CITY OF KNOXVILLE

TECHNICAL SPECIFICATIONS

CITY OF KNOXVILLE
ENGINEERING DEPARTMENT
CIVIL ENGINEERING DIVISION

CITY OF KNOXVILLE

TECHNICAL SPECIFICATION

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CITY OF KNOXVILLE

Section 1.0

Knoxville, Tennessee
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TECHNICAL SPECIFICATIONS
FOR
MOBILIZATION OF FORCES, SUPPLIES, AND EQUIPMENT

1. Description

This work shall consist of the mobilization of forces, supplies, equipment and incidentals at the project site. It shall include all preconstruction costs incurred after award of the contract which are necessary costs to the project and are of a general nature rather than directly attributable to other pay items.

2. Method of Measurement

Mobilization will be measured by the unit for the completion of the work as described above, and payment will be made on a lump sum basis.

% of Total Contract Amount on Estimate	% Allowed This Item
Not less than 5%	40%
10%	70%
25%	100%

Amount of Contract	Maximum Amount Allowed
0 - $100,000	8% of Contract Amount
$100,000 - $500,000	$4,000 + 3% of Contract Amount
$500,000 or greater	$14,000 + 1% of Contract Amount

3. Basis of Payment

Partial payments for Mobilization will be made on the basis of a percentage of the lump sum price bid or of the current maximum allowable as indicated in the Payment Schedule above, whichever is smaller. Full payment for Mobilization will be made in accordance with the provisions set out in the Payment Schedule above, which price shall be full compensation for organizing the moving all forces, supplies, equipment, and incidentals to the project site, regardless of the number of times such moves are made and also for all preconstruction costs incurred after award of the Contract.

TECHNICAL SPECIFICATIONS
FOR
CLEARING AND GRUBBING

1. Description

This work shall consist of clearing, grubbing, removal, and satisfactory disposal of all materials within the project limits, except those items designated to remain, or to be removed in accordance with other sections of these Specifications.

2. Construction Methods

(a) The project area shall be cleared of all dead trees, stumps, brush, hedges, weeds, logs and other objectionable material and vegetation within 6" of the ground surface.

(b) In areas where excavation is to be made and 5 feet beyond the excavation limits, all trees, stumps, roots, brush, hedge, heavy growth of vegetation, etc., shall be cleared and grubbed.

(c) In areas where embankments are to be constructed, all trees, stumps, roots, brush, hedge, heavy growth of vegetation, etc., shall be cleared and grubbed to a point 5 feet beyond slope intercepts. All depressions made below the ground surface shall be refilled with suitable material and compacted before the embankment is started. Unsatisfactory material such as brush, hedge, roots, stump, branches and logs of trees, heavy vegetation, etc. shall not be embedded or buried within the embankment.

(d) This work shall include the preservation from injury of all trees and other vegetation that are not within designated areas of clearing and grubbing, unless marked for removal by the Engineer.

(e) Branches of trees extending over the roadway shall be trimmed symmetrically to provide a clear height of twenty feet above the finished roadway elevation.

(f) All slopes of cuts, embankments, ditches, channels, waterways and all structures, both old and new, shall be cleared and cleaned of all brush, hedges, weeds, heavy vegetation, obstruction, rubbish and other objectionable material or growth; and shall be maintained in a neat, serviceable and satisfactory condition until the project is accepted.

(g) Borrow pits and other material pits shall be cleared and grubbed of all trees, stumps, roots, brush, hedge, and other heavy growths of vegetation, and in addition shall be stripped of overburden laying above the material to be obtained. This work is to be completed before any excavation is made in the pit area.

(h) All clearing and grubbing shall be completed a satisfactory distance ahead of the construction operations before construction stakes are set.

(i) All materials and debris from the clearing and grubbing operation shall be burned, completely destroyed, or otherwise disposed of from the project limits by the Contractor in a satisfactory manner. The Contractor must obtain written permission from any property owner if private property is used for disposal, and furnish a copy to the Engineer. All Federal, State, County and City laws, regulations and ordinances related to burning or disposal shall be observed.

3. Method of Measurement

(a) Clearing and Grubbing shall be of all areas indicated in the Contract Documents and paid for as a lump sum. No measurement of area will be made.

(b) When changes in the Contract Documents affect the area to be cleared and grubbed, a proportionate adjustment for increased or decreased area will be made.

4. Basis of Payment

(a) This item will be paid for at the Contract unit price per lump sum for Clearing and Grubbing. This price will be full compensation for completing the Clearing and Grubbing as outlined in the Plans and these Specifications including all labor, materials, and equipment necessary to complete the work.

(b) When proportionate payments are made, they will be based on the completed percentage of the total clearing and grubbing specified.

TECHNICAL SPECIFICATIONS
FOR
REMOVAL OF STRUCTURES AND OBSTRUCTIONS

1. Descriptions

This work shall consist of the removal, wholly or in part, and satisfactory disposal of all structures, old pavements, and other designated obstructions not designated to be removed and disposed of under other items in the Contract.

2. Construction Requirements

(a) General - The Contractor shall raze, remove, and dispose of all buildings and foundations, structures, culvert pipes, pavements, sidewalks, curb and gutter, fences, and other obstructions, any portions of which are on the right-of-way, except utilities and those for which other provisions have been made for removal.

(b) Removal of Foundations & Structures - Foundations of buildings and structures shall be removed to a depth of not less than two feet below subgrade elevation, or two feet below original ground in areas outside the roadway slope intercepts. Basement floors and other large slabs shall be broken up to prevent holding of water. Cavities left by structure removal shall be filled to the level of surrounding ground, and within the slope intercepts and below subgrade elevation shall be compacted in accordance with the provisions for embankment fills.

(c) Removal of Bridges and Culverts - Bridges, culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic.

Substructure of bridges shall be removed to 1 foot below adjacent ground level or natural stream bottom for such portions located in the stream. Blasting or other operations, which may damage new construction, shall be completed prior to placing new work, or adequate precautions shall be taken to prevent damage.

(d) Removal of Pipes - All designated pipe (existing pipe that is to be replaced by new pipe or determined not to be necessary due to new construction) shall be removed and disposed of by the Contractor. All existing pipe (within the roadway or within 5 feet of the outside edge of the roadway) which is removed and not necessary due to new construction shall be backfilled with mineral aggregate base as described in Section 5 of these Specifications and compacted as described in Section 5 of these Specifications. Pipe not designated to be removed shall be protected by the Contractor and if damaged replaced at the Contractor's expense.

(e) Removal of Concrete Pavement –

1) All concrete pavement, including driveways, sidewalks, and curb and gutter, that exist outside of the proposed slope intercepts and becomes abandoned because of new construction shall, if so designated on the plans or by the Engineer, be completely removed and disposed of as directed. Grading and seeding shall follow according to Plans and Specifications.

2) All concrete pavement, including driveways, sidewalks, curb and gutter, that exist within the slope intercepts of the project and are at an elevation higher than two feet below subgrade elevation shall be removed and disposed of as directed.

3) All concrete pavement, including driveways, sidewalks, and curb and gutter that exist within the slope intercepts of the project and are more than two feet below subgrade elevation, shall be broken into size not to exceed two feet in maximum dimension and remain in place.

(f) Removal of Bituminous Pavement -

1) All bituminous pavement outside of the proposed slope intercepts shall be removed and paid for as common excavation. All bituminous pavement within the slope intercepts, at an elevation higher than two feet below subgrade elevation, shall be removed and paid for as common excavation.

2) All bituminous pavement within the slope intercepts and more than two feet below subgrade shall be broken into size not to exceed two feet in maximum dimension and remain in place.

(g) All material obtained from the removal of structures, obstructions, etc. that may be satisfactorily incorporated into the embankments in the opinion of the Engineer, may be disposed of in the embankments where directed, provided that the material is broken into sizes no larger than one cubic foot and with a maximum dimension of one foot and provided that the material will be covered with at least two feet of earth embankment. The Contractor shall remove all other salvageable or discarded material, rubbish or debris from the project area and dispose of the same.

3. Method of Measurement

When the Bid Schedule stipulates that payment will be made for removal of structures and obstructions on a lump sum basis, the pay item, Removal of Structures and Obstructions, will include all structures and obstructions encountered within the rights-of-way in accordance with the provisions of this Section. Where the Bid Schedule stipulates that payment will be made for the removal of specific items on a unit basis, measurement will be made by the unit stipulated.

4. Basis of Payment

(a) The accepted quantities of Removal of Structures and Obstructions will be paid for at the Contract lump sum price bid, which price shall be full compensation for removing and disposing of obstructions in accordance with the Plans and Specifications including all labor, materials, and equipment necessary to complete the work.

(b) Specific obstruction items such as bridges and culverts, pipes, concrete pavement, and other structures, stipulated for removal and disposal under unit price pay items will be paid for at the Contract unit price bid per unit specified in the proposal, which price shall be full compensation for removal, disposal (and backfill where required) of materials, and equipment necessary to complete the work.

TECHNICAL SPECIFICATIONS
FOR
GRADING

1. Description

This work shall consist of excavating and grading the roadway, borrow pits, waterways, ditches, intersections, and other specified items, within the project limits; excavation of unsuitable material from roadbed and beneath embankment areas; excavating select material found in the roadway which is ordered for specific use in the construction; the construction and removal of detours authorized by the Engineer; trimming, shaping and dressing of all slopes; preparation of the roadbed; and disposing of all excavated materials all in accordance with the Specifications and in reasonably close conformity with the lines, grades, and typical cross-sections indicated on the Plans or established by the Engineer. It shall include the constructing of roadway embankments and the placing and compacting of approved material in the project area.

2. Classification

(a) Excavation (Unclassified)

All excavation performed under this section, including portland cement concrete located above subgrade elevation, other than Borrow Excavation, Channel Excavation and Undercutting will be considered Unclassified Excavation regardless of the nature of the material excavated.

(b) Common Excavation

Common Excavation shall consist of the removal and satisfactory placement of material classified as loam, sand, clay, loose chert, loose gravel, cemented chert, cemented gravel, gravel, soft shale, soft slate, and all pavements except those using portland cement as a bonding agent, decomposed rock, loose rock boulders, slabs or fragments of rock of less than ½ cubic yard in volume and all other material not otherwise classified in these Specifications.

This item shall also consist of the removal and satisfactory disposal of unsatisfactory materials below grade in cut sections, from areas upon which embankments are to be placed, and undercutting for pipe and box culverts where required. Common Excavation does not include the stripping, stockpiling and placing of topsoil, nor does it include step benching in preparation of embankment areas on hillsides.

(c) Rock Excavation

Rock Excavation shall consist of the removal and satisfactory disposal of non-degradable rock which, in place, rings under the hammer or which cannot be economically excavated by the proper use of a power shovel or without the use of explosives; and any boulder, slab or fragment of rock having a volume of 2 cubic yard or more.

(d) Borrow Excavation

Borrow Excavation shall consist of material required for the construction of embankments or other portions of the work, and shall be obtained from approved sources outside the right-of-way limits, unless otherwise designated in the Plans. This item shall consist of the satisfactory removal and placement of the approved material.

(e) Channel Excavation

This item shall consist of the removal and satisfactory disposal of all material, regardless of its nature or the manner in which it may be removed, that is excavated for channel changes in widening, deepening and straightening existing channels or constructing new channels, which have a width at the bottom of more than fourteen feet as indicated on the Plans. All other similar excavation with a bottom width fourteen feet or less, as shown on the Plans, shall be paid for as Common and Rock excavation.

3. Construction Requirements

(a) General

1) Prior to the beginning of grading, all necessary Clearing and Grubbing, Removal of Structures and Obstructions, and placement of Erosion Control in that area shall have been completed.

2) All suitable materials removed from the excavation shall be used in the construction of the embankments, intersecting road approaches and at such other places as indicated or directed.

3) The material to be used in excavations shall be removed in such a manner that the slopes may be neatly trimmed to the slope lines given, when being dressed. Cuts may be widened or the slopes varied during the progress of the construction, according to the stability of the material excavated or the necessity of securing additional material, and without additional compensation.

4) Excavation material shall not be wasted, deposited, or disposed of outside of the construction lines unless directed, in writing, by the Engineer.

5) Only excess or unsuitable material will be considered for disposal outside the construction limits. The material that cannot be used to widen or flatten the slopes, or other locations, and for such purposes as may be directed by the Engineer, shall be disposed of by the Contractor to the satisfaction of the Engineer. The site of disposal shall be approved by the Engineer. All applicable permits for the disposal of material shall be obtained by the Contractor.

6) Old roadways shall be obliterated by the grading operation in a manner that will incorporate the old roadway into the new roadway and the surroundings in a pleasing appearance from the new roadway.

7) The Contractor shall be responsible until final acceptance for the stability of all embankments and cut slopes made under the contract and shall replace at his own expense any portion which, in the opinion of the Engineer, has become displaced or damaged due to carelessness or negligent work by the Contractor or by normal rainfall and weathering.

8) Final clearing up shall be performed in accordance with the provisions set out in the Conditions of the Contract.

(b) Rock Excavation

Rock, including boulders, shall be removed to a depth of not less than 12 inches below subgrade and the cavities thus formed shall be backfilled with suitable material and compacted. All loose rock on the cut slopes shall be removed immediately.

(c) Borrow Excavation

1) The Contractor shall notify the Engineer 14 days in advance of the opening of any borrow pit so that the borrow material can be tested and cross-sections taken.

2) If the Contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste will be deducted from the borrow volume.

3) The borrow pit shall be excavated in such a manner as to be self-draining whenever possible and have a neat appearance. The pit shall be covered with topsoil and seeded in accordance with the Specifications for Seeding and Topsoil, but no direct payment will be made for these items as they shall be included in prices bid for other items of construction.

4) All local, state, and federal laws must be complied with for any borrow pits that are not self-draining.

(d) Undercutting

1) Unsuitable or unsatisfactory materials shall be removed to a depth not less than 2 feet below subgrade in cut sections and areas upon which embankments are to be placed. Undercutting for pipes and box culverts may also be required. These areas are to be refilled with suitable material and properly compacted.

2) The Contractor shall conduct his operation in such a manner as to allow the Engineer to take necessary cross-sections.

3) This unsuitable material can be used to flatten or widen slopes or for such purposes as the Engineer may direct. Excess material shall be disposed of by the Contractor to the satisfaction of the Engineer.

(e) Embankments

1) Preparation of Embankment Areas

a. All depression and holes below ground surface, whether caused by grubbing or otherwise, shall be filled with suitable matter and properly compacted.

b. The original ground surface, or the surface of embankment layers, shall not be frozen and shall be free from quantities of ice and mud when the subsequent layer is placed thereon.

c. Backfilling around a structure, or any unit thereof, shall have been completed and thoroughly compacted to ground surface before any embankment materials are placed thereon.

d. When embankment is to be placed and compacted on hillsides or when new embankment is to be compacted against existing embankments or when embankment is built in phases, the slopes that are steeper than 4:1 when measured at right angles to the roadway shall be continuously benched over those areas where it is required as the work is brought up in layers. Benching shall be of sufficient width to permit operations of placing and compacting equipment. Each successive cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. Material thus cut shall be recompacted along with the new embankment material at the Contractor's expense.

e. Where embankments are three feet or less in height, the entire surface upon which the embankment is to be placed shall have all vegetation and unsuitable material removed and replaced with suitable material, be thoroughly plowed and scarified, have all cleavage planes destroyed, and be recompacted.

f. Every portion of existing pavement upon which an embankment is to be constructed at an elevation higher than two feet below subgrade shall be removed and paid for as described in Section 2 (e & f) of Removal of Structures and Obstructions.

Every portion of existing pavement upon which an embankment is to be constructed more than two feet below subgrade shall be broken as described in same sections as above.

2) <u>Embankment Materials</u>

a. Unsuitable or perishable materials such as brush, hedge, stumps, roots, logs, rubbish heavy vegetation, etc. shall not be incorporated, buried or embedded in the embankment.

b. All rock shall be broken into sizes not to exceed one foot in maximum direction and have enough common excavation to fill all voids between the rocks.

c. Stones or rock four inches or greater in their greatest dimension will not be allowed in the top one foot of any embankment.

3) Formation of Embankments

a. Embankments shall be formed of suitable materials placed in successive level layers of not more than eight (8) inches in compacted depth, unless otherwise stipulated, for the full width of the cross-section. Each layer shall be thoroughly rolled and compacted by the use of compacting equipment that will produce the required compaction of 95% of maximum density. At all times the contractor shall keep the embankment in such form as to insure proper surface drainage.

b. When the embankment material consists of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed without crushing or further breaking down the pieces resulting from excavation methods, such material may be placed in the embankment in layers not exceeding in thickness the approximate average size of the larger rocks. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of earth. The lifts shall not be constructed above an elevation 2 feet below the finished subgrade. At no time shall any layer exceed two feet in depth.

c. The top six inches in both cut and fill sections shall be compacted to a density equal to 100% of maximum density.

d. The moisture content of the material being compacted shall meet both the following conditions: (1) The moisture content shall be within

the range of values at which 95 percent of the maximum density can be obtained as indicated by the moisture-density relationship curve and (2) the moisture content shall not exceed the optimum moisture content to the extent that the material pumps under loads applied by the construction equipment. Where 100 percent of maximum density is required, the moisture content of the material being compacted shall meet condition 3(d)2 above and shall not vary from the optimum moisture content by more than plus or minus three percentage points.

e. Determination of optimum moisture and maximum density will be made by the Engineer in accordance with the "Standard Method of Test for Moisture Density Relationship of Soils Using a 5.5 Pound Rammer and a 12-inch Drop," AASHTO Designation: T 99, Method C. The determination of the density of the soil in place will be in accordance with an approved AASHTO method.

f. Embankment materials shall not be placed within 50 feet of any structure until the structure has sufficiently cured in the opinion of the Engineer. The backfill material used within 50 feet shall be as free of rock as possible and carefully selected to the satisfaction of the Engineer. Special precautions shall be used to prevent any damage to the structure.

g. Each layer of embankment formation shall be compacted to the required density before the formation of the next layer is begun.

(f) Shaping and Dressing

1) The roadbed shoulders, ditches, channels, borrow pits, and slopes shall be shaped within close conformity to the specified lines, grades, and cross-sections.

2) Rock Cuts shall be scaled of all loose fragments and left in a neat safe and workmanlike condition.

3) The Contractor shall clean the entire right-of-way of all rubbish, brush, sediment, etc. and dispose of the excess material.

(g) Subgrade Preparation

1) The subgrade shall be prepared to the lines and grades staked by the Engineer and to the cross-sectional shape as indicated on the plans or as directed.

2) The finished subgrade shall be compacted to a minimum density of 100% of the maximum density as specified in subsection referring to Formation of Embankments.

3) All soft, yielding material which will not compact readily shall be reworked or removed and replaced, and the replacement material shall be compacted to the specified density.

4) The subgrade shall be graded in a manner that will provide ready drainage of water from the subgrade. Ditches and drains shall be maintained to provide proper drainage during construction.

5) The Contractor shall protect the subgrade from damage. Only hauling essential to the construction of the project will be allowed. Any ruts or rough places that develop will be reshaped and recompacted.

6) The subgrade will be checked after rolling and adjusted to conform to the lines, grades and cross-section as indicated or directed. After conforming to the proper lines, grades, and cross-sections, being free of dust and loose material, and of a uniform bearing the subgrade will be approved at least 500 feet in advance of the placing of materials, except when the distance is reduced due to unusual circumstances by the Engineer.

4. Method of Measurement

(a) General

1) All excavation shall be computed by the cubic yard.

2) The volume of all accepted excavation shall be measured by cross-sectioning the area excavated and computed by the average-end-area method.

3) Initial cross-sections will be taken during design if necessary as determined by the Engineer, and final cross-sections will be taken after topsoil has been placed. Top soil will be deducted from the final cross sections to determine the volume of road and drainage excavation.

4) Additional measurements will be taken to determine the volume of materials, removed and satisfactorily disposed of, whose volume cannot be secured by cross-section methods.

5) The volume of all materials will be measured and computed for only one pay item, unless material which has been deposited as specified, must be removed and disposed of again to conform to a change of the plans, or as directed. The volume of such material shall be reclassified and remeasured for its proper class of excavation.

6) Where excavation of different classifications overlap, the following order of measurement and computation for payment is designated as a contract provision, namely:

Excavation included in lump sum items shall supersede all other excavations.

Excavation (unclassified) shall supersede common excavation, rock excavation and channel excavation.

Common excavation and solid rock excavation shall supersede channel excavation.

7) Hauling of excavation and borrow materials shall be considered incidental to this construction and the costs thereof shall be included in the unit price bid for excavation items.

8) Embankment construction, sloping, shaping, dressing, subgrade preparation, disposal of excess, or unsuitable material, final clearing up, etc., and completing all incidentals connected therewith will not be paid for directly but will be considered to be contingent items, payment for which is included in the contract price for excavation items.

9) Excavation (unclassified) and common excavation shall be measured by initial cross-sections. The method of measurement will be the average end-area method (utilizing the initial cross-section and the design cut and fill slopes and roadway template).

(b) Rock Excavation

1) Measurements of solid rock will be taken to include only 12 inches below grade, unless the Contractor is directed, in writing, by the Engineer to excavate the rock to a depth greater than 12 inches.

2) Measurements will include over-breakage from the back slopes beyond 12 inches if it is not attributable to Contractor's carelessness.

(c) Borrow Excavation

1) Initial cross-sections will be taken after the borrow pit is cleared and grubbed, cleared of topsoil and unsuitable material, and smoothed in a manner to make cross-sectioning possible. Final cross-sections will be taken after all material is removed and before topsoil is replaced.

2) Topsoil shall be replaced and the pit seeded as instructed without any direct payment and the cost thereof shall be included in the unit price for borrow excavation.

(d) Undercutting

1) The volume of unsuitable or unsatisfactory material actually excavated, removed, and disposed of will be measured by the most feasible method and included in the volume of common excavation computed.

2) Topsoil undercut from proposed embankment areas will not be measured as common excavation unless the depth of undercut exceeds six (6) inches. All undercut exceeding six (6) inches shall be paid as Common Excavation.

(e) Embankments

1) Embankments will not be measured. The construction of embankments is the responsibility of the Contractor as specified.

2) Excavation of embankment will not be measured for payment unless specified by the Engineer.

(f) Channel Excavation

1) Channel excavation will be measured only for material indicated, or directed, to be removed in construction of a channel.

2) If channel excavation is not listed in the Bid Schedule excavation (unclassified), common excavation and/or rock excavation will be measured and computed as applicable.

5. Basis of Payment

(a) The accepted quantities of the items listed below will be paid for at the Contract Unit Price per cubic yard, complete in place, and shall be full compensation for all work, materials, including water, labor and other incidentals required to complete the work in accordance with the Plans and Specifications.

(b) Payment will be made under the following bid items as set forth in the Bid Schedule:

Excavation (Unclassified)	- per cubic yard
Common Excavation	- per cubic yard
Rock Excavation	- per cubic yard
Borrow Excavation	- per cubic yard
Channel Excavation	- per cubic yard

(c) Embankments, shaping and dressing, subgrade preparation, and water will not be paid for directly as the cost of these items is to be included in the pay items for grading as listed in the Bid Schedule.

TECHNICAL SPECIFICATIONS FOR MINERAL AGGREGATE BASE

1. Description

This work shall consist of furnishing and placing one or more courses of aggregates and additives, if required, on a prepared subgrade in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses and typical cross-section shown on the Plans or established by the Engineer. This work also includes furnishing and placing Maintenance Stone and Backfill Stone in accordance with these Specifications and the Plans.

2. Materials

All materials used in this construction, in addition to the general requirements of these Specifications, unless otherwise stipulated, shall conform to the following:

(a) Mineral Aggregate Base shall be crushed stone, Class A Aggregate Grading D, as specified in Subsection 903.05 of the TDOTSS, March 1, 2006, and all Special Provisions pertaining thereto through the date of advertisement for this Contract.

Sieve Size	Total Percentage by Weight Passing Sieves
1-1/2 inch	100
1 inch	85 - 100
3/4 inch	60 - 95
3/8 inch	50 - 80
No. 4	40 - 65
No. 16	20 - 40
No. 100	9 - 18

(b) Calcium Chloride shall meet the requirements of the AASHTO Specification for Calcium Chloride, Designation M-144 and shall be Type 2.

(c) Maintenance Stone and Backfill Stone shall be of quality and gradation as specified in Subsection 2(a) above. The backfill stone in the roadway or less than 5 feet from the outside edge of the roadway, curbs, gutters and sidewalks shall be compacted to 100% of the Standard Proctor Density at 2% less than the optimum moisture content as determined by AASHTO T99 Method D.

3. Equipment & Construction Requirements

(a) Equipment and Construction Requirements shall conform to Subsections 303.05 to 303.12 of the TDOTSS, March 1, 2006, and all Special Provisions Pertaining thereto through the date of advertisement of this Contract. In addition, the following compaction, will be required: Mineral Aggregate Base shall be compacted to 100% of the Standard Proctor Density at 2% less than the optimum moisture content as determined by AASHTO T99 Method D.

(b) The maximum speed of trucks hauling or traveling over any part of the project under construction shall be 20 mph.

4. Method of Measurement

(a) Mineral Aggregate Base, Maintenance Stone, and Backfill Stone will be measured by the ton in place, as by the actual scale weight.

(b) All moisture in the Aggregate at the time of weighing in excess of eight percent will be deducted from the weight of the Aggregate.

(c) Any water added on the road will be at the Contractor's expense.

5. Basis of Payment

(a) The accepted quantities of Mineral Aggregate Base, Maintenance Stone, and Backfill Stone of the type specified will be paid for at the Contract unit price per ton, complete in place. This price shall be full compensation for all work, materials, including calcium chloride where specified and water; labor and other incidentals required to complete the work in accordance with the Plans and Specifications.

(b) Payment will be made under the following bid item as set forth in the Bid Schedule:

Mineral Aggregate Base
Mineral Aggregate Base with Calcium Chloride
Maintenance Stone

TECHNICAL SPECIFICATIONS
FOR
PRIME COAT

1. Description

This work shall consist of an application of bituminous material on a designated base in accordance with the requirements of these Specifications.

2. Materials

(a) All materials used shall conform to the following:

Emulsified Asphalt, SS-1	AASHTO M-140
Cut-Back Asphalt	
Grade No. MC-70 or MC-250	AASHTO M-82
Grade No. RC-70 or RC-250	AASHTO M-81

(b) The Contractor has his choice of the above materials unless otherwise stipulated.

3. Equipment & Construction Requirement

(a) Equipment and Construction Requirements shall conform to Subsections 402.03 to 402.06, and 402.08 TDOTSS, March 1, 2006.

(b) Rate of application of bituminous prime coat shall be .20 gallons per square yard.

(c) Temperature of application of the bituminous prime coat shall be as follows: AE-P and CAE-P 60-140˚F (15-60˚C).

4. Method of Measurement

Bituminous material will be measured by the number of gallons used in the accepted work, as determined by the Engineer, and at the temperature of application.

5. Payment

Prime Coat will be paid at the Contract unit price per gallon and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
TACK COAT

1. Description

This work shall consist of the application of bituminous material on a prepared base course, binder course, or existing pavement to provide a bond for superimposed course, in accordance with the requirements of these Specifications.

2. Materials

Bituminous materials used shall conform to the following:

AC-20	AASHTO M-226
Cut-Back Asphalt	AASHTO M-81
Grade No. RC-70 or RC-250	
Emulsified Asphalt SS-1,	AASHTO M-140
SS-1H, CSS-1, CSS-1H	

3. Equipment & Construction Requirements

(a) Equipment and Construction Requirements shall conform to Subsections 403.03 to 403.05 of the TDOTSS, March 1, 2006, and all Special Provisions pertaining thereto through the date of advertisement of this Contract.

(b) The ranges of application temperatures in degrees Fahrenheit shall be as follows:

AC-20	375-400 F
RC-70	80-150 F
RC-250	100-175 F
SS-1, SS-1H CSS-1, or CSS-1H	60-140 F

(c) Special care shall be given to the application of a "paint coat" of tack coat material to curbs, the edges of manholes and catch basins and to the cold edge of bituminous material to secure an even coating of tack coat material so that a tight, waterproof bond is secured when the hot plant mix material is placed against these surfaces.

The application rate of tack coat shall be as noted on Plans or as directed by the Engineer. Tack coat shall be applied only so far in advance of the paving operation as is necessary to obtain the proper condition of tackiness.

4. Method of Measurement

Bituminous material will be measured by the number of gallons used in the accepted work, as determined by the Engineer, and at the temperature of application.

5. Payment

Tack Coat will be paid at the Contract unit price per gallon and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
BITUMINOUS PLANT MIX SEAL COAT

1. Description

This work shall consist of constructing a bituminous plant mix surface course on an existing roadway pavement in accordance with these Specifications and in reasonably close conformity with the details on the Plans or established by the Engineer.

Note: References to Sections and Subsections in this Specification are Sections and Subsections of the TDOTSS, March 1, 2006, and all subsequent revisions, except that all reference to the DEPARTMENT contained therein shall be interpreted to be the City of Knoxville.

2. Materials

The materials used in this construction shall conform to the following Specifications:

(a) Asphalt Cement, Viscosity Grade AC-20 meeting the requirements of AASHTO M226.

(b) Anti-stripping Additive, meeting the requirements of Subsection 918.09 (B).

(c) Tack Coat, Viscosity Grade AC-20 as above, (with anti-stripping additive).

(d) Mineral Aggregate - The mineral aggregate shall be crushed siliceous gravel, consisting of clean particles meeting the applicable quality requirements set forth in Subsection 903.11. The use of limestone material will not be permitted.

3. Composition of Mixture

The specified mineral aggregate and asphalt cement with anti-stripping additive shall be combined in such proportions as to produce a mixture conforming to the following limits by weight:

Item	Percent
Mineral Aggregate	89 - 94
Asphalt Cement (including additive)	6 - 11

The aggregate for this construction shall be sized or combined in such proportions that the resulting blend will meet the following grading requirements:

Sieve Size	Total Percent by Weight
½”	100
3/8”	85-100
No. 4	25-45
No. 8	0-12
No. 16	0-5
No. 100	0-3

The Contractor shall submit for the Engineer's approval a job mix formula for the mixture to be supplied for the project. The job mix formula shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, and a single temperature at which the mixture is to be discharged from the plant. The job mix formula shall be within the specified grading range by an amount sufficient to provide for gradation variations at the mixing plant. Once approved, the job mix formula shall be in effect until modified in writing by the Engineer.

Prior to the approval of the job mix formula and at least 5 working days prior to the beginning of this construction, a sample of each material to be used in the mix shall be submitted to the Engineer for laboratory tests and evaluation.

When satisfactory results or other conditions make it necessary, the job mix formula shall be adjusted to the satisfaction of the Engineer.

4. Equipment

The equipment used in this construction shall meet the requirements of Subsections 407.04, 407.05, 407.06, and 407.08. All equipment necessary for the satisfactory performance of this construction shall be on the project and approved before work will be permitted to begin.

Rollers shall be of self-propelled steel-wheel types and shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The use of the equipment, which results in excessive crushing of the aggregate, will not be permitted.

5. Construction Requirements

The construction requirements for this work shall be as prescribed in Subsection 407.14.

6. Weather Limitations

Bituminous plant mix seal coat shall not be placed on a wet surface, when the air temperature is below 50 degrees F, or when weather conditions otherwise prevent the proper handling or finishing of the bituminous mixtures.

7. Method of Measurement

Mineral aggregate and bituminous material will be measured by the ton of 2,000 pounds, accepted and placed as indicated or directed.

8. Basis of Payment

The accepted quantities of bituminous seal coat will be paid for at the Contract unit price per ton for bituminous material and per ton for mineral aggregate, complete in place.

TECHNICAL SPECIFICATIONS
FOR
BITUMINOUS PLANT MIX BASE

1. Description

This work shall consist of a foundation composed of hot mixture of aggregate and asphalt prepared in a hot bituminous mixing plant. It shall be constructed in one or more layers, on a prepared subgrade, subbase, or base, in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or as directed by the Engineer. Each course shall have a thickness after compaction of not more than 4 inches. This construction shall include a leveling course if specified on the Plans.

2. Materials

(a) Asphalt Cement shall conform to the requirements of AASHTO Designation M 226 for Viscosity Grade AC-20.

(b) Aggregates shall conform to Subsection 903.06 of TDOTSS, March 1, 2006, and all Special Provisions through the date of the advertisement for this Contract. Grading B and B-M shall be used for base placed upon subgrade or base, and Grading C shall be used on existing pavement for leveling courses, Grading C-S and C-W shall be used for surface unless otherwise specified in the Contract or Plans.

3. Composition of Mixtures

(a) The bituminous base shall be composed of aggregate and bituminous material. The mix shall comply with the applicable requirements of Subsection 407.03 of TDOTSS, March 1, 2006.

(b) The proportions by weight of the total mixture shall be as follows:

Mixtures	Combined Mineral Aggregate	Asphalt Cement
Grading “B” and “B-M”	93.8 - 95.8	4.2 - 6.2
Grading “C” and “C-W”	93.8 - 95.8	4.2 - 6.2
Grading “C-S”	92.3 - 94.7	5.3 - 7.7

4. Equipment

All equipment necessary for the construction shall be approved before the work will be permitted to begin. The equipment shall meet the requirements of Subsections 407.04 through 407.08 of TDOTSS, March 1, 2006, and as revised by all Special Provisions dated through the date of the advertisement for this Contract.

5. (a) The construction requirements shall be as prescribed in Subsection 407.09 and Subsections 407.11 through 407.16 TDOTSS, March 1, 2006, and as revised by all Special Provisions dated through the date of this advertisement, and the requirements listed below.

(b) The Plans will indicate whether the bituminous pavement is to be constructed on a subbase, mineral aggregate base, asphalt base, or an existing surface. The surface of the base or subbase upon which the construction is to be placed shall meet the requirements of the applicable Sections of the Grading, Mineral Aggregate Base, and Bituminous Plant Mix Base Specifications.

(c) When bituminous mixes are placed upon existing concrete pavement, with or without bituminous overlay, all excess bituminous material shall be removed from joints and cracks.

When bituminous mixes are placed upon existing bituminous pavement, any areas containing excess bitumen and any failures in existing pavement shall be removed to a depth up to 3 feet and backfilled with crushed stone base up to the bottom of the surrounding pavement structure and with appropriate asphaltic base, leveling or surface material to the existing surface, all as directed by the Engineer. Crushed stone base material, asphaltic base, leveling, and surface materials to be paid at the Contract Unit Price for those items. Pavement removal and undercut up to 3 feet will be measured and paid in accordance with subparagraph 6(c) and 7(b) of this Section.

The existing pavement surface shall be thoroughly cleaned of all dirt and loose particles prior to the application of tack coat or prime coat as specified in Specifications for Tack Coat and Prime Coat.

(d) Thickness shall be controlled during the spreading operation by frequent measurements taken of the freshly spread mixture to establish relationship between the uncompacted mixture and the completed course. Thickness or pounds per square yard shall be within reasonably close conformity with that specified on the Plans.

(e) Under Subsection 407.18 of TDOTSS, March 1, 2006, the surface of the bases meet the requirements specified and when tested in accordance with the provisions of that Subsection, the deviation of the surfaces from the testing edge of the straightedge shall not exceed the amounts shown below for the several types of mixtures.

Grading B and B-M Mixture	3/8 inch
Grading C Mixture	3/8 inch
Grading C-W Mixture	3/8 inch
Grading C-S Mixture	3/8 inch

(f) Subsection 307.03(b), Recycled Asphalt Pavement, will be accepted for Grading B, Grading B-M and Grading C with the following exception: The Contractor shall be responsible for providing a fully coated and workable mixture that shall have a marshall stability of not less than 1,000 pounds when tested in accordance with AASHTO - T-245, and the compactive effort for all specimens shall be 75 blows of the hammer on each end. No adjustments for asphalt content increases or decreases shall be provided under these Specifications.

6. Method of Measurement

(a) Bituminous plant mix base, including the mineral aggregate and asphalt cement as specified or required by these Specifications, will be measured by the ton of 2,000 pounds, accepted and placed as indicated or directed.

(b) Materials for prime or tack coat will be measured for payment as prescribed in their Specifications.

(c) The surface measurements of any pavement, base or subbase removal shall be made in square yards by the Engineer prior to backfilling.

(d) Bituminous mixtures used to fill openings left by pavement removal will be measured for payment. Base materials used to fill openings left by base removal will be measured as provided for in the respective Sections for each type specified.

(e) Adjustment of sewer manholes and castings will be measured for payment as prescribed in its Specification.

(f) No allowance will be made for unacceptable material; for material used in replacing defective or condemned construction; or for material wasted in handling, hauling or otherwise.

7. Basis of Payment

a) The accepted quantity of bituminous plant mix base, complete in place, will be paid for at the Contract Unit Price per ton for each "Grading" listed in the Bid Schedule and constructed in accordance with the Plans and Specifications.

b) The accepted quantity of pavement, base and subbase removal up to 3 feet in depth will be paid for at the Contract Unit Price per square yard listed in the Bid Schedule and performed in accordance with the Plans, Specifications, and under the direction of the Engineer.

TECHNICAL SPECIFICATIONS
FOR
ASPHALTIC CONCRETE SURFACE

1. Description

This work shall consist of an asphaltic concrete pavement composed of a mixture of coarse aggregate, fine aggregate, mineral filler if specified or required, and asphalt cement, constructed on a prepared roadbed in accordance with these Specifications and in reasonably close conformity with the lines, grades, typical cross sections and rate of application shown on the Plans, or established by the Engineer.

2. Materials

(a) Asphalt Cement

1) Asphalt cement shall conform to the requirements of PG-64-22 as specified in Subsection 904.01 TDOTSS, March 1, 2006, and all special provisions pertaining thereto through the date of the advertisement for this Contract.

2) Asphalt cement used with aggregate Grading D and E mixtures shall be treated with an anti-stripping additive as specified in Subsection 918.09(B) TDOTSS, March 1, 2006, and all special provisions pertaining thereto through the date of the advertisement for this Contract.

(b) Mineral Aggregate

Mineral aggregates shall conform to the following requirements and Subsection 903.11, TDOTSS, March 1, 2006, and as revised by all Special Provisions dated through the date of the advertisement of this Contract, with the following exceptions and additions:

The Combined Grading:

The several aggregate fractions shall be sized, graded, and combined in such proportions that the resulting composite blend will meet one of the following grading requirements, as specified, together with the stipulations pertaining to the constituents of the blend hereinafter specified.

ASPHALTIC CONCRETE SURFACE COURSE
MIXTURE DESIGNATION

MASTER RANGE OF GRADATIONS

Total Percent Passing, by Weight

Grading Sieve Size	D	E
1/2”	95-100	95-100
3/8”	80-93	80-93
No. 4	54-76	54-76
No. 8	35-57	35-57
No. 30	17-29	17-29
No. 50	10-18	10-18
No. 100	3-10	3-11
No. 200	0-6.5	0-8

Grading D

The coarse aggregate shall consist of crushed gravel, crushed granite, crushed quartzite or crushed gneiss. Other crushed aggregate may be used provided it has the following chemical, physical, and performance characteristics for Type I, Type II or Type III aggregate, per TDOTSS 903.11. Crushed slag will not be permitted as a coarse or fine aggregate.

The fine aggregate shall consist of natural sand or sand manufactured from gravel or from crushed stone aggregate meeting the physical and chemical requirements listed above. The use of carbonate rocks such as limestone and dolomite or other aggregates tending to polish under traffic will not be permitted in the coarse aggregate and will be permitted only to the extent specified herein in the fine aggregate.

In addition to the other requirements of these Specifications, the composition of the mineral aggregate shall be such that when combined with the required amount of bitumen the resultant mixture shall have:

High Volume Roads (ADT over 1000)

*Minimum Stability, kN (lbs) -	9.0 (2000)
*Void Content (%) -	3-5.5
*Flow, mm (.01 inch) -	2-4 (8-16)
*Minimum VMA (%) -	14
**Dust to Asphalt Ratio -	0.6-1.2

*Tested in accordance with AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

**The dust to asphalt ratio is the percent of the total aggregate sample that passes the 75 um (200 mesh) sieve as determined by AASHTO T11 divided by the percent asphalt in the total mix.

The addition of limestone screenings or agricultural limestone in a maximum amount of 25 percent by weight of the mineral aggregate may be required to comply with this section. When crushed stone screenings meeting the requirements of Subsection 903.11(c) are used, all additional fines shall be natural or manufactured sand. A maximum of 5 percent mineral filler meeting the requirements of Subsection 903.16 may be substituted for an equal quantity of the limestone fines. If the mixture does not comply with the design criteria, another source of aggregate shall be required.

When gravel is used as the coarse aggregate for a 411 Grading "D" mix, a minimum of 20 percent by weight limestone screenings, agricultural limestone and/or mineral filler shall be required.

Grading E:

When Grading E is to be used as a surface for traffic lanes, the mineral aggregate shall be composed of not less than 50 percent, nor more than 80 percent crushed limestone, and not more than 50 percent or not less than 20 percent natural sand, sand manufactured from gravel, or any combination of these materials, except as herein specified. All or any part of this mix may be calcareous sandstone, including Size 10 (screenings) or manufactured sand.

The sand percentage on the job mix formula shall be in the range of 20-50 percent. However, if needed to meet or improve the specified design criteria, the limestone and sand percentage may be altered by the numerical value of 5 percent from the percentage shown by the Contractor on the original job mix formula. If the aggregate percentages shown on the original job mix formula are altered, the Contractor shall submit a new job mix formula using the aggregate percentages shown on the Design.

In addition to the other requirements of these Specifications where Grading E is used for the riding surface, the composition of the mineral aggregate shall be such that when combined with the required amount of bitumen, the resultant mixture shall have:

<u>High Volume Roads (ADT over 1000)</u>

*Minimum Stability, kN (lbs) -	9.0 (2000)
*Void Content (%) -	3-5.5
*Flow, mm (.01 inch) -	2-4 (8-16)
*Minimum VMA (%) -	14

*Tested in accordance with AASHTO T245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

If the design criteria above cannot be obtained with the aggregate submitted to the laboratory for design, another source of aggregate will be necessary.

3. Composition of Mixtures

(a) The asphaltic concrete surface shall be composed of aggregate, filler if required, and bituminous material. The mix shall meet all applicable requirements of Subsection 407.03 of TDOTSS March 1, 2006.

(b) The proportions by weight of the total mixture shall be combined in such proportions as to produce mixtures within the following master composition limits.

Proportions of Total Mixture, Percent by Weight

Surface Courses	Combined Mineral Aggregate	Asphalt Cement
Grading D and E*	93.0 - 94.7%	5.3 - 7.0

* If Grading "E" is used as a roadway surface mix, the above proportions shall be changed to 93.0-95.5 and 4.5-7.0 for mineral aggregate and asphalt cement respectively.

4. Equipment

All the equipment necessary for the construction shall be approved before the work will be permitted to begin. The equipment shall meet the requirements of Subsections 407.04 through 407.08, TDOTSS, March 1, 2006, and as revised by all Special Provisions dated through the date of advertisement for this Contract.

5. Construction Requirements

(a) The construction requirements shall be as prescribed in Subsection 407.09 and Subsections 407.11 through 407.16 of TDOTSS, March 1, 2006, and the requirements listed below.

(b) The Plans will indicate whether the bituminous pavement is to be constructed on an asphalt base or an existing surface.

(c) When bituminous mixes are placed upon existing bituminous pavement, any areas containing excess bitumen and any failures in existing pavement shall be removed to a depth up to 3 feet and backfilled with crushed stone base up to the bottom of the surrounding pavement structure and with appropriate asphaltic base, leveling or surface material to the existing surface, all as directed by the Engineer. Crushed stone base material, asphaltic base, leveling and surface materials to be paid at Contract Unit Price for those items. Pavement removal and undercut up to 3 feet will be measured and paid in accordance with Subparagraphs 6(e) and 7(c) of this section.

The existing pavement surface shall be thoroughly cleaned of all dirt and loose particles prior to the application of tack coat as specified in Specifications for Tack Coat.

(d) The joints, between new asphaltic pavement and bridges, concrete pavement, etc. shall have a joint prepared with the existing pavement by grinding, scarifying, or saw cutting the existing pavement for a length of six (6) feet, the full width of the existing pavement, and to the depth of the overlay of new material. The six (6) feet length of cut may be a wedge cut varying from zero (0) to the required depth over six (6) feet). On new construction projects, all joints shall be constructed as above.

(e) Thickness shall be controlled during the spreading operation by frequent measurements taken of the freshly spread mixture to establish relationship between the noncompacted mixture and the completed course. Thickness or pounds per square yard shall be within reasonably close conformity with that specified on the Plans.

(f) The surface shall meet the requirements of Subsection 407.18 of TDOTSS, March 1, 2006, and when tested the deviation of the surface from the testing straightedge shall not exceed 1/4 inch.

(g) Costs for joints shall be included in the cost of the aggregate for asphaltic concrete surface.

6. Method of Measurement

(a) Asphaltic concrete surface shall include mineral aggregate and asphaltic cement. Measurement shall be by the ton of 2,000 pounds of asphaltic concrete surface accepted and placed as indicated or directed.

(b) Material for tack coat will be measured for payment as prescribed in the Specifications for tack coat.

(c) Adjustment of sewer manholes and castings will be measured for payment as prescribed in its Specifications.

(d) No allowance will be made for unacceptable material, for material used in replacing defective or condemned construction, or for materials wasted in handling, hauling, or otherwise.

(e) The surface measurements of any pavement, base or subbase removal shall be made in square yards by the Engineer prior to backfilling.

7. Basis of Payment

(a) The accepted quantity of Mineral Aggregate and Asphalt Cement (PG-64-22) for Asphaltic Concrete Surfaces, complete in place shall be paid for at the Contract unit price per ton listed in the Bid Schedule. This price shall be full compensation for all work, materials, labor and other incidentals required to complete the work in accordance with the Plans and Specifications.

(b) The acceptance of the mixture shall be as determined in Subsection 407.20(B) of TDOTSS, March 1, 2006, and all Special Provisions pertaining thereto through the date of the advertisement for the Contract.

(c) The accepted quantity of pavement removal (up to 3' in depth) shall be paid for at the Contract Unit Price per square yard listed in the Bid Schedule. This price shall be full compensation for all work, labor, equipment, and other incidentals required to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
PORTLAND CEMENT CONCRETE PAVEMENT (PLAIN)

1. Description

This work shall consist of a pavement composed of portland cement concrete constructed on a prepared roadbed in accordance with these specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross-sections shown on the Plans or established by the Engineer.

2. Materials

(a) Concrete

Concrete shall be composed of portland cement, aggregates, and water. Air-entrainment shall be provided by adding an air-entraining agent.

(b) Portland Cement

Portland cement shall conform to AASHTO M85 or ASTM C150. The cement used in the work shall correspond to that on which selection of concrete proportions was based.

When Types IV and V cements are used, proper recognition shall be given to the effects of slower strength gain and lower heat of hydration on concrete proportioning and construction practices.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement, that for any reason has become partially set or which contains lumps of caked cement shall be rejected.

(c) Aggregates

Fine aggregate for concrete shall conform to the requirements of Subsection 903.01 of TDOTSS, May 1, 2006. Coarse aggregate for concrete shall conform to the requirements of Subsection 903.03 of TDOTSS, March 1, 2006.

Fine aggregate manufactured from limestone or other polishing aggregate will not be permitted in traffic lanes.

(d) Water

Water used in mixing or curing shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, or other substance injurious to the finished product. Water shall be tested in accordance with and shall meet the requirements of AASHTO T26. Water known to be potable may be used without test.

(e) Admixtures

No admixtures shall be used in the concrete without prior approval, and all approved admixtures shall conform to applicable AASHTO and ASTM requirements.

Air-entraining agents shall conform to AASHTO M154 and shall have proven compatibility with all local concrete materials, including cement, and shall be capable of providing in the concrete the required air contents and an air-void system known to produce durable, scale resistant concrete.

Admixtures other than air-entraining agents shall not be used until trial mixes with job materials have shown them to be compatible at job temperatures. Trial mixes must also show that desired properties will be imparted to the fresh concrete without any subsequent loss of strength or durability in the hardened concrete.

(f) Steel

Unless otherwise specified, all steel reinforcement for concrete shall meet the requirements of TDOTSS, March 1, 2006.

(g) Joint Materials

Unless otherwise specified or requested by the Engineer, poured sealer for joints shall conform to the requirements of Subsection 905.05 of TDOTSS, March 1, 2006, for Hot Poured Elastic Type Sealant.

Preformed fillers for joints shall meet the requirements of Subsection 905.01 of TDOTSS, March 1, 2006.

(h) Curing materials

Curing materials shall conform to the requirements of Section 913 of TDOTSS, March 1, 2006.

3. Proportioning

Unless otherwise provided herein, each cubic yard of concrete shall contain a minimum of 470 lb. of cement, and the water-cement ratio by weight shall not exceed 0.50. An air-entraining agent shall be used to produce an air content of 5 □%, plus or minus 1%, by volume of concrete as determined by AASHTO T152.

After the materials have been accepted by the Engineer, they shall be so proportioned as to produce a workable concrete having a maximum slump of 3 in. for vibrated placement or 1 in. for slip-formed placement as determined by AASHTO T119. The concrete shall have a flexural strength at 14 days of not less than 550 pounds per square inch when tested in accordance with AASHTO T97, or a compressive strength of 3,500 pounds per square inch when tested in accordance with AASHTO T22.

The Contractor shall submit a job-mix design and certified test reports indicating compliance of the materials to the applicable specifications in 2. and the job mix to those listed above. Such design and reports shall be submitted in duplicate to the Engineer and other such agencies or persons he may designate well in advance of the time scheduled for starting the work. The Engineer must approve such information before starting concrete operations. Reports or certificates indicating compliance of any shipment of materials shall be placed in the hands of, and approved by the Engineer, prior to use of such materials. The cost of testing materials and the job-mix design shall be borne by the Contractor.

Where reputable materials suppliers maintain regular recognized testing services, certified copies of such tests will be accepted by the Engineer. However, in any case of

doubt as to the accuracy and/or adequacy of such tests, the Engineer may require that materials be tested by a recognized commercial testing laboratory which has been selected by the Contractor and approved by the Engineer. The testing laboratory shall then test the cement and aggregates and prepare written reports showing the results of such tests on each shipment. The laboratory shall also certify that the materials covered by the report comply in all respects with these Specifications. In general, materials shall be tested by the manufacturer/producer, but if untested shipments require sampling and testing after arrival at the site of work, the Contractor shall be fully responsible for delays in the progress of the work due to delays in testing and reporting.

If it is impossible to obtain concrete of the desired plasticity and workability with the proportions originally designated, the Engineer shall change aggregate weights as required, maintaining the cement content originally designated. No change in the sources or character of the materials shall be made without due notice to the Engineer.

4. Equipment

All the equipment necessary for the construction shall be approved by the Engineer before the work will be permitted to begin. The equipment shall meet the requirements of Subsection 501.04 of TDOTSS, March 1, 2006.

5. Construction Requirements

(a) Subgrade Preparation

Subgrade preparation shall be performed as provided for under Section 4.0 of these Specifications.

(b) Construction of Base

The base course, if required by the plans, shall be constructed in accordance with Section 5.0 of these Specifications and the requirements listed:

1) The Contractor shall be responsible for constructing or correcting the base to such grade tolerances as will insure the concrete pavement thickness required.

2) The base shall be completed not less than 500 linear feet in advance of the paving unless otherwise authorized by the Engineer.

3) The base shall be in a moist condition at the time of placing concrete. If it becomes dry prior to the actual placing of the concrete, it shall be sprinkled, but the formation of pools of water shall be avoided. The base shall not be muddy or soft.

(c) Setting Forms

Forms shall be set in accordance with the requirements of Subsection 501.07 of TDOTSS, March 1, 2006. In lieu of setting forms, the edge of a previously placed curb and gutter section may be used as a form if approved by the Engineer.

(d) Handling, Measuring, and Batching Materials

All handling, measuring, and batching of materials shall be performed in accordance with the requirements of Subsection 501.09 of TDOTSS, March 1, 2006.

(e) Mixing Concrete

Concrete shall be mixed in accordance with the requirements of Subsection 501.10 of TDOTSS, March 1, 2006, with the limitations of Subsection 501.11 of TDOTSS, March 1, 2006.

(f) Placing Concrete

Concrete shall be placed in accordance with Subsection 501.12 of TDOTSS, March 1, 2006, except as herein noted.

Paragraphs one, three, and five of Subsection 501.12 of TDOTSS, March 1, 2006, shall be deleted and the following added:

1) The mechanical spreader may not be required at the discretion of the Engineer.

2) All concrete placed shall be vibrated. The use of hand vibrators will only be permitted at the discretion of the Engineer. Vibrators mounted on a machine shall be operated only while the machine is in motion.

(g) Test Specimens

The Contractor shall furnish the concrete necessary for casting test specimens in the field and shall provide water-tight tanks of satisfactory size and number to accommodate the test specimens. The Engineer will designate the frequency of sampling the fresh concrete and will prepare the test specimens. The method of making and curing test specimens will be in accordance with AASHTO T23. The cost of testing shall be borne by the City of Knoxville.

(h) Strike-Off, Consolidation, and Finishing

The strike-off, consolidation, and finishing of the concrete shall be performed in accordance with Subsection 501.16 of TDOTSS, March 1, 2006, and the following.

The Contractor shall always have available materials to protect the surface of the plastic concrete against rain. These materials shall consist of burlap, curing paper, or plastic sheeting. When slip-form construction is being used, materials such as wood planks or forms to protect the edges of the pavement shall also be required.

Transverse grooving after the burlap drag finishing shall not be required unless shown in the plans or directed by the Engineer.

(i) Surface Test

The pavement surface shall be tested in accordance with Subsection 501.17 of TDOTSS, March 1, 2006.

(j) Curing

Curing operations shall be done in accordance with Subsection 501.18 of TDOTSS, March 1, 2006, except as follows.

Membrane curing will not be permitted in frost-affected areas or paving that will be exposed to deicing chemicals within 30 days after completion of the curing period.

(k) Removal of Forms

Removal of the concrete forms shall meet the requirements of Subsection 501.19 of TDOTSS, March 1, 2006.

(l) Joints

Joints shall be constructed of the type and dimensions, and at the locations required by the plans, and in accordance with the provisions of the Specifications.

Longitudinal joints shall be perpendicular to the pavement surface and shall be along or parallel to the centerline of the pavement, unless otherwise specified. Transverse joints shall be straight, vertical to the pavement surface and shall be at the angle to the centerline of the pavement as shown on the Plans.

1) Transverse Contraction Joints

Transverse contraction joints shall be placed at the intervals and dimensions specified and shall be of the plain sawed groove type as detailed on the Plans and in accordance with these Specifications.

Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling, usually six to twelve hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both day and night, regardless of weather conditions. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. The sawing of a joint shall be discontinued when a crack develops ahead of the saw. In general, all joints shall be sawed in sequence.

All contraction joints in lanes adjacent to previously constructed lanes shall be sawed before uncontrolled cracking occurs. If extreme conditions exist which makes it impractical to prevent erratic cracking by early sawing, a contraction joint groove shall be formed at intervals of every third or fourth joint, or as often as required prior to initial set of concrete by placing inserts in the plastic concrete at the angle to the centerline of the pavement indicated on the plans and perpendicular to the surface. When the concrete has attained its initial set and after the joint has been carefully finished, the insert shall be removed. The groove so formed shall maintain its full width and depth as shown on the Plans, and the pavement at the joint shall meet surface requirements.

Immediately after sawing, the joints shall be cleaned of all residue by flushing with water under pressure.

2) Transverse Construction Joints

Transverse construction joints of the type shown in the plans shall be placed whenever the placing of concrete is suspended for more than 30 minutes. A butt joint with dowels shall be used if the joint occurs at the location of a contraction joint. Keyed joints with tie bars shall be used if the joint occurs at any other location.

3) Transverse Expansion Joints

Transverse expansion joints shall consist of a vertical expansion joint filler placed on a butt-type joint with dowel bars as shown in the plans. The expansion joint filler shall be continuous from form to form for the full depth of the pavement and shaped to the subgrade, curb section, and to the key way along the form. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

The expansion joint filler shall be held in a vertical position. An approved installing bar or other device shall be used if necessary to ensure proper grade and alignment during placing and finishing of the concrete.

Finished joints shall not deviate in horizontal alignment more than 1/4 in. from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. The top edge of the filler shall be protected, while the concrete is being placed, by an approved metal channel cap. Dowels shall be held in position, parallel to the surface and centerline of the slab, by an approved metal device that is left in the slab. Dowels that are not corrosion-resistant shall be painted with one coat of approved primer. When the paint has dried and immediately before placing the dowel in position, the sleeve-end of the dowel shall be thoroughly greased. Bond breaker for corrosion-resistant dowels shall be as recommended by the coating manufacturer.

4) Longitudinal Joints

Longitudinal joints shall be constructed by forming a keyed butt-type joint or sawing a groove in the surface of the pavement as detailed in the Plans.

If required by the Plans, deformed steel tie bars of specified length, size, spacing, and materials shall be placed across and perpendicular to the longitudinal joints. They shall be placed by approved mechanical equipment or rigidly secured by chairs, or other approved mechanical equipment, or rigidly secured by chairs or other approved supports to prevent displacement.

When adjacent lanes of pavement are constructed separately, a key-way shall be formed along the construction joint of the first lane constructed by any method approved by the Engineer and to

the dimensions shown on the Plans. If required, tie bars may be bent at right angles against the form and straightened into final position before the concrete of the adjacent lane is placed, or they may be placed in holes drilled through the forms.

Longitudinal sawed joints shall be cut by means of approved concrete saws to the depth, width and line shown on the Plans, not later than 4 days after placing concrete and before any equipment or vehicles are allowed on the pavement.

Immediately after sawing, all longitudinal contraction and construction joints shall be thoroughly cleaned of all residue by flushing with water under pressure.

5) Isolation Joints

Expansion joints shall be formed about all structures and features projecting through, into or against the slab by the use of premolded joint filler. Unless otherwise indicated, such joints shall be 3/4 inch in width.

(m) Sealing Joints

Joints shall be sealed in accordance with the requirements of Subsection 501.20 of TDOTSS, March 1, 2006.

(n) Protection of Pavement

The pavement shall be protected in accordance with the provisions of Subsection 501.21 of TDOTSS, March 1, 2006.

(o) Opening to Traffic

The Engineer shall decide when the pavement shall be opened to traffic. It shall not be opened to traffic until the field-cured concrete has attained a flexural strength of 550 psi, or a compressive strength of 3,500 psi. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Before opening to traffic, the pavement shall be cleaned.

6. Method of Measurement

The quantity of pavement laid shall be the number of square yards of full-depth pavement. The number of square yards shall be determined by the Engineer after construction of the pavement has been completed.

7. Basis of Payment

The accepted quantities of concrete pavement will be paid for the contract unit price per square yard for the specified thickness for Portland Cement Concrete Pavement (Plain).

Payment shall constitute full compensation for furnishing and preparation of all materials, including all joints, joint fillers, dowels and reinforcing if required in the construction drawings or special provisions; placing, finishing, curing; and all labor, equipment, tools, incidentals, and testing necessary to complete these items. No additional payment over the contract unit bid price will be made for pavement which has an average thickness in excess of that shown on the Plans.

TECHNICAL SPECIFICATIONS
FOR
CONCRETE CURB, GUTTER, AND COMBINED CURB AND GUTTER

1. Description

This work shall consist of Curb, Extruded Curb, Gutter, or Combined Curb and Gutter constructed of portland cement concrete in accordance with these Specifications and in conformity with the lines, grades and dimensions shown on the Plans, or established by the Engineer.

2. Materials

(a) Materials shall meet the applicable requirements of Section 15, City of Knoxville Standard Specification for Concrete Structures together with Section 702 of TDOTSS, March 1, 2006, and all Special Provisions thereto dated prior to the advertisement of the Contract.

(b) Sampling and testing cement aggregates shall be performed as specified in Section 15-2(b) of these Specifications.

3. Equipment and Construction Requirements

Equipment and construction shall meet the requirements of Subsection 702.03 and 702.05 through 702.11 TDOTSS, March 1, 2006.

4. Method of Measurement

(a) Concrete curb, extruded curb, concrete gutter, and concrete combined curb and gutter will be measured for payment by the linear foot, complete in place. Sections formed by curb inlets shall not be measured for payment under this item.

(b) No measurement for payment will be made for excavation in preparing the foundation or for backfill materials, unless otherwise indicated on the plans, as these are a necessary part of the construction and a responsibility to be assumed by the Contractor.

5. Basis of Payment

These items will be paid for at the Contract unit price per linear foot for concrete curb, extruded curb, gutter, and combined curb and gutter, complete in place, which price shall be full compensation for work, materials, labor, and incidentals required to complete this item in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
CONCRETE SIDEWALKS, DRIVEWAYS, AND MEDIAN STRIP

1. Description

   (a) This work shall consist of constructing sidewalks, driveways and median strip, except sidewalk driveways and median strip that is integrally a part of a structure, constructed of portland cement concrete, at the locations and to the dimensions, lines, grades, and cross section indicated on the Plans or as directed by the Engineer, and in conformity with the provisions and requirements set out in these Specifications.

   (b) Concrete sidewalk, driveway, and median strip shall include all the necessary excavation, unless otherwise indicated; the subgrade and subbase preparation; the backfilling; the final clearing up; and completing all incidentals thereto; as indicated on the Plans or as directed by the Engineer.

2. Materials

   (a) Materials shall meet the applicable requirements of Section 15, City of Knoxville Standard Specification for Concrete Structures together with Section 701 of the TDOTSS, March 1, 2006, and all Special Provisions thereto dated prior to the advertisement of the Contract.

   (b) Sampling and testing Cement Aggregates shall be performed as specified in Section 15 - 2(b) of these Specifications.

3. Equipment and Construction Requirements

   Equipment and construction shall meet the requirements of Subsection 701.03 and 701.05 through 701.12 TDOTSS, March 1, 2006.

4. Method of Measurement

   (a) Concrete sidewalks, driveways, and medians will be measured for payment per square foot, complete in place.

   (b) The area shall be obtained from surface measurements. The area measured shall not exceed standard widths indicated on the plans, unless otherwise directed in writing by the Engineer.

   (c) Concrete sidewalks, driveways, and medians will be measured separately.

   (d) No measurement for payment will be made for excavation, subgrade preparation, jointing, jointing materials, or for backfill materials, unless the otherwise indicated on the Plans, as these are a necessary part of the construction and a responsibility to be assumed by the Contractor.

5. Basis of Payment

This item will be paid for at the Contract unit price per square foot for concrete sidewalk, driveway, and median, complete in place. The price shall be full compensation for all work, materials, labor and incidentals required to complete this item in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
FLOWABLE FILL MATERIAL (FLOWABLE MORTAR)

1. Description

This work shall consist of the placing of flowable mortar fill material at locations shown on the Plans or as directed by the Engineer. All work shall be done in accordance with TDOTSS, March 1, 2006, except as modified herein.

2. Materials

Materials used in this construction shall meet the following requirements of TDOTSS, March 1, 2006, and any current revisions and special provisions thereto:

Material	Subsection
Portland Cement, Type 1	901.01
Fly Ash, Class C or Class F	AASHTO M 295
Water	918.01
Chemical Additives	918.09
Air Entraining Admixtures	918.09

Fine aggregate shall conform to the requirements of TDOTSS, March 1, 2006, Subsection 903.01 - Fine Aggregate for Concrete except that the gradation shall be as follows:

Sieve Size	Percent Passing
3/4 inch	100
No. 200	0-10

Proportioning

Flowable mortar shall be proportioned as follows:

Material	Per Cubic Yard
Portland Cement, Type 1	100 lbs.
Fly Ash, Class C or F	250 lbs. (Minimum)
Fine Aggregate	2800 lbs.
Water	60 gal. (Approximate)

The above proportions may be adjusted by the Engineer to obtain the consistency required for satisfactory flow. Consistency shall be determined as follows:

> Place an open-ended cylinder (pipe) three (3) inches in diameter by six (6) inches in height in an upright position on a smooth, level surface. Fill the cylinder with a representative sample of the flowable mortar proposed for use. Remove the cylinder by lifting it straight up thus allowing the sample to diffuse on the smooth, level surface. The flowable mortar should diffuse into a circular shape having an approximate diameter of not less than eight (8) inches.

3. Construction Requirements

Flowable Mortar shall be placed at locations as directed by the Engineer. The flowable mortar shall be covered or otherwise protected while in the plastic state. Backfill shall not be placed on the flowable mortar prior to final set or hardening as determined by the Engineer. The entire length and diameter of pipe shall be filled with flowable fill material (Flowable Mortar).

4. Method of Measurement

Measurement for payment shall be made by the cubic yard. The volume shall be determined by the Engineer from field measurements.

5. Basis of Payment

Flowable Fill Material (Flowable Mortar) shall be measured by the cubic yard complete in place. Such payment shall be full compensation for all materials, mixing, transporting, placing and finishing of the flowable mortar as well as all labor, tools, equipment and other incidentals necessary for the satisfactory completion of the work.

TECHNICAL SPECIFICATIONS FOR CONCRETE

1. Description

(a) This work shall consist of the construction of structures composed of portland cement concrete and steel reinforcement. They shall be constructed on prepared foundations at the locations indicated or directed, in conformity to the dimensions, lines, and grades shown on the Plans or as directed by the Engineer, and in accordance with these Specifications.

(b) Concrete structures shall be constructed of Class A Concrete, unless otherwise specified. The concrete shall be composed of a mixture of portland cement, aggregates, air-entraining agents, water and chemical additives when approved, combined and proportioned as specified.

(c) The work covered by this item shall consist of furnishing, erecting and removing concrete forms; furnishing, proportioning and mixing concrete ingredients; placing, curing and finishing plain and reinforced concrete masonry and all other work incidental thereto as required for the proper construction of the structures shown on the Plans or specified herein.

2. Materials

(a) Materials shall meet the requirements of Subsection 604.02 and 604.03 TDOTSS, March 1, 2006, and any Special Provisions which are dated prior to the advertisement of this Contract.

(b) Sampling and testing cement and aggregates shall be performed as specified below:

1) The Contractor shall determine the source, kind and quality of the cement, aggregates and admixtures to be used in the work well in advance of the time scheduled for starting the work and shall submit such information to the Engineer for approval before starting concrete operations.

2) The cost of testing cement, aggregates and admixtures shall be borne by the Contractor. Certified test reports and certificates shall be submitted in duplicate to the Engineer and to such other agencies or persons as he may designate. Reports or certificates indicating compliance of any shipment of cement, aggregate or admixtures shall be placed in the hands of the Engineer prior to use of such materials.

3) Where reputable cement and aggregate suppliers maintain regular recognized testing services, certified copies of such tests will be accepted by the Engineer. However, in any case of doubt as to the accuracy and/or adequacy of such tests, the Engineer may require that cement and aggregates be tested by a recognized commercial testing laboratory which has been selected by the Contractor and approved by the Engineer. The testing laboratory shall then test the cement and aggregates and prepare

written reports showing the results of such tests on each shipment. The laboratory shall also certify that the materials covered by the report comply in all respects with these Specifications. In general, cement and aggregates shall be tested at the mill but if untested shipments require sampling and testing after arrival at the site of the work, the Contractor shall be fully responsible for delays in the progress of the work due to delays in testing and reporting.

4) No cement or aggregate which fails to meet the requirements shall be incorporated into the work. In case of emergency, the Engineer may authorize the use of specific lots of cement which have satisfactorily passed the soundness test and the 7-day strength test only.

3. Classification and Proportioning of Concrete

Concrete shall be classified as shown in the proportioning table. Each class shall be manufactured by combining the several materials in the proportion specified. Proportioning shall be based on a predetermined cement content, water cement ratio and air content. The water cement ratio shall not exceed the maximum shown in the proportioning table. Below this limit , the quantity of water shall be adjusted to meet the slump requirement. Unless otherwise specified, the concrete shall contain 6 percent entrained air with a tolerance of plus or minus 1 percent. In no case shall the fine aggregate exceed 44 percent by volume calculation of the total aggregate.

CLASSIFICATION AND PROPORTIONING TABLE

Minimum 28 Day Compressive Strength (PSI)	Minimum Cement Per C.Y. (Sacks)	Maximum Water/Cement lb/lb	Air Content %
	CLASS A CONCRETE		
4,000	5.0	0.50	6 ± 1%
	CLASS F (LEAN CONCRETE)		
2,500	4.0	0.60	N/A

Fine Aggregate manufactured from limestone will not be permitted in concrete to be used as a riding surface in traffic lanes.

Cement replacement with fly ash in Portland Cement Concrete shall be in accordance with TDOTSS Subsection 604.03 or any subsequent Special Provision dated prior to advertisement of this Contract. In general, fly ash meeting all the requirements of 604.03 may be used as follows:

Case I

Where a concrete production facility has sufficient test records and experience to meet ACI 318-95, Section 4.3.1.1 or 4.3.1.2 and has significant experience in the use and testing of fly ash concrete, the concrete mixture may contain fly ash as shown in the following table.

Class of Fly Ash	Maximum Fly Ash Replacement, lb	Minimum Fly Ash Cement Substitution Ratios (by weight)
F	150	1.25 : 1
C	150	1 : 1

Case II

Where a concrete production facility can meet the requirements of ACI 318-95, Section 4.3.1.1 or 4.3.1.2, and has minimal experience in the use and testing of fly ash concrete, the concrete mixture may contain fly ash as shown in the following table.

Class of Fly Ash	Maximum Cement Replacement, (% by weight)	Minimum Fly Ash Cement Substitution Ratios (by weight)
F	15.0	1.25 : 1
C	15.0	1 : 1

Case III

Where a concrete production facility cannot meet the requirements of ACI 318-95, Section 4.3.1.1 or 4.3.1.2, no fly ash may be used. The mixture shall be proportioned according to the above proportioning table.

In the event the Contractor desires to replace a portion of cement with fly ash, a mix design with fly ash as a partial cement replacement shall be submitted to the Engineer for review and approval together with the following minimum data as verified by an approved independent testing laboratory.

(a) Certified results of compressive strength tests at ages of 7, 14, and 28 days conducted in accordance with ASTM C-192

(b) Tests for slump, entrained air content, unit weight and yield conducted in accordance with ASTM C-192

(c) Copies of results of all tests performed by the fly ash producer within the previous 30 days on shipments to the concrete supplier showing:

1) Fineness (percent retained on No. 325 sieve)

2) L.O.I. (loss on ignition)

3) Specific Gravity

4) Soundness (Autoclave Expansion)

5) Moisture content

6) Pozzuolanic activity, 7 day cement (AASHTO M-295)

(d) A notarized certification from the fly ash producer stating that the fly ash meets the City of Knoxville and TDOTSS as amended by Special Provisions dated prior to the advertisement for this Contract.

In addition to the above, fly ash materials, proportioning of aggregates, cement water, air and admixtures shall be in accordance with Section 604.02 and 604.03 of TDOTSS, March 1, 2006, or Special Provisions dated prior to the date of advertisement of this Contract.

4. Equipment and Construction Requirements

Equipment and Construction shall meet the requirements of subsections 604.04 and 604.05 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

5. Falsework

All falsework used to support the forms and concrete for concrete structures shall be in accordance with TDOTSS, March 1, 2006, or any Special Provisions dated prior to the advertisement of this Contract.

6. Camber

Structures of any type or size shall be constructed to a permanent camber only when shown on the construction drawings. Sufficient camber shall be provided in the falsework and forms for each span to allow for the tightening of joints in the forms and supporting falsework.

7. Reinforcement

All reinforcement shall conform to Subsection 604.08 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

8. Drainage and Weep Holes

Drainage openings and weep holes shall meet the requirements as set forth on the construction drawings or as directed by the Engineer together with applicable and non-conflicting requirements of Subsection 604.09 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

9. Placing Pipes, Conduits, Anchors, Castings and Other Appurtenances

Placing of pipes, conduits, anchors, castings and other appurtenances shall be in accordance with details and notes on the construction drawings or as directed by the Engineer. Applicable and nonconflicting provisions of Subsection 604.10 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract shall govern in the absence of details on the Construction Drawings.

10. Handling, Measuring, and Batching Materials

The handling, measuring and batching of Portland Cement Concrete Materials shall be in accordance with Subsection 501.09 and 604.12 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

11. Limitations of Mixing

Conditions limiting the mixing of Structural Concrete shall be as prescribed in Subsection 501.11 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

12. Mixing Concrete

The requirements for mixing concrete shall be as prescribed in Subsections 501.10, 604.04, and 604.11 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of the Contract.

13. Consistency of Concrete (Slump)

The slump of the concrete shall be measured in accordance with AASHTO T-119 and unless otherwise permitted, shall meet the following requirement:

> Mass concrete and heavy, reinforced sections require a 2 inch slump with a tolerance of plus or minus one inch; girders, columns, slabs and thin sections require a slump of three inches with a tolerance of plus or minus one inch. Class "F" (lean concrete) may have a slump up to six inches depending upon its use and directions from the Engineer. The consistency of Class "A" concrete may be varied as directed by the Engineer to meet the requirements in different parts of the construction, provided however, that there shall be no increase in the ratio of water to cement, and the total amount of fine and coarse aggregate shall not be more than the amount designated by the Engineer. In general and unless otherwise directed, the slump of Class "A" concrete shall be 3 inches with a tolerance of plus or minus one inch.

14. Compressive Strength Tests of Concrete

The compressive strength of the various classes of concrete shall be as specified for minimum 28-day compressive strength in the Classification and Proportioning Table in Subsection 3 of this Specification. The verification and testing for compressive strength shall be in accordance with Subsection 604.15 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

15. Placing Concrete

The placing of concrete shall be in accordance with Subsection 604.16 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

16. Bonding Construction Joints

Bonding of Construction Joints shall be in accordance with good practice, workmanship and in accordance with the provisions of Subsection 604.17 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

17. Depositing Concrete Under Water

No concrete except for cofferdam seals shall be deposited under water without the written detailed instructions from the Engineer. Concrete deposited under water for Cofferdam seals or special cases shall be in accordance with Subsection 604.18 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the advertisement of this Contract.

18. Removal of Forms and Falsework

The removal of Forms and/or Falsework shall be in accordance with Subsection 604.19 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the advertisement of this Contract.

19. Defective Concrete

Any defective concrete discovered after placement and form removal shall be removed immediately and replaced. If the surface of the concrete is bulged, uneven, or shows honey-combing which cannot be repaired satisfactorily, the entire section shall be removed and replaced.

Concrete having a 28-day strength of less than the minimum specified in Subsection 3 of this Specification, shall be removed and disposed of by the Contractor, at his expense, unless specifically authorized in writing by the Engineer to remain in place. The removal shall be in such a manner as will not cause damage to the remaining concrete or to other structural units or other facilities and property.

The Engineer may at his discretion, allow concrete which fails to meet the strength specified to remain in place, provided the durability is good, but the payment for such concrete will be made at a reduced price to compensate the City of Knoxville for the loss of strength. The bid price for concrete failing to meet the specified strength, yet considered to be structurally adequate to remain in place shall be adjusted downward in accordance with the following formulas:

$$A.P. = B.P. \frac{fc}{S.S.}$$

where A.P. = Adjusted Price
B.P. = Contract Bid Price
fc = Actual 28-day Compressive Strength of Affected Concrete
S.S. = Minimum Specified Strength

20. Finishing Concrete Surfaces

Unless otherwise detailed on the Construction Drawing or authorized by the Engineer, the Finishing of Concrete Surfaces shall be in accordance with Subsection 604.21 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

21. Finishing Slab Surfaces for Pavements or Bases

The finishing of bridge floors, or top slabs of structures serving as finished pavements or bases shall be in accordance with Subsection 604.22 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this Contract.

22. Curing Concrete

All concrete surfaces, except those surfaces protected by forms that remain in place 7 days or longer as required under the provisions of Subsection 18 of this Specification, shall be cured as specified herein. All curing materials shall meet the requirements of Section 913 TDOTSS, March 1, 2006, or any Special Provisions dated prior to the date of advertisement of this

Contract. Curing shall begin as soon as the Concrete has hardened sufficiently to withstand surface damage to unformed surfaces and immediately after form removal from formed surfaces. Only white-pigmented curing compound shall be used.

When the temperature is expected to fall below 35 degrees F, the concrete shall be protected in accordance with the provisions of Subsection 24 of this Specification.

The "Water Method" of curing with burlap will be required for all bridge decks.

(a) Water Method

All concrete slabs shall be covered immediately with material suitable for use with the water cure and kept thoroughly wet for at least 120 hours from the beginning of the initial curing period. All surfaces other than slabs shall be protected from the sun and shall be kept wet for a period of at least 72 hours from the beginning of the curing period. Curbs, walls, handrails and other surfaces requiring a class II finish may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

(b) Membrane-Forming Compound Method

All surfaces shall be given the required surface finish prior to the application of the curing compound. Prior to the application of the curing compound, the surface shall be kept moist.

The rate of application of curing compound shall be as recommended by the manufacturer, but shall not be less than one gallon for 150 square feet of concrete surface. The curing compound shall be applied under pressure, immediately after acceptance of the concrete finish. Hand sprays shall only be used in areas that are inaccessible to pressure equipment. If the surface is dry, the concrete shall be thoroughly wetted with water and the curing compound applied just as the surface film of water disappears. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment or dye uniformly dispersed throughout the vehicle. If the application of the compound results in a streaked or blotchy appearance, the method shall be stopped and water curing as described herein above, applied until the cause of the defective appearance is corrected. The coating shall be protected against marring for a period of five days from the date of application. Any coating marred or otherwise disturbed within the five day period shall be replaced at once.

23. Protection of Concrete in Cold Weather

After the concrete has been placed, if it is expected that the ambient temperature will drop below 35 degrees F, the contractor shall provide sufficient canvas and framework, or other types of housing, to enclose and protect the structure in such a way that the air surrounding the fresh concrete can be maintained at a temperature of not less than 45 degrees F, and the surface temperature of the concrete shall not exceed 80 degrees F. The above conditions shall be maintained for a period of 120 hours after the concrete is placed. The Contractor shall furnish a maximum/minimum thermometer to the Engineer for the purpose of temperature documentation.

24. Painting Metals

The painting of metals shall meet the requirements of Section 604.25 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the advertisement of this Contract.

25. Waterproofing and Waterstops

Waterproofing where indicated on the Plans or directed by the Engineer shall be in accordance with Section 605 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to the advertisement of this Contract.

Waterstops, as specified, shall be installed in accordance with the details on the Plans and in conformity with Section 604.26 of TDOTSS, March 1, 2006, or any Special Provisions dated prior to advertisement of this Contract.

26. Loading and Opening to Traffic

No traffic, heavy equipment, storage of materials, or other loading on a structure or any part thereof until after all forms and falsework have been removed and 10 calendar days have elapsed from the date of removal of forms, falsework and supports is permitted under the provisions of Subsection 19 of this Specification.

27. Method of Measurement

(a) Concrete for concrete structures, unless otherwise stipulated, will be measured for payment by the cubic yard. Computation of the quantities will be based on the dimensions shown on the plans or ordered in writing by the Engineer. Where concrete masonry for which specific dimensions are not given on the Plans is ordered by the Engineer, the volume shall be determined by the Engineer from field measurements.

(b) No deductions will be made in concrete volumes for drainage openings 6 inches in diameter or less, individual cavities or embedded pieces less than 1 cubic foot, or for reinforcement.

28. Basis of Payment

(a) Payment will be made for Structural Concrete and Reinforced Structural Concrete as specified on the Bid Schedule at the Contract unit price per cubic yard.

(b) The volumes allowed for payment shall include only the items of concrete placed in accordance with the Plans and Specifications and accepted by the Engineer.

Payment shall be full compensation for all labor, materials including steel reinforcement where specified, equipment, tools, plant services and all other expenses incidental to the structural concrete work.

TECHNICAL SPECIFICATIONS FOR CONCRETE MASONRY UNITS

1. Description of Work

The work specified under this section consists of all concrete block and brick work.

2. Mortar

(a) All mortar materials shall be delivered, stored, and handled to prevent damage, deterioration, or contamination. All mortar materials shall be stored under cover in a dry place and in the original packaging.

(b) Materials

1) Water shall be clean and free of deleterious materials.

2) Portland Cement: AASHTO M85, Type I

3) Hydrated lime: ASTM C 206

4) Sand: AASHTO M45

(c) Proportioning

Mortar shall be composed of one part Portland Cement and two parts sand. Hydrated lime, in an amount not to exceed ten percent, may be added to Portland Cement. Water shall be added to the mixture in such quantity as to form a stiff paste.

(d) Mortar shall be power mixed until the entire batch is homogeneous and the proper consistency.

(e) Retempering of mortar which has begun to set will not be permitted.

3. Concrete Masonry Units

Concrete masonry units shall conform to TDOTSS, March 1, 2006, Subsection 912.04.

4. Building Brick

Building brick shall conform to TDOTSS, March 1, 2006, Subsection 912.01.

5. Sewer Brick

Sewer brick shall conform to TDOTSS, March 1, 2006, Subsection 912.02.

6. Reinforcement

Reinforcing shall be placed as shown on the Plans or as directed by the Engineer.

7. Execution

(a) No masonry shall be laid in freezing weather unless heating of materials and protection of the masonry from cold are provided for.

(b) All masonry shall be laid true to dimensions, plumb, square, in bond, and properly anchored. Joints of uniform thickness.

(c) Work to be built into the masonry shall be built in as the masonry work progresses. All spaces about built in work shall be solidly filled with masonry.

(d) Blocks shall be cut accurately to fit around pipe, openings, etc., with all voids slushed full.

(e) All joints shall be tooled with a convex tool, slightly larger than the joint width.

8. Method of Measurement

Concrete masonry units (block and/or brick) shall be measured by the square foot of wall in place unless otherwise specified in the Contract Documents or Plans.

9. Basis of Payment

(a) Accepted quantities of concrete masonry units will be paid for at the Contract Unit Price per square foot for Concrete Masonry Units, which price shall be full compensation for all labor and materials necessary to complete the construction as shown in the plans and including masonry units, mortar, waterproofing, and expansion material.

(b) Payment will be made under the following bid item as set forth in the Bid Schedule:

Concrete Masonry Units (Blocks)
Concrete Masonry Units (Bricks)

TECHNICAL SPECIFICATIONS
FOR
WATERPROOFING

1. Description

   (a) All Masonry walls shall be waterproofed with Philip Carey Foundation Coating, or equal.

   (b) Material shall be applied in strict accordance with the manufacturer's recommendations in all aspects of application.

2. Basis of Payment

   No separate payment will be made for this item. The cost of this item should be included in the price bid for masonry wall units.

TECHNICAL SPECIFICATIONS FOR MINERAL AGGREGATE TRAIL BASE AND SURFACE WITH 5% PORTLAND CEMENT

1. Description

This work shall consist of furnishing and placing one or more courses of aggregates and additives, if required, on a prepared subgrade in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses and typical cross-section shown on the Plans or established by the Engineer.

2. Materials

All materials used in this construction, in addition to the general requirements of these Specifications, unless otherwise stipulated, shall conform to the following:

(a) Mineral Aggregate Trail Base and Surface (i.e., "CHATT") shall be crushed stone, Class A Aggregate for Micro-Surface, as specified in Subsection 903.05 and Subsection 903.12 of the TDOTSS, March 1, 2006, and all Special Provisions pertaining thereto through the date of advertisement for this Contract.

Sieve Size	Total Percentage by Weight Passing Sieves
3/8 inch	100
No. 4	70 - 98
No. 8	45 - 70
No. 16	30 - 55
No. 30	20 - 35
No. 50	12 - 25
No. 100	7 - 18
No. 200	4 - 12

(b) Hydraulic Cement shall be Portland Cement as specified in TDOTSS Section 901.01 and shall conform to the specifications of AASHTO M 85.

(c) Proportioning: The placed material shall contain 5% Portland Cement by weight.

3. Equipment & Construction Requirements

(a) Equipment and Construction Requirements shall conform to Subsections 303.05 to 303.12 of the TDOTSS, March 1, 2006, and all Special Provisions Pertaining thereto through the date of advertisement of this Contract. In addition, the following compaction, will be required: Mineral Aggregate Trail Base and Surface shall be compacted to 100% of the Standard Proctor Density at 2% less than the optimum moisture content as determined by AASHTO T99 Method D.

(b) The Portland Cement shall be mixed with the Class A aggregate for Micro Surface at such time and in such a way that the Portland Cement will be uniformly spread throughout the material. The Portland Cement shall be mixed with the Class A Aggregate for Micro-Surface and this mixture shall be transported in such a way that the Portland Cement neither settles nor separates from the aggregate. The moisture content of the Aggregate for Micro-Surface shall be controlled and the method and residence time in transport of the Class A Aggregate for Micro Surface once improved with the cementitious additive shall be controlled. Any Class A Aggregate for Micro Surface improved with Portland Cement which for any reason has become partially set or which contains lumps of caked cement at the location and time of placement will be rejected.

(c) The maximum speed of trucks hauling or traveling over any part of the project under construction shall be 10 mph.

4. Method of Measurement

(a) Mineral Aggregate Trail Base and Surface will be measured by the ton in place, as by the actual scale weight.

(b) All moisture in the Aggregate at the time of weighing in excess of eight percent will be deducted from the weight of the Aggregate.

(c) Any water added on the road will be at the Contractor's expense.

5. Basis of Payment

(a) The accepted quantities of Mineral Aggregate Trail Base and Surface of the type specified will be paid for at the Contract unit price per ton, complete in place. This price shall be full compensation for all work, materials, including calcium chloride where specified and water; labor and other incidentals required to complete the work in accordance with the Plans and Specifications.

(b) Payment will be made under the following bid item as set forth in the Bid Schedule:

Mineral Aggregate Trail Base and Surface

TECHNICAL SPECIFICATIONS
FOR
STORM SEWERS AND PIPE CULVERTS

1. Description

This work shall consist of the placing of precast concrete pipe, corrugated metal pipe, structural plate pipe and pipe arches, and all fittings as called for in the Plans and in accordance with the Specification including trench excavation, bedding, and backfill.

2. Materials

(a) Pipe Materials

1) Reinforced concrete pipe shall conform to AASHTO M 170 for the specified diameters and strength classes. Horizontal and vertical elliptical pipe shall conform to AASHTO M 207. Precast end sections shall conform to the above specifications to the extent to which they apply. The pipe shall have tongue and groove joints for mortar joints, or bell and spigot joints suitable for the use of a rubber gasket to be provided as a part of this item.

2) Corrugated metal pipe, pipe arches, and their coupling bands shall conform to AASHTO M 36 for the specified sectional dimensions and gauges. Special sections such as elbows and end sections shall be the same gauge as the pipe and conform to the applicable requirements of AASHTO M 36. All pipes and pipe arches shall be bituminous coated as specified on the Plans and conforming to AASHTO M 190 Specifications.

3) Structural Plate for pipe, pipe arches, arches and their accessories shall conform to the requirements of AASHTO M 167.

4) Each pipe shall be clearly marked to show its class or gauge, date of manufacture, name of manufacturer, and mark of approval by an approved commercial testing laboratory prior to delivery. All costs of inspection are to be included in the cost of furnishing and installing the pipe.

5) All pipe and special fittings shall be new materials which have not been previously used and free of any defects or damage.

6) Pipe sizes, class or gauge, and type of bituminous coating will be shown on the Plans. Size of the pipe is nominal inside diameter.

(b) Joint Material

1) Pipe joint mortar shall consist of one part Portland Cement and 1 parts sand with water necessary to obtain the required consistency. The materials used shall meet the requirements for these items as specified in the Standard Specifications for Concrete Structures.

2) Rubber Gaskets for concrete pipe shall be O-ring rubber gasket joints conforming to the requirements of AASHTO M 198 or an approved equal.

3) Joints for corrugated metal pipe, pipe arches, and fittings shall be coupling bands that have galvanized steel angles riveted near the ends and bolts through the angles to draw the bands tight.

(c) Bedding Material

Bedding Material shall consist of well-graded crushed stone or crushed gravel meeting the requirements of TDOTSS, March 1, 2006, Section 903, Grading Size No. 57 or No. 67.

(d) Backfill Material

Backfill Material for pipe in the roadway or less than 5 feet from the outside edge of the roadway shall be of quality and gradation as specified in Section 5, Subsection 2-a of these Specifications. Also, this backfill shall be compacted to 100% of the standard Proctor Density at 2% less than the optimum moisture content as determined by AASHTO T99, Method D. In addition, all backfill material for pipe more than 5 feet from the outside edge of the roadway shall be fine compactable soil free of sod, brush, roots, and other perishable material and stones having a maximum dimension of more than six (6) inches. Also, this material shall be compacted in layers of not more than six inches to 95% of the Standard Proctor Density at the optimum moisture content as determined by AASHTO T99, Method D.

3. Equipment

(a) The Contractor shall provide all equipment necessary and required for the construction of storm sewers and culverts, and have all equipment on the project in proper working condition before construction will be permitted to begin.

(b) The Contractor shall provide hoisting equipment to handle the pipe in unloading and placing in its final position, without damage to the pipe.

(c) The Contractor shall provide mechanical tampers of a design or designs approved by the Engineer.

4. Construction Requirements

(a) Excavation (unclassified)

1) Excavation (unclassified) shall consist of the removal of all materials necessary for the construction of storm sewers, culvert pipes, other pipe lines and all drainage structures such as manholes, catch basins, junction boxes, head walls, wing walls and concrete collars.

2) Excavation shall be made in open cuts unless shown otherwise on the Plans. Excavation shall be made to the lines and grades shown on the Plans or established by the Engineer. The width of trenches shall be sufficient to permit satisfactory jointing of the pipe, but shall not exceed the width where specified for Class "A" Bedding and permit thorough tamping around the pipe. The bottom of the trenches shall be carefully cut to the required grade of the pipe except where bedding material or cradles are shown; in which case the excavation shall extend to the bottom of the

bedding or cradles as shown on the plans. Excavation around manholes, catch basins, junction boxes, and end walls shall be such as to allow proper compaction around the structure.

3) Any unsatisfactory material shall be excavated below the grades shown on the Plans as directed by the Engineer, and backfilled with bedding material or other approved material and compacted.

4) Any excavation below the elevations shown on the Plans other than unsuitable material as designated by the Engineer shall be filled at the Contractor's expense with properly compacted bedding material or concrete.

5) Pipe trenches shall not be excavated more than 400 feet in advance of pipe laying and all work shall be performed to cause the lease possible inconvenience to the public. Adequate temporary bridges or crossings shall be constructed and maintained where required to permit uninterrupted vehicular and pedestrian traffic.

6) In all cases where materials are deposited along open trenches they shall be placed so that no damage will result to the work and/or adjacent property in case of rain or other surface wash.

7) Rocks and/or boulders not classified as rock excavation shall be removed to the limits of excavation and grades shown on the plans. The spaces created outside the excavation limits by such removal shall be backfilled with suitable material and compacted to the proper lines and grades.

(b) Rock Excavation

Rock excavation when specifically provided for in the Contract Documents and Plans shall be performed and paid for as set forth in Section 4 of the Standard Specifications for Sewer and Pipe Excavation.

(c) Laying and Bedding Pipe

1) Pipe shall be laid true to line and grade on a bed which is uniformly firm throughout its entire length. If material in the bottom of the excavation is of such character as to cause unequal settlement along the length of the storm sewer or culvert, the material shall be removed below the grade given, to such depth as ordered and shall be backfilled with bedding material and thoroughly tamped or otherwise compacted to insure an unyielding foundation.

2) Pipes shall be laid only on a foundation which is practically free of water.

3) Pipes shall be laid beginning at the downstream end of the pipe line. The lower segment of the pipe shall be in contact with the shaped bedding throughout its full length.

4) Concrete pipe shall be laid with the hubs or receiving ends upgrade. The spigot or tongue end shall be inserted into the receiving end as far as the pipe will permit. Circumferential laps of corrugated metal pipe shall be placed facing upstream and any longitudinal seams at the sides.

5) Concrete pipe joints shall be made with portland cement mortar, rubber gaskets, or other joints recommended by the pipe manufacturer and approved by the Engineer.

When mortar joints are used the pipe ends shall be thoroughly cleaned and wetted before the joint is made. Stiff mortar shall then be placed so as to completely fill and seal the joint. The inner surface shall be finished smooth and any surplus material removed. The completed joint shall be protected against rapid drying by suitable covering material.

Rubber ring gaskets shall be installed so as to form a flexible watertight seal.

Other type joints that are permitted shall be installed according to manufacturer's specifications.

6) Each section or joint of corrugated metal pipe shall be securely attached to the adjoining section or joint of pipe with connecting bands or other approved type of joint and drawn or connected as to form a rigid joint.

7) Any breaks in the bitumen or treatment of bituminous coated pipe shall be refilled with the type and kind of bitumen used in coating the pipe originally.

8) The ends of pipe shall be rigidly supported to prevent any movement pending and during the construction of end supports.

9) Any pipe which is not in true alignment or which shows any settlement after laying or is damaged shall be taken up and relaid at the Contractor's expense.

(d) Bedding and Backfilling

1) The bed for the pipe shall be shaped as specified for Class B in the City of Knoxville Standard Drawing for Storm Pipe Bedding and Backfilling. If bell and spigot pipe is used, the area under the bell shall be excavated so that the barrel supports the entire weight of the pipe.

2) Bedding material shall be Mineral Aggregate Base, Section 5, No. 57 or No. 67 stone and the cost of furnishing and placing the bedding material shall be included in the bid price per linear foot.

3) After the pipe has been laid to line and grade and properly bedded, the backfill material shall be placed and where required compacted by means of a vibrator or mechanical tamper. Tamping by hand will not be permitted. The trench shall be filled in 6-inch lifts and each lift shall be compacted with mechanical tampers. Compaction shall be 100% of the Standard Proctor Density at 2% less than the optimum moisture content as determined by AASHTO T99, Method D.

4) Backfill of pipes, sewers and culverts under streets (or less than 5 feet from the outside edge of the roadway), curbs, gutters and sidewalks shall be accomplished with Mineral Aggregate Base Material meeting the requirements of Section 5 of these Specifications and compacted as herein above specified. The cost of the backfill is not a separate pay item and shall be included in the bid price per linear foot.

5) The bedding for pipe must be laid in a dry trench. Removal of water encountered in ditches, springs, etc. shall be considered a necessary part of construction and shall be handled by pumping, ditching or any other method satisfactory to the Engineer.

(e) Existing Utilities

1) All existing sewers, water lines, gas lines, underground conduits, telephone lines, electric lines, or other utilities or structures in the vicinity of the work shall be carefully protected by the Contractor from damage at all times.

5. Method of Measurement

(a) The quantities of concrete pipe, corrugated metal pipe, corrugated metal pipe arches, and structural plate pipe arches shall be measured by the linear foot for each size and type of pipe and pipe arch shown on the Bid Schedule and shall be the horizontal length of pipe or pipe arch installed complete in place as measured along the centerline of the conduit from end to end with no deduction for fittings or bends.

(b) No separate payment will be made for unclassified or common excavation, bedding, or backfill. The cost of these items is to be included in the bid price per linear foot for pipe and pipe arch.

(c) Concrete for collars, cradles, piers, pipe protection and/or encasement shall be measured in cubic yards of concrete furnished and placed in accordance with Plan dimensions and these Specifications and payment for this item of work shall be made at the applicable unit price per cubic yard of the class of concrete placed as set forth under Standard Specifications for Concrete Structures.

6. Basis of Payment

The accepted quantities of pipe culverts and storm sewers, measured as provided for above, will be paid for at the Contract unit price per linear foot for each type, class, shape and size constructed, complete in place, which price shall be full compensation for labor and materials used in bedding, making joints and connections to other structures, for strutting, when required for backfilling, and for completing all incidentals necessary to complete the item in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS FOR UNDERDRAINS

1. Description

This work shall consist of the construction of underdrains composed of stone, gravel, slag, or a combination of any one of these materials and perforated or semicircular drainpipe (with connections or filter cloth). They shall be constructed in accordance with these Specifications, on prepared foundations at the locations shown on the Plans, and in reasonably close conformity to the lines and grades indicated thereon, or as directed by the Engineer. The work shall include all necessary excavation and backfill, together with such work and materials as may be necessary to make connections with other drainage structures, as shown on the Plans.

2. Materials

Materials used in this construction shall meet the following requirements:

(a) Pipe used for underdrains shall conform to the requirements of AASHTO M-252 and ASTM F405 for Corrugated Polyethylene Tubing and Fittings.

(b) Aggregates for underdrains shall be crushed stone, gravel, slag or a combination meeting the gradation as follows:

Sieve Size	Total Percent Passing by Weight
1/2"	100
3/8"	85 – 100
No. 4	10 - 30
No. 8	0 - 10
No. 16	0 - 5
No. 200	0 - 1

The aggregate shall meet the quality requirements of ASTM D 692.

(c) Mortar for joints shall meet the requirements of the Standard Specifications for Storm Sewers and Pipe Culverts.

3. Construction Requirements

(a) Underdrains shall be of the kind specified on the Plans. Unless otherwise specified, circular pipe for underdrains shall have a diameter of 6 inches nominal inside diameter.

(b) The trench to receive the pipe shall be excavated at the locations shown on the Plans, or as directed by the Engineer. In case the dimensions are not shown, the width of the trench shall be not less than the outside diameter of the pipe plus 12 inches. The trench shall be deep enough to intercept the water-bearing strata and to allow installation of the pipe and cover material, but in no case shall it be less

than 16 inches deep. Unless otherwise shown on the Plans, a 2-inch layer of aggregate shall be spread on the bottom of the trench, compacted and brought to uniform grade.

(c) The pipe shall be firmly embedded in the layer of aggregate. Perforations shall be laid with the flow and perforations at the bottom.

(d) If an underdrain is extended through a dry fill or other area where perforations are undesirable, it shall be constructed with pipe without perforations where specified.

(e) After the pipe has been laid and approved, the backfilling around the pipe shall be with the aggregate specified. Unless otherwise designated on the Plans, or by special provision, the backfilling shall be 6 inches on each side of the pipe and 6 inches over the pipe. The aggregate around the pipe shall be thoroughly tamped with an approved tamp. The backfill above the aggregate shall be of suitable nonporous material placed in layers not exceeding 6 inches (loose measurement) and thoroughly compacted with mechanical tamp, hand tamp or roller to a density at least equal to that of the existing material adjacent to the trench.

(f) Dead ends of pipe underdrains shall be closed with a suitable concrete plug placed over and around the end and held firmly in place.

(g) Outlet ends of pipe underdrains shall be covered with screens of ½ inch openings. The screens are to be securely and satisfactorily attached to the end of the pipe. The outlet ends of pipe shall be marked for the benefit of proper maintenance.

(h) Lateral and other connections shall be made where indicated on the Plans or as directed by the Engineer.

(i) All excess and unsuitable material shall be removed from the site and disposed of as directed by the Engineer.

4. Method of Measurement

Aggregate underdrains (with pipe) will be measured for payment by the linear foot along the centerline of the pipe, and from end to end of pipe, including connections, complete in place.

5. Basis of Payment

Accepted quantities of underdrain of the various sizes measured as specified above will be paid at the Contract unit price per linear foot, for the individual sizes, complete in place. Such payment shall be full compensation for all excavation, backfill, connections, specials and all incidentals necessary to complete the construction, in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
MANHOLES, CATCHBASINS, INLETS, AND JUNCTION BOXES

1. Description

   (a) This work shall consist of constructing the following drainage structures: manholes, catch basins, inlets, and junction boxes. Construction shall be in conformity to the lines, grades, dimensions, and sizes shown on the Plans or as directed by the Engineer.

   (b) The height or depth of these drainage structures will vary with location, but unless otherwise shown on the plans, shall be such that the frames will match the grades and lines of the roadway surface and the invert will be at designed elevations.

   (c) Cast iron frames, grates, and covers shall be provided as specified on the Plans.

   (d) Connections to pipes and other existing structures as may be necessary as a required part of the construction.

2. Materials

   (a) Concrete, cement, sand, and water shall conform to the applicable requirements of the Standard Specifications, Section 15.0, Concrete Structures. Concrete shall be Class A.

   (b) Brick shall conform to AASHTO Designation M 91 Grade SM.

   (c) Frames, covers, and grates shall be the type specified on the drawings. The castings shall conform to AASHTO Designation M 105, Class 30 (ASTM A 48, Class 30). All castings shall be true to pattern, to form and dimension, free from any faults or cracks, and cleaned of sand in a manner to provide a clean uniform surface. Bearing surfaces between frames and grates shall be machined to provide uniform bearing. Castings shall be treated with two coats of bituminous paint. All castings shall weigh at least 95% of the theoretical weight shown on the drawings. All castings shall have the date of manufacture cast into each unit.

   (d) Round precast concrete structures shall conform to ASTM C 478. Square and rectangular precast concrete structures shall conform to ASTM C 913 for wall thickness, slab thickness, concrete strength and steel reinforcement requirements.

   (e) Prior to delivery all basic materials specified herein shall be tested and inspected by an approved independent commercial testing laboratory or, if approved by the Engineer, certified copies of test reports prepared by the manufacturer's testing laboratory will be acceptable. All materials which fail to conform to these Specifications shall be rejected. After delivery to the site, any materials which have been damaged in transit or are otherwise unsuitable for use in the work shall be rejected and removed from the site.

3. Construction Requirements

(a) General

1) Manholes, inlets, catch basins, and junction boxes shall conform to the Standard Detail Drawings and Specifications. Deviations from these drawings may be approved by submitting a detailed drawing to the Engineer before construction begins. When poured concrete is to be used instead of brick, a minimum wall thickness of 8 inches for unreinforced concrete and 6 inches for reinforced concrete must be used on the detailed drawing submitted.

2) Structural excavation and backfill shall be done in accordance with the Standard Specifications for Grading.

3) After the foundation has been prepared, the bottom shall be constructed to the required lines and grades. After the bottom has been allowed to set for at least 24 hours, the structure shall be constructed with care being exercised to form the incoming and outgoing sewer pipes into the walls of the structure at the required elevations. Pipe shall be placed in the wall and beyond the outside surface of the walls to allow for connections, the end of the pipe being placed flush with the inside face of the wall. Masonry shall be carefully constructed around the pipe so there will be no leakage around the outer surface. Inverts shall be constructed as shown on the drawings, and be smooth and accurately shaped to the same cross section as the invert of the sewer pipes which they connect.

4) Cast iron frames shall be set in cement mortar beds accurately to line, finished elevation, slope, and crown so that subsequent adjustments will not be necessary.

5) After the masonry and frames have time to set, but in no case less than 24 hours, the space around the drainage structure shall be backfilled and compacted to the required grade. The interior shall be cleaned of debris and excess material, the grating or cover placed, and all unused material, equipment, tools, and debris removed from the area.

(b) Precast Reinforced Concrete Manholes

1) Precast sections shall consist of reinforced concrete sections manufactured, tested, and marked in accordance with the provisions of AASHTO Designation M 199(ASTM C 478).

2) Each section of the precast manhole shall have not more than three holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with stoppers or mortar after installation.

(c) Drop Manholes

1) Where the difference in the invert elevation of a sewer 18 inches in diameter or smaller and any other sewer intersecting in one manhole is 3 feet or more, a drop manhole shall be constructed as shown on the plans. They shall be similar in construction to the standard manhole except that a drop connection of pipe and fittings of the proper size and material shall be constructed outside the manhole and supported by Class A concrete.

4. Method of Measurement

(a) Manholes, catch basins, inlets, and junction boxes will be listed on the Bid Schedule for each type as detailed on the Plans.

(b) The quantity of each type of drainage structure for which payment will be allowed shall be the actual number constructed by the Contractor in accordance with the Plans and Specifications accepted by the Engineer.

5. Basis of Payment

Payment shall be made for the quantities as measured and listed under the applicable pay items in the Bid Schedule.

Payment shall constitute full compensation to the Contractor under this item and shall cover the cost of furnishing all labor, materials, tools, plant equipment, services and other expenses in connection with the construction of manholes, inlets, catch basins and junction boxes complete in place including common excavation, shoring, backfill, masonry, castings, concrete reinforcing steel, inspection and test, all as herein specified and shown on the Plans.

TECHNICAL SPECIFICATIONS
FOR
ADJUSTING STORM SEWER FRAMES

1. Description

This item shall consist of adjusting storm sewer frames and furnishing all labor, materials, and other items necessary to bring them to the grades as shown on the Plans or as specified by the Engineer.

The adjustment of frames includes only storm sewer frames, such as storm sewer manholes, and catch basins. All other frames such as water, electric, gas, etc. shall be adjusted by the Knoxville Utilities Board or other companies and are not included as a part of this Contract unless otherwise noted.

2. Materials

(a) Concrete or mortar shall be Class A. Mortar shall be one part Portland cement and two parts sand. Concrete materials shall comply with the Specifications for Concrete.

(b) Brick shall conform to AASHTO M91, Grade SM. Sand for mortar shall conform to AASHTO M45. Hydrated lime shall conform to ASTM C 206.

(c) Backfill material shall conform to the Specifications for Mineral Aggregate Base.

3. Construction Requirements

(a) All Sewer frames shall be reset as follows:

1) Manholes that are more than 1/4 inch over or under the specified grade.

2) Catch basins that are specified on the Plans or determined necessary by the Engineer.

(b) The sewer frames shall be accurately set to line and grade by one of the following methods:

1) Removing the frame and cover grating and raising or lowering the masonry top of the structure and resetting on a cushion of cement mortar and brick.

2) Use of an adjustment ring fitted to the manhole frame.

(c) Excavation shall be performed whenever necessary to bring the frames to grade on the Plans and as designated by the Engineer. Backfill material and compaction shall conform to the Specifications for Mineral Aggregate Base.

(d) All frames shall be thoroughly cleaned of all excess mortar and accumulations of silt, clay, debris or foreign matter of any kind and shall be free from such at the time pavement is to be laid.

(e) Flat metal manhole covers shall be temporarily placed immediately ahead of the paver so that the paver shall never pass over crowned manholes. A sufficient number of flat covers shall be available on the job site to allow the paving operation to progress smoothly.

4. Measurement

The number of storm sewer frames adjusted and accepted will be measured for payment per each.

5. Payment

Payment will be made at the Contract unit price per each frame adjusted and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
RIP RAP

1. Description

This work shall consist of furnishing and placing one or more classes of crushed or fractured limestone on a prepared surface in accordance with these Specifications and in reasonably close conformity with the sizes, thicknesses and typical cross-section shown on the Plans or established by the Engineer.

2. Materials

All materials used in this construction, in addition to the general requirements of these Specifications, unless otherwise stipulated, shall conform to the following:

Class I
Stones ranging from 1" to 5" with 75% greater than 4".

Class II
Stones ranging from 6" to 10" with 75% greater than 8".

Class III
Stones ranging from 9" to 12" with 75% greater than 11".

Class IV
Stones ranging from 12" to 18" with 75% greater than 15".

3. Preparation of Foundation

Immediately prior to the construction of rip rap, the sand filter bed, filter fabric surface or natural ground surface shall be trimmed within reasonably close conformity to the lines and grades indicated on the Plans or as directed by the Engineer. The natural ground or sand filter bed shall be thoroughly compacted by the use of hand or mechanical tamps. On slopes, the bottom of the rip rap shall be placed at least 2 feet below the natural ground surface, unless otherwise directed.

4. Construction

Rip rap shall be constructed upon the prepared foundation by hand placing, so that the stones shall be as close together as is practicable, in order to reduce voids to a minimum.

When rip rap is constructed in more than one layer, it shall be placed so that it will be thoroughly tied together with the larger store protruding from one layer into the other.

The standard depth of rip rap shall be 12 inches for Class I, and Class II, 18 inches for Class III and 24 inches for Class IV, unless otherwise directed; and in no instance shall be less than 10 inches in depth.

The main stones shall be thoroughly "chinked" and filled with the smaller stones by throwing them over the surface in any manner that is practical to fill the voids. Napping

the stones will not be required, except stones protruding more than 4 inches above what is considered normal surface of the stones.

5. Method of Measurement

Rip rap will be measured by the ton, complete in place. The volume shall be obtained from the thickness shown on the Plans and surface measurement. No measurement for payment will be made for excavation or for preparing the foundation for rip rap.

6. Basis of Payment

Accepted quantities of rip rap will be paid for at the Contract unit price per ton, and measured as set out above, complete in place.

Payment will be made under:

Description	Unit
Rip Rap Class I	Tons
Rip Rap Class II	Tons
Rip Rap Class III	Tons
Rip Rap Class IV	Tons

TECHNICAL SPECIFICATIONS
FOR
TOPSOIL

1. Description

Topsoil shall consist of a soil conforming to the requirements of these Specifications, obtained from locations indicated on the Plans or approved by the Engineer, and placed in conformity with the provisions and at locations specified.

Suitable topsoil which has been stripped off of excavation and embankment areas of roadway construction projects shall be stockpiled as directed by the Engineer and later used before additional topsoil is hauled on to the work site. Unsuitable material shall not be included in these stockpiles and shall be wasted as directed by the Engineer.

2. Materials

(a) Topsoil shall consist of the natural loam, sandy loam, silt loam, or clay loam humus-bearing soils adapted to the sustenance of plant life, and such topsoil shall be neither excessively acid or alkaline.

(b) Topsoil shall be free from foreign material such as hard pan, stones larger than one inch diameter, concrete, cinders, brick asphalt, or other undesirable materials. It shall also be reasonably free from weeds and objectionable plant material.

3. Construction Requirements

(a) All areas designated to be covered with topsoil shall be undercut or underfilled to such a degree so that when covered to the required depth with topsoil the finished work will be in accordance with the required lines, grades, slopes, and cross sections.

Such work in fill areas shall be considered subsidiary to the item of Topsoil and no additional compensation will be made, nor will allowance be made in the final measurement for the quantities of Grading. (See Standard Specifications for Grading Subsections 4(a) and 4(d).)

(b) All areas from which topsoil is procured shall be cleared, if necessary, by means of mowing weeds or other vegetation to a height of approximately 6 inches and freed from any litter such as brush, rock, or foreign material of objectionable size or quantity.

(c) The available humus-bearing soil shall then be stripped off to such depth as available, or as necessary to produce sufficient volumes to cover the designated areas to the required depths, taking all practicable care to avoid incorporation of any of the underlying sterile soil therewith.

The topsoil thus stripped from these areas may be stockpiled on any convenient place on the right-of-way so that it can be reclaimed and spread on the areas designated, or it may be placed directly on the designated areas provided they have been prepared to receive the same.

(d) After the areas upon which the topsoil is to be placed have been prepared and finished to the required lines, grades, slopes, and cross section, the topsoil shall be placed and spread thereon to a uniform depth as shown on the Plans or required in the Contract, or if none is so shown, to a depth of 3 inches.

(e) All clods and lumps shall be broken down by means of harrows, discs or other appropriate equipment to provide a uniformly textured soil.

Rocks, twigs, large clods that will not break down, and other foreign material shall be removed and the entire surface shall be dressed to present a uniform appearance. Rolling will not be required.

(f) If the quantity of topsoil available in the right-of-way is insufficient, the Contractor shall make up the deficiency with topsoil from a source outside the right-of-way.

4. Method of Measurement

(a) Topsoil will be measured for payment by the cubic yard.

(b) The volume of topsoil, in cubic yards, for which payment shall be made shall be computed by multiplying the area of ground actually covered by the nominal depth of topsoil as indicated on the Plans or as directed by the Engineer. No payment shall be made for any area where the average depth in place measured in the field is significantly less than the nominal depth indicated on the Plans or as directed by the Engineer. Payment shall be made only for that yardage actually used and required in accordance with the requirements and provisions set out in these Specifications or as directed by the Engineer.

(c) Topsoil not required, will not be measured for payment.

5. Basis of Payment

This item will be paid for at the Contract unit price per cubic yard for topsoil, complete in place, which price shall be full compensation for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS FOR SEEDING

1. Description

Seeding shall consist of placing seed commercial fertilizer, agricultural limestone, and mulch material as specified on prepared ground in accordance with the Plans and these Specifications. All newly graded earthen areas that are not to be paved, stabilized, or sodded shall be seeded unless otherwise indicated on the Plans or as directed by the Engineer.

2. Materials

Materials shall conform to Subsection 801.02 of TDOTSS, March 1, 2006.

3. Construction Requirements

(a) General - The Contractor shall notify the Engineer at least 48 hours in advance of the time he intends to begin sowing seed and shall not proceed with such work until permission to do so has been granted by the Engineer. Before starting seeding operations on any area, final dressing and placing of topsoil shall have been completed in accordance with the applicable Specifications.

(b) Preparation for Seeding - The seed bed shall be prepared in the following manner and sequence:

1) Each area to be seeded shall be scarified, disked, harrowed, raked or otherwise worked until it has been loosened and pulverized to a depth of one inch and brought to the lines and grades indicated on the Plans or directed by the Engineer.

2) This operation shall be performed only when the soil is in a tillable and workable condition. Fertilizer, at the rate of not less than 20 pounds of grade 10-10-10 or equivalent, per 1,000 square feet, and agricultural limestone at the rate of not less than 100 pounds per 1,000 square feet, shall be uniformly incorporated in the soil for a depth of approximately ½ inch. Fertilizer need not be incorporated in the soil as specified above when mixed with seed in water and applied with power sprayer equipment.

(c) Time for Seeding - The seeding dates for each seed group shall be as shown in Subsection 918.14 TDOTSS, March 1, 2006.

(d) Seeding - Seed of the specified group shall be sown as soon as preparation of the seed bed has been completed. It shall be sown uniformly by means of a rotary seeder, hydraulic equipment, or other satisfactory means. Seed shall be sown at the rate of 2.5 pounds per 1,000 square feet for Groups “A,” “B,” and “C,” 0.6 pounds per 1,000 square feet for Group “B1” and at a rate of 1.5 per 1,000 square feet for all other groups. Group “C” seed and seed of legumes when sown alone

shall be inoculated before sowing in accordance with the recommendations of the manufacturer of the inoculant and as directed by the Engineer.

No seeding shall be done during windy weather or when the ground surface is frozen, wet or otherwise nontillable.

No seeding shall be performed during December and January unless otherwise permitted.

(e) Mulching - When the mulching material is hay or straw, it shall be spread evenly over the seeded area at an approximate rate of 100 pounds per 1,000 square feet for straw and 150 pounds per 1,000 square feet for hay immediately following the seeding operations. This rate may be varied by the Engineer depending on the texture and condition of the mulch material and the characteristics of the area seeded.

Hay or straw mulch shall be held in place by emulsified asphalt applied at the approximate rate of 6 gallons per 1,000 square feet as required to hold the mulch in place. The Contractor shall cover bridges, guardrails, signs and appurtenances if the mulch binder is applied in such a way that it would come in contact with or discolor the structures.

(f) Maintenance - All seeded areas shall be cared for properly to the Engineer's satisfaction until acceptance of the work. Areas which have been previously seeded and mulched in accordance with this Section but which have been damaged or failed to successfully establish an acceptable stand of grasses or legumes shall be repaired as directed by the Engineer. All material and labor required to repair seeded areas made necessary by negligence on a part of the Contractor will be furnished by the Contractor at no cost.

After an acceptable stand of grass has been attained, seeded areas shall be uniformly topdressed with not less than 10 pounds of fertilizer of grade 10-10-10, or equivalent, per 1,000 square feet at approximately six month intervals, unless otherwise specified or directed.

(g) Final Cleaning Up - After the completion of seeding, the area shall be cleaned of all rubbish, excess material, and any other items that will mar the appearance of the projects as in accordance with the General Specifications.

4. Method of Measurement

The area of seeding to be measured for payment shall be the number of square yards seeded in accordance with these Specifications and accepted by the Engineer.

5. Basis of Payment

Seeding will be paid for at the Contract unit price per square yard for Seeding, complete in place, which payment shall be full compensation for preparing the seed bed; for furnishing and placing all materials including fertilizer, agricultural limestone, seed, water, mulch, mulch binder, and inoculants if specified; and for maintenance of the area after the materials have been placed.

TECHNICAL SPECIFICATIONS FOR SODDING

1. Description

Sodding shall consist of furnishing and placing sod at all locations shown on the Plans or where directed by the Engineer, and in conformity with these Specifications.

2. Materials

(a) Sod shall consist of a live, dense, well-rooted growth of permanent grasses, free of weeds and weedy grasses. All sod shall be cleanly cut in strips having a reasonably uniform thickness of not less than 1 inch, a reasonable uniform width of not less than 8 inches, and a length not less than 12 inches. Sod shall be Kentucky 31 Fescue, Bluegrass, or Bermuda grass.

(b) Fertilizer shall be Grade 10-10-10 commercial grade and shall conform to local, state, and federal fertilizer laws. The fertilizer shall be furnished in standard containers with the name, weight and guaranteed analysis of the contents clearly labeled.

(c) Limestone shall be ground limestone containing not less than 85 percent of total carbonates, and shall be ground to such fineness that 85 percent will pass through a No. 10 mesh sieve and 50 percent through a 40 mesh sieve.

(d) Ammonium Nitrate shall be standard commercial product and have a minimum of 33 percent nitrogen.

3. Construction Methods

(a) Sod shall be set or reset only when the soil is moist and favorable to growth. Setting will be as follows unless permission is granted by the Engineer.

Kentucky 31 Fescue - Anytime weather permits
Bermuda grass - April 15 through August 14
Bluegrass - March 1 through April 30; September 1 through October 31

(b) The area to be sodded shall be constructed to the lines and grades indicated on the Plans or as directed by the Engineer, and the surface loosened to a depth of not less than 1 inch with a rake or other device. If necessary, it shall be sprinkled until saturated at least one inch in depth and kept moist until the sod is placed thereon. Immediately before placing the sod, the fertilizer shall be uniformly applied at the rate of 12 pounds of Grade 10-10-10, or equivalent, per 1,000 sq. ft. Agricultural limestone shall be applied at the rate of 100 pounds per 1,000 sq. ft.

(c) The sod shall be placed on the prepared surface with the edges in close contact and, as far as possible, in a position to break joints. Sod strips should be laid across the slope-not up and down. The sod shall be fitted tightly in the space

placed and shall be pounded into place. The entire area should be thoroughly covered with sod.

(d) Sod shall be placed as soon as practical after removal from the point or origin, and shall be kept moist in the interim. Immediately after placing, it shall be thoroughly wetted and rolled with a satisfactory roller.

(e) On steep slopes and channels sod shall be fastened to the ground with wire staples or wood pegs. Where surface water cannot be diverted from flowing over the face of slopes, install a strip of heavy jute or plastic netting and fasten tight along the crown or top of the slope for extra protection against lifting and undercutting of sod.

(f) The sod shall be watered as directed by the Engineer for a period of 2 weeks after which ammonium nitrate shall be applied at the rate of 3.5 pounds per 1,000 sq. ft. and the sod given a final watering.

(g) The Contractor shall not allow any equipment or material placed on any planted area, and shall erect suitable barricades and guards to prevent his equipment, labor or the public from traveling on or over any area planted with sod.

(h) It shall be the obligation of the Contractor to secure a satisfactory growth of grass before final acceptance of the project.

4. Method of Measurement

Sod will be measured for payment by the square yard from surface measurements.

5. Basis of Payment

(a) This item will be paid for at the Contract unit price per square yard for sodding.

(b) This unit price will be full compensation for completing sodding, as outlined in the Plans and these Specifications, including the cost of excavation and disposal of material, fertilizer, lime, ammonium nitrate, water, labor, equipment, and all other incidentals.

TECHNICAL SPECIFICATIONS
FOR
LANDSCAPE DEVELOPMENT, GENERAL

1. Description of Work

In addition to general requirements applicable to landscape work, this section includes requirements for the following:

(a) Preparation of plant soil.

(b) Furnishing of new topsoil.

(c) Furnishing and application of soil amendments.

(d) Furnishing and application of fertilizers.

(e) Furnishing and application of miscellaneous landscape materials.

2. General

Excavation, filling and grading required to establish elevations shown on the drawings have been (or will be) done under a separate section. Verify subgrade elevations and bring any discrepancies to the attention of the Engineer. Do not proceed with landscape work until discrepancies have been corrected, or until directed by the Engineer to proceed. Contractor shall supply necessary topsoil for all planting.

3. Landscape Materials

(a) New Topsoil

1) Provide topsoil which is a fertile, friable, natural loam, surface soil, reasonably free of subsoil, clay lumps, brush, weeds and other litter and free of roots, stumps, stones larger than 2" in any dimensions, and other extraneous or toxic matter harmful to plant growth.

2) Obtain topsoil from local sources or from areas having similar soil characteristics to that found at the side of the work. Obtain topsoil only from naturally, well-drained sites where topsoil occurs in a depth of not less than 4"; do not obtain from bogs or marshes.

(b) Soil Amendments

1) Lime

Natural limestone containing not less that 85% of total carbonates and ground to such fineness that not less than 90% passes a 10-mesh sieve and not less than 50% passes a 100-mesh sieve.

Provide lime in the form of dolomite limestone meeting the specified requirements.

2) Peat Humus: FS Q-P-166, of the following types and characteristics:

For tree and shrub-planting soil mixture, provide moss peat composed of Type II mosses (other than sphagnum) or reed-sedge peat (Type IV) of a coarse fibrous texture and with a pH of 6.0 to 7.5, unless otherwise specified.

For acid-loving trees and shrubs, provide a moss peat with a pH of 3.2 to 4.5 and of a coarse fibrous texture, Type I, Class B (medium divided sphagnum moss peat) or Type IV (reed-sedge moss peat).

For lawns and other bed-type planting soil mixtures, provide a peat of a finely divided or granular texture and with a pH of 6.0 to 7.5 composed of Type II moss peat (other than sphagnum), or peat moss (Type II), or reed-sedge peat (Type IV).

(c) Fertilizer

Commercial Fertilizer: Complete fertilizer of neutral character, with some elements derived from organic sources and containing the following percentages of available plant nutrients:

For trees and shrubs, provide 10-10-10 fertilizer with not less than 10% available phosphoric acid and from 3% to 5% total nitrogen and from 3% to 5% soluble potash.

4. Installation, General

(a) Planting Time

Plant or install materials only during normal planting season for each type of landscape work required. Correlate planting with specified maintenance periods to provide maintenance until occupancy by the Owner.

(b) Planting Schedule

Proceed with and complete the landscape work as rapidly as portions of the site become available, working within the seasonal limitations of each kind of landscape work required.

(c) Utilities

Determine location of underground utilities and perform work in a manner which will avoid possible damage. Do not permit heavy equipment such as trucks, rollers, or bulldozers to damage utilities. Hand excavate, as required, to minimize possibility of damage to underground utilities. Maintain grade stakes set by others until removal is mutually agreed upon by all parties concerned.

(d) Excavation for Planting

Where rubble fill is encountered, notify Engineer and prepare planting pits properly by use of clay or other acceptable methods. When conditions encountered are severe, the Engineer may issue a change order to direct the installation of pit linings.

(e) Obstructions

If rock, underground construction work, or other obstructions are encountered in excavation for planting of trees or shrubs, notify the Engineer. New locations may be selected by the Engineer, or the Engineer may issue change order to direct

removal of obstructions to a depth of not less than 6" below the required planting depth.

(f) Preparation of Planting-Soil Mixtures

1) Before mixing, clean topsoil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful or toxic to plant growth.

2) Mix specified soil amendments and fertilizers with topsoil at the rates specified. Delay mixing of fertilizer if planting will not follow placing of planting soil within a few days.

3) For pit and trench type backfill, mix planting soil prior to backfilling and stockpile at the site.

4) For bed type planting, mix planting soil either prior to planting or apply on surface of topsoil and mix thoroughly before planting.

Mix lime with dry soil prior to mixing of fertilizer.

Prevent lime from contacting roots of acid-loving plants.

Apply phosphoric acid fertilizer (other than that constituting a portion of complete fertilizers) directly to subgrade before tilling.

5. Landscape Maintenance and Guarantee Requirements

(a) Begin maintenance period immediately after planting of landscape materials.

(b) Maintain trees and shrubs until final acceptance but in no case less than the following period:

One full growing season.

(c) Guarantee trees and shrubs through the specified maintenance period, and until final acceptance.

(d) Remove and replace trees, shrubs, and other plants found to be dead or in unhealthy condition during the guarantee period. Plant missing trees, shrubs and plants. Make replacements during the growth season following end of guarantee period. Furnish and plant replacements which comply with requirements shown and specified. Also, replace trees and shrubs which are in doubtful condition at the end of the guarantee period; unless in the opinion of the Engineer, it is advisable to extend the guarantee period for a full-growing season. The Engineer will make another inspection at the end of the extended guarantee period, if any, to determine acceptance or rejection. Only one replacement will be required at the end of the guarantee period, except for losses or replacements due to failure to comply with specified requirements.

6. Inspection and Acceptance

(a) When the landscape work is completed, including maintenance, the Engineer will, upon request, make an inspection to determine acceptability.

(b) The landscape work may be inspected for acceptance in parts agreeable to the Engineer, provided the work offered for inspection is complete, including maintenance, and that the area comprises one complete unit, not too small for individual consideration.

(c) If landscape work is not acceptable to the Engineer, replace rejected work and continue specified maintenance until reinspected by the Engineer and found acceptable.

7. Clean-up, Protection, and Repairs

(a) During landscape work, store materials and equipment where directed. Keep pavements clean and work area in an orderly condition.

(b) Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

(c) Barricade open excavations and post with warning lights for the safety of persons. Operate warning lights during hours from dusk to dawn each day.

8. Basis of Payment

No separate payment for work described in this General Specification will be made. Payment will be made under the specific item described in other sections of these Specifications.

TECHNICAL SPECIFICATIONS
FOR
TREES

1. Description of Work

The types of work required include the following:

(a) Furnishing trees.

(b) Preparation of planting pits and beds including excavation, backfilling, and disposal of surplus and unsuitable excavated material.

(c) Planting of trees including fertilizing, mulching, trimming, guying, and wrapping.

(d) Maintenance of trees.

2. General

(a) Provide the quantity, size, and species of trees shown and scheduled for landscape work.

(b) Measurements

Measure trees with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6" above ground for trees up to 4" caliper size, and 12" above ground for larger sizes. Measure main body of tree or shrub for height and spread dimensions, do not measure from branch or root tip-to-tip.

(c) Inspection

The Engineer may inspect trees either at the place of growth or at the site before planting for compliance with the requirements for name, variety, size, and quality. The Engineer retains the right to further inspect trees and shrubs for the size and condition of balls and root systems, insects, injuries, and latent defect, and to reject unsatisfactory or defective material at any time during the progress of the work. Remove rejected trees or shrubs immediately from the project site.

(d) Delivery of Trees

Provide freshly dug trees and shrubs. Do not use trees or shrubs which have been in storage or heeled-in. Do not prune prior to delivery, except as approved by the Engineer. Provide adequate protection of root system and balls from drying winds and sun. Do not bend or bind-tie trees or shrubs in such a manner as to damage bark, break branches or destroy natural shape. Provide protective covering during delivery. Do not drop balled and burlap stock during delivery.

3. Trees and Shrub Material

(a) Provide nursery grown trees and shrubs.

(b) Nursery Grown Stock

Provide trees and shrubs grown in a recognized nursery in accordance with good horticultural practice, with healthy root systems developed by transplanting or root pruning. Provide only healthy, vigorous stock grown for at least 2 years under climatic conditions similar to conditions in the locality of the project and free of disease, insects, eggs, larvae, and defects such as knots, sun-scald, injuries, abrasions, or disfigurement.

(c) Name and Variety

Provide trees and shrubs true to name and variety established by the American Joint Committee on Horticultural Nomenclature "Standardized Plant Names", Second Edition, 1942.

(d) Size

Provide trees and shrubs of the size shown or specified in the Planting List and in accordance with the dimensional relationship requirements of USAS Z60.1 for the kind and type of trees and shrubs required. Trees and shrubs of larger size than specified may be used if acceptable to the Engineer, in which case, increase size of roots and balls proportionately.

1) Provide the quantity of trees and shrubs required to complete the work shown on the drawings.

2) Label each tree and shrub with a securely attached waterproof tag bearing legible designation of botanical and common name.

3) Where formal arrangements or consecutive order of trees or shrubs are shown, select stock for uniform height and spread, and label with number to assure symmetry in planting.

(e) Quality

Provide trees and shrubs complying with the recommendations and requirements of USAS Z60.1 "Standard for Nursery Stock" and as further specified.

(f) Deciduous Trees

1) Size: Provide trees of the height and caliper listed or shown.

2) Where shade trees are required, provide single stem trees with straight trunk and intact leader, free of branches to a point about 60% of their height, as recommended by USAS Z60.1 for the size and kind of trees required.

3) Where small trees of upright or spreading type are required, provide trees with single stem, branched or pruned naturally according to species and type, and the relationship of caliper and branching recommended by USAS Z60.1, unless otherwise shown.

(g) Deciduous Shrubs

1) Form: Provide deciduous shrubs with not less than the minimum number of canes required by USAS Z60.1 for the type and height of shrub required.

2) Size: Dimensions shown or listed indicate required height.

3) Provide bare-rooted deciduous shrubs.

4) Container grown deciduous shrubs will be acceptable in lieu of bare rooted deciduous shrubs subject to specified limitations for container grown stock.

(h) Coniferous and Broad Leaf Evergreens

1) Size: Provide evergreens of the sizes shown. Dimensions indicate minimum spread for spreading and semi-spreading type evergreens and height for all other types, such as globe, dwarf, cone, pyramidal, broad up-right, and columnar. Provide evergreens with well-balanced form complying with requirements for other size relationships to the primary dimension shown.

2) Provide balled and burlap evergreens.

3) Container grown evergreens will be acceptable subject to the specified limitations for container grown stock.

(i) Requirements for B & B Stock

1) General: Where shown or specified to be balled burlap, provide trees and shrubs dug with firm, natural ball of earth in which they are grown.

2) Provide ball size not less than size shown.

3) Provide ball size of not less than the diameter and depth recommended by USAS Z60.1 for they type and size of tree or shrub required. Increase ball size or modify ratio of depth to diameter as required to encompass the fibrous and feeding root system necessary for full recovery of trees or shrubs subject to unusual or a typical conditions of growth, soil conditions or horticultural practice.

4) Wrap and tie earth ball as recommended by USAS Z60.1 for the size of balls required. Drum-lace balls with a diameter of 30" or greater.

(j) Requirements for Container Grown Stock

1) General

Where specified as acceptable, provide healthy, vigorous, well-rooted trees established in the container in which they are sold. Provide balled and burlap stock, when required trees exceed maximum size recommended by USAS Z60.1 for container grown stock.

Established container stock is defined as a tree or shrub transplanted into a container and grown in the container for a length of time sufficient to develop new fibrous roots so that root mass will retain its shape and hold together when removed from the container.

2) Containers

Use rigid containers which will hold ball shape and protect root mass during shipping. Provide trees and shrubs established in containers of not less than the minimum sizes recommended by USAS Z60.1 for the kind, type, and size of trees and shrubs required.

3) Miscellaneous Materials

a. Mulch: Peat moss complying with the requirements of FS Q-P-166 for fibrous type and approximately neutral. Do not use finely divided or granular type. Contractor may submit other mulch examples for Engineer's approval.

b. Wrapping: Tree wrap tape not less than 4" wide, designed to prevent borer damage, winter freezing, and sun scald.

c. Stakes and Guys: Provide stakes of sound new hardwood, free of knot holes and other defects. Provide wire ties and guys of 2-strand, twisted, pliable galvanized iron wire not lighter than 12 ga. Provide new 2-ply garden hose not less than ½" in diameter, cut to required lengths to protect tree trunks from damage by wires or guys.

4. Planting of Trees

(a) Timing

Plant trees and shrubs during normal seasons for such work in the location of the project. Plant bare rooted and flowering trees and shrubs only during the spring planting season, except as may be otherwise acceptable to the Engineer.

Plant frost-tender trees and shrubs only after danger of frost is past or sufficiently before frost to allow for establishment before first frost. Do not plant in frozen ground.

(b) Coordination with Lawns

1) Plant trees and shrubs after final grades are established and prior to planting of lawns, unless otherwise acceptable to the engineer. If planting of trees and shrubs occur after lawn work, protect lawn areas and promptly repair damage to lawns resulting from planting operations.

2) Deliver trees and shrubs after preparations for planting have been completed and plant immediately. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather and mechanical damage, and keep roots moist as follows:

a. Set balled stock on ground and cover ball with soil, peat moss, or other acceptable material.

b. Do not remove container grown stock from containers until planting time.

(c) Excavation

1) Excavate pits, beds, and trenches with vertical sides and with bottom of excavation slightly raised at center to provide proper drainage. Loosen hard subsoil in bottom of excavation.

2) For balled and burlap trees, make excavations at least twice as wide as the ball diameter and equal to the ball depth, plus the following allowance for setting of ball on a layer of compacted backfill:

   Allow for 3" setting layer of planting soil mixture.

3) For container grown stock, excavate as specified for balled and burlap stock, except container width and depth shall govern.

4) Dispose of subsoil removed from landscape excavations. Do not mix with planting soil or use as backfill.

(d) Setting and Backfilling

1) Set balled and burlap stock on layer of compacted planting soil mixture, plumb and in center of pit or trench with top of ball at same elevation as adjacent finished landscape grades. Remove burlap from sides and tops of balls but do not remove from under balls. Remove platforms, if any, before setting. Do not use stock if ball is cracked or broken before or during planting operation. When set, place additional backfill around base and sides of ball, and work each layer to settle backfill and eliminate voids and air pockets. When excavation is approximately 2/3-full, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing final layer of backfill.

2) Set container grown stock as specified for balled and burlap stock, except cut cans on 2 sides with an approved can cutter; remove bottoms of wood boxes before setting. Carefully remove cans and sides of wooden boxes after partial backfilling so as not to damage root balls. Do not cut or remove containers with spade.

3) Move and set large specimen trees with crane or other approved tree moving equipment.

4) Dish top of backfill to allow for mulching.

5) For spring planting, provide additional backfill berm around edge of excavations to form shallow saucer to collect water.

6) Mulch pits, trenches and planting areas. Provide not less than the following thickness of mulch and work into top of backfill and finish level with adjacent grades.

   Provide 2" thickness of mulch.

7) Prune, thin out and shape trees and shrubs in accordance with standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by the engineer, do not cut tree leaders, and remove only injured or dead branches from flowering trees, if any. Prune shrubs to retain natural character and accomplish their use in the landscape design. Required shrub sizes are the size after pruning.

8) Remove and replace excessively pruned or misformed stock resulting from improper pruning.

9) Paint cuts over ½" in size with standard tree paint or compound, covering all exposed, living tissue. Use paint which is waterproof, antiseptic, adhesive, elastic and free of kerosene, coal tar, creosote, and other substances harmful to plants. Do not use shellac.

10) Stake trees as shown immediately after planting.

11) Stake trees of less than 4" caliper. Use stakes of the length required to penetrate at least 18" below bottom of backfilled excavation and to extend to at least 6' above grade. Set stakes vertical and space to avoid penetrating balls or root masses. Support trees with 2 strands of wire encased in hose sections at contact points with tree trunk and twist securely. Provide not less than one stake for trees 10' to 12' high and 2" or less in caliper, except not less than 2 shorter stakes may be used for low-branched trees. Used not less than 2 stakes for trees over 12' high and less than 4" caliper size. Space stakes equally around trees.

12) Wrap tree trunks of 2" caliper and larger. Start at ground and cover trunk to height of first branches and securely attach. Inspect tree trunks for injury, improper pruning and insect infestation and take corrective measures required before wrapping.

5. Maintenance

(a) Maintain trees and shrubs after planting for one full growing season.

(b) During the maintenance period, prune, water, cultivate and weed, as required for healthy growth. Restore planting saucers. Tighten and repair stake and guy supports and reset trees and shrubs to proper grades of vertical position as required. Restore or replace damaged wrappings. Spray as required to keep trees and shrubs free of insects and disease.

6. Method of Payment

This item will be paid for at the Contract Unit Price per each as shown on the Bid Schedule which price shall be full compensation for furnishing, staking, wrapping, and planting trees as described in this Specification, including prepared backfill.

TECHNICAL SPECIFICATIONS
FOR
TEMPORARY WATER POLLUTION CONTROL

1. Description

This work shall consist of temporary control measures as shown on the plans or as ordered by the Engineer during the life of the Contract to control soil erosion and water pollution. Such measures shall include, but are not limited to, the use of silt barriers, fiber mats, netting, mulches, grasses, slope drains, and other control devices. Erosion and siltation control measures as described herein shall be applied to any erodible material exposed by any activity within the project limits.

2. Materials

(a) Seeding – Seed, mulches, fertilizer, agricultural limestone and other materials for seeding shall conform to the Standard Specifications for Seeding.

(b) Sodding – Sod, fertilizer, agricultural limestone and other materials for sodding shall conform to the Standard Specifications for Sodding.

(c) Temporary Slope Drains – Slope drains may be constructed of pipe, fiber mats, rubble, Portland cement concrete, bituminous concrete, sod or other materials acceptable to the Engineer that will adequately deter erosion.

(d) Silt Barriers

1) Silt barriers may be brush barriers, baled straw barriers, or silt fences.

2) Brush barriers shall consist of brush, trees and trimmings, shrubs, plants and other approved refuse from the clearing and grubbing operation.

3) Baled straw barriers shall consist of tightly baled straw, plastic or wire binding preferred to twine, firmly anchored to the ground with steel drift pins or wooden stakes.

4) Silt fences shall consist of an approved fabric filter, Mirafi 140 or equivalent, suitable supported by a woven wire fence.

3. Construction Methods

(a) General

1) Prior to or simultaneously with the clearing and grubbing operations, the Contractor shall install siltation control devices in accordance with the approved erosion control plan. Such work may involve the construction of temporary berms, dikes, dams, silt fences, sediment basins, lined channels, permanent cut-off ditches, slope drains or other control devices as necessary to control erosion and siltation. Water from cofferdams is not to be pumped directly into streams, but is to be pumped into sediment ponds or traps. No grading shall be performed until the siltation control devices are in place to the satisfaction of the Engineer. Areas to be graded shall

not be cleared and grubbed more than 20 calendar days prior to beginning grading operations in such areas. Stockpiled topsoil or fill material is to be treated so the sediment runoff will not contaminate surrounding areas or enter nearby streams. In order to reduce sediment in runoff, erosion control structures shall be installed promptly during all construction phases.

The Contractor's operations shall be staged so that graded or otherwise disturbed erodible surfaces are protected as the work progresses. Once the Contractor begins grading for a roadway cut or embankment, he shall maintain a continuous, viable operation to complete the cut or embankment to subgrade elevation, unless otherwise approved in writing by the Engineer. Exposed erodible cut or embankment slopes shall be final dressed, topsoiled and protected with permanent seeding or sodding in vertical increments not exceeding 25 feet as the work progresses; and no portion of these slopes shall remain unprotected for more than 20 calendar days unless the Engineer determines that weather conditions or other special circumstances preclude current placement of permanent control measures. Temporary erosion control measures shall be implemented as directed by the Engineer.

Seeding or sodding operations shall be initiated within 48 hours after any one of the following conditions occurs:

a. Each 25 foot vertical increment is graded, or

b. Upon suspension or completion of grading operations is a specific area.

The above requirements for progressive siltation control also apply to graded areas off the rights-of-way such as waste area, borrow areas and haul roads.

The Contractor shall incorporate all permanent erosion and siltation control features into the project at the earliest practicable time. Temporary siltation control features shall be used to control erosive conditions that warrant protection prior to installation of permanent control features or that are needed to temporarily control erosion or siltation that develops during construction but which is not associated with permanent control features on the Project.

2) In the event of conflict between these requirements and siltation control laws, rules, or regulations of other Federal or Sate or local agencies, the more restrictive laws, rules or regulations shall apply.

3) The temporary erosion control features installed by the Contractor shall be acceptable maintained by the Contractor until the completion of the Project, and he shall remove such installation if ordered by the Engineer. Any materials removed shall become the property of the Contractor.

4) In case of repeated failure on the part of the Contractor to control erosion, pollution and siltation, the Engineer reserves the right to employ outside assistance or to use his own forces to provide the necessary corrective measures. Such incurred direct costs plus project engineering costs will be

charged to the Contractor and appropriated deductions made from the Contractor's monthly progress estimate.

(b) Seeding – Temporary seeding shall conform to the standard Specifications for Seeding except agricultural limestone need not be applied.

(c) Sodding – Sodding shall conform to the Standard Specifications for Sodding. Care must be taken to properly anchor the sod to prevent any washouts.

(d) Temporary Slope Drains

Temporary slope drains shall consist of metal pipe, plastic pipe, flexible rubber pipe, or other materials which can be used as temporary measures to carry water accumulating in the cuts and on the fills down the slopes prior to installation of permanent facilities or growth of adequate ground cover on the slopes.

All temporary slope drains shall be adequately anchored to the slope to prevent disruption by the force of the water flowing in the drains. The base for temporary slope drain shall be compacted and concavely formed to channel the water or hold the slope drain in place. The inlet end shall be properly constructed to channel water into the temporary slope drain. Energy dissipaters, sediment basins or other approved devices shall be constructed at the outlet end of the slope drains to reduce erosion downstream. An ideal dissipater would be dumped rock or a small sediment basin which would slow the water as well as pick up some sediment. All temporary slope drains shall be removed when no longer necessary and the site restored to match the surroundings.

(e) Silt Barriers – Silt barriers shall be constructed by one of the methods listed below. It shall be the Contractor's choice of which barrier to use unless the silt barrier type is specified in the plans.

1) Brush barriers shall consist of brush, trees and trimmings, shrubs, plants and other approved refuse from the clearing and grubbing operations. The brush barriers shall be constructed approximately parallel to original ground contour, placed at the bottom of fill slopes to trap and retain sediment. The top of the brush barrier shall be at least five (5) feet below finished roadway grade. The brush barrier shall be compressed to an approximate height of three (3) to five (5) feet and an approximate width of five (5) to ten (10) feet. The embankment <u>shall</u> <u>not</u> be supported by the construction of brush barriers.

2) Baled Hay or Straw Erosion Checks – Hay or straw erosion checks shall be embedded in the ground a minimum of 4 inches to prevent water flowing under them. The bales shall also be anchored securely to the ground by wooden stakes driven through the bales into the ground. Bales can remain in place until they rot, or be removed after they have served their purpose, as determined by the Engineer. The Contractor shall keep the checks in good condition by replacing broken or damage bales immediately after damage occurs. Normal debris clean-out will be considered routine maintenance.

3) Silt fences shall consist of an approved fabric filter, Mirafi 140 or equivalent, suitable supported by a woven wire fence, and are located at the bottom of fill slopes to trap and retain sediment. Fence posts may be

wood or metal securely anchored to the ground on centers not to exceed twelve (12) feet. The woven wire fence shall be from two (2) to four (4) feet in height as required, and the mesh openings shall be 4" x 4".

The Contractor shall be required to maintain the silt fence and filter barriers in a satisfactory condition for the duration of the Project or until its removal is requested by the Engineer. The silt accumulation at the fence may be left in place and seeded, removed, etc. as directed by the Engineer. Unless otherwise directed by the Engineer, all silt fence or filter barrier shall be removed prior to completion of the Project and shall become the property of the Contractor.

The Contractor shall install and maintain all temporary erosion and siltation control features until no longer needed or permanent control measures are installed. Any materials removed shall become the property of the Contractor. In order to insure erosion and siltation control structures work properly, it is imperative the sediment be removed; therefore, inspection and maintenance of structures is to be performed on a regular basis. During sediment removal, the Contractor shall take care to insure that structural components of erosion and siltation control structures are not damaged and thus made ineffective. If damage does occur, the Contractor shall repair the structures at his own expense. Upon complete removal of sediment traps, special ditches, etc., the area where they were constructed is to be topsoiled, seeded and mulched.

In the event that temporary erosion and siltation control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of work as scheduled, and are ordered by the Engineer, such work shall be performed by the Contractor at his own expense.

(f) Sediment Structures

1) Sediment structures can be utilized in many locations to control sediment; at the foot of embankments where slope drains outlet; at the bottom as well as in the ditch lines atop waste sites; in the ditch lines on borrow pits. Sediment structures may be used in most drainage situations to prevent excessive siltation of pipe structures. All sediment structures should be at least twice as long as they are wide.

2) When use of temporary sediment structures is to be discontinued, all sediment accumulation shall be removed, all excavation backfilled and properly compacted and the existing ground restored to its natural or intended conditions.

4. <u>Method of Measurement</u>

(a) In the event that temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of work as scheduled and are ordered by the Engineer, such work shall be performed by the Contractor at his own expense. Temporary erosion and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will

be measured and paid for as specified for all acceptable work.

(b) Seeding will be measured by the square yard seeded in accordance with the Specifications for Seeding.

(c) Sodding – Sod will be measured by the square yard sodded in accordance with the Specifications for Sodding.

(d) The quantity of temporary slope drains to be paid for shall be determined by the linear foot constructed and measured. All cost of material, installation, and removal involved with temporary slope drains shall be considered the unit price for slope drains.

(e) Silt barriers shall be measured and paid for by the linear foot constructed and accepted.

(f) Excavation for sediment structures shall be measured by the cubic yard on the basis of cross-sectioned measure, or the most feasible method. The unit price for sediment structures shall include excavation, disposal of excavated material, and removal and restoration when no longer required. If not otherwise noted on plans, excavation of the sediment structures shall be paid for under Common Excavation.

(g) All temporary berms shall be considered as a necessary part of the unit price for road and drainage excavation and shall not be paid for separately.

5. Basis of Payment

(a) The accepted quantities of the items listed below will be paid for at the Contract price per unit of measurement for each of the pay items that is listed in the Bid Schedule.

(b) Payment will be made under:

1) Seeding as specified under Specifications for Seeding.

2) Sodding as specified under Specifications for Sodding.

3) Temporary Slope Drains per lineal foot.

4) Silt Barriers per lineal foot.

5) Sediment Removal per cubic yard.

(c) The above unit prices will be full compensation for completing the work as outlined in the Plans and Specifications including all materials, labor, and incidentals.

TECHNICAL SPECIFICATIONS
FOR
CHAIN LINK FENCE

1. Description

This work will consist of furnishing and constructing chain link fences where shown on the Construction drawings.

2. Materials

(a) The height of the fence will be as indicated on the Project Plans.

(b) The fabric will be 2" mesh galvanized chain link fabric and 1.2 oz. coated.

(c) Barbed wire will be 3 strands of double strand 12 ½ gauge wire with 4 point barbs spaced approximately 5" apart.

(d) Top rail and bracing will be 1 5/8" O.D. schedule 40 galvanized pipe weighing 2.27# per foot (ASTM 120). A 3.8" truss rod and turn buckle will be placed at the end and corner posts.

(e) Line posts will be 2 ½" O.D. schedule 40 galvanized pipe weighing 3.65# per foot and spaced on 10 foot centers (ASTM 120).

(f) Terminals will be 3" O.D. schedule 40 galvanized pipe weighing 5.79# per foot (ASTM 120).

(g) Gate posts will be 4" O.D. schedule 40 galvanized pipe weighing 9.11# per foot (ASTM 120).

(h) Posts will be set in concrete at least 3 feet deep.

(i) Redwood wood chain link fence will be same as above except no barbed wire, and redwood wood slats, 1 1/8" X 1/4", shall be placed in the mesh.

3. Equipment Construction Requirements

Construction will be in accordance with the guidelines set up by the Chain Link Fence Manufacturing Institute.

4. Method of Measurement

The chain link and redwood chain link fences will be measured by the linear foot of accepted work, and gates will be paid for each as determined by the Engineer.

5. Payment

Gates will be paid for each and fencing will be paid at the Contract unit price per linear foot and shall be full compensation for all work, materials, labor, and incidentals to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
GUARDRAIL

1. Description

This work shall consist of furnishing and erecting Guardrail, and the construction of anchor blocks and approach ends, of the specified kind and dimensions, in accordance with these Specifications, and in reasonably close conformance with the lines, grades and locations shown on the Plans, or as directed by the Engineer.

Guardrail shall include appurtenant materials and work in making connections with other Guardrail or structures, as may be required to complete the construction as indicated on the Plans.

2. Materials

Materials used in the construction of Guardrail, in addition to the general requirements of these Specifications, shall conform, unless otherwise stipulated, to the following TDOTSS, March 1, 2006:

Material	T.D.O.T. Subsection
Metal Beam Guardrail	909.05
Guardrail Posts	909.07
Guardrail Hardware	909.08

Portland Cement Concrete shall be Class A, and shall be manufactured, placed and cured in accordance with the applicable requirement of Section 15.0 of these Specifications.

3. Construction Requirements

(a) Preliminary Work - Clearing and Grubbing, Removal of Structures and Obstructions, Excavation, Undercutting and Embankment Construction shall be performed in accordance with the provisions of Sections 2, 3, and 4 of these Specifications.

(b) Posts - All posts shall be the shape, size and dimension shown on the Plans, and shall be set reasonably true to the lines and grades shown on the Plans or established by the Engineer.

(c) Installation of Posts - Before beginning any excavation or driving any Guardrail post, the Contractor shall determine the location of any underground electrical, telephone, drainage, water, gas, sewer or other utility lines in the vicinity and shall conduct his work in such a manner as to avoid damage to them. Holes shall be dug or drilled to the depth indicated in the plans; or posts may be driven by approved methods and equipment, provided the posts are erected in the proper position and are free of distortion and burring or any other damage.

All post holes that are dug or drilled shall be of such size as will permit proper setting of the posts, and allow sufficient room for backfilling and tamping.

Holes shall be backfilled with selected earth, or other suitable materials in layers not to exceed 4 inches in thickness and each layer shall be thoroughly tamped. When backfilling and tamping is completed, the posts or anchors shall be held securely in place.

Post holes that are drilled in rock and holes for anchor posts or anchor devices shall be backfilled with concrete.

Posts for metal divider guardrail or bridges shall be bolted to the surface as detailed on the Plans. The anchor bolts shall be set to proper location and elevation, with templates, and carefully checked after the median is placed, and before the concrete has set.

Anchor bolts for metal divider Guardrail, to be placed on a previously constructed bridge, shall be set by drilling holes in proper locations and anchoring the bolts as detailed on the Plans.

Any damaged coating on galvanized steel posts shall be repaired in accordance with TDOTSS, March 1, 2006, Subsection 713.04(b), or the posts replaced, at the Engineers direction, at no cost to the City of Knoxville.

4. Erection

All Guardrail anchors shall be set and attachments made and placed as indicated on the Plans, or as directed by the Engineer.

All bolts or clips used for fastening the Guardrail or fittings to the posts shall be drawn up tightly. End bolts shall have sufficient length to extend at lease 1/4-inch through and beyond the full nut, except where such extension might interfere with or endanger traffic, in which case, the bolt shall be cut off flush with the nut.

All railings shall be erected, drawn, and adjusted so that the longitudinal tension will be uniform throughout the entire length of rail.

5. Method of Measurement

Guardrail of the various classes and dimensions will be measured for payment in linear feet in place between the terminal anchor posts or end elements.

Terminal anchors of end elements of the various types will be measured for payment by the unit per each.

No measurement for payment will be made for projections or anchors beyond the end post except as noted.

Furnishing and placing anchor bolts, and/or devices for Guardrail posts on bridges will be considered incidental to the construction and the costs thereof will be included in the price bid for other items of construction.

No measurement for payment will be made for excavation or backfilling performed in connection with Guardrail erection.

6. Basis of Payment

(a) Guardrail will be paid for at the Contract Unit Price per linear foot for each class and dimension, complete in place which payment shall be full compensation for all posts, blocks, rail elements, fittings, hardware and all incidentals necessary to complete the work.

(b) Guardrail terminal anchors or end elements for each class and dimension, complete in place will be paid for at the Contract Unit Price per each, which payment shall be full compensation for all posts, blocks, rail elements, fittings, hardware, and all incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
Guardrail - W - Beam	Linear Foot
Guardrail - W - Beam with Rub Rail	Linear Foot
Guardrail - Thrie Rail	Linear Foot
Terminal Anchor - Rounded Element	Each
Terminal Anchor - Type II	Each
Terminal Anchor - Flared End Element	Each

TECHNICAL SPECIFICATIONS
FOR
CONSTRUCTION AREA TRAFFIC CONTROL

1. Contractor Responsibility and General Provisions

(a) The Contractor shall provide, erect, and maintain all traffic control devices necessary to preserve the safe and orderly movement of traffic. All operations shall be scheduled and conducted in such a manner and sequence as to cause the least practicable interference with the traveling public, fire protection, and public utility service.

(b) Payment for materials and labor associated with the required construction area traffic control shall normally be included in the pay item(s) provided by the Contract. In the event that no such pay item(s) are included, the Contractor shall include such costs in the prices bid for other appropriate Contract items.

(c) All necessary protective devices and operations shall be in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), published by the Federal Highway Administration. A Traffic Control Plan is included with many projects to define specific or typical traffic control needs. However, the Contractor may request a revision or addition to these plans of operation by making a written request in advance to the Director of Engineering.

(d) A project safety officer or other similarly responsible individual shall be made known to the Director of the Engineering Division prior to the commencement of construction. This notification shall include a telephone number or numbers where the individual(s) may be reached on a 7 day, 24 hour basis.

(e) Except as otherwise noted in the "Special Conditions," total road closures are not permitted. However, if the Contractor determines in his opinion that one is required, a written request shall be made at least 72 hours in advance to the Director of the Engineering Division for his consideration. This request shall state the reason for the closure, estimated duration of the closure, proposed traffic control devices, and the routing of detours, if necessary.

(f) Except as otherwise noted in the project "Special Conditions," the Contractor shall provide one adequate traffic lane, minimum of 10' in width, in each direction during the hours of 7:00 A.M. - 9:00 A.M. and 3:00 P.M. - 6:00 P.M.

During hours when work is not in progress, the Contractor shall also maintain one similarly adequate traffic lane in each direction. Exceptions to the above must be approved by the Director of Engineering.

(g) The Contractors attention is called to the *City of Knoxville Policy on Work Zone Traffic Control* (a copy of which is included at the end of this Specification following Section 6).

2. Installation and Maintenance of Traffic Control Devices

(a) The Contractor shall be fully responsible for the supplying, erection, and maintenance of all traffic control devices. These functions shall occur in a workmanlike manner such that all supports are vertical, sign panels generally perpendicular to the travelway and legends horizontal so that they effectively convey the intended message. Signs shall be mounted on stationary or portable supports dependent on the type work being performed. In general, work being performed at spot locations and of short duration will necessitate the use of portable supports properly weighted for stability.

(b) All existing traffic signs within the limits of this project shall also be the maintenance responsibility of the contractor for the duration of construction. This includes STOP and street name signs on side streets which intersect within the project limits. This responsibility shall include temporary sign relocations caused by construction activities.

The Contractor shall provide continuous and expeditious maintenance of all required traffic control devices. This shall include replacement of sign panel, barricades, and other devices which in the opinion of the Engineering Division are damaged or deteriorated beyond continued use, replacement of broken supports, plumbing of leaning signs, cleaning of dirty signs, barricades and other devices, repair of defaced sheeting and legends, replacement of stolen items, etc. All items used for traffic control shall be generally maintained in their original placement condition and such maintenance will be considered a part of the original installation cost. Failure to maintain all traffic control devices in such a manner as to provide continuous safety to the public will be cause for suspension of construction operations until proper traffic control is re-established.

(c) In the event that the Contractor, in the opinion of the Director of Engineering, has failed to provide or maintain adequate traffic control devices, the City of Knoxville shall have the right to provide the necessary items and deduct the expense of same from payments due the Contractor.

3. Application and Use of Traffic Control Devices

(a) Cones are not permissible as channelizing devices during hours of darkness. Standard barricades, drums or vertical panels are permissible, but where used to delineate vehicle paths during hours of darkness, they must be accompanied by steady-burn lights.

(b) Except as otherwise directed by the Director of Engineering or his representative, the Contractor shall maintain centerline striping throughout the duration of this project. Where a newly asphalted section of roadway is to be maintained overnight, temporary centerline and lane line stripes shall be provided by the Contractor at the conclusion of each work day. These stripes shall be a temporary reflective tape or paints with four-inch wide line segments. The segments shall be two feet long with thirty-eight foot gaps. Skip lines shall not be used for lane lines separating a turn lane from a through lane or for edge lines.

(c) All conflicting and confusing pavement marking shall be removed or obliterated in a fashion consistent with MUTCD, Section 6D-1. Painting over existing

striping is not considered to meet the requirements for removal or obliteration. The methods listed below are considered acceptable:

1) Sand blasting using air or water
2) High pressure water
3) Steam or super-heated water
4) Mechanical devices such as grinders, sanders, scrapers, scarifiers, and wire brushes
5) Solvents and chemicals
6) Burning

Any damage to the pavement or surfacing caused by the Contractor's pavement marking removal shall be repaired by the Contractor at his expense and by methods and materials acceptable to the Engineering Department.

(d) Short term operations will be permissible which conflict with existing pavement markings, but proper vehicle path must be ensured through the appropriate use of warning signs, flagmen and/or channelizing devices.

(e) Mesh or other fabric type signs are not considered acceptable for use during hours of darkness.

(f) Except in operations of short duration, where good sight distance is available, "Flagger Ahead" signs shall be installed where flaggers are required. Flaggers shall utilize STOP/SLOW paddles and proper attire, including a reflectorized orange vest.

Flagmen will be considered a general requirement of traffic control and no direct payment will be made for such.

(g) During periods of non-use, warning signs and other devices shall be promptly removed from the work area, covered or otherwise positioned so they do not convey their message to the traveling public. If covered, the covering material shall be maintained in a neat and workmanlike manner.

(h) The official maximum speed limit is to be used for determining taper lengths, device spacing, sign placement and other pertinent details unless otherwise notified.

4. Materials

Materials for all traffic control and marking devices shall be in accordance with the provisions of the current edition of the MUTCD. Exceptions are listed below with reference to the appropriate subsections of the TDOTSS, March 1, 2006.

Material	Subsection
Signs:	
Aluminum	916.02 (a)
Reflective Sheeting	916.06, Type III
Paint	916.09
Cold Rolled Carbon Steel-16 gal.	ASTM A366
Drums and Barricades:	
Reflective Sheeting	916.06, Type I

Temporary Pavement Marking Material:

The material for temporary traffic centerline and lane line marking shall be a pressure-sensitive, adhesive backed, reflective pavement marking tape, or reflectorized paint.

Cones:

Cones shall be a minimum of 28 inches high and weighted at the base.

In addition to the materials certifications required above, the Contractor shall submit a signed, notarized statement that the materials to be used for temporary traffic control comply with the above provisions. This statement shall be submitted prior to the beginning of the work.

5. Method of Measurement:

When the Bid Schedule stipulates that payment will be made for Construction Area Traffic Control on a Lump Sum basis, the pay item Construction Area Traffic Control will include all sign, barricades, lights, flag persons, temporary pavement markings and all incidentals required by this specification, the Traffic Control Plan included in the Contract Drawings, if any, and the Manual on Uniform Traffic Control Devices for Streets and Highways. Where the Bid Schedule stipulates that payment will be made for Specific Items on a unit basis, measurement will be made by the unit stipulated. Where the Special Conditions and/or notes on the construction drawings stipulate that the cost of Construction Area Traffic Control will be included in other Items Bid, no measurement will be made.

6. Basis of Payment

The accepted quantity of Construction Area Traffic Control will be paid for at the lump sum price bid, which price shall be full compensation for providing Construction Area Traffic Control for the duration of the project in accordance with the Traffic Control Plan provided with the construction drawings and/or submitted by the Contractor and these Specifications. This compensation shall include all labor, materials, equipment and incidentals necessary to complete the work.

The compensation shall be paid in accordance with the following schedule.

Percent of Total Contract on Partial Pay Estimate	Total Percent Allowed for Compensation for Lump Sum Item
5%	30%
50%	50%
75%	75%
100%	100%

POLICY ON WORK ZONE TRAFFIC CONTROL
CITY OF KNOXVILLE, TENNESSEE
February 10, 2009

I. Introduction

A. The proper use of warning devices in roadway construction and maintenance work areas must be planned in advance to meet the individual requirements of the job site. The objective of this policy is to provide maximum protection to employees, plant, equipment, and to the public while causing minimum interference to vehicular and pedestrian traffic.

B. When guarding work areas, always provide more protection than may appear necessary rather than under-protecting. Inadequate protection may promote accidents by presenting the driver or pedestrian with a false impression of the extent of the work area and the deviations that he must take from his route in order to safely pass the work area.

C. Early project planning for traffic control in construction and maintenance areas and implementation and surveillance of these controls during construction are very important.

II. Need for Standards

A. Problems of traffic control occur when traffic must be moved through, around, or adjacent to road or street construction, maintenance operations, and utility work. No one standard sequence of signs or other control devices can be set up as an inflexible arrangement for all situations due to the variety of conditions encountered.

B. The Manual on Uniform Traffic Control Devices (MUTCD) has been adopted as Federal and Tennessee Law. The MUTCD established principles to be observed in the design, installation, and maintenance of traffic control devices.

C. These principles and standards are directed to the safe and expeditious movement of traffic through work areas and to the safety of the work force performing those operations.

III. Responsibility

A. Adequate public protection shall be provided by contractors, public utility companies, railroads, State and City agencies performing any work on roadways or so closely adjacent as to create hazards or to restrict pedestrian or vehicular flow.

B. It is important that the authorities having jurisdiction be able to require proper protection, that responsibility be clearly assigned, adequate training of personnel be provided, and that there be adherence to the provisions of the MUTCD.

C. A temporary traffic control plan (TTCP) should include, but not be limited to such items as signing, application and removal of pavement and markings; construction; scheduling; methods and devices for delineation and channelization; placement and maintenance of devices; roadway lighting; traffic regulations; and surveillance and inspection.

D. A TTCP and permit form should be completed in detail to the complexity of the work project and noting the date of planned beginning of construction and duration shall be prepared by the contractor, public utility company, State or City agency proposing to do work on or adjacent to the roadway.

E. The TTCP shall be reviewed and approved by the Director of Engineering or his designee. Although every effort will be made to review the TTCP immediately upon submittal, a minimum of 48 hours should be allowed for review of the TTCP. The TTCP is to be approved by the Permitting Office at the City of Knoxville Engineering Department, 1400 Loraine Street, Telephone 215-6100.

F. When the TTCP and permit are approved, the City of Knoxville Engineering Department will fax the information to the following agencies:

AGENCY	PHONE NUMBER	FAX NUMBER
*E-911 - (Amy)	215-1141	215-1103
Knoxville Police Department - (Bryan Bates)	215-8622	215-7000
*Knoxville Area Transit (R. Boone)	215-7820	215-7800
Tennessee Dept. of Transportation (M. Dykes)	594-5626	594-4512
*Knoxville Fire Department (Steve Sherrod)	595-4482	595-4474

*(Total road closures only.)

G. When construction is required that will block one or more lanes of principal collector or arterial roadways or close any principal collector or arterial roadway, the responsible work authority shall notify the public. This is currently best handled by notifying the Permitting Office at the City of Knoxville Engineering Department, telephone 215-6100. The deadline for media notification is 2:00 P.M. for the next day release to radio.

H. Construction on or adjacent to local streets (traffic volumes of less than 1,000 vehicles-per-day) requiring one lane closures will only require implementation of adequate work zone traffic control procedures as outlined in the MUTCD.

IV. Road Closures

A. Total Road Closures for construction and maintenance activities are typically not permitted on principal collector or arterial roadways. Total road closures on secondary collectors and local streets will be considered on a case-by-case basis. Traffic control plans for total road closures must be sealed by a Professional Engineer registered in the State of Tennessee.

B. In the event of an emergency and there is no alternative but to close the roadway, adequate work zone traffic control procedures as outlined in the MUTCD shall be implemented. Notification of proper authorities must be made as soon as possible by contacting the E-911 Dispatcher at 215-4010.

V. Hours of Work

A. When construction is required that will block one or more lanes of a principal collector or arterial roadway, the hours of work shall be limited on weekdays to avoid conflict with peak hour traffic movement. Work on weekdays is permitted before 6:00 A.M., from 9:00 A.M. to 3:00 P.M., and after 6:30 P.M. Work is

permitted during off peak conditions and on weekends (except for unusual circumstances, i.e. parades, U.T. football games, etc.). More liberal hours are typically allowed on local streets. Work during peak hours in the off peak travel direction is often permitted. Other arrangements may be approved on a case-by-case basis.

B. When an emergency occurs that requires total road closure on a principal collector or arterial roadway, every effort should be made to make the repairs as soon as possible. Notification of proper authorities must be made as soon as possible by contacting the E-911 Dispatcher at 215-4010. Overtime should be authorized for evening and weekend work.

VI. Street Cut Permits

A. When the work requires that city streets be cut, a permit shall be required from the Permitting Office at the City of Knoxville Engineering Department, 1400 Loraine Street. On an emergency basis, these permits may be obtained by notifying the City of Knoxville Engineering Department at 215-6100 and then following up with a written request as soon thereafter as practical. In routine situations, a written request outlining the need for cutting the street, the proposed location, the proposed date of work and the contractor involved shall be supplied in writing to the individuals at the City of Knoxville Engineering Department at Loraine Street, preferably 48 hours in advance of the cut.

B. Construction standards are available at the City of Knoxville Engineering Division offices at 1400 Loraine Street and on the City's website: http:/www.cityofknoxville.org.

VII. Principal Collector and Arterial Roadways

For purposes of this policy, the following shall be defined as principal collector or arterial roadways. Time restrictions apply. See Sec. V. A., Hours of Work.

A. All streets in the Central Business Improvement District (CBID). See map on page TS-34.0-13.

B. Principal collectors, arterials and selected minor collectors:

Adair Drive, Bruhin Road to Sanders Drive
Ailor Avenue, Western Avenue to 21st Street
Alcoa Highway
Amherst Road, Middlebrook Pike to McKamey Road
Anita Drive, Sevier Avenue to Hillwood Drive
Asheville Highway
Atlantic Avenue, Central Street to Broadway
Ault Road, Buffat Mill Road to Hillview Avenue

Ball Camp Pike, Western Avenue to John May Road
Baxter Avenue, Beaumont Avenue to Central Street
Beaumont Avenue, Baxter Avenue to Keith Avenue
Bennington Drive, Corteland Drive to Vanosdale Road
Bernard Avenue, Elm Street to Central Avenue
Beverly Road, Tazewell Pike to Greenway Drive
Blount Avenue, Gay Street to Maryville Pike

Boyds Bridge Pike, Brooks Avenue to Holston River Bridge
Bradshaw Garden Drive, Pleasant Ridge Road to Clinton Highway
Bradshaw Road, Ball Camp Pike to Pleasant Ridge Road
Bridgewater Road, Cross Park Drive to Kingston Pike
Broadway
Brooks Avenue, Dandridge Avenue to Boyds Bridge Pike
Broome Road, N. Gallaher View Road to Middlebrook Pike
Bruhin Road, Inskip Drive to Heiskell Avenue
Buckingham Road, Kingston Pike to Vanosdale Road
Buffat Mill Road, Whittle Springs Road to Loves Creek Road

Cecil Avenue, Broadway to Cherry Street
Cedar Bluff Road, Kingston Pike to Cross Park Drive
Cedar Lane, Central Avenue Pike to Broadway
Central Avenue Pike, Murray Drive to Bruhin Road
Central Street, Bruhin Road to Neyland Drive
Chapman Highway
Cherokee Boulevard, Scenic Drive to Kingston Pike
Cherokee Trail, Alcoa Highway to Scottish Pike
Cherry Street, Cecil Avenue to Magnolia Avenue
Chilhowee Drive, Rutledge Pike to Holston Hills Drive
Clancy Avenue, Blount Avenue to Scottish Pike
Clinch Avenue, 22nd Street to 11th Street
Clinton Highway
Coleman Road, Lonas Drive to Papermill Drive
Concord Street, Kingston Pike to Sutherland Avenue
Copper Kettle Street, Western Avenue to Ed Shouse Drive
Cross Park Drive, Cedar Bluff Road to Bridgewater Road
Cumberland Avenue

Dale Avenue, 21st Street to Western Avenue
Dandridge Avenue, Hill Avenue to Brooks Avenue
Dandridge Avenue, Brooks Avenue to Riverside Drive
Davenport Road, Sevier Avenue to Moody Avenue
Deane Hill Drive, Morrell Road to Kingston Pike
Delrose Avenue, Dandridge Avenue to Boyds Bridge Pike
Downtown West Boulevard, Kingston Pike to Gleason Road
Dry Gap Pike, Central Avenue Pike to Rifle Range Road
Dutch Valley Drive, Bruhin Road to Old Broadway

Ed Shouse Drive, Western Avenue to Middlebrook Pike
11th Street, Western Avenue to Cumberland Avenue
Elm Street, Oldham Avenue to Bernard Avenue
Emory Road
Essary Drive, Broadway to Briarcliff Road

Fairmont Boulevard, Broadway to Whittle Springs Road
5th Avenue, University Avenue to Winona Street
Forest Glen Drive, Tobler Lane to Kingston Pike
Forest Park Boulevard, Sutherland Avenue to Kingston Pike
Fairway Road, Valley View Road to Washington Pike

Francis Road, Middlebrook Pike to Amherst Road

Gallaher View Road, Middlebrook Pike to Gleason Drive
Gap Road, I-640 to Wilson Road
Gleason Drive, Morrell Road to Gallaher View Road
Gov. John Sevier Highway
Greenway Drive, Broadway to Washington Pike

Hall of Fame Drive, E. Hill Avenue to Broadway
Haynes Sterchi Road, Dry Gap Pike to Cedar Lane
Heiskell Avenue, Texas Avenue to Central Street
Henley Street
Highland Avenue, 22nd Street to 16th Street
Highland Drive, Inskip Road to Broadway
Hillview Avenue, Ault Road to Rutledge Pike
Hinton Road, Third Creek Road to Western Avenue
Hollywood Drive, Lonas Drive to Sutherland Avenue
Hotel Road, Broadway to Holbrook Drive

Inskip Drive, Clinton Highway to Bruhin Road
Inskip Road, Cedar Lane to Adair Drive
Island Home Avenue, Sevier Avenue to Island Home Pike
Island Home Pike, Island Home Avenue to Sevierville Pike

Jacksboro Pike, Tazewell Pike to Broadway
Jackson Road, Amherst Road to Cecil Johnson Road
James White Parkway
Johnston Street, Heiskell Avenue to Tennessee Avenue

Keith Avenue, Beaumont Avenue to Sanderson Road
Kingston Pike
Knott Road, Middlebrook Pike to Tenwood Drive

Lake Loudoun Boulevard, Volunteer Boulevard to Neyland Drive
Liberty Street, Keith Avenue to Sutherland Avenue
Lonas Drive, Weisgarber Road to Middlebrook Pike
Loves Creek Road, Millertown Pike to Rutledge Pike
Lyons Bend Road, Northshore Drive to Glen Cove Drive
Lyons View Pike, Northshore Drive to Kingston Pike

Mabry Hood Road, Pellissippi Parkway to Kingston Pike
Magnolia Avenue
Mall Road N, Millertown Pike to Washington Pike
Mall Road S, Washington Pike to Millertown Pike
Martin Luther King, Jr. Avenue, Dandridge Avenue to Holston Drive
Martin Mill Pike, Chapman Highway to Ogle Avenue
Maryville Pike, Ogle Avenue to Caleb Avenue
McCalla Avenue, Jessamine Street to Martin Luther King, Jr. Avenue
McDonald Road, Boyds Bridge Pike to Sunset Road
McKamey Road, Amherst Road to Western Avenue
Merchant Drive, Pleasant Ridge Road to Central Avenue Pike
Middlebrook Pike
Millertown Pike, Washington Pike to Mill Road

Mineral Springs Road, Broadway to Whittle Springs Road
Montvue Road, Kingston Pike to Gleason Road
Moody Avenue, Chapman Highway to South Knoxville Boulevard
Morrell Road, Kingston Pike to Northshore Drive
Murray Drive, Pleasant Ridge Road to Central Avenue Pike

Neubert Springs Road, Martin Mill Pike to W. Ford Valley Road
Neyland Drive
Northshore Drive

Ogle Avenue, Maryville Pike to Martin Mill Pike
Oglewood Avenue, Harvey Street to Broadway
Old Broadway, Broadway to Mineral Springs Road

Palmetto Road, Western Avenue to Sullivan Road
Papermill Drive, Kingston Pike to Liberty Street
Parkdale Road, Rifle Range Road to Cedar Lane
Parkside Drive, City Limit to beginning of N. Peters Road
Pellissippi Parkway
N. Peters Road, Kingston Pike to beginning of Parkside Drive
Pleasant Ridge Road, Western Avenue to City Limit (N. of Murray Drive)
Proctor Street, Middlebrook Pike to Western Avenue
Prosser Road, Buffat Mill Road to Magnolia Avenue

Ray Mears Boulevard, Downtown West Boulevard to Montvue Road
Riverside Drive, South Knoxville Boulevard to Delrose Drive
Riverside Drive, Delrose Drive to Holston Hills Road
Rutledge Pike

Sanders Drive, Adair Drive to Jacksboro Pike
Sanderson Road, Pleasant Ridge Road to Keith Avenue
Scenic Drive, Kingston Pike to Southgate
17th Street, Western Avenue to Cumberland Avenue
Sevier Avenue, Gay Street to Island Home Avenue
Sevier Avenue, Island Home Pike to Sevierville Pike
Sevierville Pike, Sevier Avenue to City Limit (E. of E. Ford Valley Road)
Shea Street, Western Avenue to College Street
Sisk Road, Hazelwood Road to Pleasant Ridge Road
South Knoxville Boulevard
Strawberry Plains Pike, Bell Lane to Huckleberry Springs Road
Stone Road, Chapman Highway to Magazine Road
Sullivan Road, Western Avenue to Pleasant Ridge Road
Sutherland Avenue, University Avenue to Westwood Drive

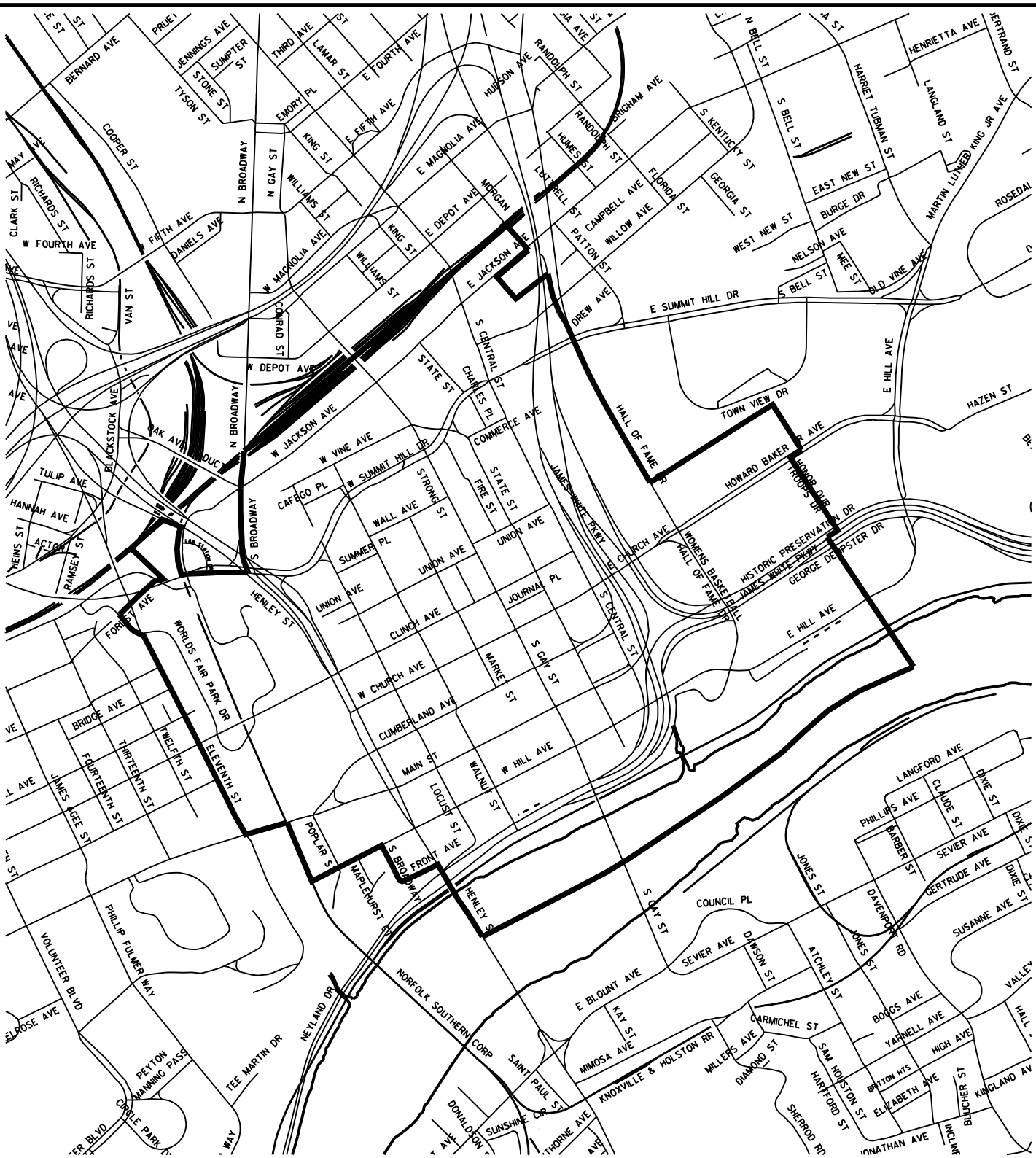
Tazewell Pike
Tennessee Avenue, Western Avenue to Johnston Street
Texas Avenue, Western Avenue to Heiskell Avenue
Third Creek Road, Hinton Road to Middlebrook Pike
Tillery Road, Wilson Road to Central Avenue Pike
Tobler Lane, Sutherland Avenue to Forest Glen Drive
21st Street, Dale Avenue to Leslie Avenue

University Avenue, Western Avenue to Bernard Avenue

Valley View Drive, Whittle Springs Road to Washington Pike
Vanosdale Road, Buckingham Road to Middlebrook Pike
Volunteer Boulevard, Cumberland Avenue to Cumberland Avenue

Walker Springs Road, Walbrook Drive to Kingston Pike
Walnoaks Road, Sullivan Road to Pleasant Ridge Road
Washington Pike, Broadway to Murphy Road
Weisgarber Road, Middlebrook Pike to Papermill Drive
Western Avenue
Westland Drive, Northshore Drive to Morrell Road
Westwood Drive, Sutherland Avenue to Papermill Drive
Whittle Springs Road, Mineral Springs Avenue to Cecil Avenue
Wilson Road, Pleasant Ridge Road to Clinton Highway
Winston Road, Kingston Pike to Corteland Drive
Woodland Avenue, I-75 to Broadway
Woodlawn Pike, Chapman Highway to Chapman Highway

Young High Pike, Martin Mill Pike to Woodlawn Pike



CITY OF KNOXVILLE

CENTRAL BUSINESS IMPROVEMENT DISTRICT (CBID)

TECHNICAL SPECIFICATIONS
FOR
ELECTRICAL EQUIPMENT, WIRING AND INSTALLATION

1. Description

(a) This Specification covers the necessary labor, materials, supervision, tools and services required for the installation of a complete and operable electrical system as shown on the Plans.

(b) The work shall include complete installation of the electrical service and testing of all equipment and wiring at the completion of the work and making any minor connection changes or adjustments necessary for the proper functioning of the system. The system shall be properly adjusted and in working order at the time of final acceptance.

(c) Where cutting of existing asphalt or concrete is required for the installation of electrical conduit, it shall be done in a neat and workmanlike manner and repaired in accordance with the City of Knoxville Utility Maintenance and Improvement Policy.

2. Materials

(a) All materials shall conform to the latest issue of all applicable standards as established by NEMA, ASA, IEFE, ASTM, IPCEA, National Fire Underwriters, and Underwriters Laboratories, Inc., and shall bear the manufacturer's name, trade name, and brand.

(b) All work shall be installed and completed in accordance with the latest rules and regulations of the NEC, NESC, and all State and local codes and ordinances and such work not so installed shall be removed and reinstalled at the Contractor's expense. Only experienced electrical workers shall be employed on the electrical installation.

(c) Material and installation of all:

1) Rigid metal conduit systems or raceways shall conform to the most recent edition of the NEC, Article 346, including supplemental updates.

2) Rigid non-metallic conduit systems or raceways shall conform to the most recent edition of the NEC, Article 347, including supplemental updates.

(d) All branch circuits in conduit shall be no smaller than 3/4 inch.

(e) 100 AMP box, rain type, installation on a pedestal - 24 circuits.

(f) All 110-volt circuits shall be on 15 or 20 AMP breakers.

(g) All 220-volt circuits shall be double pole breakers - 40 AMP.

(h) All wire shall be T.H.W. or equal.

(i) All work shall conform to the 1993 National Electrical Code (NEC); State of Tennessee, Division of Fire Prevention, Electrical Section, Chapter 0780-2-1; Knoxville City Ordinance No. 0-191-95; and all other applicable state and local codes.

3. Permits and Inspection

All permits required by local ordinances shall be obtained and paid for by the Contractor and after completion of the work, the Engineer shall be furnished a certificate of final inspection and approval from the electrical inspection department of local authority having jurisdiction.

4. Basis of Payment

All electrical work will be paid for at the Contract Unit Price for furnishing and installing all electrical improvements including all wiring, outlets, meters, boxes, and related work as shown in the Bid Schedule, which price shall be full compensation for all labor and materials necessary to complete the work as shown in the Plans and outlined in these Specifications.

TECHNICAL SPECIFICATIONS
FOR
GEOTEXTILES

1. Description

This work shall consist of placing the approved geotextile fabric over a prepared area in preparation for pavement overlay, slope protection, subsurface drainage applications, base reinforcement, or erosion stabilization.

2. Materials

(a) Geotextile Fabric for Pavement Overlay shall be a fabric produced specifically for overlaying existing pavement in preparation for an overlay of asphaltic concrete base, leveling, or surface course. Acceptable fabric shall be produced by a reputable manufacturer engaged in the production of such fabrics and shall include, but not limited to the following: AMOPAVE as manufactured by AMOCO Fabrics Co., Dupont Repave Style T-376 Paving Fabric, Mirafi, 900N as manufactured by Dominion Textile Co., Petromat non-woven fabric as manufactured by Phillips Petroleum Co., or Trevira Spunbond Engineering Fabric for Asphalt Pavement Systems as manufactured by Hoechst Fiber Industries. Other fabrics may be submitted for approval by the Engineer.

(b) Tack Coat for Pavement Overlay shall be Asphalt Cement or Emulsified Asphalt meeting the requirements of Section 7.0 of these Specifications for the referenced materials.

(c) Geotextile Fabric for Slope Protection shall be a non- woven fabric of polyester or polypropylene inert to commonly encountered chemicals, hydrocarbons, mildew and rot resistant, resistant to ultraviolet light exposure, insect and rodent resistant, and conform to the following properties:

Grab Tensile Strength (ASTM D1682)	200 lbs min
Puncture Strength (ASTM D751)	125 psi min
Equivalent Opening Size (CW2215)	
No larger than USS Standard Sieve No. 50 or smaller than 100	

(d) Geotextile Fabric for Subsurface Drainage Applications shall be a nonwoven fabric of polyester or polypropylene inert to commonly encountered chemicals, hydrocarbons, mildew and rot resistant, insect and rodent resistant and conform to the following properties:

Grab Tensile Strength (ASTM D1682)	90 lbs min
Puncture Strength (ASTM D751)	125 psi min
Coefficient of Normal Permeability - K	0.1 cm/sec
Equivalent opening size (CW 2215)	
No larger than U.S. Standard Sieve No. 50 or smaller than 100	

(e) Securing pins for anchoring c) and d) above shall be 3/16 inch steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1.5 inches. The pin shall not be less than 18 inches. U-shaped pins shall be an acceptable option.

(f) Geotextile for base reinforcement shall be a heavy duty geotextile produced specifically for base reinforcement such as Synthetic Industries 300 ST, Mirafi 600X, Exxon GTF 300, or approved equal.

(g) Geotextile for Erosion Stabilization shall be a three dimensional, polypropylene geotextile specially designed for erosion control applications on steep slopes and vegetated waterways. The matrix shall be composed of monofilament strands woven into a uniform, dimensionally stable configuration of resilient pyramid-like projections and shall have the following properties:

<u>Mechanical Properties</u>	
Tensile Strength:	3,200 x 2,200 lb/ft per ASTM D-4595
Tensile Elongation:	55% (max.) per ASTM D-5035
Tensile Strength at 10% Elongation:	1,850 x 1,600 lb/ft (typ) per ASTM D-4595
<u>Physical Properties</u>	
Thickness:	0.5” per ASTM D-1777
Mass per Unit Area:	14 oz./square yard per ASTM D-5621
Resiliency:	80% per ASTM D-1777
<u>Endurance</u>	
UV Resistance at 1,000 hours:	80% per ASTM D-4355

The Geotextile for Erosion Stabilization shall be Synthetic Industries, Pyramat High Performance Turf Reinforcement Mat, or equal.

3. <u>Equipment</u>

All equipment necessary for the placing of the geotextile fabric shall be approved before the work will be permitted to begin.

4. <u>Construction Requirements</u>

The special conditions will generally identify which street will require the use of geotextile fabric for Pavement Overlay; however, the Engineer may select additional streets or specific areas of certain streets from which deletions or additions of fabric will be made.

(a) The adhesive or tack coat application for Geotextile Fabric for Pavement Overlay will be in accordance with the manufacturers written recommendations.

(b) The placing and lap for the fabric will be in accordance with the manufacturers written recommendations.

(c) The placing and lap for the Geotextile Fabric for Pavement Overlay will be in accordance with the manufacturers written recommendations.

(d) The installation of Geotextile Fabric for Slope Protection and Subsurface Drainage shall be in accordance with the Plans and the manufacturer's recommendations. Overlaps when necessary shall be 18 inches minimum.

Securing pins shall be used when necessary to insure proper anchoring of the fabric.

(e) The installation of geotextile for base reinforcement shall be in accordance with manufacturer's recommendations. Overlaps at ends of rolls and at roll widths shall be in accordance with manufacturer's recommendations or as directed by the Engineer.

(f) The installation of geotextile for erosion stabilization shall be in accordance with the manufacturer's recommendation. Overlaps at ends of rolls and at roll widths shall be in accordance with the manufacturer's recommendations or as directed by the Engineer.

5. Method of Measurement

The Geotextile Fabric shall be measured by the square yard or fraction thereof in place.

6. Basis of Payment

Unless otherwise noted in the Plans, the accepted quantity of Geotextile Fabric complete in place will be paid for at the contract unit price per square yard. This price shall constitute full compensation for all work materials, labor and other incidentals required to complete the work in accordance with these Specifications. Payment will be made under the following bid items as set forth in the Bid Schedule:

Geotextile Fabric for Pavement Overlay
Geotextile Fabric for Slope Protection
Geotextile Fabric for Subsurface Drainage
Geotextile Fabric for Base Reinforcement
Geotextile Fabric for Erosion Stabilization

TECHNICAL SPECIFICATIONS
FOR
REWORKING AND RESURFACING EXISTING ASPHALT PAVEMENTS

1. Description

This work shall consist of heating and scarifying an existing asphaltic concrete pavement, the addition of an asphalt or emulsified asphalt recycling agent, the redistribution of the heated and scarified processed material, and the overlay with an asphaltic concrete surface course in a single operation.

2. Materials

(a) Asphalt Recycling Agent shall be a soft asphalt cement, or asphalt cement blended, as required, with a softening agent or flux oil and which will meet the following requirement:

Absolute Viscosity, (V60) (after thin film oven test)	3:1 Ratio Min.
Smoke Point	260° F Min.
Flash Point	400° F Min.
Solubility	97.5%

The asphalt recycling agent shall contain an approved anti-stripping agent.

Silicone shall be added to the asphalt recycling agent at the rate of 25 cubic centimeters silicone mixed to each 5,000 gallons of asphalt recycling agent. If a dispersing fluid is used in conjunction with the silicone, the resulting mixture containing the full 25 cubic centimeters of silicone shall be added in accordance with the manufacturer's recommendation. The blending of the silicone mixture with the asphalt recycling agent shall be accomplished by the asphalt producer prior to shipment. The producer shall certify in writing the compliance with the above requirements.

(b) Emulsified Asphalt Recycling Agent shall meet the following requirements:

Storage Stability (24 hrs)	1.0% max
Sieve Test	0.1% max
Residue by Evaporation	65% min

Residue from the emulsified asphalt recycling agent shall meet requirements of Federal Department of Transportation Specifications, 329-34.1

The emulsified asphalt recycling agent shall contain an approved anti-stripping agent.

Silicone shall be added to the base stock of asphalt prior to emulsifying at the rate of 25 cubic centimeters of silicone mixed to each 5,000 gallons of asphalt. If a dispersing fluid is used in conjunction with the silicone, the resulting mixture containing the full 25 cubic centimeters of silicone shall be added in accordance with the manufacturer's recommendations. The blending of the silicone mixture

with the emulsified asphalt recycling agent shall be accomplished by the producer prior to shipment. The producer shall certify in writing the compliance with the above requirements.

(c) The Recycling agent shall be of the type and grade capable of producing a resultant viscosity (140° F) of from 3,000 to 6,000 poises in the recycled pavement when applied at a rate not to exceed 0.1 gallon per square yard.

(d) Asphaltic Concrete Surface course shall conform to the requirements set forth in Section 10 of these Specifications for the Grading specified.

3. Equipment

The equipment used to recycle and resurface the existing asphaltic concrete pavement shall be of the type specifically designed and built for this specific purpose. The equipment must be capable of a continuous single pass, multi-step process of heating, scarifying, application of recycling agent, redistribution of the existing pavement materials, and the placement of an asphaltic concrete surface source. The single pass of the multi-step process shall be a minimum of 10 feet in width.

The equipment must also be capable of raising and lowering sections of the scarifiers in order to recycle the material around manholes, and other obstacles as required on City streets. The machine shall be equipped with Transverse augers, leveling blade, receiving hopper, and screed for the placement of the Asphaltic Concrete Surface Course over the recycled layer. The screed shall be a 4 foot section heated vibratory screed equipped with crown controls on each section and be capable of adjustment to regulate the thickness of the Asphaltic Concrete Surface Course in order to produce the specified longitudinal grade and transverse cross section.

The machine shall be on the site in operating condition sufficiently in advance of beginning of the surface recycling project to allow for full evaluation. As required by the Engineer, the Contractor shall demonstrate the equipment proposed for use that will achieve the results specified.

4. Construction Requirements

(a) Prior to beginning the recycling and resurfacing operation, the existing pavement shall be cleaned so as to be reasonably free from sand, dirt, and other deleterious materials that would affect the quality of the recycled mix.

(b) The entire width of pavement surface being processed in a single pass shall be uniformly heated by indirect heat in such a manner as to soften the existing pavement to the extent that it can be scarified to a minimum depth of 1 inch. The operation must be conducted in a manner such that the existing pavement is not damaged by exposure to direct heat or heat of excessive intensity or prolonged duration.

(c) Immediately following heating, the existing pavement shall be scarified in a manner which will result in a layer of uniformly loosened material without appreciable ridges of undistributed material and to a depth of at least one inch, but in no case to a depth less than that which will produce sufficient scarified material to allow the pavement surface to be restored to the shape specified. The heated and scarified material shall then be distributed by transverse augers over the width being processed so as to form a uniform cross section.

(d) An approved recycling agent as specified in item 2 shall be applied uniformly to the scarified material. The exact amount of recycling agent will be determined by an approved testing laboratory to meet the requirements set forth in 2(c) of this section.

(e) The Asphaltic Concrete Surface Course shall be placed in the same operation as recycling and addition of the recycling agent, and shall be placed immediately after the scarified material is distributed over the area being processed such that the scarified material shall be hot enough to be properly compacted. The scarified material shall be compacted in conjunction with the compaction of the new Asphaltic Concrete Surface Course.

The rolling pattern required to achieve compaction shall be established by the Contractor using the Nuclear Density Backscatter Method as specified by FM-1-T238 (Method B, D.D.O.T.); This is accomplished by recording the nuclear density measurement after each roller pass until no additional increase in density is obtained and the highest density obtained is in excess of 85% of the theoretical density. The compactive effort applied at this point will become the rolling pattern and will be applied at the relative same temperature uniformly throughout the project.

5. Method of Measurement

The reworking and resurfacing of existing asphaltic concrete pavement shall be measured in square yards for the recycled pavement. The Asphaltic Concrete Surface Course shall be measured by the Ton of 2,000 pounds as provided for in section 10 of these Specifications.

6 Basis of Payment

The accepted quantity of recycled pavement in place will be paid for at the contract unit price per square yard.

The accepted quantity of Asphaltic Concrete Surface Course placed in the single operation over the recycled pavement will be paid for at the Contract unit price per ton for each "Grading" listed in the Bid Schedule and constructed in accordance with the Plans and/or these Specifications, or under the direction of the Engineer.

TECHNICAL SPECIFICATIONS
FOR
MILLING OR GRINDING OF ASPHALTIC CONCRETE FROM STREETS

1. Description

This work shall consist of pavement removal by milling or grinding in conformity with the lines, grades and dimensions shown on this construction drawing and/or as directed by the Engineer and in accordance with these Specifications.

Milling or grinding of asphaltic concrete from streets is divided into two distinct categories for pay purposes under these specifications: Milling or grinding of asphaltic concrete from streets (surface milling) consists of removing a specified depth of asphaltic concrete or a variable depth to either improve drainage or profile of the street. Milling or Grinding of asphaltic concrete from streets (full depth to concrete) is to remove all of the existing asphaltic concrete over an underlying Portland Cement concrete pavement regardless of depth.

2. Materials

The materials removed from the street may be recycled and used in Asphaltic Concrete base courses and leveling course as provided for in Section 9 of these Specifications. The material becomes the property of the Contractor.

3. Equipment

The equipment shall consist of one or more milling machines or grinders with the capability to remove up to three (3) inches of asphaltic concrete in one pass. The milling or grinding machine shall be equipped with a broom or series of brooms to collect the milled asphaltic concrete for picking up and loading a conveyor which in turn will load the material into trucks for disposal. Additional brooms and loading equipment sufficient to remove all the loose material from the streets may be required.

4. Construction Requirements

The depth, width, and length of cut as established by the Construction Drawings or as specified by the Engineer shall be obtained to a tolerance of 1/4" $\pm$ for the depth and to width and length as marked or otherwise specified. Milling or grinding of asphaltic concrete from streets (full depth to concrete) requires the removal of all asphaltic concrete from the underlying Portland Cement Concrete pavement.

Once milling or grinding of a street has begun, the operation must continue through the paving stage without interruption or delay unless interruptions or delays are expressly approved in writing by the Engineer.

Milling or grinding around utility manholes and catch basins shall be accomplished with care to prevent damage to utility property and/or the Contractor's equipment. Unless otherwise approved by the Engineer, milling or grinding shall be carried to within one (1) foot of all manholes or catch basins. The utility companies will be responsible for hand chipping the remaining one foot on all utility company manholes. The Paving

Contractor will be required to hand grind or chip around all storm sewer catch basins and manholes. Milling adjacent to curbs or gutters shall be carried the full depth specified to the concrete curb or gutter. Over grinding or milling to a greater depth than specified shall be corrected by the Contractor by replacing the material with new material at no cost to the City of Knoxville.

All loose material shall be removed from the streets, gutters, driveways, sidewalks and shoulders, and in general the construction area shall be left in a condition after milling or grinding as clean or cleaner than before beginning the operation.

When milling the entire width of the street, joints to match the milling depth shall be made at all intersecting driveways and streets. These joints will be located by the Engineer.

5. Method of Measurement

The milled material taken from the street shall be weighed on certified scales with a bonded and certified weigh person and measured by the ton of 2,000 pounds or fraction thereof. The project representative of the City of Knoxville will designate under which item each truck load of material will be paid for and will reconcile each day the total quantities for each item with the Contractor's project superintendent.

6. Basis of Payment

(a) Milling or grinding of asphaltic concrete from streets (surface milling) shall be paid for at the Contract unit price per ton of 2,000 pounds or fraction thereof.

(b) Milling or grinding of asphaltic concrete from street (full depth to concrete) shall be paid for at the Contract unit price per ton of 2,000 pounds or fraction thereof.

Compensation for either of the above items shall constitute full payment for all work, materials, labor, and other incidentals required to complete the work and dispose of the materials in accordance with these Specifications.

TECHNICAL SPECIFICATIONS
FOR
PAVEMENT MARKINGS AND TEMPORARY PAINT

1. Description

This work shall consist of furnishing and supplying pavement markings to be applied on asphaltic concrete surfaces at the direction of the Engineer. This work will be accomplished after the entire paving has been completed. All work shall be in accordance with the Manual on Uniform Traffic Control Devices. Temporary pavement marking will be paid under this item.

2. Materials

Reference for material specification is made to the TDOTSS, March 1, 2006, and any applicable special provision thereto. Specific reference is made to Section 716, Pavement Markings.

3. Equipment

All equipment necessary for the placing of pavement markings shall meet the above-mentioned TDOTSS, March 1, 2006.

4. Measurement

(a) Pavement Marking (Line) - The mileage of line complete in place and accepted, shall be measured along the center of each line. Where double solid barrier lines are used, each solid barrier line will be measured separately for payment. Where broken lane lines are used, only the marked line will be measured for payment. For quantities of Pavement Marking (Line) less than one mile, the accepted method of measurement shall be linear feet.

(b) Pavement Marking (Crosswalk Striping) and Pavement Marking (Stop Bar) - The length of each striping complete in place and accepted will be measured in linear feet to the nearest foot along the center line of each pavement marking.

(c) Pavement Marking (Channelization Striping) - The area of channelization striping including the boundary lines complete in place and accepted shall be measured and computed in square yards to the nearest square yard.

(d) Pavement Marking (Designs) - Designs or lettering will be measured for payment by the unit (each) complete in place or as stipulated in the Contract and on the Plans.

(e) Pavement Marking (Raised Reflective) and Pavement Marking (Snowplowable Reflective) - The number of each type of pavement markers installed as directed and accepted will be counted separately for payment.

(f) Removal of Existing Painted Line- The removal of broken lane line and solid barrier line will be measured along the center of each line. Only the painted line will be measured for payment.

5. Basis of Payment

(a) The Contractor shall be required to establish and locate all non-passing zones as well as provide the layout of all pavement markings for approval of the Engineer prior to placement of markings.

(b) Payment will be made under the following bid items as set forth in the Bid Schedule:

Pay Item	Unit
Pavement Marking (Line)	Lin. Mi.
Pavement Marking (Line)	Lin. Ft.
Pavement Marking (Cross-walk Striping)	Lin. Ft.
Pavement Marking (Stop Line)	Lin. Ft.
Pavement Marking (Channelization Striping)	Sq. Yd.
Pavement Marking (Designs)	Ea.
Pavement Marking (Raised Reflective)	Ea.
Pavement Marking (Snowplowable Reflective)	Ea.
Removal of Existing Painted Line	Lin. Ft.

TECHNICAL SPECIFICATIONS
FOR
RETROREFLECTIVE PREFORMED PAVEMENT MARKINGS

1. Description

This work shall consist of furnishing and installing retroreflective high performance and high durability preformed pavement markings. All preformed markings shall be installed in accordance with this provision and in conformance to the dimensions and lines shown on the Plans or established by the Engineer. All work shall be in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways, dated 1988, or as modified.

2. Materials

The preformed patterned markings shall consist of white or yellow films with clear and/or yellow-tinted microcrystalline ceramic beads incorporated to provide immediate and continuing retroreflection. These films shall be manufactured without the use of lead chromatic pigments or other similar, lead-containing chemicals. The films shall have a pressure sensitive adhesive pre-coated on the non-reflective side.

Preformed symbol and legend markings shall conform to the applicable shapes and sizes as outlined in the Manual on Uniform Traffic Control Devices for Streets and Highways, dated 1988, or as modified.

The material, when applied according to the manufacturer's instructions, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and, through normal traffic wear, shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking and shall show no significant tearing, roll back, or other signs of poor adhesion.

(a) Classification

1) Type 1 - High Performance Patterned Centerline Markings

The markings shall be highly durable retroreflective pliant polymer materials designed for longitudinal centerline and word/symbol markings subject to high traffic volumes and severe wear conditions such as shear action from crossover or encroachment on typical longitudinal configurations.

2) Type 2 - Durable Longitudinal Edgeline Markings

The markings shall be durable, retroreflective, foil-based pavement marking film designed for preformed markings with free-rolling traffic for edge lines.

3) Type 3 - High Durability Channelizing and Transverse Markings

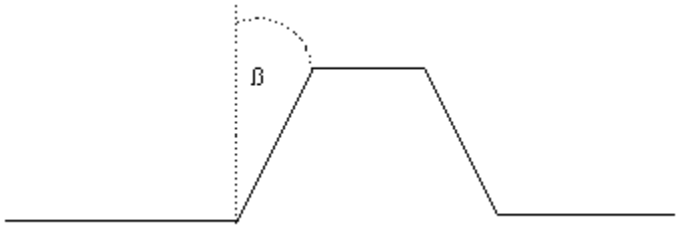
High durability retroreflective preformed pavement marking film shall be used as channelizing and transverse markings such as stop bars, cross walks, and gore markings subjected to high traffic volumes and severe wear conditions such as repeated shear action from crossover or encroachment.

(b) Requirements

1) Composition

Type 1 - High Performance Patterned Centerline Markings

The retroreflective pliant polymer pavement markings shall consist of a mixture of high-quality polymeric materials, pigments, and glass beads distributed throughout its base cross-sectional area, with a reflective layer of microcrystalline ceramic beads bonded to a durable polyurethane topcoat surface. The patterned surface shall have approximately 50%. 15% of the surface area raised and presenting a near vertical face (ß angle of 0° to 60°) to traffic from any direction. (See diagram below.) The channels between the raised areas shall be substantially free of exposed beads or particles. The film shall have a pre-coated pressure sensitive adhesive.



Type 2 - Durable Longitudinal Edgeline Markings

The retroreflective pavement marking material shall consist of microcrystalline ceramic beads and glass beads with ceramic skid-resistant particles embedded in a top ployolefin wear surface with a thin, flexible, conformable backing. The film shall have a pre-coated pressure sensitive adhesive.

Type 3 - High Durability Channelizing and Transverse Markings

The preformed markings shall consist of white or yellow films with pigments selected to conform to standard highway colors. The preformed markings shall consist of a mixture of high quality polymeric materials, pigments, and glass beads distributed throughout its base cross-sectional area.

A retroreflective layer of glass beads and a layer of ceramic skid resistant particles shall be bonded to the top urethane wear surface. The urethane wear surface shall have a nominal thickness of 0.005 inches (0.13mm). The film shall have a pre-coated pressure sensitive adhesive.

2) Retroreflectance

The white and yellow markings shall have the following initial expected retroreflectance values as measured in accordance with the testing procedures of ASTM D4061. The photometric quantity to be measured shall be coefficient of retroreflected luminance (RL) and shall be expressed as millicandelas per square foot per foot-candle [(mcd x ft^{-2}) x fc^{-1}]. The metric equivalent shall be expressed as millicandelas per square meter per lux [(mcd x m^{-2}) x lx^{-1}].

Type 1 - High Performance Patterned Centerline Markings

	WHITE			YELLOW		
Entrance Angle	86.0°	86.5°	88.8°	86.0°	86.5°	88.8°
Observation Angle	0.2°	1.0°	1.05°	0.2°	1.0°	1.05°
Retroreflected Luminance R_L [(mcd x ft^{-2}) x fc^{-1}]	1100	700	500	800	500	300

Type 2 - Durable Longitudinal Edgeline Markings

	WHITE			YELLOW		
Entrance Angle	86.0°	86.5°	88.8°	86.0°	86.5°	88.8°
Observation Angle	0.2°	1.0°	1.05°	0.2°	1.0°	1.05°
Retroreflected Luminance R_L [(mcd x ft^{-2}) x fc^{-1}]	930	575	450	430	300	205

Type 3 - High Durability Channelizing and Transverse Markings

	WHITE			YELLOW		
Entrance Angle	86.0°	86.5°	88.8°	86.0°	86.5°	88.8°
Observation Angle	0.2°	1.0°	1.05°	0.2°	1.0°	1.05°
Retroreflected Luminance R_L [(mcd x ft^{-2}) x fc^{-1}]	700	400	300	410	175	150

3) Beads

Type 1 - High Performance Patterned Centerline Markings

Index of Refraction - All microcrystalline ceramic beads bonded to the polyurethane-coated, patterned surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method.

The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.50 when tested by the liquid oil immersion method.

Type 2 - Durable Longitudinal Edgeline Markings

Index of Refraction - All microcrystalline ceramic and glass beads bonded to the polyolefin-coated surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method.

Type 3 - High Durability Channelizing and Transverse Markings

Index of Refraction - All glass beads bonded to the polyurethane-coated surface of the material shall have a minimum index of refraction of 1.50 when tested using the liquid oil immersion method. The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.50 when tested by the liquid oil immersion method.

4) Skid Resistance

Type 1 - High Performance Patterned Centerline Markings

The patterned surface of the retroreflective pliant polymer shall provide an initial average skid resistance value of 45 BPN as measured by the British Portable Skid Tester in accordance with ASTM E303 except values will be taken downweb and at a 45□ angle from downweb. These two values will then be averaged to find the skid resistance of the patterned surface.

Type 2 - Durable Longitudinal Edgeline Markings

The surface of the durable retroreflective films shall provide an initial minimum average skid resistance value of 55 BPN as measured by the British Portable Skid Tester in accordance with ASTM E303.

Type 3 - High Durability Channelizing and Transverse Markings

The surface of the highly durable retroreflective films shall provide an initial minimum average skid resistance value of 55 BPN as measured by the British Portable Skid Tester in accordance with ASTM E303.

5) Patchability

The pavement marking materials shall be capable of use for patching worn areas of the same type in accordance with the manufacturer's instructions.

6) Thickness

Type 1 - High Performance Patterned Centerline Markings

The film, without adhesive, shall have a minimum caliper of 0.065 inches (1.651mm) at the thickest portion of the patterned cross-section and a minimum caliper of 0.020 inches (0.508mm) at the thinnest portion of the cross-section.

Type 2 - Durable Longitudinal Edgeline Markings

The film without adhesive shall have a minimum thickness of 0.012 inches (0.30mm).

Type 3 - High Durability Channelizing and Transverse Markings

The film without adhesive shall have a minimum thickness of 0.060 inches (1.52mm).

(c) General Performance Considerations

The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and, through normal traffic wear, shall show no fading, lifting, or

shrinkage which will significantly impair the intended usage of the marking and shall show no significant tearing, roll back, or other signs of poor adhesion.

3. Equipment

Following proper application, the markings shall be immediately ready for traffic. The bidder, when bidding, shall identify the proper equipment necessary for proper application and make recommendations for application that will assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's instruction.

4. Warranty

(a) Type 1 - High Performance Patterned Centerline Markings

Warranty

The manufacturer warrants that pavement marking material sold for applications in the United States will remain effective for its intended use under normal traffic conditions and meet the minimum retained coefficient of retroreflection value of 100 millicandelas per foot squared per foot-candle (measured at 1.0□ observation and 86.5° entrance angles) subject to the following provisions:

Table 1

Application	Warranty Period
Longitudinal markings	4 years
Words and Symbols	2 years

If the markings are applied in accordance with all the manufacturer's application recommendations and fail during the warranty period to retain the minimum reflectance values, fail to adhere to the roadway, or fail due to complete wear-through during the warranty period shown above (from the date of installation), the manufacturer's sole responsibility and purchaser's and user's exclusive remedy shall be:

The manufacturer will provide the replacement materials to restore the marking to its original effectiveness.

A visual night inspection must be made with a manufacturer's representative and a customer representative present to identify areas of the installation which appear to be below the minimum retained reflectance values specified in Table 1. Areas which appear to be below the minimum retained reflectance value shall be identified as "zones of measurement." To qualify for material replacement, a "zone" must be at least 360 feet in road length and consist of either edge lines, center lines, or lane lines, but not in combination, or a single word or symbol marking.

(b) Type 3 - High Durability Channelizing and Transverse Markings

Warranty

The manufacturer warrants that pavement marking material sold for applications in the United States will remain effective for road presence and non-wear through under normal traffic and meet the minimum retained skid resistance of 45 BPN (ASTM E-303), subject to the following provisions:

Table 2

	Warranty Period		
Application	Legends	Symbols	Channelizing Markings
New Asphalt Inlay	2 years	2 years	1 year

	Stop Bars	Crosswalks	Gore Markings w/ ADT Lane of 6,000 or Less
New Asphalt Inlay	1 year	2 years	1 year

If the pavement markings are applied in accordance with application procedures provided by the manufacturer (which will be furnished to the applier upon request), and fail to retain the minimum skid resistance value, fail to adhere to the roadway, or fail due to complete wear-through during the warranty period shown above (from the date of installation), the manufacturer's sole responsibility and purchaser's and user's exclusive remedy shall be:

The manufacturer will provide replacement materials to restore the marking to its original effectiveness.

5. Construction Requirements

The markings shall be applied in accordance with the manufacturer's installation instructions. Marking configurations shall be in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways, dated 1988, or as modified.

The manufacturer shall provide application equipment, manual or automatic as necessary for the job requirements. These applicators shall be capable of applying two lines simultaneously of the appropriate width and spacing as determined by the marking requirements. This equipment shall be provided to the agency or its contractor representative at no cost for whatever period or number of occasions necessary to complete the work schedule.

6. Method of Measurement

Linear pavement markings will be measured in linear feet (linear meters) complete-in-place for the width specified.

7. Basis of Payment

(a) Retroreflective preformed pavement markings will be paid for at the Contract Unit Price, which shall be full compensation for preparing the pavement surface, for furnishing and placing all materials, and for all materials, labor, tools, equipment, and incidentals necessary to complete the work.

(b) Payment will be made under the following Bid Items as set forth in the Bid Schedule:

Pay Item	Unit
Preformed Pavement Marking, Linear (Type)	Lin. Ft.
Preformed Pavement Marking, Symbols/Legends	Ea.

TECHNICAL SPECIFICATIONS
FOR
PAINTED PAVEMENT MARKING

1. Description

This work shall consist of furnishing and installing a multiple component, retroreflective traffic marking system in accordance with this provision and in reasonably close conformity to the lines, dimensions, patterns, locations, and details shown on the plans or established by the Engineer. This specification describes the system which consists of an acrylic, high build, fast drying, white and yellow waterborne traffic marking paint; bonded core elements; and glass beads that can be used on bituminous and Portland cement concrete pavements. The waterborne traffic marking paint shall be applied by spray method onto asphalt cement concrete and Portland cement concrete surfaces and immediately followed by the application of bonded core reflective elements and glass beads. Upon drying, the resulting traffic marking shall be adherently reflectorized and capable of resisting deformation by traffic. This work will be accomplished after all paving has been completed. All work shall be in accordance with the Manual on Uniform Traffic Control Devices. Temporary pavement marking will not be paid for under this item.

2. Materials

a. General- The markings shall be comprised of a durable, low VOC, fast drying, white and yellow waterborne traffic paint with an acrylic polymer emulsion and with reflective media adhered to the paint. The reflective media shall consist of glass beads as well as bonded core reflective elements.

b. Composition

i. Waterborne Traffic Marking Paint- The finished paint shall be formulated and manufactured from first-grade materials and shall be a fast drying, water based, acrylic resin type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring, or deforming.

1. Condition in the Container - The paint, as received, shall show no evidence of; biological growth, corrosion of the container, livering or hard settling. The paint shall be returned to a smooth and homogeneous consistency, which is free from; gel structures, persistent foam or air bubbles, using only hand mixing.

2. Shelf life - When stored in a three-quarters filled can for a period of thirty days, the paint shall be in a homogeneous state with no skinning, curdling, hard settling or caking that cannot be readily remixed.

3. Degree of Settling, minimum, ASTM D869

White	Yellow
7	7

A 500 ml (1 pint) paint can is filled with a well-mixed sample. The can is capped and allowed to set undisturbed at 23±2°C and 50±5% relative humidity for 14 days. The settling is then determined as specified in ASTM D869. The 1-quart laboratory samples of each batch, as received, shall also pass this test.

4. Nonvolatile Content, Weight %, ASTM D2369

White	Yellow
77	76
±2.0	±2.0

5. Pigment Content, Weight %, ASTM D3723

White	Yellow
60	58
±2.0	±2.0

6. % Nonvolatile in Vehicle (%NVV), Weight %, minimum

White	Yellow
42	42

Calculated as; $\%\ NVV = \frac{\%\ \text{Nonvolatile Content} - \%\ \text{Pigment}}{100 - \%\ \text{Pigment}} \times 100$

7. Density, g/ml at 25°C, ASTM D1475

White	Yellow
1.68± 0.04 (14.0 lbs/gallon)	1.63± 0.04 (13.6 lbs/gallon)

8. Consistency, K.U. at 25±1°C, ASTM D562A

White	Yellow
80-95	80-95

9. Fineness of Dispersion, Hegman, minimum, ASTM D1210

White	Yellow
3.0	3.0

10. Dry to No Pick-Up Time, without beads, minutes, maximum, ASTM D1640

White	Yellow
10	10

11. Dry Through, at 90% Relative Humidity, minutes, maximum, ASTM D1640

White	Yellow
120	120

A 15 mil wet film of the candidate paint placed immediately in a humidity chamber maintained at 72.5°F±2.5°F and 90%±3% relative humidity shall have a “dry-through” time less than, equal to, or up to 15 minutes longer than the specifier’s laboratory reference paint when run at or close to the same time.

Alternatively, 120 minutes maximum dry through can be used. The dry through time must be tested in accordance with ASTM D1640, except that the pressure exerted will be the minimum needed to maintain contact between the thumb and film.

12. Volatile Organic Compounds (VOC), grams per liter of paint, excluding water, maximum

White	Yellow
150	150

Use ASTM D3960 or other approved method in effect at the time of paint manufacture to determine the VOC level and water content of the paint.

13. Flashpoint, °C, minimum, ASTM D93 Method A

White	Yellow
60	60

14. Flexibility, ASTM D522 Method B

White	Yellow
Pass	Pass

Use 100x150 mm tin-plated steel panels 250μm thick. Prepare the panel by lightly buffing one side with Grade 0 (medium-fine) steel wool, followed by cleaning with toluene and drying. Draw down the paint on the buffed side of the panel to a wet film thickness of 130μm. Air dry the panels for 24 hours at standard conditions, then bake for 5 hours at 105±2°C and finally condition the panel for 30 minutes at standard conditions. Bend the panel 180° over a 13 mm mandrel in 1 second, then examine under a magnification of 10 diameters. The paint film shall not; crack, chip, or flake when the panel is bent around the mandrel.

15. Appearance

White	Yellow
Pass	Pass

Draw down a 330μm thick wet film of the paint on a glass plate and allow to dry for 24 hours at standard conditions. The paint shall produce a film, which is smooth, uniform, and free from; grit, undispersed particles, craters, pinholes and cracking.

16. Dry Opacity, minimum

White	Yellow
0.93	0.87

On a black-white Leneta chart, Form 2C-Opacity, draw down a uniform 130μm (±5μm) thick wet film of paint covering both the black and white portions of the chart. Measure the wet film thickness with an appropriate gauge. Dry for 24 hours at standard conditions. Use a BYK-Gardner “Color-Guide” Spectrophotometer

to measure the opacity according to the manufacturer's instructions. Calibrate the spectrophotometer according to the manufacturer's instructions using; 2° Observer/Illuminant "C" measurement conditions, and the (Y, x, y) color system.

17. Yellowness Index, maximum

White	Yellow
8	-

Draw down a 330μm thick wet film of the white paint on two-75x150 mm chromate treated aluminum panels (i.e.: Q Panel Co., type AL). Dry for 24 hours at standard conditions. Save one panel for the Accelerated Weathering test (section 2.b.1.t). Using a BYK-Gardner "Color-Guide" Spectrophotometer, follow the manufacturer's instructions, and measure the Yellowness Index of the white paint film using the ASTM E313 mode.

18. Daylight Luminous Reflectance

White	Yellow
≥87	47-60

Using the draw down panels prepared in the Dry Opacity test, measure the reflectance of the white and yellow paint films using the BYK-Gardner "Color-Guide" Spectrophotometer. Follow the manufacturer's instructions to obtain the Reflectance or "Y" value.

19. Yellow Color

Draw down the yellow paint on two chromate treated aluminum panels as described in the Yellowness Index test. One panel should be used for the Accelerated Weathering test. Retain the other yellow panel as a control and for the Reflectance test. The yellow color shall match Federal Standard 595b, color #33538.

20. Accelerated Weathering Test, Ultraviolet Light and Condensate Exposure, 300 hours total, ASTM; G154 and G151

Prepare samples of the white and yellow paints as described in the Yellowness Index and Yellow Color tests. Alternately expose the samples to; eight hours of UV exposure at 60°C, followed by four hours condensate exposure at 50°C in a QUV Accelerated Weathering Tester. Type UVA-340 bulbs are used at an irradiance level of 0.77 watts per square meter per nm at 340 nm, as measured at the sample surface during the UV cycle. After 300 hours total exposure the paint samples shall meet the requirements below.

White – Yellowness Index after weathering, maximum, 12
Yellow – Must pass Yellow Color test after weathering

21. Scrub Resistance, cycles, minimum

White	Yellow
800	800

Follow the procedure in ASTM D2486. Prepare a panel using an appropriate bird doctor blade that will produce a uniform dry film thickness of paint between 80 and 100µm. Dry the panel for 7 days at standard conditions. The panel shall require more than 800 cycles to remove the paint film in one continuous line across the width of the shimmed area.

22. Lead, mg/kg in dried paint, maximum, ASTM D3335

White	Yellow
20	20

The white & yellow paints shall be free of lead, mercury, cadmium, hexavalent chromium and other toxic heavy metals as defined by the United States Environmental Protection Agency.

23. Chromium, mg/kg in dried paint, maximum, ASTM D3718

White	Yellow
5	5

24. Thick Application Cracking Resistance

White	Yellow
Pass	Pass

On a black-white Leneta chart, Form 2C-Opacity, draw down a stripe of the paint 75 mm wide and at least 150 mm long and having a 1530±130µm wet film thickness. Allow the paint to dry for 48 hrs. at standard conditions on a horizontal surface. After 48 hrs. the paint film shall not contain any cracks.

25. pH, minimum, ASTM E70

White	Yellow
9.9	9.9

ii. Acrylic Polymer Emulsion- The paint shall consist of a commercial high-build acrylic polymer emulsion.

iii. Reflective Media- The reflective media shall be made up of reflective bonded core elements and glass beads for drop-on application and shall conform to the following requirements:

1. Bonded Core Reflective Elements- The bonded core reflective elements shall contain either clear or yellow tinted microcrystalline ceramic beads bonded to the outer surface.

a. Index of Refraction- All microcrystalline ceramic beads bonded to reflective elements shall have a minimum index of refraction of 1.8 when tested using the liquid oil immersion method.

b. Testing Procedure for Refractive Index of beads by liquid immersion

Equipment Required:

- Microscope (minimum 100X magnification)
- Light Source- preferably sodium light or other monochromatic source, but not absolutely essential
- Refractive Index Liquids (available from R.P. Cargille Laboratories, Inc., Cedar Grove, NJ)
- Microscope Slide and Slide Cover
- Mortar and Pestle

Procedure:

- Using the mortar and pestle, crush a few representative beads and place a few of these crushed particles on a microscope slide.
- Place a drop of a refractive index liquid, with an index as close to that of the crushed particles as can be estimated, on the particles.
- Cover the slide with a microscope slide cover and view the crushed particles by transmitted light normal to the slight surface (illuminated from the bottom).
- Adjust the microscope mirror to allow a minimum light intensity for viewing. This is particularly important if sodium light is not used.
- Bring a relatively flat and transparent particle into focus.

Testing Criteria:

By slightly raising and lowering the objective (microscope tube), look for one or both of the following:

Becke Line- This light line will appear to move either into the particle or away from it. In general, if the objective is raised, the line will move toward the material of higher refractive index; if the objective is lowered, the line will move toward the material of lower index.

c. Variation in Particle Brightness- When raising the objective from a sharp focus, the particle will appear to get brighter or darker than the surrounding field. If it becomes brighter, the particles have a higher refractive index than the liquid. If it becomes darker, the glass has a lower refractive index than the liquid. In both cases, the opposite will be true if the objective is lowered. This test can be used to confirm that the beads are above or below a specified index. It can also be used to give an accurate determination of the index (+ or – 0.001). This is done by using several refractive index liquids until a match or near match of indices occurs.

The index of the glass will equal that of the liquid when no Becke line and no variation in bead brightness are observed. The size and quality of the beads shall be such that the performance requirements for the retroreflective material shall be met.

d. Acid Resistance- A sample of microcrystalline ceramic reflective elements supplied by the manufacturer, shall show resistance to corrosion of their surface after exposure to a 1% solution (by weight) of sulfuric acid. The 1% acid solution shall be made by adding 5.7cc of concentrated acid into 1000cc of distilled water. CAUTION: Always add the concentrated acid into the water, not the reverse. Place 10g of the beads into a 100ml beaker and cover with 30-40 ml of the 1% sulfuric acid solution. Cover the beaker to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution and rinse the sample with fresh DI water followed by drying the sample in a 150°F (66°C) oven for approximately 15 minutes or until the sample is dry. Microscopic examination (20X) shall show not more than 15% of the beads having the formation of a very distinct opaque white (corroded) layer on their entire surface to be classified as passing the acid resistance test.

2. Glass Beads- The required glass beads shall have an index of refraction of 1.5 when tested by the immersion method at 25°C (77°F). The glass beads shall be surface treated for optimal performance with waterborne traffic marking paint. The glass beads shall have a minimum of 70% Rounds as measured according to ASTM D1155. The surface of the glass beads shall be free of pits and scratches. The glass beads retained on the #40 U.S. Mesh Sieve (425 microns) shall have minimum crush strength of 30 pounds in accordance with ASTM D1213. The glass beads shall conform to either of the following gradation specifications:

P40 or equivalent

U.S. Standard Sieve Number	Size in Microns	% Passing By Weight
20	850	90 - 97
30	600	50 - 75
40	425	15 - 45
50	300	0 - 15
80	180	0 - 5

AASHTO M247 Type 1 or equivalent

U.S. Standard Sieve Number	Size in Microns	% Passing By Weight
20	850	100
30	600	75 - 95
40	425	-
50	300	15 - 35
80	180	-
100	150	0 - 5

c. Characteristics of Finished Traffic Marking- Because of normal variances in road surfaces, application processes, and measurement, the properties of markings made from the materials specified herein will vary from one installation to the next. When the materials are applied according to these specifications, they shall be capable of forming markings with the following reproducibility of properties:

i. Skid Resistance- The average initial skid resistance shall be 45 BPN or greater when tested according to ASTM E303.

ii. Retro-Reflectance- The initial retro-reflectance averaged over many installations shall be at least the values in the following table:

Retroreflectivity (mcd(ft^{-2})(fc^{-1})) {metric equivalent mcd(m^{-2})(lux^{-1})}

	White	Yellow
Dry	350	275
Wet recovery (ASTM 2177)	350	275
Wet continuous (ASTM 2176)	100	75

The initial retroreflectance of a single installation shall be the average value determined according to the measurement and sampling procedures outlined in ASTM D6359, using a 30-meter (98.4 feet) retroreflectometer. The 30-meter retroreflectometer shall measure the coefficient of retroreflected luminance, R_L, at an observation angle of 1.05 degrees and an entrance angle of 88.76 degrees. R_L shall be expressed in units of millicandelas per square foot per foot-candle [mcd(ft^{-2})(fc^{-1})]. The metric equivalent shall be expressed in units of millicandelas per square meter per lux [mcd(m^{-2})(lux^{-1})].

Initial performance of pavement markings shall be measured within 7 days after application.

iii. On-the-road Track-Free Time- When installed at 77°F and at a wet film thickness of 25±2 mils, the markings shall reach a no-track condition in less than 5 minutes. Track-free shall be considered as the condition where no visual deposition of the traffic paint marking to the pavement surface is observed when viewed from a distance of 50 feet, after a free-rolling traveling vehicle's tires have passed over the line. The track-free time shall not increase

substantially with decreasing temperature.

iv. Color after Application- The color of the applied white and yellow stripes and markings (with beads) shall conform to the daytime and nighttime color requirements in ASTM D6628.

3. Equipment & Construction Requirements

The Contractor shall furnish equipment and apply the materials according to the following specifications:

a. Equipment- The equipment shall be capable of producing markings that meet the specifications contained herein using the materials specified in Section 2 Materials.

i. The equipment shall be a mobile, truck mounted and self-contained pavement marking machine.

ii. The equipment shall be designed to maintain a uniform rate of speed at increasing or decreasing road grades.

iii. The equipment shall be capable of air blasting the pavement, spraying the traffic marking paint, and immediately dropping the reflective elements and glass beads in a single pass at speeds up to 8 mph.

iv. If using equipment containing a heat exchanger it shall be capable of heating and maintaining the heated temperature of the liquid not exceeding 100°F in the heat exchanger and 100°F at the spray nozzle to enable proper spraying of the traffic marking paint.

v. At any time throughout the duration of the project, the Contractor shall provide free access to his application equipment by the Engineer, his authorized representative, or a materials representative.

b. Construction Requirements

i. Moisture- The markings shall only be applied during conditions of dry weather and when the pavement surface is dry and free of moisture.

ii. Air Temperature and Humidity- The markings shall only be applied when road and air temperatures are above 50°F under humidity conditions of 85% or less.

iii. Surface Preparation- Marking operations shall not begin until applicable surface preparation work is completed and approved by the Engineer.

1. Prior to applying the markings, the contractor shall remove any remaining existing markings showing obvious signs of degradation and/or lack of adhesion.

2. Prior to applying the markings, the contractor shall remove all curing compounds on new Portland cement concrete surfaces.

3. Prior to applying the markings, the contractor shall remove all dirt, sand, dust, oil, grease and any other contaminants from the road surface.

iv. Dimensions- The reflectorized pavement markings shall be placed only on properly prepared surfaces and at the widths and patterns as designated on the

contract plans. The markings shall be applied in accordance with the Manual on Uniform Traffic Control Devices and in accordance with the Engineer's plans.

v. Other Restrictions- The Engineer and/or contractor shall determine further restrictions and requirements of weather and pavement conditions necessary to meet all other application specifications and produce markings that perform to the satisfaction of the Engineer. If the pavement surface contains heavy tines or very large aggregate used in open grade friction course or stone matrix asphalt mixes it may require additional surface preparation prior to application of liquid traffic marking system.

vi. Liquid Thickness- The liquid paint shall be applied at 25 mil ±2 mil wet film thickness.

vii. Reflective Media Application- The specified reflective media shall be dropped at rates to achieve the following coating weights:

Units	Glass Beads	Composite Reflective Elements
Pounds per 4-inch linear foot	0.026 lbs/4 -inch lf	0.011 lbs/4-inch lf
Grams per 4-inch linear foot	12 grams per 4-inch lf	5 grams per 4-inch lf
Pounds per gallon- 25 mils, 190 theoretical feet per gallon (4" line width)	5.3 lbs/gal	2.1 lbs/gal

viii. Overspray- The contractor shall ensure the traffic paint does not exhibit excessive overspray.

ix. Adhesion- The contactor shall ensure that the traffic paint is well adhered to the road surface, and that the beads and elements are well adhered to the binder.

x. Marking Performance- The typical average initial retroreflectance of the markings shall be those in the table that follows:

Condition	White	Yellow
Dry	350	275
Wet recover (ASTM 2177)	350	275
Wet continuous (ASTM 2176)	100	75

The average initial retroreflectance shall be determined according to the measurement and sampling procedures outlined in ASTM D6359, using a 30-meter retroreflectometer. The 30-meter retroreflectometer shall measure the coefficient of retroreflected luminance, R_L, at an observation angle of 1.05 degrees and an entrance angle of 88.76 degrees. R_L shall be expressed in units of millicandelas per square foot per foot-candle [$(mcd(ft^{-2})(fc^{-1})$]. The metric

equivalent shall be expressed in units of millicandelas per square meter per lux [$mcd(m^{-2})(lux^{-1})$].

Initial performance of pavement markings shall be measured within 7 days after application.

4. Inspection and Testing

During the application of the traffic paint, the Engineer may request the following tests to verify application to the parameters required in this specification.

a. Liquid thickness- During the appropriate locations along the alignment of the project site, the Engineer may obtain a sample of the wet traffic paint applied onto a test panel of aluminum for the purposes of checking for proper wet traffic paint film thickness. The traffic paint shall be applied without reflective elements or glass beads. Upon drying of the liquid material, the dry thickness shall be verified by the Engineer to meet the requirements of Section "Construction Requirements- Liquid Thickness" in this specification. The contractor shall provide to the Engineer the application speed of the equipment during the time of the sample.

b. Reflective Media- When required by the Engineer, the Contractor shall demonstrate to the Engineer the proper calibration of reflective elements and glass beads compared with the manufacturer's requirement. The calibration shall be conducted with a graduated cylinder or other similar device. Reflective elements or glass beads shall be collected from the reflective element and glass bead guns for a timed period. The volume of the reflective elements and glass beads collected shall be measured and compared with the manufacturer's requirements.

c. Application Panel- The Contractor shall provide to the Engineer at least one dry sample coated on aluminum, with typical dried liquid paint and reflective media applied onto the surface. This sample will serve as a record of the project application conditions and settings.

Method of Measurement

d. Painted Pavement Marking (Line) - The mileage of line complete in place and accepted, shall be measured along the center of each line. Where double solid barrier lines are used, each solid barrier line will be measured separately for payment. Where broken lane lines are used, only the marked line will be measured for payment. For quantities of Pavement Marking (Line) less than one mile, the accepted method of measurement shall be linear feet.

e. Painted Pavement Marking (Crosswalk Striping) and Pavement Marking (Stop Bar) - The length of each striping complete in place and accepted will be measured in linear feet to the nearest foot along the center line of each pavement marking.

f. Painted Pavement Marking (Channelization Striping) - The area of channelization striping including the boundary lines complete in place and accepted shall be measured and computed in square yards to the nearest square yard.

g. Painted Pavement Marking (Designs) - Designs or lettering will be measured for payment by the unit (each) complete in place or as stipulated in the Contract and on the Plans.

5. Basis of Payment

a. The Contractor shall be required to establish and locate all non-passing zones as well as provide the layout of all pavement markings for approval of the Engineer prior to placement of markings.

b. Retroreflective markings will be paid for at the contract unit price, which shall be full compensation for cleaning and preparing the pavement surface, for furnishing and placing all materials, and for all materials, labor, equipment and incidentals necessary to complete the work.

c. Payment will be made under the following bid items as set forth in the Bid Schedule:

Pay Item	Unit
Painted Pavement Marking (Line)	Lin. Mi.
Painted Pavement Marking (Line)	Lin. Ft.
Painted Pavement Marking (Cross-walk Striping)	Lin. Ft.
Painted Pavement Marking (Stop Line)	Lin. Ft.
Painted Pavement Marking (Channelization Striping)	Sq. Yd.
Painted Pavement Marking (Designs)	Ea.

d. When materials are found to be non-conforming under Sections 2(a) and 2(b), the material supplier shall provide replacement materials at no cost.

e. When markings are found to be non-conforming under Section 2(c), the contractor shall bear full responsibility for all repair work and associated costs, including purchase of replacement materials.

f. When the fault of non-conformance with the specification is indeterminate or in dispute, the materials supplier shall provide replacement materials and the contractor shall repair the markings, both at no cost to the Engineer and/or Agency.

TECHNICAL SPECIFICATIONS
FOR
CONCRETE DITCH

1. Description

This work shall consist of furnishing all materials and construction of a concrete ditch on a prepared subgrade. The pavement shall be constructed to the specified thickness and within reasonably close conformity to the lines, grades and cross-sections indicated on the Plans or as directed by the Engineer.

2. Materials

Materials used in this construction shall meet the applicable requirements of Item 15.0, Concrete Structures.

Concrete for cement concrete ditch paving shall be Class "A" concrete.

3. Construction Requirements

Subgrade preparation shall be made to the required depths and to a width that will permit the installation and bracing of forms. The subgrade shall be shaped and compacted to a firm, even surface. All soft and yielding material shall be removed and replaced with acceptable material, which shall be compacted as directed.

The Contractor shall protect the ditch paving until final acceptance of the project. Any concrete that is damaged prior to acceptance shall be reconstructed at the Contractor's expense.

Immediately after the concrete has set sufficiently, and the forms removed, the spaces on each side of the ditch shall be backfilled with suitable material.

4. Method of Measurement

Concrete Ditches will be measured for payment by linear foot, complete in place.

No measurement for payment will be made for preparing the subgrade, backfill expansion joint materials, or for contraction joints unless otherwise indicated on the Plans.

5. Basis of Payment

The accepted quantities of Concrete Ditching will be paid for at the Contract unit price per linear foot.

STANDARD SPECIFICATIONS FOR GABION

1. Description

This work shall consist of the installation of gabions. This installation shall include the placing of filter fabric and the assembly, rock fill and placing of the gabions.

2. Materials

(a) Gabions shall be a rectangular basket manufactured from heavily zinc coated steel wire of double twist hexagon weave, having a nominal mesh opening of 3 1/4" x 4 ½". The steel wire shall be heavily galvanized with zinc coating exceeding Federal Specification requirements (QQW-461H. Class 3). The mesh steel wire diameter shall be no less than 0.1181". The mesh edge wire and selvedge wire diameter shall be no less than 0.1535". The lacing steel wire for binding gabion units together shall be no less than 0.0866".

(b) The limestone contents of the gabions shall consist of "surge" stone 6" to 14" with no more than 20% being 10" to 14".

(c) Phillip Fibers Corporation Supac 8 NP non woven geotextile fabric or equal shall be installed under gabions as directed by the manufacturer or as directed by the Engineer.

(d) Backfill and bedding shall be No. 57 stone per Section 903, TDOTSS, March 1, 2006, or as directed by the Engineer.

3. Construction Requirements

All gabion assembly, filling and installation shall conform to the manufacturers recommendation or to the Engineer's direction.

All geotextile fabric installation shall conform to the manufacturer's recommendations or to the Engineer's direction.

Minimum thickness of layers for crushed aggregate bedding and backfill shall be as shown on the Plans.

4. Method of Measurement

(a) Gabions shall be measured per cubic yard.

(b) No separate payment will be made for the clean "surge" stone fill for the gabions. The cost of stone is to be included in the bid price per cubic yard of the gabions.

(c) No separate payment will be made for the non-woven geotextile fabric. The cost of the fabric is to be included in the bid price per cubic yard of the gabions.

(d) No separate payment will be made for the No. 57 stone backfill behind the gabions. The cost of the No. 57 backfill stone is to be included in the bid price per cubic yard of the gabions.

5. Basis of Payment

This item will be paid for at the Contract unit price per cubic yard of gabions, complete in place, which price shall fully compensate for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
BOLLARDS

1. Description

This work shall consist of the installation of bollards as specified by the Plans and Specifications.

2. Materials

Materials shall meet the requirements as specified on the project Plans.

3. Construction Requirements

The installation of the bollards as detailed on the Plans shall conform to the Engineer's direction. Placement of the bollards shall be as detailed on the Plans or as directed by the Engineer.

4. Method of Measurement

(a) Bollards with cable shall be measured per linear foot of bollard and cable complete in place.

(b) Bollards shall be measured per each bollard complete in place.

5. Basis of Payment

(a) Bollards with cable will be paid for at the contract unit price per linear foot, complete in place, which price shall fully compensate for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with the Plans and Specifications.

(b) Bollards will be paid for at the Contract unit price per each bollard, complete in place, which price shall fully compensate for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
LINKED CHAIN

1. Description

This work shall consist of the installation of linked chain.

2. Materials

The linked chain shall be 3/8" cadmium coated linked chain and shall be approved by the Engineer prior to installation. Eye bolts, as required for the linked chain installation, shall be corrosion resistant.

3. Construction Requirements

The 3/8" cadmium coated linked chain shall be installed after the wooden bollards are in place. The installation of the linked chain shall be through the holes drilled in the wooden bollards and the linked chain shall be fastened with eye bolts as directed by the Engineer.

4. Method of Measurement

Linked chain shall be measured per linear foot. No separate payment shall be made for the eye bolt fasteners.

5. Basis of Payment

This item will be paid for at the Contract unit price per linear foot, complete in place, which price shall fully compensate for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with the Plans and Specifications. No separate payment will be made for the fasteners necessary to secure the linked chain to the bollards.

TECHNICAL SPECIFICATIONS
FOR
FOG SEAL

1. Description

This work shall consist of the application of bituminous material on a prepared, existing pavement to provide a protective seal over the asphaltic surface, in accordance with the requirements of these Specifications.

2. Materials

Bituminous materials shall conform to the following:

Emulsified Asphalt SS-1, or SS-1h	AASHTO M-140

3. Equipment & Construction Requirements

(a) Equipment and Construction Requirements shall conform to all applicable parts of Subsections 403.03 and 403.04 TDOTSS, March 1, 2006, and all Special Provisions which are dated prior to the advertisement of this Contract. Requirements shall also conform to the Asphaltic Emulsion Manufacturers Association recommended performance guidelines for fog seals.

(b) A properly calibrated emulsion distributor or a hand sprayer shall be used for spraying emulsions. ASTM D2995 can be used for distributor calibration. The distributor shall be free of any contaminants which can harm the emulsion. A pump for circulation of emulsion through the spray bar shall be provided. Pumps should have clearance of at least 0.030 in. to prevent over-shearing. Pressure created within the distributor should be as low as possible. Heat applied to the tank or spray bar shall not exceed 185EF at any point.

(c) Recommended spray nozzle sizes are 1/8 to 3/16 inch. Spray nozzle angles and spray bar height should be adjusted to produce correct overlap. A hand sprayer should be used for applying small amounts of fog seal to small areas which cannot be sprayed by the distributor.

(d) The surface shall be free from dust, loose, or foreign matter and any objectionable material which would hinder adhesion of the emulsion. If the dust layer is minimal and brooming is not deemed necessary, a very light 0.15 gal/yd^2 spray of clean water prior to application can significantly improve penetration into the surface cracks by the fog seal. Allow excess water to run off before applying emulsion. Parking lots or other areas with heavy oil drippings should be cleaned with detergent or by other methods prior to spraying with emulsions.

(e) Emulsion applied by pressure distributor shall be applied at a uniform rate, without splattering or drilling from the spray bar, by using low pressure. See table on sheet TS-52.0-4 for suggested application rates for fog seal. Ideally, the peaks of most aggregate particles should remain uncoated with asphalt to prevent reduction of skid resistance. Two or more successive applications of the

respective proportion of the desired total application can aid in preventing excess over-application. The distributor should be operated in opposite directions on each pass to minimize inconsistencies in spray pattern. Upon over-application and at the discretion of the supervising Engineer, a light cover of clean, fine sand may be applied onto the uncured fog seal at the rate of 6 to 10 lb/yd^2 to provide for a safe, skid resistant surface. A pass of a pneumatic tired roller should be made over this light sand dusting to firmly embed the fine sand. The fog seal should be allowed to completely cure before opening to traffic.

4. Storage and Handling

Suitable storage and handling facilities shall be provided for the emulsion, so as to:

(a) Prevent contamination by water, oils, or other liquids.

(b) Prevent contamination by other incompatible emulsions.

(c) Protect from freezing or boiling temperatures which break the emulsion and cause separation into asphalt and water.

(d) Protect from local overheating by high temperature heating coils. Use of hot water is recommended for heating emulsion. Where steam, hot oil, or direct fire must be used, control must keep coil surfaces below 185EF.

(e) Use bottom loading wherever possible or employ full length drop hose to eliminate foaming. Foaming may cause a volume gauge error due to inclusion of air from free fall.

(f) Allow surface crust which forms on emulsion in storage to float without disturbance. Vertical tanks can help maintain constant and minimal surface area. Return lines into tanks should have outlets near the tank bottom and circulation should not free fall or disturb surface crust.

(g) Reduce high shear which can break emulsions by enlarging clearances on new gear pumps by milling if necessary.

(h) Prevent unnecessary circulation which can cause drop in emulsion viscosity or actual emulsion breakdown.

(i) Do not agitate emulsion with forced air as it may cause the emulsion to break in the tank.

5. Method of Measurement

Bituminous material will be measured by the number of gallons used in the accepted work, as determined by the Engineer, and at the temperature of application.

6. Payment

Fog seal will be paid at the Contract unit price per gallon and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

SUGGESTED APPLICATION RATES
FOG SEAL

TYPE OF SURFACE TO BE FOG SEALED

RATE OF DILUTION	DENSE SURFACE low absorption	OPEN SURFACE high absorption
% Emulsion (emulsion + water)	gal/yd2	gal/yd2
Net residual asphalt desired	0.01 to 0.03	0.03 to 0.05
50% (1+1)	0.03 to 0.10	0.09 to 0.23
40% (2+3)	0.04 to 0.12	0.11 to 0.28
25% (1+3)	0.06 to 0.19	0.19 to 0.46
20% (1+4)	0.08 to 0.24	0.23 to 0.57
16.7% (1+5)	0.10 to 0.29	too high
14.3% (1+6)	0.13 to 0.39	too high
12.5% (1+7)	0.15 to 0.44	too high

TECHNICAL SPECIFICATIONS
FOR
COAL TAR SEALCOAT

1. Description

This work shall consist of the application of a refined coal tar emulsion and sand mixture to an existing bituminous pavement in accordance with the requirements of these Specifications.

2. Materials

(a) Coal tar emulsions shall conform to the requirements set forth in Federal Specification R-P-355E.

(b) Sand shall conform to the requirements of Subsection 903.02 of TDOTSS, March 1, 2006, except as noted in gradation requirements below.

Sieve Size	% Passing, by Weight
No. 30	95-100
No. 70	5-30
No. 100	0-10
No. 200	0-5

(c) Coal tar emulsion and sand shall be mixed at a rate of 2-3 pounds of sand per gallon of emulsion. Sand shall be uniformly distributed throughout the emulsion upon application to surface.

3. Equipment and Construction Requirements

(a) All equipment necessary for the satisfactory performance of this construction shall be on hand and approved before work will be permitted to begin. The required equipment shall include a power broom or other mechanical sweeping equipment, equipment for agitating the sand and coal tar emulsion and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

(b) The sealcoat shall be applied by broom and squeegee at a rate of two gallons (before dilution) per 100 sq. ft. in two coats.

(c) Before applying sealcoat the surface shall be cleaned of all excess joint material, dirt and vegetation to the satisfaction of the Engineer.

4. Method of Measurement

Coal tar sealcoat will be measured by the number of gallons (before dilution) used in the accepted work, as determined by the Engineer.

5. Payment

Coal tar sealcoat will be paid at the Contract unit price per gallon and shall be full compensation for all work, materials, labor and incidentals required to complete the work in accordance with the Plans and Specifications.

6. Health Hazard Data

(a) Coal tar pitch is considered a carcinogen or potential carcinogen. Coal tar pitch volatiles, soots, tars and oils are listed as a carcinogen by OSHA, National Toxicology Program and International Agency for Research on Cancer.

(b) Skin contact with coal tar or high vapor concentrations may cause burning and itching, changes in pigmentation, and skin eruptions. Sensitivity to sunlight may occur. Prolonged or repeated skin contact may cause dermatitis and with poor hygiene may lead to skin cancer.

(c) Coal tar vapors are irritating to the eyes. Direct contact with coal tar may cause inflammation, discomfort, conjunctivitis, and possible abrasion to the cornea.

TECHNICAL SPECIFICATIONS
FOR
HOT-POURED JOINT AND CRACK SEALANTS
FOR CONCRETE AND ASPHALT PAVEMENTS

1. Description

This work shall consist of the application of a hot-poured elastic sealant to a prepared joint or crack in an asphalt or concrete pavement in accordance with the requirements of these Specifications.

2. Materials

Materials shall conform to AASHTO M-173 except as noted in Subsection 905.05 of the TDOTSS, March 1, 2006.

3. Equipment and Construction Requirements

(a) All equipment necessary for the satisfactory performance of this construction shall be on the Project and approved before work will be permitted to begin.

(b) Special care shall be given to the cleaning of the joint or crack of any foreign materials before applying sealant. Application of sealant to damp or improperly cleaned surfaces may result in a low degree of adhesion which can cause the sealant to pull out of the crack or joint.

4. Method of Measurement

Hot-poured joint/crack sealant shall be measured by the number of pounds used in the accepted work, as determined by the Engineer.

5. Payment

Hot-poured joint/crack sealant will be paid at the Contract unit price per pound and shall be full compensation for all work, materials, labor and incidentals required to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
FIELD DRAINS

1. Description

This work shall consist of the construction of field drains composed of stone, washed gravel, crushed slag, or a combination of any one of these materials and filter cloth. They shall be constructed in accordance with these Specifications, on prepared foundations at the locations shown on the Plans, and in reasonably close conformity to the lines and grades indicated thereon, or as directed by the Engineer. The work shall include all necessary excavation and backfill, together with such work and materials as may be necessary to complete the work as shown on the Plans.

2. Materials

Materials used in this construction shall meet the following requirements:

(a) Filter cloth shall meet the requirements of Section 36.0, Paragraph 2(d), City of Knoxville Standard Specifications for Geotextiles.

(b) Aggregates for field drains shall be crushed stone, gravel, slag or a combination meeting the gradation as follows:

Sieve Size	Total Percent Passing by Weight
3"	100
2 ½"	90 - 100
2"	35 - 70
1 ½"	0 - 15
3/4"	0 - 5

The aggregate shall meet the quality requirements of ASTM D692.

3. Equipment

All equipment necessary for the satisfactory performance of the work shall be on the project and approved by the Engineer before construction will be permitted to begin.

4. Construction Requirements

(a) Trenches shall be excavated at the location indicated on the plans and to the detailed depth and width. The sides and bottom of the trenches shall be prepared to a relatively smooth condition free of sharp objects, obstructions, depressions and debris which might damage the filter cloth during installation.

(b) The material removed from the trench shall be removed from the area and disposed of outside of the rights-of-way at locations obtained by the Contractor unless the Engineer authorizes its disposition within designated locations.

(c) The filter cloth shall be placed with the long dimension parallel to the center line of the channel and shall be laid loosely without wrinkles or creases. When more

than one width of filter cloth is necessary, the joints shall be overlapped a minimum of 12 inches. Securing pins with washers shall be inserted through both strips of overlapped material and into the material beneath, until the washer bears against the cloth and secures it firmly to the base material. These securing pins shall be inserted through the overlapped cloth at not greater than 2 feet intervals along a line through the midpoint of the overlap.

(d) The cloth shall be protected at all times during construction from contamination by surface runoff and any cloth so contaminated shall be removed and replaced with uncontaminated cloth at the Contractor's expense. Any damage to the cloth during its installation for subsurface drainage structures shall be replaced by the Contractor at his own expense. Stone overlaying the cloth shall not be dropped on the cloth from a height greater than three feet. The cloth shall be placed such that the downstream edges overlap the upstream edges.

(e) The filter cloth shall be installed in such a manner that all splice joints are provided with a minimum overlap of three (3) feet. The overlap of the closure at the top of the trench shall be as indicated on the Plans and secured with mechanical ties.

(f) Field splices of filter cloth shall be anchored with securing pins as directed to insure the required overlap is maintained. Care shall be taken during the aggregate filler placement operation to prevent damage to the filter cloth. To repair a torn, punctured, or otherwise damaged section, a piece of filter cloth is cut large enough to cover the damaged area and overlap all around the damaged area a minimum of 12 inches.

(g) The aggregate shall be placed in 6 inch layers and each layer compacted by the use of vibratory compactor to the satisfaction of the Engineer before making the filter cloth closure at the top of the trench.

5. Method of Measurement

Field drains will be measured for payment by the linear foot along the centerline of the trench, and from end to end of trench, complete in place.

6. Basis of Payment

Accepted quantities of field drain measured as specified above will be paid at the Contract unit price per linear foot, complete in place. Such payment shall be full compensation for

all excavation, materials, backfill, and all incidentals necessary to complete the construction, in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
TIMBER STRUCTURES

1. Description

This work shall consist of constructing structures or parts of structures, other than piling, composed of timber, treated or untreated, or a combination of both. Timber structures shall be constructed on prepared foundations at the locations indicated or directed, in reasonably close conformity with the dimensions, lines, and grades shown on the Plans or as directed by the Engineer, and in accordance with these Specifications.

Parts of timber structures to be constructed with materials other than timber, such as concrete, steel, etc., shall be constructed in accordance with the requirements of the Sections pertaining to the respective types of structure.

2. Materials

Timber shall meet the requirements of Subsections 911.01 and 911.02 of the TDOTSS, March 1, 2006, unless otherwise shown on the Plans.

Timber shall be of the dimensions shown on the Plans. The dimensions indicated on the Plans are intended to represent the commercial product.

Hardware and connectors for timber structures shall be of the design, size, kind and composition shown on the Plans or as directed by the Engineer. All hardware and connectors shall be of noncorrosive metal.

3. Construction Requirements

(a) Care and Protection of Timber

Timber, either treated or untreated, shall be carefully handled by the Contractor. All timber shall be stored upon platforms, skids or other supports at least 12 inches above the ground surface and shall be so stacked and stripped as to permit free circulation of air between the tiers and courses. The stacked timber shall be covered as directed. The ground underneath and in the vicinity of the timber shall be cleared of weeds and rubbish.

(b) Components of Timber Structures

1) Concrete pedestals or footings for the support of timber posts/columns shall be constructed to the dimensions shown on the Plans. Concrete shall meet the requirements of Section 15.0 of these Specifications.

2) Beam and column timbers shall be cut and framed to a close fit in such manner that they will have an even bearing over the entire contact surface of the joint without requiring blocking or shimming.

3) Joists shall be so set or placed to required elevations as to give flooring an even bearing at all contacts or intersections. Joist to beam connections shall be as detailed on the Plans.

4) Flooring shall be constructed as indicated on the Plans. Flooring shall have even, full, and uniform bearing on each and all stringers and outside beams and shall not be pulled or warped so as to have such bearing.

5) Railing shall be built in accordance with the designs indicated on the Plans. Unless otherwise indicated, all rail posts shall be bolted to beams.

6) Bolts, nuts and washers shall be of the kinds and sizes specified. Wherever possible, bolts shall be placed so that the nut is hidden from view. Holes for bolts shall be bored with a bit of the same diameter as the bolt. Washers shall be used underneath the head or nut of all bolts coming in contact with timber.

7) Nails for all framing connections shall be of the type and size specified in the Plans and shall have a minimum embedment into the framing member as specified.

(c) Erection

1) In erecting timber structures, or parts of structures, to finished or required elevations and required dimensions, knowledge of the variations in Plans dimensions from commercial dimensions of timber shall be exercised in order that the required finished elevations and finished dimensions of the structure will be obtained, without the use of shims or blocks.

2) Timbers shall be positioned and fastened as shown on the Plans or as directed by the Engineer. A minimum of two fasteners shall be used at all timber connections. All construction shall be performed in workmanlike manner and the structure shall present a neat finish and appearance when completed.

3) Planks shall be laid with the heart side down, with 1/4-inch openings between planks, unless otherwise indicated or directed and shall be fastened at each intersection to a nail strip or joist with two common nails of the size indicated or as directed.

4) Any timber damaged or found unsatisfactory in the structure shall be removed and replaced at the Contractor's expense.

4. Method of Measurement

Timber structures using treated or untreated timber, or other acceptable material, complete in place and accepted, will be measured for payment by the foot board measure (FBM). Measurement will be based on nominal widths and thicknesses and the extreme length of each piece. No allowance will be made for hardware used in a structure as this is a necessary part of the structure and is to be included in the unit price bid for timber.

5. Basis of Payment

The accepted quantities of timber structures will be paid for at the Contract unit price per foot board measure (FBM) for Timber Structures (Description), complete in place.

TECHNICAL SPECIFICATIONS
FOR
WIRE MESH MATTRESSES

1. Description

This work shall consist of the installation of wire mesh mattresses. This installation shall include the placing of filter fabric and the assembly, rock fill and placing of wire mesh mattresses.

2. Materials

(a) Wire mesh mattresses shall be a rectangular mattress manufactured from heavily zinc coated steel wire of double twist hexagon weave, having a nominal mesh opening of 2 ½" x 3 ¼ ". The steel wire shall be heavily galvanized with zinc coating exceeding Federal Specification requirements (QQW-461H. Class 3). The mesh steel wire diameter shall be no less than 0.0866". The mesh edge wire and selvedge wire diameter shall be no less than 0.1063". The lacing steel wire for binding wire mesh mattress units together shall be no less than 0.0866". Each wire mesh mattress shall be 12' x 6' x 6" consisting of four (4) area cells.

(b) The limestone contents of the wire mesh mattresses shall consist of 4" to 6" "Surge" Stone.

(c) Phillip Fibers Corporation Supac 8 NP non-woven geotextile fabric or equal shall be installed under the wire mesh mattresses as directed by the manufacturer or as directed by the Engineer.

3. Construction Requirements

All wire mesh mattress assembly, filling and installation shall conform to the manufacturer's recommendation or to the Engineer's direction.

All geotextile fabric installation shall conform to the manufacturer's recommendations or to the Engineer's direction.

4. Method of Measurement

(a) Wire mesh mattresses shall be measured by the square yard of surface area.

(b) No separate payment will be made for the clean "surge" stone fill for the wire mesh mattresses. The cost of stone is to be included in the square yard of surface area bid price.

(c) No separate payment will be made for the non-woven geotextile fabric. The cost of the fabric is to be included in the square yard of surface area bid price.

(d) No separate payment will be made for any subgrade preparation required. The cost of all subgrade preparation is to be included in the square yard of surface area bid price.

5. Basis of Payment

This item will be paid for at the Contract unit price per square yard of wire mesh mattress, complete in place, which price shall fully compensate for all work, materials, labor, maintenance and other incidentals necessary to complete the item, in accordance with the Project Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
ADJUSTING MANHOLES

1. Description

This item shall consist of adjusting sanitary sewer manhole frames and water manhole frames (i.e. air releases) and furnishing all labor, materials, and other items necessary to bring the frames to the grades as shown on the Plans or as specified by the Engineer.

Milling or grinding around manholes shall be accomplished with care to prevent damage to utility property. Unless otherwise approved by the Engineer, milling or grinding operations shall be carried to within one (1) foot of all manholes. The Contractor will be responsible for hand chipping the remaining one foot on all manholes.

The adjustment of other utility facilities owned by Knoxville Utilities Board (KUB) Electric, BellSouth, AT&T and others shall be provided by the respective owner. Payment for the adjustment of storm sewer frames and manholes will be made under Item 23.0.

2. Materials

(a) Gray iron adjusting rings of 1", 1½" and 2" in height shall be used to adjust existing manhole frames to final grade. The ring shall be 23 5/8” in diameter and capable of accepting a 1 1/8" lid. Ring shall be a minimum of 3/4" thick by appropriate height meeting ASTM A36 or A.I.S.I. 1020 Hot Rolled Steel. A maximum of one new adjusting ring may be used per manhole. Acceptable adjustment rings shall be as supplied by American Highway Products, Massillon, Ohio or W.M. Miller, Knoxville, Tennessee or approved equal.

(b) Clay brick shall be medium hard or better quality Grade SM sewer brick conforming to the requirements of ASTM C32. Brick shall be solid and not cored.

(c) Precast grade rings, either 4" or 6", may be installed above the manhole cone. No more than two grade rings shall be used. Where manholes are to be raised or lowered 12 inches or more, the existing cone shall be removed and precast sections installed.

(d) Butyl mastic sealant shall be used when rejoining the manhole frame to the precast manhole following milling operations and for all adjustments to provide a watertight structure. The sealing compound shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, and shall contain no solvents, irritating fumes, or obnoxious odors. The compound shall not depend on oxidizing, evaporation, or chemical action for its adhesive or cohesive strength. It shall be supplied in extruded rope form of suitable cross section and in such sizes to seal the joint space. Use 2 complete ropes at each joint.

3. Construction Requirements

(a) All manhole frames shall be reset as follows:

Manholes that are more than 1/4 inch over or under the specified grade.

(b) The manhole frames shall be accurately set to line and grade by one of the following methods:

1) Removing the frame and lid and raising or lowering the masonry top of the structure and resetting with either clay brick and mortar or by using precast grade rings.

2) Use of one new adjustment ring fitted to the manhole frame. Placement of adjusting ring shall occur immediately in advance of the paving operation. The Contractor shall install the adjusting ring according to the manufacturer's specifications and recommendations which will be provided by KUB. The ring shall be adequately tightened to insure proper operation under normal traffic conditions. The grade of the lid shall be within a 1/4" tolerance of the surrounding pavement and shall provide a smooth riding surface.

(c) Excavation shall be performed whenever necessary to bring the frames to grade on the Plans and as designated by the Engineer. Backfill material and compaction shall conform to the Specifications for Mineral Aggregate Base.

(d) All frames shall be thoroughly cleaned of all excess mortar and accumulations of silt, clay, debris or foreign matter of any kind and shall be free from such at the time pavement is to be laid.

(e) Flat metal manhole covers shall be temporarily placed immediately ahead of the paver so that the paver shall never pass over crowned manholes. A sufficient number of flat covers shall be available on the job site to allow the paving operation to progress smoothly. Once the ring area has been paved, the temporary manhole cover shall be removed and the original manhole cover placed on the ring. The Contractor shall fill in any needed asphaltic concrete to insure a proper, neat and long-lasting installation. The Contractor will be responsible for any repair or maintenance due to poor workmanship.

(f) All manhole and valve box covers shall be cleaned and returned to their original condition after paving. No asphalt or debris shall be left on any lid or cover.

(g) All installations shall be inspected and approved by a KUB inspector.

4. Equipment

The Contractor shall provide the necessary tools and equipment to complete all work as described above.

5. Measurement

The number of manhole frames adjusted and accepted will be measured for payment per each.

6. Payment

Payment will be made under the following bid items as set forth in the Bid Schedule and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

Pay Item	Unit
Adjusting Manhole Frames (Full Mill Depth)	Ea.
Adjusting Manhole Frames (Adjustment Ring Only)	Ea.

On milled streets, manholes will be lowered in order that leveling can be accomplished. After leveling is complete, the manholes will be raised to the correct surface grade. This will be one adjustment and paid for under pay item, Adjusting Manhole Frames (full mill depth).

TECHNICAL SPECIFICATIONS
FOR
ADJUSTING VALVE BOXES

1. Description

This item shall consist of adjusting water and gas valve boxes including furnishing all labor, materials, and other items necessary to bring the valves to the grades as shown on the Plans or as specified by the Engineer.

Milling or grinding around valve boxes shall be accomplished with care to prevent damage to utility property. Unless otherwise approved by the Engineer, milling or grinding operations shall be carried to within one (1) foot of all valve boxes. The Paving Contractor will be responsible for hand chipping the remaining one foot on all valve boxes.

2. Materials

Valve box risers shall be Class 35-B gray iron, meeting the requirements of ASTM A48-83. The risers shall be as manufactured by Atchinson Foundry, Chattanooga, Tennessee, or approved equal. Standard riser sizes shall be 1", 1 ½ ", or 2". A maximum of one new riser may be used per valve box.

3. Construction Requirements

(a) All valve boxes shall be reset as follows:

1) Valve boxes that are more than ¼ inch over or under the specified grade.

(b) The valve boxes shall be accurately set to line and grade by one of the following methods:

1) Use of a valve box riser fitted to the valve box.

(c) Excavation shall be performed whenever necessary to bring the valve box to grade on the Plans and as designated by the Engineer. Backfill material and compaction shall conform to the Specifications for Mineral Aggregate Base.

4. Equipment

The Contractor shall provide the necessary tools and equipment to complete all work as described above.

5. Measurement

The number of valve boxes adjusted and accepted will be measured for payment per each.

6. Payment

Payment will be made under the following bid items as set forth in the Bid Schedule and shall be full compensation for all work, materials, labor, and incidentals required to complete the work in accordance with the Plans and Specifications.

Adjusting Valve Box (Full Mill Depth)	Ea.
Adjusting Valve Box (Valve Box Riser Only)	Ea.

On milled streets, valve boxes will be lowered in order that leveling can be accomplished. After leveling is complete, the valve boxes will be raised to the correct surface grade. This will be one adjustment and paid for under Adjusting Valve Box (Full Mill Depth).

TECHNICAL SPECIFICATIONS
FOR
CHAIN LINK CANTILEVER SLIDE GATES

1. Description

This work will consist of furnishing and constructing chain link cantilever slide gates where shown on the construction drawings.

2. Materials

(a) The height of the gate will be 5 feet.

(b) The wire will be 60" wide with 2" mesh galvanized chain link fabric and 1.2 oz. coated. Install the fabric with hook bolts and tension bars at all 4 sides. Attach to gate frame at not more than 15 inches on center.

(c) The gate frames will be fabricated in accordance with ASTM F 1184, Class 2, using 2 inch square aluminum members, ASTM B 221, alloy and temper 6063-T, weighing 0.94 lb/ft. Weld members together forming rigid one-piece frame integral with top track. Provide 2 truck assemblies for each gate leaf, except as indicated for gates larger than 30 feet. Gates over 27 feet in single opening shall be shipped in 2 parts and field spliced with special attachments provided by the manufacturer.

(d) For gate leaf sizes 23 feet to 30 feet, weld an additional 2 inch square lateral support rail adjacent to top horizontal rail. Bottom rail shall consist of 2 inch x 4 inch aluminum member weighing 1.71 lb/ft. The cantilever support (overhang) shall be 12 feet for gate leaf sizes 23 feet to 30 feet.

(e) The bracing shall consist of diagonal adjustable length truss rods, of 3/8 inch galvanized steel, in each panel of gate frames.

(f) The top track/rail shall consist of an enclosed, combination one-piece track and rail, aluminum extrusion with weight of 3.72 lb/ft. Track to withstand reaction load of 2,000 lb.

(g) The truck assembly will consist of a swivel type, zinc die cast, with 4 sealed lubricant ball bearing rollers, 2 inches in diameter by 9/16 inch in width, and 2 side rolling wheels to ensure truck alignment in track. Mount trucks on post brackets using 7/8 inch diameter ball bolts with ½ inch shank. Design truck assembly to withstand same reaction load as track.

(h) The gate hangers, latches, brackets, guide assemblies, and stops shall consist of malleable iron or steel, galvanized after fabrication. Provide positive latch with provisions for padlocking.

(i) The bottom guide wheel assemblies shall consist of two 4 inch diameter rubber wheels, straddling bottom horizontal gate rail, allowing adjustment to maintain gate frame plumb and in proper alignment. Attach one assembly to each guide post.

(j) The gate posts shall consist of 4 inch O.D. schedule 40 galvanized steel pipe weighing 9.1 lb/ft. Provide 4 support posts for double slide gates.

(k) The gate posts will be set in Class A concrete as described in the City of Knoxville Technical Specifications, Section 15.0.

3. Equipment Construction Requirements

Drill holes in firm, undisturbed or compacted soil. Holes shall have diameter 4 times greater than outside dimension of post, and depths approximately 6 inches deeper than the post bottom. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads. Set post bottom 36 inches below surface when in firm, undisturbed soil. Place Class A concrete around posts in a continuous pour, tamp for consolidation. Trowel finish around post and slope to direct water away from posts. Check each post for vertical and top alignment, and maintain in position during placement and finishing operations.

The gates shall be installed plumb, level and secure for full opening without interference.

All hardware shall be attached by means which will prevent unauthorized removal.

All hardware shall be adjusted for smooth operation.

Construction will be in accordance with the manufacturer's guidelines and the guidelines established by the Chain Link Fence Manufacturing Institute.

4. Method of Measurement

The chain link cantilever slide gates will be measured on a per each basis for each size as indicated on the Project Plans.

5. Payment

Chain link cantilever slide gates will be paid for on a per each basis for each size. Payment shall be full compensation for all work, materials, labor, and incidentals to complete the work in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
BORING AND CASING FOR STORM SEWERS

1. Description

The work to be performed hereunder shall consist of the installation of a casing pipe for the purpose of installing a storm sewer as shown on the drawings or as called for in these Specifications. It shall include the excavation of a boring pit, auger boring between the points specified on the drawings, furnishing and installing of the carrier pipe, and disposing of the excavated materials in the manner herein provided.

2. Materials

(a) Casing Pipe

1. The casing pipe shall be of steel meeting the latest approved American Railway Engineering Association Specifications for Pipelines for Carrying Flammable and Nonflammable Substances." The steel casing pipe shall have a minimum yield strength of 35,000 psi and shall have the minimum wall thickness shown in the following table:

TABLE OF MINIMUM WALL THICKNESS FOR STEEL CASING PIPE FOR E72 LOADING

CARRIER PIPE	CASING PIPE	NOMINAL THICKNESS
4	8	0.281 inch
6	12	0.281 inch
8	16	0.312 inch
10	20	0.344 inch
12	24	0.406 inch
14	27	0.469 inch
16	30	0.469 inch
18	30	0.469 inch
20	36	0.532 inch
24	36	0.532 inch

2. When the casing pipe is installed without benefit of a protective coating, the wall thickness shown above shall be increased to the nearest standard size, which is a minimum of 0.063 inch greater than the thickness shown.

(b) Carrier Pipe

The carrier pipe shall be as called for in the plans.

3. Construction Requirements for Boring

(a) Boring

1. The boring shall be accomplished by means of auguring to the size, line, and grade shown on the drawings.

(b) Installation of Casing Pipe

1. Jack the steel casing pipe into place as the boring proceeds. Weld sections of casing pipe together to provide watertight joints.

2. Do not remove unacceptable casing without prior approval from the Engineer. If the removal of casing pipe is permitted, make proper provisions to prevent caving in of the earth surrounding the casing.

(c) Installation of Carrier Pipe

1. The carrier pipe shall be furnished by the Contractor. Upon acceptance of the casing, install the carrier pipe in the casing by jacking it through the casing. If necessary to achieve proper line and grade on the carrier pipe, strap wood or other suitable blocking to the carrier pipe to offset any minor variations in the alignment of the casing.

(d) Layout of Work

1. The Owner will provide the necessary control points required by the Contractor for this construction. The Contractor will provide the detailed layout required to keep the tunnel or bore on grade.

(e) Guarantee of Work

1. Guarantee a usable completed casing between the points specified and to the line and grade specified. The allowable tolerance at the downstream end point of the bore shall be such that the invert of the carrier pipe may be positioned within a vertical area limited on the top by an elevation no higher than the elevation shown on the drawings and on the bottom by an elevation no lower than the existing inlet pipe invert. For sewers, the sides shall be a minimum of 8 inches inside the interior face of the manhole at the end of the bore.

2. The allowable tolerance at the upstream end point of the bore shall be such that the invert of the carrier pipe may be positioned at the elevation shown on the drawings.

4. Construction Requirements for Tunneling Alternative

(a) General

In the event boring and jacking is impossible because of pipe size, rock, or other factors and the highway department or railroad will not permit open cutting, make crossings by tunneling using liner plates. Conduct tunneling operations as approved by the railroad or highway department. If voids are caused by the tunneling operations, fill by pressure grouting or by other approved methods that will provide proper support.

(b) Galvanized Plates

1. After the plates are formed to shape, the plates shall be galvanized on both sides by the hot dip process. A coating of prime western spelter, or equal, shall be applied at the rate of not less than 2 ounces per square foot of

double exposed surface. If the average spelter coating as determined from the required samples is less than the amount specified above, or if any one specimen shows a deficiency of 0.2 ounce, the lot shall be rejected. Spelter coating shall be of first class commercial quality free from injurious defects such as blisters, flux, and uncoated spots.

2. The outside of the plates shall be give a bituminous coating meeting the AASHO M-190 specifications for bituminous protected corrugated metal pipe.

(c) Design and Construction

1. Construct the tunnel and completely line on the inside with structural steel line plates meeting all requirements specified hereinafter. The dimensions of the tunnel shall be as shown on the drawings.

2. The tunneling operation is to commence from a pit that is a minimum of 12 feet long and 4 feet wider than the diameter of the tunnel, bottom to grade, and sheeted and shored, if necessary. Furnish line and grade stakes.

3. All excavation for the entire length of the tunnel shall be done by tunneling, and the work may be done from either or both ends of the conduit. Trim the periphery of the tunnel smooth to fit the outside of the steel liner plate as nearly as is practical, and fill all space outside of the steel liner plate with a sand cement grout mixture.

4. Install the steel liner plates immediately after the excavated material has been removed. Do not remove material more than 24 inches ahead of the installed liner plates.

5. Provide all necessary bracing, bulkheads, and/or shields to ensure complete safety to all traffic at all times during the progress of the work, and perform the work in such a manner as to not interfere with normal traffic over the work.

6. The steel lining shall consist of plates 16 inches wide, and each circumferential ring shall be composed of the number and length plates necessary to complete the required diameter.

7. The inside diameter of the completed ring shall be as shown on the drawings, and no part of the plate or reinforcing ribs will be allowed to extend inside this net diameter.

8. The strength of the tunnel lining will be determined by its section modulus. In no case shall it be less than 0.0590 inch cubed per inch of plate width based on the average for one ring of plates. Thickness of the metal for these steel plates shall be not less than 10 gauge, allowing for standard mill tolerances. The tunnel strength shall be equal to AASHO railroad E80 loading at the depth of cover obtaining.

9. All plates shall be punched for bolting on both longitudinal and circumferential seams and shall be fabricated so as to permit complete erection from the inside of the tunnel. The longitudinal seam shall be of the lap type with offset equal to gauge of metal for the staggered bolt construction fabricated so as to allow the cross section of the plate to be

continuous through the seam. All plates shall be of uniform fabrication, and those intended for one size tunnel shall be interchangeable.

10. The material used for the construction of these plates shall be new and unused and suitable for the purpose intended. Workmanship shall be first class in every respect.

11. Install the carrier pipe to the line and grade shown on the drawings. After the carrier pipe is installed adequately block it, and backfill the space between the carrier pipe and the tunnel liner with sand. The method of placing this sand shall be approved by the Engineer.

5. Method of Measurement

(a) The quantity of carrier pipe shall be measured by the linear foot for each size and type of pipe shown on the bid schedule and shall be the horizontal length of the pipe installed complete in place as measured along the centerline of the conduit from end to end.

(b) No separate payment will be made for the excavation of the boring pit, auger boring between the points specified on the drawings, furnishing and installing the casing pipe, disposing of the excavated materials and for all incidentals necessary to complete the item in accordance with the Plans and Specifications.

6. Basis of Payment

The accepted quantities of carrier pipe, measured as provided for above, will be paid for at the Contract unit price per linear foot for each size and type of pipe constructed, complete in place, which price shall be full compensation for labor and materials and for completing all incidentals necessary to complete the item in accordance with the Plans and Specifications.

TECHNICAL SPECIFICATIONS
FOR
SIGNAGE

1. Description

Provide all products, equipment, transportation, protection and labor required to construct and install the warning, regulatory, directional, entrance and information signage as shown on the drawings.

2. Quality Assurance

Comply with applicable city, state, and federal requirements regarding material, method of work, and installation standards.

3. Materials

Materials used in the installation of signs and posts, in addition to the requirements of these Specifications, shall conform to the applicable requirements of Section 916, Highway Signing Materials, of TDOTSS, March 1, 2006, and any applicable Special Provision thereto.

Specific material requirements are summarized in the following:

Item	Specification
Posts (U-Channel)	Steel: ASTM A-499, Fy=50,000 psi, Grade 50 Galvanizing: ASTM A-123 Weight: Bikeway Posts-2.5 lbs/ft Roadway Posts-2.0 lbs/ft
Sign Blade	Aluminum: 0.080 inch thick sheet ASTM B-209, Alloy 6061-T6 or 5052-H38
Reflective Sheeting	Material Type III from TDOTSS, March 1, 2006, Subsection 916.06
Legends and Borders	TDOTSS, March 1, 2006, Subsection 916.07
Bolts, Nuts, and Washers	Steel: ASTM A307 Galvanizing: ASTM A153 Alternative Hardware - Stainless Steel

4. Preparation

Examine proposed sign location, mark with stake and seek Contracting Officer's approval before installation.

5. Fabrication, Equipment, and Construction Requirements

(a) Fabrication of all signs, posts and attachment hardware shall be in accordance with the applicable portions of TDOTSS, March 1, 2006, Subsection 916.05.

(b) Equipment required for the satisfactory performance of the work shall be on hand and approved by the Engineer before construction will be permitted to begin.

(c) Construction Methods and Requirements shall conform to the applicable portions of TDOTSS, March 1, 2006, Subsection 713.04. The following installation specifics shall also be conformed with:

1) All sign faces shall be fully attached to post at top and bottom, in accordance with the connection detail shown on T.D.O.T. Standard Roadway and Structure Drawing T-S-16.

2) Post installations in asphalt and concrete surfaces shall include drilling through to subgrade prior to setting posts. Drilled holes shall have neat edges, and shall be no larger than necessary for post insertion.

3) The top of sign posts shall not extend above the top of the uppermost sign face on an assembly.

6. Method of Payment

Signage will be paid for at the lump sum price bid, which price shall be full compensation for providing all signage shown in the Plans. This compensation shall include all labor, materials, equipment and incidentals necessary to complete the work. The signage to be installed includes warning, regulatory, directional, entrance and information types.

TECHNICAL SPECIFICATIONS
FOR
PAINTING OF BRIDGE DECK DRAINAGE SYSTEM

1. Description

The work addressed by this Specification pertains to the painting of the iron storm drain pipes and pipe support hardware that constitute the bridge deck drainage system. The work shall be considered to fall under the category of "Repainting Existing Steel Structures" as it pertains to TDOTSS 603. This work shall consist of preparing the surface, furnishing and applying the paint, furnishing protection from paint spatter and disfigurement, and final clean up, all in conformity with TDOTSS 603 and all other TDOTSS referenced therein. The type, color, and number of coats of paint shall be as designated in TDOTSS Subsection 603.06. The schedule of painting shall be System "A", or System "B". The color shall be black.

2. Materials

The materials shall conform to TDOTSS 603.02.

3. Equipment

All equipment for the satisfactory performance of this work shall be on hand and approved before work will be permitted to begin.

4. Construction Requirements

Construction requirements shall conform to TDOTSS Subsections 603.04 through 603.16.

5. Method of Measurement

Measurement will conform to TDOTSS 603.17 with the following stipulations. Piping of the drainage system is a metallic material, though not necessarily steel. Painting of the drain pipes and drain support hardware shall be a separate pay item and shall be paid for on a lump sum basis. The entire bridge deck storm drainage system that is exposed beneath the bridge deck, including pipes, pipe supports, scuppers, hangers, and fasteners shall be considered as one unit. Containment and disposal of waste generated during the work covered under this Specification shall not be a separate pay item, but the work shall be performed and the cost thereof shall be included in the lump sum bid price bid for pay item "Painting of Bridge Deck Drainage System."

6. Basis of Payment

Payment shall conform to TDOTSS 603.18 with the following stipulations: the lump sum bid price for pay item "Painting of Bridge Deck Drainage System" shall include, but not be limited to, all costs associated with furnishing all labor, materials, and equipment to prepare surfaces to be painted, furnish and apply paint, furnish protection from paint spatter and disfigurement, and final clean up. Any fines incurred by the City of Knoxville as a result of the Contractor's operation shall be deducted from the monies due the Contractor.

STANDARD SPECIFICATIONS
FOR
CLEANING CONCRETE SURFACES

1. Description

The work shall consist of cleaning concrete surfaces by removing all stains, dirt, dust, deposits, pollution, leachates, oil, grease, efflorescence, calcium carbonate deposits and build-up, unauthorized paint marks, undifferentiated spills, tail pipe emission pollutants, moss, lichen and other invasive vegetation; animals and animal wastes, and any other discolorations from the exposed concrete surfaces; and to contain and dispose of the waste stream and all materials and solvents used in the cleaning process in a safe and approved manner. "Cleaning" shall also mean removing loose concrete surface material that has resulted from scaling and spalling.

The objective of cleaning is to return the color of all exposed concrete surfaces to the original color, as closely as possible, of the newly built condition, recognizing that different structural elements had different original colors and architectural finishes.

The performance of the work shall clean all the exposed concrete surfaces without removing sound structural concrete, or diminishing in any way the existing structural sections of the structural members. The methods, techniques, and equipment used in the cleaning, and in the containment and disposal of waste processes shall at all times be at the discretion of the Engineer.

The Contractor shall not use equipment, methods, or solvents that will cause spreading of existing stains, drive existing surface pollutants further into the concrete, or add new areas of discoloration.

The cleaning methods to be used shall be pressure water blasting; manual brushing; and automatic brushing.

2. Materials

The Contractor shall use fresh water from a potable water source.

3. Equipment

The pressure water blasting equipment shall be capable of delivering nozzle pressures between 3,000 psi and 5,000 psi. The Contractor shall provide, and have on hand, a full range of nozzle types and stream patterns from a flat-fan to a straight jet tip. Nozzle pressures in excess of 5,000 psi will be considered to be too likely to cause damage to the concrete structural members and will not be allowed.

Brushes used to loosen dirt, pollutants, and calcium deposits shall have natural, non-ferrous, or stainless steel bristles. Brushes having ferrous bristles shall not be used. Both manual and automatic brushing will be allowed at the discretion of the Engineer.

4. Construction Requirements

Surfaces to be cleaned shall be pressure water blasted. If discoloration persists on the surface, the surfaces shall be brushed and then the pressure water blasting procedure shall be repeated as many times as necessary to remove the dirt, pollution, rust stains and calcium deposits, or until the Engineer directs otherwise.

After pressure water blasting, the surface shall be allowed to thoroughly dry before a final determination is made as to the necessity of repeating the procedure.

Once a surface has been cleaned, subsequent cleaning operations shall be conducted to not get the newly cleaned surface dirty.

5. Method of Measurement

The measurement for cleaning concrete surfaces shall be on a single lump sum basis, which lump sum shall include cleaning all exposed concrete surfaces of the structure, including the parapet wall; the sidewalk; the curb; the sides and underside of the deck; the spandrels; the arch rings; the foundations; the abutments; the breast walls; the columns; and the beams.

6. Basis of Payment

The accepted single, lump sum quantity for cleaning concrete surfaces, measured as provided for above, will be paid for at the Contract lump sum bid price, which price shall be full compensation for all labor, materials, and equipment needed to perform the Work, including all labor, materials, equipment, and incidentals required to protect adjacent property and persons from potential damages attributable to the cleaning operations.

The Contractor shall obtain all permits associated with performing the Work. The costs of obtaining permits shall not be a separate pay item, but shall be included in the lump sum price bid for “Cleaning Concrete Structures.”

The Contractor shall satisfy all OSHA, EPA, and TDEC rules and regulations governing the activities and performance of the Work. The costs associated with complying with OSHA, EPA, and TDEC rules and regulations shall not be a separate pay item, but shall be included in the lump sum price bid for “Cleaning Concrete Structures.”

The Contractor shall coordinate the performance of the Work with all State of Tennessee Department of Transportation (TDOT) construction projects and construction schedules in the general vicinity of the work. The costs associated with coordinating the work with TDOT construction projects and construction schedules shall not be a separate pay item, but shall be included in the lump sum price bid for “Cleaning Concrete Structures.”

STANDARD SPECIFICATION FOR SIMULATED STONE SURFACES

1. Description

(a) This work shall consist applying a specified pattern to the surface of cast-in-place concrete retaining walls, headwalls, bridge rails, bridge abutments, etc. through the use of manufactured form liners during wall construction, and color staining the finished surface.

(b) Concrete structures specified to have a simulated stone surface in the plans shall comply with Technical Specification 15.0, Concrete.

(c) The work covered by this item shall consist of developing, furnishing, and placing simulated stone masonry form liners in accordance with these Specifications and in reasonably close conformity with the lines, patterns, textures, grades, and dimensions as shown on the Plans or established by the Engineer.

2. Materials

Simulated Stone Form Liners

Simulated stone form liners shall be used which will result in the finish detail indicated in the Plans and approved by the Engineer. Samples shall be submitted by the Contractor for approval by the Engineer. Three manufacturers of simulated stone masonry form liners are HUNT VALLEY CONTRACTORS, INC., 11460 Cronridge Drive, Suite 132; Owings Mills, MD 21117; Telephone: 410-356-9677; BOMANITE OF EAST TENNESSEE; P.O. Box 53197-37950; Knoxville, TN 37950; Telephone: 865-971-1760; and names of the manufacturers are provided here for information purposes only.

Simulated stone form liners shall be a high quality re-usable product manufactured of high-strength urethane which attaches easily to the forming system and shall not compress more than .021’ when poured at a rate of 10 vertical feet per hour.

For each pattern required, five (5) different form liners with a minimum size of eight (8) square feet (2’-0” x 4’-0”) with the capability of being turned 180 degrees to result in a minimum of ten different pattern combinations shall be provided. None of the individual combinations shall be repeated side by side. The minimum area for each pattern combination shall be 40 square feet.

Form oil shall be a non-staining petroleum distillate free from water, asphaltic and other insoluble residue or equivalent product. The form oil shall be worked into all areas, especially pattern recesses.

Color and Surfacing Materials

The coloration of the simulated stone surfaces shall be hand applied to match the appearance, texture and the full range of colors present in the stone work in East Tennessee. These colors shall include the range of browns, tans, buffs, grays, whites, and blacks.

Penetrating Stain shall maintain the following minimum standards:

(1) Mildew Resistance: In accordance with Fed. Test Method Std. 144, Method 6271.
(2) Wheatherometer: Base material tested in accordance with ASTM G-26, 1000 hours.
(3) Non Volatile Vehicle: 73.4% of the total N.V.
(4) Viscosity: 58" 2KU
(5) Solids Content: 40.3%
(6) Form: viscous, opaque liquid
(7) Specific gravity: 1.17
(8) Weight Solids: 40.3%
(9) Volume Solids: 29.5%
(10) Lb/gallon: 9.8
(11) VOC: 170 g/l
(12) Viscosity (77 deg. F): 58 RU"2
(13) Hardness: H-2H
(14) Abrasion resistance (Tabor/CF-10) 500 cycles: 17 gram loss
(15) Gloss 60 deg.: low luster
(16) Coverage: 250 sq. ft./gallon
(17) Scrub Test (1000 revolutions): pass
(18) Ultraviolet Resistance QUV 1000: no effect
(19) Alkali Resistance: excellent
(20) Acid Resistance: good - excellent

3. Construction

(a) Simulated Stone Form Liner System and Surface Finish

Shop drawings and sample panels: Prior to beginning any work, representative shop drawings shall be provided for each form liner pattern and wall. The shop drawings shall represent the average full height of the wall to be constructed for a 90 foot length. For each wall type, one shop drawing shall be provided which indicates the layout of the finish pattern and shall be drawn at a scale sufficient to show the detail of all stone and joint patterns. For each wall type, a shop drawing shall be provided which indicates the specific form liner arrangement, which exactly correlates to the pattern indicated on its companion pattern shop drawing. The form liner shall be patterned so that long continuous horizontal or vertical lines do not occur on the finished exposed surface. The line pattern shall be of a random nature.

The shop drawings shall be submitted to the Engineer for review and approval. If necessary, the shop drawings shall be revised by the Contractor, at no additional cost to the City, until the proposed form liner patterns and arrangement receive the approval of the Engineer.

Once the representative shop drawings have been approved, the Contractor shall then provide and erect on-site, sample panels of the simulated stone masonry form liner patterns and coloration for each pattern type. The size of the sample panels shall be 6 in. thick, 4 ft. wide and 4 ft. high. Sample panels shall also demonstrate the pattern continuing through the expansion joint.

The location of the sample panels shall be readily visible from the proposed work where possible and placed as approved by the Engineer. The Contractor is required to receive approval of sample panels by the Engineer 14 days prior to wall construction starting. The sample panels approved by the Engineer shall remain on the site as a basis for comparison for the work constructed on the project. These sample panels shall serve as "referee walls" and shall be duplicated in form and appearance (texture, size, joint dimension, stone size, and coloration) by all work constructed on the project. Any sample rejected by the Engineer shall be removed from the project and a new sample submitted at no additional cost to the City. Sample panels shall be made until approved by the Engineer.

The architectural surface treatments and patterns of the finished work shall achieve the same final effect as demonstrated on the approved sample panel or panels.

The simulated stone form liner used shall produce the same pattern that is intended for use on the finished structure and shall be incorporated into final work. The test panels shall be unreinforced, vertically cast, concrete constructed to determine the surface texture resulting by use of simulated stone form liner. Unsatisfactory panels shall be removed and replaced with satisfactory panels. Dispose of test panels when all wall construction, finishing, and review is complete, in accordance with the Engineer.

In contracts which specify a special surface finish continuing over the top of poured structures, the sample panel shall demonstrate the final effect as described in this special provision. In wall situations where the rock surface texture is to continue across the top of the wall pour, the simulated stone form liner system supplier shall instruct and supply Contractor with adequate material, training and/or manpower to achieve a realistic simulation of stone texture and patterning. The finish will be achieved at the time the walls are being poured, by hand carving and embossing the still wet, pliable concrete. All rustication joints that are carved in the wet concrete will align with the joints coming from the vertically formed concrete and create natural-looking stone shapes. Great care will be taken to achieve as much relief as possible on all embossed surfaces as per approved test panel/sample. The special simulated stone surface finish continuing over horizontal surface of the top of wall structures shall have a smoother texture and the minimum specified reveal for the pattern.

The simulated stone form liners shall be capable of withstanding anticipated concrete pour pressures without leakage causing physical or visual defects. The simulated stone form liners shall be removable without causing concrete surface deterioration or weakness in the substrate. Form release agents, form stripping methods and patching materials, as well as related construction shall be mutually compatible with Special Surface Finish and Color System to be applied.

Liner butt joints shall be carefully blended into the approved pattern and finished off the final concrete surface. No visible vertical or horizontal seams or conspicuous form marks created by butt joining simulated stone masonry form liners will be allowed.

If form ties (wall ties) are used which result in a portion of the tie permanently embedded in the concrete, the Contractor shall submit the type of form ties to the Engineer for approval prior to use in this work. Form tie holes shall be placed in the high point of the rustication or mortar joint. As described elsewhere in this Specification, the ties shall be so designed that all material in the device to a depth of at least one inch (1") back of the concrete face (bottom of rustication groove or joint) can be disengaged and removed without spalling or damaging the concrete. Form tie holes shall be finished in accordance with standard concrete practices and acceptable to the Engineer. All patching material shall exactly match the color and appearance of the poured concrete wall surface.

When using simulated stone masonry form liners, form designs for the retaining walls shall be sufficient to allow minimum 4-foot on center form ties (wall ties).

Simulated stone masonry form liners shall be installed, prepared, stripped, handled, or otherwise utilized in accordance with the manufacturer's recommendations, or a directed by the Engineer.

(b) Surface Finish

Concrete surfaces as shown in the Plan documents and constructed under this Contract shall receive Special Surface Finish and Color System.

Manufacturer's Technical Representative shall be available for recommendations to the Contractor prior to and during work under this Section. Application test areas for each color will be required prior to beginning the project work as follows:

1) Test (sample) areas shall be located on the test panels in the areas designated by the Engineer and shall include all operations and preparations.

   a. Retesting will be required where results do not meet requirements of these special provisions.

   b. The sample panels shall be finished with the approved finish.

   c. All subsequent work shall conform to the approved test panel.

      Special surface color system shall be performed using approved stains suitable for the purpose intended and applied in a manner consistent with the design intent of the project. The approved sample shall be the basis for determining the appropriate color/stain application.

2) The coloring agent shall be a penetrating stain mix, compatible color finish designed for exterior application on new or old concrete with field evidence of resistance to moisture, alkali, acid and mildew, mold and fungus discoloration or degradation. The coloring agent shall be breathable, allowing moisture and vapor transmission.

3) Final stain colors require approval by the Engineer. Multiple colors will be required, so as to give the appearance of the full range of colors present in the stone work in East Tennessee. These colors shall include the range of browns, tans, buffs, grays, whites, and blacks.

4) All materials shall be furnished, prepared, applied, cured, and stored according to Product Manufacturer directions specified for use intended as specified herein, with special attention given to recommended temperature range.

5) Special Surface Preparation

Work under this Section shall include surface cleaning preparation to assure the surface is free of all latency, dirt, dust, grease, efflorescence, paint, and any foreign material prior to the stain application in accordance with the manufacturer's recommendations. The Contractor shall correct, at his own cost, any surface problems created as a direct result of the surface preparation methods used.

The Contractor is advised that sandblasting will not be allowed for cleaning concrete surfaces, as it will reduce the special surface texture specified elsewhere herein. Pressure washing with water (minimum 3000 psi) is the preferred method of removing latence. If cleaned by pressure washing, a pressure of 3000 psi is a rate of three to four gallons per minute using a fan nozzle held perpendicular to the surface at a distance of one to two feet. The completed surface shall be free of blemishes, discolorations, surface voids, and conspicuous form marks to the satisfaction of the Engineer.

6) Special surface finish shall be applied to all exposed simulated stone formed concrete surfaces except the cap stones, which shall be left unfinished and sealed with a matte finish transparent waterproofing coating, as detailed in the Plan documents.

As may be required on the project, at boundaries between two color tones or between surfaces receiving color at different times, care shall be taken and protection provided to avoid color overlap.

Any areas lacking a uniform appearance (consistent with the approved sample) shall be re-coated to the satisfaction of the Engineer with no additional cost to the City.

7) Grout pattern joints shall have the appearance of mortared joints in a laid up masonry wall. This appearance may be created by spraying a base color over the entire wall. All other colors shall then be hand applied; only the base color may be sprayed.

8) The expansion joints shown on the Plan details shall be finished so as to visually continue the simulated stone pattern uninterrupted. A sample of the colored expansion joint material shall be included in the test panel for approval.

3. Measurement and Payment

Simulated stone surfaces, unless otherwise stipulated, will be measured for payment by the square yard. Computations of the quantities will be based on the dimensions shown on the plans or as ordered in writing by the Engineer. The areas allowed for payment shall include only the areas constructed in accordance with the Plans and Specifications and accepted by the Engineer.

Payment shall be full compensation for the development and preparation of shop drawings, the development and furnishing of all form liners, the construction and finishing of all test panels and all equipment, labor, materials and incidentals necessary to complete the work as specified above and in the Plans.

STANDARD SPECIFICATION FOR MICROPILE CONSTRUCTION

1. Description

   a) This work shall consist of constructing micropiles as shown on the Contract plans in accordance with these Specifications.

   b) The verification of micropile load capacities through the performance of proof load tests.

   c) The work covered by this item shall consist of furnishing of all materials, products, accessories, tools, equipment, services, transportation, labor and supervision, installation and testing of micropiles and pile top attachments.

2. Materials

   a) Admixtures for Grout: Admixtures shall conform to the requirements of ASTM C 494/AASHTO M194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of the Engineer. Admixtures shall be compatible with the grout and mixed in accordance with the manufacture's recommendations. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations and anchorage covers. Accelerators are not permitted. Admixtures containing chlorides are not permitted.

   b) Cement: All cement shall be Portland cement conforming to ASTM C 150/AASHTO M85, Types II, III or V.

   c) Centralizers and Spacers: Centralizers and spacers shall be fabricated from schedule 40 PVC pipe or tube, steel, or material non-detrimental to the reinforcing steel. Wood shall not be used. Centralizers and spacers shall be securely attached to the reinforcement; sized to position the reinforcement within ½ inch of plan location from center of pile; sized to allow grout tremie pipe insertion to the bottom of the drillhole; and sized to allow grout to freely flow up the drillhole and casing and between adjacent reinforcing bars.

   d) Encapsulation: Encapsulation (double corrosion protection) shall be shop fabricated using high-density, corrugated polyethylene tubing conforming to the requirements of ASTM D3350/AASHTO M252 with a nominal wall thickness of 1/32inches. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of ¼ inch and be fully grouted with non-shrink grout conforming to this section.

   e) Epoxy Coating: The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.01 inches. Epoxy coating shall be in accordance with ASTM A775 or ASTM A 934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated.

f) Fine Aggregate: If sand – cement grout is used, sand shall conform to ASTM C 144/AASHTO M45.

g) Grout: Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 2000 psi and a 28-day compressive strength of 4000 psi per AASHTO T106/ASTM C109.

h) Grout Protection: Provide a minimum 1 inch grout cover over bare or epoxy coated bars (excluding bar couplers) or minimum 1/2 inch grout cover over the encapsulation of encapsulated bars.

i) Permanent Casing Pipe: Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness shown on the Drawings. The permanent steel casing/pipe:

1. shall meet the Tensile Requirements of ASTM A252, Grade 3, except the yield strength shall be a minimum of 50 ksi to 80 ksi as indicated on the drawings.
2. may be new "Structural Grade" (a.k.a. "Mill Secondary") steel pipe meeting above but without Mill Certification, free from defects (dents, cracks, tears) and with two coupon tests per truckload delivered to the fabricator.

For permanent casing/pipe that will be welded, the following material conditions apply:

1. the carbon equivalency (CE) as defined in AWS 1.1, Section X15.1, shall not exceed 0.45, as demonstrated by mill certifications.
2. the sulfur content shall not exceed 0.05%, as demonstrated by mill certifications.

For permanent casing/pipe that will be shop or field welded, the following fabrication or construction conditions apply:

1. the steel pipe shall not be joined by welded lap splicing.
2. welded seams and splices shall be complete penetration welds.
3. partial penetration weld may be restored in conformance with AWS D1.1.
4. the proposed welding procedures certified by a welding specialist shall be submitted for approval.

Threaded casing joints shall develop at least the required nominal resistance used in the design of the micropile.

j) Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to ASTM A 36/AASHTO M31, Grade 420 or Grade 520 or ASTM A 722/AASHTO M275, Grade 1035. When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, the threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the Plans shall be provided, at no additional cost.

Bar tendon couplers, if required, shall develop the ultimate tensile strength of the bars without evidence of any failure.

3. Construction Requirements

a) Site Drainage Control

The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accord with the standard Specifications and all applicable local codes and regulations. Provide positive control and discharge of all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the work, remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place, may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation or drilling. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Cost of remedial measures or repair work resulting from encountering unanticipated subsurface drainage structures, will be paid for as Extra Work.

b) Excavation

Coordinate the work and the excavation so the micropile structures are safely constructed. Perform the micropile construction and related excavation in accordance with the Plans and approved submittals. No excavations steeper than those specified herein or shown on the Plans will be made above or below the micropile structure locations without written approval of the Engineer.

c) Micropile Allowable Construction Tolerances

1. Centerline of piling shall not be more than 3 inches from indicated plan location.
2. Pile shall be plumb within 2 percent of total-length plan alignment.
3. Top elevation of pile shall be plus 1 inch or minus 2 inches maximum from vertical elevation indicated.
4. Centerline of reinforcing steel shall not be more than ½ inch from indicated location.

d) Micropile Installation

The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the micropiles. The micropile Contractor shall also determine the micropile casing size, final drillhole diameter and bond length, and central tendon reinforcement steel sizing necessary to develop the specified load capacities and load testing requirements. The micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

e) Drilling

The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services. The drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement.

Temporary casing or other approved method of pile drillhole support will be required in caving or unstable ground to permit the pile shaft to be formed to the minimum design drillhole diameter. The Contractor's proposed method(s) to provide drillhole support and to prevent detrimental ground movements shall be reviewed by the Engineer. Detrimental ground movement is defined as movement that requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

f) Ground Heave or Subsidence

During construction, the Contractor shall observe the conditions vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the Engineer if signs of movements are observed. Contractor shall immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer, the costs of providing corrective actions will be done by the Contractor. When due to differing site conditions, as determined by the Engineer, the costs of providing corrective actions will be paid as Extra Work.

g) Pipe Casing and Reinforcing Bars Placement and Splicing

Reinforcement may be placed either prior to grouting or placed into the grout - filled drillhole before temporary casing (if used) is withdrawn. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

The Contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations.

Centralizers and spacers (if used) shall be provided at 10 foot centers maximum spacing. The upper and lower most centralizer shall be located a maximum of 5 feet in from the top and bottom of the micropile. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. The central reinforcement bars with centralizers shall be lowered into the stabilized drill hole and set. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially

inserted reinforcing bars shall not be driven or forced into the hole. Contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion.

Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Splices and threaded joints shall meet the requirements of the Materials Section. Threaded pipe casing joints shall be located at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, bar splices shall be staggered at least 1 foot.

h) Grouting

Micropiles shall be primary grouted the same day the load transfer bond length is drilled. The Contractor shall use a stable neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength of 4000 psi. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations. The grouting equipment used shall produce a grout free of lumps and undispersed cement. The Contractor shall have means and methods of measuring the grout quantity and pumping pressure during the grouting operations. The grout pump shall be equipped with a pressure gauge to monitor grout pressures. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauges shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. The

grout shall be kept in agitation prior to mixing. Grout shall be placed within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. The grout shall be injected from the lowest point of the drill hole and injection shall continue until uncontaminated grout flows from the top of the pile. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed the grout level is brought back up to the ground level before the next length is removed. The tremie pipe or casing shall always extend below the level of the existing grout in the drillhole. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations. Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout.

If the Contractor elects to use a postgrouting system, Working Drawings and details shall be submitted to the Engineer for review.

i) Grout Testing

Grout within the micropile proof test piles shall attain the minimum required 3-day compressive strength of 2000 psi prior to load testing. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of initial production piles. During production, micropile grout shall be tested by the Contractor for compressive strength in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one set of three 2-inch grout cubes from each grout plant each day of operation or per every 10 piles, whichever occurs more frequently. The compressive strength shall be the average of the 3 cubes tested.

Grout consistency as measured by grout density shall be determined by the Contractor per ASTM C 188/AASHTO T 133 or API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API R-P-13B- I is an approved device for determining the grout density of neat cement grout.

Grout samples shall be taken directly from the grout plant. Provide grout cube compressive strength and grout density test results to the Engineer within 24 hours of testing.

j) Micropile Installation Records

Contractor shall prepare and submit to the Engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on the micropile installation log included at the end of this specification. A separate log shall be provided for each micropile.

k) Pile Load Tests

Perform proof testing of piles at the locations specified herein or designated by the Engineer. Perform compression load testing in accord with ASTM D1143 and tension load testing in accord with ASTM D3689, except as modified herein.

l) Proof Load Tests

Perform proof load tests on the first set of production piles installed at each designated substructure unit prior to the installation of the remaining production piles in that unit. The first set of production piles is the number required to provide the required reaction capacity for the proof tested pile. Proof testing shall be conducted at a frequency of 5% (1 in 20) of the subsequent production piles installed, beyond the first 20, in each abutment and pier. Location of additional proof test piles shall be as designated by the Engineer.

m) Proof Test Loading Schedule

Test piles designated for compression or tension proof load testing to a maximum test load of 1.67 times the micropile Design Load shown on the Plans or Working Drawings. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule, to be used for both compression and tension loading:

AL = Alignment Load		DL = Design Load
	LOAD	HOLD TIME
1	AL	1 minute
2	0.25 DL	1 minute
3	0.50 DL	1 minute
4	0.75 DL	1 minute
5	1.00 DL	1 minute
6	1.33 DL	10 or 60 minute Creep Test
7	1.67 DL (Maximum Test Load)	1 minute
8	AL	1 minute

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.3 3 DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 1 mm, the Maximum Test Load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of DL. Dial gauges shall be reset to zero after the initial AL is applied.

The acceptance criteria for micropile proof load tests are:

1. The pile shall sustain the compression or tension 1.0 DL test load with no more than ¼ inch total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.
2. At the end of the 1.33 DL creep test load increment, test piles shall have a creep rate not exceeding 1 mm/log cycle time (1 to 10 minutes) or 2 mm/log cycle time (6 to 60 minutes). The creep rate shall be linear or decreasing throughout the creep load hold period.
3. Failure does not occur at the 1.67 DL maximum test load. Failure is defined as the load at which attempts to further increase the test load simply result in continued pile movement.

n) Proof Test Pile Rejection

If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall immediately proof test another micropile within that footing. For failed piles and further construction of other piles, the Contractor shall modify the construction procedure or the Engineer shall modify the design or both. These modifications may include installing replacement micropiles, incorporating piles at not more than 50% of the maximum load attained, postgrouting, modifying installation methods, increasing the bond length, or changing the micropile type. Any modification that necessitates changes to the structure design shall require the Engineer's prior review and acceptance. Any modifications of construction procedures, or cost of proof load testing, or replacement production micropiles, shall be paid at the Contract unit price.

4. Method of Measurement

Measurement will be made as follows for the quantity, as specified or directed by the Engineer:

a) Micropiles will be measured per each, installed, and accepted.

b) Micropile proof load testing will be measured per each.

The final pay quantities will be the design quantity increased or decreased by any changes authorized by the Engineer.

5. Basis of Payment

a) The accepted quantities for the items listed below will be paid for at the Contract Unit Price and shall be full compensation for all materials, labor, equipment and incidentals to complete the work in accordance with the Plans and Specifications.

b) The Contract Unit Price for Micropiles shall include the drilling, furnishing, and placing the reinforcing steel and casing, grouting, and pile top attachments.

c) Payment will be made under the following bid items as set forth in the Bid Schedule:

Pay Item	Unit
Micropile	Ea.
Micropile Proof Load Test	Ea.
Micropiles Variations in Length to Top of Rock	Lin. Ft.**

**Where piles are founded in rock, micropiles will be paid on a per each basis assuming Rock at Elevation –25 feet below existing grade. Additional length or shorter length due to variations in the top of rock will be paid on an add or deduct lineal foot basis where the linear footage = Elevation - minus Elevation of As-Built Rock.

TECHNICAL SPECIFICATION
FOR
PERMANENT SOIL NAILS AND WALL EXCAVATION

1. Description

   a) The work shall consist of constructing permanent soil nail retaining walls as specified herein and shown on the plans.

   b) Soil nailing work shall include excavating in accordance with the staged lifts shown in the plans; drilling soil nail drillholes to the specified minimum length and orientation indicated on the plans; providing, placing and grouting the encapsulated or epoxy coated nail bar tendons into the drillholes; placing drainage elements; placing shotcrete reinforcement; applying shotcrete facing over the reinforcement; attaching bearing plates and nuts; performing nail testing; and installing instrumentation (if required).

   c) The work covered by this item shall consist of furnishing all labor, materials and equipment.

2. Materials

   a) Solid Bar Nail Tendons: AASHTO M31/ASTM A615, Grade 60. Deformed bar, continuous without splices or welds, new, straight, undamaged, bare or epoxy coated or encapsulated as shown on the Plans. Threaded a minimum of 6 inches on the wall anchorage end to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g. continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, provide the next larger bar number designation from that shown on the Plans, at no additional cost.

   b) Fusion Bonded Epoxy Coating: ASTM A775. Minimum 0.3 mm thickness electrostatically applied. Bend test requirements are waived. Coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate.

   c) Encapsulation: Minimum 1 mm thick corrugated HDPE tube conforming to AASHTO M252 or corrugated PVC tube conforming to ASTM D1784, Class 13464-B. Encapsulation shall provide at least 5 mm of grout cover over the nail bar and be resistant to ultra violet light degradation, normal handling stresses, and grouting pressures. Factory fabrication of the encapsulation is preferred. Upon the Engineers approval, the encapsulation may be field fabricated if done in strict accordance with the manufacturer's recommendations.

   d) Centralizers: Manufactured from Schedule 40 PVC pipe or tube, steel or other material not detrimental to the nail steel (wood shall not be used); securely attached to the nail bar; sized to position the nail bar within 1 inch of the center of the drillhole; sized to allow tremie pipe insertion to the bottom of the drillhole; and sized to allow grout to freely flow up the drillhole.

e) Nail Grout: Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 1500 psi and a minimum 28-day compressive strength of 3000 psi per AASHTO T106/ASTM C109.

f) Admixtures: AASHTO M194/ASTM C494. Admixtures that control bleed, improve flowability, reduce water content and retard set may be used in the grout subject to review and acceptance by the Engineer. Accelerators are not permitted. Expansive admixtures may only be used in grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations.

g) Cement: AASHTO M85/ASTM C150, Type I, II, III or V.

h) Fine Aggregate: AASHTO M6/ASTM C33.

i) Film Protection: Polyethylene film per AASHTO M171.

j) Bar Couplers: Bar couplers shall develop the full ultimate tensile strength of the bar as certified by the manufacturer.

3. Construction Requirements

a) Site Drainage Control

Provide positive control and discharge of all surface water that will affect construction of the soil nail retaining wall. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the wall, remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place, may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

The regional groundwater table is anticipated to be below the level of the wall excavation based on the results of the geotechnical site investigation. Localized areas of perched water or seepage may be encountered during excavation at the interface of geologic units or from localized groundwater seepage areas.

Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Capture surface water runoff flows and flows from existing subsurface drainage structures independently of the wall drainage network and convey them to an outfall structure or storm sewer, as approved by the Engineer. Cost of remedial measures required to capture and dispose of water resulting from encountering unanticipated subsurface drainage structures will be paid for as Extra Work.

b) Excavation

Coordinate the work and the excavation so the soil nail wall is safely constructed. Perform the wall construction and excavation sequence in accordance with the Plans and approved submittals. No excavations steeper than those specified herein or shown on the Plans will be made above or below the soil nail wall without written approval of the Engineer.

1. Excavation and Wall Alignment Survey Control

Unless specified otherwise, the Engineer will provide survey reference and control points at or offset along the top of wall alignment at approximate 30 foot intervals prior to starting wall excavation. The Contractor will be responsible for providing the necessary survey and alignment control during excavation of each lift, locating and drilling each drillhole within the allowable tolerances and for performing the wall excavation and nail installation in a manner which will allow for constructing the shotcrete construction facing to the specified minimum thickness and such that the finish shotcrete permanent structural facing can be constructed to the specified minimum thickness and to the line and grade indicated in the Plans. Where the as-built location of the front face of the shotcrete exceeds the allowable tolerance from the wall control line shown on the Plans, the Contractor will be responsible for determining and bearing the cost of remedial measures necessary to provide proper attachment of nail head bearing plate connections and satisfactory placement of the final facing, as called for on the Plans.

2. General Excavation

Complete clearing, grubbing, grading and excavation above and behind the wall before commencing wall excavation. Do not over excavate the original ground behind the wall or at the ends of the wall, beyond the limits shown on the Plans. Excavation shall proceed from the top down in a horizontal staged excavation lift sequence with the ground level for each lift excavated no more than mid-height between adjacent nail rows, as illustrated on the Plans. Do not excavate the full wall height to the final wall alignment as shown on the Plans but maintain a working bench of native material to serve as a platform for the drilling equipment. The bench shall be wide enough to provide a safe working area for the drill equipment and workers.

Perform rock blasting within 200 feet of the soil nail wall using controlled blasting techniques designed by a qualified blasting consultant or a Professional Engineer registered in the State of Tennessee. Blasting shall not damage completed soil nail work or disrupt the remaining ground to be soil nailed or shotcreted. Repair damaged areas at no additional cost.

3. Soil Nail Wall Structure Excavation

Structure excavation in the vicinity of the wall face will require special care and effort compared to general earthwork excavation. The excavation Contractor should take this into account during bidding. Due to the close coordination required between the soil nail Contractor and the excavation Contractor, the excavation Contractor shall perform the structure excavation for the soil nail wall under the direction of the soil nail specialty Contractor. The structure excavation pay limits are shown on the Plans.

Excavate to the final wall face using procedures that: (1) prevent over excavation; (2) prevent ground loss, swelling, air slaking, or loosening; (3)

prevent loss of support for completed portions of the wall; (4) prevent loss of soil moisture at the face; and (5) and prevent ground freezing. Costs associated with additional thickness of shotcrete or concrete or other remedial measures required due to irregularities in the cut face, excavation overbreak or inadvertent over excavation, shall be borne by the Contractor.

The exposed unsupported final excavation face cut height shall not exceed the vertical nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Complete excavation to the final wall excavation line and application of the shotcrete in the same work shift unless otherwise approved by the Engineer. Application of the shotcrete may be delayed up to 24 hours if the Contractor can show that the delay will not adversely affect the excavation face stability. A polyethylene film over the face of the excavation may reduce degradation of the cut face caused by changes in moisture. Damage to existing structures or structures included in the Work shall be repaired and paid by the Contractor where approval is granted for the extended face exposure period.

At the Contractor's option, during each excavation lift, nails may be drilled and installed through a temporary stabilizing berm, as illustrated on the Plans. Purpose of the stabilizing berm is to prevent or minimize instability or sloughing of the final excavation face due to ground conditions and/or drilling action. The stabilizing berm geometry illustrated on the plans shows the top of berm extending horizontally out from the bottom front face of the overlying shotcrete a distance of 1 foot and cut down from that point to the base grade for that excavation lift at a slope not steeper than 1H:1V. The Contractor may use a different berm geometry than illustrated on the Plans, upon satisfactory demonstration that the different geometry provides satisfactory performance. Following the installation of nails in that lift, excavate the temporary stabilizing berm to the final wall face excavation line and clean the final excavation face of all loose materials, mud, rebound and other foreign matter which could prevent or reduce shotcrete bond. Ensure that installed nails and corrosion protection are not damaged during excavation of the stabilizing berm. Repair or replace nails or corrosion protection damaged or disturbed during excavation of the stabilizing berm, to the Engineer's satisfaction, at no additional cost. Do not excavate the stabilizing berm until the nail grout has aged for at least 24 hours. Remove hardened nail grout protruding from the final wall excavation line more than 2 inches in a manner that prevents fracturing the grout at the nail head. Sledgehammer removal of the grout is not allowed. The use of hand held rock chippers is acceptable provided their use does not damage or disturb the remaining grout at the nail head, the nail bar or corrosion protection. Alternative excavation and soil nail installation methods that meet these objectives may be submitted to the Engineer for review in accordance with the Submittal section.

Excavation to the next lift shall not proceed until nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts and nail testing has been completed and accepted in the current lift. Nail grout

and shotcrete shall have cured for at least 72 hours or attained at least their specified 3-day compressive strength before excavating the next underlying lift. Excavating the next lift in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for tests performed by a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

Notify the Engineer immediately if raveling or local instability of the final wall face excavation occurs. Unstable areas shall be temporarily stabilized by means of buttressing the exposed face with an earth berm or other methods. Suspend work in unstable areas until remedial measures are developed.

4. Wall Discontinuities

Where the Contractor's excavation and installation methods result in a discontinuous wall along any nail row, the ends of the constructed wall section shall extend beyond the ends of the next lower excavation lift by at least 10 feet. Slopes at these discontinuities shall be constructed to prevent sloughing or failure of the temporary slopes. If sections of the wall are to be constructed at different times, prevent sloughing or failure of the temporary slopes at the end of each wall section.

5. Excavation Face Protrusions, Voids or Obstructions

Remove all or portions of cobbles, boulders, rubble or other subsurface obstructions encountered at the wall final excavation face which will protrude into the design shotcrete facing. Determine method of removal of face protrusions, including method to safely secure remnant pieces left behind the excavation face and for promptly backfilling voids resulting from removal of protrusions extending behind the excavation face. Notify the Engineer of the proposed method(s) for removal of face protrusions at least 24 hours prior to beginning removal. Voids overbreak or over-excavation beyond the plan wall excavation line resulting from the removal of face protrusions or excavation operations shall be backfilled with shotcrete or concrete, as approved by the Engineer. Removal of face protrusions and backfilling of voids or over-excavation is considered incidental to the work. Cost due to removal of unanticipated man-made obstructions will be paid as Extra Work.

c) Nail Installation

Determine the required drillhole diameter(s), drilling method, grout composition and installation method necessary to achieve the nail pullout resistance(s) specified herein or on the Plans, in accordance with the nail testing acceptance criteria in the Nail Testing section.

No drilling or installation of production nails will be permitted in any soil/rock unit until successful pre-production verification testing of nails is completed in that unit and approved by the Engineer. Install verification test nails using the same equipment, methods, nail inclination and drillhole diameter as planned for the production nails. Perform pre-production verification tests in accordance with

the Verification Testing Section prior to starting wall excavation and prior to installation of production nails in the specific lift in which the designated verification test nails are located. The number and location of the verification tests will be as indicated on the Plans or specified herein. Verification test nails may be installed through either the existing slope face prior to start of wall excavation, drill platform work bench, stabilization berm or into slot cuts made for the particular lift in which the verification test nails are located. Slot cuts will only be large enough to safely accommodate the drill and test nail reaction setup. Subject to the Engineer's approval, verification test nails may also be installed at angle orientations other than perpendicular to the wall face or at different locations than specified, as long as the Contractor can demonstrate that the test nails will be bonded into ground which is representative of the ground at the verification test nail locations designated on the Plans or herein. Install the production soil nails before the application of the reinforced shotcrete facing. At the Contractor's request and subject to the Engineer's written approval, the shotcrete facing may be placed before drilling and installing the nails. Provide a blockout through the shotcrete facing at drillhole locations using PVC pipe or other suitable material, to prevent damage to the facing during drilling. As part of the required construction submittals, provide the Engineer with acceptable structural design calculations demonstrating that the facing structural capacity will not be reduced and that the bearing plates are adequate to span the nail drillhole blockout through the construction facing. If this requires larger size bearing plates and/or additional reinforcement beyond that detailed on the Plans, the extra cost will be incidental.

Where necessary for stability of the excavation face, the Contractor shall have the option of placing a sealing layer (flashcoat) of unreinforced shotcrete or steel fiber reinforced shotcrete or of drilling and grouting of nails through a temporary stabilizing berm of native soil to protect and stabilize the face of the excavation per Section 3.b.3 Wall Structure Excavation. Cost shall be incidental to the Work.

The Engineer may add, eliminate, or relocate nails to accommodate actual field conditions. Cost adjustments associated with these modifications shall be made in accordance with the General Provisions of the Contract. The cost of additional material, or installation modifications resulting from actions of the Contractor shall be borne by the Contractor.

1. Drilling

   The drill holes for the soil nails shall be made at the locations, orientations, and lengths shown on the Plans or as directed by the Engineer. Select drilling equipment and methods suitable for the ground conditions encountered. Select drillhole diameter(s) required to develop the specified pullout resistance and to also provide a minimum 1-inch grout cover over bare or epoxy coated bars or minimum 1/2-inch grout cover over the encapsulation of encapsulated nails. A minimum required drillhole diameter is shown on the plans. It is the Contractor's responsibility to determine the final drillhole diameter(s) required to provide the specified pullout resistance. Use of drilling muds such as bentonite slurry to assist in drill cutting removal is not allowed but air may be used. With the Engineer's approval, the Contractor may be allowed to use water or foam flushing upon successful demonstration, at the

Contractor's cost, that the installation method still provides adequate nail pullout resistance. If caving ground is encountered, use cased drilling methods to support the sides of the drillholes. Where hard drilling conditions such as rock, cobbles, boulders, or obstructions are encountered, percussion or other suitable drilling equipment capable of drilling and maintaining stable drillholes through such materials will be used.

Immediately suspend or modify drilling operations if ground subsidence is observed, if the soil nail wall is adversely affected, or if adjacent structures are damaged from the drilling operation. Immediately stabilize the adverse conditions at no additional cost.

2. Nail Bar Installation

Provide nail bars in accordance with the schedules included in the Plans. Provide centralizers sized to position the bar within 1 inch of the center of the drillhole. Position centralizers as shown on the Plans so their maximum center-to-center spacing does not exceed 10 feet. Also locate centralizers within 2feet from the top and bottom of the drillhole. Securely attach centralizers to the bar so they will not shift during handling or insertion into the drill hole yet will still allow grout tremie pipe insertion to the bottom of drillhole and allow grout to flow freely up the hole.

Inspect each nail bar before installation and repair or replace damaged bars or corrosion protection. Check uncased drillholes for cleanliness prior to insertion of the soil nail bar. Insert nail bars with centralizers into the drill hole to the required length without difficulty and in a way that prevents damage to the drill hole, bar, or corrosion protection. Do not drive or force partially inserted soil nails into the hole. Remove nails which cannot be fully inserted to the design depth and clean the drill hole to allow unobstructed installation.

When using cased or hollow stem auger drilling equipment which does not allow for the centralizers to pass through the casing or auger stem, the Contractor may delete the centralizers if the neat cement grout pumped through the casing is placed using grout pressures greater than 150 psi or if the sand-cement grout placed through the stem of the auger has a slump of 8 inches or less.

3. Nail Installation Tolerances

Nails shall not extend beyond the right-of-way or easement limits shown on the Plans. Nail location and orientation tolerances are:

- Nail head location, deviation from plan design location; 6 inches any direction.
- Nail inclination, deviation from plan; + or - 3 degrees.
- Location tolerances are applicable to only one nail and not accumulative over large wall areas. Center nail bars within 1 inch of the center of the drillhole

Soil nails that do not satisfy the specified tolerances, due to the Contractor's installation methods, will be replaced at no additional cost. Backfill abandoned nail drill holes with tremied grout. Nails that encounter unanticipated obstructions during drilling shall be relocated, as approved by the Engineer. Cost of drilling and backfilling drillholes abandoned due to unanticipated obstructions will be paid as Extra Work.

d) Grouting

1. Grout Mix Design

Use a neat cement grout or sand-cement grout. Submit the proposed nail grout mix design to the Engineer for review and approval. The design mix submittal shall include compressive strength test results verifying that the proposed mix will have a minimum 3-day compressive strength of 1500 psi and minimum 28-day compressive strength of 3000 psi.

2. Grout Testing

Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of pre-production verification test nails and initial production nails. During production, nail grout shall be tested by the Contractor in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one test for every 50 cubic yards of grout placed. Provide grout cube test results to the Engineer within 24 hours of testing.

3. Grouting Equipment

Grout equipment shall produce a uniformly mixed grout free of lumps and undispersed cement, and be capable of continuously agitating the mix. Use a positive displacement grout pump equipped with a pressure gauge that can measure at least twice but no more than three times the intended grout pressure. Size the grouting equipment to enable the entire nail to be grouted in one continuous operation. Place the grout within 60 minutes after mixing or within the time recommended by the admixture manufacturer, if admixtures are used. Grout not placed in the allowed time limit will be rejected.

4. Grouting Methods

Grout the drillhole after installation of the nail bar. Each drillhole will be grouted within 2 hours of completion of drilling, unless otherwise approved by the Engineer. Inject the grout at the lowest point of each drill hole through a grout tube, casing, hollow-stem auger, or drill rods. Keep the outlet end of the conduit delivering the grout below the surface of the grout as the conduit is withdrawn to prevent the creation of voids. Completely fill the drillhole in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test bond length of proof tested production nails. At the Contractor’s option, the grout tube may remain in the hole provided it is filled with grout. Grouting before

insertion of the nail is allowed provided the nail bar is immediately inserted through the grout to the specified length without difficulty.

During casing removal for drillholes advanced by either cased or hollow-stem auger methods, maintain sufficient grout level within the casing to offset the external groundwater/soil pressure and prevent hole caving. Maintain grout head or grout pressures sufficient to ensure that the drillhole will be completely filled with grout and to prevent unstable soil or groundwater from contaminating or diluting the grout. Record the grout pressures for soil nails installed using pressure-grouting techniques. Control grout pressures to prevent excessive ground heave or fracturing.

Remove the grout and nail if grouting is suspended for more than 30 minutes or does not satisfy the requirements of this specification or the Plans, and replace with fresh grout and undamaged nail bar at no additional cost.

e) Nail Testing

Perform both verification and proof testing of designated test nails. Perform pre-production verification tests on sacrificial test nails at locations shown on the Plans or listed herein. Perform proof tests on production nails at locations selected by the Engineer. Required nail test data shall be recorded. Do not perform nail testing until the nail grout and shotcrete facing have cured for at least 72 hours and attained at least their specified 3-day compressive strength. Testing in less than 72 hours will only be allowed if the Contractor submits compressive strength test results, for tests performed by a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in the lesser time.

1. Proof Test Nail Unbonded Length

Provide temporary unbonded lengths for each test nail. Isolate the test nail bar from the shotcrete facing and/or the reaction frame used during testing. Isolation of a test nail through the shotcrete facing shall not affect the location of the reinforcing steel under the bearing plate. Accepted proof test nails may be incorporated as production nails provided the temporary test unbonded length is fully grouted subsequent to testing. Submit the proposed test nail isolation methods, methods for providing an unbonded test length and methods for grouting the unbonded length subsequent to testing to the Engineer for review and approval in accordance with the Submittals section. Where temporary casing of the unbonded length of test nails is provided, install the casing in a way that prevents any reaction between the casing and the grouted bond length of the nail and/or the stressing apparatus.

2. Testing Equipment

Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The load cell is required only for the creep test portion of the verification test. Provide description of test setup and jack, pressure gage and load cell calibration curves in accordance with Submittals section.

Design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur. If the reaction frame will bear directly on the shotcrete facing, design it to prevent cracking of the shotcrete. Independently support and center the jack over the nail bar so that the bar does not carry the weight of the testing equipment. Align the jack, bearing plates, and stressing anchorage with the bar such that unloading and repositioning of the equipment will not be required during the test.

Apply and measure the test load with a hydraulic jack and pressure gage. The pressure gauge shall be graduated in 50-psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. Monitor the nail load during verification tests with both the pressure gauge and the load cell. Use the load cell to maintain constant load hold during the creep test load hold increment of the verification test.

Measure the nail head movement with a dial gauge capable of measuring to 0.001 inches. The dial gauge shall have a travel sufficient to allow the test to be done without having to reset the gauge. Visually align the gauge to be parallel with the axis of the nail and support the gauge independently from the jack, wall or reaction frame. Use two dial gauges when the test setup requires reaction against a soil cut face.

3. Pre-production Verification Testing of Sacrificial Test Nails

Pre-production verification testing shall be performed prior to installation of production nails to verify the Contractor's installation methods and nail pullout resistance. Perform pre-production verification tests at the locations and elevations shown on the Plans or herein and per Nail Installation Section 3(c), unless otherwise approved by the Engineer. Perform a minimum of 2 verification tests in each different soil/rock unit and for each different drilling/grouting method proposed to be used, at each wall location. Verification test nails will be sacrificial and not incorporated as production nails. Bare bars can be used for the sacrificial verification test nails.

Develop and submit the details of the verification testing arrangement including the method of distributing test load pressures to the excavation surface (reaction frame), test nail bar size, grouted drillhole diameter and reaction frame dimensioning to the Engineer for approval in accordance with Submittals section. Construct verification test nails using the same equipment, installation methods, nail inclination, and drillhole diameter as planned for the production nails. Changes in the drilling or installation method may require additional verification testing as determined by the Engineer and shall be provided at no additional cost. Payment for additional verification tests required due to differing site conditions, if determined by the Engineer, shall be per the Contract unit price.

Test nails shall have both bonded and temporary unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The

temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable bar structural load is not exceeded during testing, but shall not be less than 10 feet. The allowable bar structural load during testing shall not be greater than 90 percent of the yield strength for Grade 60 bars. The Contractor shall provide larger verification test bar sizes, if required to safely accommodate the 10-foot minimum test bond length and testing to 2 times the allowable pullout resistance requirements, at no additional cost.

The verification test bonded length L_{BV} shall not exceed the test allowable bar structural load divided by 2 times the allowable pullout resistance value. The following equation shall be used for determining the verification test nail maximum bonded length to be used to avoid structurally overstressing the verification test nail bar size:

$L_{BV} = C f_Y A_S / 2 Q_d$, or 10 feet, whichever is greater.

L_{BV} = Maximum Verification Test Nail Bonded Length (feet)
C = 0.9 for Grade 60 bars
f_Y = Bar Yield or Ultimate Stress (psi)
(Note: f_Y = 60 ksi for Grade 60 bars)
A_S = Bar Steel Area (in^2)
2 = Pullout resistance safety factor
Q_d = Allowable pullout resistance (lb/ft, pounds force per lineal foot of grouted nail length, specified herein or on the Plans)

The Design Test Load (DTL) during verification testing shall be determined by the following equation:
DTL = Design Test Load (lbs) = L_{BV} x Q_d
L_{BV} = As-built bonded test length (ft)
Q_d = Allowable pullout resistance (lbs/ft. pounds force per lineal foot of grouted nail length, specified herein or on the Plans)
MTL = 2.0 x DTL = Maximum Test Load (lb)

Verification test nails shall be incrementally loaded to a maximum test load of 200 percent of the Design Test Load (DTL) in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment.

VERIFICATION TEST LOADING SCHEDULE

LOAD	HOLD TIME
AL (.05 DTL max.)	1 minute
0.25 DTL	10 minutes
.50 DTL	10 minutes
0.75 DTL	10 minutes
1.00 DTL	10 minutes
1.25 DTL	10 minutes
1.50 DTL (Creep Test)	60 minutes
1.75 DTL	10 minutes
2.00 DTL(Max.Test Load)	10 minutes

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the Design Test Load (DTL). Dial gauges should be set to "zero" after the alignment load has been applied.

Each load increment shall be held for at least 10 minutes. The verification test nail shall be monitored for creep at the 1.50 DTL load increment. Nail movements during the creep portion of the test shall be measured and recorded at 1 minute, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes. The load during the creep test shall be maintained within 2 percent of the intended load by use of the load cell.

4. Proof Testing of Production Nails

Perform proof testing on 5 percent (1 in 20) of the production nails in each nail row or minimum of 1 per row as designated by the Engineer. A verification test nail successfully completed during production work shall be considered equivalent to a proof test nail and shall be accounted for in determining the number of proof tests required in that particular row.

Production proof test nails shall have both bonded and temporary unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The temporary unbonded length of the test nail shall be at least 3 feet. The bonded length of the test nail shall be determined based on the production nail bar grade and size such that the allowable bar structural load is not exceeded during testing, but shall not be less than 10 feet. Production proof test nails shorter than 4 meters in length may be constructed with less than the minimum 10-foot bond length with the unbonded length limited to 3 feet. The allowable bar structural load during testing shall not be greater than 90 percent of the yield strength for Grade 60 bars.

The proof test bonded length L_{BP} shall not exceed the test allowable bar load divided by 1.5 times the allowable pullout resistance value, or above minimum lengths, whichever is greater. The following equation shall be used for sizing the proof test nail bonded length to avoid overstressing the production nail bar size:

$L_{BP} = C f_Y A_S / 1.5 Q_d$, or above minimum lengths, whichever is greater.

L_{BP} = Maximum Proof Test Nail Bonded Length (ft)
C = 0.9 for Grade 60 bars
f_Y = Bar Yield or Ultimate Stress (psi)
(Note: f_Y = 60,000 psi for Grade 60 bars)
A_S = Bar Steel Area (in^2)
1.5 = Pullout resistance safety factor
Q_d = Allowable pullout resistance (lb/ft, pounds force per lineal foot of grouted nail length, specified herein or on the Plans)

The Design Test Load (DTL) during proof testing shall be determined by the following equation:

DTL = Design Test Load (lb) = L_{BP} x Q_d
L_{BP} = As-built bonded test length (ft)
Q_d = Allowable pullout resistance (lb/ft, pounds force per lineal foot of grouted nail length, specified herein or on the Plans)
MTL = 1.5 x DTL = Maximum Test Load (lb)

Proof tests shall be performed by incrementally loading the proof test nail to a maximum test load of 150 percent of the Design Test Load (DTL). The nail movement at each load shall be measured and recorded by the Engineer in the same manner as for verification tests. The test load shall be monitored by a jack pressure gauge with a sensitivity and range meeting the requirements of pressure gauges used for verification test nails. At load increments other than maximum test load, the load shall be held long enough to obtain a stable reading. Incremental loading for proof tests shall be in accordance with the following loading schedule. The soil nail movements shall be recorded at each load increment.

PROOF TEST LOADING SCHEDULE

LOAD	HOLD TIME
AL (.05 DTL max.)	Until Stable
0.25 DTL	Until Stable
0.50 DTL	Until Stable
0.75 DTL	Until Stable
1.00 DTL	Until Stable
1.25 DTL	Until Stable
1.50 DTL (Max. Test Load)	See Below

The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the Design Test Load (DTL). Dial gauges should be set to "zero" after the alignment load has been applied.

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests shall be performed at the maximum test load (1.50 DTL). The creep

period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1 minutes, 2, 3, 5, 6, and 10 minutes. Where the nail movement between 1 minute and 10 minutes exceeds 1 mm, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20 minutes, 30, 50, and 60 minutes.

5. Test Nail Acceptance Criteria

   a. For verification tests, a total creep movement of less than 2 mm per log cycle of time between the 6 and 60 minute readings is measured during creep testing and the creep rate is linear or decreasing throughout the creep test load hold period.

   b. For proof tests, a total creep movement of less than 1 mm is measured between the 1 and 10 minute readings or a total creep movement of less than 2 mm is measured between the 6 and 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.

   c. The total measured movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.

   d. A pullout failure does not occur at the maximum test load. Pullout failure is defined as the load at which attempts to further increase the test load simply result in continued pullout movement of the test nail. The pullout failure load shall be recorded as part of the test data.

   Successful proof tested nails meeting the above test acceptance criteria may be incorporated as production nails, provided that (1) the unbonded length of the test nail drillhole has not collapsed during testing, (2) the minimum required drillhole diameter has been maintained, (3) the specified corrosion protection is provided, and (4) the test nail length is equal to or greater than the scheduled production nail length. Test nails meeting these requirements shall be completed by satisfactorily grouting up the unbonded test length. Maintaining the temporary unbonded test length for subsequent grouting is the Contractor's responsibility. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, the proof test nail shall become sacrificial and shall be replaced with an additional production nail installed at no additional cost.

f) Test Nail Rejection

If a test nail does not satisfy the acceptance criterion, the Contractor shall determine the cause.

1. Verification Test Nails

The Engineer will evaluate the results of each verification test. Installation methods that do not satisfy the nail testing requirements shall be rejected. The Contractor shall propose alternative methods and install replacement verification test nails. Replacement test nails shall be installed and tested at no additional cost.

2. Proof Test Nails

The Engineer may require the Contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the Engineer may require the installation and testing of additional proof test nails to verify that adjacent previously installed production nails have sufficient load carrying capacity. Contractor modifications may include, but are not limited to; the installation of additional proof test nails; increasing the drillhole diameter to provide increased capacity; modifying the installation or grouting methods; reducing the production nail spacing from that shown on the Plans and installing more production nails at a reduced capacity; or installing longer production nails if sufficient right-of way is available and the pullout capacity behind the failure surface controls the allowable nail design capacity. The nails may not be lengthened beyond the temporary construction easements or the permanent right-of-way shown on the Plans. Installation and testing of additional proof test nails or installation of additional or modified nails as a result of proof test nail failure(s) will be at no additional cost.

g) Nail Installation Records

Records documenting the soil nail wall construction will be maintained by the Engineer, unless specified otherwise. The Contractor shall provide the Engineer with as-built drawings showing as-built nail locations and as-built shotcrete facing line and grade within 5 days after completion of the shotcrete facing and as-built shotcrete permanent facing line and grade within 5 days after completion of the shotcrete permanent facing.

4. Method of Measurement

The unit of measurement for production soil nails will be per lineal foot. The length to be paid will be the length measured along the bar centerline from the back face of shotcrete to the bottom tip end of nail bar as shown on the Plans. No separate measurement will be made for proof test nails, which shall be considered incidental to production nail installation. Specified verification test nails will be measured on a unit basis for each verification test successfully completed. Failed verification test nails or additional verification test nails installed to verify alternative nail installation methods proposed by the Contractor will not be measured.

5. Basis of Payment

a) The accepted quantities of soil nails will be paid for at the Contract unit prices.

b) Payment will be full compensation for all labor, equipment, materials, material tests, field tests and incidentals necessary to acceptably fabricate and construct the soil nails and perform the wall alignment survey control, for the soil nail wall in accordance with all requirements of the Contract.

c) Payment will be made under the following bid items as set forth in the Bid Schedule:

Pay Item	Unit
Permanent Soil Nails	Lineal Feet
Verification Test Nails	Each

TECHNICAL SPECIFICATIONS
FOR
PERMANENT SHOTCRETE FACING AND WALL DRAINAGE

1. Description

Shotcrete facing and wall drainage work consists of furnishing all materials and labor required for placing and securing geocomposite drainage material, connection pipes, footing drains, weepholes and horizontal drains, drainage ditch behind shotcrete wall, reinforcing steel and shotcrete for the permanent shotcrete facing and nail head bearing plates and nuts for the soil nail walls shown on the Plans. The Work shall include any preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints to receive new shotcrete.

2. Materials

Materials shall be delivered, stored and handled to prevent contamination, segregation, corrosion or damage. Store liquid admixtures to prevent evaporation and freezing.

a) Cement: All cement shall conform to ASTM C 150/AASHTO M85, Types I, II, III or V.

b) Aggregates: Aggregate for shotcrete shall meet the strength and durability requirements of AASHTO M6/M80 and the following gradation requirements:

Sieve Size	Percent Passing by Weight
12.5 mm	100
9.50 mm	90-100
4.75 mm	70-85
2.36 mm	50-70
1.18 mm	35-55
0.60 mm	20-35
0.30 mm	8-20
0.15 mm	2-10

Fine aggregate shall conform to the requirements of AASHTO M6/ASTM C33 clean, natural.

Coarse aggregate shall conform to the requirements of AASHTO M80, Class B for quality.

c) Water: AASHTO M157/ASTM C94, clean and potable.

d) Admixtures: Do not use admixtures unless approved by the Engineer. Thoroughly mix admixtures into the shotcrete at the rate specified by the manufacturer. Accelerators (if used) shall be compatible with the cement used, be non-corrosive to steel and not promote other detrimental effects such as cracking or excessive shrinkage. The maximum allowable chloride ion content of all ingredients shall not exceed 0.10% when tested to AASHTO T260.

1. Chemical Admixtures

    a. Accelerator: Shall be fluid type, applied at nozzle, and meet the requirements of AASHTO M194/ASTM C494/ASTM C1141.

    b. Air-Entraining Agent: AASHTO M154/ASTM C260

    c. Water-reducer and Superplastisizer: AASHTO M194/ASTM C494 Type A, C, D, E, F, or G

    d. Retarders: AASHTO M194/ASTM C494 Type B or D

2. Mineral Admixtures

    a. Fly Ash: AASHTO M295/ASTM C618 Type F or C, cement replacement up to 35 percent by weight of cement.

    b. Silica Fume: ASTM C1240, 90 percent minimum silicon dioxide solids content, not to exceed 12 percent by weight of cement.

e) Welded Wire Fabric: AASHTO M55/ASTM A185 or A497

f) Reinforcing Bars for Shotcrete Facing: AASHTO M31/ASTM A615, Grade 420, deformed.

g) Bearing Plates: AASHTO M183/ASTM A36

h) Nuts: AASHTO M291, Grade B, hexagonal, fitted with beveled washer or spherical seat to provide uniform bearing.

i) Curing Compounds: AASHTO M148, Type 1D or Type 2

j) Prepackaged Shotcrete: ASTM C928

k) Drainage Geotextile: Drainage geotextile shall be provided in rolls wrapped with a protective covering and stored in a manner which protects the fabric from mud, dirt, dust, debris, and shotcrete rebound. Protective wrapping shall not be removed until immediately before the geotextile is installed. Extended exposure to ultra-violet light shall be avoided. Each roll of geotextile in the shipment shall be labeled to identify the production run.

    1. For Wall Footing Drain: AASHTO M288 Class 2, Permittivity minimum 0.2 per second; AOS 0.25 mm maximum.

    2. For Drain Strip: AASHTO M288 Class 3, Permittivity minimum 0.2 per second; AOS 0.25 mm maximum.

l) Drainage Aggregate: AASHTO M43/ASTM C33 No. 67 with no more than two percent passing the 0.075 mm sieve.

m) Geocomposite Drain Strip: Geocomposite drain strips shall be provided in rolls wrapped with a protective covering and stored in a manner which protects the fabric from mud, dirt, dust, debris, and shotcrete rebound. Protective wrapping shall not be removed until immediately before the drain strip is installed. Extended exposure to ultra-violet light shall be avoided. Each roll of drain strip in the shipment shall be labeled to identify the production run.

    Miradrain 6000, Amerdrain 500 or approved equal.

n) Film Protection: Polyethylene films per AASHTO M-171.

o) PVC Connector and Drain Pipes

1. Pipe: ASTM 1785 Schedule 40 PVC, solid and perforated wall, cell classification 12454-B or 12354-C, wall thickness SDR 35, with solvent weld or elastomeric gasket joints.

2. Fittings: ASTM D3034, cell classification 12454-B or 12454-C, wall thickness SDR35, with solvent weld or elastomeric gasket joints.

p) Solvent Cement: ASTM D2564

q) Primer: ASTM F656

3. Shotcrete Mix Design

The Contractor must receive notification from the Engineer that the proposed mix design and method of placement are acceptable before shotcrete placement can begin.

a) Proportioning

Proportion the shotcrete to be pumpable with the concrete pump furnished for the work, with a cementing materials content of at least 650 pounds per cubic yard and water/cement ratio not greater than 0.45.

b) Air Entrainment

Air entrainment is required for wet-mix shotcrete. The air content measured at the truck shall be between 7 to 10 percent when tested in accordance with AASHTO T152/ASTM C231. Air entrainment is not required in dry-mix shotcrete.

c) Strength and Durability Requirements

Provide a shotcrete mix capable of attaining 2000 psi compressive strength in 3 days and 4000 psi in 28 days. The average compressive strength of each set of three test cores extracted from test panels or wall face must equal or exceed 85 percent of specified compressive strength, with no individual core less than 75 percent of the specified compressive strength, in accordance with ACI 506.2. The boiled absorption of shotcrete, when tested in accordance with ASTM C642 at 7 days, shall not exceed 8.0 percent.

d) Mixing and Batching

Aggregate and cement may be batched by weight or by volume in accordance with the requirements of ASTM C94 or AASHTO M241/ASTM C685. Mixing equipment shall thoroughly blend the materials in sufficient quantity to maintain placing continuity. Ready mix shotcrete shall comply with AASHTO M157. Shotcrete shall be batched, delivered, and placed within 90 minutes of mixing. The use of retarding admixtures may extend application time beyond 90 minutes if approved by the Engineer.

Premixed and packaged shotcrete mix may be provided for on-site mixing. The packages shall contain materials conforming to the Materials section of this specification. Placing time limit after mixing shall be per the manufacturers' recommendations.

4. Field Quality Control

Both preconstruction test panels (for nozzlemen without previous ACI certification) and production test panels or test cores from the wall facing are required. Qualified personnel in the presence of the Engineer shall perform Shotcreting and coring of test panels. The Contractor shall provide equipment, materials, and personnel as necessary to obtain shotcrete cores for testing including construction of test panel boxes, field curing requirements and coring. Compressive strength testing will be performed by the Engineer. Shotcrete final acceptance will be based on the 28-day strength.

Shotcrete production work may commence upon initial approval of the design mix and nozzlemen and continue if the specified strengths are obtained. The shotcrete work by a crew will be suspended if the test results for their work do not satisfy the strength requirements. The Contractor shall change all or some of the following: the mix, the crew, the equipment, or the procedures. Before resuming work, the crew must shoot additional test panels and demonstrate that the shotcrete in the panels satisfies the specified strength requirements. The cost of all work required to obtain satisfactory strength tests will be borne by the Contractor.

a) Preconstruction Test Panels

Each nozzleman without previous ACI certification shall furnish at least two preconstruction test panels for each proposed mixture being considered and for each shooting position to be encountered on the job. Preconstruction test panels shall be made prior to the commencement of production work using the same equipment, materials, mixture proportions and procedures proposed for the job.

Make preconstruction test panels with minimum dimensions of 2.5 feet square and at least 4 inches thick. Slope the sides of preconstruction and production test panels at 45 degrees over the full panel thickness to release rebound. One preconstruction test panel shall include the maximum anticipated reinforcing congestion shown on the Plans. Cores extracted from the test panel shall demonstrate encapsulation of the reinforcement in accordance with ACI 506.2 equal to core grade 2 or better. The other preconstruction test panel shall be constructed without reinforcement and have cores extracted for absorption and compressive strength testing.

b) Production Test Panels

Furnish at least one production test panel or, in lieu of production test panels, nine 3-inch diameter cores taken from the shotcrete facing, during the first production application of shotcrete and henceforth for every 5000 ft^2 of shotcrete placed. Construct the production test panels simultaneously with the shotcrete facing installation at times designated by the Engineer. Make production test panels with minimum full thickness dimensions of 1.5 feet square and at least 4 inches thick.

c) Test Panel Curing, Test Specimen Extraction and Testing

Immediately after shooting, field moist cure the test panels by covering and tightly wrapping with a sheet of material meeting the requirements of ASTM C171 until they are delivered to the testing lab or test specimens are extracted. Do not immerse the test panels in water. Do not further disturb test panels for the first 24 hours after shooting. Provide at least three 3-inch diameter core samples cut from each preconstruction test panel with reinforcement, for core grading. Provide

at least nine 3-inch diameter core samples cut from each unreinforced preconstruction and production test panel for absorption and compressive strength testing. Contractor has the option of extracting test specimens from test panels in the field or transporting to another location for extraction. Keep panels in their forms when transported. Do not take cores from the outer 6 inches of test panels measured in from the top outside edges of the panel form. Trim the ends of the compressive strength cores to provide test cylinders at least 3 inches long. Do not trim the ends of the cores to be tested for boiled absorption. If the Contractor chooses to take cores from the wall face in lieu of making production test panels, the Engineer will designate locations. Clearly mark the cores and container to identify the core locations and whether they are for preconstruction or production testing. If for production testing, mark the section of the wall represented by the cores on the cores and container. Immediately wrap cores in wet burlap or material meeting the requirements of ASTM C171 and seal in a plastic bag. Deliver cores to the testing lab within 48 hours of shooting the panels. The remainder of the panels will become the property of the Contractor. The Contractor shall perform compressive strength and boiled absorption tests. Upon delivery to the testing lab, samples will be placed in the moist room until the time of test. When the test length of a core is less than twice the diameter, the correction factors given in AASHTO T24/ASTM C42 will be applied to obtain the compressive strength of individual cores. Three cores will be tested at 3 days and three cores will be tested at 28 days for compressive strength per AASHTO T24/ASTM C42. Three cores will be tested at 7 days for boiled absorption per ASTM C642.

Fill core holes in the wall by dry packing with non-shrink patching mortar after the holes are cleaned and dampened. Do not fill core holes with shotcrete.

5. Construction Requirements

a) Wall Drainage Network

Install and secure all elements of the wall drainage network as shown on the Plans, specified herein, or as required by the Engineer to suit the site conditions. The drainage network shall consist of installing geocomposite drain strips, PVC connection pipes and wall footing drains as shown on the Plans or as directed by the Engineer. Exclusive of the wall footing drains, all elements of the drainage network shall be installed prior to shotcreting.

Unanticipated subsurface drainage features exposed in the excavation cut face shall be captured independently of the wall drainage network and shall be mitigated prior to shotcrete application. Costs due to the required mitigation will be paid for as Extra Work.

1. Geocomposite Drain Strips

Install geocomposite drain strips centered between the columns of nails as shown on the Plans. The drain strips shall be at least 12 inches wide and placed with the geotextile side against the ground. Secure the strips to the excavation face and prevent shotcrete from contaminating the groundside of the geotextile. Drain strips will be continuous. Splices shall be made with a 1-foot minimum overlap such that the flow of water is not impeded.

Repair damage to the geocomposite drain strip, which may interrupt the flow of water.

2. Footing Drains

Install footing drains at the bottom of each wall as shown on the Plans. The drainage geotextile shall envelope the footing drain aggregate and pipe and conform to the dimensions of the trench. Overlap the drainage geotextile on top of the drainage aggregate as shown on the Plans. Replace or repair damaged or defective drainage geotextile.

3. Connection Pipes and Weepholes

Install connection pipes as shown on the Plans. Connection pipes are lengths of solid PVC pipe installed to direct water from the geocomposite drain strips into a footing drain or to the exposed face of the wall. Connect the connection pipes to the drain strips using either prefabricated drain grates as shown on the Plans or using the alternate connection method described below. Install the drain grate per the manufacturer's recommendations. The joint between the drain grate and the drain strip and the discharge end of the connector pipe shall be sealed to prevent shotcrete intrusion. Connection pipes that end at the footing drain shall be extended to the edge of the drain. Do not puncture the drainage fabric around the footing drain.

The alternative acceptable method for connection of the connector pipe to the drain strip involves cutting a hole slightly larger than the diameter of the pipe into the strip plastic core but not through the geotextile. Wrap both ends of the connection pipe in geotextile in a manner that prevents migration of fines through the pipe. Tape or seal the inlet end of the pipe where it penetrates the drain strip and the discharge end of the connector pipe in a manner that prevents penetration of shotcrete into the drain strip or pipe. To assure passage of groundwater from the drain strip into the connector pipe, slot the inlet end of the connector pipe at every 45 degrees around the perimeter of the pipe to a depth of 6 mm.

Weepholes, if required, shall be provided through the shotcrete facing to drain water from behind the facing. Install as shown on the Plans. Use PVC pipe to form the weephole through the shotcrete. Cover the end of the pipe contacting the soil with a drainage geotextile. Prevent shotcrete intrusion into the discharge end of the pipe.

b) Permanent Shotcrete Facing

1. Shotcrete Alignment and Thickness Control

Ensure that the thickness of shotcrete satisfies the minimum requirements shown on the Plans using shooting wires, thickness control pins, or other devices acceptable to the Engineer. Install thickness control devices normal to the surface such that they protrude the required shotcrete thickness outside the surface and maintain a plane surface. The maximum distance between the wires on any surface shall be equal to the vertical nail spacing. Ensure that the alignment wires are tight, true to line, and placed to allow further tightening. Remove shooting wires after

completion of shotcreting and/or screeding. Ensure that the front face of the shotcrete does not extend beyond the limits shown on the Plans.

2. Surface Preparation

Clean the face of the excavation and other surfaces to be shotcreted of loose materials, mud, rebound, overspray or other foreign matter that could prevent or reduce shotcrete bond. Protect adjacent surfaces from overspray during shooting. Avoid loosening, cracking, or shattering the ground during excavation and cleaning. Remove any surface material that is so loosened or damaged, to a sufficient depth to provide a base that is suitable to receive the shotcrete. Remove material that loosens as the shotcrete is applied. Cost of additional shotcrete is incidental to the work. Divert water flow and remove standing water so that shotcrete placement will not be detrimentally affected by standing water. Do not place shotcrete on frozen surfaces.

3. Delivery and Applications

Maintain at all times a clean, dry, oil-free supply of compressed air sufficient for maintaining adequate nozzle velocity and for simultaneous operation of a blowpipe for cleaning away rebound. The equipment shall be capable of delivering the premixed material accurately, uniformly, and continuously through the delivery hose. Control shotcrete application thickness, nozzle technique, air pressure, and rate of shotcrete placement to prevent sagging or sloughing of freshly applied shotcrete.

Apply the shotcrete from the lower part of the area upwards to prevent accumulation of rebound. Orient nozzle at a distance and approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. Pay special attention to encapsulating reinforcement. Care shall be taken while encasing reinforcing steel and mesh to keep the front face of the reinforcement clean during shooting operations, so that shotcrete builds up from behind, to encase the reinforcement and prevent voids and sand pockets from forming. Use a blowpipe to remove rebound and overspray immediately ahead of the nozzle. Do not work rebound back into the construction. Remove rebound that does not fall clear of the working area. Hardened rebound and hardened overspray shall be removed prior to application of additional shotcrete, using abrasive blast cleaning, chipping hammers, high pressure water blasting or other suitable techniques. When the thickness of an individual shotcrete layer is 6 inches or greater, or when shotcreting is conducted through two curtains of reinforcement, place shotcrete by the bench gunning method. The bench gunning method shall consist of building up a thick layer of shotcrete from the bottom of the lift and maintaining the top surface at approximately a 45-degree slope. Where shotcrete is used to complete the top ungrouted zone of the nail drill hole near the face, position the nozzle into the mouth of the drillhole to completely fill the void.

A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements after they are covered with

shotcrete will be considered an indication of insufficient reinforcement cover or poor nozzle techniques. In this case the application of shotcrete shall be immediately suspended and the Contractor shall implement corrective measures before resuming the shotcrete operations. The shotcreting procedure may be corrected by adjusting the nozzle distance and orientation, by insuring adequate cover over the reinforcement, by adjusting the water content of the shotcrete mix or other means. Adjustment in water content of wet-mix will require requalifying the shotcrete mix.

When using multiple layer shotcrete construction, the surface of the receiving layer shall be prepared before application of a subsequent layer, by either: (a) Brooming the stiffening layer with a stiff bristle broom to remove all loose material, rebound, overspray or glaze, prior to the shotcrete attaining initial set: or (b) If the shotcrete has set, surface preparation shall be delayed at least 24 hours, at which time the surface shall be prepared by sandblasting or high pressure water blasting, to remove all loose material, rebound, hardened overspray, glaze, or other material that may prevent adequate bond.

4. Defective Shotcrete

The Engineer shall have authority to accept or reject the shotcrete work. Shotcrete that does not conform to the project Specifications may be rejected either during the shotcrete application process, or on the basis of tests on the test panels or completed work. Repair shotcrete surface defects as soon as possible after placement. Remove and replace shotcrete that exhibits segregation, honeycombing, lamination, voids, or sand pockets. In-place shotcrete determined not to meet the specified strength requirement will be subject to remediation as determined by the Engineer. Possible remediation options include placement of additional shotcrete thickness or removal and replacement, at the Contractor's cost.

5. Construction Joints

Taper construction joints uniformly toward the excavation face over a minimum distance equal to the thickness of the shotcrete layer. Square joints are not permitted. The surface of the joints shall be rough, clean, and sound. Provide a minimum reinforcement overlap at reinforcement splice joints as shown on the Plans. Clean and wet the surface of a joint before adjacent shotcrete is applied. Where shotcrete is used to complete the top ungrouted zone of the nail drill hole near the face, to the maximum extent practical, clean and dampen the upper grout surface to receive shotcrete, similar to a construction joint.

6. Final Face Finish

Shotcrete finish shall be either an undisturbed gun finish as applied from the nozzle or a rod, broom, wood float, rubber float, steel trowel or rough screeded finish as shown on the Plans or specified herein.

7. Attachment of Nail Head Bearing Plate and Nut

Attach a bearing plate and nut to each nail head as shown on the Plans. While the shotcrete is still plastic and before its initial set, uniformly seat the plate on the shotcrete by hand wrench tightening the nut. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout. After grout has set for 24 hours, hand wrench tighten the nut. Embed the bearing plate and nut in the wall as shown on the Plans. Ensure full shotcrete encapsulation of the bearing plate and nut free of any voids or pockets behind the plate. Ensure bearing plates with headed studs are located within the tolerances shown on the Plans or specified herein.

8. Weather Limitations

Protect the shotcrete if it must be placed when the ambient temperature is below 5°C and falling or when it is likely to be subjected to freezing temperatures before gaining sufficient strength. Maintain cold weather protection until the in-place compressive strength of the shotcrete is greater than 750 psi. Cold weather protection includes blankets, heating under tents, or other means acceptable to the Engineer. The temperature of the shotcrete mix, when deposited, shall be not less than 10° C or more than 35° C. Maintain the air in contact with shotcrete surfaces at temperatures above 0° C for a minimum of 7 days shall.

If the prevailing ambient conditions (relative humidity, wind speed, air temperature and direct exposure to sunlight) are such that the shotcrete develops plastic shrinkage and/or early drying shrinkage cracking, shotcrete application shall be suspended. The Contractor shall: (a) reschedule the work to a time when more favorable ambient conditions prevail; and/or (b) adopt corrective measures, such as installation of sun-screens, wind breaks or fogging devices, to protect the work. Remove and replace newly placed shotcrete exposed to rain that washes out cement or otherwise makes the shotcrete unacceptable.

a. Curing

Protect permanent shotcrete from loss of moisture for at least 7 days after placement. Cure shotcrete by methods that will keep the shotcrete surfaces adequately wet and protected during the specified curing period. Commence curing within 1 hour of shotcrete application. When the ambient temperature exceeds 27° C, plan the Work such that curing can commence immediately after finishing. Complete curing in accordance with the following requirements.

b. Water Curing

Regulate the rate of water application to keep the surface continuously wet and to provide complete surface coverage with a minimum of runoff. The use of intermittent wetting procedures that allow the shotcrete to undergo wetting and drying during the curing period is prohibited.

c. Membrane Curing

Do not use curing compounds on any surfaces against which additional shotcrete or other cementitious finishing materials are to be bonded unless the surface is thoroughly sandblasted in a manner acceptable to the Engineer. Membrane curing compounds are to be spray applied as quickly as practical after initial shotcrete set at a coverage of not less than 2.5 m^2/liter.

d. Film Curing

Film curing with polyethylene sheeting may be used to supplement water curing on shotcrete that will be covered later with additional shotcrete or concrete. Spray the shotcrete surface with water immediately prior to installation of the polyethylene sheeting. Polyethylene sheeting shall completely cover the surfaces. Overlap the sheeting edges for proper sealing and anchorage. Joints between sheets shall be sealed. Promptly repair any tears, holes, and other damage. Anchor sheeting as necessary to prevent billowing.

9. Permanent Shotcrete Facing Tolerances

Construction tolerances for the permanent shotcrete facing are as follows:

Horizontal Location of Wire Mesh; Rebar; Headed Studs on Bearing Plates, from Plan location; + or – 5/8 inches

Headed studs location on bearing plate, from plan location: 1/4 inch

Spacing between reinforcing bars, from plan dimension: 1 inch

Reinforcing lap, from specified dimension: - 1 inch

Complete thickness of shotcrete, from plan dimension:

If troweled or screeded: - ½ inch
If left as shot: - 1 inch

Planeness of finish face surface-gap under 10 foot straightedge-any direction:

If troweled or screeded: ½ inch
If left as shot: 1 inch

Nail head bearing plate, deviation from parallel to wall face: 10 degrees

c) Backfilling Behind Wall Facing Upper Cantilever

Compact backfill within 3 feet behind the wall facing upper cantilever using light mechanical tampers.

d) Safety Requirements

Nozzlemen and helpers shall be equipped with gloves, eye protection, and adequate protective clothing during the application of shotcrete. The Contractor is responsible for meeting all federal, state and local safety code requirements.

6. Method of Measurement

The shotcrete facing will be measured in square feet of the shotcrete area completed and accepted in the final work. The net area lying in a plane of the outside front face of the structure as shown on the Plans will be measured. No measurement or payment will be made for additional shotcrete or Shotcrete permanent facing needed to fill voids created by irregularities in the cut face, excavation overbreak or inadvertent excavation beyond the plan final wall face excavation line, or failure to construct the facing to the specified line and grade and tolerances. The final pay quantity shall include all structural shotcrete, admixtures, reinforcement, welded wire mesh, wire holding devices, wall drainage materials, bearing plates and nuts, test panels and all sampling, testing and reporting required by the Plans and this Specification. The final pay quantity shall be the design quantity increased or decreased by any changes authorized by the Engineer.

7. Basis of Payment

a) The accepted quantity measured as provided above will be paid for at the Contract unit price per square foot.

b) Payment will be full compensation for furnishing all equipment, materials, labor, tools and incidentals necessary to complete the work as specified and as detailed on the Plans, including the work required to provide the proper shotcrete facing alignment and thickness control.

c) All wall drainage materials including geocomposite drain strips, connection pipes, drain grates, drain aggregate and geotextile, fittings, and accessories are considered incidental to the shotcrete facing and will not be paid separately.