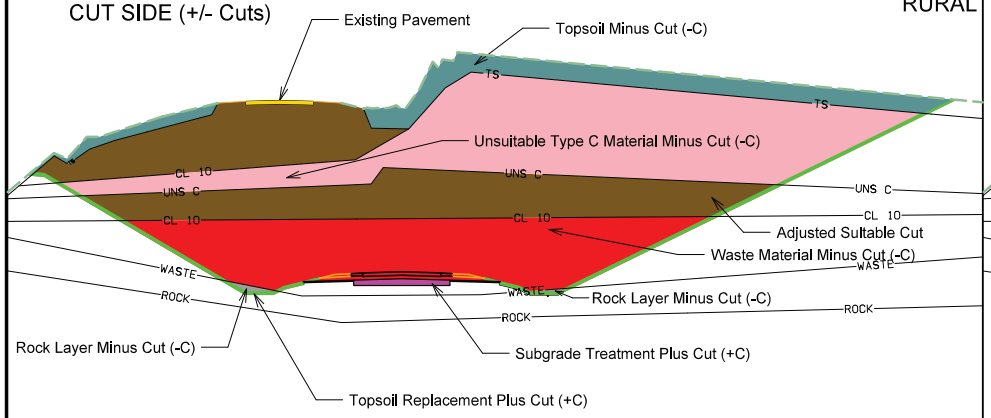


Notes:

1. "Total Fill Adjusted" Column includes all Class 10, 12, and 13 fill and adjustments for additional fill from cuts such as existing pavement, plowing and shaping operations, entrances, dikes, and topsoil stripping.
2. The available area to place unsuitable materials in the T Sheet tabulation does not include the undercut values from the topsoil stripping, existing pavement, or plowing and shaping

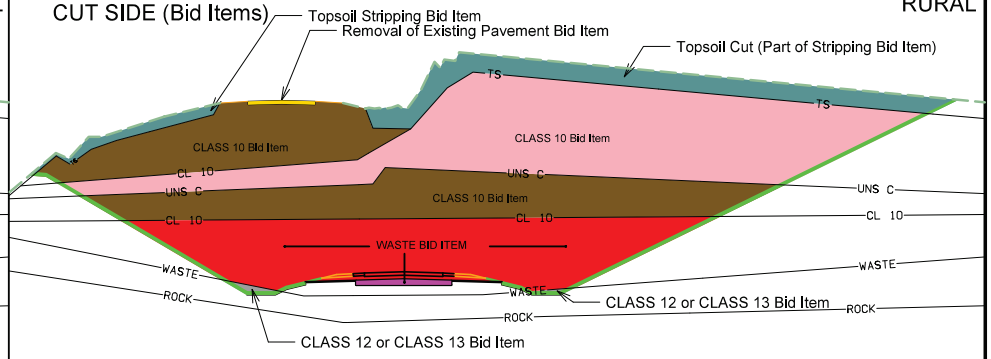
CUT SIDE (+/- Cuts)

RURAL



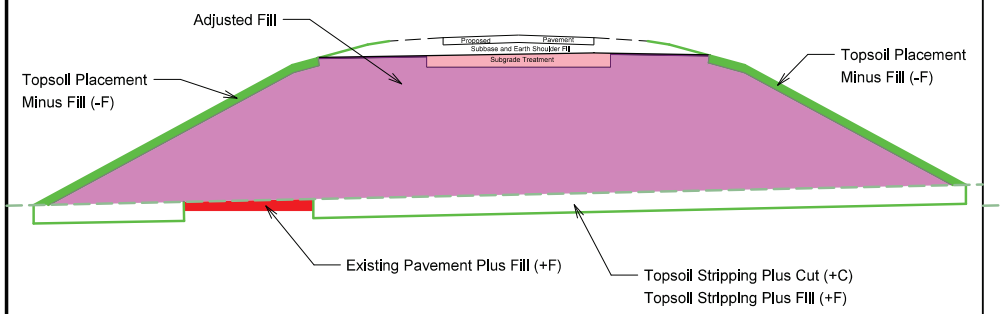
CUT SIDE (Bid Items)

RURAL



FILL SIDE (+/- Fills)

RURAL

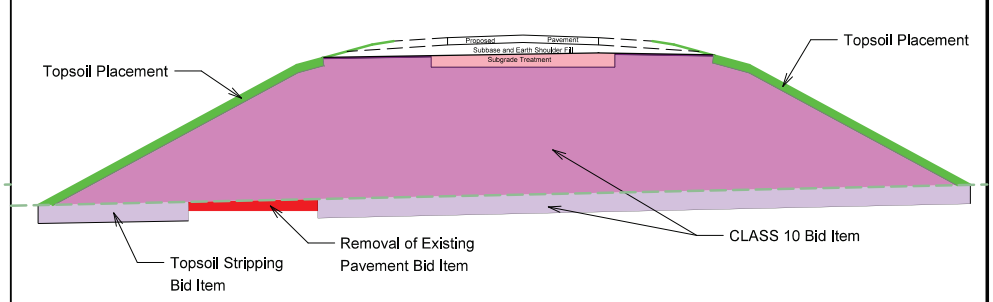


Notes:

1. "Add Quantity +C" columns are additional cut encountered that is not Typical, Topsoil, or Subgrade Treatment Based. (Entrance, Dike, Etc.)
2. "-C" columns are either soil types or Class 10, 12, or 13 designated material that is encountered in the cut station range that is paid for by other bid items.
3. The "(SoilType) Cut" columns are soil types encountered in the cut that are paid by either Class 10, 12 or 13.
4. The "Adjusted Clas (10,12 or 13)" columns are the sum of all various soil types encountered in that station range, that are paid by Class 10, 12, or 13 bid items.
5. Refer to Standard Road Plan EW-102 for placement of unsuitable soil types.

FILL SIDE (Bid Items)

RURAL



Notes:

1. Refer to Standard Road Plan EW-102 for placement of unsuitable soil types.

FILE NO.	ENGLISH	DESIGN TEAM Project Manager\Designer	County COUNTY	PROJECT NUMBER	SHEET NUMBER T.1B

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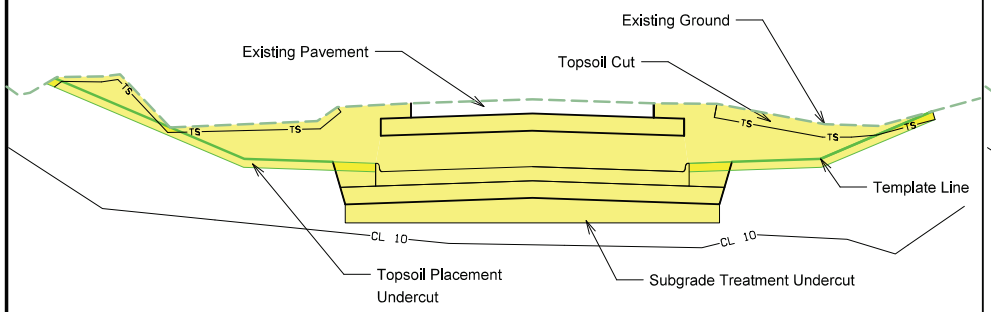
CUT SIDE Total Cut Unadjusted — URBAN



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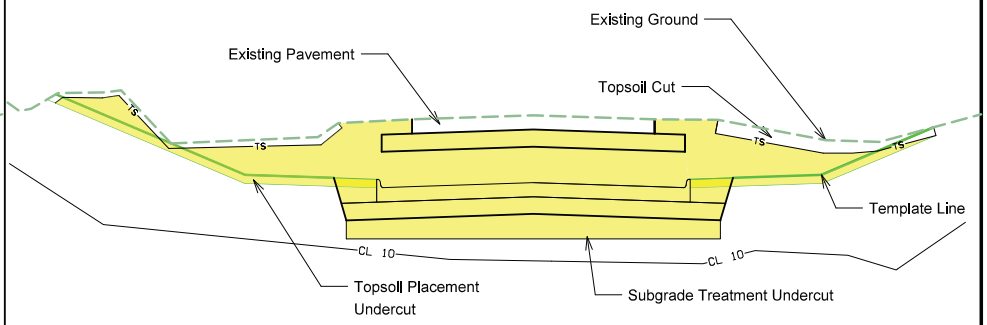
CUT SIDE Total Cut Adjusted — URBAN



Notes:

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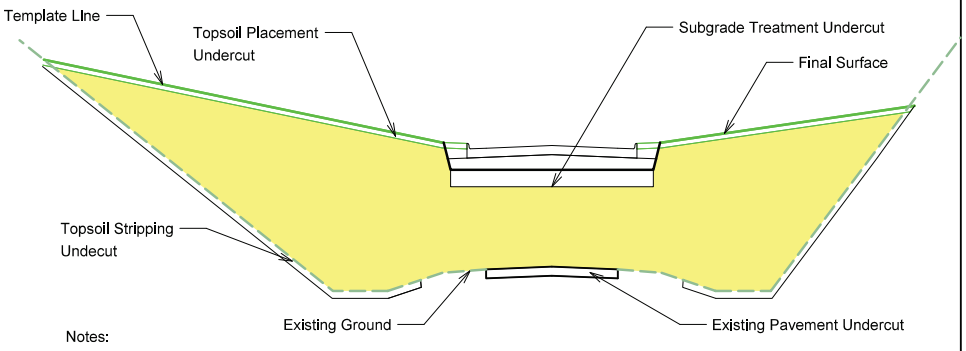
FILL SIDE Total Fill Unadjusted — URBAN



Notes:

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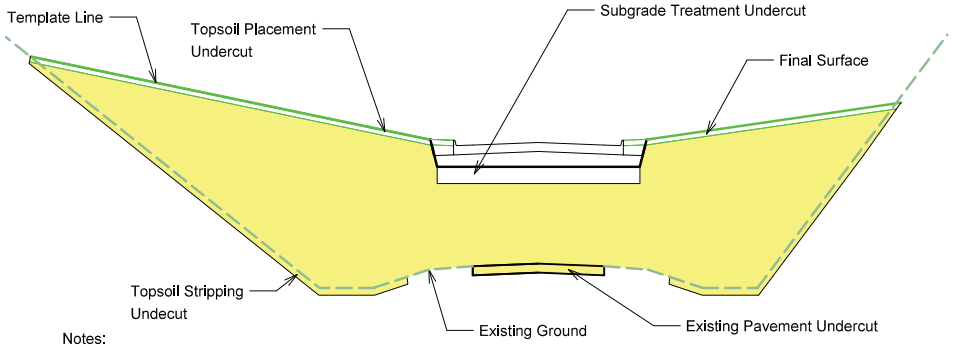
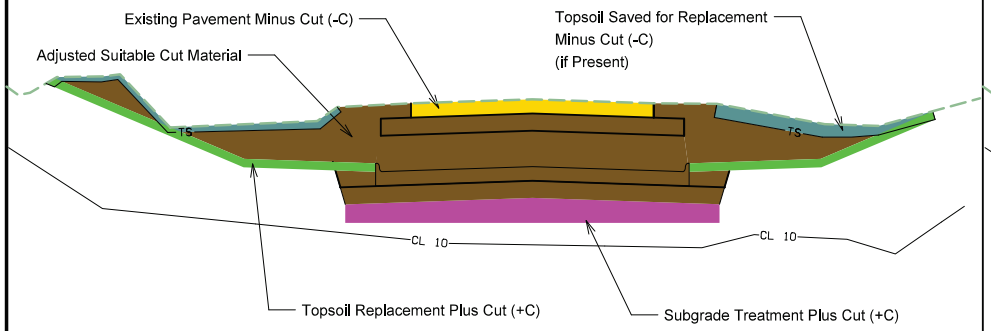
FILL SIDE Total Fill Adjusted — URBAN



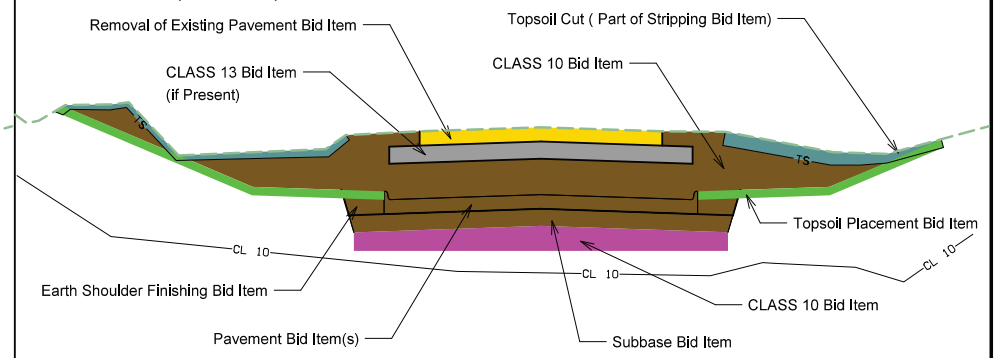
Notes:

1. "Total Fill Adjusted" Column includes all Class 10, 12, and 13 fill and adjustments for additional fill from cuts such as existing pavement, plowing and shaping operations, entrances, dikes, and topsoil stripping.
2. The available area to place unsuitable materials in the T Sheet tabulation does not include the undercut values from the topsoil stripping, existing pavement, or plowing and shaping

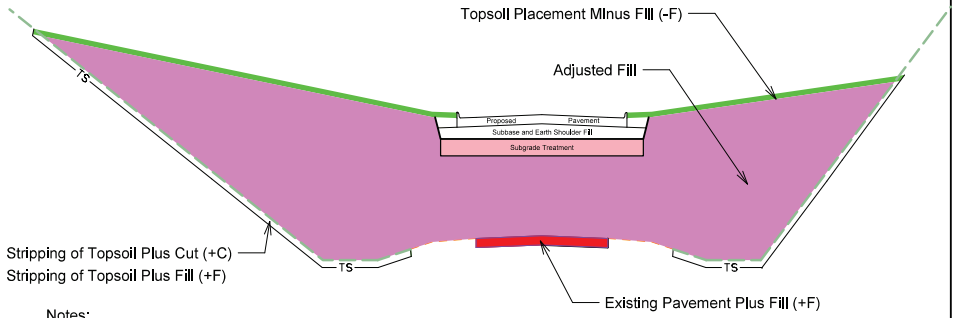
CUT SIDE (+/- Cuts) — URBAN



CUT SIDE (Bid Items) — URBAN



FILL SIDE (+/- Fills) — URBAN



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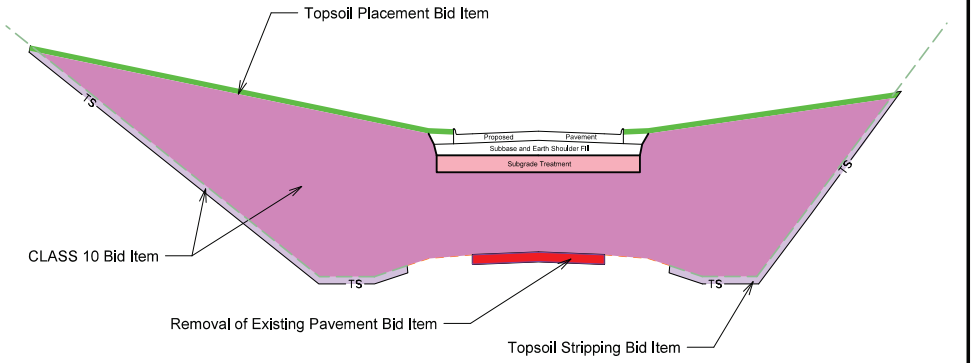
FILL SIDE (Bid Items) — URBAN



FILE NO.	ENGLISH	DESIGN TEAM Project Manager\Designer	County COUNTY	PROJECT NUMBER	SHEET NUMBER T.1D

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PIPE CULVERT

BEDDING & BACKFILL

VIII. Pipe Culvert Bedding & Backfill

Specification Section 2416 Rigid Pipe Culverts
Specification Article 2402.03, J Backfilling and Compaction of Pipe and Reinforced Box Culverts by Flooding
Standard Road Plan DR-101

Currently there are two classes of pipe bedding – Class B and C. If not specified, Class B is the default.

- **Class B Bedding.**
  Class B bedding consists of a 2 inch (50 mm) cushion of sand shaped with a template to a concave saddle in compacted or natural earth to such a depth that 15% of the height of the pipe rests on the sand cushion below the adjacent ground line.

- **Class C Bedding.**
  Class C bedding consists of a concave saddle shaped with a template, or shaped by other means and checked with a template, in compacted or natural earth to such a depth that 10% of the height of the pipe rests below the adjacent ground line.

Figure 8-1: Type C bedding

Standard Road Plan DR-101 shows both classes of bedding.

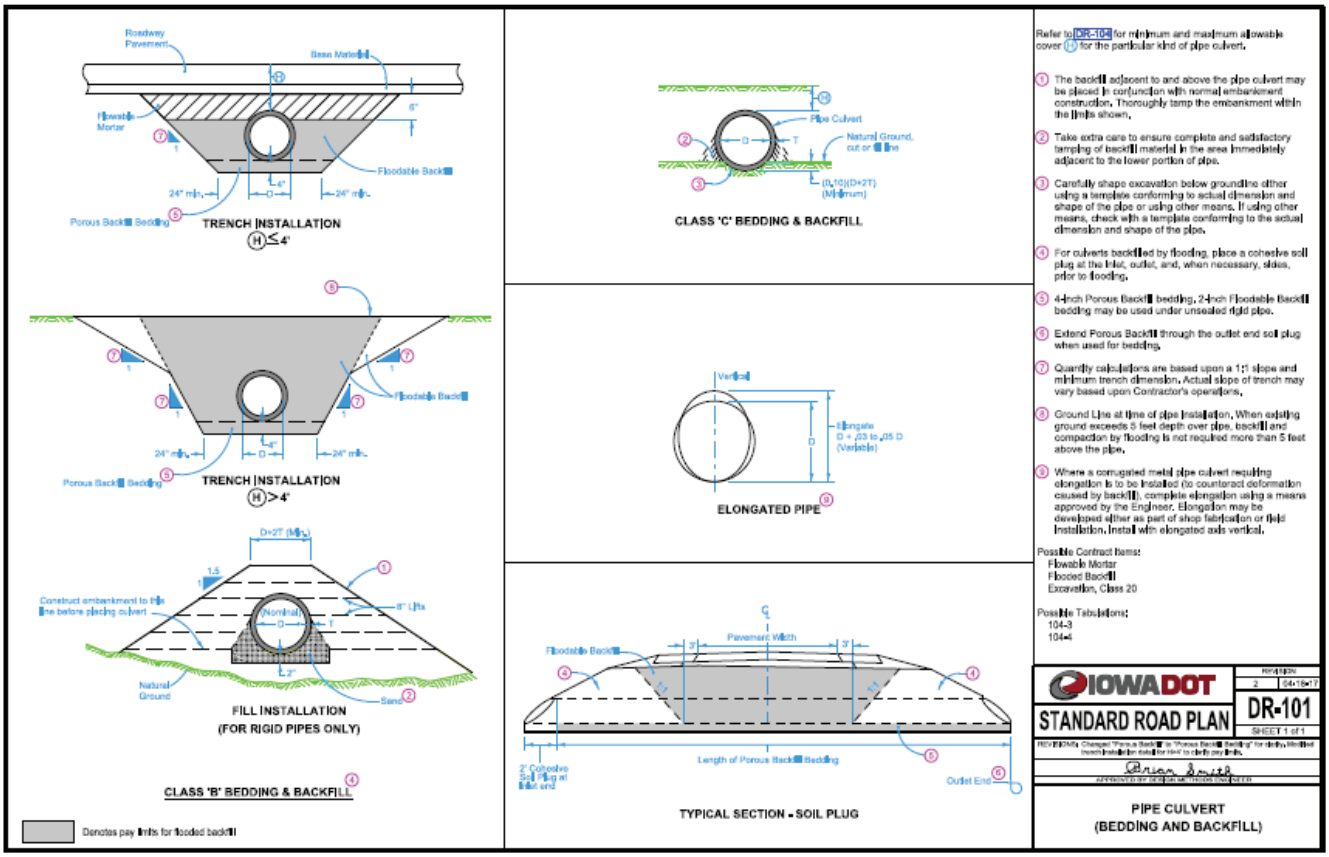

Figure 8-2: Standard Road Plan DR-101 showing both trench and fill installations of culvert pipe.

Backfilling and adequately compacting the soil around the pipe are not that easy. This leads to low stability and settlement problems. As a result, a bump or dip may show up after some time. The Iowa DOT in Specification Section 2402 has a flooded backfill method to reduce these problems.

Standard Road Plan DR-101 illustrates Class B backfill that uses flooded backfill in a trench installation. A mortar cap is installed on top of the flooded backfill depending on the cover over the top of pipe. The purpose of this cap is to cap and stabilize the granular backfill material that has been consolidated by flooding – it is not for structural reasons.

In order to determine the type of backfill required a pipe culvert, check Tab 104-3.

Rigid pipes may also be installed using the fill installation. In this case, the pipe would not require flooded backfill nor a mortar cap.

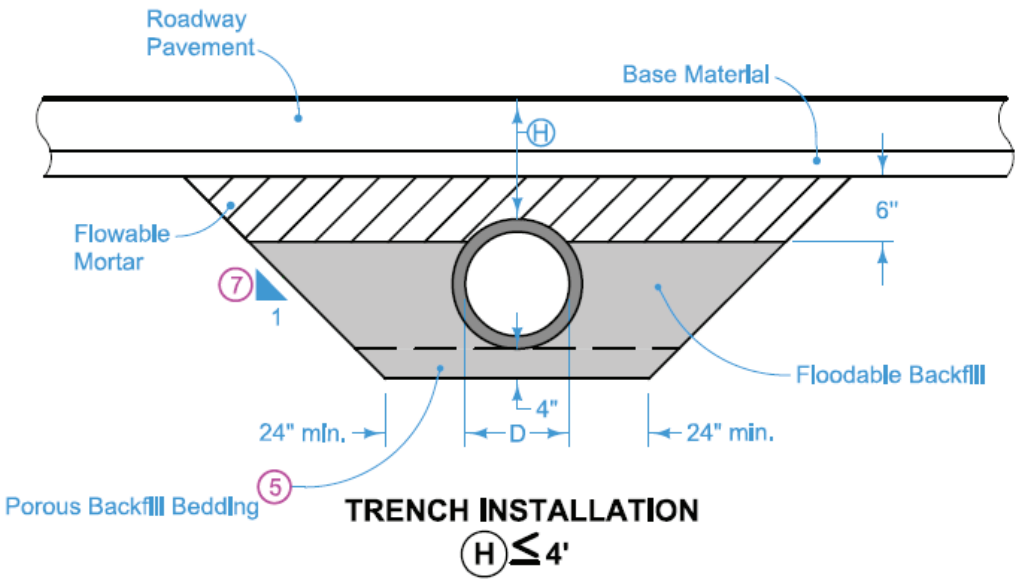

Figure 8-3: Shallow trench installation with flowable mortar cap.

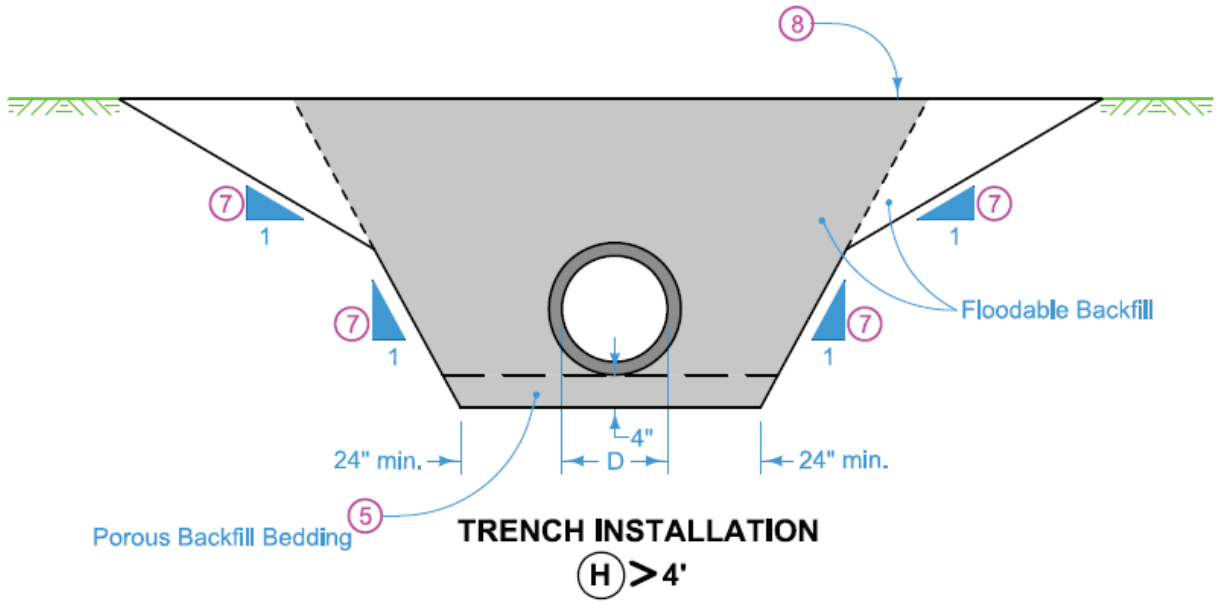

Figure 8-4: Trench installatin with no flowable mortar cap.

Figure 8-5: Applying water to flooded backfill

DRAINAGE

IX. Drainage

Drainage is one of the most important issues to consider during a grading project and during the service life of a highway. Without proper drainage, there will be many problems. Some information the inspector should keep in mind when it comes to proper drainage is:

1. Water Table

The term "water table" was mentioned in the Shear Strength of Embankment Construction. It was said that the effective stress decreases as the pore pressure increases. In other words, when the water table goes up, the shear resistance or the stability support of the soil can go down. Hence, it is very important to keep the water table as low as possible. On the Q-sheets, the water table is marked as the little dash line. One thing to keep in mind is the information on the Q sheets may have been obtained several years before the project actually starts. The actual water table may have changed before or during the construction time. Modifications in backslope subdrain elevation, working sand blanket, etc. may have to be made. The following topics will discuss some of the key methods to deal with drainage.

2. Sand Blanket

A sand blanket could be specified for different reasons and sometimes multiple reasons. They could be (a) working blanket, (b) drainage, (c) stability/settlement and/or (d) core-outs. The inspector needs to understand how each type works to make certain that the installation is done properly.

a. Working Blanket

The working blanket is specified to help the construction traffic and to provide better "foundation" in fill sections. It is usually called for at locations where the water table is high (close to the ground) or at a drainage way. If there is no drain with this blanket, then the blanket will usually be a working blanket. This blanket location may be adjusted during the construction due to a change in the drainage way or it may be deleted if the stability is enough to carry the construction traffic through. However, it the fill is more than 25 feet, the working blanket should typically not be deleted. Also, outlets should be installed if the fill is high. Embankments that cross low, wet areas may require an initial stabilization layer or working platform, which is typically a thick lift of granular material. This layer may be needed to provide adequate support for hauling and spreading equipment while subsequent layers are being placed.

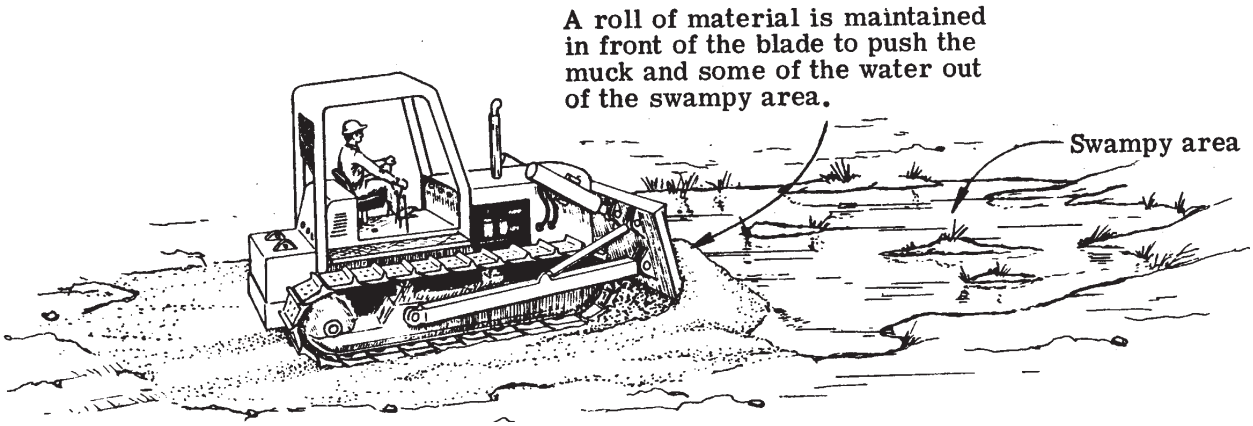

Figure 9-1: Pre-construction photo of a marsh-like area (top). Installation of granular working blanket (middle). First lifts being placed and compacted on top of the granular working blanket (bottom).

b. Drainage

When a granular blanket is specified, there is typically also a drain with this blanket. This blanket must be there to provide drainage for the layer underneath. This drainage is required to allow the consolidation of the soft layer underneath so that the stability would increase or settlement rate would accelerate. The pressure release pipe from this blanket usually has a bend at some point. Thus, the level of the outlet is higher than that of the sand blanket, which is acceptable from a design standpoint. However, the outlet does not have to be that way. If modification can be made in the field to have the outlet at the same level with the sand blanket, please do so. If there is a culvert nearby, small weep holes should be made to allow the water to drain into the culvert.

c. Stability Requirement

When shale is encountered, a sand blanket or stone key may be used to provide the frictional resistance between the shale and the Class 10 fill. The inspector should recognize this if the soil sheets indicate there is shale underneath. It is very important to have this sand blanket in contact with or key into the shale. A visual check must be done to make sure that the excavation for this blanket is down to the shale layer. Remove as much soft shale as possible before placing the blanket.

d. Core-Outs (for over-excavation and backfilling)

Core-outs which are subsequently backfilled with sand are frequently used because of stability and/or settlement issues. The basic idea here is to remove the soft and compressible soils to a specified design depth and replace it with stronger, less compressible soils to alleviate the stability or settlement problem. It is feasible that some core-outs will not have drains, but this does not negate their need or function. When this layer is below the water table, an outlet or outlets may be necessary.

Figure 9-2: This photo shows a core-out to remove compressible soils as well as a sand blanket to be used to provide a workable platform from which to build the embankment.

3. Trench Drains

Standard Road Plan DR-301

Sometimes trench drains may be required to provide drainage and lower the water table at some locations. The function of the trench drain is similar to that of the sand blanket, that is, either for stability or settlement improvement. The trench drain, however, is installed much deeper. Since the area is unstable, the installation of the trench drain may be difficult. There are cases where the top layer had to be removed and replaced so the surface was adequate to support construction equipment. Other times the trench drains have been done with a "dig and push" operation. Trench drains may also be used to drain the water from sand pockets underneath the embankment to provide better stability. Clean and porous materials should be used in backfilling the trenches.

Trench drains must be installed at the designed depth and spacing so that other design requirements aren't changed as a result. If trench drains cannot be installed at the specified depth and spacing, please contact the Construction and Materials Bureau and Soils Design.

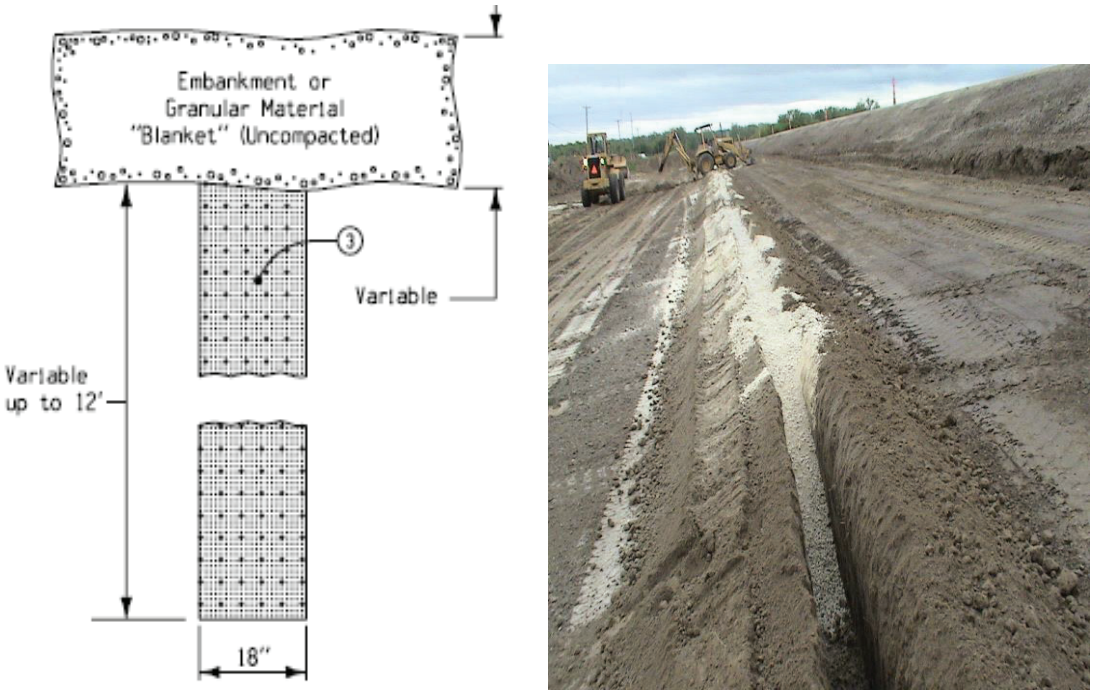

Figure 9-3: Trench drain detail and photo of installation

3. Subdrains

Subsurface water affects the strength and stability of the soil. It is a factor in almost all slope failures. Subsurface water is usually removed with subdrains (also called underdrains).

Once subdrains are in place and the soil is loaded, the water has a place to go and is squeezed out. Subgrade conditions should then improve. Otherwise when drainage is not in place, the subgrade may be saturated and act like a waterbed when it is hauled on or proof-rolled.

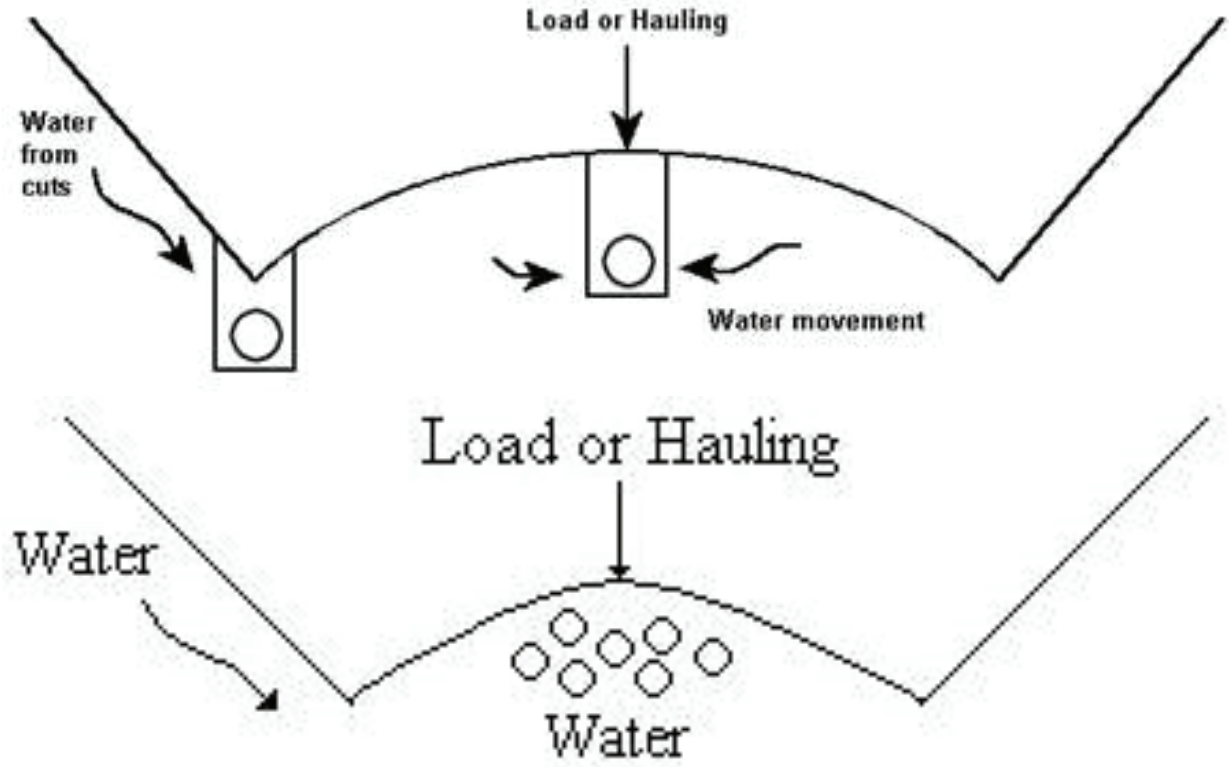

Figure 9-4: Illustration showing embankment with subdrains (top) and without (bottom)

a. Backslope Subdrain
Standard Road Plan DR-303

This type of subdrain allows the water in the backslope to drain off. Again, a quick refresher on the water table, the shear strength, which is the resistance to shear failure, decreases as the pore pressure or water table goes up. Therefore, in order to prevent backslope failure, the backslope subdrain has to be installed. It is critical to install the subdrain at the proper elevation. The subdrain has to be on or somewhat in the layer of clay, shale, gumbotil, glacial clay, etc. The reason for this is clay is considered impervious. Thus, the water cannot drain through this layer. Hence, the subdrain has to be there to drain off the water. The backslope subdrain has to be installed as soon as possible after the cut is made. The longer the delay, the bigger the chance for problems.

In cases where different layers of shale are encountered in the backslope, the backslope subdrain must be placed below the shale layer that the water is running on.

Backslope subdrains should be added as needed.

b. Longitudinal Subdrains
Standard Road Plans DR-303

Oftentimes, longitudinal subdrains are used to keep water from building up underneath the roadway. Figure 9-5 shows a longitudinal subdrain being installed on the outside shoulder adjacent to new pavement. Figure 9-6 shows subdrain outlets being installed that will outlet to the foreslope.

Figure 9-5: Installation of longitudinal subdrain

Figure 9-6: Longitudinal subdrain outlets

5. Ditch Cut

It is very important to have the ditch cut to the proposed level as soon as possible. This should be done so that the storm water can drain properly. Also, since the ditch level is low, it would allow any water at the upper portion of the embankment to drain off. This, once again, will provide higher stability for the embankment.

6. Wick Drains & Vertical Sand Drains

Specifications Section 2112

Wick drains and vertical sand drains are used to accelerate consolidation settlement of deep, soft, saturated, and compressible soil layer(s). The basic concept of stabilization by consolidation is to force possible detrimental settlements to occur during construction when they can be tolerated instead of after construction.

Subsurface water flows vertically and through the sand columns, thus the length of the drainage path becomes very short. This helps speed up drainage and consequently accelerates consolidation.

Wick drains function in a similar fashion as vertical sand drains, except the wicks are a prefabricated, synthetic material.

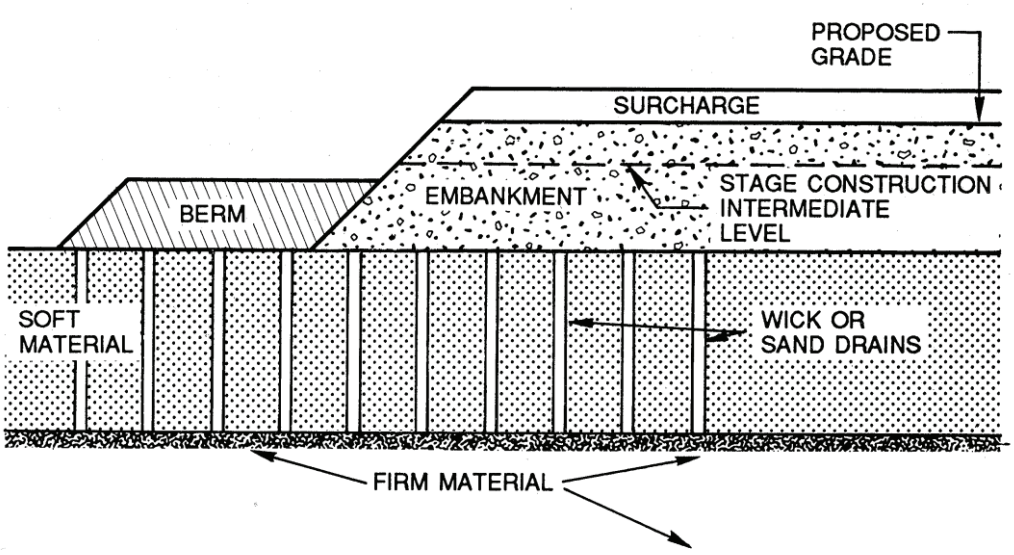

Figure 9-7: Illustration of wick or sand drains used to accelerate consolidation of soft material

Figure 9-8: Rows of installed wick drains

7. Stone Columns

Stone columns are a type of foundation improvement used so that the soft soils can be left in place. They increase bearing capacity and slope stability, reduce settlement, increase time-rate of consolidation, and reduce liquefaction potential.

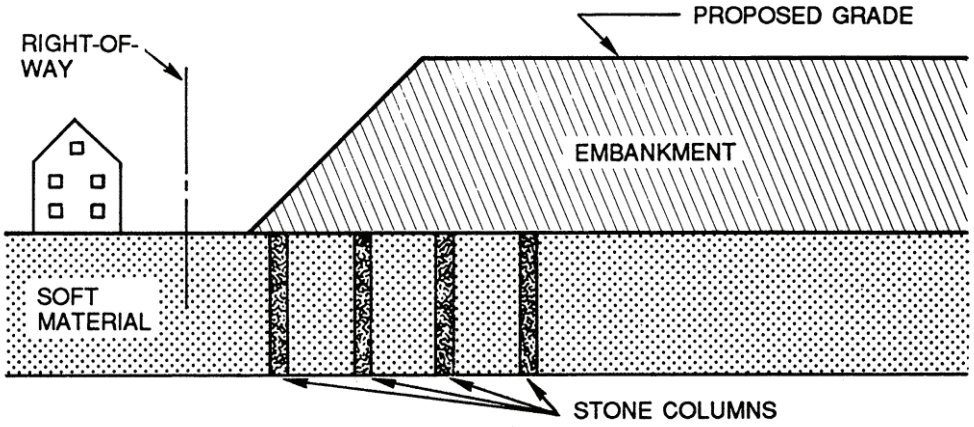

Figure 9-9: Stone columns are used to increase bearing capacity and reduce settlement

Figure 9-10 shows installation of aggregate in a predrilled hole that is then compacted in lifts by a vibrator.

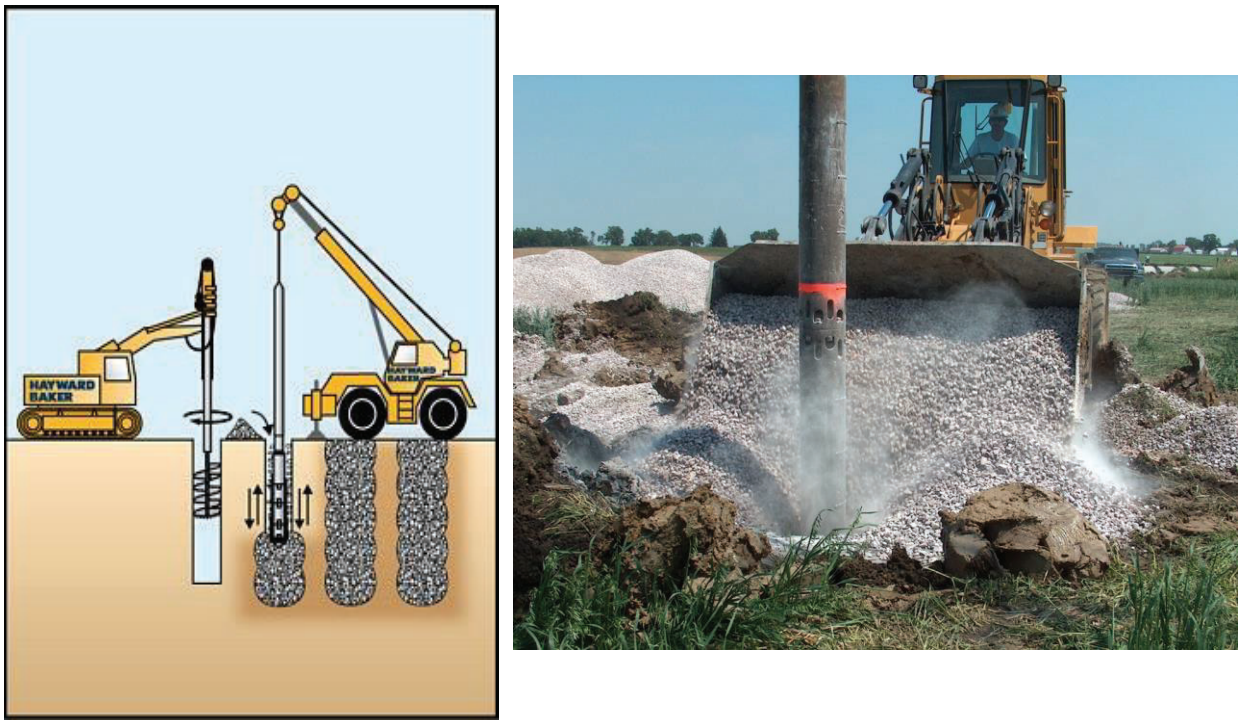

Figure 9-10: Illustration and photo showing installation of stone columns

STABILIZATION METHODS

X. Stabilization Methods

In this section the stabilization methods are referred to as subgrade treatment. The reason we have subgrade treatment is to provide the best possible support for the subbase (if needed) and the pavement. The type of subgrade treatment used depends on the type, the quality and quantity of natural soils available on the project. The subgrade treatment material is much stronger than the regular Class 10. It is to provide uniform and better support for the pavement. However, it is not there to cover up unstable locations. Thus, it is critical to make sure the subgrade is in reasonable condition before the subgrade treatment is placed because once it is placed, it may not be economical to remove it.

The following are some of the typical materials used as subgrade treatment:

1. Select Soil

The normal materials for the select are clay loam, loam, or sand. From the textural classification table, it should be recognized that these classes contain either predominantly sand or a good mixture of sand, silt, and clay. Because of the composition, the density and the shear strength are much higher when they are properly compacted. At locations where modifications were done but stability is questionable, additional select should be considered. This is an economical way to improve stability.

2. Special Backfill

The special backfill is a uniform mixture of coarse and fine particles of crushed concrete, crushed limestone, composite pavement, or a mixture of gravel, sand, soil, or a mixture of crushed limestone, gravel, sand, and soil. In other words, the special backfill could be a variety of different materials. The requirement for this material is that it has to meet a certain gradation. Since the materials vary, different behaviors should be expected. For example, a piece of gravel is going to provide much less stability than a piece of crushed limestone. In order to get the best material, the inspector may need to work with the contractor to get the better material for each situation. The additional special backfill at the questionable locations will certainly improve stability.

3. Polymer Grid

Specifications Section 2113

A polymer grid is a high strength polymer material. It is used to provide additional support at unstable locations and in reinforcement of MSE Walls, steep slopes, roadway bases, and stabilization of foundation soils.

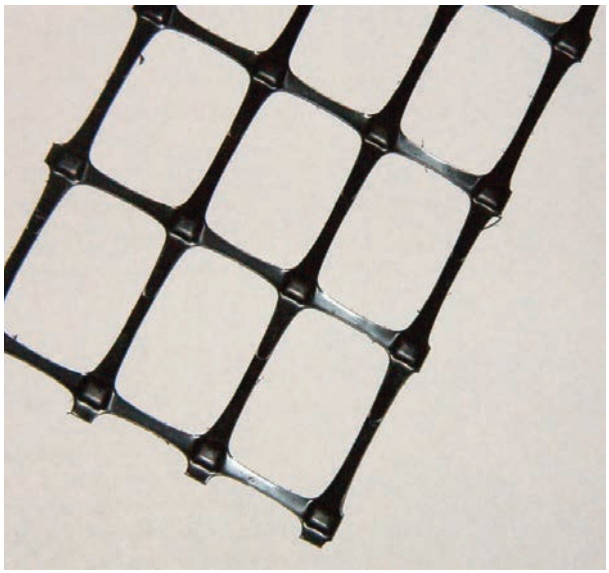

Figure 10-1: Polymer grid

The open grid structure material works well with an aggregate base for the interlocking effect. A polymer grid might be used by the Soils Design for subgrade strength when on-site materials are not of sufficient quality to use in the upper part of the subgrade. “Grid” will most likely be used with special backfill material or 1.0’ of moisture control of the on-site soils. Grids work because the material has a very high tensile strength which allows wheel loads to be spread over a much larger area rather than having localized punching failure, ruts, etc. By distributing heavy loads over soft soils like a snowshoe, geogrids help by stiffening the granular platform and reducing subgrade stress. They may also help with constructability.

A polymer gird should not be extended beyond the edge of the pavement so it will not interfere with the longitudinal subdrain installation.

A polymer grid should be utilized when there is an unstable location and other methods have been tried to rectify the situation but were not successful.

Do not attempt to fix the polymer grid if the stability is not enough. The best thing to do is to add more special backfill on top.

It is important to limit the exposure of polymer grids to UV light. See manufacturer specifications for each product.

4. Chemical Stabilization:

Fly-ash, lime, and cement stabilization are used for controlling the swelling and frost heave of soils and improving the strength characteristics of unsuitable soils. They may also be used to dry soil more rapidly so that construction can proceed.

- Fly ash – Fly ash reduces the shrink-swell properties of soils and dries the soil to facilitate soil compaction.
- Lime -- Lime modification is used in many areas of the U.S. to obtain a good construction foundation in wet weather above highly plastic clays and other fine-grained soils.
- Cement -- Portland cement is used widely for stabilizing low-plasticity clays, sandy soils, and granular soils to improve strength and stiffness.

Installation of chemical stabilization involves the following steps:

- Application - Material should not be placed when wind conditions may cause excessive blowing. Blowing material may create both a health hazard and a loss of material from the roadway.
- Incorporation – Typically a pulverizer is used to mix the material to the required depth (see Figure 10-2).
- Compaction – Soil is then compacted, typically by a sheepsfoot roller, until density specifications are met (see Figure 10-3).
- Surface Finishing - Final surface should be smoothed, and the roadbed should be allowed to cure in accordance with the specification requirements.

Figure 10-2: Pulverizer mixing fly-ash with subgrade soil.

Figure 10-3: Compaction following behind pulverizer.

FINISHING ROADWAY

& SLOPES

XI. Finishing Roadway and Slopes

Finishing work should be done as soon as possible. This work should be done as the project progresses. Do not wait until the end of the grading project to do everything at once. In order to complete an area, finishing and seeding must be performed.

1. Finishing

When all the embankment lifts have been placed and compacted, the surface of the earthwork is ready for final dressing. Final shaping -- or final dressing -- is the final grading operation which shapes the earthwork surfaces to the lines, grades and cross sections shown in the plans. This includes achieving the correct elevations of the roadbed, depths of roadway ditches and lengths of front/foreslopes and backslopes. Typically topsoil is placed on slopes in conjunction with these operations.

Motor graders and dozers are used in final dressing. Hand dressing is not generally required, except in confined areas where equipment cannot operate.

Finishing work for grading must be precise and accurate. Surfaces and slopes must be smooth to provide good drainage. This is extremely important because the grade can get unstable before the paving starts. The finishing work is also important because the stormwater permit requires that any area where there is no construction for 21 days or more must be seeded or stabilized within 14 days. Therefore, do not delay the finishing work.

Ruts should be smoothed out when rain is likely to occur.

2. Surface Tolerance Checks

Surface tolerance checks should be done to determine whether or not embankment surfaces have been constructed to the correct lines and grades. To check the finished grade, the subgrade surface is measured to be sure that it is in accordance with the plan's typical section.

These checks not only ensure the embankment was constructed per plan but also help control future quantity under-runs and over-runs.

One method of checking the surface elevation is a stringline, such as shown in Figure 11-1.

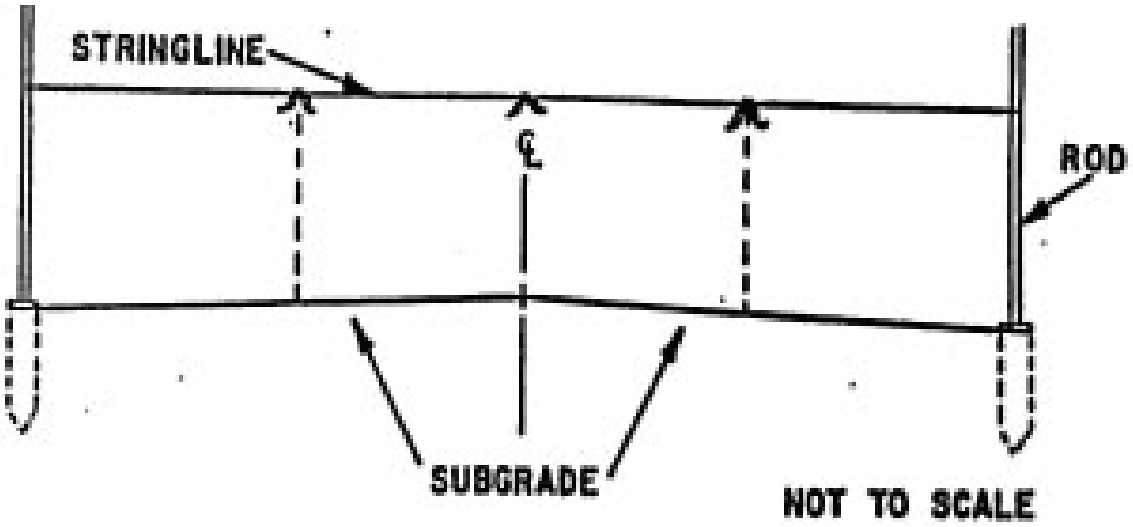

Figure 11-1: Use of stringline to check road grades.

Sample question: The plans indicate that the surface should decrease 0.02 ft per foot. If the centerline measures 0.335 ft from the string line, what should the measurement be 3.00 ft on either side?

Answer: 0.275 ft. from stringline.

If the project was constructed using machine control, a GPS rover is often times used to check surface elevations. However, the vertical accuracy is about 1/10 of a foot.

Figure 11-2: GPS rover being used to check surface elevation.

3. Seeding

Embankments should be finished as the work progresses. This means as sections of the roadway are completed -- final dressed and checked. The sooner this work is done, the less chance there is for erosion.

They must be fertilized, mulched, grassed, watered and sodded, as called for in the plans. Be sure that you are familiar with each project's specific requirements.

Successful seeding cannot be obtained all year long. The germination and growth depend on temperature and moisture. This does not mean that seeding can only be done at certain time. Seeding must be done as soon as possible, when specifications permit. To be in compliance with the stormwater regulations, seeding or mulching will be needed on the project as finishing progresses. For more information about erosion control, please refer to erosion control section and Sections 7.40 and 7.41of the Construction Manual.

Figure 11-3 shows an embankment that was finished and seeded in stages. Staged seeding helps reduce erosion.

Figure 11-3: Staged seeding is a good practice to reduce erosion.

BEFORE THE

PAVING

XII. Before the Paving

1. Proof Rolling

Specification Section 2301.10, Paragraph C, "Proof Rolling Requirements" requires that the subgrade be proof rolled no more than one week prior to trimming of the final grade. This proof rolling is very critical to make sure that the subgrade is strong enough to help support the pavement. Soft spots or unstable areas must be reworked to obtain adequate stability.

Figure 12-1: Inspector measuring ruts following the proof-roll test.

Response of the embankment under the proof-roller should be watched. Look for inadequate stability in the surface by:

- Deflection
- Cracking
- Rutting

One trip with a proof roller is usually enough. An overloaded proof roller may cause instability, while an under loaded proof roller will not find the soft areas.

The Contractor should not proof roll to demonstrate that subgrade correction is required. Rather if there are obvious unstable areas, they should be corrected prior to the proof-roll. Areas that have failed the proof roll may require further investigation to determine an appropriate corrective treatment. Additional soils testing may need to be done through new soil borings or from a test pit. This information will be used to determine the undercut depth requirements or another subgrade treatment that may be more economical.

2. Trimming

The method of trimming is not specified, so we are not able to require a specific piece of equipment. However, the specifications require that contractor not be allowed to tear the subgrade or compacted special backfill/select for the trimming purposes. Because of this, an automated profile controller, i.e., CMI trimmer, is preferred.

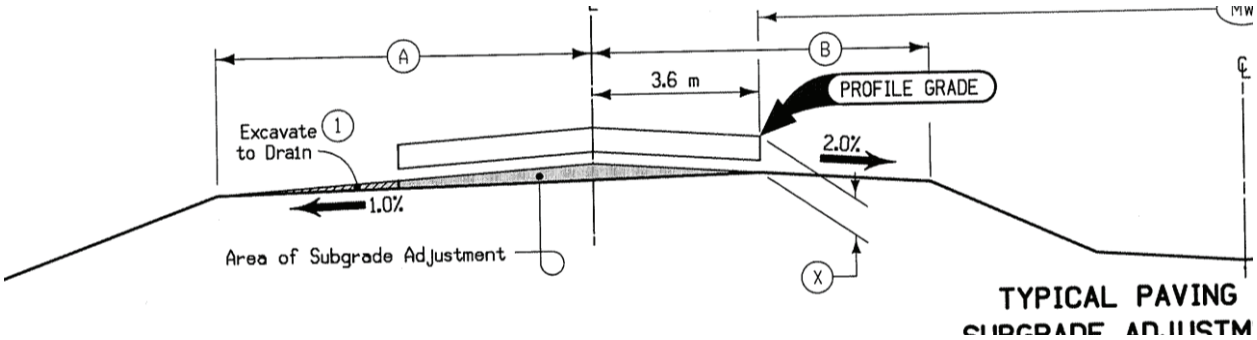

Figure 12-2: Subgrade adjustment by trimming grade from 2% to 1%

Figure 12-3: Subgrade trimming operations

3. Granular Subbase

The main purpose of the granular subbase material is to provide drainage under the pavement. Since this material has an open gradation, the maximum density is not very high. In addition, this material is compacted with a maximum of three passes of a self propelled, non-vibratory steel or pneumatic roller, the compacted density may be from 100 to 120 pcf. Thus, the percent voids could be as high as 40%. This is the reason why it is very permeable. Since it is there mainly for drainage, the structural support is also not very high. It is usually specified under Portland cement concrete (PCC) pavement which can provide the mat foundation or bridging support across the granular subbase layer.

No construction traffic is allowed on top of the granular subbase layer.

During the construction of the granular subbase, it is very important to check the permeability of this layer. One quick and easy way to do this is to fill one-gallon milk jug with water. Pour this gallon of water from waist level down at one spot. If the water drains away and no sign of any buildup after one minute, the granular subbase layer is considered permeable.

4. Modified Subbase

Modified subbase is used mainly for stability/support. It is normally specified under hot mix asphalt (HMA) pavement. A vibratory steel roller is normally used for compaction. This makes this layer very strong. Construction traffic is allowed to run on it.

Modified subbase is also used under PCC pavement when the access is limited, such as urban reconstruction projects.

Modified subbase is generally less permeable than granular subbase, but more permeable than most Class 10 or select soil materials. As a general rule, it is considered permeable enough to require installation of continuous longitudinal subdrains when it is used.

Figure 12-4: Modified subbase

XIII. Summary

It should be very obvious by now that in order to achieve a quality and successful project, there are several things the inspector needs to pay special attention to. They are:

1. Erosion Control

Erosion control devices have to be installed and maintained properly. Sometimes it is difficult to get the attention and cooperation from the contractor. There is no option in this issue. It must be done and done as quickly as possible.

2. Compaction

In order to get good strength/support and minimize the settlement and failure, adequate compaction must be achieved. There are three factors that need to be considered. They are soil type, moisture content, and equipment. The inspector needs to recognize what is going on and should try to work with the contractor to get a better product. Sheepsfoot roller walkout condition, in general, works. However, quality cannot be achieved without the solid data.

3. Proper Drainage

Water is very powerful and it is the worst enemy to soils work. Unstable subgrade and failure can happen if water is not drained away. The inspector should do whatever it takes to make sure that the water table is as low as possible.

4. Documentation

Documentation relates to the payment procedure and sometimes legal issues, it must be done as adequately as possible.

5. Communication

It would take more than just the inspector or any one person to get the job done. Do not be afraid to let someone know there are some questions, problems, etc. Help is always available

References

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T. W. Lambe and R. V. Whitman. Soil Mechanics. John Wiley and Sons, Inc., New York, New York, 1979.

W.C. Teng. Foundation Design. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962.

"Basic Earthwork Inspection School", District 1, Iowa Department of Transportation, February 14-15, 1991.

"Compaction Handbook", Third Edition, Hyster Company, Tractor Equipment Division, 1962.

"Construction Manual", Construction Office, Iowa Department of Transportation, Ames, Iowa.

"Design and Construction of Driven Pile Foundations", Workshop Manual, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, January 1996.

"Standard Specifications for Highway and Bridge Construction", Iowa Department of Transportation, Ames, Iowa

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"Soil & Geology Reference Guide for Iowa DOT Soil Survey", Version II, Iowa Department of Transportation, August 2012.

Transportation Research Board/National Research Council, "Guide to Earthwork Construction", State of the Art Report 8, 1990.

APPENDIX

Appendix Table of Contents

Links for reference information & various forms:

Bidx

https://www.bidx.com/ia/main Then select letting date, find Bid Order Number (BON)

Link to proposals, plans, and e-files

https://iowadot.gov/contracts/Plans-and-estimation-proposals Then select letting date, find BON

Link to Construction & Materials: Earthwork & Erosion Control page

https://iowadot.gov/construction_materials/Earthwork-and-erosion-control

Link to Construction & Materials: Environmental FAQ

https://iowadot.gov/construction_materials/FAQs/Environmental

Materials Forms

https://iowadot.gov/construction_materials/Materials-forms

Inspection Forms

https://iowadot.gov/construction_materials/Inspection-tool

E107 Field Moisture Test

www.iowadot.gov/Construction_Materials/inspection_tools/Grading/E107_Field_Moisture_Test.xlsx

www.iowadot.gov/Construction_Materials/inspection_tools/Grading/E107%20Field%20Moisture%20Test.pdf

E108 Proctor Tests

www.iowadot.gov/Construction_Materials/inspection_tools/Grading/E108_Proctor_Test.xlsx

Form 821258 Nuclear Test Report

https://forms.iowadot.gov/FormsMgt/External/821258.pdf

Proctor Density Calculation Spreadsheet

www.iowadot.gov/Construction_Materials/earthwork_erosion/Proctor%20Density%20Calculation%20Sheet.xlsm

Random Sampling Worksheet

www.iowadot.gov/Construction_Materials/earthwork_erosion/Embankment_random_sample_locations.xlsx

Sample Documentation Forms

Rev 1/97

Form E008

Line No.: ______

Item Code: ______

Description: ______

Project No.: ______

Page No.: ______

Category No.: ______

Contract ID: ______

Date	Location			Plan Length (ft)	Plan Width (ft)	Plan Depth (ft)	Lift No.	Moist. (%)	Opt. Moist. (%)	Density (%)	Comp (Y/N)	Roller Check	Today (CY)	To Date (CY)	By
	Sta	Sta	(Side)												
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	
				0.00									0.000	0.000	

Qty. Awarded: ______

CO Adjust.: ______

Authorized: ______

Quantity Paid: ______

% Authorized: 0.0

Method of Measurement: ______

Basis of Payment: ______

Checked By: ______

Audited By: ______

Field Moisture Test

Line No.: _____

Item Code: _____

Description: _____

Project No.: _____

Page No.: _____

Category No.: _____

Contract ID: _____

Date	Test Section Location (Sta. to Sta.)	Sample Location (Sta.)	Material Type	Wet Wt. (g)	Dry Wt. (g)	Difference (g)	Moisture (%)	Opt. MC (%)	Source of Proctor (Type & Location)[1]	Contr. or QA MC (%)	Remarks (e.g. Pass/Fail or Verified)	By

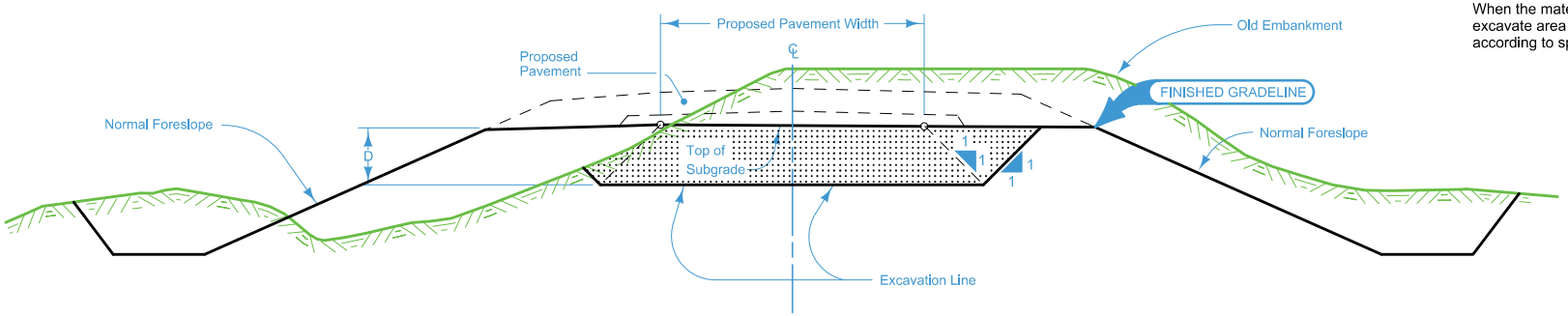
Note 1: MP = Multi point proctor, 1P = One point proctor, Q = Q sheets, SD = Soils Data Sheets

Standard Road Plans

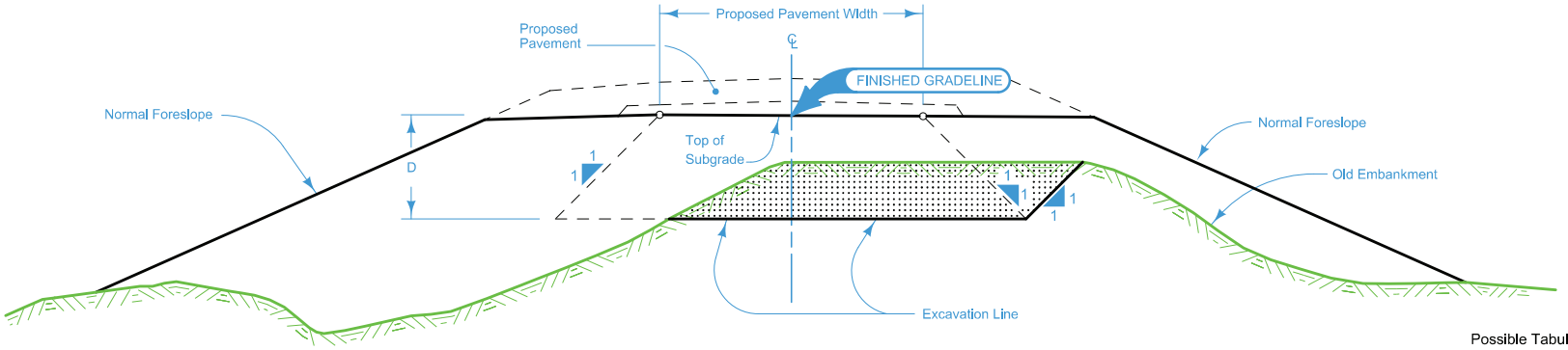
DESIGNER INFO

Refer to contract documents for removal limits and allowable placement areas for excavated material.

When the material is to be deposited in the same area, excavate area shown, then spread and recompact material according to specifications.



TYPICAL CROSS SECTION REBUILDING EMBANKMENT
OLD EMBANKMENT HIGHER THAN NEW EMBANKMENT
(Plowing and Shaping)



TYPICAL CROSS SECTION REBUILDING EMBANKMENT
OLD EMBANKMENT LOWER THAN NEW EMBANKMENT
(Plowing and Shaping)

Possible Tabulation:
107-31

LEGEND

Area of Plowing and Shaping

IOWA DOT

REVISION
3 | 10-17-17

STANDARD ROAD PLAN

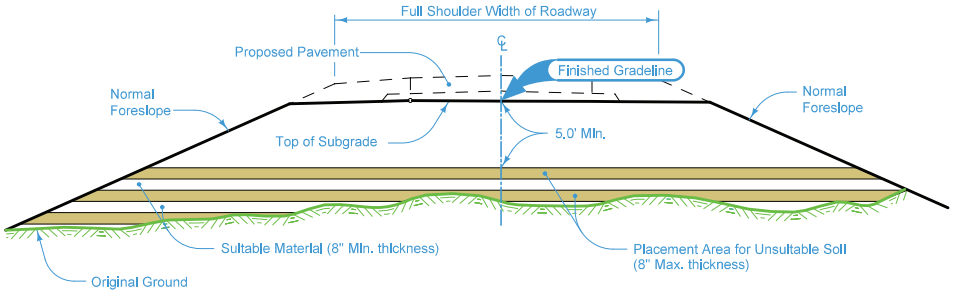
EW-101

SHEET 1 of 1

REVISIONS: Added Designer Info button. Modified legend and top drawing.

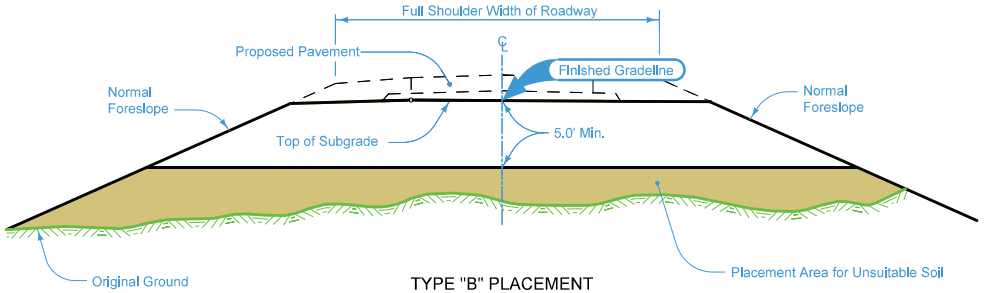
Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

EMBANKMENT AND REBUILDING EMBANKMENTS

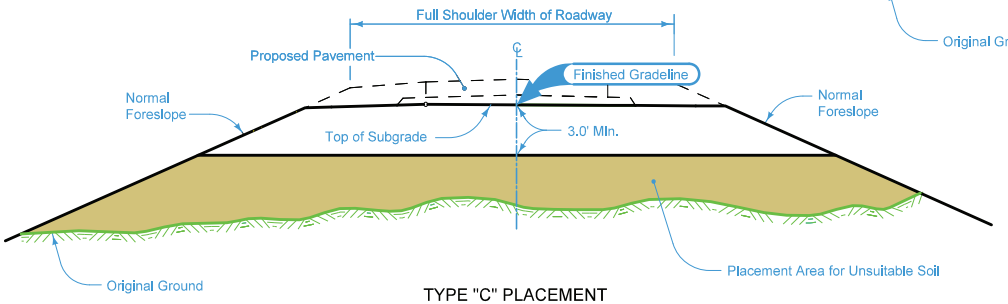


TYPE "A" PLACEMENT

Place unsuitable soil as detailed for the particular type of soil described in Section 2102 of the Standard Specifications. Project plan details or specific directions of the Engineer may require placement of topsoil or other unsuitable soil by methods other than those shown. Refer also to plan cross sections and soil survey sheets for additional information.

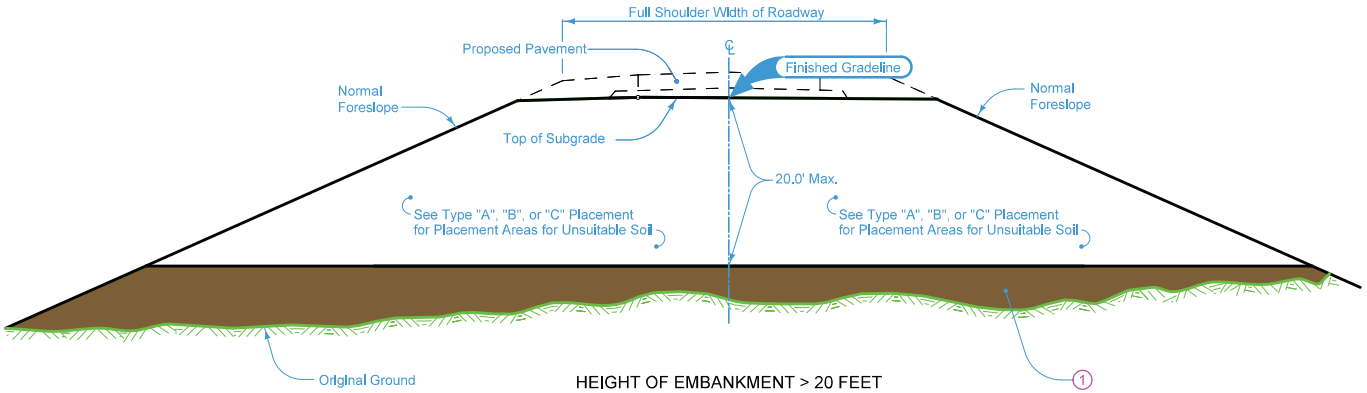


TYPE "B" PLACEMENT



TYPE "C" PLACEMENT

(1) In new embankments greater than 20 feet in height, only Select, Suitable Class 10, or Type 'C' Unsuitable material will be allowed below that 20 foot depth.



HEIGHT OF EMBANKMENT > 20 FEET

IOWA DOT

REVISION	
2	10-20-15

STANDARD ROAD PLAN

EW-102

SHEET 1 of 1

REVISIONS: Replaced the DOT logo in the title block with the new version.

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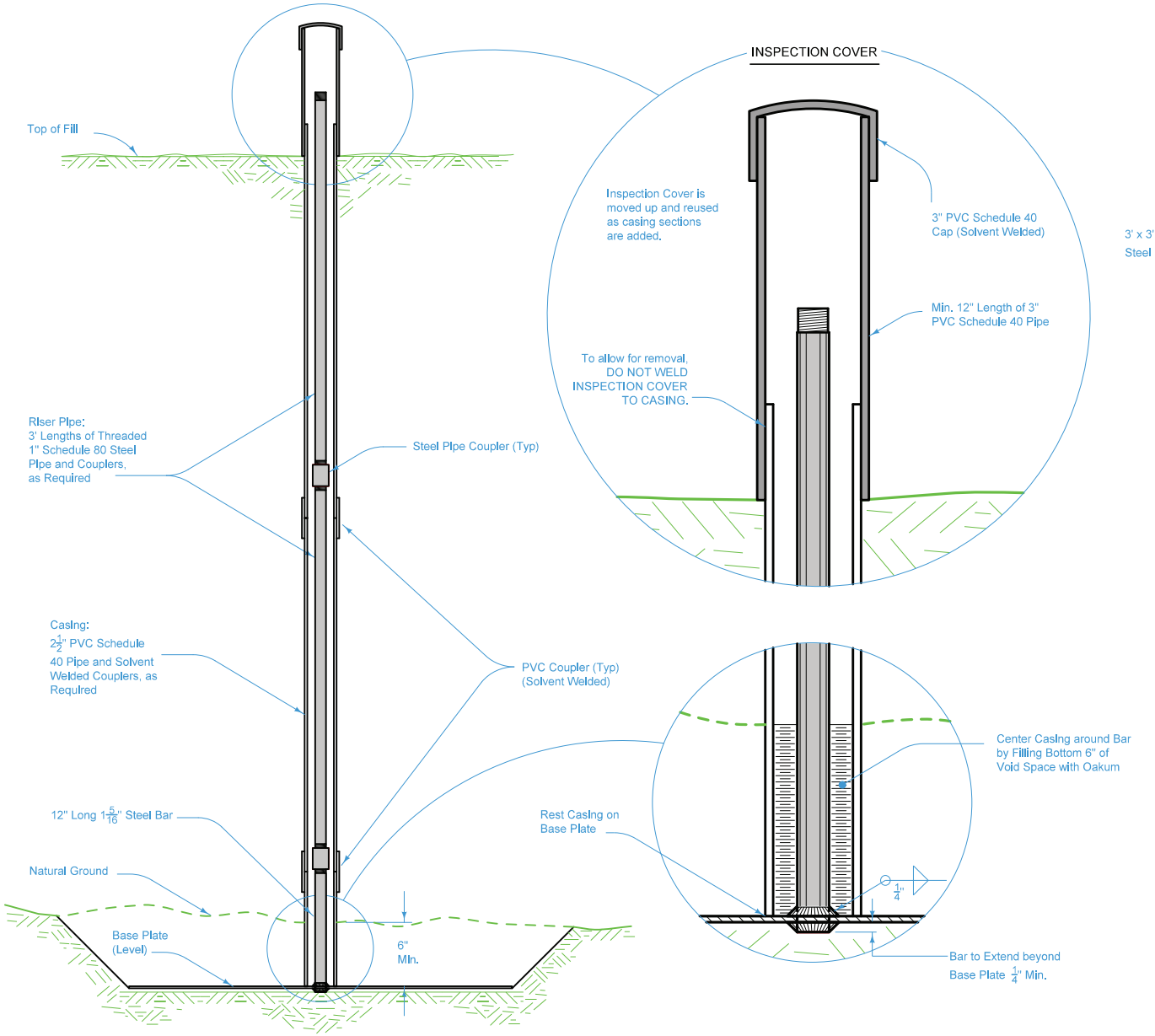
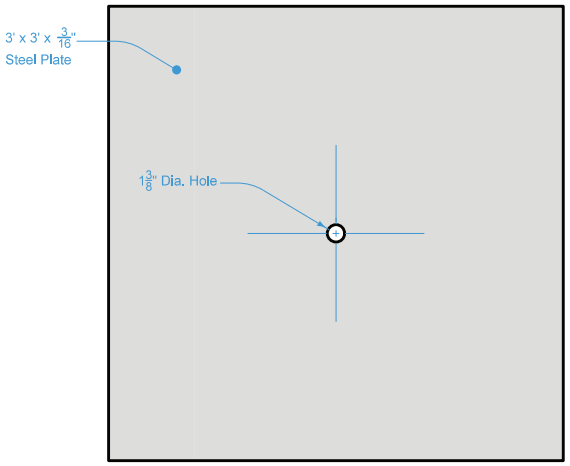
APPROVED BY DESIGN METHODS ENGINEER

ALLOWABLE PLACEMENT OF UNSUITABLE SOIL IN EMBANKMENTS

Refer to Section 2106 of the Standard Specification for additional information.





BASE PLATE

Possible Tabulation:
103-5

IOWA DOT

REVISION
2 | 10-20-15

STANDARD ROAD PLAN

EW-212

SHEET 1 of 1

REVISIONS: Replaced the DOT logo in the title block with the new version.

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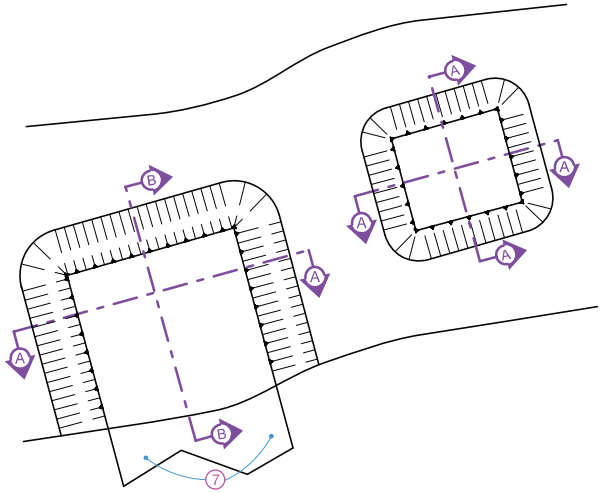
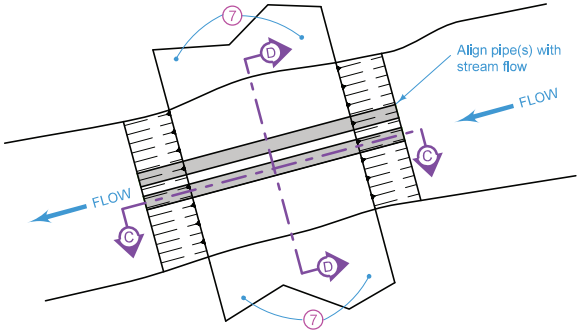
SETTLEMENT PLATE

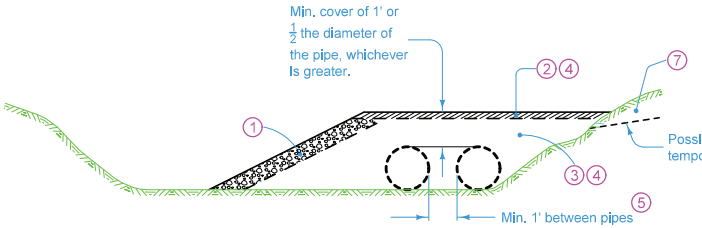
DESIGNER INFO



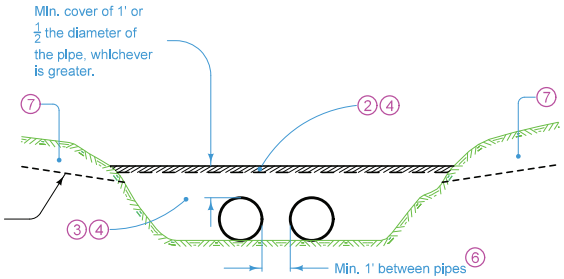
TYPICAL PLAN (CAUSEWAY OR EQUIPMENT PAD) (5)



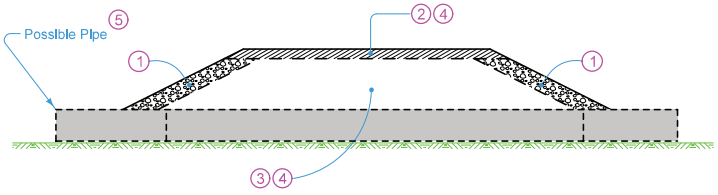
TYPICAL PLAN (STREAM CROSSING) (6)



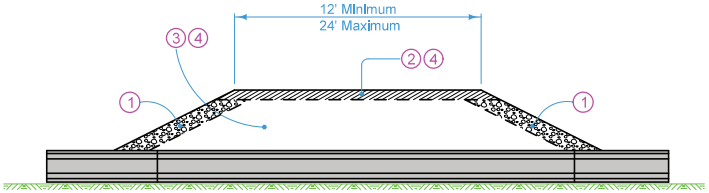
SECTION B-B (CAUSEWAY) (5)



SECTION D-D (STREAM CROSSING) (6)



SECTION A-A (5)



SECTION C-C (6)

1. Minimum 1 foot of Class D revetment, Class E revetment, or broken concrete meeting the requirements of Section 4130 of the Standard Specifications.
2. Possible choke layer for construction traffic. Use any combination of erosion stone, granular backfill, special backfill (except with reclaimed HMA), granular surfacing material, or granular soils of AASHTO classification A-1 or A-2 with less than 5% fines passing the #200 sieve.
3. Use clean material with less than 5% fines passing the #200 sieve. Acceptable materials include revetment and granular materials.
4. When dredging is allowed by a permit, use dredged material containing 10% or less passing the #200 sieve. Prior to beginning construction according to EW-401 , install erosion control measures according to EC-202. Leave these measures in place and maintain until temporary EW-401 materials have been completely removed. Installation, maintenance, and removal of these erosion control measures is incidental and will not be paid for separately.
5. Pipe required if structure spans more than half the distance between banks. Contractor determines size and number of pipe(s) unless specified otherwise in the contract documents.
6. Pipe required. Contractor determines size and number of pipe(s) unless specified otherwise in the contract documents.
7. When material needs to be cut from the bank to provide for access to construct and use a temporary stream structure, move this material to an upland location.

IOWA DOT

REVISION	
2	10-20-15

STANDARD ROAD PLAN

EW-401

SHEET 1 of 1

REVISIONS: Corrected typo in note 4. Updated the DOT logo.

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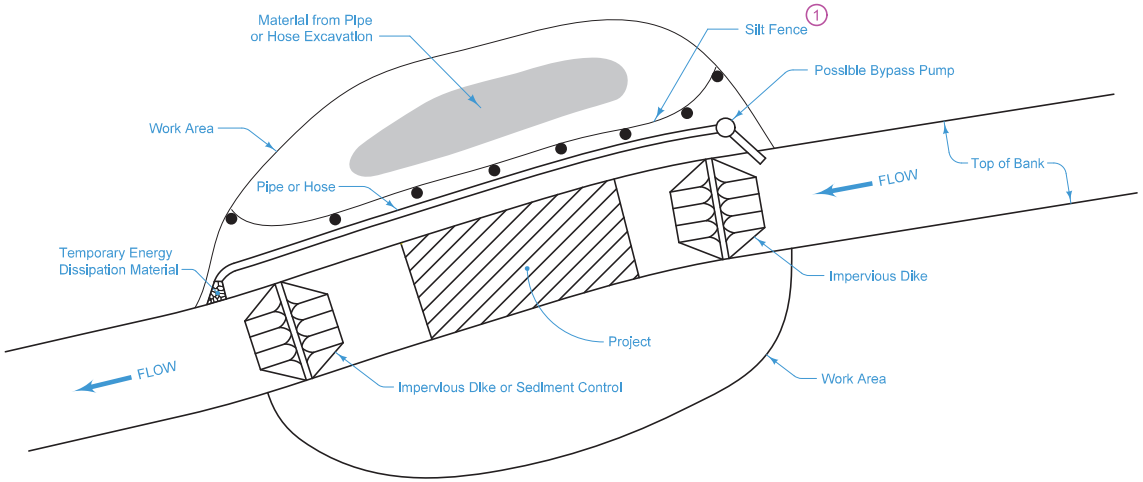
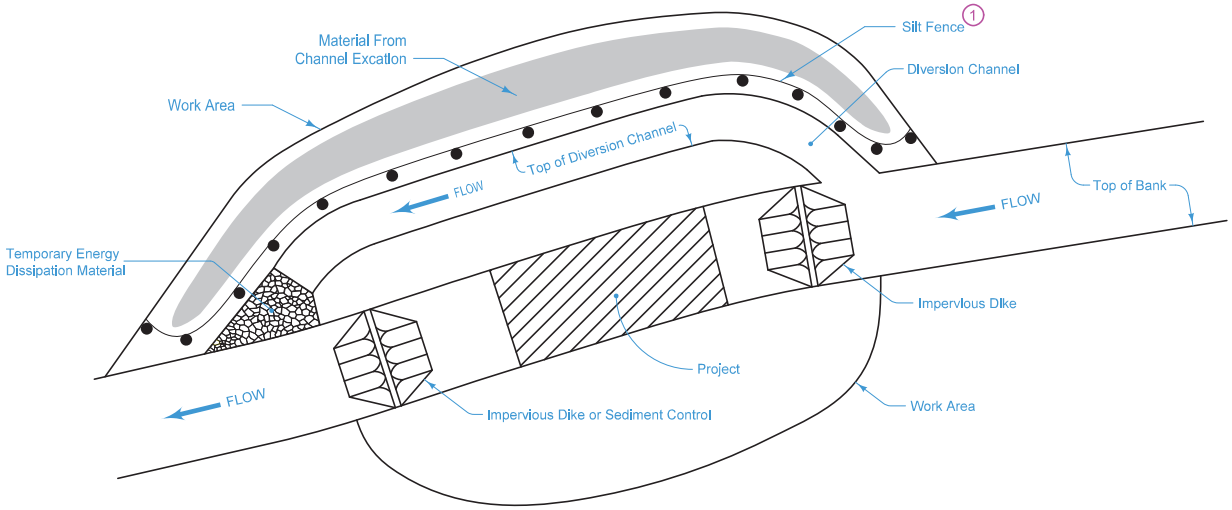
APPROVED BY DESIGN METHODS ENGINEER

TEMPORARY STREAM CROSSING, CAUSEWAY, OR EQUIPMENT PAD

DESIGNER INFO



PIPE OR HOSE



DIVERSION CHANNEL

1 Extend ends of silt fence to work area boundry.

Possible Contract Items:

Temporary Stream Diversion
Silt Fence
Removal of Silt Fence or Silt Fence for Ditch Check
Perimeter and Slope Sediment Control Device

Possible Tabulations:

100-26
100-17

IOWA DOT

STANDARD ROAD PLAN

REVISION	
2	04-18-17

EW-402

SHEET 1 of 1

REVISIONS: Added silt fence in DIVERSION CHANNEL and PIPE OR HOSE views.

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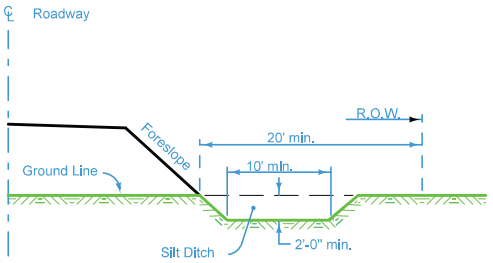
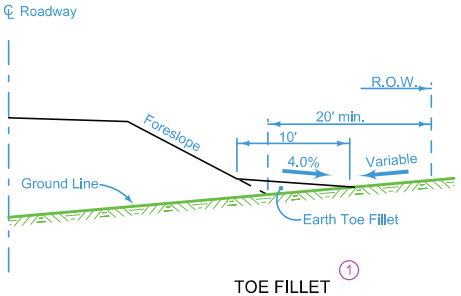
APPROVED BY DESIGN METHODS ENGINEER

TEMPORARY STREAM DIVERSION

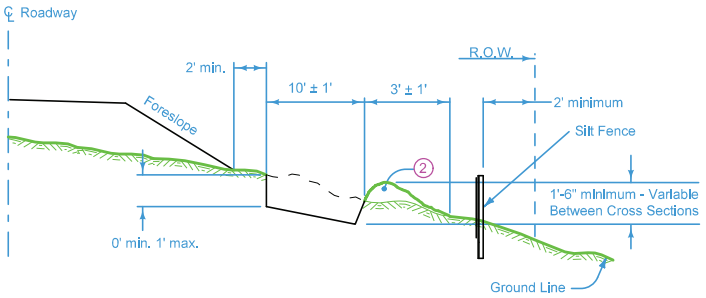
DESIGNER INFO



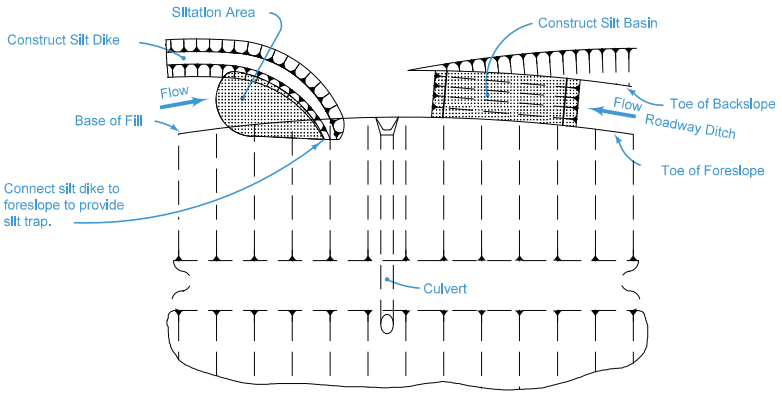
SILT DITCH



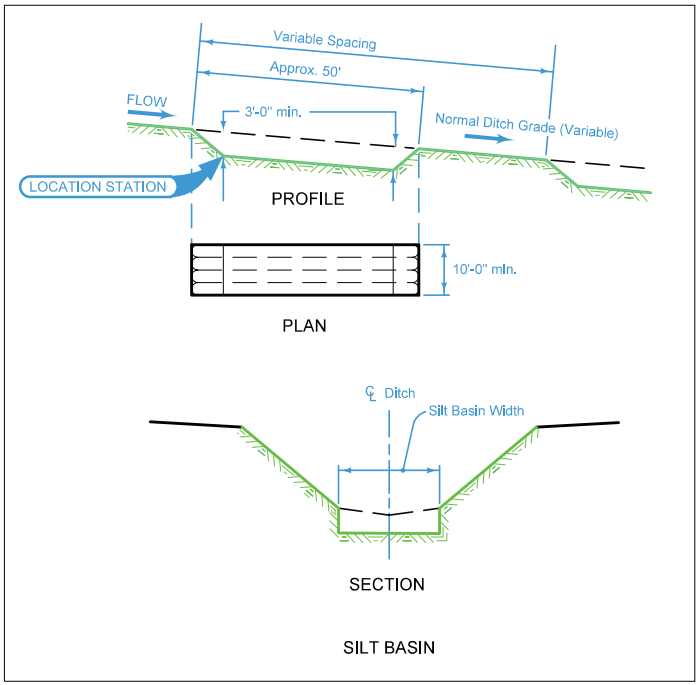
TOE FILLET ①



SILT DIKE



TYPICAL PLAN WITH
PERMANENT CULVERT INSTALLATION



SILT BASIN

Obtain the Engineer's approval for installation locations.

① Construct an earth fillet at the toe of the roadway foreslope for areas where a roadway ditch, silt ditch, or silt dike is not provided. This Toe Fillet is incidental to "Roadway and Borrow Excavation".

② Windrow of excavated and compacted silt material or deposited and compacted earth.

Possible Contract Items:

Silt Ditch
Silt Dike
Silt Basin

Possible Tabulations:

100-13
100-14
100-15

IOWA DOT

REVISION 3 04-18-17

STANDARD ROAD PLAN

EW-403

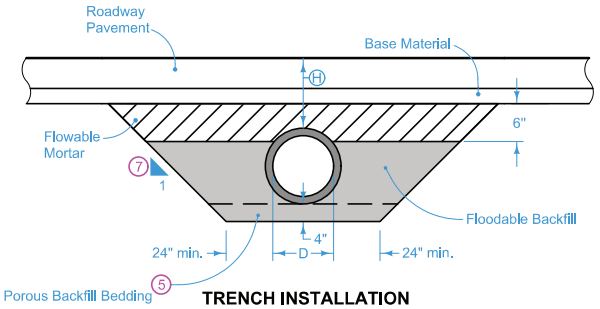
SHEET 1 of 1

REVISIONS: Added Location Station to Silt Basin view. Added Designer Info button.

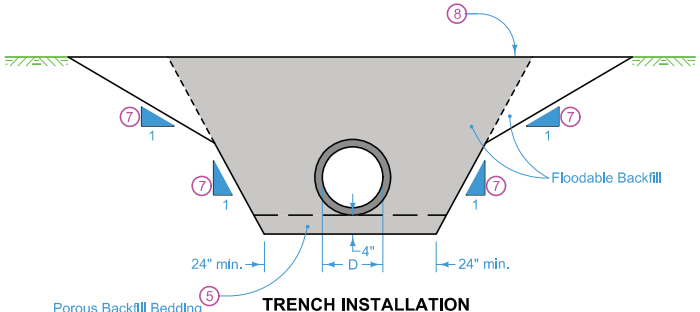
Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

TEMPORARY EROSION CONTROL MEASURES

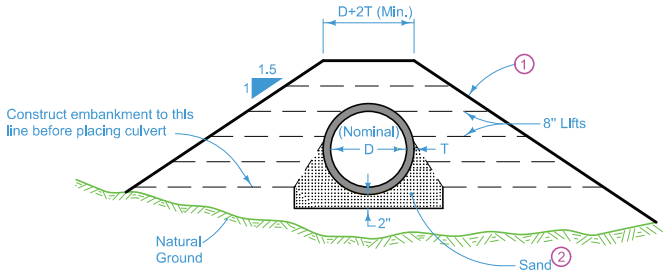
DESIGNER INFO



TRENCH INSTALLATION
(H) ≤ 4'



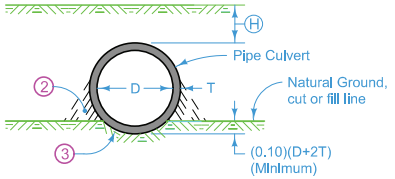
TRENCH INSTALLATION
(H) > 4'



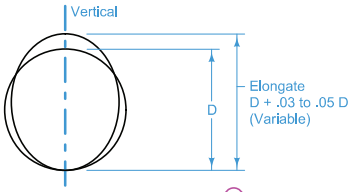
FILL INSTALLATION
(FOR RIGID PIPES ONLY)

CLASS 'B' BEDDING & BACKFILL (4)

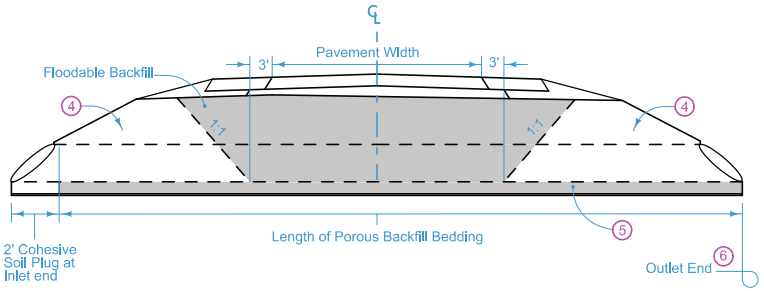
Denotes pay limits for flooded backfill



CLASS 'C' BEDDING & BACKFILL



ELONGATED PIPE (9)



TYPICAL SECTION - SOIL PLUG

Refer to DR-104 for minimum and maximum allowable cover (H) for the particular kind of pipe culvert.

1. The backfill adjacent to and above the pipe culvert may be placed in conjunction with normal embankment construction. Thoroughly tamp the embankment within the limits shown.
2. Take extra care to ensure complete and satisfactory tamping of backfill material in the area immediately adjacent to the lower portion of pipe.
3. Carefully shape excavation below groundline either using a template conforming to actual dimension and shape of the pipe or using other means. If using other means, check with a template conforming to the actual dimension and shape of the pipe.
4. For culverts backfilled by flooding, place a cohesive soil plug at the inlet, outlet, and, when necessary, sides, prior to flooding.
5. 4-inch Porous Backfill bedding. 2-inch Floodable Backfill bedding may be used under unsealed rigid pipe.
6. Extend Porous Backfill through the outlet end soil plug when used for bedding.
7. Quantity calculations are based upon a 1:1 slope and minimum trench dimension. Actual slope of trench may vary based upon Contractor's operations.
8. Ground Line at time of pipe installation. When existing ground exceeds 5 feet depth over pipe, backfill and compaction by flooding is not required more than 5 feet above the pipe.
9. Where a corrugated metal pipe culvert requiring elongation is to be installed (to counteract deformation caused by backfill), complete elongation using a means approved by the Engineer. Elongation may be developed either as part of shop fabrication or field installation. Install with elongated axis vertical.

Possible Contract Items:
- Flowable Mortar
- Flooded Backfill
- Excavation, Class 20

Possible Tabulations:
- 104-3
- 104-4

IOWA DOT

REVISION	
2	04-18-17

STANDARD ROAD PLAN

DR-101

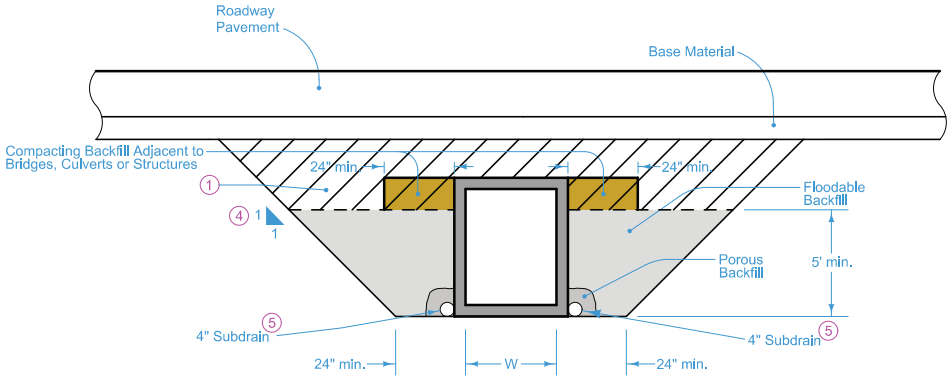
SHEET 1 of 1

REVISIONS: Changed "Porous Backfill" to "Porous Backfill Bedding" for clarity. Modified trench installation detail for H>4' to clarify pay limits.

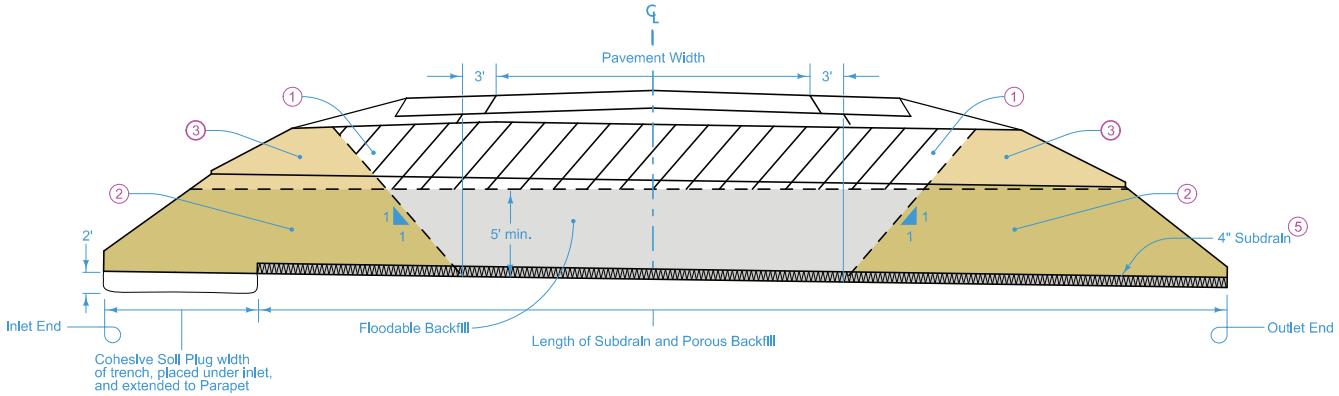
Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

PIPE CULVERT
(BEDDING AND BACKFILL)

DESIGNER INFO



RCB INSTALLATION



TYPICAL SECTION - COHESIVE SOIL PLUG

Denotes pay limits for flooded backfill

1. Excavated material meeting the requirements of the Standard Specifications. Compact using moisture control. The Contractor has the option to use Floodable Backfill. No additional compensation will be provided if the Contractor elects to use Floodable Backfill in lieu of suitable soil.
2. Prior to flooding, place a cohesive soil plug to the height of the floodable backfill at the inlet, outlet and sides of the culvert.
3. Excavated material meeting the requirements of the Standard Specifications. Compact using moisture control. If the option to use Floodable Backfill to the top of subgrade is used, extend the cohesive soil plug to the top of subgrade.
4. Quantity calculations for payment are based on a 1:1 slope and minimum trench dimension. Actual slope of trench may vary based upon Contractor's operations. No additional payment will be made for additional quantities resulting from use of flatter slopes.
5. Place at flowline elevation of culvert starting at parapet for inlet and outletting at end of outlet headwall wings. Cover with a minimum of 4 inches of Porous Backfill.

Possible Contract Items:
- Flooded Backfill
- Excavation, Class 20
- Compaction with Moisture Control
- Compacting Backfill Adjacent to Bridges, Culverts or Structures

Possible Tabulations:
- 103-6
- 104-4

IOWA DOT

STANDARD ROAD PLAN

REVISION	
2	04-17-18

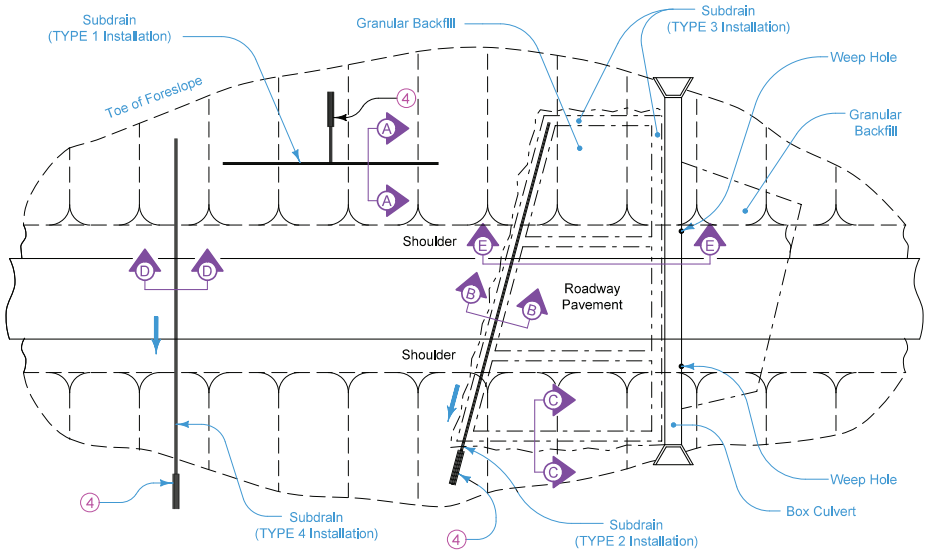
DR-111

SHEET 1 of 1

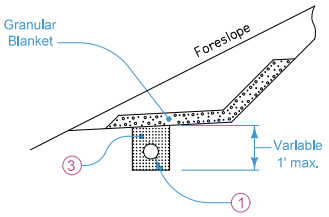
REVISIONS: Added Compacting Backfill Adjacent to Bridges, Culverts or Structures to Possible Contract Items and RCB Installation detail. Revised notes 3 and 4.

Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

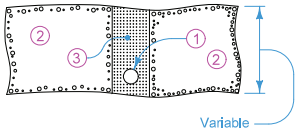
BOX CULVERT (BACKFILL)



PLAN VIEW OF TYPICAL STANDARD SUBDRAIN INSTALLATIONS



TYPE 1 INSTALLATION
BENCH DRAIN
SECTION A-A



TYPE 2 INSTALLATION
SUBDRAIN
SECTION B-B

For specific information for individual locations, refer to the detail project plans, soils survey sheets, and tabulations of subdrains.

Dispose of material excaluated from trenches for subdrain as directed by the Engineer. No extra compensation will be made for such disposal.

Cap blind ends of subdrains with a metal cap or by other methods approved by the Engineer. Install all perforated pipe with the perforations centered on flowline of the bottom side of the subdrain.

Place Granular Material for Blankets as indicated on the plans.

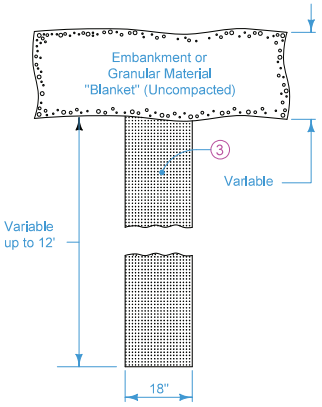
(1) Perforated Subdrain (Polyethylene Corrugated Tubing).

(2) Granular Material for Blanket (Uncompacted).

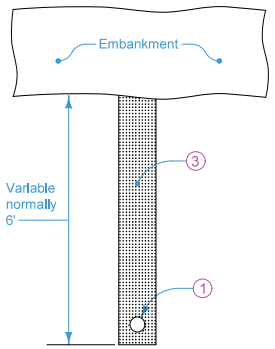
(3) Porous Backfill (Uncompacted).

(4) For Subdrain outlet construction details, see DR-305 and DR-306.

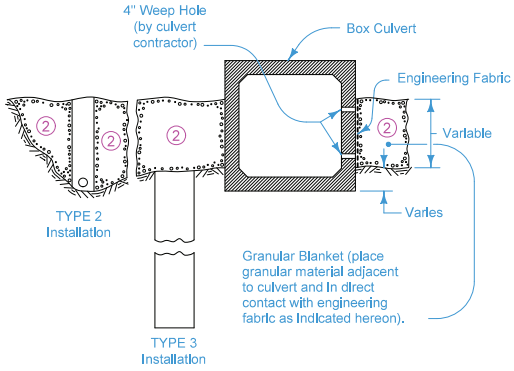
(5) 10 inches for 4 inch subdrain; 12 inches for 6 inch subdrain.



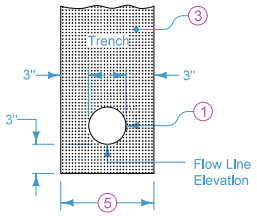
TYPE 3 INSTALLATION
TRENCH DRAIN
SECTION C-C



TYPE 4 INSTALLATION
SUBDRAIN
SECTION D-D



SECTION E-E
SUBSOIL DRAINAGE



TUBING PLACEMENT DETAIL
ALL TYPES

Possible Contract Items:
- Standard Subdrain
- Trench Drain
- Granular Material for Blanket and Subdrain
- Subdrain Outlet (DR-305)
- Subdrain Outlet (DR-306)

Possible Tabulations:
- 104-5C
- 104-6

IOWA DOT

REVISION
2 04-19-22

STANDARD ROAD PLAN

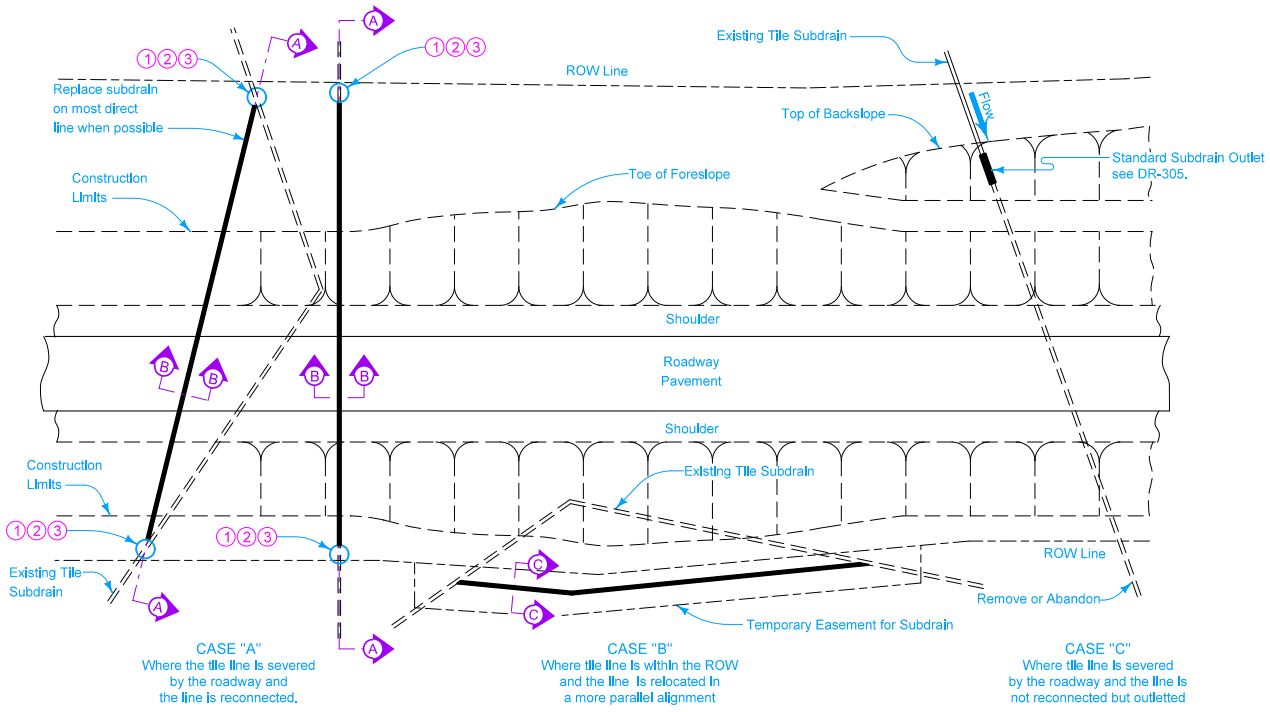
DR-301

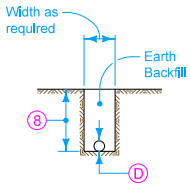
SHEET 1 of 1

REVISIONS: Added 104-6 to Possible Tabulations.

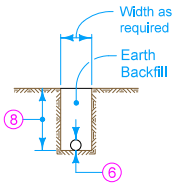
APPROVED BY DESIGN METHODS ENGINEER

SUBDRAINS
FOR FILL OR FOUNDATION DRAINAGE
(STANDARD)



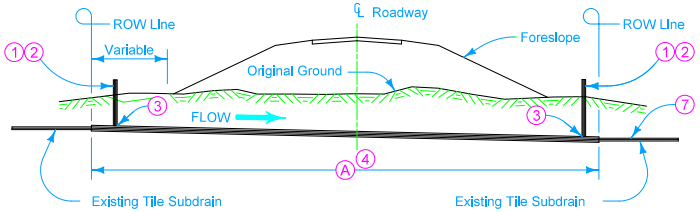


CASE "A"
SECTION B-B



CASE "B"
SECTION C-C

TYPICAL PLAN FOR REPLACING OR RELOCATING EXISTING FIELD TILE



CASE "A"
SECTION A-A

1. 4 inch diameter inspection access with cap. Minimum of 3 feet above ground. Use PVC meeting the requirements of Article 4146.03 of the Standard Specifications.
2. Inspection access is required to allow inspection by the upstream and downstream property owners. Perforated pipe may be used to allow ditch drainage into subdrain if approved by adjacent property owners.
3. A t-fitting or saddle connection is required unless an alternate connection is approved by the Engineer.
4. Dimension (A) indicates the R.O.W. limits in which replacement of tile subdrain according to the replacement schedule is required.
5. Replacement sizes provide equivalent capacity based on a 6 inch settlement assuming a 0.20% slope with n=0.013 for concrete pipe and n=0.025 for corrugated pipe (Manning's Formula)
6. Replace in kind (size and type) or with 'PE' slotted pipe, a minimum of one size larger than existing line.
7. When multiple drains are connected to one outlet, the outlet is to provide full capacity for all connected drain systems.
8. Depth as required.

When the existing tile lines are intercepted by roadway construction, replace them within the ROW limits of the project, or outlet them in a ditch or channel. Where the roadway intersects the tile line in an undesirable alignment, as shown in Case 'A', relocate the tile line to accomplish a more nearly right angle. Where the existing tile line alignment is more parallel to the roadway and within the construction limits, relocate the tile outside the ROW line, as shown in Case 'B'. In cases where new construction requires existing subdrain to outlet into the roadway ditch, as shown in Case 'C', provide the Standard Subdrain Outlet shown in DR-305.

Replace tile lines within the ROW limits according to the replacement schedule shown below. Install an inspection access at each end of replaced tile line. Replace tile lines outside the ROW limits using the same size of pipe as existing line.

REPLACEMENT SCHEDULE CASE 'A' (Pipe size in inches)		
Existing Tile Size	PROPOSED SUBDRAIN SIZE (D) (5)	
	Concrete Pipe	Coated CMP Pipe
4	-	10
6	-	12
8	12	15
10	15	18
12	15	21
15	18	24
18	21	30
21	24	36
24	30	36
> 24	Existing tile size + 6"	(6)

Install relocated or replacement subdrain so as to cause a minimum of disturbance to existing field tile. Connect to lines of existing tile drains in such a way as to leave the existing tile drains in a functional condition.

Cap blind ends of subdrains with a metal cap or as approved by the Engineer.

When concrete culvert pipe of 2000D (Class III) or stronger is required, furnish and install a DR-121 Type 1 connection at no additional cost to the Contracting Authority.

Possible Contract Items:
Standard Subdrain
Subdrain Outlet

Possible Tabulation:
104-5C

IOWA DOT

REVISION
2 4-18-23

STANDARD ROAD PLAN

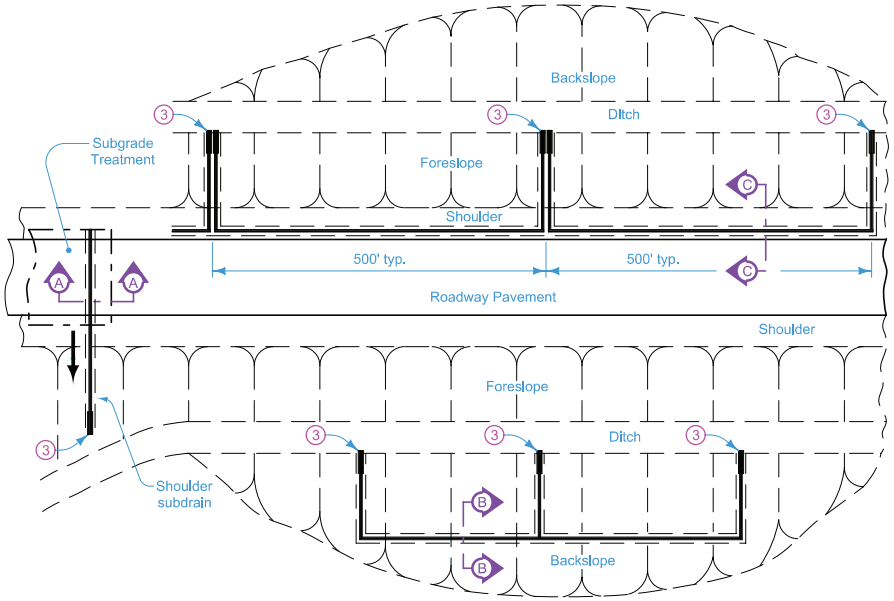
DR-302

SHEET 1 of 1

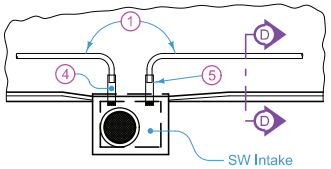
REVISIONS: Added note 3. Renumbered notes 4-8.

APPROVED BY DESIGN METHODS ENGINEER

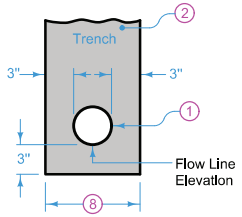
SUBDRAINS STANDARD (FARM TILE REPLACEMENT)



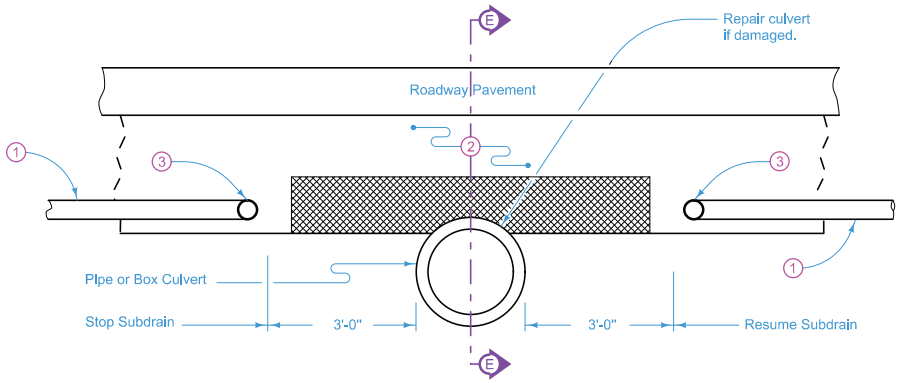
PLAN



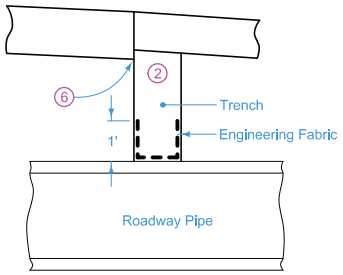
INTAKE OUTLET



TUBING PLACEMENT ALL TYPES



TRENCH REPAIR AT PIPE CULVERT (7)



SECTION E-E

When culverts which are less than 1 foot below the trench bottom are encountered within a tabulated subdrain, stop the trench 3 feet from the culvert and resume 3 feet beyond the culvert.

On new construction projects, place the subdrain after the special backfill, if required, and prior to granular or paved shoulder material.

Except for backslope installations, if the Contractor's operations result in a trench, place and compact granular shoulder material in the trench to be level with the adjacent surface prior to opening lanes to traffic.

(1) Perforated Subdrain (Corrugated Polyethylene Tubing).

(2) Porous Backfill for Subdrain (compacted).

(3) Subdrain outlets. See DR-306.

(4) 2 foot section of corrugated metal pipe of diameter 2" larger than subdrain or 2 foot section of double-walled PE or PVC pipe of the same diameter as subdrain. Pipe will be paid for as "Subdrain Outlet (DR-303)".

(5) Connect PE or PVC outlet with an appropriate coupler. Connect CMP outlet one of two ways: (1) Inside-fit reducer coupler (1 foot minimum fit inside CMP); or (2) Insert 1 foot of the 4 inch subdrain into 6 inch CMP and fully seal entire opening with grout.

(6) Place porous backfill in direct contact with a minimum of 2 inches of pavement and continuous to shoulder material as per note 10 or 11.

(7) If the trench is inadvertently carried over the culvert, repair the trench as detailed on this sheet. If obstruction is 1 foot or more below trench bottom, carry subdrain line over in continuous alignment. No payment will be made for trench repair.

(8) 10 inches for 4 inch subdrain. 12 inches for 6 inch subdrain.

Possible Contract Items:
Subdrain, Longitudinal, (Backslope)
Subdrain, Longitudinal, (Shoulder)
Subdrain Outlet (DR-303)
Subdrain Outlet (DR-306)

Possible Tabulation:
104-9

IOWA DOT

REVISION	
3	10-17-17

STANDARD ROAD PLAN

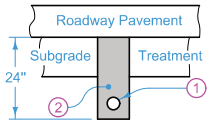
DR-303

SHEET 1 of 2

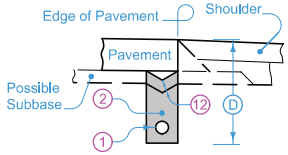
REVISIONS: References to the DR-304 have been changed to the DR-306.

Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

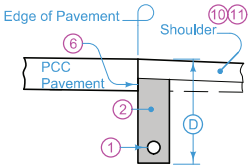
SUBDRAINS (LONGITUDINAL)



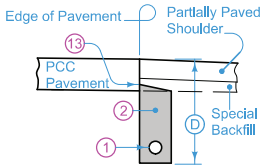
TYPE 5 INSTALLATION
SECTION A-A
Subgrade Treatment Subdrain



TYPE 6 INSTALLATION
SECTION C-C
For Drain Placement Prior to
Subbase or Pavement Placement



TYPE 7A INSTALLATION
SECTION C-C



TYPE 7B INSTALLATION
SECTION C-C

(1) Perforated Subdrain (Corrugated Polyethylene Tubing).

(2) Porous Backfill for Subdraln (compacted).

(6) Place porous backfill in direct contact with a minimum of 2 inches of pavement and continuous to shoulder material as per note 11 or 12.

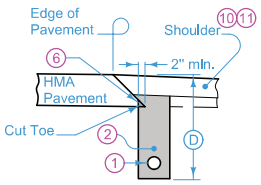
(9) Install subdrain as cut proceeds.

(10) On existing Granular or Earth Shoulders, replace with 4 inch minimum depth granular shoulder material.

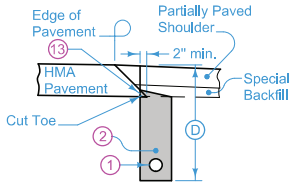
(11) On Paved Shoulders, refer to Section 2502 of the Standard Specifications for finishing shoulder.

(12) Cut "V" notch just prior to subbase (if proposed) or pavement placement to assure uncontaminated contact.

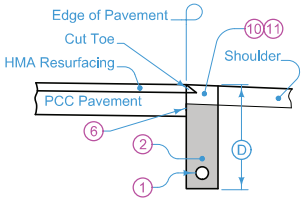
(13) Place top of subdrain trench at the bottom of pavement. Backfill trench so that a wedge of porous backfill has a minimum vertical contact of 2 inches with the pavement.



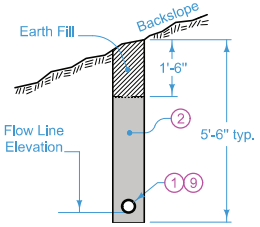
TYPE 8A INSTALLATION
SECTION C-C



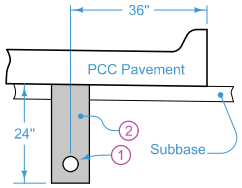
TYPE 8B INSTALLATION
SECTION C-C



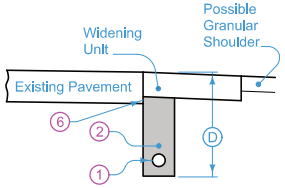
TYPE 9 INSTALLATION
SECTION C-C
Composite Pavement
with Existing Shoulder



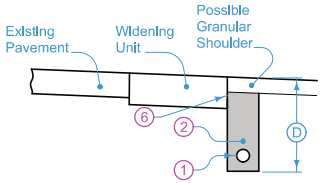
TYPE 11 INSTALLATION
SECTION B-B
Backslope



TYPE 12 INSTALLATION
SECTION D-D



TYPE 13 INSTALLATION
SECTION C-C
For New Widening Unit if
Thinner than Existing Pavement



TYPE 14 INSTALLATION
SECTION C-C
For New Widening Unit if
Thicker than Existing Pavement

IOWA DOT

STANDARD ROAD PLAN

REVISION	
3	10-17-17

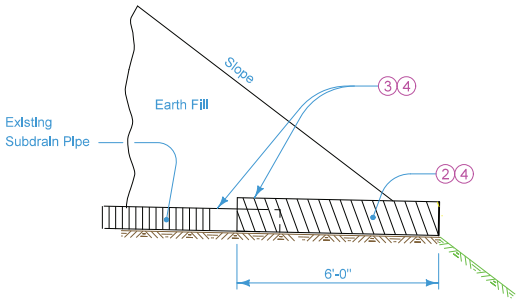
DR-303

SHEET 2 of 2

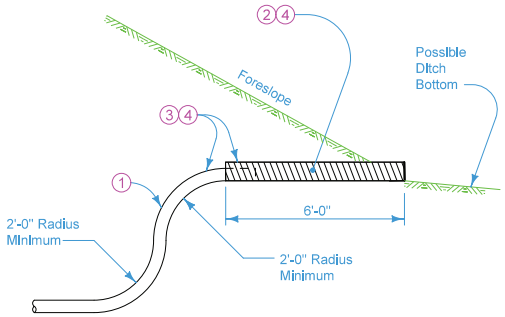
REVISIONS: References to the DR-304 have been changed to the DR-306.

Brian Smith
APPROVED BY DESIGN METHODS ENGINEER

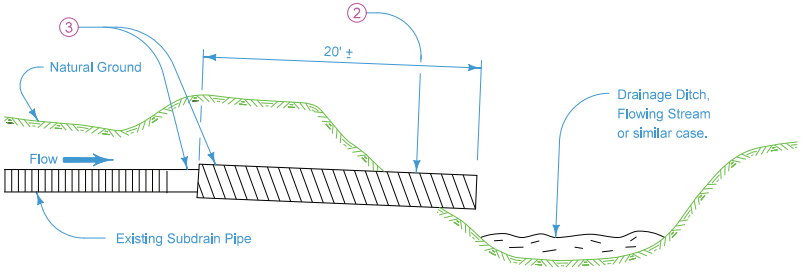
SUBDRAINS
(LONGITUDINAL)



STANDARD SUBDRAIN OUTLET
TYPE A
For existing subdrain pipes 12" or less in diameter. (5)



PRESSURE RELEASE OUTLET
TYPE B



SPECIAL OUTLET
TYPE C

(1) Perforated Subdrain (Polyethylene Corrugated Tubing).

(2) If corrugated metal pipe is used, an outlet 2 inches larger than existing subdrain pipe is required. If double-walled PE or PVC pipe is used, an outlet pipe of the same diameter as the existing subdrain pipe may be used.

(3) The pipes should be coupled in one of the two following ways: (1) Use an inside fit reducer coupler (coupler must be inserted a minimum of 12 inches into C.M.P.); or (2) Insert 12 inches of the existing subdrain pipe into the corrugated metal outlet pipe, then fully seal the entire opening with grout.

(4) If a concrete headwall is used, refer to DR-306.

(5) For existing subdrain pipes larger than 12 inches in diameter, use Special Outlet, Type C.

Possible Contract Item:
Subdrain Outlet (DR-305)

Possible Tabulations:
104-5C
104-6

IOWA DOT

REVISION	
2	04-19-22

STANDARD ROAD PLAN

DR-305

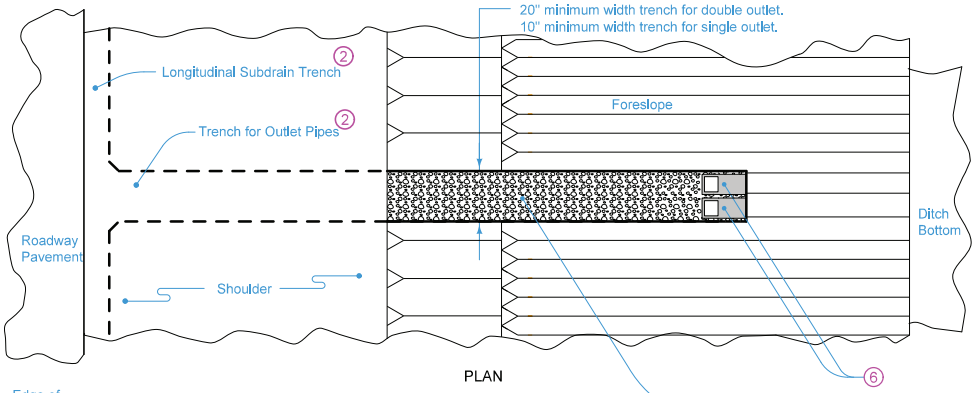
SHEET 1 of 1

REVISIONS: Added 104-6 to Possible Tabulations.

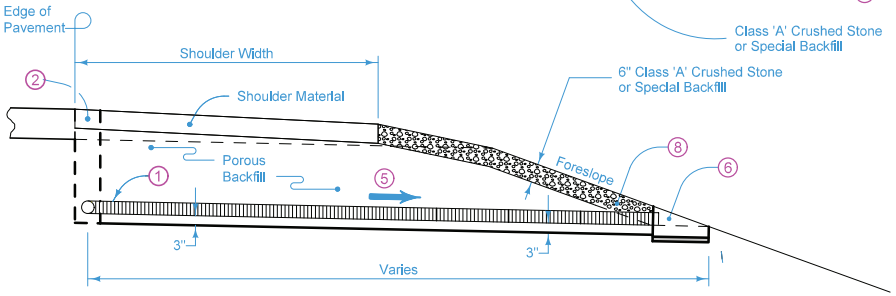
APPROVED BY DESIGN METHODS ENGINEER

SUBDRAIN OUTLETS (STANDARD SUBDRAIN, PRESSURE RELEASE AND SPECIAL)

DESIGNER INFO



PLAN



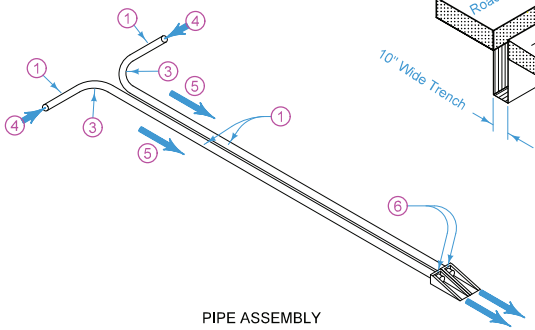
TYPICAL SECTION

LONGITUDINAL AND TRANSVERSE OUTLETS

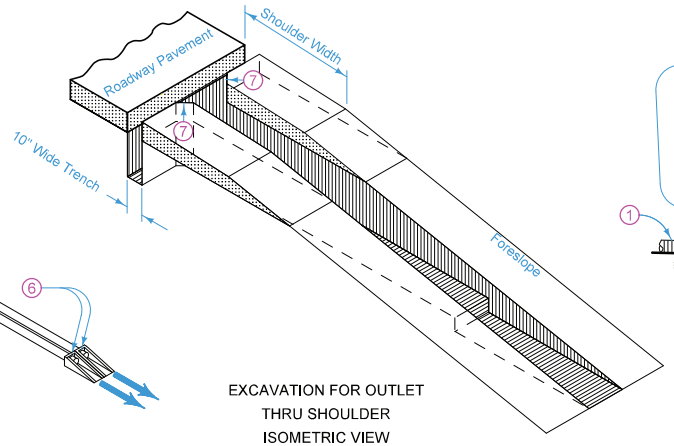
Extend subdrain 3 inches minimum (6 inches maximum) into precast subdrain headwall. Connect using one of the following methods:
-Grouted connection using a non-shrink grout complying with Materials I.M. 491.13.
-Gasketed connection approved by the Engineer.

Shape adjacent slope to match slope of precast subdrain headwall.

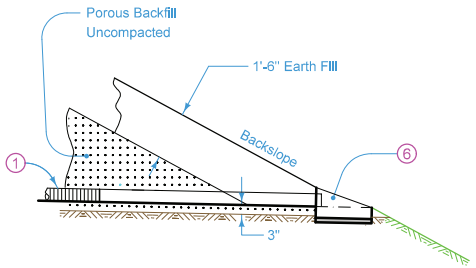
1. Perforated Subdrain (Polyethylene Corrugated Tubing).
2. On projects where existing shoulder material is removed, replace the shoulder material according to Article 2502.03, C of the Standard Specifications.
3. 'Y' or 'T' connection will not be allowed. Place subdrain on 1 foot minimum radius.
4. Direction of flow.
5. 6 inch minimum drop in elevation between longitudinal subdrain and outlet. 12 inch minimum drop for projects using recycled PCC subbase.
6. Precast concrete headwall.
7. Bevel the trench to provide a minimum of 3 inches of porous backfill surrounding all portions of subdrain pipe.
8. Place class 'A' crushed stone or Special Backfill over outlet and carefully compact to avoid damaging outlet pipe.



PIPE ASSEMBLY
ISOMETRIC VIEW



EXCAVATION FOR OUTLET
THRU SHOULDER
ISOMETRIC VIEW



BACKSLOPE OUTLET
TYPICAL SECTION

Possible Contract Item:
Subdrain Outlet, DR-306

Possible Tabulation:
104-5C
104-9

IOWA DOT

STANDARD ROAD PLAN

REVISION	
1	10-16-18

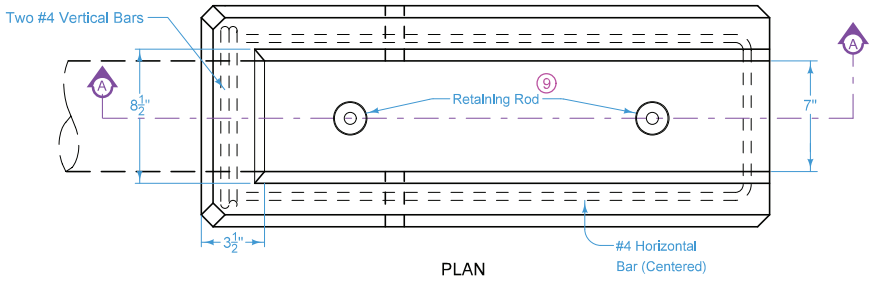
DR-306

SHEET 1 of 2

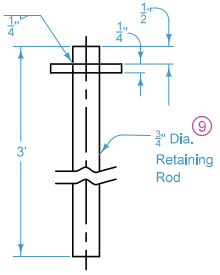
REVISIONS: Modified drawing on sheet 2 to allow one size headwall to be cast. Modified circle note 9 and added circle note 12 on sheet 2.

APPROVED BY DESIGN METHODS ENGINEER

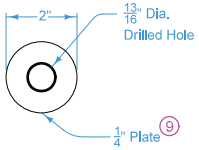
PRECAST CONCRETE HEADWALL FOR SUBDRAIN OUTLETS



PLAN

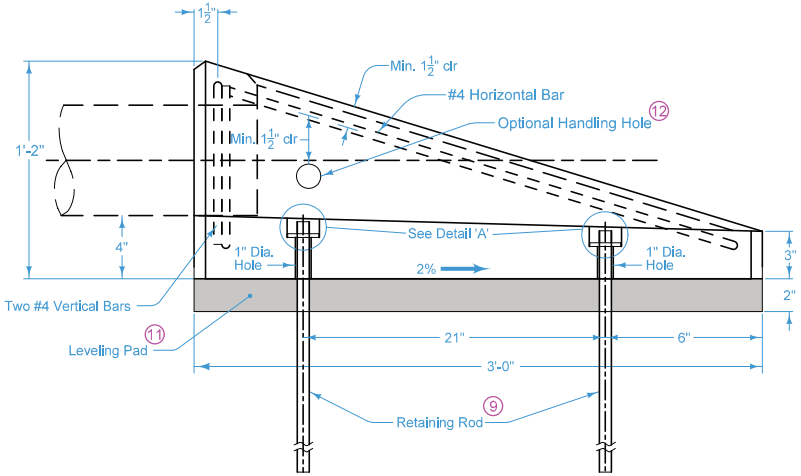


ELEVATION

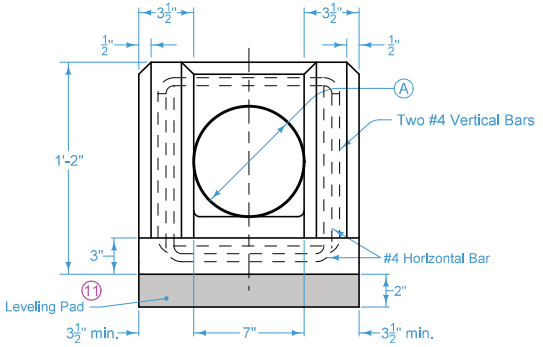


TOP

RETAINING ROD



SECTION A-A



END

Comply with Section 2419 of the Standard Specifications.

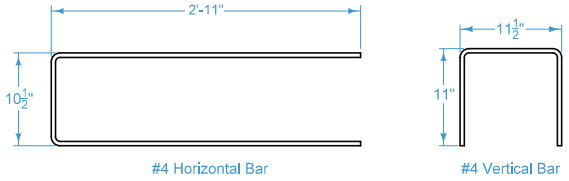
(9) ASTM A36 Steel galvanized according to ASTM A123 or ASTM F2329 after shop welding is complete.

(10) After installing retaining rod, fill recess with bituminous material complying with ASTM C990 to prevent moisture infiltration.

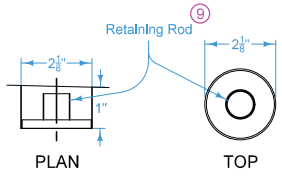
(11) Granular material complying with Section 4133 of the Standard Specifications.

(12) Maximum diameter 2 inches. Fill hole with soil tight plug after placing headwall and before placing backfill.

DIMENSION	4" DIA PIPE	6" DIA PIPE
(A)	5"	7"



BENT BAR SHAPES



PLAN TOP

DETAIL 'A' (10)
(Recess for Retaining Rod)

IOWA DOT

STANDARD ROAD PLAN

DR-306

REVISION 1 10-16-18

SHEET 2 of 2

REVISIONS: Modified drawing on sheet 2 to allow one size headwall to be cast. Modified circle note 9 and added circle note 12 on sheet 2.

APPROVED BY DESIGN METHODS ENGINEER

PRECAST CONCRETE HEADWALL FOR SUBDRAIN OUTLETS

Specifications

Section 2102. Roadway and Borrow Excavation

2102.01 DESCRIPTION.
Excavate, haul, place, compact, and shape construction materials.

2102.02 MATERIALS.

A. Class 10.
Includes:
- Normal earth materials such as loam, silt, gumbo, peat, clay, soft shale, sand, and gravel.
- Fragmentary rock or boulders handled in the manner normal to this class of excavation.
- Any combination of the above described materials and any other material not classified as Class 12 or Class 13.

B. Class 12.
Includes:
- Granite, trap, quartzite, chert, limestone, sandstone, hard shale, or slate in natural ledges or displaced masses.
- Rock fragments or boulders which occur on the surface or in subsurface deposits mixed with earth, sand, or gravel when their size, number, or location prevents them from being handled in a manner normal to Class 10 excavation.

C. Class 13.
Includes all materials included under the definitions of Classes 10 and 12 and any other material encountered, regardless of its nature.

D. Material Suitability.

1. Select Treatment Material.

a. Cohesive Soils.
Meet all of the following requirements:
1) 45% or less silt size fraction. Silt size particles are 0.074 to 0.002 mm.
2) 110 pounds per cubic foot or greater density (AASHTO T 99 Proctor Density or Materials I.M. 309).
3) Plasticity index greater than 10.
4) A-6 or A-7-6 soils of glacial origin.

b. Granular Soils.
Meet all of the following requirements:
1) 15% or less silt and clay.
2) 110 pounds per cubic foot or greater density (AASHTO T 99 Proctor Density or Materials I.M. 309).
3) Plasticity index, 3 or less.
4) A-1, A-2, or A-3 (0).

c. Special Backfill Material.
Meet the requirements of Section 4132.

d. Modified Subbase Material.
Meet the requirements of Section 4123.

2. Suitable Soils.

a. Ensure all soils provided for the construction of embankments meet the requirements below. They are suitable when moisture control or moisture and density control is designated.
1) 95 pounds per cubic foot or greater density (AASHTO T 99 Proctor Density or Materials I.M. 309).
2) AASHTO M 145 index of less than 30.
3) Liquid Limit (LL) less than 50.

b. Soils not meeting these requirements are considered unsuitable soils, regardless of classification.

c. When placing soil below water, use clean granular material.

3. **Unsuitable Soils.**
Place in the work only as specified by Standard Road Plan EW-102. Use in the work will be according to the definitions in Table 2102.02-1:

Table 2102.02-1: Uses for Unsuitable Soils

Definition	Use
1. Peat or Muck.	Topsoil Applications.
1. Soils with a plasticity index of 35 or greater. **2.** A-7-5 or A-5 having a density less than 85 pcf (AASHTO T 99 Proctor Density or Materials I.M. 309).	To be wasted off-site, unless shown otherwise in the contract documents.
1. All soils other than A-7-5 or A-5 having a density of 95 pcf or less (AASHTO T 99 Proctor Density or Materials I.M. 309). **2.** All soils other than A-7-5 or A-5 containing 3.0% or more carbon.	Type C placement placed 3 feet below top of subgrade in fills.
1. A-7-6 (30 or greater). **2.** Residual clays (overlaying bedrock), Paleosols, claypan, gumbo, and gumbotils regardless of classification.	Type B placement placed 5 feet below top of subgrade in fills.
1. Shale. **2.** A-7-5 or A-5 soils having a density greater than 86 pcf but less than 95 pcf (AASHTO T 99 Proctor Density or Materials I.M. 309).	Type A placement placed in layers 5 feet below top of subgrade in fills (Alternate layers to consist of suitable soils or Type C placement soils).

E. Selected Backfill Material.
Shown in the contract documents.

F. Special Backfill Material.
Meet the requirements of Section 4132.

2102.03 CONSTRUCTION.

A. General.

1. Prepare the site and construct the embankment according to Section 2107.

2. Remove materials as indicated in the contract documents and from borrow pits, exclusive of that designated as channel excavation.

3. Remove material necessary to provide suitable approaches from intersecting highways and private entrances.

4. Shape and slope materials for construction of the roadbed, slopes, gutters, and inlet and outlet ditches according to these specifications and the alignment, grade, and cross sections shown in the contract documents or established by the Engineer.

5. Before beginning construction, remove grass, weeds, other herbaceous vegetation, and rubbish as provided in Article 2102.03, G.

6. Work around utility poles if it is impractical to remove them before excavation or embankment construction.

B. Classification of Excavation.

1. Class 10 Excavation.
Excavate Class 10 material.

GS-23001

Section 2107. Embankments

2107.01 DESCRIPTION.

A. Prepare the site.

B. Place and compact excavated materials.

2107.02 MATERIALS.
Specified in the contract documents.

2107.03 CONSTRUCTION.

A. General.

1. Prepare the site, and place and compact excavated materials to the required elevation and cross section shown in the contract documents.

2. If the type of compaction is not specified, Type A compaction will be required.

This will be defined on next page.

B. Equipment.
Use equipment that meets the requirements of Section 2001 and the following:

1. Compaction Equipment.

a. When compaction with moisture and density control is not specified, use equipment that meets the requirements of Article 2001.05, A. Other types of compacting equipment may be used as provided in Article 2107.03, G.

This is sheepsfoot roller.

b. For compaction of sand or other granular material, use either a:

- Self propelled pneumatic roller meeting the requirements of Article 2001.05, C, or
- Self propelled vibratory roller meeting the requirements of Article 2001.05, F.

c. Compact special backfill material with equipment meeting the requirements of Articles 2001.05, B; C; D; F; or other types of compacting equipment as provided in Article 2107.03, G.

d. When compaction with moisture and density control is specified, any type of equipment which will produce the desired results may be used for compaction.

2. Equipment for Applying Water.
Apply Article 2001.09.

C. Preparation of the Site.

1. Strip topsoil as required by the contract documents.

2. When an embankment is placed on or against an existing slope which is generally steeper than 3 horizontal to 1 vertical and is more than 10 feet high, cut the slope into steps as the construction of the new embankment progresses. Assure that sod or other potential sliding surfaces are removed. Cut each step or series of steps to approximate horizontal planes with vertical slope cut dimensions of no less than 3 feet.

D. Depositing Embankment Material.

1. Comply with the following:

a. Except for rock fills and granular blankets, deposit embankments in horizontal layers not over 8 inches in loose thickness.

b. Keep the outer portion lower than its center.

c. When construction will be suspended for a period during which rain is likely to occur, smooth the surface to produce a smooth and compact surface to shed water.

d. Deposit soils containing quantities of roots, sod, or other vegetable matter outside of the shoulder line and within the outer 3 feet of the embankment.

e. Do not deposit tree stumps and other large woody objects in embankments.

f. Alternate layers of drier soils with wetter soils whenever it is practical to do so without an increase in average haul.

g. Do not construct embankments on frozen ground. Do not use frozen material to construct embankments.

2. Apply the following where Type A or Type B compaction operations are to be used:

a. When the width at the attained height is 30 feet or more, divide the area upon which the layer is to be placed into separate and distinct dump areas having widths no less than 15 feet. If hauling equipment is operated within a dump area, disk the area with a least one pass of a tandem axle disk or two passes with a single axle disk prior to compaction.

b. During compacting operations, keep hauling equipment off dump areas of embankments 36 feet wide or more. Empty hauling units may travel on the dump area during compaction operations as necessary to pass loaded hauling units if:

- Within 36 feet of a bridge or other limiting structure.
- The width of the embankment is less than 36 feet at the attained height.

c. If the design width of embankment is less than 30 feet at the attained height, hauling units will be allowed to travel through areas where compaction operations are in progress. Ensure hauling equipment passing through compaction operations does not force water, disking, and compacting equipment to deviate from their intended paths.

d. Deposit the material over the dump area as a separate and distinct operation. If the material, as deposited, contains an average of more than 1 lump per square yard large enough to have at least one dimension greater than 12 inches, disk the area with at least one pass of a tandem axle disk or two passes of a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer.

3. After depositing and disking (if required), smooth the material to a uniform depth using a suitable motor patrol, bulldozer, or self propelled sheepsfoot type roller with a blade attachment. In addition to the initial smoothing, continue smoothing and leveling during compaction as necessary to provide a surface area free from ruts and other objectionable irregularities. The self propelled, sheepsfoot type roller with blade attachment may be used under the following conditions:

a. Leveling is completed according to the prescribed rolling pattern.

b. Compaction is the major function of this unit.

c. Power drums are prevented from spinning.

4. When, in the Engineer's opinion, the unit cannot satisfactorily accomplish both leveling and rolling, use a separate dozer or motor patrol for the leveling operation prior to initiation of compaction.

E. Type A Compaction.

1. Type A compaction refers to compaction requiring a minimum of one rolling per inch depth of each lift. A further requirement is that the roller continues operation until it is supported on its feet, or the equivalent.

2. After smoothing the surface of the layer and before depositing material for the next layer, compact the layer with at least one pass of the sheepsfoot type roller for each inch of loose thickness of the layer. Compact until the roller is supported entirely on its feet. This occurs when the tamping feet penetrate no more than 3 inches into an 8 inch lift or 33% of the depth of the layer being placed.

Roller walk-out

3. Determine if the moisture content of the material is excessive or suitable for satisfactory compaction. The Contractor may elect to start rolling operations immediately after the smoothing operation, or may elect to delay rolling operations, and instead, aerate the material in preparation for rolling. Proceed with aeration and compaction operations in an orderly fashion without unreasonable and unnecessary delay. Rolling operations made prior to any aeration operations for a lift will not be counted as any of the required coverages.

4. Should the material be dry to the extent that it is likely to fail to be satisfactorily compacted by rolling, the Contractor may moisten the material. The Engineer may order the material to be moistened uniformly before compacting. Authorization may be given for the use of water in the final finishing of the roadbed.

5. Compensation will not be allowed for delays occasioned by the ordering of moistening or by drying.

6. The Contractor may request approval of other methods and equipment according to Article 2107.03, G.

See next page

F. Type B Compaction. ← As noted earlier in the specifications, if no type of compaction is required, then Type A is required.

1. Type B compaction refers to compaction requiring a specified number of diskings and roller coverages, or the equivalent.

2. After smoothing the surface of the layer and before depositing the next layer, compact or smooth and compact the layer.

3. If the entire weight (mass) of the roller is supported on its feet after one pass of the roller for each inch of loose thickness of the layer, no further compacting is necessary. A roller will be considered to be supported entirely on its feet when the feet penetrate no more than 3 inches into an 8 inch lift or 33% of the depth of the layer being placed.

4. If the soil in the layer is too wet when it is deposited to compact to the degree that the entire weight of the roller is supported on its feet, the Engineer may require one disking per 2 inches of loose thickness of the layer in addition to the disking required in the smoothing operation. A disking consists of a complete coverage of the layer with either a tandem axle disk or a single axle disk. Use a disk designed and operated to cut and stir to the full depth of the layer. The Engineer may require an interval no longer than 2 hours between successive diskings. After the disking has been completed, compact the layer with one pass of a sheepsfoot type roller per inch of loose thickness of the layer.

5. The manipulation and compaction specified above is incidental to Class 10 or Class 13 excavation. The Engineer may require additional manipulation and compaction as extra work. If the soil is so dry that it will fail to be satisfactorily compacted by rolling, the Engineer may require the Contractor to moisten the material uniformly before it is compacted.

6. Compensation will not be allowed for delays caused by the ordering of moistening or by disking.

7. The Contractor may substitute Type A compaction at no additional cost to the Contracting Authority where Type B compaction is specified, by written notification to the Engineer, or the Contractor may request approval of other methods and equipment according to Article 2107.03, G.

G. Compaction by Other Methods and Equipment. ← Referenced on bottom of previous page

1. Other methods of compaction may be used. Demonstrate they will obtain suitable compaction of a variety of soil types and moistures normally encountered. Compaction will be considered suitable if the resulting density, with adequate moisture, is both:
   - Reasonably uniform throughout the compacted lift.
   - At least 95% of maximum density, determined according to Iowa DOT Materials Laboratory Test Method No. Iowa 103.

2. Other types of compacting equipment may be used. Demonstrate they will obtain equivalent compaction results using a variety of soil types and moistures normally encountered. Demonstrations are to be such that results can be compared.

3. For Type A compaction, equivalent compaction must be recognizable by roller penetration or other significant characteristic.

4. For other methods or other equipment, a definite approval will be necessary, including any limitations the Engineer deems advisable.

5. Use of other methods and equipment prior to approval, except for demonstration tests, must provide 6 inch compacted lifts at 95% of maximum density, during which moisture is maintained no drier than 3% below optimum moisture.

H. Compaction with Moisture and Density Control.

1. The contract documents will indicate where to construct embankments with moisture and density control. When a specific depth is required, the contract documents will also indicate the distance below the elevation of the completed grading work to which such methods are to be applied.

Here are moisture limits.

Unless specified otherwise in the contract documents, maintain moisture content within the limits of -2.0% and +2.0% of optimum moisture content for maximum dry density.

2. Where construction with moisture and density control is indicated in cut sections:
   a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches above the elevation shown for the bottom of the moisture and density control section.
   b. Thoroughly scarify the remaining 6 inch layer.
   c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch layer within the moisture limits specified.
   d. Compact this 6 inch layer to no less than 90% of maximum density determined according to Iowa DOT Materials Laboratory Test Method No. Iowa 03.
   e. Deposit the remainder of the cut section to the completed grade elevation in layers according to Article 2107.03, D.
   f. Uniformly moisten each layer as necessary to bring to within the specified moisture limits.
   g. Compact each layer to no less than 95% of maximum density.

This refers to max. 8" loose lifts.

3. Where construction with moisture and density control is indicated in embankment sections outside cuts:
   a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture and density control.
   b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
   c. Compact the first layer placed with moisture and density control to no less than 90% of maximum determined according to Iowa DOT Materials Laboratory Test Method No. Iowa 103.
   d. Compact each succeeding layer to no less than 95% of maximum density.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture and density to within the specified limits of the optimum moisture content. After field tests determine that a layer is within the specified moisture limits, begin compaction and continue until the required density is obtained. If compaction is interrupted or delayed on a layer, bring the moisture of the layer to within the specified limits before resuming compaction.

I. **Compaction with Moisture Control.**

Here are moisture limits.

1. The contract documents will indicate where to construct embankments with moisture control. When a specific depth is required, the contract documents will indicate the distance below the elevation of the completed grading work to which such methods are to be applied. Unless specified otherwise in the contract documents, maintain moisture content within the limits of -2.0% and +2.0% of optimum moisture content for maximum dry density.

2. Where construction with moisture control is indicated in cut sections:
   a. Excavate the roadbed below proposed subgrade elevation to a plane 6 inches above the elevation shown for the bottom of the moisture control section.
   b. Thoroughly scarify the remaining 6 inch layer.
   c. Increase or reduce the moisture content as necessary to bring the moisture throughout this 6 inch layer within the moisture limits specified.
   d. Compact this 6 inch layer as specified in Article 2107.03, E.
   e. Deposit the remainder of the cut section in layers according to Article 2107.03, D.
   f. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
   g. Compact each succeeding layer as specified in Article 2107.03, E.

Type A compaction

Max. 8" loose lifts

3. Where construction with moisture control is indicated in embankment sections outside cuts:
   a. Deposit in layers, according to Article 2107.03, D, all material in fill above the designated elevation for compaction with moisture control.
   b. Uniformly moisten or dry as necessary to bring each layer within the specified moisture limits.
   c. Compact layers placed with moisture control as specified in Article 2107.03, E.

4. Prior to compaction, bring the moisture content of each layer of earth to be compacted with controlled moisture within the specified limits of the optimum moisture content. After field tests determine that a layer is within the specified moisture limits, begin compaction and continue unit the requirements of Article 2107.03, E, are obtained. If compaction is interrupted or delayed for more than 1 hour on a layer, bring the layer within the specified moisture limits before resuming compaction.

J. Rock Fills.

1. When the excavated material consists of rock fragments too large to be placed in layers of the thickness prescribed without further breaking them down, it may be placed in the embankment in horizontal layers 4 feet or less in thickness. Place each layer to avoid future water entrapment. In most cases, this will require placement to full embankment width, except for topsoil on the foreslope. Level each layer with a suitable dozer. Smooth each layer by choking the surface of the rock with spalls and finer fragments or earth.

2. Do not construct the 4 foot lifts above an elevation 2 feet below the finished grade line. The next foot of embankment height may be placed in one layer using rock spalls and finer fragments which may be satisfactorily consolidated by the dozer and tractor. For the last foot below the finished grade line, use either:
   - Earth smoothed and placed in layers not exceeding 8 inches thickness and rolled as described above, or
   - Special backfill material placed as shown in the contract documents.

3. Conduct operations in such a way that the Engineer is given the opportunity to take cross sectional measurements required before the earth cover is placed.

K. Granular Blankets.

1. Where a granular blanket is specified, spread material meeting the requirements of Section 4133 to the width and thickness shown in the contract documents. Do not use compaction equipment. The blanket may be constructed in several lifts. Do not incorporate foreign material from hauling equipment or other sources.

2. In areas requiring both granular blanket and subdrain backfill material, the sequence of operations will be the option of the Contractor. Ensure that contact areas between porous backfill material, granular material for subdrains, and granular blankets are free from clay or silt.

L. Rebuilding Embankments.

1. Do not place a pavement partly on an old and partly on a newly constructed embankment. Remove the part of the old embankment that would be under the pavement as below grade excavation to the natural ground line, or to a depth of 5 feet below the proposed grade line, whichever is higher. Rebuild as prescribed for new embankments.

2. Rebuild embankments according to Article 2107.03, C, unless otherwise specified in the contract documents. Compact the material according to Article 2107.03, E.

3. At locations where the width of embankment widening is less than 4 feet, widening material may be placed and shaped to the bottom of pavement or base elevation without compaction other than that obtained with wheels of motor graders and hauling equipment. Placement and compaction may be accomplished in 8 inch lifts parallel to the finished slope, provided the existing slope has been roughened by disking or scarification.

4. In all cases of embankment widening, remove surface vegetation from slopes against which the widening material is to be placed. Deposit this material according to Article 2107.03, D.

M. Compacting Trench Bottom.
When designated in the contract documents, excavate the roadbed for the width shown to 1 foot below subgrade elevation. Scarify the next 6 inch depth and compact as for Type B compaction, unless otherwise specified. When the bottom of the trench has been compacted, place suitable backfill material in the excavation and compact. If the type of compaction is not specified for this upper 1 foot, Type A compaction will be required on Primary projects and Type B compaction on Secondary projects.

N. Use of Unsuitable Soils.

1. Unsuitable soils may be used in embankments according to Standard Road Plan EW-102.

2. Unless otherwise specified, when used in embankments, spread unsuitable material in uniform layers no more than 8 inches in loose thickness. Cover each layer with a layer or layers of suitable material.

O. Embankments Adjacent to Culverts and Structures.

1. When the contract documents require embankment construction adjacent to a bridge, culvert, or other structure, construct the compacted embankment to the height shown and to the full width of the roadway. Secure material for constructing these embankments from within the right-of-way or authorized borrow area as directed by the Engineer. Waste the material from within the waterway of bridges or culverts which is too wet to be suitable for compaction. Do not place this material in the embankment.

2. Place embankments adjacent to bridges, culverts, and structures with the same precautions and methods described in Article 2402.03, H. The contract documents may require moisture control.

3. Use mechanical or pneumatic tampers for compaction in areas occupied by embankments which are too narrow for the operation of rollers. The Contractor may elect to enlarge the area in which the embankment is to be constructed by cutting down the elevation of the old fill to permit rolling equipment to operate efficiently. When old fill is removed for this purpose, step it up to its original height such that each step has a horizontal dimension no less than 3 feet with a vertical rise.

4. Flowable mortar may be placed as backfill material adjacent to bridges, culverts, and structures, at no additional cost to the Contracting Authority. Place this backfill material according to Section 2506.

P. Quality Control Program (Embankment Construction).
On projects where the Department is the Contracting Authority:

This gives QC sampling & testing to contractor

1. Provide and maintain a Quality Control Program (Embankment Construction). This is defined as process control sampling, testing, and inspection as described in Materials I.M. 540 for construction of embankments with moisture control, or moisture and density control.

2. Provide a Quality Control Technician who is responsible for all process control sampling, testing, and inspection. The Quality Control Technician shall obtain Soils Technician certification through the Iowa DOT Technical Training and Certification Program (TTCP).

3. Provide a laboratory facility and necessary calibrated equipment to perform required tests.

4. Notify the Engineer when a moisture content falls outside specified control limits or density falls below required minimum. If a moisture content falls outside control limits, fill material in this area will be considered unacceptable for compaction. Perform corrective action(s) to bring uncompacted fill material within control limits. If material has been compacted, disk it, bring to within control limits, and re-compact. When project has a density requirement, if an in-place density does not meet the requirements, compacted fill material in this area will be considered unacceptable. Perform corrective action(s) to material to meet density requirements. Compensation will not be allowed for delays resulting from moistening, disking, or re-compacting.

2107.04 METHOD OF MEASUREMENT.

A. Measurement will be as provided in Article 2102.04. The following will be included in Class 10 excavation:

1. Excavation in preparation for constructing embankment by compaction with moisture control.

2. Excavation in preparation for constructing embankment by compaction with moisture and density control.
3. Excavation in preparation for compacting trench bottom.

4. Excavation in preparation for rebuilding embankment.

B. Embankment construction will not be measured separately for payment except as follows:

1. **Compaction with Moisture and Density Control.**
   Cubic yards shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture and density control quantity.

2. **Compaction with Moisture Control.**
   a. Cubic yards shown on the contract documents as determined by the template fill volume. Shrinkage will not be included in moisture control quantity.
   b. When moisture control is required adjacent to culverts and stockpasses (Article 2107.03, O) the volume will be computed using the formula in Article 2107.04, B, 4. When moisture control is required adjacent to pipe culverts, the volume will be computed as provided in Article 2402.04.

3. **Compacting Trench Bottom.**
   Stations shown on the contract documents as determined along the center line of the roadbed.

4. **Compacting Backfill Adjacent to Bridges, Culverts, or Structures.**
   The quantity of backfill material placed and compacted by the grading contractor adjacent to bridges, box culverts, or structures or their extensions will be the quantity obtained by the following formula:

$$Q = \frac{(4 \text{ ft.} \times L \times H)}{27}$$

   Where: Q = quantity of compacted backfill material in cubic yards;

   L = (1) length in feet of the culvert or stock pass from back to back of parapet, or
   (2) length in feet from back of existing parapet to back of parapet of the extension;

   H = nominal height of structure opening, feet. If floodable backfill per Standard Road Plan DR-111 is used, H is the height from top of floodable backfill to top of structure.

5. **Granular Material for Blanket and Subdrain.**
   Cubic yards according to Article 2312.04, A.

6. **Water for Embankment Construction.**
   Except when compaction with control of moisture and density or moisture is specified, water for embankment construction required for moistening materials to be placed in embankment will be measured in thousands of gallons by gauging the contents of the transporting vehicle or by metering the supply. Authorized water for finishing the roadbed will not be measured for payment if a period in excess of 2 calendar days has elapsed between final compaction of a dump area and final finishing of the same area.

2107.05 BASIS OF PAYMENT.

A. Payment for embankment construction will be contract unit price as for Embankment-In-Place according to Article 2102.05, with the following additions:

1. **Compaction with Moisture and Density Control.**
   a. Per cubic yard.
   b. Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials to the specified density.
   c. On projects where the Department is the Contracting Authority, payment includes process control sampling, testing, and inspection.

2. **Compaction with Moisture Control.**
   a. Per cubic yard.
   b. Payment is full compensation for the work of drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

c. On projects where the Department is the Contracting Authority, payment includes process control sampling, testing, and inspection.

3. **Compacting Trench Bottom.**
   a. Per station.
   b. Payment is full compensation for the work of scarifying, drying material, furnishing and applying water, controlling moisture content of the materials, and compacting the materials, as specified.

4. **Compacting Backfill Adjacent to Bridges, Culverts, or Structures.**
   Per cubic yard.

5. **Granular Material for Blanket and Subdrain.**
   Per cubic yard.

6. **Water for Embankment Construction.**
   a. Except when compaction with moisture and density control or moisture control is specified, payment for water for embankment construction added at the Engineer's direction will be the contract unit price per 1000 gallons.
   b. In case the contract does not contain a unit price for water, and moistening of the material is authorized or ordered, payment for water will be as extra work at the rate of $12.00 per 1000 gallons.
   c. When Type A compaction or compacting embankments with moisture and density control or moisture control is specified, manipulation necessary to incorporate water or work necessary to dry the material will be considered as incidental work and will not be paid for separately.
   d. When Type B compaction is specified, manipulation necessary to incorporate water will be considered incidental to other work. Work performed at the Engineer's direction to dry or compact the material, in excess of that obtained by the maximum number of diskings and roller coverages specified for Type B compaction, will be paid for as extra work according to Article 1109.03, B.

B. Payment for Compaction with Moisture and Density Control, Compaction with Moisture Control, Compacting Trench Bottom, and Compacting Backfill Adjacent to Culverts and Stockpasses will be for plan quantities in conjunction with quantities shown in the contract documents described in Article 2102.04 and under the conditions described therein.

Handouts

How to define your Soil Texture.

Try this simple exercise:

Take a small sample, moisten it slightly from a water bottle, and work it into a ball between your thumb and fingers,

How long do you have to work a soil between your fingers to get it to a putty-like consistency?

Clay soils can take several minutes. Silty soils can be worked up very quickly.

The first picture is of a silty clay soil. The soil took a long time to work up so it could be easily molded. It contained approximately 40-45% clay.

Will the soil adhere to your thumb as a ball?

Clay soils cannot be easily "flicked" from your thumb. Silty soils can be "flicked" off easily.

Does the soil form "peaks" on your finger and thumb when you pull it apart?

Clay soils form large peaks between your finger and thumb. Silty soils do not form peaks of any significance.

This is a clay soil - *see how it peaks easily?*

Can you clean the soil off your finger when you rub it across with your thumb?

Clay soils leave their color on your finger. Silty soils can be cleaned right off so that all you see is your finger.

Does the soil feel "soapy" or "buttery" when worked up?

Silty soils feel "soapy". Clay soils feel "buttery".

Try this with a clearly silty soil and a clearly clay soil and you will understand the difference in touch.

From http://informedfarmers.com/defining-your-soils-texture/

POWERPOINT