

# **APPENDIX A**

## **Modified Unified Description of Soil Samples \***

### **Introduction**

For many years the Unified Soil Classification System has been used successfully by soils engineers to categorize soil samples. The major advantage of this system is the easily understood word picture used to describe the soil samples after classification. The major disadvantage is the number of time consuming classification tests that must be done to develop the word picture.

At present, numerous private firms and State agencies are using the nomenclature of the Unified System but without the classification testing. This process of visually identifying and describing soil samples is known as the Modified Unified Description (MUD).

The procedure involves visually and manually examining soil samples with respect to texture, plasticity and color. A method is presented for preparing a "word picture" of a sample for entering on a subsurface exploration log or other appropriate data sheet. The procedure applies to soil descriptions made in the field or laboratory.

It should be understood that the soil descriptions are based upon the judgement of the individual making the description. Classification tests are not intended to be used to verify the description, but to provide further information for analysis of soil design problems or for possible use of the soil as a construction material.

It is the intent of this system to describe only the constituent soil sizes that have a significant influence on the visual appearance and behavior of the soil. This description system is intended to provide the best word description of the sample to those involved in the planning, design, construction, and maintenance processes.

<b>Terms</b>	<b>Definition of Terms</b>
Boulder	A rock fragment, usually rounded by weathering or abrasion, with average dimension of 12 inches or more.
Cobble	A rock fragment, usually rounded or subrounded, with an average dimension between 3 to 12 inches.
Gravel	Rounded, subrounded, or angular particles of rock that will pass a 3-inch square opening sieve (76.2 mm) and be retained on a Number 4 U.S. standard sieve (4.76 mm).  (The term "gravel" in this system denotes a particle size range and should not be confused with "gravel" used to describe a type of geologic deposit or a construction material.)
Sand	Particles that will pass the Number 4 U.S. standard sieve and be retained on the Number 200 U.S. standard sieve (0.074 mm).
Silt	Material passing the Number 200 U.S. standard sieve that is nonplastic and exhibits little or no strength when dried.
Clay	Material passing the Number 200 U.S. standard sieve that can be made to exhibit plasticity (putty like property) within a wide range of water contents and exhibits considerable dry strength.
Fines	The portion of a soil passing a Number 200 U.S. standard sieve.
Marl	Unconsolidated white or dark gray calcium carbonate deposit.
Muck	Finely divided organic material containing various amounts of mineral soil.
Peat	Organic material in various stages of decomposition.
Organic Clay	Clay containing microscopic size organic matter. May contain shells and/or fibers.
Organic Silt	Silt containing microscopic size organic matter. May contain shells and/or fibers.
Coarse Grained Soil	Soil having a predominance of gravel and/or sand.
Fine Grained Soil	Soil having a predominance of silt and/or clay.
Mixed-Grained Soil	Soil having significant proportions of both fine-grained and coarse-grained sizes.

NOTE: When applied to gradation test results, silt size is defined as that portion of the soil finer than the No. 200 U.S. standard sieve and coarser than 0.002 mm. Clay size is that portion of soil finer than 0.002 mm. For the visual-manual procedure the identification will be based on plasticity characteristics.

### Visual – Manual Identification

Gravel	Identify by particle size. The particles may have an angular, rounded, or subrounded shape. Gravel size particles usually occur in varying combinations with other particle sizes.
Sand	Identified by particle size. Gritty grains that can easily be seen and felt. No plasticity or cohesion. Size ranges between gravel and silt.
Silt	Identified by behavior. Fines that have no plasticity. May be rolled into a thread but will easily crumble. Has no cohesion. When dry, can be easily broken by hand into powdery form.
Clay	<p>Identified by behavior. Fines that are plastic and cohesive when in a moist or wet state. Can be rolled into a thin thread that will not crumble. When dry, forms hard lumps which cannot be readily broken by hand.</p> <p>Clay is often encountered in combination with other soil sizes. A sample which exhibits plasticity or cohesion contains clay. The amount of clay can be related to the degree of plasticity or cohesiveness; the higher the clay content the greater the plasticity.</p>
Marl	A white or gray calcium carbonate paste. May contain granular spheres, shells, organic material or inorganic soils. Reacts with weak hydrochloric acid.
Muck	Black or dark brown finely divided organic material mixed with various proportions of sand, silt, and clay. May contain minor amounts of fibrous material such as roots, leaves, and sedges.
Peat	Black or dark brown plant remains. The visible plant remains range from coarse fibers to finely divided organic material.
Organic Clay	Dark gray clay with microscopic size organic material dispersed throughout. May contain shells and/or fibers. Has weak structure which exhibits little resistance to kneading.
Organic Silt	Dark gray silt with microscopic size organic material dispersed throughout. May contain shells and/or fibers. Has weak structure which exhibits little resistance to kneading.
Fill	Man-made deposits of natural soils and/or waste materials. Document the components carefully since presence and depth of fill are important engineering considerations.

### Soil Sample Identification Procedure

1 <sup>st</sup> Decision	Is sample coarse-grained, fine-grained, mixed-grained or organic? If mixed-grained, decide whether coarse-grained or fine-grained predominates.
2 <sup>nd</sup> Decision	What is principal component? Use a <u>noun</u> in soil description. Example: Sand.
3 <sup>rd</sup> Decision	What is secondary component? Use as <u>adjective</u> in soil description. Example: Silty Sand.
4 <sup>th</sup> Decision	Are there additional components? Use as additional adjectives. Example: Silty Sand, Gravelly.

### Example of Description of the Soil Components

Sand	Describes a sample that consists of <u>both</u> fine and coarse sand particles.
Gravel	Describes a sample that consists of <u>both</u> fine and coarse gravel particles.
Silty Fine Sand	Major component fine sand, with non-plastic fines.
Sandy Gravel	Major component gravel size, with fine and coarse sand. May contain small amount of fines.
Gravelly Sand	Major component sand, with gravel. May contain small amount of fines.
Gravelly Sand, Silty	Major component sand, with gravel and non-plastic fines.
Gravelly Sand, Clayey	Major component sand, with gravel and plastic fines.
Sandy Gravel, Silty	Major component gravel size, with sand and non-plastic fines.
Sandy Gravel, Clayey	Major component gravel size, with sand and plastic fines.
Silty Gravel	Major component gravel size, with non-plastic fines. May contain sand.
Clayey Gravel	Major component gravel size, with plastic fines. May contain sand and silt.
Clayey Silt	Major component silt size, with sufficient clay to impart plasticity and considerable strength when dry.
Silty Clay	Major component clay, with silt size. Higher degree of plasticity and higher dry strength than clayey silt.

The above system may be expanded where necessary to provide meaningful descriptions of the sample.

Examples: Shale fragments - Cobble and gravel size, silty

Decomposed rock - Gravel size

<b>Other Information for Describing Soils</b>	
Color of the Sample	Brown, Gray, Red, Black, etc.
Moisture Condition	Dry, Moist, Wet. Judge by appearance of sample before manipulating.
Plasticity	Plastic, Low Plastic, Non-plastic. Sample must be in moist or wet condition for plasticity determination. For dry samples requiring wetting make note in description. Example - "plastic (low or non-plastic) when wet." Plasticity not required for marl, muck and peat.
Structure	Fissured, Blocky, Varved, Layered. (Indicate approximate thickness of layers). The description of layering for coarse-grained soils must be made from field observations before sample is removed from sampler.
Particular Shape	Angular, Rounded, Subrounded.
Other words, phrases, notes or remarks that will add to the meaningfulness of the complete soil description.	

### **Preparing the Word Picture**

The word-picture is the description of the soil sample as determined by the visual-manual procedure. Where applicable, the following are to be included in the word-picture:

<u>Pertinent Information</u>	<u>Example</u>
Color of the sample	Brown
Description of soil components	Silty gravel
Moisture condition	Moist
Plasticity	Non-plastic
Structure	Blocky
Particle Shape	Angular
Other	Cemented

The written description for the given example is: Brown Silty Angular Gravel, Moist, Non-plastic, and Cemented.

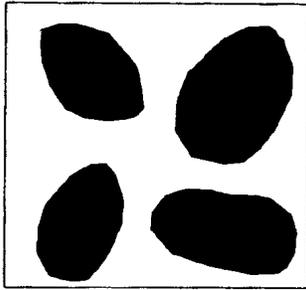
#### Examples of Complete Soil Descriptions

- Light Gray Silty Clay, moist, plastic, with ½ inch layers of wet gray silt, non-plastic.
- Red brown Clayey silt with ¼ inch layers of Silty clay, moist, plastic
- Brown Silty fine Sand, wet, non-plastic
- Gray Sandy rounded Gravel, dry non-plastic
- Gray Sandy angular Gravel, Clayey, moist, low plastic
- Dark Brown Silty Sand, wet, non-plastic
- Red Brown Silty Sand, wet, non-plastic

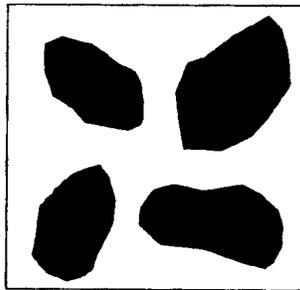
- Fill – Brown Sandy subrounded Gravel, with pieces of brick and cinders, wet, non-plastic.
- Fill containing cinders, paper, garbage, and glass, wet
- Dark Gray Organic Clay, with Shells and roots, moist, plastic.

Boulder	Cobble	Gravel		Sand		Silt	Clay
		Coarse	Fine	Coarse	Fine		
SIEVE SIZES							
12*	3*	1*	#4	#40	#200		
304.8	76.2	25.4	4.76	0.42	0.074		0.002
PARTICLE SIZE - mm							

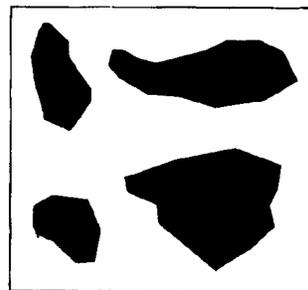
**PARTICLE SIZE LIMITS**



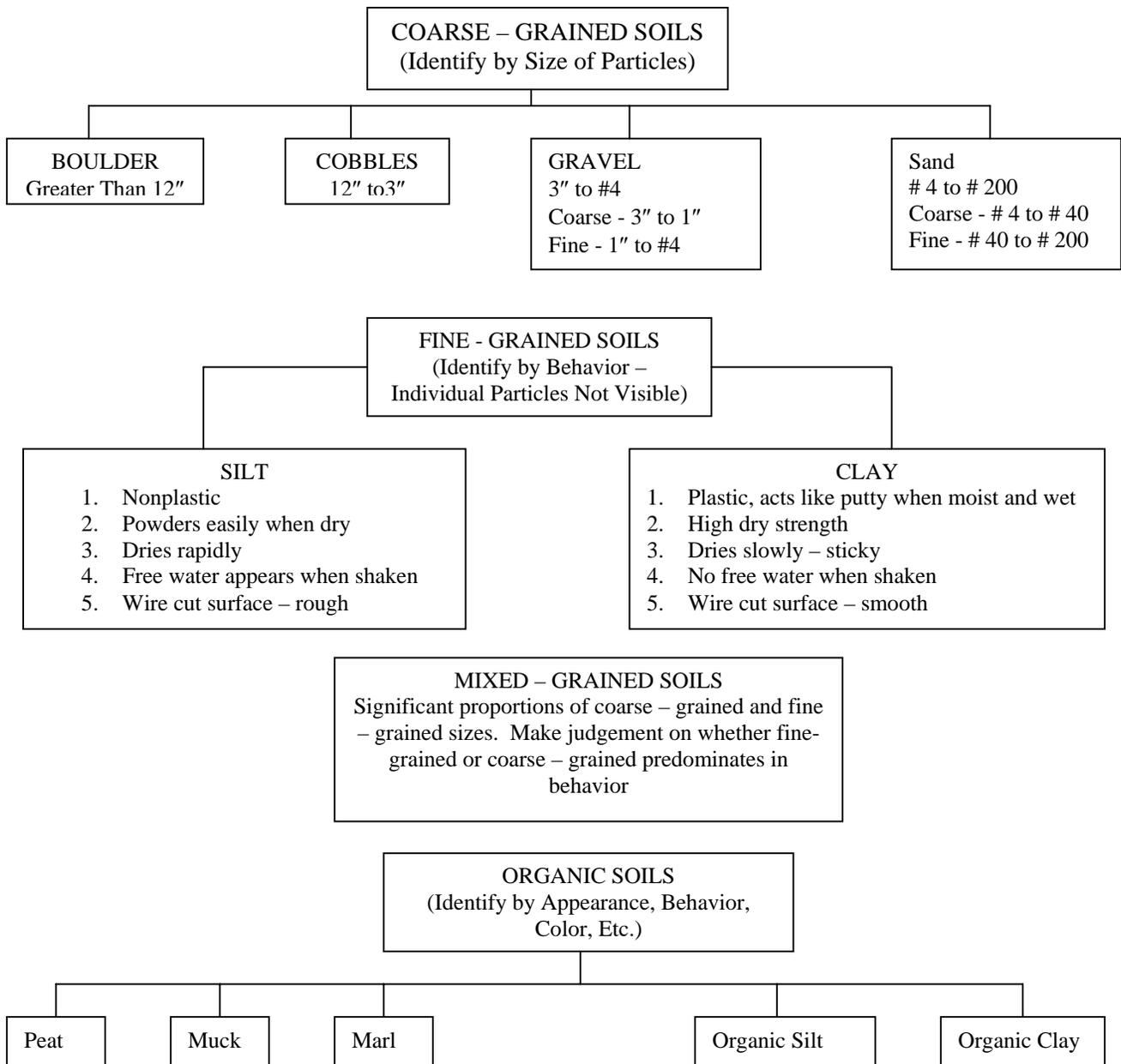
Rounded



Subrounded



Angular



# **APPENDIX B**



# **APPENDIX C**

## **EMBANKMENT IN PLACE (LIGHTWEIGHT FILL)**

### **Description**

Under this Item, the Contractor shall furnish and place lightweight fill necessary to complete the embankments shown on the plans or as ordered by the Engineer.

### **Materials**

The material shall be blast furnace slag, expanded shale or other materials as approved by the Deputy Chief Engineer, Technical Services. The material shall have a maximum particle size of 24 inches in greatest dimension and the compacted wet density shall not exceed the density specified in the proposal as measured in a test embankment.

### **Construction Details**

The compacted wet density shall be determined in test embankments containing a minimum of 400 cubic yards of material constructed on firm flat surfaces. The Contractor shall construct each test embankment in an area bounded by 100 ft. by 50-ft. dimensions and shall give the Engineer at least one (1) week written notice prior to beginning each test in order for the location to be inspected and surveyed.

The lightweight fill material shall be stored in piles not exceeding 20,000 cubic yards prior to testing. Representative material from each storage pile shall be used to construct a test embankment to a minimum height of four (4) feet in accordance with this specification.

The Contractor shall weigh all the material prior to placement in the test embankment. The embankment shall be constructed in uniform layers not exceeding 24 inches in thickness prior to compaction. Each layer shall be rolled over its entire area by a vibratory steel drum roller. The number of passes, the size of vibratory steel drum roller, and the need for actually vibrating the roller will be as directed by the Engineer.

The Engineer shall determine the volume of the test embankment. If the compacted wet density of the material in the test embankment is greater than the specified density, both the material contained in the test embankment and the material from the storage pile it represents shall be rejected for use under this Item.

The design embankment shall be constructed using the same methods, equipment and procedures used to construct the test embankments. However, the following requirements contained in the earthwork section shall now apply:

- a. The density requirements both in the embankment and in the subgrade area.
- b. The maximum particle size in the subgrade area.
- c. Proof rolling.
- d. Compaction.

The top surface of the lightweight embankment lying directly beneath the subbase course materials shall be chinked to the satisfaction of the Engineer with lightweight material to prevent infiltration of the subbase materials.

**Method of Measurement**

The quantity of lightweight fill to be paid for under this Item shall be the number of cubic yards of material computed in its final compacted position between the payment lines shown on the plans or between revised payment lines established by the Engineer prior to performing the work.

**Basis of Payment**

The unit price bid per cubic yard shall include the cost of furnishing all labor, material and equipment necessary to complete the work including the test embankments.

No payment will be made for any loss of material which may result from foundation settlement, erosion or any other cause. The cost of such losses shall be included in the price bid for this item.

# **APPENDIX D**

## **Lightweight Fill - Sawdust**

The following is the special provision for lightweight sawdust fill used by the Washington State DOT.

### **Sawdust borrow in place**

Where shown in the plans or where directed by the Engineer, the Contractor shall furnish, load, haul, place, and compact sawdust borrow in place.

### **Materials**

The sawdust borrow shall consist of 100 percent wood fibers, such as sawdust, hog fuel or wood chips. No composition wood products, such as particle or chip board, pressed hard board, or presto-log fragments shall be used in this embankment. Maximum size shall be 6 inches in the greatest dimension. Sufficient smaller sized material shall be used to produce a uniformly dense fill. Cedar sawdust borrow will not be allowed.

### **Construction**

The sawdust borrow embankments may be constructed by dumping from trucks or by any other methods approved by the Engineer. Sawdust borrow shall be placed in lifts a maximum of 1 foot in depth of uncompacted material.

Compaction shall be obtained by covering the entire surface of each lift with a minimum of two passes with a D8-Caterpillar tractor or other similar compaction units as approved by the Engineer. Hauling units shall be routed over the entire fill for additional compaction.

### **Measurement**

Sawdust borrow in place will be measured by the cubic yard of neat line volume in place.

### **Payment**

The unit contract price per cubic yard for "Sawdust Borrow in Place" shall be full compensation for furnishing all labor, tools, equipment and materials necessary or incidental to complete the work as specified, including loading, hauling, placing, and compacting.

# **APPENDIX E**

## Typical Specification for Select Material

DESCRIPTION – This work shall consist of excavation, disposal, placement, and compaction of all materials that are not provided for under another section of these specifications, and shall be executed in conformance with payment lines, grades, thickness, and typical sections specified in the contract documents.

MATERIALS – Tests and Control Methods. Materials tests and control methods pertaining to the item requirements and work of this section will be performed in conformance with the procedures used by the Department.

Materials furnished under these items shall conform to the following requirements:

1. Gradation – The material shall have the following gradation:

Sieve Size	Percent Passing by Weight
4 inches	100
No. 40	0 – 70
No. 200	0 – 15

2. Soundness – The material shall be substantially free of shale or other soft, poor durability particles. Where the State elects to test for this requirement, a material with a magnesium sulfate soundness loss exceeding 30 percent after four (4) cycles will be rejected.

CONSTRUCTION – The type of material to be used in filling and backfill at structures, and payment lines, therefore, shall be in conformance with the details shown on the appropriate Standard Sheet or as noted on the plans or as ordered by the engineer.

Fill or backfill material at structures, culverts, and pipes shall be deposited in horizontal layers not exceeding 6 inches in thickness prior to compaction. Compaction of each layer shall be as specified. A minimum of 100 percent of standard Proctor maximum density (AASHTO T99) will be required. When filling behind abutments and similar structures, all material shall be placed and compacted in front of the walls prior to placing fill behind the walls to a higher elevation. The limits to which this subsection will apply, shall be in accordance with the Standard Sheets or as modified on the plans.

MEASUREMENT – Quantities for this work shall be computed in cubic yards in the final compacted position. A deduction shall be made for pipes (based on nominal diameters) and other payment items when the combined cross-sectional area exceeds one square foot unless otherwise shown on plans. No deduction will be made for the cross-sectional area of an existing facility.

BASIS OF PAYMENT – The unit price bid for all pay items of work encompassed by this section, shall include the costs of furnishing all equipment, labor, and materials as necessary to complete the work of the item, except where specific costs are designated or included in another pay item of work. All incidental costs, such as acquisition of borrow pits or material outside of the right-of-way, rock drilling and blasting, compaction and special test requirements, stockpiling, and rehandling of materials, precautionary measures to protect private property and utilities and to form and trim graded surfaces, shall be included in the unit price of the pay item where such costs are incurred.

# **APPENDIX F**

## Typical Specifications for Underdrain Filter Material

**DESCRIPTION** – The work shall consist of constructing underdrain filter installations in accordance with these specifications and in conformity with the plans.

**MATERIAL** – Underdrain Filter Material shall consist of crushed stone, sand, gravel, or screened gravel. Material tests and quality control methods pertaining to the item requirements and work of this Section will be performed in conformance with the procedures in use by the Department.

Underdrain Filter Material shall be stockpiled.

Gradation:

<b>Sieve Size</b>	<b>Percent Passing by Weight</b>
1 inch	100
½ inch	30 – 100
¼ inch	0 – 30
No. 10	0 – 10
No. 20	0 – 5

**Soundness:** The soundness of the material shall be tested. This material shall have a loss not exceeding 20 percent by weight after four (4) cycles of the magnesium sulphate soundness test.

**CONSTRUCTION DETAILS** – Underdrain Filter material, shall be placed adjacent to structures as specified on the contract plans. The lift thickness for the loose material shall not exceed six (6) inches and shall precede the placement of each lift of adjacent backfill material. A physical barrier may be used to facilitate placement of the Underdrain Filter and adjacent backfill. This barrier shall not be left in place and shall be removed prior to compaction of the material. Each lift of filter material and backfill material located within a minimum distance of 3 feet from the back wall plus the footing heel projection shall be compacted simultaneously. Compactive effort for this material shall be provided by two passes of vibratory compactor approved by the engineer. Placement and compaction operations shall be conducted in a manner so as to insure that the top surface of each lift of filter material shall not be contaminated by the adjacent backfill materials. No compaction control tests will be required for the filter material.

**METHOD OF MEASUREMENT** – The quantity of Underdrain Filter material shall be computed for payment as the number of cubic yards placed between the payment lines shown on the contract Plans or as modified by the engineer. No deduction will be made for the volume occupied by the underdrain pipe.

**BASIS OF PAYMENT** – The unit price bid per cubic yard shall include the cost of furnishing all labor, materials, and equipment necessary to complete the work. No direct payment will be made for any losses of material which may result from compaction, foundation settlement, erosion, or any other causes; the cost of such losses shall be included in the price bid for this item. Any contaminated underdrain filter material shall be replaced by the contractor as directed by the engineer at no cost to the State. Excavation, granular fill, and backfill will be paid for separately under their appropriate items.

# **APPENDIX G**

## **Example Specification for Bitumen Coating**

### **Description**

This work shall consist of furnishing and applying bituminous coating and primer to prestressed concrete pile surfaces as required in the plans and as specified herein.

### **Materials**

- A. Bituminous Coating. Bituminous coating shall be an asphalt type bitumen conforming to ASTM D946, with a minimum penetration grade 50 at the time of pile driving. Bituminous coating shall be applied uniformly over an asphalt primer. Grade 40-50 or lower grades shall not be used.
- B. Primer. Primer shall conform to the requirements of ASTM D41.

### **Construction Requirements**

All surfaces to be coated with bitumen shall be dry and thoroughly cleaned of dust and loose materials. No primer or bitumen shall be applied in wet weather, nor when the temperature is below 65 degrees F.

The primer shall be applied to the surfaces and allowed to completely dry before the bituminous coating is applied. Primer shall be applied uniformly at the quantity of one gallon per 100 square feet of surface.

Bitumen shall be applied uniformly at a temperature of not less than 300 degrees F., nor more than 350 degrees F. and shall be applied either by mopping, brushing, or spraying at the project site. All holes or depressions in the concrete surface shall be completely filled with bitumen. The bituminous coating shall be applied to a minimum dry thickness of 1/8 inch but in no case shall the quantity of application be less than 8 gallons per 100 square feet.

Bitumen coated piles shall be stored before driving and protected from sunlight and heat. Pile coatings shall not be exposed to damage during storage, hauling or handling. The Contractor shall take appropriate measures to preserve and maintain the bitumen coating. At the time of pile driving, the bitumen coating shall have a minimum dry thickness of 1/8 inch and a minimum penetration value of 50. If necessary, the Contractor shall re-coat the piles, at his expense, to comply with these requirements.

### **Method of Measurement**

Bitumen coating will be measured by the square yard of coating in place on concrete pile surfaces. No separate payment will be made for primer.

### **Basis of Payment**

The accepted quantities of bitumen coating will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in applying the bituminous coating and primer, as shown in the plans, and as specified in these specifications, and as directed by the Engineer.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Bitumen Coating	Square Yard.

# **APPENDIX H**

## **Example Specification for Bitumen Coating**

### **Description**

This work shall consist of furnishing and applying bituminous coating and primer to steel pile surfaces as required in the plans and as specified herein.

### **Materials**

- A. Bituminous Coating. Canal Liner Bitumen (ASTM D-2521) shall be used for the bitumen coating and shall have a softening point of 190 degrees F., to 200 degrees F., a penetration of 56 to 61 at 25 degrees C., and a ductility at 25 degrees C., in excess of 3.5 cm.
- B. Primer. Primer shall conform to the requirements of ASTM D-41.

### **Construction Requirements**

All surfaces to be coated with bitumen shall be dry and thoroughly cleaned of dust and loose materials. No primer or bitumen shall be applied in wet weather, nor when the temperature is below 65 degrees F.

Application of the prime coat shall be with a brush or other approved means and in a manner to thoroughly coat the surface of the piling with a continuous film of primer. The purpose of the primer is to provide a suitable bond of the bitumen coating to the pile. The primer shall set thoroughly before the bitumen coating is applied.

The bitumen should be heated to 300 degrees F., and applied at a temperature between 200 degrees F., to 300 degrees F., by one or more mop coats, or other approved means, to apply an average coating depth of 3/8 inch. Whitewashing of the coating may be required, as deemed necessary by the engineer, to prevent running and sagging of the asphalt coating prior to driving, during hot weather.

Bitumen coated piles shall be stored immediately after the coating is applied for protection from sunlight and heat. Pile coatings shall not be exposed to damage or contamination during storage, hauling, or handling. Once the bitumen coating has been applied, the contractor will not be allowed to drag the piles on the ground or to use cable wraps around the pile during handling. Pad eyes, or other suitable devices, shall be attached to the pile to be used for lifting and handling. If necessary, the contractor shall recoat the piles, at his expense to comply with these requirements.

A nominal length of pile shall be left uncoated where field splices will be required. After completing the field splice, the splice area shall be brush or mop coated with at least one coat of bitumen.

### **Method of Measurement**

Bitumen coating will be measured by the linear foot of coating in place on the pile surfaces. No separate payment will be made for primer or coating of the splice areas.

### **Basis of Payment**

The accepted quantities of bitumen coating will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in applying the bituminous coating and primer, as shown in the plans, and as specified in these specifications, and as directed by the Engineer.

Payment will be made under:

Pay Item  
Bitumen Coating

Pay Unit  
Square Yard.