SECTION 03015
STRUCTURAL CONCRETE

PART I: GENERAL

1.1 GENERAL REQUIREMENTS

A. Requirements for materials, proportioning, batching, mixing, delivery, and testing of Portland Cement Concrete to be used for concrete paving, concrete structures, and all other types of concrete construction.

B. Requirements for furnishing, erecting and removing form work, constructing expansion, construction, and control joints.

C. Requirements for placing, curing, protecting and finishing of concrete.

1.2 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. No payment will be made for concrete for utility construction under this Section. Include cost in applicable utility structure.
2. Obtain services of and pay for certified testing laboratory to prepare design mixes.
3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum):

1. If Contract is Stipulated Price Contract, payment for work in this Section shall be included in Total Stipulated Price.

1.3 REFERENCES

A. ACI – American Concrete Institute.

1. ACI 117 – Standard Tolerances for Concrete Construction and Materials.
2. ACI 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
3. ACI 302.1R – Guide for Concrete Floor and Slab Construction.
4. ACI 304R – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
5. ACI 308 – Standard Practice for Curing Concrete.
6. ACI 309R – Guide for Consolidation of Concrete.
7. ACI 311 – Guide for Concrete Plant Inspection and Field Testing of Ready-Mix Concrete.
8. ACI 315 – Details and Detailing of Concrete Reinforcement.
9. ACI 318 – Building Code Requirements for Reinforced Concrete and Commentary.
10. ACI 544 – Guide for Specifying, Mixing, Placing, and Finishing Steel Fiber Reinforced Concrete.

B. ASTM – American Standards and Testing of Materials.

1. ASTM A82 – Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.

2. ASTM A185 – Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
3. ASTM A615 – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
4. ASTM A767 – Standard Specifications for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
5. ASTM A775 – Standard Specification for Epoxy-Coated Reinforcing Steel Bars.
6. ASTM A820 – Standard Specification for Steel Fibers for Fiber-Reinforced Concrete.
7. ASTM A884 – Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement.
8. ASTM C31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field.
9. ASTM C33 – Standard Specification for Concrete Aggregates.
10. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
11. ASTM C42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
12. ASTM C94 – Standard Specification for Ready-Mixed Concrete.
13. ASTM C138 – Standard Test Method for Unit Weight Yield and Air Content (Gravimetric) of Concrete.
14. ASTM C143 – Standard Test Method for Slump of Hydraulic Cement Concrete.
15. ASTM C150 – Standard Specification for Portland Cement.
16. ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete.
17. ASTM C173 – Standard Test Method for Air Content of Freshly Mixed Concrete by Volumetric Method.
18. ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
19. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
20. ASTM C309 – Standard Specifications for Liquid Membrane-Forming Compounds for Curing Concrete.
21. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete.
22. ASTM C595 – Standard Specification for Blended Hydraulic Cements.
23. ASTM C685 – Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.
24. ASTM C618 – Standard Specification for Coal Fly Ash or Calcined Natural Pozzolan for Use in Concrete.
25. ASTM C1064 – Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.
26. ASTM C1077 – Standard Practice for Laboratory Testing of Concrete and Concrete Aggregate for Use in Construction and

Criteria for Laboratory Evaluation.

C. CFTS – City of Friendswood Technical Specifications.
D. CRSI – Concrete Reinforcing Steel Institute.
   1. CRSI MSP-1 – Manual of Standard Practice.
   2. CRSI – Placing Reinforcing Bars.
E. Federal Specifications.
   1. Federal Specification SS-S-210A – Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints.
F. NRMCA – National Ready Mix Concrete Association
   1. Concrete Plant Standards.

1.4 SUBMITTALS

A. Conform to requirements of Section 01330 – Submittal Procedures.
B. Submit proposed mix design and test data prepared by a certified testing laboratory for each type and strength of concrete in Work.
C. Submit laboratory reports prepared by independent testing laboratory stating that all material used in concrete mix design comply with requirements in this Section.
D. Submit manufacturer's mill certificates for reinforcing steel. Provide specimens for testing when required by Project Manager.
E. Submit certification from concrete supplier that all materials and equipment used to produce and deliver concrete comply with this Technical Specification.
F. When required on The Drawings, submit shop drawings showing reinforcement type, quantity, size, length, location, spacing, bending, splicing, support, fabrication details, and other pertinent information.

1.5 CONCRETE CLASSIFICATION AND USE

A. Classifications of concrete are for specific use and material only. Compressive Strengths shall vary depending on Designs, Details and Individual Technical Specifications, but at a minimum shall meet the minimum requirements as Specified in TABLE 4.1 – CONCRETE CLASSIFICATION MINIMUM REQUIREMENTS.
B. Class of concrete shall be identified as follows:
   1. Class A Concrete – Paving, drilled shafts, non-structural culverts, inlets, manholes, curb, curb and gutter, sidewalk, driveway, wheelchair ramp, pilot channel and slope paving.
   2. Class B Concrete – Paving, structural culverts, wingwall, headwall and bridge structures.
   3. Class C Concrete – Small signs, anchors, and pipe blocking.
   4. Class D Concrete – Seal slab.
   5. Class E Concrete – Prestressed concrete beams, boxes and traffic barriers.
   6. Class F – “High Early Strength” concrete for traffic surfaces only and only with approval of Director of Engineering.

1.6 HANDLING AND STORAGE

A. Cement: Store cement off of ground in well-ventilated, weatherproof building to prevent deterioration or exposure to moisture. Different brands of cement or same brand from different sources shall not be used on the same project unless approved by the Director of Engineering.

B. Aggregates: All aggregates shall be transported and stockpiled separately according to their sources and gradations. Aggregates shall be handled in accordance with ACI requirements to prevent segregation and loss of fines or contamination with foreign materials.
   1. If aggregates show segregation or the different grades become mixed, aggregates shall be re-screened before placing in the proportioning bins.
   2. Aggregates from different sources or different gradations shall be segregated to prevent intermixing. Mixing of aggregates in stockpiles shall not be permitted.
   3. No aggregate shall be transferred to proportioning bins when the moisture content of the aggregate is such that it will affect the accuracy of proportioning. Such aggregates shall be removed and stockpiled until a dry surface condition is obtained.

PART II: PRODUCTS

2.1 CONCRETE MATERIALS

A. Portland cement concrete shall be composed of Portland cement fine aggregate, coarse aggregate, water and admixtures as approved by the Project Manager and shall be proportioned and mixed as specified in this Section.

B. Cementitious Material:
   1. Portland Cement: ASTM C150, Type I/II, unless use of Type III is authorized by Project Manager; or ASTM C595, Type IP. For concrete in contact with sewage use Type II cement.
   2. When aggregates are potentially reactive with alkalis in cement, use cement not exceeding four pounds per cubic yard (4 Lbs/Cy) alkali content in form of $Na_2O + 0.658K_20$.

C. Water: Clean, free from harmful amounts of oils, acids, alkalis, organic or other deleterious substances, and meeting requirements of ASTM C94. Water from municipal supplies approved by State agencies will not require testing, but water from other sources shall be tested before use in concrete.
   1. Tests shall be made in accordance with AASHTO T26. One gallon (1 Gal) shall be taken to qualified testing laboratory for testing.
   2. Water used in white Portland cement concrete shall be free from iron and other impurities which may cause staining or discoloration.

D. Aggregate:
   1. Coarse Aggregate: ASTM C33. Unless otherwise indicated, use following ASTM standard sizes: No. 357 or No. 467; No. 57 or

No. 67, No. 7. Maximum size: Not larger than one-fifth (1/5) of narrowest dimension between sides of forms, nor larger than three-quarters (3/4) of minimum clear spacing between reinforcing bars. Coarse aggregates shall meet the requirements as specified in TABLE 4.2 – COARSE AGGREGATE GRADATION in this Section.

a. Coarse aggregate material shall be made of either durable crushed or uncrushed gravel, crushed stone having uniform quality throughout. All coarse aggregate material shall have a wear of not more than forty percent (40%).
b. Deleterious substance shall have a maximum permissible percentage by weight as specified in TABLE 4.3 – DELETERIOUS SUBSTANCES in this Section. Aggregate to be free from excess of salt, alkali, vegetable matter or other objectionable material either free or as adherent coating.

2. Fine Aggregate: ASTM C33. Fine aggregates shall meet the requirements as specified in TABLE 4.4 – FINE AGGREGATE GRADATION in this Section. Fine aggregates shall be sand or combination of sand and not more than fifty percent (50%) stone screenings.
   a. Sand shall be clean, hard, durable and uncoated grains.
   b. Stone screenings shall be clean, hard, durable and uncoated fragments resulting from crushing of stone.
3. Determine potential reactivity of fine and coarse aggregate in accordance with Appendix to ASTM C33.
4. Mineral filler – The addition of stone dust and/or sand as filler in Portland Cement Concrete paving may be used when approved by the Project Manager. Stone dust and sand shall be of acceptable quality and cleanliness as a mineral filler to improve workability and plasticity of the concrete mixture, in amounts not to exceed fifteen percent (15%) of the weight of fine aggregate. When tested with standard laboratory sieves, the mineral filler shall meet the requirements as specified in TABLE 4.5 – MINERAL FILLERS in this Section. Fly Ash shall not be used as a filler unless approved by the Director of Engineering. If approval has been granted for use of Fly Ash, then fly ash shall conform to ASTM C618.

E. Air Entraining Admixtures: An air entraining agent shall be required and shall conform to ASTM C260. Air entrainment shall be four percent (4%) plus or minus one percent (±1%) for all concrete classes and verified for conformity in the field by a certified testing laboratory. Concrete with air entrainment quantity of five percent and one-half (5.5%) to seven percent (7.0%) may be accepted on condition of passing twenty-eight day (28 D) compressive strength tests and approval of the Project Manager. Concrete with air entrainment quantity greater than seven percent (7%)

or less than two percent (2%) shall be rejected. Air content shall be determined by ASTM C138 or ASTM C173. No air entrainment shall be required for seal slabs.

F. Chemical Admixtures:
   1. Water Reducers: ASTM C494, Type A.
   2. Water Reducing Retarders: ASTM C494, Type D.
   3. High Range Water Reducers (Superplasticizers): ASTM C494, Types F and G.

G. Prohibited Admixtures: No admixtures containing calcium chloride, thiocyanate, or materials that contribute free chloride ions in excess of one tenth of a percent (0.1%) by weight of cement shall be used in concrete mixes.

H. Fiber:
   1. Fibrillated Polypropylene Fiber:
      a. Addition Rate: One and one-half pounds (1-1/2 Lbs) of fiber per cubic yard of concrete.
      b. Physical Properties:
         (1) Material: Polypropylene.
         (2) Length: One-half inch (1/2 In) or greater.
         (3) Specific Gravity: 0.91.
      c. Acceptable Manufacturer: W. R. Grace Company, Fibermesh, or approved equal.
   2. Steel Fiber: Comply with applicable provisions of ACI 544 and ASTM A820.
      a. Ratio: Fifty pounds (50 Lbs) to two hundred pounds (200 Lbs) of fiber per cubic yard of concrete.
      b. Physical Properties.
         (1) Material: Steel.
         (2) Aspect Ratio [for fiber lengths of one-half inch (1/2 In) to two and one-half inch (2-1/2 In), length divided by diameter or equivalent diameter]: Thirty to One (30:1) – one hundred to one (100:1).
         (3) Specific Gravity: 7.8.
         (4) Tensile Strength: Forty kilo-pounds per square inch (40 ksi) – four hundred kilo-pounds per square inch (400 ksi).
         (5) Young's Modulus: Twenty-nine thousand kilo-pounds per square inch (29,000 ksi).
         (6) Minimum Average Tensile Strength: Fifty thousand kilo-pounds per square inch (50,000 psi).
         (7) Bending Requirements: Withstand bending around one eighth inch (0.125 In) diameter mandrel to angle of ninety degrees Fahrenheit (90° F), at temperatures not less than sixty degrees Fahrenheit (60° F), without breaking.

I. Curing Compounds: Type 2 white-pigmented liquid membrane-forming compounds conforming to ASTM C309.

2.2 PRODUCTION METHODS

A. Use either ready-mixed concrete from a source approved by the Director of Engineering conforming to requirements of ASTM C94, or concrete produced by volumetric batching and continuous mixing in accordance with ASTM C685.

2.3 MEASUREMENT OF MATERIALS

A. Measure dry materials by weight, except volumetric proportioning may be used when concrete is batched and mixed in accordance with ASTM C685.
B. Measure water and liquid admixtures by volume.

2.4 DESIGN MIX

A. Use design mixes prepared by certified testing laboratory in accordance with ASTM C1077 and conforming to requirements of this Section. Design shall be based on the required over-design factor according to ASTM C94 and assuming a coefficient of variation equal to fifteen (15). The average of three (3) consecutive strength tests shall be equal to or greater than the specified strength. Classification shall meet the requirements as specified in TABLE 4.1 – CONCRETE CLASSIFICATION MINIMUM SPECIFICATIONS in this Section.
B. Proportion of concrete materials shall be based on ACI 211.1 to comply with durability and strength requirements of ACI 318, Chapters 4 and 5, and this Specification. Submit concrete mix designs to Project Manager for review and approval.
C. Variations in proportions of concrete may be based on field experience or trial mixtures, in accordance with requirements at Section 5.3 of ACI 318, may be made, but only when approved by Project Manager.
D. Proportioning of Portland Cement and water shall meet the requirements as specified in TABLE 4.1 – CONCRETE CLASSIFICATION MINIMUM SPECIFICATIONS in this Section.
E. Add steel or polypropylene fibers only when called for on The Drawings or in another Section of these Technical Specifications.
F. Determine air content in accordance with ASTM C138, ASTM C173 or ASTM C231.
G. Once a design mix for any class of concrete has been approved by the Project Manager, the mix shall not be varied as to source, quantity, quality, grading of materials, proportioning of any other way except as allowed for moisture adjustment and tolerances as specified in ASTM C685.

PART III: EXECUTION

3.1 BATCHING AND MIXING

A. Measure, batch, mix, and deliver ready-mixed concrete in accordance with ASTM C94, Sections 8 through 11. Produce ready-mixed concrete using automatic batching system as described in NRMCA Concrete Plant

Standards, Part 2 – Plant Control Systems.

B. Measure, mix and deliver concrete produced by volumetric batching and continuous mixing in accordance with ASTM C685, Sections 6 though 8.

C. Maintain concrete workability without segregation of material and excessive bleeding. Obtain approval of Project Manager before adjustment and change of mix proportions.

D. Ready-mixed concrete delivered to site shall be accompanied by batch tickets providing information required by ASTM C94, Section 16. Concrete produced by continuous mixing shall be accompanied by batch tickets providing information required by ASTM C685, Section 14. Water withheld from the mix shall also be noted on the batch ticket. In addition to the referenced information, each batch ticket shall also include the design mix information so that the batch can be compared on site to the mix design.

E. Clean, maintain and operate equipment so that it thoroughly mixes material as required.

F. Moisture Control:
   1. At the time of batching, all aggregates shall have been dried or drained sufficiently to result in a stable moisture content such that no visible separation of water from aggregate will take place during transportation from the proportioning plant to the point of mixing.
   2. In no event shall the free moisture content of the fine aggregate at the time of batching exceed eight percent (8%) of its saturated, surface-dry weight. The batch-to-batch uniformity of all aggregates shall be such that variations in moisture content within one hour (1 Hr) do not exceed twelve pounds (12 Lbs) in the batch quantity for one cubic yard (1 Cy) of concrete, or that a gradual change does not exceed twenty-four pounds (24 Lbs) in a period of four hours (4 Hrs).
   3. The Contractor shall install, and maintain in operating condition, an electrically actuated moisture meter which will indicate on a readily visible scale the percentage of moisture in the fine aggregate as it is batched, within a sensitivity of one-half percent (1/2%) by weight of the fine aggregate.

G. Scales
   1. Scales shall be used for the accurate measurement of each of the materials entering each batch of concrete.
   2. If scales are of the dial type, the dial shall be of such size and so arranged that it may be read easily from the operating platform.
   3. If scales are of the multiple beam type, the scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or underweight. The indicator shall be so designed that it will operate during the addition of the last two hundred pounds (200 Lbs) of material of any weighing. The over-travel of the indicator hand shall be at least one-third (1/3) of the loading travel. Indicators shall be

enclosed to protect against moisture and dust.

4. Scales shall be tested by a commercial scale company and certified that the scales meet all requirement for weighing equipment. Certification shall be required whenever a scale is relocated, and at least once every six months (6 Mos). Copies of the certifications shall be provided to the Project Manager when requested.

H. Recorders

1. An accurate recorder shall be provided for producing a digital printout of the batch number and scale readings corresponding to each of the ingredients of each concrete batch, including zero (0) initial readings. The individual ingredients shall be indicated by name or code corresponding to each weight.
2. Each printout shall indicate date and time of batching, identification number identical to that of the concrete delivery ticket and codes for the mix design and of the Work.
3. The printout shall be prepared in duplicate, with one (1) copy delivered together with its corresponding concrete delivery ticket to the Project Manager, as specified herein before.
4. Each recorder mechanism shall be enclosed in a locked, dust tight cabinet and shall be placed in a position convenient for observation.

3.2 DELIVERY AND DELIVERY EQUIPMENT

A. Hand-mixed concrete shall be made in batches not larger than one-third cubic yard (1/3 Cy) and only with approval of the Project Manager. Concrete shall be Sakrete or approved equal, no separate proportioning of materials outside of a batch plant will be allowed. Batching shall be in accordance with manufactures directions and stated measurements.

1. Mixing of concrete shall be in a clean, water tight mixing box.
2. Introduce measured amount of clean water.
3. Mix water and cement a minimum of six (6) turns or until batch maintains uniform color and consistency.
4. At no time shall bags of Sakrete be put in place, sliced open and water added in a ditch or hole.

B. Pumping and pneumatic conveying equipment shall be of a suitable kind with adequate pumping capacity. Equipment shall be cleaned at the end of each operation. Pneumatic placement shall be controlled so that segregation does not occur in the discharged concrete. Concrete shall not be conveyed through any pipe made of aluminum or aluminum alloy.

C. Transit mix trucks shall be in good working order. All trucks shall have the following operational, delivery and placing conditions and equipment:

1. Actuated drum revolution counter shall be in good working order.
   a. Batch shall be mixed at the plant between fifty (50) and seventy (70) revolutions before being transported to site.
   b. At no time shall a batch be placed when mixed less than seventy (70) revolutions or more than 100 revolutions,

except as noted in 3.2.C.1.c.

c. Batch shall be mixed for a minimum of twenty-five (25) revolutions after additional water has been introduced into the mix on site. This procedure shall be repeated for each instance when water is added.

2. Water supply reserve tank shall be supplied on each truck.
   a. Water tank shall be full on arrival at site.
   b. Water tank shall have accurate scale to measure gallons of water to be introduced to truck mixer.
   c. Project Manager shall verify the amount of water used on site for mixing and verify the recording on the trip ticket.
3. Drum mixer shall be watertight and shall be free of hardened concrete and shall have fins that are capable of thoroughly mixing concrete.
4. Any defective equipment that cannot meet the Specifications of 3.2.C shall not be allowed on site until the deficiencies have been corrected.

3.3 PLACING CONCRETE

A. Give sufficient advance notice to the Project Manager [at least forty-eight hours (48 Hrs) prior to commencement of operations] to permit inspection of forms, reinforcing steel, embedded items and other preparations for placing concrete. Place no concrete prior to the Project Manager's approval.

B. Schedule concrete placing to permit completion of finishing operations in daylight hours. However, when necessary to continue after daylight hours, site shall be illuminated completely as required. When rainfall occurs after placing operations are started, provide covering to protect work.

C. Subgrade surface shall be sprinkled sufficiently with water to prevent absorption of water from freshly placed concrete.

D. Forms and rebar shall be cleaned of all foreign materials; subgrade shall be free of all trash and other materials.

E. Batches that do not have computer batch tickets or delivery tickets shall be refused. Once a truck has been refused for any reason it shall leave the site. Attempts to fix deficiencies on site shall not be allowed.

F. Temperature specifications for placement of concrete shall be as follows and as specified in TABLE 4.6 – TEMPERATURE REQUIREMENTS FOR PLACEMENT in this Section:
   1. Ambient (Air) temperature shall be taken in the shade and shielded from direct sunlight and wind.
   2. Minimum ambient temperature for concrete placement shall be thirty-five degrees Fahrenheit (35° F) and rising. At no time shall concrete be placed when ambient temperature is below forty degrees Fahrenheit (40° F) and falling.
   3. Maximum ambient temperature shall be ninety degrees

Fahrenheit (90° F). Addition of ice to concrete mix shall allow ambient temperature maximum to be one hundred degrees Fahrenheit (100° F), upon approval of the Project Manager.

4. Minimum concrete temperature shall be fifty degrees Fahrenheit (50° F).
5. Maximum concrete temperature shall be ninety degrees Fahrenheit (90° F). Addition of ice shall permit the maximum temperature to be ninety-five degrees Fahrenheit (95° F). At no time shall any concrete be placed when concrete temperature exceeds ninety-five degrees Fahrenheit (95° F).

G. When adverse weather conditions affect quality of concrete, postpone concrete placement. Protect placed concrete from temperatures below thirty-two degrees Fahrenheit (32° F) until concrete has cured for minimum of three days (3 D) at seventy degrees Fahrenheit (70° F) or five days (5 D) at fifty degrees Fahrenheit (50° F).

H. Time constraints – Concrete shall be placed so that there is no more than one hour (1 Hr) of time elapsed from last discharge to next discharge. Addition of allowable dosage of water retardation agent shall extend time limit by one-half hour (1/2 Hr). Limit on time from batch to placement shall be as specified in TABLE 4.7 – TRANSPORTING TIME REQUIREMENTS in this Section.

I. If no water has been withheld from the mix at the plant, then addition of water to mix on site shall not exceed two gallons per cubic yard (2 Gal/Cy) of concrete. If water has been withheld, then up to the amount withheld can be added upon approval of the Project Manager. Any additional water above that, but not to exceed two gallons per cubic yard (2 Gal/Cy), shall be added only with the approval of the Project Manager. At no time shall slump exceed mix design nor be more than one and one-half inches (1-1/2 In) less than specified slump. All water that has been added to the truck shall be written on the trip ticket and batch ticket by the Project Manager.

J. Use troughs, pipes and chutes lined with approved metal or synthetic material for placing concrete so that concrete ingredients are not separated. Keep chutes, troughs and pipes clean and free from coatings of hardened concrete. Allow no aluminum or aluminum alloy material to come in contact with concrete.

K. Limit free fall of concrete to four feet (4 Ft). Do not deposit large quantities of concrete at one location so that running or working concrete along forms is required. Do not jar forms after concrete has taken initial set, and do not place strain on projecting reinforcement rods or anchor bolts.

L. Use tremies for placing concrete in walls and similar narrow or restricted locations. Use tremies made in sections, or provide in several lengths, so that outlet may be adjusted to proper height during placing operations.

M. Place concrete in continuous horizontal layers approximately twelve inches (12 In) thick. Place each layer while layer below is still plastic.

N. Compact each layer of concrete with concrete spading implements and

mechanical vibrators of approved type and adequate number for size of placement. When immersion vibrators cannot be used, use form vibrators. Apply vibrators to concrete immediately after depositing. Move vibrator vertically through layer of concrete just placed and several inches into plastic layer below. Do not penetrate or disturb layers previously placed which have partially set. Do not use vibrators to aid lateral flow concrete. Closely supervise consolidation to ensure uniform insertion and duration of immersion.

O. Handling and Placing Concrete: Conform to ACI 302.1R, ACI 304R and ACI 309R.

3.4 FIELD QUALITY CONTROL

A. Testing shall be performed under provisions of Sections 01470 – Testing Laboratory Services and 01475 – Quality Control Testing Procedures.

B. Unless otherwise directed by the Project Manager, the following minimum testing of concrete shall be required. Testing shall be performed by qualified individuals employed by approved independent testing laboratory, and conform to requirements of ASTM C1077.

1. Take concrete samples in accordance with ASTM C172.
2. Make one (1) set of compression test specimens for each mix design at least once per day and for each one hundred cubic yards (100 Cy) or fraction thereof. Make, cure and test specimens in accordance with ASTM C31 and ASTM C39.
    a. Tests are representative random sampling of each one hundred cubic yard (100 Cy) unit placement of concrete. Passing or failure of compressive testing shall represent all one hundred cubic yard (100 Cy) for acceptance or deficiency.
3. When taking compression test specimens, test each sample for slump according to ASTM C143, for temperature according to ASTM C1064, for air content according to ASTM C231, and for unit weight according to ASTM C138.
4. Inspect, sample and test concrete in accordance with ASTM C94, Section 13, 14, and 15, and ACI 311-5R.

C. Test Cores: Conform to ASTM C42.

D. Testing High Early Strength Concrete: When Type III cement is used in concrete, specified seven day (7 D) and twenty-eight day (28 D) compressive strengths shall be applicable at three days (3 D) and seven days (7 D), respectively.

E. Seven day (7 D) compressive strengths shall be seventy (70%) percent of twenty-eight day (28 D) strength requirement.

F. If twenty-eight day (28 D) compressive strengths fail to meet class specified requirements, then those portions of structure represented by test specimens shall be replaced at no additional cost to City.

G. Take one (1) slump test a minimum of every fifty cubic yards (50 Cy) of placement according to ASTM C143. Project Manager shall be authorized to have testing laboratory take slump on any questionable concrete.

3.5 FINISHING

A. Burlap drag or transverse broom for finishing slab.
   1. Burlap Finish – Furnish four (4) plies of ten ounce (10 oz) burlap material fastened to bridge to form continuous strip of burlap full width of pavement. Maintain contact three foot (3 Ft) width of burlap material with pavement surface. Keep burlap drags clean and free of encrusted mortar. Burlap shall be dragged longitudinally (parallel) with the centerline of the roadway. Finish look shall be straight lined. Swoops, diagonals or ridges shall not be allowed.
   2. Broom Finish – Furnish brooms with either horsehair or synthetic fiber bristles. Straw bristles shall not be allowed. Keep bristles clean and free of encrusted mortar. Broom shall be dragged latitudinally (perpendicular) with the centerline of the roadway. Adequate combination of pressure and bristle thickness shall be used to provide medium to heavy texture. Finish look shall be straight lined. Swoops, diagonals or ridges shall not be allowed.
   3. Fire hose finishing shall not be allowed.

B. Finishing for patches and structures shall conform to the following requirements.
   1. Patch honeycomb, minor defects and form tie holes in concrete surfaces with cement mortar mixed one part cement to two parts fine aggregate. Repair defects by cutting out unsatisfactory material and replacing with new concrete, securely keyed and bonded to existing concrete. Finish to make junctures between patches and existing concrete as inconspicuous as possible. Use stiff mixture and thoroughly tamp into place. After each patch has stiffened sufficiently to allow for greatest portion of shrinkage, strike off mortar flush with surface.
   2. Apply rubbed finish to exposed surfaces of formed concrete structures as noted on The Drawings. After pointing has set sufficiently, wet surface with brush and perform first surface rubbing with No. 16 carborundum stone, or approved equal. Rub sufficiently to bring surface to paste, to remove form marks and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Spread or brush material, which has been ground to paste, uniformly over surface and allow to reset. In preparation for final acceptance, clean surfaces and perform final finish rubbing with No. 30 carborundum stone or approved equal. After rubbing, allow paste on surface to reset; then wash surface with clean water. Leave structure with clean, neat and uniform-appearing finish.

C. Finish tolerances shall be as follows:
   1. Top concrete surface of sidewalks shall be true planes within one-quarter inch (1/4 In) in ten feet (10 Ft).
   2. Wheelchair ramps shall be held to tolerances as stated in Sections 02820 – Concrete Sidewalks and 02825 – Colored Concrete for Wheelchair Ramps.
   3. Roadway slabs parallel to the centerline shall be true planes within one-sixteenth inch (1/16 In) in ten feet (10 Ft).
   4 All other surfaces shall be true planes within one-quarter inch (1/4 In) in ten feet (10 Ft).
   5. All tolerances shall be checked with a steel edge that has zero (0) tolerance deviation.

3.6 CURING

A. Comply with ACI 308. Cure by preventing loss of moisture, rapid temperature change and mechanical injury for period of seven (7) curing days when Type II or IP cement has been used and for three (3) curing days when Type III cement has been used. Start curing as soon as free water has disappeared from concrete surface after placing and finishing. A curing day is any calendar day in which temperature is above fifty degrees Fahrenheit (50° F) for at least nineteen hours (19 Hrs). Colder days may be counted when air temperature adjacent to concrete is maintained above fifty degrees Fahrenheit (50° F). In continued cold weather, when artificial heat is not provided, removal of forms and shoring may be permitted at end of calendar days equal to twice required number of curing days. However, leave soffit forms and shores in place until concrete has reached specified twenty-eight day (28 D) strength, unless directed otherwise by the Project Manager.
   1. Moisture Cover Curing Method: The concrete surfaces to be cured shall be covered with specific moisture-retaining cover material placed in the widest practical width with sides and ends lapped at least three inches (3 In) and sealed by waterproofing tape or adhesive. All holes or tears that develop during curing period shall be repaired immediately. Minimum curing time for this method shall be seven days (7 D).
   2. Liquid Membrane Curing: The specified membrane curing compound shall be applied to damp concrete surfaces as soon as possible after the final finishing operations are complete, but in no case later than two hours (2 Hrs) after finishing. Curing compound shall be applied uniformly over the concrete surfaces by means of approved spray equipment in accordance manufacturer's instruction. No deformities (tear drop, pattern, etc.) shall be accepted. Should the cure coat be damaged from any cause during the curing period, damaged portions shall be repaired and recoated immediately with additional compound.

B. Formed surfaces not requiring rubbed-finished surface shall be cured by leaving forms in place for full curing period. Keep wood forms wet during

curing period. Add water as needed for other types of forms. Non-structural concrete forms, upon approval of the Project Manager, may be removed after two days (2 D) and curing compound applied.

C. Rubbed Finish:
   1. For formed surfaces requiring rubbed finish, remove forms as soon as practicable without damaging surface.
   2. After rubbed-finish operations are complete, continue curing formed surfaces by using either approved curing/sealing compounds or moist cotton mats until normal curing period is complete.

D. Unformed Surfaces: Cure by membrane curing compound method.
   1. After concrete has received final finish and surplus water sheen has disappeared, immediately seal surface with uniform coating of approved curing compound, applied at rate of coverage recommended by manufacturer or as directed by the Project Manager. Do not apply less than one gallon (1 Gal) per one hundred eighty square feet (180 Sf) of area. Provide satisfactory means to properly control and check rate of application of compound.
   2. Thoroughly agitate compound during use and apply by means of approved mechanical power pressure sprayers equipped with atomizing nozzles. For application on small miscellaneous items, hand-powered spray equipment may be used. Prevent loss of compound between nozzle and concrete surface during spraying operations.
   3. Do not apply compound to dry surface. When concrete surface has become dry, thoroughly moisten surface immediately prior to application of compound. At locations where coating shows discontinuities, pinholes or other defects, or when rain falls on newly coated surface before film has dried sufficiently to resist damage, additional coat of compound shall be applied at specified rate of coverage.

3.7 PROTECTION

A. Protect concrete against damage until final acceptance by City.

B. Protect fresh concrete from damage due to rain, hail, sleet, or snow. Provide protection while concrete is still plastic, and whenever precipitation is imminent or occurring.

C. Do not backfill around concrete structures or subject them to design loadings until components of structure needed to resist loading are complete and have reached specified twenty-eight day (28 D) compressive strength, except as authorized otherwise by the Project Manager.

D. Concrete pavement shall not be used before the twenty-eight day (28 D) compressive strength unless the seven day (7 D) compressive strength test has reached the twenty-eight day (28 D) strength requirement. Pavement can be used for light vehicles only after the twenty-eight day

(28 D) strength has been met. At no time shall any equipment or vehicles heavier than eight thousand pounds (8000 Lbs) GVW (Gross Vehicle Weight) be allowed on pavement before it passes the twenty-eight day (28 D) compressive strength tests.

3.8 REMOVAL OF FORMS AND SHORING

A. Remove forms from surfaces requiring rubbing only as rapidly as rubbing operation progresses. Remove forms from vertical surfaces not requiring rubbed-finish when concrete has aged for required number of curing days. When curing compound is used, do not remove forms before during first (1st) two (2) full days after concrete placement.

B. Leave soffit forms and shores in place until concrete has reached specified twenty-eight day (28 D) strength, unless directed otherwise by the Project Manager.

3.9 DEFECTIVE WORK

A. Immediately repair defective work discovered after forms have been removed. When concrete surface is bulged, uneven, or shows excess honeycombing or form marks which cannot be repaired satisfactorily through patching, remove and replace entire section.

PART IV:TABLES

4.1 CONCRETE CLASSIFICATION MINIMUM SPECIFICATIONS

CONCRETE CLASSIFICATION MINIMUM SPECIFICATIONS					
Class of Concrete	Sacks of Cement per Cubic Yard Minimum	Minimum Compressive Strength at 28 Days	Maximum Cement to Water Ratio	Coarse Aggregate Grade Number	Slump
A	5.0	3000**	6.25	2 – 3	3 – 5*
B	6.0	3600**	6.00	1,2,3,4,5	4
C	4.0	2000**	8.00	2,3,4,5,6,7	5
D	6.0	3000**	6.00	2,3,4,5	5
E	6.0	As specified	5.50	3,4,5,6	5
F	8.75	5500**	3.6	6	5

*When ASTM C494, Type F or Type G admixture is used to increase workability, this range may be 6 to 9.

**These are minimum compressive strengths; please note a mix design is required for various applications to ensure specified compressive strengths are met for their intended use.

4.2 COARSE AGGREGATE GRADATION

COARSE AGGREGATE GRADATION CHART										
Aggregate Grade No.	Nominal Size Inches	Percent Retained on Each Sieve								
		2-1/2 In.	2 In.	1-1/2 In.	1 In.	3/4 In.	1/2 In.	3/8 In.	No. 4	No. 8
1	2	0	0-20	15-50		60-80			95-100	
2 (467)*	1-1/2		0	0-5		30-65		70-90	95-100	
3	1-1/2		0	0-5		10-40	40-75		95-100	
4 (57)*	1			0	0-5		40-75		90-100	95-100
5 (67)*	3/4				0	0-10		45-80	90-100	95-100
6 (7)*	1/2					0	0-10	30-60	85-100	95-100
7	3/8						0	5-30	75-100	
8	3/8						0	0-5	35-80	90-100

* Numbers in parenthesis indicate that the gradations conform to Corresponding ASTM gradation in ASTM C33.

4.3 DELETERIOUS SUBSTANCES

MAXIMUM PERMISSIBLE PERCENTAGES	
Deleterious Material	Maximum Percentage
Material removed by decantation, ASTM C117	1.0 %
Shale, slate or similar materials	1.0 %
Clay lumps	0.25 %
Soft fragments	3.0 %
Others, including friable, thin, elongated or laminated pieces	3.0 %

Sum of all deleterious ingredients, exclusive of material removed by decantation shall not exceed 5 % by weight.

4.4 FINE AGGREGATE GRADATION

FINE AGGREGATE GRADATION CHART								
Aggregate Grade No.	Percent Retained on Each Sieve							
	3/8 In.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
1	0	0-5	0-20	15-50	35-75	65-90	90-100	97-100

4.5 MINERAL FILLERS

MINERAL FILLER GRADATION CHART		
Percent Retained on Each Sieve		
No. 20	No. 30	No. 100
0 %	0 to 5 %	0 to 30 %

4.6 TEMPERATURE REQUIREMENTS FOR PLACEMENT

PLACEMENT TEMPERATURE REQUIREMENTS	
AMBIENT TEMPERATURE[1]	
Minimum temperature to start placing concrete	35° and rising
Minimum temperature to stop placing concrete	40° and falling
Maximum temperature for placing concrete without ice	90°
Maximum temperature for placing concrete with ice	100°
CONCRETE TEMPERATURE	
Minimum concrete temperature	50°
Maximum concrete temperature without ice	90°
Maximum concrete temperature with ice	95°
MINIMUM CURING TIMES WHEN PLACED CONCRETE HAS BEEN EXPOSED TO FREEZING TEMPERATURES	
From 50° to 70°, minimum days	5
70° and above, minimum days	3
[1]Ambient temperature is to be taken as specified in paragraph 3.3.F.1 of this Section.	

4.7 TRANSPORTING TIME REQUIREMENTS

TRANSPORTING TIME REQUIREMENTS FOR PLACEMENT		
Ambient Temperature	Maximum Time (No Retarding Agent) in Minutes	Maximum Time (With Retarding Agent) in Minutes[1]
Non-Agitated Concrete		
Above 80° F	15	30
80° F and Below	30	45
Agitated Concrete		
Above 90° F	45	75
75° F to 90° F	60	90
75° F and Below	90	120
NOTE: Time interval shall be from the addition of cement to the batch to start of placement of concrete in the forms. [1]Normal Dosage of retarder.		

END OF SECTION