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Section 10

CONCRETE

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PART II - CONSTRUCTION MATERIALS AND METHODS

Section 10

CONCRETE

10.1 GENERAL

All concrete and reinforcing placed in newly constructed structures that are considered as capital improvements to the City of Arvada shall conform to approved engineered plans and these Specifications. These Specifications shall apply to all new construction within the City of Arvada.

Specifications of the American Society for Testing Materials (ASTM), detailed recommendations for acceptable practices set forth by the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI) and the Colorado Department of Transportation (CDOT) are made a part of these Specifications.

The Contractor, through his fabricator, shall prepare and submit shop drawings showing all dimensions for fabrication and placing of the reinforcing steel, form work and accessories for review and approval before fabrication when called for in the Special Conditions on City projects or on the construction plans for developer projects.

10.2 MATERIALS

Materials that are to be incorporated in the structure shall conform to the minimum Specifications hereinafter referred to, unless otherwise approved.

10.2.1 Cement

- A. Portland Cement, conforming to the requirements of ASTM C-150 Type II, except where sulfate conditions dictate otherwise. In general, Type II "low alkali" cement shall be used in concrete which will be in contact with the soil unless otherwise allowed or directed by the Engineer. Recommendations for sulfate resistance are given in Table 2.2.3 in Chapter 2.2 of ACI 201. High early strength Type III or IIIA may be used only for concrete in anchors and thrust blocks. Use of any other type of concrete requires the approval of the Engineer. Other high-early strength concretes may be used where special conditions warrant, subject to written approval of the mix design by the Engineer. No accelerators or admixtures containing calcium chlorides will be permitted.
- B. Chemcomp, expansive shrinkage compensating cement, as manufactured by Texas Industries, Inc., or equal product licensed by and conforming to the requirements of the Chemical Pre-stressed Concrete Corp. (CPCC).
- C. Fly Ash, only when approved or required by the Engineer, shall conform to the requirement of CDOT Specifications subsection 701.02.

10.2.2 Admixtures

- A. Air Entraining Agent conforming to the requirements of AASHTO M154.
- B. Water Reducing Agent conforming to the requirements of ASTM C-494 or approved equal. No accelerators or admixtures containing calcium chlorides will be permitted.
- C. Retarding Agent conforming to the requirements of ASTM C-494, Type B. If Type D is used, adjust mixture of water reducing agent. Lignin type retardants will not be permitted.

10.2.3 Color

- A. Coloring Agent, when called for in the Special Conditions, shall conform to the following.
- B. Coloring Agent for the colored portion of ADA ramps shall be Davis Colors product: Tile Red or approved equal. Three (3) pounds of Davis Colors pigment #1117 per 94 pound sack of cement shall be used or as per manufacturer's recommendation for approved equal product.

10.2.4 Fibrous Concrete Reinforcement

1.5 lbs/cy of 100% virgin polypropylene fibrillated fibers shall be plant batched into the mix for all concrete used in flatwork.

10.2.5 Water

Potable, non-alkaline water in accordance with CDOT Specifications subsection 712.01 and devoid of salts and other injurious elements for concrete mixing shall be used.

10.2.6 Aggregates

- A. General: All fine and coarse aggregates shall conform to the following specifications:

Coarse Aggregates	ASTM C-33 #57/67 (3/4")
Coarse Aggregate Wear, 45 max	ASTM C-33, #89 (3/8")
Fine Aggregate	ASTM C-33 Concrete sand
- B. Gradation: Fine and coarse aggregates are regarded as separate ingredients and each shall be well graded between the limits as shown in the following charts and in accordance with CDOT Specifications subsections 703.01 and 703.02:

**FINE AGGREGATES FOR
PORTLAND CEMENT CONCRETE**

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT
3/8"	100
#4	95 - 100
#8	80 - 100
#16	50 - 85
#30	25 - 60
#50	5 - 30
#100	0 - 10
#200	3, Max.
Friable Particles, %	1.0, Max.
Coal & Lignite, %	1.0, Max.
Deleterious Material (AASHTO T-11), %	3, Max.
Sand Equivalent (AASHTO T176), %	80, Min.
Fineness Modulus	2.50 - 3.50
Sodium Sulfate Soundness, %	20.0, Max.

**COARSE AGGREGATES FOR
PORTLAND CEMENT CONCRETE**

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT
1.5"	100
1"	100
3/4"	90-100
1/2"	25-60
3/8"	20-55
#4	0-10
#8	0-5
#200	1.5, Max.
% Wear	45, Max.
Clay Lumps & Friable Particles, %	2.0, Max.
Coal & Lignite, %	0.5, Max.
Sodium Sulfate Soundness, %	12, Max.

10.2.7

Reinforcing Steel

- A. Bar steel shall be round bars conforming to ASTM A-615, Grade 60, except #3 bars shall be Grade 40, and deformed in accordance with the requirements of ASTM A-305. All bars shall be epoxy coated in accordance with AASHTO M-284.
- B. Epoxy-coated reinforcing bars shall be epoxy coated by electrostatic spray methods meeting the requirements of AASHTO M-284. The coating material shall be a light colored powdered epoxy resin which will highlight rusting of untreated bar area.
- C. Dowels for Slabs on Grade at joints where indicated shall be hot rolled merchant bars conforming to ASTM A-151, C-1020.
- D. Miscellaneous Reinforcement not covered above must conform with the requirements of ACI-315 and ACI-318.

10.2.8

Joint Materials

- A. Preformed sponge rubber and cork expansion joint fillers shall be in accordance with AASHTO M 153.
- B. Preformed expansion joint fillers (non-extruding and resilient bituminous) shall be in accordance with AASHTO M 33.
- C. Preformed expansion joint filler (bituminous type) shall be in accordance with AASHTO M 213.
- D. Joint sealant for concrete pavement shall be silicone material, self or non-self leveling, such as Dow 888, Dow 888-SL or equal.
- E. Backer rod shall be extruded closed-cell polyethylene foam material.

10.2.9

Curing Compounds

Curing compounds shall be white pigmented liquid membrane forming on non-colored concrete and conform to AASHTO M 148. Curing compounds shall be clear on colored concrete or as recommended by the manufacturer.

10.2.10

Curing Materials

Burlap cloth made from Jute or Kenaff shall conform to AASHTO M 182. Sheet materials for curing concrete shall conform to AASHTO M 171

10.2.11

Rapid-setting Pavement Patch Materials

Partial-depth pavement patch material shall be Type III portland cement with set-accelerator, polymer-modified (methacrylate) concrete or epoxy concrete material. Cure time shall be less than 4 hours. A mix design shall be submitted and approved for Type III portland cement material prior to placement.

10.2.12 Truncated Domes Detectable Warning Materials

Acceptable detectable warning materials are as follows:

“Cast in Place” by Armor-Tile, Inc.
“Cast in Place” by ADA Solutions, Inc.
“CASTinTACT” by Masons Supply Company
Cast Iron DWP with Red color as produced by East Jordan Iron Works
Precast Concrete Detectable Warning Paving Slabs by StoneBilt Concepts
USA Safety Domes

All detectable warning panels shall be bolted together as necessary using manufacturer supplied or recommended nuts and bolts prior to placement in fresh concrete. Alternative truncated dome detectable warning materials will be considered by the Engineer and must be approved by the Engineer prior to being incorporated into any work.

10.3 **PROPORTIONING INGREDIENTS**

Concrete ingredients shall be proportioned so as to provide concrete which is workable and homogeneous, yet when cured it will provide the required strength, durability, resistance to deterioration, abrasion, water tightness, appearance and other specified properties.

10.3.1 Class A Concrete

Concrete shall have a maximum allowable water/cement ratio of 0.48 by weight. Minimum cement content shall be six sacks per cubic yard with a maximum of 33.7 gallons of water per cubic yard. The fine aggregate shall be between 37% and 44% by volume of the total aggregates and the end product shall have a minimum 28 day compressive strength of 4,000 psi when tested in accordance with ASTM C-31. 1.5 lbs/cy of 100% Virgin polypropylene fibrillated fibers shall be plant batched into the mix for all curbs, gutters, sidewalks, crosspans, and other slabs on grade as determined by the Engineer.

10.3.2 Class B Concrete

Concrete shall have a maximum allowable water cement ratio of 0.63 by weight. The fine aggregates shall be between 34% and 38% by volume of the total aggregates and the end product shall have a minimum 28 day field compressive strength of 3000 psi when tested in accordance with ASTM C-31.

10.3.3 Class C Concrete, Chemcomp

Concrete shall have a minimum of 5.5 sacks of expansive shrinkage compensating cement per cubic yard and a water reducing admixture, incorporated in strict conformance with the printed instruction of the cement manufacturers of the concrete, so as to produce a slump not to exceed six (6) inches and an end product having a minimum 28 day compressive strength of 4300 psi, when tested in accordance with ASTM C-31.

10.3.4 Class S Concrete, Calcareous Aggregate

Concrete shall conform to the requirements for Class S concrete as specified in CDOT Specifications subsections 601.02 and 601.03. Proportioning shall be in accordance with subsection 601.05. Concrete mix design for high alkalinity concrete pipe, manufactured in accordance with ASTM C-76 shall be as follows:

Portland Type II Cement \leq 5% C ₃ A	630 lbs.
Concrete Sand	600 lbs.
Calcareous Breeze	1775 lbs.
Calcareous 3/8" chips	1375 lbs.
Air Content	5-7%
Water Cement Ratio	0.44 (max)
Calcium Carbonate Equivalent > 65% when tested in accordance with ASTM C-602.	

10.3.5 Class F Concrete, Flow Fill

Concrete mix design for flow fill concrete, a substitute for Colorado Department of Transportation CL I & CL II Structural and Utility Trench Backfill, shall have a 28-day compressive strength between 40 and 60 psi and proportions as follows:

FLOWABLE FILL	
<u>Ingredients</u>	<u>Pounds Per Cubic Yard</u>
Cement	50
Class F Fly Ash	50
Coarse Aggregate(AASHTO No. 57 or 67)	1700
Fine Aggregate Sand (AASHTO M6)	1845
Air Entraining Agent	5 oz.
Water (39 Gallons)	325 (or as needed for proper consistency)

10.3.6 Class P Concrete

Concrete shall conform to the requirements for Class P concrete as specified in CDOT Specifications subsections 601.02 and 601.03. Proportioning shall be in accordance with subsection 601.05 and 20 percent fly ash shall be included as required by subsection 412.04. Minimum 28-day compressive strength shall be 4200 psi when tested in accordance with ASTM C 31.

10.3.7 Class D and BZ Concrete

Concrete shall conform to the requirements for Class D and BZ Concrete as specified in CDOT Specifications subsections 601.02 and 601.03. Proportioning shall be in accordance with subsection 601.05.

10.3.8

Construction

Application of the different classes of concrete are as shown below.

Max. Size Coarse Ag.	Air Content Range	Slump Range	Min. Cement Content	Concrete	
In.	% by Volume	In.	Sks./CY	Class	Typical Application
1 1/2"	4-7	1-4	6.0	A	Columns, Slabs on Grade, Reinforced Walls
	4-7	1-3	6.0	A	Grade Beams, Caissons, Reinforced & Plain Footings, Manhole Bases
	4-8	2-3	6.0	P	Roadway Pavement
	5-8	2-4	5.0	B	Pipe Encasement, Kickblocks
1"	5-7	1-4	6.0	A	Columns, Slabs on Grade, Reinforced Walls
	5-7	1-3	6.0	A	Reinforced & plain footings, Grade beams, Caissons, Columns
	5-8	2-4	5.0	B	Pipe Encasement, Kickblocks
	5-7	4-6	5.5	C	Reinforced Slabs on Grade
	N/A	N/A	0.45	F	Structural backfill, Utility Trenches, V-ditches
3/4 "	5-8	2-3	6.6	D	Bridge Deck
	N/A	5-8	6.6	BZ	Caissons
	5-8	1-4	6.0	A	Sidewalk, Curb and Gutter, Slope Paving, Curb Cuts, Cross Pans, Driveways, Retaining Walls, Storm Drainage Structures, Structural Slabs on Grade, Reinforced Columns, Footings, Beams and Walls
	5-8	4-6	5.5	C	Reinforced Slabs on Grade
3/8"	6-9	0	6.7	S	Concrete Sewer Pipe

Mix Designs

- A. The Contractor shall submit either standard supplier design mixes for approval or specific design mix proportions, laboratory trial mix, and aggregate test data for each class of concrete being placed. Test data shall show mix proportions, slump, air content, unit weight, water/cement ratio, and 28-day compressive strength test results as tested under laboratory conditions. The design mix proportions must produce 100% of the required 28-day laboratory compressive strengths. Each design shall establish the mix proportions and sources of all ingredients. A new mix design shall be submitted when a change occurs in the mix proportions, source of cement, aggregate or when field tests fail to meet strength specifications. Approval of mix designs does not constitute acceptance of concrete. Acceptance is based solely on test results of actual concrete placed on a project.

Designs employing the same ingredients proposed for use and used successfully on a previous project under similar conditions to those anticipated on a current project may be used, provided the Contractor requests and obtains City approval on the following, all of which must be certified to by the supplier:

1. Concrete mix designs conforming to these Specifications.
2. ID sets of 4 (2@7 day break and 2 @28 day break) concrete strength tests made during the last 6 months on concrete conforming to the design in (1) above.
3. Curve showing relationship of 7 and 28 day strengths in (2) above.
4. Reports of compliance tests of fine and course aggregates made during the last six (6) months.

OR

- B. The Contractor shall employ, at his expense an acceptable independent laboratory to design, proportion and select ingredients from the supplier's sources that will produce a concrete mix conforming to the requirements of these Specifications, while providing proper durability, strength and other required physical properties for the proposed application.

10.4**FORM WORK**

Provide all forms, shores, cores, molds and similar items in sufficient quantity and quality to properly execute the work.

Lumber or plywood contact surfaces must be free from knots, warps, breaks, or other defects likely to cause irregular surfaces. Unexposed surfaces shall have forms of No. 2 common lumber or better. Metal forms must be free from irregularities, dents and sags and suitable for concrete exposed to view in finished areas.

Do not reuse forms if there is any evidence of surface wear or tear which would impair the quality of the finish. Thoroughly clean and lubricate forms for reuse.

10.4.1

Tolerances

Construct forms so as to insure that concrete surfaces will conform to tolerances of Section 203.1 ACI 347.

10.4.2 Preparation of Form Surfaces

Make forms sufficiently tight to prevent leakage of grout or cement paste. Seal wood surfaces against absorption of moisture from the concrete with an acceptable oil, sealer, or factory applied non-absorptive liner.

Coat forms to prevent bond with concrete prior to placing of the reinforcing steel. Do not allow coating material to stand in puddles in forms nor to come in contact with concrete against which fresh concrete will be placed.

10.4.3 Removal of Forms

- A. Form work that supports weight of concrete must remain in place until concrete has reached its specified 28 day strength as indicated by compressive strength tests on field-cured specimens, unless otherwise specified or permitted by the Engineer.
- B. Form work not supporting weight of concrete may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations. Minimum form removal time after placement of concrete for curb and gutter is 4 hours. Side forms for footings and slabs shall be left in place a minimum of 12 hours after concrete placement. Side forms for walls, beams and columns shall be left in place a minimum 24 hours after concrete placement. Walks shall not be opened to pedestrian traffic for a minimum 24 hours after placement. Curb cuts, curb and gutter and crossspans shall not be opened to vehicular traffic for a minimum of 7 days after placement or until concrete has attained 2/3 of its specified 28 day field strength.
- C. Whenever the form work is removed during the curing period, the exposed concrete shall be immediately cured by one of the methods herein specified.

10.5 **FABRICATION AND PLACEMENT OF EMBEDDED REINFORCEMENT**

10.5.1 Fabrication Tolerance

- A. Sheared length and bends, $\pm 1"$.
- B. Depth of truss bars, stirrups, ties and spirals, $\pm 1/2"$.

10.5.2 Placement Tolerance

- A. Concrete cover to formed surface, minimum spacing between bars, top bars in slabs or beams and members to 8 inches deep, $\pm 1/4"$.
- B. Members between 8" to 24" deep, $\pm 1/2"$.
- C. Members more than 24" deep, $\pm 1"$.
- D. Crosswise of members spaced evenly within 2".
- E. Lengthwise of members, $\pm 2"$.

Movement of bars more than one diameter or in excess of above tolerances, to facilitate installation of embedded items, must be approved by the Engineer.

10.5.3 Reinforcement Placement

Support and wire together all reinforcing bars to prevent displacement from external loading prior to and during concrete placement. On ground where necessary supporting concrete blocks may be used, otherwise use concrete, metal, plastic or other satisfactory bar chairs and spacers. Templates will be required for all column dowels.

Epoxy coated reinforcing bars and welded wire fabric shall be tied with epoxy coated tie wire that will not damage or cut the coating. Bars shall be placed on plastic supports or steel supports fully coated with plastic or epoxy. Care shall be taken to prevent coated bars from coming into contact with other steel items. The Contractor shall repair all damaged coating prior to concrete placement.

Provide adequate support for welded wire fabric during placing of concrete to insure proper position of the fabric in the slab.

At time of concrete placement all steel is to be free from loose, flaky rust, mud, oil or other coatings that may destroy or reduce bond.

Unless otherwise noted on the drawings, the steel shall be protected by concrete, after placement as follows:

- A. 3/4" for interior slabs.
- B. 1" for interior walls and formed exterior slabs.
- C. 1 1/2" for beams, columns and concrete exposed to the weather or in contact with the ground.
- D. 3" for concrete deposited against the ground.

No. 4 rebar (1/2" dia.) dowels shall be used to join all existing concrete in crossspan areas to new concrete. Dowels shall be epoxied into drilled holes and extend into the old concrete a distance of 24 diameters. The use of heat in bending bars is not allowed. Splices, where permitted, shall be as specified in ACI 318. Dowels in crossspans shall be minimum #4 bar placed at 24" on center. Dowels (#4 bar) in ADA ramp sections shall be evenly spaced in the fresh concrete.

10.6 **JOINTS**

Provide joints only where shown unless otherwise specifically permitted by written direction from the Engineer.

10.6.1 Construction Joints

Continue all reinforcing steel and welded wire fabric across joints, unless otherwise indicated. Provide keys and inclined dowels as shown on construction drawings or as directed by the Engineer. Provide longitudinal keys at least 1 1/2" deep in all joints in walls and between walls and slabs.

Thoroughly clean surfaces and remove all laitance on the surface of joints before next placement.

When required or directed, obtain bond between hardened concrete and new concrete by:

- A. Use of an acceptable epoxy bond.
- B. Use of an acceptable chemical retarder.
- C. By roughening surface of old concrete in an acceptable manner such as sandblasting.
- D. Provide a continuous water stop as specified.

10.6.2 Expansion Joints

Expansion joints in combination curb, gutter and sidewalk, vertical curb and gutter, concrete channels or any other location that is designed to or may carry water shall be recessed $\frac{1}{2}$ " and filled with a concrete pavement joint sealant. Expansion joints shall be installed between back of sidewalks and driveways or walkways, between new concrete and existing masonry buildings and at all locations as shown on the construction drawings or as directed by the Engineer. Expansion joint width shall be $\frac{1}{4}$ ".

10.6.3 Contraction Joints

Transverse joints shall be placed at maximum intervals of ten feet (10') and minimum intervals of five feet (5') to control random cracking in curb and gutter and combination curb, gutter and walk. At least two joints equally spaced at not greater than ten foot (10') intervals shall be placed in driveways. Joints shall be tooled to a minimum depth of one-quarter ($\frac{1}{4}$) of the total thickness (minimum depth $1\frac{1}{2}$ "). If divider plates are used the maximum depth of plates shall not be greater than one half ($\frac{1}{2}$) the total thickness. The joints shall be finished with a jointer having a width no greater than $\frac{5}{16}$ " and depth not less than $\frac{3}{4}$ ". Maximum joint width at the surface shall be $\frac{5}{16}$ ". Joints in bike paths that are 10 foot (10') width or less shall also be placed at 10 foot (10') intervals unless otherwise directed by the Engineer. Joints in bike paths shall be sawed to a minimum depth of $1\frac{1}{2}$ " with carborundum or diamond-tipped blade after concrete has set.

10.6.4 Concrete Pavement Joints

Provide joints of the type, dimension and at locations required by the Contract. Joints shall be constructed and sealed in accordance with Section 412 of the Colorado Department of Transportation (CDOT) Specifications. Repairs, sandblasting, air blasting and installation of backer rod is required prior to applying sealant. Pavement shall be dry and air or surface temperature must not be less than 50 degrees F.

10.6.5 Resealing Concrete Pavement Joints

Existing sealant in concrete pavement joints shall be removed by a joint plow or a method approved by the Engineer. The plow shall be able to efficiently remove at least 95 percent of the old sealant from the joint walls and not spall the joint sidewalls. After the old sealant is removed, the joint shall be prepared and sealed as specified in subsection 10.6.4.

10.7 **EMBEDDED ITEMS**

Items to be embedded include, but are not limited to, water stops, anchor bolts, inserts, sleeves, curb angles, dovetail anchor slots, frames, etc. and shall be placed prior to concrete placement.

10.7.1 Placing Embedded Items

Position accurately and support against expansion joint material, water stop and embedded items. Fill temporarily with readily removal material to prevent the entry of concrete into the voids in sleeves, inserts and anchor bolts.

10.7.2 Water Stops

Provide water stops in construction and expansion joints in the maximum practical length possible. Forming necessary splices and intersections shall conform to manufacturer's recommendations and directions.

10.8 **CONCRETE MIXING**

Concrete shall be mixed and transported to the job site in accordance with the requirements of ASTM C-94. Ready mixed concrete shall conform to all requirements of AASHTO M 157.

The organization supplying the concrete shall have sufficient plant and transportation facilities to assure continuous delivery of the concrete at the required rate. The Contractor shall collect delivery or batch tickets from the driver for all concrete used on the project and deliver them to the Engineer. Batch tickets shall provide the following information:

- (A) Supplier's name and date
- (B) Truck number
- (C) Project number and location
- (D) Concrete class designation
- (E) Cubic yards batched
- (F) Time batched
- (G) Mix design number
- (H) Type, brand, and amount of cement and fly ash
- (I) Type, brand and amount of each admixture
- (J) Weights of fine and coarse aggregates
- (K) Moisture content of fine and coarse aggregates
- (L) Gallons of batch water (including ice)

The Contractor shall add the following information to the batch ticket at the placement site:

- (M) Gallons of water added by truck operator.
- (N) Discharge time
- (O) Water-cement ratio (bridge deck concrete only)
- (P) Air content
- (Q) Slump
- (R) Revolutions
- (S) Location of batch in placement

10.8.1 Agitating, Mix and Discharge

Concrete shall be continuously agitated from the time water is added and then mixed for 2 1/2 minutes just prior to discharge. The mix shall be discharged in place within 90 minutes after batching when delivered in truck mixers or agitating trucks and within 60 minutes after cement is batched when delivered in non agitating trucks, unless longer time is specifically authorized. The 90 minute time limit for mixer or agitating trucks may be increased to 120 minutes if no water is added after 90 minutes and the concrete temperature prior to placement is less than 90 degrees F.

10.8.2 Water

Indiscriminate addition of water to increase slump is prohibited.

10.8.3 Admixtures

- A. Liquid admixtures shall be charged into the mixer by means of an approved metering device.
- B. Powder admixtures shall be weighed or measured by volume in accordance with manufacturer's recommendation.
- C. When two or more admixtures are to be incorporated in the mix, they shall be added separately during batching sequence.

10.8.4 Re-tempering

Mix concrete only in quantities for immediate use. Concrete which has been in the mixer 120 minutes or longer shall be discarded in all cases. Re-tempering of concrete will not be allowed.

Concrete arriving at the project with slump below that suitable for placing may have water added only if neither:

- A. The maximum permissible water-cement ratio has not been exceeded.
- B. Maximum slump has not been exceeded.

10.9 **WEATHER**

Perform work in conformance with detailed recommendations in ACI 306 for cold and ACI 305 for hot weather concrete placement.

10.9.1 Batch Temperature

As mixed temperature of concrete shall be maintained above 55 degrees F and below 90 degrees F, even though the mean temperature falls below 40 degrees F. Temperature shall be taken for every 50 yd³ of concrete placed.

10.9.2 Protection

Provide adequate protection against rain, sleet, snow, cold and other weather conditions.

Concrete placed within 72 hours of ambient temperatures dropping below 40 degrees F shall be protected by suitable covering and equipment to maintain a minimum surface temperature of 50 degrees F and shall remain protected for a period of 72 hours after the concrete has been placed or until at least 60% of the 28-day field strength has been obtained, whichever is greater. If the Engineer determines that the cold or inclement weather protection is inadequate, concrete placement shall stop until adequate weather conditions exist or until protection procedures are acceptable to the Engineer.

10.10 **CONSTRUCTION PRACTICES**

10.10.1 Preparation of Surfaces

Preparation for placing shall include, but is not limited to, form construction, setting of reinforcing steel and embedded items, securing and alignment of forms, cleaning thoroughly all surfaces that will be in contact with concrete and keeping them free of debris, ice, rust, scale, grease or other coatings during placement of the concrete. Concrete shall not be placed until all forms and reinforcement have been observed by the City Inspector.

10.10.2 Equipment and Labor

Assemble and provide sufficient labor and equipment for proper mixing, transporting, placement and protection of concrete until accepted by the City.

10.10.3 Conveying

Truck mixers, agitators, and non-agitating units, including their manner of operation, must conform to the applicable requirements of ASTM C-94. Aluminum tubing or pipe for conveying concrete will not be allowed.

Concrete shall be conveyed to place of final deposit by methods which will prevent segregation or loss of ingredients and insure the required quality of the concrete is obtained. A hopper or tremie will be required at the end of metal chutes having a slope greater than 1:2 or less than 1:3 vertical to horizontal; or chutes in excess of 20 feet in length.

Use of horizontal belt conveyors discharging into a hopper and pumping or pneumatic conveying equipment such that the loss in slump does not exceed 1 1/2" shall be subject to approval.

10.10.4 Depositing

Deposit concrete continuously, or in layers of such thickness that no concrete is deposited on concrete which is hardened sufficiently to cause formation of seams or planes of weakness within the section. Deposit concrete as nearly as practical in its final position to avoid segregation due to re-handling or flowing.

Depositing of concrete in general shall conform with the applicable detailed recommendation of ACI 304.

10.10.5 Consolidation

Perform consolidation in conformance with applicable detailed recommendation of ACI 309.

Consolidate all concrete by internal and external vibrators, spading, rodding or forking so that concrete is thoroughly worked around reinforcement, embedded items and into form corners, eliminating all air or stone pockets which may cause honeycombing, pitting or planes of weakness. Thoroughly consolidate concrete in slabs and floors with vibrating bridge screeds, roller pipe screeds or other acceptable means. Only mechanical vibrators having a minimum frequency of 7000 RPM and operated by competent workmen shall be employed.

Over vibration and transporting concrete within the form by vibration will not be allowed.

10.10.6 Underwater Concreting

Placing of concrete under water will not be allowed unless specifically approved method and authorization by the Engineer in writing has been obtained.

Where concrete is authorized to be placed under water, the cement content shall be increased 25% at Contractor's expense, to compensate for losses due to water.

10.10.7 Partial-depth Pavement Patching

Rapid –setting patch material shall be used for partial-depth pavement patches. Spalled areas less than 6" long or 1.5" wide shall be filled with sealant. Patch area shall be 2" to

4" beyond limits of spalled area. Patches less than 12" from each other shall be repaired as one patch.

Existing concrete pavement shall be removed to a minimum depth of two (2) inches and no deeper than 1/3 of the concrete thickness. If dowels are exposed, a full-depth repair must be made. Concrete shall be removed by saw-cutting around the limits of the patch area and chipping the concrete out with a 15 pound jackhammer (30 pound if there is no damage to the pavement) or by milling and saw-cutting a vertical edge on the rounded sides. The removal area and vertical faces shall be sandblasted and then air blasted immediately before applying patch material. A bonding agent shall be applied after cleaning the repair area before placing portland cement repair materials.

Patches along joints shall have a joint bond breaker with a scored top strip placed in the saw-cut joint. The bond breaker shall extend 3" beyond the edges of the patch and 1" below the depth of the patch. A straight line shall be maintained. The top strip shall be torn off and the joint prepared and sealed in accordance with subsection 10.6.4.

Rapid-setting patch material shall be mixed in accordance with an approved mix design for Type III portland cement material and in accordance with the manufacturer's written instructions for other materials. Patch material shall be placed in accordance with the manufacturer's recommendations to include bonding agents if required. Material shall not be placed when the air or surface temperature is below 40 degrees F. Cementitious materials shall be consolidated by using a thin internal vibrator or a vibrating screed. Unless a patch is very small, cutting and tamping with a trowel will not be allowed. Cementitious materials shall be cured using curing compound and others shall be cured according to the manufacturer's recommendation.

10.10.8 Full-depth Pavement Repairs

A concrete mix design shall be submitted and approved prior to use for full-depth concrete repairs. Concrete shall be in accordance with Class P concrete with a minimum seven-day compressive strength of 3,000 psi when tested in accordance with ASTM C 31.

Minimum length (direction of traffic) for removal shall be 6 feet. Lengths longer than 15 feet require an intermediate joint. Minimum distance from a transverse joint shall be 6 feet.

Minimum width shall be 12 feet or the jointed lane width.

Areas to be repaired shall be saw-cut and removed without damage to the faces or edges of the cut. Smooth dowels or tie bars (when required by the Engineer) shall be placed at 12 inches on-center and at mid-depth of the slab. Tie bars would be placed at the first joint in the direction of travel and dowels placed at the second joint, if required. Add base course material as required and compact subgrade.

Place, consolidate, finish and cure concrete in accordance with the requirements of this sections. Surface shall match grade and finish of existing concrete pavement.

10.11 **SURFACE DEFECTS**

10.11.1 Tie Holes

Patch all tie holes, after being cleaned and thoroughly dampened, by filling solid with patching mortar immediately after form removal.

10.11.2 Defective Areas

Remove and repair all honeycombed and other defective concrete down to sound

concrete. Dampen area to be patched and area six (6) inches wide surrounding it. Brush into surface a bonding grout (1 part cement to 1 part sand passing a #30 sieve) mixed to a consistency of thick cream. Immediately after breaking in grout, patch the defective area with a mortar (1 part cement to 2 1/2 parts sand by damp loose volume) using no more water than necessary for handling and placing. Surface shall be left sound, smooth, even and uniform in color.

10.12 FINISHING

10.12.1 Selection of Finishes

Unless otherwise shown or called for in the Special Conditions, the following finishes shall be provided. All formed surfaces shall be finished with a CDOT Class 1 Ordinary Surface Finish.

<u>Type Finish</u>	<u>Type of Surface Intended</u>
Scratch	To receive bonded applied cementitious application
Floated	To receive water proofing membranes or terrazzo
Troweled	Walking surfaces or for reception of floor covering
Broom	Sidewalks, crosspans, curb and gutter, and ramps
Non-slip	Exterior platforms, steps, athletic courts, landings and ramps
Board Form	Concrete surfaces not exposed
Smooth Rubbed	Interior vertical and other exterior surfaces
Exposed Aggregate	Scrubbed, sandblast and tooled finishes as specified in the Special Conditions

10.12.2 Tolerances of Finish

<u>Finish Class</u>	<u>Application</u>	<u>Minimum Slope</u>
"A"	Slopes to Drains Floors	1/8" in 10 ft. using a 10 ft. straight edge
"B"	Ramps Sidewalks Crosspans Curb and Gutter	1/4" in 10 ft. using a 10 ft. straight edge
"C"	Athletic Courts	1/4" in 15 ft. using a 15 ft. straight edge.

10.12.3 Floated Finish Slabs

After concrete has been placed, struck off, consolidated, leveled and allowed to set to the point where water sheen has disappeared or where mix has stiffened sufficiently to permit proper working, begin consolidation of the surface with power driven machines. Hand float with wood or cork-faced floats in locations inaccessible to power driven machines. Recheck trueness of surface at this state with applicable straight edge applied at not less than two different angles. Cut down all high spots and fill all low spots during this procedure, then re-float the slab immediately to a uniform, smooth, granular texture.

10.12.4 Troweled Finish Slab

Perform first power troweling immediately after power floating to produce a smooth surface that is relatively free of defects but which may still contain some trowel marks. Perform additional troweling and consolidation of the surface by hand until a ringing sound is produced as the trowel is moved over the surfaces.

To resist slip, the finish surface may show trowel marks which are uniform in texture and appearance, otherwise it shall be free of all trowel marks.

10.12.5 Broom Finish

Sidewalk slabs, crosspans, curb and gutter, and other slabs so specified shall have a coarse traverse sawed texture obtained by drawing a broom across the surface immediately after floating.

10.12.6 Marking

At the Contractor's option, all concrete used in curb, gutter, sidewalk, curb cuts, driveways, inlets, bicycle paths and slope paving may have the name of the Contractor and the year of construction impressed therein using letters a minimum of 1" high and 3/8" deep. Impressions should be made in the concrete at the beginning and end of each pour and at the end of each driveway. Structures should have the year constructed impressed therein using letters 3" high and 1/2" deep.

10.13 CURING

Freshly deposited concrete shall be protected from premature drying and excessively hot or cold temperatures and maintained with minimal moisture loss at a relatively constant temperature for the time required for hydration of cement and proper hardening of the concrete.

10.13.1 Initial Curing

Immediately following finishing the Contractor shall provide methods to keep the concrete continuously moist at least overnight unless otherwise specified by:

- A. Ponding or continuous sprinkling
- B. Absorptive mat or fabric kept continuously wet
- C. Sand or other covering kept continuously wet
- D. Steam vapor mist bath at a temperature not to exceed 150 degrees F.
- E. Liquid curing compounds conforming to the requirements of Section 10.2.7, providing the surface to be cured is not to be bonded to other cementitious materials.

10.13.2 Duration of Curing

Continue curing until the cumulative number of days, or fraction thereof, not necessarily consecutive, during which the air temperature in contact with the concrete is above 50 degrees F has totaled seven (7) days.

10.13.3 Cold Weather Curing

Curing shall conform to all applicable detail recommendations in ACI-306. Temperature of concrete shall be maintained between 50 degrees-70 degrees F for the required curing period when the mean daily atmospheric temperature is less than 40 degrees F. Sufficient equipment and materials required to comply with this specification shall be at the site prior to placing concrete. Concrete shall be protected as required by subsection 10.9.2.

10.13.4 Hot Weather Curing

Curing shall conform to all applicable detail recommendations, in ACI 305. As quickly as concrete hardening and finishing will allow, the Contractor shall install such protective measures, such as, but not limited to, windbreaks, shading, fog spraying, sprinkling, ponding or wet covering as may be required.

10.13.5 Protection from Damage

Especially during the curing period and until the work is accepted, the Contractor shall protect the concrete from damage by vehicular or mechanical equipment, foreign materials and by rain or by running water.

10.14 TESTING

Technical services performing routine preliminary testing of materials of proposed mix designs and resulting concrete for compliance with the Specifications will be provided by the City, at no expense to the Contractor on City projects. On Developer projects, a City approved concrete tester hired by the developer must be used for all concrete testing.

10.14.1 Tests for Changes and Non-Compliance

Testing required because of changes in materials or proportions of the mix requested by the Contractor, as well as any extra testing of concrete, field cured cylinder, or materials occasioned by failure to meet specification requirements, shall be at the Contractor's expense.

10.14.2 Testing to be Provided by the City on City Projects or Supplied by the Owner/Developer on Development Projects

- A. Test Contractor's proposed material for compliance.
- B. Review and check Contractor's proposed mix design.
- C. Prepare and laboratory cure complete 1 set of 5 concrete cylinders, test and report results of 7 day (2 breaks), 28 day (2 breaks) and 56 day (1 break) compressive strength of the cylinders, in accordance with ASTM C-39 and AASHTO T 22, for every 50 cubic yards or fraction thereof of concrete flatwork placed (100 cubic yard intervals for paving) (See below for storm sewer inlet testing intervals). Maximum time between sampling and casting cylinders shall not exceed 45 minutes.

If the concrete cannot be taken to the laboratory and the cylinders cast within 45 minutes, four (4) cylinders shall be cast in the field. Cylinders shall be transported to the laboratory within 24 hours of casting but after the concrete has hardened in accordance with AASHTO T 23.

If samples of fresh concrete are not obtained and tested, a minimum of three cores in accordance with AASHTO T 24 per 50 yd³ placed shall be taken and broken. Air content in accordance with ASTM C 451 and cement content in accordance with AASHTO T 178 shall also be determined. All core holes shall be filled in by the Contractor with concrete meeting the same mix design criteria as the original concrete.

- D. Determine slump range of concrete as delivered in accordance with AASHTO T119 for every 50 cubic yards or fraction thereof placed. Slump test shall be taken with each cylinder series.

- E. Determine air content of standard weight concrete in accordance with AASHTO T 152 for every 50 cubic yards or fraction thereof placed. Air test shall be taken with each cylinder series.
- F. Determine temperature of concrete in accordance with ASTM C 1064 for every 50 cubic yards or fraction thereof placed.
- G. Check batching and mixing operations.
- H. Storm Sewer Inlet Testing Intervals – Prepare and laboratory cure complete 1 set of 5 concrete cylinders (minimum 3 cylinder series per project), test and report results of 7 day (2 breaks), 28 day (2 breaks) and 56 day (1 break) compressive strength of the cylinders, in accordance with ASTM C 39 and AASHTO T 22. Cylinder series shall be prepared for the floor (base) concrete, wall concrete and roof concrete of each inlet used on the project. Perform slump and air test of each cylinder series.

All concrete test reports shall include the type of structure or flatwork, cylinders, data on transporting, storing, curing, time between sampling and casting cylinders, supplier, batch ticket I.D., finisher and contractor.

10.14.3 Portland Cement Concrete Pavement

Testing to be provided by the City on City Projects or Supplied by the Developer on Development Projects. During placement of Portland cement concrete pavement, observation and testing shall be on a full-time basis.

- A. Test Contractor's proposed material for compliance.
- B. Review and check test Contractor's proposed mix design.
- C. Prepare and laboratory cure complete 1 set of 5 concrete cylinders, test and report results of 7 day (2 breaks), 28 day (2 breaks) and 56 day (1 break) compressive strength of the cylinders, in accordance with ASTM C-39 and AASHTO T 22, for every 100 cubic yards or fraction thereof of concrete pavement placed. Testing shall also include the temperature of concrete at placement.
- D. Determine slump range of concrete as delivered in accordance with AASHTO T119 and ASTM C-143.
- E. Determine air content of standard weight concrete in accordance with AASHTO T152. Air content tests shall be taken at the end of the concrete chute or outlet of the concrete pump truck.
- F. Check batching and mixing operations.

The first three (3) Concrete trucks or fraction thereof shall be tested for slump and air content. If any one test fails to meet requirements, slump and air content tests shall continue until three consecutive loads meet requirements. Thereafter, slump and air shall be tested at least every fifth load.

Thickness of concrete pavement shall be verified by coring every 250 linear feet in alternating traffic lanes. Any noted deficiency areas shall be corrected at that time. Surface smoothness shall be tested and corrected as necessary according to Section 412.17 of the CDOT Specifications. All core holes shall be filled in by the Contractor with concrete meeting the same mix design criteria as the original concrete.

10.15 CONTRACTOR RESPONSIBILITIES

10.15.1 Preliminary Material Samples and Mix Design

Deliver to City preliminary representative samples of all materials, mix designs and other materials Contractor proposes to use on the project which require testing, with request for acceptance.

10.15.2 Casual Labor

Furnish such labor as is necessary to handle samples at the project or at the material source.

10.15.3 Storage Facilities

Provide and maintain adequate facilities on the site for safe storage and proper curing of concrete test cylinder for the first 24 hours, as required by ASTM C-31.

10.15.4 Certificates of Compliance

Submit the following in duplicate for each shipment, with applicable AASHTO or ASTM Specifications:

- A. Cement - Mill Test Certificate of Conformance.
- B. Aggregate - Certified Test Report.
- C. Reinforcing Steel - Mill Test Certificate of Conformance.
- D. Air Entraining Admixture - Certificate of Conformance.
- E. Water - Reducing Admixture - Certificate of Conformance.

10.15.5 Defective Concrete

If concrete is found defective from testing, placing, curing or for other causes, and if the Contractor is so directed, he must remove and replace the concrete at no cost to the City.

Strength requirements shall be in accordance with ACI 214, Section 4.2. Strength level will be determined acceptable if the averages of all sets of three consecutive strength test results equal or exceed the specified strength (f'c). No individual test result may fall below the specified strength (f'c) by more than 500 psi.