DIVISION II
CONSTRUCTION AND MATERIAL SPECIFICATIONS
SEWERS

SECTION 2600 STORM SEWERS

APPROVED AND ADOPTED THIS 17th DAY OF APRIL, 1996

KANSAS CITY METROPOLITAN CHAPTER
OF THE AMERICAN PUBLIC WORKS ASSOCIATION

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DIVISION II
CONSTRUCTION AND MATERIAL SPECIFICATIONS
SEWERS

SECTION 2600 STORM SEWERS

SECTION 2601 GENERAL

2601.1 Description: Storm sewer construction shall consist of furnishing all labor, materials, and equipment necessary for the complete installation of storm sewers and appurtenances in accordance with the Standard Drawings, Contract Drawings, General Provisions and Covenants, specifications and standards referenced herein, and these specifications. Unless otherwise noted within these specifications, the word "sewers" shall refer to pipe sewers, box culvert sewers, or open channels.

2601.2 Definitions: The term "Engineer" whenever referred to in these specifications shall mean the representative of the Governing Agency authorized to determine compliance of the Contractor's work with the requirements of the specifications as defined in the General Provisions and Covenants and/or Special Provisions.

2601.3 Specification Modification: It is understood that throughout this section these specifications may be modified or deleted by appropriate items in the Special Provisions or notes on the Contract Drawings.

2601.4 Revisions of Standards: When reference is made to a standard specification (ASTM, AWWA, MCIB, and other technical associations), the specification referred to shall be understood to mean the latest revision of said specification as amended at the time of the Notice to Bidders, except as noted on the Contract Drawings or as provided for in the Special Provisions.

2601.5 Applicable APWA Standards: Work incidental to construction of storm sewers shall be performed in accordance with the following APWA Standard Specifications:

Section 2100 Grading and Site Preparation.

Section 2200 Paving and Curbs.

Section 2306 Maintenance of Traffic.

Section 2400 Seeding and Sodding.

2601.6 Cleanup: Cleanup shall follow the work progressively. The Contractor shall remove from the project site all rubbish, equipment, tools, surplus or discarded materials, and temporary construction items.

Streets to be opened to local traffic at the end of the day's operation shall be cleaned of dirt or mud. All equipment and material stockpiles shall be secured for safe passage of vehicles and pedestrians.

Payment, as described in Section 2606, will be made for completed units of work. A completed unit of work includes the cleanup and all the other work necessary to complete the unit for payment.

SECTION 2602 PIPE SEWER CONSTRUCTION

2602.1 Scope: This section governs the construction of pipe storm sewers and appurtenances at the location and to the lines and grades indicated on the Contract Drawings.

2602.2 Materials:

A. **Reinforced Concrete Pipe:**

1. **Pipe:** Reinforced concrete pipe shall conform to the following ASTM Standards and be of the minimum strength designated herein or such higher strength as may be required by the Contract Drawings or Special Provisions:

   a. **Round Pipe:** ASTM C 76, Class III, Wall B.

   b. **Elliptical Pipe:** ASTM C 507, Class HE-III.

   c. **Arch Culvert Pipe:** ASTM C 506, Class A-III.

2. **Joints:**

   a. **Flexible Gasket:** Flexible gaskets may be either flat gaskets cemented to the pipe tongue or spigot, O-ring gaskets, or roll-on gaskets. All gaskets shall conform to ASTM C 443.

   b. **Cement Mortar:** Cement mortar shall consist of one part Type 1 portland cement by volume to three parts sand conforming to ASTM C 144 by volume mixed with sufficient water to form a workable stiff mortar paste.

c. **Plastic Compound:** This compound shall be a homogeneous blend of bituminous material, inert filler and suitable solvents or plasticizing compounds throughly mixed at the factory to a uniform consistency suitable for sealing joints of concrete pipe. The compound shall conform to the following requirements:

Bitumen, soluble in CS_2, percent by weight, minimum	45%
Ash, percent by weight	15-50%
Penetration, standard cone, 150g, 5 seconds, 25° C	
Trowel grade, bulk type	110-250mm
Extruded rope or flat tape type	50-120mm

The above penetration ranges include test tolerances.

d. **Preformed Plastic Compound:** This compound shall be either rope form or flat tape form conforming to ASTM C 990. Primer, as recommended by the manufacturer, shall be used to maintain the material in position while pipe sections are being joined.

B. **Corrugated Steel Pipe:** Pipe and coupling bands shall conform to the requirements of ASTM A 760/A 760M. Bituminous and/or other coatings shall be provided when required by the Special Provisions. All helical pipe shall have circumferential recorrugated ends with a minimum of 4 recorrugations on each pipe. Bituminous coating shall conform to AASHTO M-190. Minimum thickness of the metal after galvanizing shall be as follows:

2602.2 B.

Circular Culvert Pipe
(2-2/3" x ½" corrugations)

Under Roadways or In Street Right-of-Way		Under Railroads		Not Under Roadways	
Diameter	Minimum Thickness	Diameter	Minimum Thickness	Diameter	Minimum Thickness
12-21"	.064"	12-18"	.079"	12-30"	.064"
24-30"	.079"	21-24"	.109"	36-54"	.079"
36-54"	.109"	30-36"	.138"	60-84"	.109"
60-72"	.138"	42-84"	.168"		
84"	.168"				

Circular Culvert Pipe
(3"x 1" and 5" x 1" corrugations)

Under Roadways or In Street Right-of-Way		Not Under Roadways	
Diameter	Minimum Thickness	Diameter	Minimum Thickness
36-54"	.079"	36-54"	.064"
60-84"	.109"	60-84"	.079"

Arch Culvert Pipe
(2-2/3" x ½" corrugations)

Equivalent Diameter	Minimum Thickness	Span*	Rise*
15"	.064"	17"	13"
18"	.064"	21"	15"
21"	.064"	24"	18"
24"	.079"	28"	20"
30	.079"	35"	24"
36"	.109"	42"	29"
42"	.109"	49"	33"
48"	.109"	57"	38"
54"	.109"	64"	43"
60"	.138"	71"	47"

* Subject to manufacturing tolerances.

Arch Culvert Pipes
(3" x 1" corrugations)

Equivalent Diameter	Minimum Thickness	Span*	Rise*
36"	.064"	40"	31"
42"	.064"	46"	36"
48"	.064"	53"	41"
54"	.079"	60"	46"
60	.079"	66"	51"
66"	.079"	73"	55"
72"	.079"	81"	59"
78"	.109"	87"	63"
84"	.109"	95"	67"
90"	.109"	103"	71"

* Subject to manufacturing tolerances.

C. **Structural Plate Pipe and Pipe Arches:** Structural plate and galvanizing shall conform to the requirements of ASTM A 761/A 761M. Bolts, nuts, and washers for connecting plates shall be galvanized in accordance with ASTM A 153. Bolts shall be not less than 3/4 inch diameter and conform to ASTM A 449. Nuts shall conform to ASTM A 563, Grade C.

D. **Vitrified Clay Pipe:** Vitrified clay pipe shall be extra strength vitrified clay pipe and shall conform to ASTM C 700. Compression joints for vitrified clay pipe and fittings shall conform to ASTM D 425.

E. **Ductile Iron Pipe:** Ductile iron pipe shall conform to ANSI/AWWA C151/A21.51 and shall be furnished with standardized mechanical or push-on joints conforming to ANSI/AWWA Cl l l/A21.l l. Minimum wall thickness shall be Class 52.

F. **Alternate Pipe Materials:** Pipe materials not covered in 2602.2A through 2602.2E may be utilized with the approval of the governing jurisdiction or Engineer and the following minimum criteria submitted.

1. Pipe material specification
2. Bedding conditions and materials
3. Backfill specifications applicable to installation
4. Quality Control required to insure proper installation
5. Manufacturers certification and test data that pipe supplied meets specification
6. Design calculations, for imposed loading as approved by Governing Jurisdiction, sealed by a Registered Professional Engineer licensed in the state of installation. Loading condition tables distributed by the pipe manufacturer may also be used if the table is computed by a Registered Professional Engineer. The tables shall state the limits of their use.
7. Hydraulic analysis and "n" values.

All other requirements specified for storm sewers are applicable.

G. **Granular Bedding Material:** Granular bedding material shall be crushed stone or pea gravel conforming to MCIB, Section No. 4 (Materials), Column No. 3, (Coarse Aggregate), or as approved by the Engineer.

H. **Flowable Backfill: Controlled Low Strength Material (CLSM)**

1. **Description.** This item shall govern for the backfilling of structures, pipes, and all spaces excavated for, and not occupied by new structures. It may be used as backfill of concrete walls, as backfill to new culverts in lieu of soil backfill, as fill in abandoned structures, and for other uses as approved by the Engineer.

The **CLSM** shall be composed of portland cement, fly ash (optional), fine aggregate, coarse aggregate (optional), water, and a shrinkage compensator, proportioned as hereinafter provided or an acceptable mix as approved by the Engineer.

2. **Materials.**

a. **Cement:** The cement shall be either Type I or II portland cement.

b. **Fly Ash:** Fly ash, when used, shall conform to the requirements of ASTM C 618 Class C.

c. **Air Entrainment:** Admixture shall consist of an organic(s) compound which when added to the mix in accordance with the manufacturer's recommendation will result in air contents as prescribed by ASTM C 173 or C 231.

d. **Fine Aggregate:** Fine aggregate shall be washed and consist of clean, hard, durable, and uncoated particles of natural or manufactured sand or a combination thereof, with or without a mineral filler. Aggregate shall be free from frozen materials or injurious amounts of salt, alkali, vegetable matter or other objectionable material.

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

e. **Coarse Aggregate:** With the Engineer's approval, the CLSM backfill may be supplemented with sound, durable, clean rock or broken concrete (2" to 8" square) to minimize the quantity of CLSM material placed. The CLSM shall be placed to a depth of 2 feet. Clean aggregate may be added to the CLSM mixture until the top of the CLSM and the top of the aggregate are approximately equal. The process may be repeated as required until the fill is completed.

f. **Mixing Water:** Mixing water shall be clean, and free from injurious amounts of sewage, oil, acid, alkali, salt, or organic matter. (Only potable water will be acceptable without testing).

3. **Mix Design.** Unless otherwise shown on the Contract Drawings the Contractor may furnish either mix design type A or B. The following is given as typical mix design for trial mixes. Adjustments of the proportions of fine aggregate and/or water may be made to achieve proper solid suspension and optimum flowability with the approval of the Engineer. The mix design shall contain a shrinkage compensator as approved by the Engineer.

MIX DESIGN TYPE A (REMOVABLE) LESS THAN 100 PSI	MIX DESIGN TYPE B (PERMANENT) GREATER THAN 150 PSI
Cement.....144 lbs	100 lbs
Water.....396 lbs	417 lbs
Sand.....2698 lbs	2766 lbs
A/E.....13%	4%
Class C Fly Ash.....0	300 lbs

The shrinkage compensator shall be proportioned in accordance with the manufacturer's recommendations.

The CLSM shall be transit mix. No blade mixing will be allowed.

4. **Construction Methods:** Where CLSM is being placed over or adjacent to crushed stone backfill, a layer of filter fabric (ref. 2605.2C2) shall be installed between the two materials.

5. **Testing:**

   a. Bearing strength shall be determined using penetration testing in accordance with ASTM C 403.

   b. The flow of CLSM shall be tested in accordance with ASTM C 939.

   c. Unit weight and yield shall be tested in accordance with ASTM C 138.

   d. Air content shall be tested in accordance with ASTM C 231.

   e. Sample and remix sample shall be tested in accordance with ASTM C 172.

6. **References:** MCIB section 4-2., "Fly Ash Mix Designs" may be used in lieu of the above mixes as approved by the Engineer or governing jurisdiction.

2602.3 Construction Details:

A. **Trench Excavation:** Trenches shall be excavated to the width and depth as necessary to lay the sewer pipe to the grade line as indicated on the Contract Drawings. Deviation in indicated alignment will not be permitted except under special circumstances; subject to approval of the Engineer. Excavated materials are to be deposited beside trenches and excavations, beyond the reach of slides, transported to the spoil banks, or used for backfilling. The length of trench excavation opened at one time shall be limited depending on the nature of the soil or other safety considerations. Prior to excavation of the sewer trench in fill areas, fill shall be compacted to a minimum 90% of maximum density (as determined by ASTM D 698) to a minimum depth of 18 inches above the top of pipe.

Trenches shall be excavated to a width which will provide adequate working space and pipe clearances for proper pipe installation, jointing, and embedment. However, the limiting trench widths must comply with bedding class requirements as shown on the Contract Drawings. Over-excavation shall be replaced with granular bedding material.

The Contractor shall brace and shore all trenches in full accordance with Occupational Safety and Health Standards - Excavations; Final Rule 29 CFR Part 1926.

1. **Unclassified Excavation:** Unclassified excavation is defined as the removal of all material encountered regardless of its nature. All material excavated will be considered as Unclassified Excavation unless the Special Provisions specify Classified Materials.

2. **Rock Excavation:** Rock excavation is defined as the removal of all rock ledges 6 inches or more in thickness, detached rock or boulders having a volume of more than 1-1/2 cubic yards, and shale occurring in its natural state, hard and unweathered.

   A rock ledge is defined as a continuous body of rock; which may include interbedded seams of shale or other soft materials. Such interbedded soft material seams less than 12 inches in thickness will be included in the measurement of rock excavation. Such seams 12 inches or greater in thickness will be included only in the measurement of earth excavation.

No soft or disintegrated rock which can be removed with a pick or digging machine, no loose, shaken or previously blasted rock, no broken stones, and no rock which may fall into the trench from outside the limits of excavation will be considered as rock excavation. When solid rock is encountered in the trench, it shall be stripped of earth, and the Engineer notified.

When blasting is permitted by the Engineer, the Contractor shall use the utmost care to protect life and property. The Contractor shall comply with all laws, ordinances, and applicable safety code requirements and regulations relative to the handling, storage and use of explosives and protection of life and property, and he shall be responsible for all damage thereto caused by his or his subcontractor's operations.

The Contractor shall provide insurance as required by the General Provisions and Covenants and Special Provisions before performing any blasting. The governing agency shall be notified at least 24 hours before blasting operations begin.

3. **Earth Excavation:** Earth excavation is defined as the removal of all material not defined as rock.

4. **De-watering:** The Contractor shall remove any water which may accumulate, or be found in the trenches and other excavations made under the Contract.

   The Contractor shall form all dams, flumes or other works necessary to keep them clear of water while the sewers and their foundations, and other foundation works, are being constructed. All water shall be removed from such excavation in a manner to avoid damage to property.

5. **Cribbing and Sheeting:** The Contractor shall furnish, install, and maintain such sheeting, bracing, and other components, as may be required to support any excavation and to prevent any movement which could in any way injure or delay the work or endanger adjacent pavement, building, or other structures. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed they shall be immediately filled and consolidated.

   For the purpose of preventing injury or property damage, contractor may leave in place all sheeting or bracing, and other items to be embedded in the backfill of the trench. No sheeting or bracing, however, shall be left in place within 5 feet of the surface without the written permission of the Engineer.

6. **Unstable Foundation:** Where materials encountered in the bottom of the trench are deemed as unsuitable by the Engineer to afford a sufficiently stable pipe foundation, the materials shall be removed to the depth and limits as ordered by the Engineer. Areas undergraded shall be backfilled with approved granular material or materials meeting the requirements of Section 2102.5 entitled "Undergrading."

7. **Protection of Property:** The Contractor shall satisfactorily shore, support, and protect any and all structures and all pipes, sewers, drains, conduits, and other facilities, and shall be responsible for any damage resulting thereto. The Contractor shall not be entitled to any damages or extra pay on account of any postponement, interference, or delay caused by any such structures and facilities being on the line of work, whether or not they are shown on the Contract Drawings; specifically, but not limited to, damage due to delay in utility relocation.

B. Laying and Jointing:

1. **Handling and Protection:** All pipe shall be protected during installation against shock and free fall, and be installed without cracking, chipping, breaking, bending, or damage to coating materials. Damaged pipe materials shall be replaced with new materials except as may be permitted by the Engineer.

2. **Grade Control:** Maximum deviation from indicated alignment of any pipe after installation and backfilling shall not be greater than 0.1 foot. All pipe shall have a continuous slope free from depressions that will not drain. The Contractor shall establish such grade control devices as are necessary to maintain the above tolerances.

3. **Laying:** The laying of pipe in finished trenches shall commence at the lowest point, and pipe shall be installed with the bell end forward or upgrade. All pipe shall be laid with ends abutting and true to line and grade. Pipe laid shall be carefully centered to form a sewer with a uniform invert.

4. **Bedding:** The class of bedding required shall be as indicated on the Contract Drawings or standard details except that as a minimum the bedding shall be granular bedding material placed to the spring line of the culvert, or in the case of an RCB, one-half of the height. Bedding shall be rodded, spaded, and consolidated as necessary to provide firm uniform support for the pipe, and not subject pipe to settlement or displacement.

5. **Jointing:** Preparatory to making pipe joints, all surfaces of the portions of the pipe to be jointed shall be clean and dry. Lubricants, primers, adhesives, and other substances that are used shall be compatible with the jointing material recommended or specified. All bell and spigot ends of concrete pipe shall be primed, as recommended by the pipe manufacturer, prior to application of a trowelable bitumastic plastic compound.

No pipes may be trimmed unless ordered by the Engineer. Pipes having defects that do not cause their rejection shall be so laid as to place these defects where they will be of least consequence.

Trenches shall be kept water-free and as dry as possible during bedding, laying, and jointing, and for as long a period as required to protect the pipe joints and concrete in structures.

As soon as possible after the joint is made, sufficient bedding material shall be placed alongside each side of the pipe to offset conditions that might tend to move the pipe off line and grade.

a. **Concrete Pipe:**

1. **Plastic Joint Sealant:** Plastic joint sealant shall be applied to the tongue or spigot prior to its insertion into the bell or groove. A sufficient amount of sealant shall be used to fill the annular joint space with some excess. Wipe the outside surface of the joint with additional material to assure a complete seal.

2. **Mortar:** When cement mortar is used, the joint surface shall be clean and wetted immediately before the joint is made. A layer of mortar shall be placed in the lower portion of the bell or groove of the installed pipe and on the upper portion of the tongue or spigot of the pipe section to be installed. The tongue or spigot shall then be inserted into the bell or groove of the installed pipe until the mortar is squeezed out on both the interior and exterior surfaces. The annular joint space shall be completely filled and the abutting joint sections flush and even, with excess mortar struck off.

3. **Flexible Gaskets:** Flat gaskets may be cemented to the pipe tongue or spigot. O-ring gaskets shall be recessed in a groove on the pipe tongue or spigot and confined by the bell or groove after the joint is completed. Roll-on gaskets shall be placed around the tongue or spigot and rolled into position as the joint is assembled. Flat gaskets and O-ring gaskets shall be lubricated as recommended by the manufacturer.

b. **Corrugated Steel Pipe:** Corrugated steel pipe shall be assembled and installed in accordance with the manufacturer's instructions and in conformance with the latest edition of Section 26 titled "Metal Culverts" of Division II AASHTO Standard Specifications for Highway Bridges. In case of a discrepancy between this specification and AASHTO Section 26 or the manufacturer's instructions, this specification shall govern.

Canvas or nylon slings (or something comparable that will not damage the pipe coating, i.e., appropriate lifting lugs) shall be used for all pipe handling. Pipe or plates shall not be rolled or dragged over gravel or rock and shall be prevented from striking rock or other hard objects during placement in trench or on bedding.

Corrugated steel pipe shall be placed on the bedding material starting at the downstream end. Pipes with circumferential seams shall be installed with their inside circumferential sheet laps pointing downstream.

Gaskets, if required, shall be furnished in accordance with the Contract Drawings and Special Provisions.

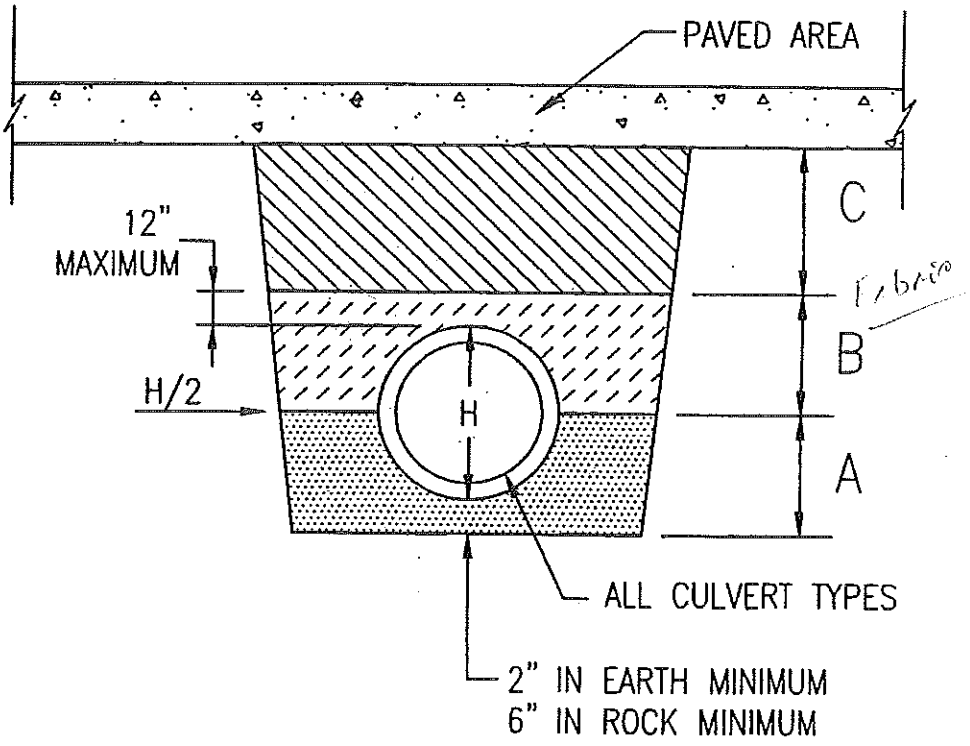
All pipes shall be protected by sufficient cover before permitting heavy construction equipment to pass over them during construction.

c. **Structure Connections:** Pipes connected to structures shall be cut parallel with the inside face of the structure for structures having plane walls and parallel with the spring line of the pipe for structures having curved walls. Projection of the pipe beyond the inside face shall not exceed 1 inch (measured at the springline for structures having curved walls.)

C. Backfill: All trenches and excavations shall be backfilled with suitable material placed and compacted in conformance with this section and Section 2102.6 entitled "Embankment."

1. Backfilling under pavements, driveways, sidewalks, and other paved areas:

Backfilling shall be placed as shown in Figure 1 except as approved by the Governing Agency.



A- Granular bedding material.

B- Granular bedding material or Flowable Fill (CLSM).

C- Flowable Fill.

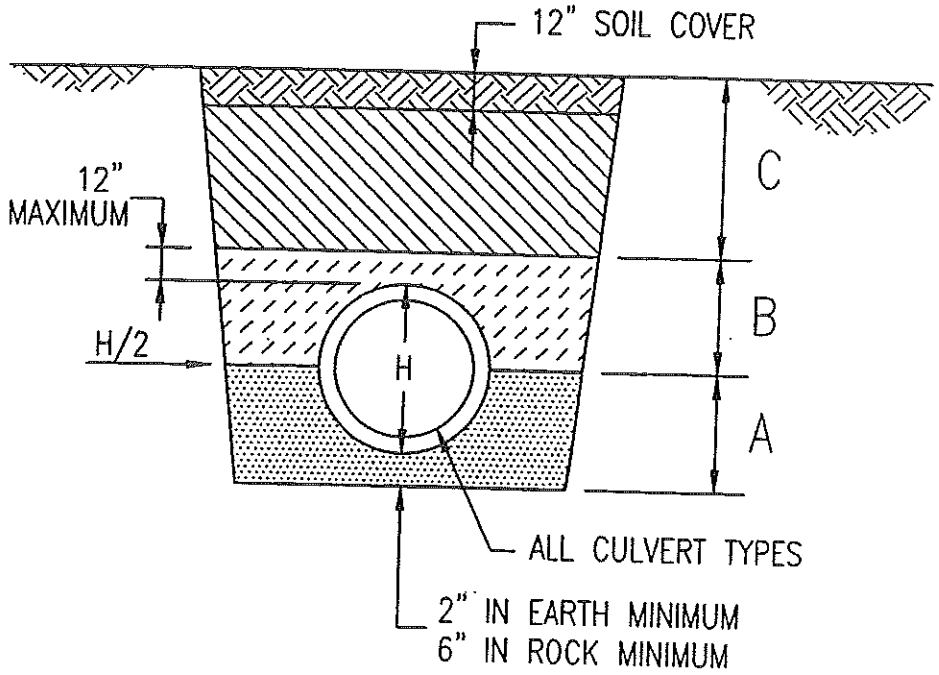
NOTE: Filter fabric at top of granular bedding where flowable fill (CLSM) used.

Figure 1

2602.3 C.2.

2. **Backfilling in areas other than pavements, driveways, sidewalks, and other paved areas:**

Backfilling shall be placed as shown in Figure 2 except as approved by the Governing Agency.



A- Granular bedding material.

B- Granular bedding material or hand compacted soil - 90% of max. density using ASTM D 698. Maximum lift thickness 6". Granular bedding material shall be used in Zone B for all pipe except reinforced concrete pipe.

C- Granular bedding material or compacted soil - compact to approximate density of adjacent soil but not less than 90% of max. density using ASTM D 698.

Figure 2

3. **Backfilling around inlet structures:**

   Backfilling shall be placed as shown in Figure 3 except as approved by the Governing Agency.

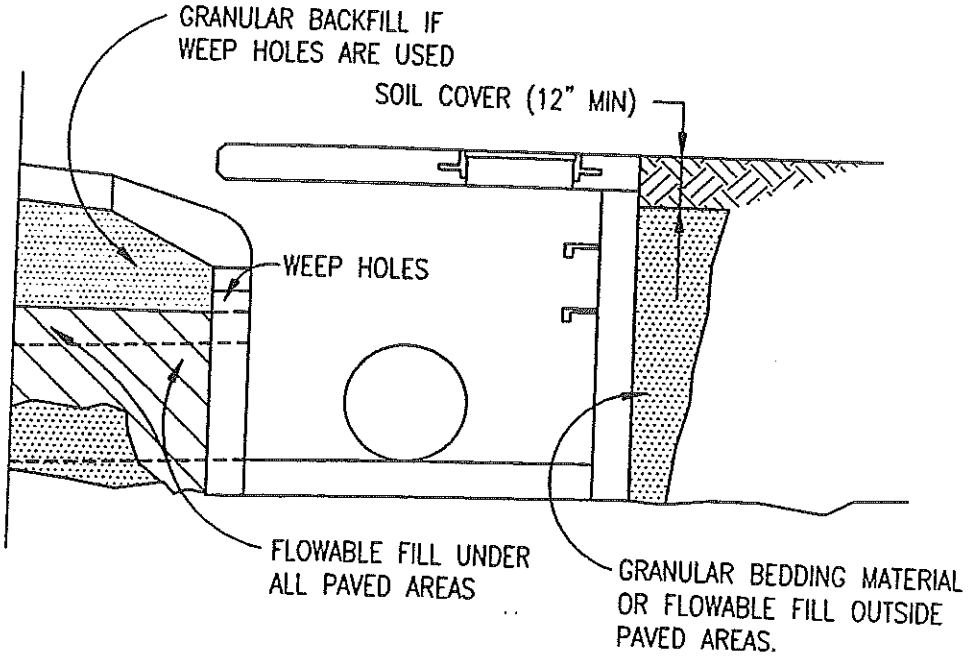


Figure 3

D. Structural Plate Erection: Structural plate pipe, fabricated from hot-dip galvanized steel plates, shall be assembled by bolting individual plates together to erect the pipes or structures as shown on the Contract Drawings. Bolts, fittings, and other appurtenances shall be furnished by the plate manufacturer. All materials shall be handled in such a manner that they are not chipped, dented, or bent. If the base metal is exposed in any way, it shall be rejected or repaired to the satisfaction of the Engineer.

SECTION 2603 BORING AND JACKING

2603.1 Scope: This section governs construction of steel casings, complete with bulkheads and sand fill, by boring and/or jacking at the locations and to the lines and grades indicated on the Contract Drawings, or where constructed at the Contractor's option, when approved, to bypass obstructions without open cutting.

2603.2 Materials:

A. **Steel Casing:**

1. Steel casing for bored or jacked construction shall conform to ASTM A 139.

2. Steel shall be grade B under railroads and grade A for all other uses.

3. Minimum wall thickness for steel casing shall be in accordance with the following table:

Diameter of Casing	Under Railroads	All Other Uses
24"	0.406"	0.281"
26"	0.438"	0.281"
28"	0.469"	0.312"
30"	0.469"	0.312"
32"	0.500"	0.312"
34"	0.500"	0.312"
36"	0.500"	0.344"

4. Casing joints shall be welded by a certified welder in accordance with ANSI/AWWA C206.

B. **End Seals:** End seals shall be brick conforming with Section 2604.2.F of these specifications. Mortar shall comply with Section 2604.2.G of these specifications.

C. **Sand Fill:** Sand fill shall comply with ASTM Designation C 33 or MCIB Section 4, Fine Aggregate. Moisture content of the sand shall not exceed 0.5 % .

2603.3 Construction Details:

A. Boring and Jacking:

1. Prior to starting work, complete details of the methods and the liner material to be used shall be submitted to the Engineer for approval.

2. The maximum allowable deviation from indicated alignment and grade shall be as follows except when altered by the Contract Drawings or Special Provisions:

   a. Alignment 1.0%

   b. Grade 1.0%

B. Casing Installation:

1. The steel casing shall be advanced in a continuous operation without interruption. Sections of the casing pipe shall be welded together to form a continuous conduit capable of resisting all stresses, including jacking stresses. The casing in its final position shall be within alignment and grade tolerances specified in Section 2603.3.A.2. There shall be no space between the earth and the outside of the casing. Any voids which do occur shall be filled by pressure grouting.

2. Boring operations shall be performed by experienced crews using a rotary type boring machine designed especially for this purpose. Boring shall be performed in a manner to prevent disturbing the overlying and adjacent materials.

3. **Jacking:**

   a. Jacking frame, guides, blocking, head, and reaction devices shall be arranged to apply uniform pressure about the casing circumference without damage to the casing material, and to maintain alignment within specified tolerances.

   b. Jacking reaction device shall provide adequate resistance to withstand 200 percent of the maximum jacking pressure.

   c. Provide jacks of adequate number and size for the required jacking pressure; but not less than two jacks.

d. Maintain jacking pit and pipe installation in such condition that drainage does not accumulate. Control and disposition of surface and subsurface water at the site of jacking operations shall be the Contractor's responsibility.

e. Excavation at the heading shall not be extended more than 1 inch outside the top and sides (upper 300-degree sector) of the casing and shall be true to grade at the invert (lower 60-degree sector).

f. Once jacking begins, it shall proceed without interruption until installation of the entire length of the jacked casing is complete.

4. **Excavation in Jacked Casings:** Perform excavation within jacked casings by hand or machine methods as necessary to remove the materials encountered without disturbing the overlying material. The jacked casing shall be advanced a sufficient distance ahead of the excavation face and/or shield used as necessary to protect the workman and the work, and to prevent the uncontrolled entry of unstable materials into the casing.

5. **Unstable Materials:** If materials are encountered during casing installation that cannot be excavated safely or without creating voids around the exterior of the casing, the Contractor shall discontinue casing installation and stabilize such materials by dewatering, chemical soil stabilization, grouting, or other methods, and/or modify equipment and procedures as necessary to complete the casing installation.

C. **Sewer Pipe Installation:**

1. Pipe shall be placed inside the casing to the indicated line and grade by the use of wood skids or other equivalent methods. The wood shall be pressure treated with creosote, pentachlorophenol, or salt-type preservative in accordance with AWPA C2. Cut surfaces shall be given 2 heavy brush coats of the same preservative. The wood skids shall be securely fastened to the sewer pipe with steel straps.

2. End seals shall be constructed after the sewer pipe is installed and approved.

3. The annular space between the casing and sewer pipe shall be filled with sand blown in so that all space is filled without disturbing the alignment and grade of the sewer pipe.

SECTION 2604 STRUCTURES

2604.1 Scope: This section governs the performance of all work necessary for construction of cast-in-place and precast concrete structures for inlets, manholes, junction boxes, box culverts, headwalls, and incidental structures. Masonry or brick structures shall not be allowed under these Specifications.

2604.2 Materials:

A. **Concrete Mixes:** Concrete shall be MCIB Mix Number A564-3/4-4 or A543-1-4 at the Contractor's option; except concrete used for soil stabilization, pipe cradles, filling, leveling courses, and other similar purposes may be either MCIB Mix Number A440-3/4-4 or A473-1/2-4.

B. **Concrete Materials:**

1. Concrete materials shall conform to MCIB Specification Section 4 entitled "Materials," except that total shale, coal, and lignite content shall not exceed 0.5 percent by weight, and clay content shall be zero.

2. Concrete shall conform to all requirements of MCIB Section 5 entitled "Concrete Mix Design Tables", and the compressive strength of each mixture shall be as designated therein.

C. **Reinforcing Steel:** Reinforcing bars shall conform to ASTM A 615/A 615M, Grade 60. Welded steel wire fabric shall conform to ASTM A 185.

D. **Precast Concrete Structures:**

1. **Manholes:** Precast manholes shall conform to ASTM C 478. Joints between concrete manhole sections shall be made with plastic joint compound or preformed plastic compound as specified in Section 2602. Minimum cross sectional area of preformed compound shall be 1 inch square or 1.25 inches diameter.

2. **End Sections for Concrete Pipe:** Shall be flared end sections of the pipe manufacturer's standard design, and shall meet all applicable requirements of ASTM C 76 for Class II or higher classes of pipe.

3. **Rectangular Structures:** Shall conform to the inside dimension indicated on the Contract Drawings and be designed for the following loads:

a. H-20 live load for all structures in/or under pavement, shoulders, driveways, and other traffic areas.

b. 2,000-lb wheel live load for curb opening inlets and junction boxes in non-traffic areas.

c. 50 pcf equivalent fluid pressure for soil pressure on vertical walls.

d. 120 pcf for unit weight of soil cover on top slabs.

E. **Air Entrainment:** All concrete shall be air entrained, and minimum strength requirements shall be as specified in Section 2604.2.B.2 above.

F. **Brick:** Brick shall conform to ASTM C 32, Grade SM, free from cracks and checks, and emit a metallic ring when struck with a hammer.

G. **Cement Mortar:** Pre-mix mortar non-shrink or expansive grout in mortar for packing pipe in openings of precast structures, setting castings, and other incidental work shall consist of one part portland cement and two parts sand by volume mixed with sufficient water to form a workable stiff grout.

H. **Metal Castings:** Castings shall be gray iron conforming to ASTM A48, Class 35B. Castings shall be of the shape, dimension, and minimum weight indicated on the Contract Drawings, and be free from manufacturing defects. If requested by special order, castings shall be cleaned and painted with one coat coal tar before delivery. Bearing surfaces between frames and covers for installation in all areas shall be machined to provide even seating.

I. **Steel End Sections:** Steel end sections shall be fabricated from galvanized base metal as specified in Section 2602, and shall be flared end sections of the metal pipe manufacturer's standard design. End sections shall be furnished with a steel toe plate. Bituminous coating is not required.

J. **Toe Walls:** Flared end sections for concrete and steel pipe shall be set on a concrete toe wall centered on the end of the section. Toe walls shall be 8 inches thick by 24 inches deep by the width of the end section.

Section 2604.3 Construction Details:

A. **Concrete Structures:** Concrete construction shall conform to the following MCIB Standard Specifications:

Section 8 - Placing of Concrete
Section 9 - Curing and Protection
Section 10 - Cold Weather Concrete
Section 11 - Hot Weather Concrete
Section 13 - Forms
Section 24 - Finishing
Bulletin 6 - Concrete Inspection
Bulletin 12- Reinforcing Steel - Handling and Placing

1. **Precast Structures:** The Contractor may, at his option, construct precast concrete inlets, junction boxes, and box culverts, in lieu of the cast-in-place structures indicated on the Contract Drawings; except that all concrete base slabs for pre-cast inlets, manholes, and junction boxes may be cast-in-place. Solid concrete brick or block shall be used to block inlets and similar structures to grade during placement of base slab concrete.

   Precast concrete box culvert sections shall be installed on a 4-inch leveling course of untreated compacted aggregate conforming to Section 2202. Leveling courses shall extend 1 foot past the line of the box section, and be finished to a true plane surface to provide uniform bearing for the precast section.

   Any adjustments required for precast structures to meet field conditions shall be at the cost of the Contractor.

2. **Finishing:**

   a. **Formed Surfaces:** Immediately following removal of the forms, fins and irregular projections shall be removed. Form tie connections, holes, honeycomb spots, and other defects shall be chipped to ensure the voided area is exposed, and shall be chipped back to solid material. These areas shall be thoroughly cleaned, saturated with water, and pointed with a grout approved by the Engineer. The repaired surfaces shall be cured in accordance with MCIB Specification Section 9.

   b. **Exposed Slabs:** Finish for exposed slabs shall be wood float texture in accordance with MCIB Specification Section 24. Exposed edges shall be beveled or edged with a radial tool.

3. **Form Removal:** Forms shall remain in place until the concrete has attained sufficient strength to support loads imposed by backfilling, construction, and traffic, but not less than:

   a. **Walls:** Forms shall remain in place for a minimum of 5 days or until the concrete reaches a minimum strength of 2000 p.s.i.

   b. **Slabs:** Form shall remain in place for a minimum of 7 days or until the concrete reaches a minimum strength of 3000 p.s.i.

B. **Invert Channels:** Form concrete invert channels in manholes, inlets, and junction boxes to make changes in direction of flow with smooth curves of as large a radius as permitted by the inside dimension of the structure. Grade changes and transitions shall be smooth and uniform, and all parts of the invert channel and adjacent floor shall slope to drain. Channel bottom shall be finished smooth without roughness or irregularity. Invert channels for precast concrete structures may be cast integrally with the structure base slabs at the Contractor's option.

C. **Excavation and Backfill:** All excavation and backfill shall be done in conformance with Section 2102 entitled "Grading."

1. **Excavation:** Excavation for structures shall be carried a sufficient distance, but not less than 18 inches outside the limits of the structure, to permit efficient erection and removal of forms and laying of masonry units, and shall be sloped, stepped, or braced as required for stability. Unsuitable soils encountered at the bearing elevation of the structure shall be removed and replaced with either fill concrete or compacted granular material at the Contractor's option. Over excavation shall be corrected in like manner. The Contractor shall maintain the excavation free of standing water until backfilling is complete.

2. **Backfilling:** Backfilling shall conform to the requirements of Section 2602.3C and as follows:

   a. No backfill shall be placed over or around any structure until the concrete or mortar therein has attained a minimum strength of 2000 p.s.i. and can sufficiently support the loads imposed by the backfill without damage.

   b. The Contractor shall use utmost care to avoid any wedging action between the side of the excavation and the structure that would cause any movement of the structure. Any damage caused by premature backfill or by the use of equipment on or near a structure will be the responsibility of the Contractor.

   c. Backfill shall be placed and compacted on all sides of the structure simultaneously, and operations shall be so conducted that the backfill is always at approximately the same elevation on all sides of the structure.

   d. No excavated rock larger than 4 inches maximum dimension shall be placed within 1 foot of the exterior surface of any structure except as allowed with CLSM placement.

SECTION 2605 OPEN CHANNELS

2605.1 Scope: This section includes all work for construction of open channel lining at the location, and to the lines, grades, and dimensions indicated on the Contract Drawings. Grading shall have been previously completed in accordance with Section 2100, "Grading and Site Preparation."

2605.2 Materials:

A. **Concrete:** Concrete shall be MCIB Mix Number A511-3/4-2. Reinforcing steel shall conform to ASTM A 615, Grade 60. Welded steel wire fabric shall conform to ASTM A 185.

B. **Stone:** Stone for riprap, grouted riprap, and gabion linings shall consist of quarried rock and be sound, durable, and angular in shape. No more than 10 percent shall have an elongation greater than 3:1, and no stone shall have an elongation greater than 4:1. Material shall be free from cracks, seams, or other defects. Shale and stone with shale seams are not acceptable.

1. The minimum unit weight of the stone shall be 155 pounds per cubic foot as computed by multiplying the specific gravity times 62.4 pounds per cubic foot.

2. Not more than 10 percent of the stone shall exhibit splitting, crumbling, or spalling when subject to 5 cycles of the sodium sulfate soundness test in accordance with ASTM C 88.

3. **Riprap and Grouted Riprap:** Stone shall be of the following gradations:

   Riprap and grouted riprap shall have a minimum thickness of 15 inches, or 1.5 times as thick as the larger stones, whichever is greater. The thickness for grouted riprap shall be measured from the top of the grout line to the bottom of the riprap. At least 60 percent of the mass shall be of pieces having a volume of one cubic foot or more and the pieces shall be well graded. No more than 6 percent of the stones shall weigh less than 10 pounds.

4. **Gabion Fill Stone:** Stone shall be of the following gradations:

U.S. Standard Square Mesh Sieve	**Percent Passing by Weight**
10"	100
8"	85 - 100
6"	0 - 15
4"	0 - 10
3"	0

Stone shall be graded within the above limits as required to provide a unit weight in-place of 100 pounds per cubic foot or greater.

C. **Filter Blanket:** Filter blanket may be either of the following types at the Contractor's option:

1. **Granular Filter:** Granular filter material shall consist of sound, durable rock particles conforming to the following gradation:

Sieve Size	Culmative Percent Passing By Weight
1"	100
½"	70-100
No. 4	50-85
No. 10	35-70
No. 40	20-50
No. 100	15-40

2. **Filter Fabric:** Filter fabric shall consist of woven or nonwoven fabric. The synthetic fiber of either the woven or nonwoven fabric shall consist of polypropylene, nylon, or polyester filaments. The percent open area shall be not less than 4 percent nor more than 10 percent. The cloth shall provide an Equivalent Opening Size (EOS) no finer than the U.S. Standard Sieve No. 100. In addition, filter fabric shall meet the following physical requirements:

   a. **Tensile Strength:** Minimum grab tensile strength, both warpwise and fillingwise, shall be 200 pounds when tested in accordance with ASTM D 5034, using a 4-inch by 6-inch specimen and a jaw speed of 12 inches per minute.

   b. **Elongation:** Grab elongation shall be not less than 15 percent nor more than 60 percent, both warpwise and fillingwise, when tested in accordance with ASTM D 5034.

   c. **Tear Strength:** Minimum trapezoid tear strength shall be 100 pounds, both warpwise and fillingwise. Method of test for woven fabrics shall be in accordance with ASTM D 1117.

   d. **Bursting Strength:** Minimum bursting strength shall be 400 psi when tested in accordance with ASTM D 3887.

   e. **Seam Strength:** Woven fabric shall have a minimum seam-breaking strength of 180 pounds when tested in accordance with ASTM D 1683, using a jaw speed of 12 inches per minute.

   f. **Width:** Filter fabric shall be furnished in widths of not less than 6 feet.

D. **Gabion Baskets:** Baskets shall be of the dimensions indicated on the drawings and be fabricated using hexagonal triple-twist wire mesh.

1. **Wire:** Wire shall be galvanized steel having a minimum tensile strength of 60,000 psi, and shall be zinc coated in accordance with ASTM A 641 Class 3.

2. **Wire Mesh:** Maximum dimension of the mesh opening shall be 4-1/2 inches or less, and the maximum area of the mesh opening shall not exceed 12 square inches. Wire shall be 0.120-inch (minimum) diameter.

3. **Selvedge Wire:** Selvedge wire shall be 0.1535-inch (minimum) diameter. All perimeter edges of the mesh forming the gabion shall be securely selvedged so that joints formed by tying the selvedges have a strength equal to or greater than the body of the basket.

4. **Lacing and Stay Wire:** Wire shall be 0.0866-inch diameter or larger. Other connection methods, such as stainless steel clips, may be substituted with approval of the Engineer.

5. **Diaphragms:** Gabions shall be divided into cells not greater than 4 feet in width by wire mesh diaphragms. Diaphragms shall be factory secured to the base of the basket by continuous spiral wire.

6. **PVC (Polyvinyl Chloride) Coating:** Where specified in the Contract Drawings, all wire used in the fabrication of the baskets and in the wiring operations during construction shall, after zinc coating, have an extruded coating of PVC. The coating shall be gray in color ranging between series 26187 and 26293 or between series 26373 and 26375, semigloss, as per Federal Standard 595B. The PVC coating shall be a nominal thickness of 0.02165 inches and shall nowhere be less than 0.015 inches in thickness. The coating shall be resistant to the destructive effects of immersion in acidic, salt or polluted water, exposure to ultraviolet light, and abrasion and shall retain these characteristics after a period of not less than 3,000 hours under test in accordance with ASTM G-23.

E. **Grout:** Grout for grouted riprap shall be a sand/cement mixture containing 420 pounds of cement per cubic yard with 6 percent air entrainment. It shall have a consistency thin enough to permit thorough penetration of the grout into the joints and voids between the stones.

F. **Sod:** Sod shall conform to the requirements of Section 2402 for Kentucky Blue Grass Sod.

G. **Seed:** Seeding shall conform to the requirements of Section 2401. Type "A" seed shall be used.

2605.3 Construction Details:

A. **Foundation Preparation:** After completion of grading in accordance with Section 2100, the area to receive channel lining shall be trimmed and dressed to conform to the cross sections indicated on the drawings within a tolerance of plus or minus 1 inch from the theoretical slope lines and grades. All deleterious materials shall be removed from the foundation area.

B. **Concrete Lining:**

1. **Preparation:** Subgrade shall be moistened by sprinkling. Forms shall be securely staked, braced, and set to line and grade. Reinforcement and tie bars shall be held in position by bar chairs, concrete brick, or other approved devices.

2. **Placing and Finishing:** Place, consolidate, and strike off concrete to the thickness indicated on the drawings. Concrete shall be tamped or vibrated to eliminate all voids and bring sufficient mortar to the top for finishing. Surface finish shall be a wood-float finish. Round all edges and joints with a 1/4 inch radius edging tool, except contraction joints may be sawed to a depth of 30 percent of the thickness of the concrete lining after concrete has hardened but before uncontrolled cracking occurs. Apply curing membrane as specified in Section 2208.2.F.

C. **Filter Blanket:**

1. **Granular Filter:** Place granular filter to its full thickness in a single operation. Construction methods shall be such that the material is placed without segregation. Compaction of granular filter material is not required.

2. **Filter Fabric:** Place filter fabric with its long dimension horizontal and lay free of tension, stress, folds, wrinkles, or creases.

   a. Place to provide 18 inches minimum overlap at each joint and anchor to prevent dislocation during construction of overlaying material.

   b. Fabric shall not be left exposed more than two weeks prior to placement of overlaying material. Tracked or wheeled equipment or vehicles shall not be operated on the fabric.

D. Riprap Placement: Riprap shall be placed on the prepared foundation in a manner which will provide a reasonably well-graded mass of stone with the minimum practicable percentage of voids. The entire mass of stone shall be placed so as to be in conformance with the lines, grades, and thicknesses indicated. A filter blanket of filter fabric conforming to Section 2605.2.C.2 shall be constructed under all riprap, grouted or ungrouted. Riprap shall be placed to full-course thickness in one operation and in such a manner as to avoid displacing the fabric. The Contractor shall place the riprap in such a way as to not tear, puncture, or shift the fabric. Riprap shall not be dropped more than 3 feet when being placed directly on the fabric. Tears or rips in the fabric shall be repaired with fabric lapped a minimum of 12 inches in all directions.

1. **Placing:** Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.

2. **Distributing:** The larger stones shall be well distributed and the entire mass of stone shall conform to the specified gradation. All material shall be so placed and distributed that there will be no objectionable accumulations of either the larger or smaller sizes of stone.

3. **Hand Placing:** It is the intent of these specifications to produce a fairly compact riprap protection in which all sizes of material are placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the specified results.

E. Grouted Riprap: Riprap shall be placed in conformance with Section 2605.3.D (Riprap Placement). Grout shall be placed in such a manner to produce a securely bound solid mass with the voids completely filled.

After the voids have been completely filled, the surface shall be swept clean with a stiff bristle broom and water to expose the stone surface and natural color of the stone. Most stones should protrude 1 to 3 inches above the grout unless otherwise specified on the Contract Drawings.

The grout shall be cured by any of the methods specified for concrete sidewalks and driveways in Section 2301.5.C, except that transparent membrane shall be used in lieu of white pigmented membrane.

During cold weather, the limitations and protection requirements of concrete as specified in the most current MCIB Standard Concrete Specifications shall apply to the grouting.

A toewall shall be constructed at the upstream and downstream ends of all grouted riprap unless another permanent lining material is constructed to continue the channel. The toewall shall be constructed across the entire section and shall be a minimum of 18 inches deep below the bottom of the grouted riprap and 12 inches wide. The toewall material shall be grouted riprap.

F. Gabion Lining:

1. **Assembly:** Assemble each gabion unit by binding all vertical edges together with a continuous piece of connecting wire stitched around the vertical edge with coils spaced at 3 inches or less. Set empty units to line and grade and join units by stitching with connecting wire along adjoining edges. Install and securely fasten internal tie wires in each cell if necessary to retain the shape of the cell during filling operations.

2. **Filling:** Fill gabion cells with stone carefully by hand or machine to provide a minimum of voids and avoid bulges and distortions of the gabion. After filling, secure the lid to the sides, ends, and diaphragm by stitching with connecting wire.

3. **Filter Fabric/Gabion Unit Placement:** A filter blanket of filter fabric conforming to Section 2605.2.C.2 shall be constructed under all Gabion Linings. The Contractor shall place the gabions in such a way as to avoid tearing, puncturing, or shifting the fabric. Tears or rips in the fabric shall be repaired with fabric lapped a minimum of 12 inches in all directions.

G. Sod: Sod shall be as specified in Section 2402, except all sod placed in drainage channels or ditches, including both the side slopes and bottom, shall be anchored as specified in Section 2402.3.C.1, Anchoring Sod.

SECTION 2606 MEASUREMENT AND PAYMENT

2606.1 Measurement: The quantities of accepted work will be measured in the following units. All measurements will be plan measure except for authorized changes.

A. Pipe: By the lineal foot of each size and type. Measurement will be to the nearest 0.1 foot for each line between structures, and made to the inside face of the connecting structure. Precast or prefabricated end sections will be excluded from the pipe measurement.

B. **Prefabricated or Precast End Sections:** By the number of each size and type.

C. **Concrete Box Culverts:** By the lineal foot of each size and type. Measurement will be along the center line of the culvert between the back faces of the headwalls. Headwalls will be measured separately as "Structures."

D. **Structures:** Inlets, manholes, headwalls, endwalls, catch basins, and other similar structures will be measured by the number of each size and type listed in the Agreement.

E. **Casings:** Casings for pipe installation by boring and/or jacking methods will be measured by the lineal foot of each size and type.

F. **Pipe Encasement:** Pipe encasement will be measured by the lineal foot of each size and type.

G. **Concrete Channel Lining:** By the square yards of surface area. Measurement will be parallel to sloping surfaces.

H. **Filter Blanket:** By the square yards of surface area covered by the blanket. Laps, splices, and anchorage for fabric blanket will be excluded from the measurement. Measurement will be parallel to sloping surfaces.

I. **Riprap:** By the cubic yard on the basis of plan dimensions as the product of surface area times thickness.

J. **Grouted Riprap:** By the square yards of surface area. Measurement will be parallel to sloping surfaces. Measurement and payment of the filter fabric shall be included in the cost per square yard of the grouted riprap.

K. **Gabions:** By the cubic yard on the basis of plan dimensions.

L. **Sodding:** Measurement shall be by the lineal foot of pipe over which sod is placed or by the lineal foot of sodded ditch unless otherwise specified. For lined (riprap, grouted riprap, or concrete) channels, sod placement and/or repairs shall be incidental to the cost of placement of the lining material.

2606.2.

2606.2 Payment: Payment will be made at the respective unit or lump sum price listed in the Agreement, and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the Agreement, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the Agreement. At the Engineer's option, partial payment may be made for any item listed in the Agreement, providing that the Contractor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.