

Granular Encasement Placed below an elevation one foot (1') (300mm) above the top of pipe, after pipe installation, for protection of the pipe and to assure proper filling of voids or thorough consolidation of backfill

K. Select Backfill

1. Job excavated and imported select backfill material shall be free from debris, organic material, and stones larger than three inches (3") (75mm) in diameter. Contractor shall be responsible, at his expense, for separating debris, organic material and stones larger than three inches (3") (75mm) in diameter.
2. Select material that the Engineer directs to be used shall be the same gradation as bedding and encasement material.
3. No asphalt chunks or concrete may be used as select backfill.

L. Ground Water Barriers

1. Low permeability ground water barriers shall be used where directed. Barrier material shall meet soil classification GC, SC, or CL per the Unified Soil Classification System and shall have a liquid limit less than 50.
2. The barrier material shall be compacted to 95 percent of maximum density.
3. Job excavated material meeting one of the above soil classifications and free from stones, organic matter, and debris may be used.

M. Steel Casing Pipe

1. Casing pipe will conform to ASTM A 139. Minimum yield strength will be 35000 psi. Wall thickness will meet the requirement of the latest revision of the American Railway Engineering Association manual of Recommended Practices unless otherwise specified. Wall thickness will be:

| Nominal Thickness (inches) | Nominal Diameter (inches) |
|----------------------------|---------------------------|
| 0.188 | Less than 14 |
| 0.219 | 14 and 16 |
| 0.250 | 18 inches |
| 0.281 | 20 |
| 0.312 | 22 |
| 0.244 | 24 |
| 0.375 | 26 |
| 0.406 | 28 and 30 |
| 0.438 | 32 |
| 0.469 | 34 and 36 |
| 0.500 | 38, 40, and 42 |

2. When casing is installed without a protective coating and is not cathodically protected, the wall thickness shown above will be increased to the nearest standard size that is the minimum of 0.063 inches greater than the thickness shown. This requirement does not apply to casing diameters less than 12 ¾ inches.

PART 3 Execution

3.01 Excavation and Preparation of Trench

- A. When cutting into existing roads, streets, alleys, or other public rights-of-way, the Contractor, shall obtain the proper licenses, cut permits, etc. from the appropriate authority when applicable.
- B. When trench excavation requires the removal of curb and gutter, concrete sidewalks, or asphaltic or concrete pavement, the pavement or concrete shall be cut in a straight line parallel to the edge of the excavation by use of a spadebitted air hammer, concrete saw, or similar approved equipment to obtain a straight, square, clean break. Cuts shall be located at standard joint locations when possible.
- C. When crossing existing or prospective cultivated areas, gravel streets or other developed surfaces the Contractor shall strip the cover material to full depth of the existing surfacing. This surfacing shall be stockpiled and placed back over the trench after backfilling to the extent that it is acceptable and usable for that purpose. New material shall be provided as necessary. Topsoil shall be removed to full depth of the topsoil, or to a maximum depth of twelve inches (12") (300mm), whichever is less.
- D. The disturbed area from construction shall be confined within the construction limits.
 1. The trench shall be dug only as far in advance of the pipeline as work can be reasonably completed that day. The sides of the trench shall be sloped and/or braced in accordance with the current OSHA Rules and Regulations and the trench drained so that workers can work safely and efficiently. All work must be done in a dry trench and no water will be permitted to discharge down the pipe previously laid. A sewer plug shall be installed at the connection to existing sewer system. Discharge of pumps shall be to approved natural drainage channels or storm sewers.
- E. Pipe crossings under sidewalks or curbs may be made by tunneling only if approved by the Engineer. If the Contractor elects to remove a portion of the sidewalk or curb, he must use a concrete saw for making neat joints corresponding to existing joints, compact the backfill as specified, and pour a new concrete sidewalk or curb section in accordance with the applicable sections of these specifications.
- F. During excavation, materials suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated materials shall be stored and retained at least two feet (2') (600mm) or more from the edge of the trench in accordance with Tennessee Occupational Health and Safety Rules and Regulations for Construction. Excavated material must not be piled over nearby existing parallel trench lines unless adequate precautions are taken by the Contractor to prevent sidewall failure. Ready access to existing fire alarm boxes, fire hydrants, valves, manholes, and other appurtenances must be maintained.

1. When making excavations, the various materials excavated shall be piled separately. All concrete and bituminous materials, any soils, which cannot be properly compacted, and all other deleterious materials shall be immediately removed from the construction site and properly disposed of in accordance with applicable laws.
- G. Surface drainage of adjoining areas shall be unobstructed. Grading shall be done as may be necessary to prevent surface water from flowing into excavations, and any other water accumulating therein shall be promptly removed. Under no circumstances shall water be permitted to rise in open trenches until after the pipe has been placed, tested, and covered with backfill. Any pipe having its alignment or grade changed as a result of a flooded trench shall be reinstalled. Gutters shall be kept clear or other satisfactory provisions made for street drainage at all times.
- H. The bottom of the trenches shall be accurately graded to the line and grade shown on the drawings. Bedding material shall be added four inches (4") (100mm) minimum to provide uniform bearing and support for each section of pipe at every point along its barrel length with bell holes dug for bells. Care must be taken to avoid over excavation. Unauthorized over-depths shall be backfilled with approved bedding material at the Contractor's expense. All bedding material added shall be moistened and compacted to a minimum of 95% density as determined by ASTM D698. The finished trench bedding beneath the pipe shall be prepared accurately by means of hand tools.
1. The bottom of all excavations shall be neat and clean, and graded accurately to the line and grade shown on the drawings. Suitable methods shall be used to produce an excavated surface without disturbance to the underlying material by compacting soil material to at least 95% Standard Proctor, ASTM D698.
 2. If in its natural state the material at the bottom of the trench is soft and, in the opinion of the Engineer, cannot support the pipe, a further depth and/or width shall be excavated as directed by the Engineer and refilled with foundation material to the midpoint of the pipe. Other approved methods may be used to assure a firm foundation.
 3. Foundation material used to dewater the trench or to replace a wet material shall be considered incidental to construction.
- I. Ledge rock, boulders, and large stones shall be removed to provide a clearance of at least six inches (6") (150mm) below the outside barrel of pipe and allow a clear width of six inches (6") (150mm) on each side of the pipe. The space between the bottom of the trench in bedrock or rocky areas and the bottom of the pipe shall be backfilled with suitable granular material in three-inch (3") (75mm) uncompacted layers and thoroughly tamped before pipe is installed.
- J. All excavated material shall be piled within the construction limits or in a location obtained by the Contractor and accepted by the Engineer in a manner that will not endanger the work and that will avoid obstructing sidewalks, driveways, and fire hydrants.
- K. The width of the trench shall be such to provide adequate working room for workers to install the pipe in the specified manner. The trench in the pipe zone and to one foot (1') (300mm) above the pipe zone shall be adequate in width to allow for proper compaction but shall in no case be

wider than the pipe diameter plus three feet (3') (900mm).

- L. Where the trench is not located near existing utilities, buildings or other structures, and where water and other conditions permit, the Contractor may omit sheeting and bracing of the excavation. In this event, sides of the trench if in unstable or soft material or five feet (5') (1.5m) or more in depth, shall be sloped to protect the workers working within them in accordance with current Occupational Safety and Health Rules and Regulations for Construction.
- M. The Contractor shall provide safety boxes or sheeting and bracing necessary to confine his work within the construction limits, to provide safe working conditions, to prevent damage and delay to the work, and to prevent the disturbing or settlement of adjacent road surfaces, foundations, structures, utility lines or railroad tracks. The Contractor shall be responsible for the strength and sufficiency of all sheeting and bracing.
- N. Any damage to the work under this contract or to adjacent structures or property caused by settlement, water or earth pressures, slides, cave-ins, or other reasons due to failure or lack of sheeting and bracing, or improper bracing, or through negligence or fault of the Contractor in any manner, shall be repaired by the Contractor without delay and at his expense. Bracing shall be so arranged as to provide ample working space, so as not to interfere with the work, and so as not to place any strain on the structures being constructed, until such structures are of sufficient strength to withstand such strain. No sheeting and bracing shall be removed until the construction has proceeded far enough to provide ample strength for its safe removal.
 - 1. Sheeting or bracing may be left in place in the trench at the discretion of the Engineer. Any sheeting or bracing left in place shall be cut off approximately three feet (3') (900mm) above the top of the pipe or two feet (2') (600mm) below finish grade, whichever is lower, and the cut-off portion removed. All sheeting or bracing left in place shall be accurately located and shown on the "Record Drawing" (See Division 600 Section 601.12 of these specifications.)
- O. The Contractor shall be responsible for enforcing safety and maintaining safe working conditions in all trenching, and shoring operations to conform to OSHA regulations.
- P. The Contractor, if required by site conditions, shall provide a dewatering operation. The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface water and groundwater entering the excavations, trenches, or other parts of the work.
 - 1. All trench excavations which extend down to or below groundwater shall be dewatered by lowering and keeping the groundwater level beneath such excavations twelve inches (12") (300mm) or more below the bottom of the excavation.
 - 2. Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches to the greatest extent practicable without causing damage to adjacent property.
 - 3. The Contractor shall be responsible for the conditions of any pipe or conduit which he may use for drainage purposes, and all such pipes or conduits shall be left clean and free of sediment.
 - 4. In areas where dewatering is required, the Contractor will comply with the following requirements:

- a. All discharges from dewatering systems, including well points, dewatering wells, pumps in the bottoms of the trenches, etc. will require a permit from the Tennessee Department of Environment and Conservation (TDEC). Before starting any construction, the Contractor shall submit an application to discharge to the TDEC along with a proposed dewatering plan for review. The application shall be submitted on "National Pollutant Discharge Elimination System, Application to Discharge from a Construction Project, Short Form E". If the dewatering plan is revised during construction, the Contractor shall immediately send a revised plan to the DEQ.
- b. One copy of the initial application, dewatering plan, and of the permit authorizing the discharge must be provided to the City Engineer with the application for an excavation permit. Copies of any revisions to the dewatering plan shall be immediately provided to the City Engineer.

Q. Trenching and tunneling standards near trees.

1. Trenches should be routed outside the tree protection zone or critical root zone (CRZ). For trees less than 6" diameter at breast height (DBH), defined as 4.5' about average ground level, that are to be retained, no trenching should occur within the dripline or tree protection/critical root zone as defined by the City of Lakeland Tree Management Ordinance. For trees 6" DBH and less than 20" DBH no trenching should occur within an area equal to 1' radius for every inch of DBH or within the tree protection/critical root zone as defined by the City of Lakeland Tree Management Ordinance. For trees 20" DBH and greater, no trenching should occur within an area equal to 1.5' of radius for every inch of DBH or within the tree protection/critical root zone as defined by the City of Lakeland Tree Management Ordinance.
2. Soil removed from the trenches should be placed on the side away from the trees and replaced as soon as possible. The width of the trench should be minimized. The use of trench walls should be considered rather than sloping sides when working around trees.
3. If placement of utilities or other infrastructure is unavoidable within the tree protection zone or critical root zone then specific measures should be applied to minimize root damage. Tunneling is recommended as soon as roots 1 inch diameter and greater are encountered. Minimum tunnel depth should be 24 inches. Launch and recovery pits should be located outside of tree protection zones and critical root zones. If tunneling is impossible due to specific soil restrictions, the trenching should be done by hand within the tree protection zone or critical root zone. If this required trenching will sever more than 25% of the tree protection/critical root zone then the trench should be re-directed at the center of the tree with the final section dug under the base of the tree. Trenches should be backfilled with native soil or a prepared soil mixture when inside of a tree protection zone or critical root zone. Gravel, slurry, stone, and concrete are not appropriate fill material within a tree protection zone.
4. Changes to the approved construction plans or methods for trenching and tunneling must be submitted to and receive approval by the City's Representative before proceeding.

P. Procedures For Boring And Jacking

1. Casing pipe larger than 36 inches shall be bored or tunneled. Casing pipe smaller than 36 inches may be jacked or bored.
2. Boring:
 - a. Extend casing through entire distance bored.
 - b. Check grade and alignment after each casing section is installed.
 - c. Coordinate operations to provide continuous support to surrounding earth materials.
 - d. If the annular space between the casing pipe and the earthen bore exceeds 4 inches, the contractor shall fill the space with dry blown sand. Dry sand shall be blown in from both sides of the casing pipe.
3. Jacking:
 - a. Progressively push carrier pipe through completed casing. A minimum clearance of at least 2 inches between the inner wall of the casing pipe and the maximum outside diameter of the cased pipe and joints shall be provided.
 - b. Strap 2 wooden saddle blocks or plastic fins to each pipe length to provide support at regular intervals.
 - b. Center carrier pipe in casing at all times.
 - c. Fill annular space between casing and carrier pipe with dry blown in sand.
 - d. Seal each end of the casing after the sand has been deposited.
 - e. A minimum of 1 foot of grout shall be placed in the void between the inner wall of the casing pipe and the cased pipe at the ends of the casing pipe after placement of sand.
4. Field Tolerances for Boring and Jacking Casing Pipe
 - a. Boring
 - i. Maximum departure from established grade = 6 inches / 100 feet.
 - ii. Maximum departure from established line = 2 inches / 100 feet.
 - iii. Maximum departure from established line and grade = 6 inches / 100 feet.
 - b. Tunneling
 - i. Maximum departure from established grade = 2 inches / 100 feet.
 - ii. Maximum departure from established line = 2 inches / 100 feet.
 - iii. Maximum departure from established line and grade = 3 inches / 100 feet.

3.02 Laying of Pipe

Contractor shall provide all plant, equipment, labor, and material necessary for the safe and convenient prosecution of the work. Pipe manufacturer's installation instructions shall be followed and supplemented by these specifications.

- A. The sewer pipe shall be carefully lowered into trench piece by piece by means of a derrick, ropes, or other suitable tools or equipment in such a manner as to prevent damage to the protective coatings and linings. The use of chains is not allowed. Under no circumstances shall sewer main materials be dumped into the trench. Any damage to pipe coatings shall be repaired with the same materials used for the original coating before laying the pipe.
- B. Before lowering and while suspended, the pipe and fittings shall be inspected for defects and to detect any cracks. Any defective, damaged, or unsound material shall be rejected.

- C. All foreign matter or dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench, and it shall be kept clean by approved means during and after laying. All openings along the line of the sewer shall be securely closed as directed and, in the suspension of work at any time, suitable watertight stoppers shall be placed to prevent earth, water or other substances from entering the main.
- D. Sewer piping shall be laid to the lines and grades indicated in the Contract Documents. Methods of maintaining alignment and grade, such as use of laser beam equipment or surveying instruments, shall be used.
- E. Fine grading of the trench bedding beneath the pipe shall proceed ahead of the pipe laying. Unauthorized over-excavation shall be backfilled with bedding material at the Contractor's expense. All bedding material added shall be moistened and compacted to 95% of maximum density (Standard Proctor).
- F. Bell holes shall be dug for the pipe bells or couplings and the materials placed along the preceding pipe laid. The pipe shall be supported for the bottom 60 degrees and throughout its length (except for the minimum distance necessary at the bell holes). Bell holes shall be adequate to make the joint, but no larger than necessary, so that maximum support on the prepared bedding beneath the pipe will be provided. The remainder of the pipe shall be surrounded to at least its midpoint by granular bedding material shovel-placed and hand-held machine tamped in maximum six-inch (6") (150mm) layers to completely fill all spaces under and adjacent to the pipe.
- G. No pipe shall be laid in water, on frozen ground, or when the trench conditions are unsuitable for such work.
- H. Pipe laying should proceed upgrade with the spigot ends pointed in the direction of the flow. The Contractor shall make all connections of pipe to the manholes that have previously been constructed.
- I. When connecting to existing sewers, the Contractor shall take every precaution necessary to prevent dirt or debris from entering the existing lines. The Contractor shall use an approved water-tight plug to securely plug the new sewer at the connection to the existing sewer immediately after the connection has been made. The plug shall be braced as necessary and tied to the manhole by a rope or chain. This plug shall remain until the new sewer mains have been accepted by the City or until otherwise directed by the City.

3.03 Installation of Manholes

- A. Excavation shall be to a depth and size to provide for construction of the manhole. Concrete bases shall be poured on undisturbed ground. Precast concrete bases shall be carefully lowered onto one of the following:
 - 1. Six-inches (6") (150mm) minimum layer of well compacted granular material accurately laid to a smooth level surface using a straight edge and hand level.
 - 2. Three inches (3") (75mm) of concrete poured on undisturbed soil.

- B. Walls shall be of precast concrete as shown in the standard drawings and shall be constructed to form a complete watertight structure.
- C. The Contractor shall provide a minimum of two inches (2") (50mm) and a maximum of twelve inches (12") (300mm) in two-inch (2") (50mm) layers of precast reinforced concrete adjusting rings between the cast iron frame and the manhole top section. Each ring shall be set on a full bed of mortar and shall be made watertight. Wood will not be allowed as spacers. Adjusting rings shall conform to the size and shape of the casting frame. Frames and covers shall be set to the designated elevation in a full mortar bed.
 - 1. The minimum two-inch (2") (50mm) concrete ring for grade is not needed if grade can be met with a six-inch (6") (150mm) flange on top of the cone section of the manhole.
 - 2. If the number of adjusting rings exceeds the maximum twelve inches (12") (300mm), the manhole shall be reexcavated and a manhole barrel section installed.
- D. Manholes shall be set as shown on the detail drawings. All lifting holes must be grouted in after placement.
- E. Riser rings, if approved by the engineer, shall be a minimum of two inches (2") (50mm) or greater in height. No aluminum risers shall be used. In gravel or unpaved roads, the manhole ring shall be kept one to two inches (1"-2") (25mm-50mm) below the road surface.
- F. In asphalt paving areas, where patching material is required around the manhole covers, asphaltic material shall be required in the top two inches (2") (50mm) of the street.
- G. The invert of all manholes shall be smoothly shaped so as to allow a free, uninterrupted flow of sanitary sewage. The invert forming system shall be "A-Lok Tru Contour", or approved equal.
 - 1. Floor troughs shall be furnished for all sewers entering manholes. Inverts shall be U-shaped to the 1.0 diameter point before sloping at a 1 to 12 slope to the manhole walls.
 - 2. Unless approved by the Engineer, the sanitary sewer pipe should be laid continuously through the manholes and cut out when the manhole invert is finished. Manhole couplings or other acceptable water stops (i.e. PVC pipe gasket stretched over outside of pipe, Ram-Nek, etc.) must be used when connecting PVC pipe to manholes. After the installation of the pipelines into the manhole, the interior annular space around the outside of the pipe shall be sealed with grout.
- H. Fittings for drop manholes shall consist of a wye and a ninety-degree bend. (see Detail Drawings unless otherwise shown in the Contract Documents or approved by the Engineer). Clean out pipe on drop manholes will penetrate the inside of the manhole twelve inches (12") (300mm) to fourteen inches (14") (350mm) with the top half of the pipe cut out. The entire drop inlet piping arrangement shall be encased in mass concrete having a twenty-eight (28) day compressive strength of at least four thousand pounds per square inch (4,000psi) (27,600 kPa).

3.04 Installation of Air Release Valve Vault

- A. The vault for the air release valve of a force main shall be installed in accordance with

3.05 Backfilling and Grading

- A. All excavation in trenches shall be backfilled to the original ground surface or to such grades as specified or as shown on the drawings. The backfill shall begin as soon as practical after the pipe has been placed and shall thereafter be carried on as rapidly as the protection of the balance of the work shall permit.
1. No pipe shall be covered before the Project Representative or the Engineer has observed and approved the pipe. If any piping or appurtenance is covered without the approval of the Engineer or Resident Project Representative, at the discretion of the Engineer, the Contractor shall be required to re-excavate to expose the covered materials. The cost of exposing those materials and then backfilling and recompacting will be at the Contractor's expense regardless of the condition of the pipe and/or the materials under question.
 2. The Contractor shall completely backfill all excavations before stopping work at the end of each day. Open excavations (fenced or unfenced) will not be allowed overnight, on weekends, or after work at any site after work has stopped for the day, unless approved by the City.
- B. Complete cleanup shall proceed directly behind the backfilling operation to accommodate the return to normal conditions. Should the Contractor, in the City's opinion, fail to pursue diligently the backfilling and cleanup, the amount of work on which complete cleanup has not been accomplished shall be limited to one thousand lineal feet (1,000') (300m) for the entire job. The Contractor shall have sufficient equipment on the job to assure timely backfill and cleanup at all times.
- C. Backfilling and compacting shall be done to meet minimum densities as required. Depositing of the backfill shall be done so the impact of falling material will not injure the pipe or structures. Grading over and around all parts of the work shall be done as directed by the Engineer.
1. Where excavations occur in unpaved surfaces, such as alleys but not previously turfed areas, the area shall be restored by placing a minimum of two inches (2") (50mm) of stabilized gravel on the surface of the excavation. Stabilized gravel shall be equal to material meeting coarse aggregate for minimum three-fourths inch (3/4") (20mm) as specified in other Divisions and Sections related to Street Construction.
- D. Class C granular bedding shall be deposited in the trench simultaneously on both sides of the pipe for the full width of the trench to a height at least to the mid-point of the pipe. The bedding material shall be shovel placed and hand-held machine tamped in maximum six-inch (6") (150mm) layers to completely fill all spaces under and adjacent to the haunches of the pipe. Encasement material will then be placed around and over the pipe to a height of at least twelve inches (12") (300mm) above the top of the pipe, but need not be hand-placed. Granular encasement material, as specified, must be used for all pipe.
- E. Succeeding layers of backfill above the twelve-inch (12") (300mm) level may contain coarse materials not exceeding three-inches (3") (75mm) in the largest dimension, but shall be free from large pieces of rock, frozen material, concrete, roots, stumps, tin cans, rubbish, and other similar articles whose presence in the backfill would, in the opinion of the Engineer, cause settlement of the trench or damage to the pipe. If suitable trench excavation is not available, Contractor shall

import pit run material for trench backfill. Pit Run material shall meet the approval of the Engineer. Whenever select material, encountered in the upper two feet of the finished grade of paved or graveled streets or roadways, is removed by the trench excavation, the Contractor shall replace said material (or material of equal quality) as backfill. Where select material does not exist in place as described above, the Contractor shall provide and place sufficient select backfill to stabilize the finished grade as directed by the Engineer.

- F. Backfilling shall be done in lifts of uniform layers which will produce the required compaction. Each lift shall be completely compacted over the full width of the excavated area. Compacting shall continue until the specified relative compaction has been attained or until no more settlement occurs. Water jetting of backfill shall not be permitted.
- G. Groundwater barriers may be directed by the City Engineer to be placed at maximum three hundred feet (300') (90m) intervals. These shall be provided to interrupt the passage of water through the foundation, bedding, encasement, and select backfill material. The barriers shall be compacted to 95% of maximum density (Standard Proctor) the full depth of the granular material, the full trench width and a minimum of three-feet (3') (900mm) long.
- H. Special attention shall be given to the compaction operation performed around all manholes, valve boxes, curb boxes, other structures, and utilities by the use of pneumatic tampers, plate tampers, or plate vibrators to obtain the required compaction requirement.
 - 1. Structure backfilling shall cover manholes, valve boxes, curb boxes, and any other structure encountered during the course of the work. Fill around structures shall consist of trench backfill meeting the requirements of bedding and encasement material or select backfill material. Fill material shall be spread and compacted to provide continuous and uniform support around the structure.
 - 2. Do not place fill when the surface to be filled is snow covered or frozen. Do not place frozen fill.
 - 3. Fill around concrete structures shall commence only after concrete has attained 80% of the ultimate compressive strength specified. Remove all form materials, concrete spills, and trash from around the structures before placing fill. Where backfilling on both sides or around the perimeter of a structure is required, place the backfill and compact simultaneously at the same elevation on opposite sides or around the perimeter in lifts.
 - 4. Place fill material in eight-inch (8") maximum lifts and compact to at least 95% density for cohesive soils and 70% relative density for non-cohesive soils. The moisture content shall be plus or minus 2% of optimum.
- I. Sewer service trenches shall be compacted in the same manner as the sewer main trenches. In streets open to traffic, service trenches must not be left open overnight. In areas where curb and gutter exist, sufficient curbing shall be removed to allow this compaction over the entire disturbed area.
- J. All deficiencies in the quantity of material for backfilling the trenches or for filling depressions caused by settlement shall be supplied by the Contractor. Any excess material shall be hauled away and disposed of in a legal manner at no additional compensation.
- K. No waste material or debris shall be deposited on any public or private property without the written permission of the Engineer. Waste material and debris shall include, but not be limited to

trees, stumps, pieces of pipe, pieces of concrete, pieces of asphaltic concrete, tin cans, or other waste material from the construction operations. Disposal of this material shall be the responsibility of the Contractor.

- L. The in-place density of the compacted soil shall be determined by the Engineer using either ASTM standard test method D1556-82 (sandcone), AASHTO T 238-97, or ASTM standard test method D2722-81 (nuclear). The maximum density of the soil shall be determined by ASTM standard test method D698 (standard proctor). The in-place density must not be less than the following percentages of the maximum density in paved areas, areas to be paved, and graveled areas:
1. 95% compaction from twenty-four inches (24") (600mm) above top of pipe to the finished surface, except that in no case shall this 95% compaction zone be less than forty-eight inches (48") (1.2m) deep..
 2. The compaction required outside paved areas, outside areas to be paved or outside graveled areas shall be 90%.
 3. The compacted backfill shall have a moisture content of $\pm 2\%$ of optimum moisture.
- M. The Engineer shall determine the frequency and number of tests to be conducted to measure the gradation, density, and moisture of the backfill. Minimum testing frequency is as follows:
1. Gradation Tests
 - a. Foundation Material. One initial gradation test for each type of material plus one additional test for each 1,000 cubic yards (1,000 yd³) (750 m³) or portion thereof placed of each material.
 - b. Bedding and Encasement Material. One initial gradation test for each type of material plus one additional test for each 10,000 cubic yards (10,000 yd³) (7,500 m³) or portion thereof placed of each material.
 - c. Select Backfill Material. One initial gradation test for each type of material plus one additional test for each 10,000 cubic yards (10,000 yd³) (7,500 m³) or portion thereof placed of each material.
 - d. All gradation tests shall be the responsibility of the Contractor using a certified approved soils testing laboratory acceptable to the Owner and Engineer. The Contractor shall be responsible for all costs associated with gradation testing.
 2. Density and Moisture Test
 - a. Pipe Encasement Material. One test for each one thousand cubic yards (1,000 yds³) (750 m³) or portion thereof placed of each material.
 - b. Foundation Material. One test for each one thousand cubic yards (1,000 yds³) (750 m³) or portion thereof placed of each material.
 - c. Bedding and Encasement Material. One test for each one thousand cubic yards (1,000 yds³) (750 m³) or portion thereof placed of each material.

- d. Select Backfill Material. One test for each one thousand cubic yards (1,000 yds³) (750 m³) or portion thereof placed of each material.
 - e. Job Excavated Select Backfill Material. Tests shall be taken as arranged by the Engineer.
 - f. Unless otherwise indicated in the Contract Documents, density and moisture tests shall be the responsibility of the Engineer. The Contractor shall cooperate with the Engineer or the soils testing agency in taking density and moisture tests.
- N. When the trench excavation for the sewer main and appurtenances is within the rights-of-way of state or county highways, the backfilling of the trench, compaction of materials, subgrade preparation and surfacing shall be done in strict accordance with the requirements and specifications of the authority having jurisdiction or as required by these specifications, whichever is more stringent.
- O. In all cases, the Contractor shall blade and compact the roadway after the trench has been backfilled, so that it shall be passable to traffic at all times. The Contractor shall maintain the roadway in a condition acceptable to the City at all times until final acceptance of the entire work by the City.
- P. The Contractor shall also blade and maintain all detours and bypasses. All maintenance work shall be done at no additional compensation. In addition to the blading and maintenance requirements specified, the Contractor shall provide at least one tank truck with pressurized spray bars for spraying water on the streets to control the dust. Dust control shall be required as necessary on all streets after compaction and grading and on all detours and bypasses.
- Q. The Contractor is responsible for the complete maintenance of his work at all times. If he fails to provide proper maintenance, and safety or nuisance conditions arise, it is expressly understood that City crews may be directed by the City to provide essential maintenance, and that such work will be done at the expense of the Contractor.
- R. The Contractor shall remedy at his own expense any defects that appear in the backfill following completion and during the warranty period.

3.06 Service Connections

- A. It shall be the duty of the Contractor to keep an accurate record of service connections as to the location, elevation of the service at the property line, type of connection provided, and other pertinent data and to include this information on the record drawings. Locations shall be made in respect to the survey line stationing and house corners or lot corners. The Engineer, prior to any backfill, shall approve all service installations.
- B. The Contractor shall construct services for building connections and shall extend such services to the back of the utility easement. Service connections shall have a wye or tee installed at the main

line. The sewer lateral will be aligned at a 90 degree angle with the main line. Service connections shall not enter at an angle greater than 45 degrees from the horizontal. Contractor shall leak test all new service lines in conjunction with new sewer mains being leak tested.

- C. Sewer service riser pipes shall not be installed directly into the main line. The bottom section of the sewer service line (installed at an angle not greater than 45 degrees from the horizontal) shall be a minimum length of eighteen inches (18") (450 mm) between the main line and the riser pipe installed at a grade not greater than 1/2 – inch per foot. The trench bottom below the bottom sections and the riser of the sewer service line shall be compacted to support the sewer service riser pipe. Riser pipes shall be laid against the trench wall to help prevent drag down loading from soil settlement. An engineer will design all sewer service riser pipes where the depth of the main line is twelve feet (12') (3.6m) or greater.
- D. Sewer services shall be installed ten feet (10') (3m) from the lot centerline on the downhill side of the sewer main. Services may be installed at a greater distance from the centerline if required by the sewer elevation. Services shall be installed perpendicular to the sewer main between the main and the property line.
- E. Sewer service lines shall be kept as deep as required to serve the property and shall extend on a straight-line grade to the property line unless otherwise directed by the Engineer. Where possible, all sewer service connections shall end above the groundwater table.
 - 1. All sewer service connections shall be capped with stoppers which shall effectively prevent water from entering the sewer until the connection is placed in service. The cap shall be as recommended by the pipe manufacturer, sealed firmly in place, or by other methods accepted by the Engineer. The service connection end shall be clearly marked by a rebar extending from the pipe end to at least three feet (3') (1m) above the ground. The service line location shall also be marked in the concrete curbwalk by an arrow with the letter "S".
- F. In some areas, the sewer services may be laid at the minimum grade allowed by the plumbing code in effect due to a shallow sewer line or low abutting property. Services shall be at right angles to the main sewer unless otherwise directed by the Engineer.
- G. Where it is necessary to tap sewer services into existing mains, the City shall make the taps for the Contractor using saddle adapters. The Contractor shall be responsible for installing the service line from the installed tap to the property. The Contractor shall be responsible for obtaining a street cut permit, laying out and excavating the trench, protecting all mains and service pipes and backfilling the excavation in an approved manner. Contractor shall adhere to OSHA trenching and shoring rules and regulations.
- H. All abandoned or unused sewer service lines must be plugged at the property line and capped with a watertight stopper.

3.07 Leak Testing

- A. Upon completion of all utility construction and before any sewer service line is connected into, leak testing will be required of all sanitary sewer pipe lines. The Contractor has the option of performing either an air test or a water exfiltration test. Testing shall be performed after complete compaction and backfill and completion manholes, but may be performed before the

final surfacing.

1. Leak testing, using low-pressure air shall be performed with suitable equipment specifically designed for air testing sewers.
 - a. The air test shall be made when the sewer is clean. Sections of sewer pipe to be tested may be wetted before the air test. The pipeline shall be plugged at each manhole with pneumatic balls. Low-pressure air shall be introduced into the plugged line until the internal pressure reaches four-pounds per square inch (4.0 psig) (28 kPa) greater than the average back pressure of any groundwater pressure that may submerge the pipe. At least two (2) minutes shall be allowed for the air temperature to stabilize before readings are taken and the time started.
 - b. The portion of the sewer line being tested shall pass if it does not lose air at a rate to cause the pressure to drop one-half pound per square inch (0.5 psig) (greater than the average back pressure of any groundwater that may submerge the pipe) in less time than listed below.

| Pipe Diameter in. (mm) | Minimum Time (min:sec) | Specified Time for L (min:sec) | | | | | | | |
|---------------------------|---------------------------|--------------------------------|---------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | | 100' (30m) | 150' (45m) | 200' (60m) | 250' (75m) | 300' (90m) | 350' (105m) | 400' (120m) | 450' (135m) |
| 4 (100) | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 |
| 6 (150) | 2:50 | 2:50 | 2:50 | 2:50 | 2:50 | 2:50 | 2:50 | 2:51 | 3:12 |
| 8 (200) | 3:47 | 3:47 | 3:47 | 3:47 | 3:47 | 3:48 | 4:26 | 5:04 | 5:42 |
| 10 (250) | 4:43 | 4:43 | 4:43 | 4:43 | 4:57 | 5:56 | 6:55 | 7:54 | 8:54 |
| 12 (300) | 5:40 | 5:40 | 5:40 | 5:42 | 7:08 | 8:33 | 9:58 | 11:24 | 12:50 |
| 15 (375) | 7:05 | 7:05 | 7:05 | 8:54 | 11:08 | 13:21 | 15:35 | 17:48 | 20:02 |
| 18 (450) | 8:30 | 8:30 | 9:37 | 12:49 | 16:01 | 19:14 | 22:26 | 25:38 | 28:51 |
| 21 (525) | 9:55 | 9:55 | 13:05 | 17:27 | 21:49 | 26:11 | 30:32 | 34:54 | 39:16 |
| 24 (600) | 11:20 | 1:24 | 17:57 | 22:48 | 28:30 | 34:11 | 39:53 | 45:35 | 46:54 |
| 27 (675) | 12:45 | 14:25 | 21:38 | 28:51 | 36:04 | 43:16 | 50:30 | 57:42 | 51:17 |
| 30 (750) | 14:10 | 17:48 | 26:43 | 35:37 | 44:31 | 53:25 | 62:19 | 71:13 | 80:07 |
| 33 (825) | 15:35 | 21:33 | 32:19 | 43:06 | 53:52 | 64:38 | 75:25 | 86:11 | 96:58 |
| 36 (900) | 17:00 | 25:39 | 38:39 | 51:17 | 64:06 | 76:56 | 89:45 | 102:34 | 115:24 |

- c. If the pipeline section fails this test, the testing equipment may be used to determine the location of the pipe leak.
 - d. All service plugs shall be secured in place to prevent displacement during testing operations.
2. In lieu of the standard sanitary sewer air test, the Contractor may perform leakage testing on sewers using water and measuring the exfiltration.
 - a. The test section shall be bulkheaded at both ends and the pipe subjected to a hydrostatic pressure produced by a head of water at a depth of three feet (3') (1m) above the top of the sewer at the upper manhole under this test. In areas where ground water exists, this head of water shall be three feet (3') (1m) above the existing water table.

- b. For purposes of the test, the line between adjoining manholes will be considered a section and will be tested as such
 - i The head of water shall be obtained by means of an open ended stand-pipe projecting from a test plug on the upper manhole. Placing water in the upper manhole is not permissible as a means of obtaining the necessary pressure head of water.
 - ii This head of water shall be maintained for a period of one (1) hour during which it is presumed that full absorption of the pipe body has taken place, and thereafter for a further period of one (1) hour for the actual test of leakage. During this one (1) hour test period, the measured maximum allowable rate of exfiltration for any section of sewer, including service stubs, shall be listed below:

| MAIN SEWER DIAMETER | MAXIMUM ALLOWABLE EXFILTRATION |
|---------------------|---|
| inches(mm) | Gallons Per Hour Per 100 feet(l/hr/30m) |
| 4 (100) | 0.6 (2.2) |
| 6 (150) | 0.9 (3.4) |
| 8 (200) | 1.2 (4.5) |
| 10 (250) | 1.5 (5.5) |
| 12 (300) | 1.9 (7) |
| 15 (375) | 2.3 (9) |
| 18 (450) | 2.8 (10.5) |
| 21 (525) | 3.3 (12.5) |
| 24 (600) & larger | 38 (14) |

- iii In case measurements indicate an exfiltration greater than the maximum allowable leakage, additional measurements shall be taken and continued until all leaks are located and the necessary repairs and corrective work have reduced the leakage in the section being tested below the maximum allowable by the specifications.
3. The Contractor shall furnish the plugs, standpipe, and other material and labor for placing the plugs and standpipe in the sewer.
 4. The introduction of any substance into the water used for testing with the intent of sealing such leaks as may be indicated will not be permitted.
 5. If results of either of these leakage tests are not satisfactory, repairs or pipe replacement will be required until the Engineer is satisfied that the leakage requirements are being met. All repair methods and materials used shall be approved by the Engineer.

B. Manholes will be tested for leakage separately from the pipe by one of the following methods:

1. Vacuum Testing
 - a. All manholes shall be vacuum tested for leaks upon the completion of the backfill and compaction operation. The vacuum test method shall be in accordance with ASTM

C1244-05a, except as specified otherwise herein. The vacuum test shall be performed by the Contractor and witnessed by the Engineer or representative of the Engineering Department. Twenty-four hours (24hr) advance notice shall be provided before testing begins.

- b. The Contractor shall furnish all equipment and labor required, including necessary piping/hoses, pneumatic plugs, test vacuum equipment (vacuum pump and vacuum plate/head), vacuum gauge and second timer. The vacuum gauge shall have a maximum range of 0-30 inches of mercury (Hg) and the vacuum gauge figure intervals shall be in ½ inch increments.
- c. After cleaning the interior surface of the manhole, the Contractor shall place and inflate pneumatic plugs in all the connecting pipes with the exception of sewer services to isolate the manhole. Complete sewer services entering the manhole shall be part of manhole vacuum test.
- d. The vacuum plate/head shall be placed on the top of the manhole lid frame. The vacuum pump shall be connected to the outlet port with the valve open. When a vacuum of ten (10) inches of mercury has been attained, the outlet valve shall be closed and the test period is started. The minimum test period is determined from the following table:

| DEPTH OF MANHOLE (ft) | DIAMETER OF MANHOLE (ft) | |
|--------------------------|--------------------------|-----|
| | 4 | 6 |
| | TIME (sec) | |
| <14 | 60 | 60 |
| 16 | 60 | 67 |
| 18 | 60 | 73 |
| 20 | 60 | 81 |
| 22 | 60 | 89 |
| 24 | 60 | 97 |
| 26 | 64 | 105 |
| 28 | 69 | 113 |
| 30 | 74 | 121 |

- e. All pneumatic plugs shall be removed from the manhole after the test.
- f. Any manhole that fails the initial vacuum test must be repaired with a non-shrink grout material. The Contractor shall apply non-shrink grout on the interior of the manhole. Upon completion of the repairs, the manhole shall be retested as described in the above test procedures. The cost of the manhole repair and backfill is incidental to the cost of the project.
- g. Any manhole that fails the three vacuum tests must be removed and replaced with a new manhole. The new manhole shall be backfilled to grade and tested as described in the above test procedures. The cost of the new manhole and backfill is incidental to the cost of the project.
- h. The manhole shall have passed the vacuum test if the manhole vacuum does not drop below nine (9) inches of mercury during the minimum specified test period.

2. Manholes shall be filled with water to a depth of five feet (5') (1.5m) above the invert or five feet (5') (1.5m) above the groundwater table whichever is higher. If the groundwater level is more than five feet (5') (1.5m) above the invert, inflow to the manhole shall be measured. Allowable leakage into or out of or both shall be one gallon per hour (1g/h) (3.75l/h) per manhole measured over a minimum four (4) hours. At least 20% of all manholes shall be tested. Based on these tests, and visual inspection of all manholes, additional tests may be required for other manholes. Any manhole whose test is unsatisfactory shall be repaired and retested until satisfactory results are obtained.

3.08 PVC Deflection Test

A. All PVC pipe shall be subject to a deflection test by use of cage type approved mandrel.

1. In paved areas or areas to be paved, the Contractor has the option of:

- a. Testing PVC sewer lines with a 4% deflection mandrel after completed backfill and compaction of trench but before paving, or
- b. Testing PVC sewer lines with a 5% deflection mandrel after paving is complete.

2. In non-paved areas Contractor has the option of:

- a. Testing PVC sewer lines with a 4% deflection mandrel after complete backfill and compaction of trench but before placing and spreading topsoil, or
- b. Testing PVC sewer lines with a 5% deflection mandrel after placing and spreading topsoil (but before seeding).

B. All mandrels shall be precisely made to the diameters specified below (which include allowances for pipe manufacturer's outside diameter tolerance, excess wall thickness tolerance, and out-of-roundness tolerance).

| NOMINAL PIPE DIAMETER | MANDREL MINIMUM OD FOR 4% DEFLECTION | MANDREL MINIMUM OD FOR 5% DEFLECTION |
|------------------------------|---|---|
| 8"(200mm) | 7.358" (187mm) | 7.282" (185mm) |
| 10" (250mm) | 9.180" (233mm) | 9.085" (231mm) |
| 12" (300mm) | 10.907" (277mm) | 10.793" (274mm) |
| 15" (375mm) | 13.342" (339mm) | 13.203" (335mm) |
| 18" (450mm) | 16.297" (414mm) | 16.127" (410mm) |
| 21" (525mm) | 19.204" (488mm) | 19.004" (483mm) |
| 24" (600mm) | 21.581" (548mm) | 21.356" (542mm) |
| 27" (675mm) | 24.314" (618mm) | 24.061" (611mm) |

* OD – Outside Diameter

3.09 Separation of Water Mains and Sewers.

- A. Minimum horizontal separation shall be ten feet (10') (3m) where the invert (bottom) of the water main is less than eighteen inches (18") (450mm) above the crown (top) of the sewer line. Minimum vertical separation shall be eighteen inches (18") (450mm) at crossings. Joints in sewers at crossings shall be located at least ten feet (10') (3m) from water mains. The upper line of a crossing shall be specially supported. Where vertical and/or horizontal clearances cannot be maintained, the sewer or water piping shall be placed in a separate conduit pipe.

3.10 Inspection and Acceptance

- A. Prior to acceptance of each section of sanitary sewer line, the Contractor shall flush a ball the full diameter of the pipe through all pipelines up to eighteen inches (18") (450mm) in diameter. Larger pipelines shall be cleaned by other appropriate methods. All dirt and debris shall be prevented from entering the existing sewer system by suitable methods.

B. Preliminary Acceptance

- 1. Prior to preliminary acceptance of a sanitary sewer collection system, regardless of ownership, the following inspection tests shall be made and certified for each section of sewer line.
 - a. Gradation tests. Copies of the test results shall be enclosed as an attachment to the "Certificate of Completion".
 - b. Density and moisture tests. Copies of the test results shall be enclosed as an attachment to the "Certificate of Completion".
 - c. Air tests or exfiltration tests. Copies of the test results shall be enclosed as an attachment to the "Certificate of Completion".
 - d. Deflection test (PVC). Copies of the test results shall be enclosed as an attachment to the "Certificate of Completion".
 - e. Cleaning and flushing of the lines and manholes.
- 2. Each manhole shall be inspected for:
 - a. Proper construction. The invert of the manholes shall be smooth, clean, and free of obstructions.
 - b. Leakage
 - c. Cover accessible and at proper grade.
- 3. Items 1.c. and 1.d. above shall be performed only after complete backfill and compaction; items 1.e. and items 2.a., 2.b., and 2.c. shall be performed after an all-weather roadway is completed and complete easement restoration is accomplished.

4. The “Certificate of Completion” and “Record Drawings” shall be submitted to the City prior to preliminary acceptance.

C. Final acceptance

1. Final acceptance will not take place until preliminary acceptance is obtained and all paving and curbside is completed.
2. Before final acceptance of any sanitary sewer, the following inspections shall be made:
 - a. All lines clean and flushed.
 - b. Manholes up to proper grade in a proper condition.
3. All punch list items must be completed prior to final acceptance.
4. The warranty period shall not start until final acceptance is obtained and a complete set of “Record Drawings” is submitted to the City.

3.11 Record Drawings

- A. “Record Drawings” shall be submitted to the City prior to preliminary acceptance of the construction project. “Record Drawings” shall include, in addition to construction drawings and details, “as built” information where it differs from construction drawings and locate information including horizontal and vertical coordinates in the datum established by the City for the Geographical Information System.

END OF SECTION

SECTION 02741

ASPHALTIC CONCRETE PAVEMENT

PART 1 – Description

This work shall consist of an asphaltic concrete pavement constructed in one or more layers for surface course(s) and binder course(s). The binder course may also be used as a leveling or bushing course. Binder course shall consist of a hot mixture of aggregate and asphalt prepared in a hot bituminous mixing plant. The binder course shall be constructed on a prepared subgrade, subbase, or base conforming to the lines, grades, thicknesses, and cross-sections shown on the Plans or as directed by the Engineer. The surface course shall consist of an asphaltic concrete pavement composed of a mixture of coarse aggregate, fine aggregate, mineral filler, and asphalt cement, constructed on a prepared roadbed in conformity with the lines, grades, thicknesses, and cross-sections shown on the Plans or directed by the Owner.

PART 2 – Materials And Equipment

2.01 MATERIALS

- A. Asphalt Cement. Asphalt cement shall conform to the requirements of ASSHTO M 226, Table 2, for the grade specified. Unless otherwise directed, asphalt shall be Viscosity Grade AC-20, PG64-22, or PG 64-28. The type and grade of bituminous material may be changed one step by the Engineer during construction, at now change in unit price.
- B. Course Aggregate. Course aggregate (aggregate retained on the No. 4 sieve) shall be crushed stone meeting the quality requirements of ASTM D 692 with the following exceptions:
 - 1. Crushed limestone shall have a sodium sulfate soundness loss not exceeding 9 percent.
 - 2. For Mix No. 1, material retained on the No. 4 sieve shall have a maximum of 20 percent elongated pieces (length greater than five times the average thicknesses).
 - 3. For Mix No. 2, the aggregate shall contain no more than 5 percent soft or nondurable particles.
 - 4. For Mix No. 3, the aggregate shall contain no more than 5 percent soft or nondurable particles.
- C. Fine Aggregate. The fine aggregate shall consist of natural sand consisting of hard, clean, tough grains which will have a maximum loss of 12 percent when subjected to the sodium sulfate soundness test.
- D. Composition of Mixtures

1. Asphaltic Concrete Surface, Mix No. 1, shall be laid in one course to the thickness shown on the Plans.
2. Asphaltic Concrete Binder, Mix No. 2, shall be laid in one or more courses to the thicknesses shown on the Plans. Mix No. 2 may also be used as a leveling course or bushing course.
3. Asphaltic Concrete Binder, Mix No. 3 shall be laid in one or more courses to the thickness shown on the plans.
4. The composition of the mixes shall be as follows:

| Sieve Size | Total Percent Passing by Weight | | |
|------------|---------------------------------|-----------|-----------|
| | Mix No. 1 | Mix No. 2 | Mix No. 3 |
| 2" | 100 | 100 | 100 |
| 1-1/2" | 100 | 100 | 90 - 100 |
| 3/4" | 100 | 100 | 65 - 90 |
| 3/8" | 76 - 96 | 65 - 95 | ----- |
| No. 4 | 51 - 76 | 45 - 70 | 30 - 55 |
| No. 8 | 36 - 60 | 25 - 50 | 20 - 45 |
| No. 30 | 16 - 40 | 12 - 30 | 8 - 25 |
| No. 100 | 3 - 12 | 2 - 12 | 2 - 12 |
| No. 200 | 2 - 8 | 1 - 6 | 1 - 6 |

5. The proportions of the total mixture, in percent by weight, shall be as follows:

| Courses | Combined Mineral Asphalt | Aggregate Cement |
|-------------------------------|-----------------------------|------------------|
| Mix No. 1, Surface(Limestone) | 92.0 - 96.0 | 4.0 - 8.0 |
| Mix No. 2, Binder | 93.0 - 97.5 | 2.5 - 7.0 |
| Mix No. 3, Binder | 93.0 - 97.5 | 2.5 - 7.0 |

6. It is the intent of this Section of the Specifications that the above described mixes shall conform to the following mixtures specified in the Tennessee Department of Transportation Standard Specifications for Road and Bridge construction.

Mix No. 1 - Section 411, Asphaltic Concrete Surface (Hot Mix), Aggregate Grading E.
 Mix No. 2 - Section 307, Bituminous Plant Mix Base (Hot Mix), Aggregate Grading C.

Mix No. 3 – Section 307, Bituminous Plant Mix Base (Hot Mix),
Aggregate Grading B.

7. For multiple layer construction, succeeding layers shall not be laid until the previous layer has cooled sufficiently to support the construction equipment
8. When Mix No. 1 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 nor less than 20 percent natural sand. When Mix No. 1 is used for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone, including screening and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50 percent limestone. The natural sand shall be so graded that not more than 5 percent will be retained on the No. 4 sieve.

2.02 EQUIPMENT

- A. All equipment necessary for the satisfactory performance of this construction shall be on the Project and approved of before work will be permitted to begin. The equipment shall meet the requirements of Specification Section 02710.

PART 3 – Execution

3.01 General

- A. The general construction requirements for surface and binder courses shall be as prescribed in the applicable portions of Specification Section 02710

3.02 Preparation of Base or Existing Surface

- A. The designated surface upon which asphalt concrete courses are to be placed shall meet the applicable requirements of Specification 02710 and be thoroughly cleaned of all dirt and other foreign or loose matter prior to the application of the Tack Coat or Prime Coat, as specified in TDOT Specification Sections 402 and 403.

3.03 Thickness And Surface Requirements

- A. Thickness shall be controlled during the spreading operations by frequent measurements taken of freshly spread mixture to establish a relationship between the un-compacted and compacted material. This thickness shall remain in conformity with that specified on the Plans. The surface of all courses shall meet the requirements specified under Specification Section 02710 and when tested in

accordance with the provisions of Specification Section 02710 the deviation of the surfaces from the testing edge of the straightedge shall not exceed 1/4 inch for Mix No. 1 or 3/8 inch for Mix No. 2 and Mix No. 3.

3.04 Manhole Adjustments

- A. Drainage and sanitary sewer manholes owned by the City shall be adjusted and set at final grade by the Contractor as necessary for compliance with the Plans. Adjustments of City owned manholes shall be as specified in Section 02530 or 02632 of these Specifications. Manholes, valve boxes, and other utility structures not owned by the City but within the right-of-way of the project shall be adjusted as necessary by the owner of such facilities. The Contractor shall be responsible for notifying other owners of any required adjustments and for the accomplishment of that work by the owner of such facilities according to the project schedule.

3.05 Traffic And Maintenance

- A. The Owner will determine when the surface course has sufficient compaction and has cured sufficiently to allow construction equipment, slow moving local traffic, or normal traffic to use the completed surface.

END OF SECTION

SECTION 03050

PORTLAND CEMENT CONCRETE

Part 1-Description.

The work covered in this section includes the classification, materials, proportioning of materials, equipment, mixing requirements, and testing for Portland Cement Concrete to be used for curbs, curb and gutter, and sidewalks, streets, bridges, and miscellaneous structures.

Part 2 - Materials

2.01. Classes of Portland Cement Concrete. Portland cement concrete used for construction of the various items specified elsewhere in these Specifications shall be classified by usage as follows:

A. Class A.

Class A concrete shall be used as specified for such items as directed by the Engineer and other uses as noted in the Special Provisions.

B. Class AS.

Class AS concrete shall be used for storm and sanitary structures, concrete curb, curb and gutter, valley gutters, sidewalks, ditch paving, and similar structures unless otherwise noted in the Special Provisions.

C. Class B.

Class B concrete shall be used for roadway base, soil cement, and pavement.

D. Class C.

Class C concrete shall be used as specified for such items as concrete cradles, encasements, embankment slope paving at bridge abutments, and other low strength applications.

E. Class P.

Class P concrete shall be used for cast-in-place box culverts and precast and precast-prestressed concrete structures or structural members. High-early-strength concrete shall be as specified in Specification Section 03050 Paragraph 6.05.

2.02 Materials.

A. Portland Cement.

1. Type I or Type I-SM cement shall be used unless otherwise specified. Different types of cement shall not be mixed. Portland Cement shall conform to all requirements of the "Standard Specifications for Portland Cement," AASHTO M 85. M. Specification C150 for Class Type I, except that for high early strength concrete, Type III cement may be used.

B. Fine Aggregate.

1. Fine aggregate for concrete shall consist of sand and shall conform to the following ASSHTO M6 with the following exceptions.

i. General Composition. Concrete sand shall be composed of clean (washed), hard, durable, uncoated grains, free from injurious amounts of clay, dust, soft flaky particles, loam, shale, alkali, organic matter, or other deleterious matter. Fine aggregate shall not contain appreciable materials which have unsatisfactory expansive properties when combined with Portland Cement and water.

ii. Sieve Analysis. Fine aggregate shall be graded within the following limits:

| Sieve | % Passing by Weight | |
|-----------------|---------------------|------|
| | Min. | Max. |
| 3/8" (9.5mm) | 100 | --- |
| No. 4 (4.75mm) | 95 | 100 |
| No. 8 (2.36mm) | 80 | 100 |
| No. 16 (1.18mm) | 50 | 90 |
| No. 50 (330um) | 5-30 | |
| No. 100 (150um) | 0 | 10 |
| No. 200 (75um) | 0 | 3 |

Deleterious Substances. The fine aggregate shall not contain more than the following maximum amounts of deleterious substances:

| | Max. % of Weight |
|---|------------------|
| Clay lumps. | 0.5 |
| Coal, lignite, or shale. | 0.5 |
| Material passing the No. 200 Sieve. | 3.0 |
| Other deleterious substances such as Shale, alkali, mica, coated/grains soft and flaky particles. | 3.0 |

If the fine aggregate is manufactured from limestone or dolomite and if the material finer than the No. 200 sieve consists of dust of fracture, essentially free from clay or shale, this limit may be increased from 3% to 5%

iv. Organic Impurities. Fine aggregate subjected to the colorimetric test as per ASTM C40 for organic impurities and producing a color darker than the standard shall be rejected unless it passes the mortar strength test as specified herein, Organic Impurities ASTM C40.

C. Coarse Aggregate. Coarse aggregate for concrete shall consist of crushed stone or gravel or crushed or uncrushed gravel and shall conform to the following requirements:

1. Coarse aggregate for Class A, Class B, or Class C concrete shall be furnished in two sizes: Size No. 4 and Size No. 67 as shown hereinafter in the attached Table Coarse

Aggregate Gradation Table.

2. The two sizes shall be manufactured, within the specified limits, to produce Size No. 467 when combined in the proper proportions at the batching plant. If the supplier provides a proper stockpile to prevent segregation, then a combined Size No. 467 can be used in lieu of blending Size No. 4 and Size No. 67.
3. Coarse aggregate for Class AS concrete shall be Size No. 57. Only limestone coarse aggregate will be used for Class AS concrete; gravel coarse aggregate will not be permitted.
4. Coarse aggregate for Class P concrete shall be size No. 57 or Size No. 67 as may be specified or directed. Only limestone coarse aggregate shall be used for Class P concrete; gravel coarse aggregate will not be permitted.
5. Coarse aggregate for concrete curbing placed by machine extrusion methods shall be Size No. 57 or Size No. 67.
6. The coarse aggregates shall otherwise conform to the requirements of AASHTO M 80 and ASTM C 33 with the following exceptions and stipulations:

a. Deleterious Substances. The coarse aggregate shall not contain more than the following maximum amounts of deleterious substances:

| | <u>Max. % of Weight</u> |
|---|-------------------------|
| Clay lumps | 0.25 |
| Material passing No. 200 sieve | 1.0 |
| Coal or Lignite | 1.0 |
| Other deleterious substances such as | |
| friable, thin, elongated, or laminated pieces | 10.00 |
| Other Local deleterious substances | 1.00 |
| Soft or nondurable fragments (fragments which | |
| Are structurally weak such as shale, soft | |
| Sandstone, limonite concretions, gypsum, | |
| Weathered schist, or cemented gravel. | 3.0 |

7. The sum of the above, excepting thin or elongated pieces, shall not exceed 5% by weight.
8. Soundness. When subjected to 5 cycles of the soundness test, as set forth in ASTM C88, the loss in weight of coarse aggregate weighted in accordance with the grading of a sample complying with the grading requirements specified, shall not exceed nine (9) percent for sodium sulfate.
9. Abrasion. The coarse aggregate shall not have an abrasive loss greater than 40% as determined by AASHTO T96.
10. In the case of crushed aggregate, if all the material finer than the 200 mesh sieve consists of the dust of fracture essentially free of clay or shale, Item 4, Maximum Per Cent by Weight, may be increased to 1.5.

COARSE AGGREGATE GRADATION TABLE
 Amounts Finer than Each Lab. Sieve (Sq. Opening), %By Weight

| SIZE NO. | 2" | 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | NO. 4 | NO. 8 |
|----------|-------|--------|--------|---------|-------|-------|-------|-------|
| 4 | 100 | 90-100 | 20-55 | 0-15 | ----- | 0-5 | ---- | ---- |
| 467 | 100 | 95-100 | ----- | 35-70 | ----- | 10-30 | 0-5 | ---- |
| 57 | ----- | 100 | 95-100 | ---- | 25-60 | ---- | 0-10 | 0-5 |
| 67 | ---- | ---- | 100 | 90--100 | ---- | 20-55 | 0-10 | 0-5 |

- D. Water for Concrete. The water shall be clean and free from objectionable amounts of oil, acid, alkali, organic matter, or other deleterious materials and shall not be used until the source of supply has been approved. If at any time the water from an approved source becomes of unsatisfactory quality or insufficient quantity, the Contractor will be required to provide satisfactory water from another source. Water of questionable quality shall be subject to the acceptance criteria of Table I, as specified in ASHTO T26.
- E. Air-Entraining Admixture. The Contractor shall use a regular Portland Cement with the addition of an air-entraining admixture meeting requirements of AASHTO M 154. Air-entraining admixtures to be used in air-entrained concrete shall be Darex AEA, Neutralized Vinsol Resin, and Protex, or any other air-entraining agent meeting the approval of the Engineer. Air-entraining admixtures shall contain no chlorides. The air-entraining characteristics of the admixture, in suitable proportions in combination with Portland Cement, fine aggregate and water, within the limits of the proportion specified, shall be such that the resulting concrete will have a satisfactory workability, and the total air content shall be as provided below in the following table.

| Nominal Max Size of Coarse Aggregate | Total Air Content Percentage by Volume Concrete |
|--------------------------------------|---|
| 3/8 inch | 6 to 10 |
| 1/2 inch | 5 to 9 |
| 3/4 inch | 4 to 8 |
| 1 inch | 3 1/2 to 6 1/2 |
| 1 1/2 inch | 3 to 6 |
| 2 inch | 2 1/2 to 5 1/2 |
| 3inch | 1 1/2 to 4 1/2 |

- F. Chemical Admixtures. Chemical admixtures shall conform to ASTM C494, except TYPE C accelerating admixtures shall contain no chlorides, shall be non-toxic after thirty (30) days, and shall be compatible with air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
- G. Pozzolan Admixture. Pozzolan admixture shall conform to the requirements of ASTM C311 and ASTM C618-85 (including Table IA) for either Class C or Class F. Class C fly ash may be used as a replacement for Portland cement if approved in writing by the Owner. The maximum amount of cement being replaced by fly ash shall not exceed 15 percent. When a specific air content has been required and fly ash is being used, the air content shall be tested on each truck load of concrete at the batch plant and the tested value shall be indicated on the ticket.
- H. Fiber-Reinforced Concrete shall conform to ASTM C1116 material requirements and classifications. Concrete containing fibers (steel, glass fibers, or synthetic fibers) shall conform to the manufacturers addition rate and shall be included in the mix design approved by the Engineer. Glass Fiber and synthetic fiber reinforced concrete shall not be used to replace structural reinforcement, and shall be added at the batch plant.

PART 3 – Execution

3.01 Sampling and Testing and Storage of Materials.

- A. Cement. Cement may be accepted on the basis of mill tests and the manufacturer's certification of compliance with the specifications, provided the cement is the product of a mill with a record for production of high quality cement. Certificates of compliance shall be furnished the Engineer by the Contractor, for each lot of cement furnished prior to use of cement in the work. This requirement is applicable to cement for job- mixed, ready-mixed, or transit-mixed concrete. Cement proposed for use where no certificate of compliance is furnished, or where, in the opinion of the Engineer, the cement furnished under certificate of compliance may have become damaged in transit or deteriorated because of age or improper storage, will be sampled at the mixing site and tested for conformance to the specifications.
 - 1. Cement will be approved for use if it satisfactorily passes the fineness, soundness, and time of set test requirements specified, provided the general run of materials has been satisfactorily meeting the 28-day strength requirements. Any approved cement failing to pass the 28-day strength requirements, if unused, shall be rejected. If, in the judgement of the Engineer, it is considered necessary, other lots of shipments from the same mill may be held for the results of tests before being used.
 - 2. If cement is supplied from a new source or from a source of unknown quality, it may be held for the results of strength test before being approved.
- B. Fine and Coarse Aggregate. At least two (2) weeks in advance of the beginning of concrete work the Contractor shall submit to an approved materials testing laboratory approximately five hundred pound (500#) (225kg) samples of each concrete aggregate proposed for use unless otherwise waived by the Engineer in writing. All tests which are necessary to determine the

compliance of the concrete materials with these specifications shall be performed on these samples. These samples shall also be used by the laboratory as the basis for a concrete mix design. The results of all tests and the concrete mix design shall be submitted to and approved by the City Engineer prior to the start of any concrete work. Standards shall conform to the latest applicable codes. The sampling and testing shall conform to the following standard procedures:

- C. Cement. The Contractor shall provide adequate protection for the cement against dampness. No cement shall be used that has become caked or lumpy. Accepted cement which has been held in storage more than 90 days after shipment from the mill shall be retested, and if failing to meet the requirements specified herein shall be rejected.
 - 1. Accepted cement which has been stored in approved sealed bins at the mill for not more than six (6) months may be used without further testing unless a retest is specifically requested by the Engineer.

- D. Aggregate. Aggregates shall be handled and stored in separate piles at the site in such manner as to avoid a separation of the coarse and fine particles and contamination by foreign materials. Sites for stockpiles shall be prepared and maintained in such a manner as to prevent the mixing of deleterious materials with the aggregate. The Contractor shall deposit material in stockpiles at the batching plant site until the moisture content becomes uniform. Stockpiles shall be built in layers not to exceed three feet (3') (1m) in height, and each layer shall be completed before beginning the next one.
 - 1. Coning or building up stockpiles by depositing the materials in one place will not be permitted. The storing of aggregates in stockpiles, or otherwise, upon the subgrade or shoulders will not be permitted.

3.02 Concrete Mixture Requirements.

- A. The concrete shall meet the following requirements as outlined in the Concrete Classification Table attached to the end of this Section.
 - 1. If it is found impossible to produce concrete having the required air content with the materials and mixing procedures that are being used, the Contractor shall make such changes in the materials or mixing procedures, or both, as may be necessary to insure full compliance with the requirements of air content in the concrete.
 - 2. The total weight of aggregates per sack of cement and the relative proportions of coarse and fine aggregate shall be determined by yield tests made during the progress of the work. The Engineer may, at his discretion, adjust the laboratory mix design to obtain the proper yield, and consistency of concrete.
 - 3. The Contractor shall receive written permission from the Engineer prior to adding Pozzolan admixture to Portland Cement Concrete.

4. Any combination of aggregates which requires the use of more than six and one-half gallons (6.5g) (25l) of water per sack of cement to produce a workable mixture, with the brand of cement used will be considered as being unsatisfactory, and all such combinations of aggregate will be rejected.
5. Concrete shall be uniformly plastic, cohesive, and workable. Workable concrete is defined as concrete which can be placed without honeycomb and without voids in the surface. Workability shall be obtained without producing a condition such that free water appears on the surface when finished. The consistency of the mixture shall be that required for the specified conditions and methods of placement; however, the previously determined maximum water cement ratio shall not be exceeded.

3.03 Proportioning of Materials.

All materials shall be separately and accurately measured by weight, and each batch shall be uniform. The coarse and fine aggregates shall be weighed separately. A sack of cement shall weigh ninety-four pounds (94#) (43kg). When bulk cement is used, ninety-four pounds (94#) (43kg) shall be considered as one sack. The Contractor shall furnish and use approved weighing devices, which, in operation, will give the exact quantity of materials required for the class of concrete. When the cement is in contact with the aggregate, it shall not remain more than forty-five (45) minutes before being deposited into the mixer.

3.04 Measurement of Aggregate.

- A. Where sack cement is used, the quantities of aggregate for each batch shall be exactly sufficient for one or more sacks of cement. No batch requiring a fraction of a sack of cement will be permitted. All measurements shall be by weight, upon approved weighing scales and shall be such as will insure separate and uniform proportions. Scales shall be of either beam or springless dial types, and shall be suitable for supporting the hopper or hoppers. They shall be set accurately in substantial mountings which will insure a permanent spacing of the knife edges under all conditions of loading and use. They shall be so designed and maintained that they will at all times be accurate to within one-half (1/2) of one (1) percent throughout the entire weight range. Clearance shall be provided between the scale parts and the hopper or the bin structure to prevent displacement of the scale parts due to vibrations, accumulations, or any other cause. The value of the minimum gradations on any scale shall not be greater than five pounds (5#) (2.3kg). The weighing beam or dial shall be so placed that it will be in full view of the operator during the operation of the gate which delivers the material to the hopper. Scales shall be protected from air currents that may affect the accuracy of weighing.
- B. Separate hoppers shall be provided for weighing fine and coarse aggregate. They shall be of suitable size and tight enough to hold the aggregate without leakage, and shall be supported entirely upon the scales. Suitable provisions shall be made for removal of overload from the hopper by the operator while he operates the bin gates.
- C. The Contractor shall provide a sufficient number of fifty-pound (50#) (23kg) standard test weights for calibrating the weighing equipment.

- D. The volume of concrete mixed per batch shall not exceed the manufacturer's guaranteed capacity of the mixer.
- E. When the aggregates are delivered to the mixer in trucks, each batch shall be in a separate compartment of the capacity required by the Engineer. Suitable covers shall be provided for the batch compartments of the trucks to protect the cement from the wind. All trucks, truck bodies, bulkheads, and compartments used in proportioning and transporting to the mixer of concrete materials shall be so designed and operated to insure the charging of the mixer, batch by batch, with the proper amounts of each material without overspillage, intermixing of batches or wastage. Any units which, in the opinion of the Engineer, do not operate satisfactorily, shall be removed from the work until properly rebuilt and corrected.

3.05 Mixing Concrete.

- A. Consistency. The quantity of water to be used shall be determined by the Engineer and shall not be varied without his consent. The Contractor shall furnish and use with the mixer an approved adjustable, water measuring device which will prevent excess water flowing into the mixer, in order that the consistency may be under positive control and that all batches may be of the same consistency.
 - 1. In general, the minimum amount of water shall be used which will produce the required workability. The mortar shall cling to the coarse aggregate and shall show no free water when removed from the mixer.
- B. Mixer. The mixing machine used shall be of an approved type known as a batch mixer, and of a design having a suitable device attached for automatically measuring the proper amount of water accurate to one percent (1%) and for automatically timing each batch of concrete so that all materials will be mixed together for the minimum time required. Such device shall be easily regulated and controlled to meet the variable conditions encountered. If the time device becomes broken or fails to operate, the Contractor will be permitted to continue the balance of the day without the timing device while the same is being repaired, provided that each batch of concrete is mixed two (2) minutes.
 - 1. The normal mixing time for each batch shall be one (1) minute, and the measuring of this period shall begin after all the materials are in the drum. During this mixing period, the drum shall revolve at the speed for which the mixer is designed, but shall make not less than fourteen (14) nor more than twenty (20) revolutions per minute.
 - 2. No materials for a batch of concrete shall be placed in the drum of the mixer until all of the previous batch has been discharged therefrom. The discharge of water into the drum shall commence with the flow of the aggregates, but shall not be started before the entrance into the drum of part of the aggregates. The discharge of all of the mixing water for any batch shall be completed within ten (10) seconds after all of the aggregates are in the drum. The inside of the drum shall be kept free from hardened concrete.
 - 3. The use of mixers having a chute delivery will not be permitted except by permission of

the Engineer. In all such cases the arrangement of chutes, baffle plates, etc., shall be such as will insure the placing of fresh concrete without segregation.

4. Ready-mixed concrete from a central mixing plant delivered at the work ready for use, will be permitted, provided the mixture is transported to the job site in an agitating truck having the concrete contained in a revolving drum and provided there is no segregation of the mixture at the point of placing. Ready-mixed concrete from a central batching plant and mixed in transit will be permitted; however, the mixing and transporting equipment will be subject to the special approval of the Engineer. Any ready-mixed concrete shall comply with all of the requirements of these specifications.
5. The time elapsing from the time the water is added to the mix until the concrete is deposited in place at the site of the Work shall not exceed 30 minutes when hauled in non-agitating trucks, not 60 minutes when hauled in truck mixers or truck agitators. In addition, the total revolutions at mixing speed shall not be less than 70 nor more than 100. When truck mixers are used on hauls in excess of 1 hour, the cement shall be added at the site of the work. The concrete must be of workable consistency when placed. No mixer which has a capacity of less than a two-sack batch shall be used.
 - i. Hand mixing will not be permitted except with the permission of the Engineer and then only in very small quantities or in case of an emergency.
6. Retempering concrete by adding water or by other means will not be permitted; however, a portion of the mixing water may be withheld from transit mixers and added at the work site provided the delivery ticket indicates the amount withheld. The batch shall be mixed for 30 revolutions at mixing speed after adding the water. Water cannot be added to a partial load of concrete mix. Concrete that is not within the specified slump limits at time of placement shall not be used.
7. In using air-entraining admixtures, the mixer shall be equipped with a suitable automatic dispensing device which will proportion the air entraining admixture accurately to each batch of concrete. The device shall be calibrated and adjusted to deliver to each batch of concrete the quantity of admixture required to produce the specified air content in the concrete.
8. The manufacturer of the concrete shall furnish to the purchaser with each batch of concrete before unloading at the site, a delivery ticket. The purchaser shall provide the Engineer with one (1) copy of each delivery ticket.

3.06 Forms.

- A. Forms shall be made of wood or metal. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. The top and face of forms shall be cleaned and oiled prior to the placing of concrete.

3.07 Placing Concrete.

- A. The concrete shall be unloaded into an approved spreading device, or deposited on the base, and spread in such a manner as to prevent segregation of the materials. As deposited, the mixture shall be placed where it will require as little rehandling as possible. No concrete shall be placed on frozen grade.
- B. Necessary hand spreading shall be done with shovels or other approved tools. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated in earthen or other foreign substances.
- C. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 5 seconds in any one location.

3.08 Protection.

- A. It shall be the responsibility of the Contractor to protect from damage all freshly poured concrete regardless of the location or type of structure for a minimum period of seven (7) days or for such longer period as the Engineer may direct. Any concrete which is damaged shall be repaired to the satisfaction of the Engineer prior to acceptance of the completed work.

3.09 Quality Control Testing.

- A. The Owner or Consultant will employ a testing laboratory to perform test and submit test reports. Test reports will be reported in writing to Consultant, Owner, and Contractor as soon as possible upon completion of tests.
 - 1. Compressive Strength Tests. Concrete test cylinders will be made by a qualified technician from a certified material testing laboratory.
 - 2. The cylinders shall be made and tested in accordance with ASTM C39.
 - 2. Tests may be required for each day's run or according to the following schedule:

| <u>Total Cubic Yards of Concrete Placed (m³)</u> | <u>Minimum Number of Tests*</u> <u>(3 cylinders each)</u> |
|---|--|
| 0 – 100(0-75) | One for 7 days, two at 28 days |
| 100 – 1000 (75 -750) | One for each 50 cu. Yds. (38m ³) |
| 1000 – 2000 (750 – 1500) | One for each 125 cu. Yds. (100m ³) |
| 2000 and Over (1500) | One for each 175 cu. Yds. (125 m ³) One for each 250 cu. Yds. (200 m ³) |

*One test per pour minimum.

- iii. Results of all tests shall be furnished to the Engineer as soon as they are available.
- 2. Slump. Slump test shall be conducted in accordance with ASTM C172. A test shall be performed for each day's pour of each type of concrete and for each set of compressive strength test.
- 2. Air Content. Air content shall be tested in accordance with ASTM C143 or ASTM C231. Air content test shall be performed for each set of compressive strength tests of each type of air-entrained concrete.

CONCRETE CLASSIFICATION TABLE

| Class of Concrete | Min. 28 day Compressive Strength (psi) | Slump in Inches | Min Cement-Sacks//CY | | Min Cement-#/CY (3) | Net Water Max. Gal/CY (3) | | Net Water Max-#/CY (3) | |
|-------------------|--|-----------------|-------------------------|----------------------------|---------------------|---------------------------|----------------------------|-------------------------|----------------------------|
| | | | Gravel Course Aggregate | Limestone Course Aggregate | | Gravel Course Aggregate | Limestone Course Aggregate | Gravel Course Aggregate | Limestone Course Aggregate |
| A | 3000 | 3-5 | 6.0 | 5.5 | 564 | 36 | 33 | 300 | 275 |
| AS | 4000 | 3-5 | (2) | 6.2 | (2) | (2) | 37.2 | (2) | 310 |
| B | 3500(1) | 1-2.5 | 6.2 | 5.8 | 583 | 34.1 | 31.9 | 284 | 266 |
| C | 2500 | 2-4 | 5.0 | 4.5 | 470 | 34 | 30.6 | 283 | 255 |
| P | 5000 | 1-3 | (2) | 7.0 | (2) | (2) | 35 | (2) | 292 |

Notes:

- (1) Minimum compressive strength at 14 days. Minimum flexural strength at 14 days of 550 psi per AASHTO T 22
- (2) Gravel Coarse Aggregate not permitted.
- (3) Tabulated values are for Type I cement conforming to the requirement of AASHTO M 85 only.

END OF SECTION