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CHAPTER 7
CONCRETE

7.00.00 **INTRODUCTION**

7.01.00 **GENERAL**

This specification enumerates the requirements for the materials, storage, transportation, measuring, mixing, placing, and curing of Portland cement concrete. This specification applies to all Portland cement concrete used in but not limited to pavement, sidewalks, trails, shared pathways, driveways, approaches, alley ways, patches, manholes, inlets, and other structures constructed in the CITY. Engineering plans, licenses, permits, inspection, warranty, and acceptance shall be as detailed in these STANDARDS AND SPECIFICATIONS for the applicable type of construction involved. All applicable permits shall be obtained a minimum of 48 hours before work begins. The CONTRACTOR shall contact the CITY INSPECTOR a minimum of forty-eight (48) hours in advance of concrete placement when the form work is ready to receive the concrete. Where required, compaction test results and proof rolling shall verify the adequacy of all ground upon which concrete is to be placed. When proof rolling is required, a minimum five thousand (5,000) gallon loaded water truck or other loaded trucks approved by the CITY INSPECTOR shall be driven over the finished subgrade.

7.02.00 **REMOVALS**

All removals shall be to the limits shown on the approved drawings or as directed by the CITY INSPECTOR. Replacement or repair of damaged improvements outside of these limits shall be repaired at no expense to the CITY. Removals shall be to a clean vertical face or as shown in the approved plans.

7.10.00 **DESIGN STANDARDS**

Design specifications for sidewalks, curb and gutter, driveways, concrete pavement, inlets, and sidewalk are in this chapter. Design specifications for concrete pipe, manholes, inlets, and other drainage and wastewater concrete structures are in Chapter 3, Chapter 4 and Chapter 5 of these STANDARDS AND SPECIFICATIONS. Design specifications relative to traffic signals and traffic control items are in Chapter 8 of these STANDARDS AND SPECIFICATIONS.

7.20.00 **CONSTRUCTION**

7.20.01 **Preparation**

Before depositing concrete, debris shall be removed from the space to be occupied by the concrete and the forms. Concrete shall not be placed until all forms and reinforcing steel have been inspected and approved by the CITY INSPECTOR and all subgrade compaction test results or proof rolling have been verified. The soil receiving the concrete shall be moist, but not wet, and shall not contain frost or frozen material.

7.20.02 Timing

Concrete which has developed initial set or does not have workable consistency shall not be used. Concrete shall be continuously mixed or agitated from the time the water is added until the time of use, and shall be completely discharged from the truck mixer or truck agitator within one-and-one-half (1-1/2) hours after it comes in contact with the mixing water or with the aggregates. Retempered concrete will not be allowed.

7.20.03 Concrete Temperature

At the time of concrete placement, the mix temperature shall be between fifty degrees Fahrenheit (50°F) and ninety degrees Fahrenheit (90°F). In cold weather (see Section 7.20.06), aggregates and water may be heated as part of the batching operation but they shall not be heated beyond a temperature of one-hundred-and-fifty degrees Fahrenheit (150°F). Aggregates shall not be heated directly by gas or oil flame or on sheet metal over direct flame. Materials containing frost or lumps of frozen material shall not be used in the mix, and their presence in the concrete shall be cause for rejection of that batch.

7.20.04 Handling

- (A) Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible by methods which prevent separation or loss of ingredient. The concrete shall be deposited in the forms as nearly as practicable in its final position to avoid rehandling. Concrete shall be deposited in continuous layers, the thickness of which generally shall not exceed twelve inches (12"). Concrete shall be placed in one continuous operation, except where keyed construction joints are shown on the plans or as approved by the CITY ENGINEER. Delays in excess of thirty (30) minutes may require removal and replacement of that pour, as determined by the CITY INSPECTOR.
- (B) Concrete shall be placed in a manner that will avoid segregation and shall not be dropped freely more than five feet (5'). If segregation occurs, the CITY ENGINEER may require the concrete to be removed and replaced at the CONTRACTOR's expense. Necessary hand spreading shall be done with shovels and not with rakes.
- (C) Concrete shall be thoroughly consolidated. All concrete shall be consolidated by internal vibration using mechanical vibrating equipment, except that concrete in floor slabs, sidewalks, or curb and gutter, not poured against form linings, shall be either tamped or vibrated. Care shall be taken in vibrating the concrete to vibrate only long enough to bring a continuous film of mortar to the surface. Vibration shall stop before any segregation of the concrete occurs. Mechanical vibrators shall be an approved type as specified in ACI Publication 309, Chapter 5. Vibrators shall not be used to move or spread the concrete. Any evidence of lack of consolidation or over consolidation will be regarded as sufficient reason to require the removal of the section involved and its replacement with new concrete at no cost to the CITY. The CONTRACTOR shall be responsible for any defects in the quality and appearance of the completed work.

7.20.05 Workability

The consistency of concrete shall be kept uniform for the approved work and shall be checked by means of a slump test. At all times, concrete shall have a consistency such that it can be worked into corners and angles of the forms and around joints, dowels, and tie bars by the construction methods which are being used without excessive spading, segregation, or undue accumulation of

water or laitance on the surface. If, through accident, intention, or error in mixing, any concrete that fails to conform to the proportions of the approved mix design, such concrete shall not be incorporated in the work but shall be discarded off the project site as waste material at no cost to the CITY.

Water is only allowed to be added upon delivery prior to discharge within forms or final placement. Water shall only be added up to the amount shown on the concrete ticket based on actual batch information as to not exceed the maximum water cement ratio per the approved mix design. Water will not be allowed to be added to concrete truck once discharging has commenced. Slump tests shall be run and test cylinders cast following the addition of the water. Any expense incurred in excess of ordinary tests will be borne by the CONTRACTOR.

7.20.06 Weather Restrictions

(A) Hot Weather:

Except by written authorization, concrete will not be placed if the temperature of the plastic concrete cannot be maintained at ninety degrees Fahrenheit (90°F) or lower. The placement of concrete in hot weather shall comply with ACI 305.

(B) Cold Weather:

During inclement weather conditions, placing of concrete will be permitted only when the temperature of the concrete placed in the forms will not be less than fifty degrees Fahrenheit (50°F), nor more than ninety degrees Fahrenheit (90°F). To maintain this temperature range, the SUBCONTRACTOR (supplier) shall provide acceptable heating apparatus for heating the aggregates and the water.

Concrete slabs shall not be placed, regardless of temperature conditions, if the supporting ground is frozen or contains frost. Use of salt or other additives to prevent concrete from freezing shall not be allowed. Concrete which has been frozen or failed to have adequate cold weather protection shall be completely removed and replaced as directed by and to the satisfaction of the CITY INSPECTOR.

Concrete may be placed when the air temperature in the shade is at least forty degrees Fahrenheit (40°F) and rising. No concrete shall be placed, regardless of the present temperature, when the weather forecast promises freezing weather before final set of the concrete unless special means of heating and protection are used. Protection against freezing is the CONTRACTOR's responsibility regardless of the weather forecast or climatic conditions at the time of placing.

During cold weather conditions, concrete less than seventy-two (72) hours old shall be protected at a minimum as follows. Maturity meters, to monitor and record time and pavement temperature, shall be installed at the time of placement when the air temperature is expected to fall below forty degrees Fahrenheit (40°F) during the next seventy-two (72) hours or as requested by the Inspector.

Potential methods of cold weather concrete protection include, but are not limited to: Additional layers of plastic or burlap, insulated blankets, heater enclosures, etc.

Cold weather concrete protection must remain in place until the concrete is at least seventy-two (72) hours cured. All finished surfaces shall be protected from defects or scars from cold weather protection.

7.20.07 Jointing

(A) Expansion Joints:

Expansion joint material shall be provided at the following locations and shall be in place prior to the placing of concrete:

1. Between new concrete and existing masonry buildings
2. As shown on the drawings
3. As directed by the CITY ENGINEER

(B) Contraction Joints:

Transverse joints shall be placed at maximum intervals of ten feet (10') to control random cracking. Joints shall be formed, sawed, or tooled to a minimum depth of one-third (1/3) of the total thickness, but no less than 1.5 inches, and shall be a maximum of one-quarter inch (1/4") wide. Tooled or formed joints shall include a rounded radius of one-quarter inch (1/4"). The CITY may require sawed joints based on the type and location of the project.

Contraction joints shall be placed as follows:

1. Not more than ten feet (10') nor less than six feet (6') apart in curb and gutter and combination curb-walk.
2. Not more than the walk width in non-monolithic concrete sidewalk.
3. At least two joints equally spaced at not greater than ten-foot (10') intervals as applicable in driveways.
4. Not more than ten feet (10') in concrete median cover material. Median cover joints shall match adjacent curb and gutter joints whenever possible.
5. As approved and shown on the plans for special concrete structures.

(C) Dowelled Construction Joints:

Construction joints between new and existing concrete, whether the existing concrete is part of the same project or not, shall include dowel bars. Dowel bars shall be epoxy coated and be formed or drilled and grouted into the existing concrete. The dowels shall be #4 bars spaced at eighteen inches (18") on-center or as directed by the Inspector.

(D) Bond-Breaker Joints:

A bond breaker joint consisting of polyethylene sheeting with a minimum thickness of 4 mils and maximum thickness of 6 mils shall be required around the perimeter of concrete median cover material where it contacts curb and gutter as shown in the Standard Details.

7.20.08 Finishing and Curing

In addition to the curing techniques unique to hot and cold weather placement, adequate attention shall be given to finishing and curing the fresh concrete. Exposed faces of curbs and sidewalks shall be finished to true line and grade, as shown on the plans. The surface shall be floated to a smooth, but not slippery, finish. **The addition of surface water or finishing agents to assist in the finishing process is prohibited.** Sidewalk and curb shall be broomed or combed and edged, unless otherwise indicated by the City Engineer. After completion of brooming and before concrete has taken its initial set, all edges in contact with the forms shall be tooled with an edger having a three-eighths-inch (3/8") radius. **No dusting or topping of the surface or sprinkling with water or finishing agents to facilitate finishing will be permitted.**

Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces cavities produced by form ties, honeycomb spots, broken corners or edges, and other defects shall either be thoroughly cleaned, moistened with water, and carefully pointed and trued with a mortar consisting of cement and fine aggregate or removed and replaced at the direction of the CITY ENGINEER. The surface shall be left sound, smooth, even, and uniform in color. Mortar used in pointing shall not be more than thirty (30) minutes old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

Fresh concrete shall be adequately protected from weather damage and mechanical injury during the curing periods. The selected curing process shall be started as soon as it can be done without injury to the concrete surface. The use of a membrane-curing compound is required. The following curing procedures may be used subject to the approval of the CITY ENGINEER.

(A) Liquid Curing Membrane:

Immediately after the surface water has disappeared from the concrete surface, the liquid membrane curing compound (white pigmented) shall be sprayed under pressure to the concrete surface at a rate not less than one (1) gallon per one-hundred-fifty (150) square feet with a spray nozzle, or nozzles, so it covers the entire pavement with a uniform water-impermeable film. Clear curing compound shall be used in the winter months of October to May and shall be placed under the direct supervisions of the CITY INSPECTOR. If the forms are removed within seven (7) days, the exposed sides and edges shall be sprayed in the above-described manner or the backfill completed immediately.

(B) Plastic Sheet Curing:

As soon after the completion of the finishing operation as the concrete has set sufficiently to prevent marring of the surface, the top surface and sides shall be entirely covered with plastic sheet materials. The plastic sheet as prepared for use shall have such dimensions that each unit as laid will extend beyond the edges of the concrete at least twice the thickness of the concrete. The units as used shall be lapped at least twelve inches (12"), and the laps of plastic sheet shall be secure such that they do not open up or separate. The plastic shall be placed and weighted so it remains in contact with the surface covered, curing the entire curing period of seven (7) days. The placement of plastic sheets shall not mar or leave defects in the concrete surface. Curing compound shall be applied to the

concrete within 24 hours. Plastic sheet curing will be allowed only during inclement weather as approved by the CITY INSPECTOR.

(C) Insulation Pad:

Insulation pads or other thermal devices may be used to protect concrete in cold weather.

(D) Wax base and resin base solutions shall not be used if linseed oil protection is to be applied to the concrete surface. If linseed oil protection is to be utilized, the method of curing shall be either linseed oil base curing compound, wet burlap, plastic sheet, or waterproof paper curing.

7.20.09 Testing of Concrete

The requirements of Table 7.20.01 shall apply to testing services for all concrete curb and gutter, sidewalk, slope paving, retaining walls, structures, and for all miscellaneous concrete testing. Testing for concrete pavement shall be in accordance with Table 7.20.02.

The CONTRACTOR shall furnish the concrete necessary for casting test cylinders. The number of cylinders and tests shall be as follows:

TABLE 7.20.01
Test Requirements for Curb and Gutter, Sidewalk, Slope Paving,
Retaining Walls, Structures and Miscellaneous Concrete

<u>Type of Test</u>	<u>Frequency</u>
Slump	1 per set of cylinders and as often as needed for quality control
Air Content	1 per set of cylinders and as often as needed for quality control
Yield and Cement Factor	1 per set of cylinders and as often as needed for quality control
Compressive Strength*	1 set of five (5) cylinders per 100 cubic yards or major fraction thereof on each day concrete is placed with standard breaks of the cylinders at: 2 @ 7 days, 2 @ 28 days and 1 held or as specified by the CITY INSPECTOR. Additional field cylinders may be required to determine early opening strength.

*Alternative compressive strength methods such as maturity meters shall be approved by the CITY ENGINEER in advance in writing.

TABLE 7.20.02
Test Requirements for Concrete Pavement

<u>Type of Test</u>	<u>Frequency</u>
Gradation (aggregate)	1 per 2500 sq. yard or fraction thereof for each size aggregate
Moisture Content, fine aggregate	1 per day or as often as needed for quality control
Moisture Content, coarse aggregate	1 per day minimum where moisture content is +0.5 percent from SSD condition
Slump	1 per set of cylinders and as often as needed for quality control
Air Content	1 per set of cylinders and as often as needed for quality control
Yield and Cement Factor	1 per set of cylinders and as often as needed for quality control
Compressive Strength	1 set of four (4) cylinders per 5000 sq. yards or major fraction thereof on each day pavement is placed, with two (2) cylinders to be field-cured. One additional set shall be made if the CONTRACTOR intends to open early for traffic
Thickness	1 per 1250 linear feet each traffic lane on freshly finished concrete and as often as needed for quality control

The degree and frequencies of all concrete testing beyond normal specified frequencies, if necessary to assure quality control, shall be determined by the CITY ENGINEER at the time of concrete construction. All concrete testing necessary shall be paid for by the CONTRACTOR/DEVELOPER.

7.20.10 Repairs

After stripping of the forms, if any concrete is found to be not formed as shown on the drawings or is out of alignment or level or shows a defective surface, it shall be considered as not conforming with the intent of these STANDARDS AND SPECIFICATIONS and shall be removed and replaced by the CONTRACTOR at his expense unless the CITY ENGINEER gives written permission to patch the defective area. In this case, patching shall be done as described in the following paragraphs. Defects that require replacement or repair are those that contain honeycomb, damage due to stripping of forms, loose pieces of concrete, bolt holes, tie-rod holes, uneven or excessive ridges at form joints, and bulges due to movement of the forms and other deficiencies noted in Section 10.40.06. Ridges and bulges shall be removed by grinding. Honeycombed and other defective concrete that does not affect the integrity of the structure shall be chipped out and the vacated areas shall be filled in a manner acceptable to the CITY ENGINEER. The repaired area shall be patched with a non-shrink, non-metallic grout with a minimum compressive strength of five thousand (5000) psi in twenty-eight (28) days. All repair areas treated with an epoxy bonding agent shall have the approval of the CITY ENGINEER before the repair filling is placed.

Bolt holes, tie-rod holes, and minor imperfections as approved by the CITY ENGINEER shall be filled with dry-patching mortar composed of one (1) part Portland cement to two (2) parts of regular concrete sand (volume measurement) and only enough water so that after the ingredients are mixed thoroughly the mortar will stick together on being molded. Mortar repairs shall be placed in layers and thoroughly compacted by suitable tools. Care shall be taken in filling rod and bolt holes so that the entire depth of the hole is completely filled with compacted mortar. The mortar mix proportions described above are approximate.

Those areas with excessive deficiencies as determined by the CITY INSPECTOR shall be removed and replaced at no cost to the CITY. Where repairs are made in existing sidewalks, all edges of the old sidewalk allowed to remain shall be saw-cut to a minimum depth of two inches (2"). No rough edges will be permitted where new construction joins the old section. Unless directed by the CITY INSPECTOR, no section less than five feet (5') in length shall be placed or left in place. Where new sidewalk construction abuts existing sidewalks, the work shall be accomplished so that there is no abrupt change in grade between the old section and the new work.

7.30.00 MATERIAL SPECIFICATIONS

7.31.00 CONCRETE MIX DESIGN

Concrete shall be classed according to CDOT Table 601-1. Project application of the different concrete classes shall be as follows:

Concrete Sidewalk	--	Class B
Concrete Curb and Gutter	--	Class B
Concrete Structures	--	Class D
Concrete Pavement	--	Class P
Precast Products	--	Refer to <u>Materials</u> Section of appropriate chapter

7.32.00 CONCRETE MATERIALS

Concrete shall be composed of Portland cement and aggregate and water and shall be reinforced with steel bars, steel strands, or steel-wire fabric where required. No admixture other than air-entraining agents shall be used without written permission of the CITY ENGINEER.

7.32.01 Cement

Portland Cement shall conform to the requirements of the following specifications for the type specified or permitted:

<u>Type</u>	<u>Specification</u>
Portland Cement, Type I, II, III	ASTM C 150, AASHTO M 85
Air-Entraining Portland Cement	AASHTO M 134
Fly Ash, Type C/F	ASTM C 618
Masonry Cement	AASHTO M 150

In general, Type II cement shall be used in concrete which will be in contact with the soil unless otherwise allowed or directed by the CITY ENGINEER. Unless otherwise permitted by the CITY ENGINEER, the product of only one (1) mill of any one brand and type of Portland cement shall be used on the project, except for reduction of any excessive air entrainment, where air-entrainment cement is used. The CONTRACTOR shall provide suitable means of storing and protecting the cement against dampness. Cement which for any reason has become partially set or

which contains lumps of caked cement shall be rejected. Cement salvaged from discarded or used bags shall not be used.

7.32.02 Aggregate

Aggregate for concrete shall be proportioned in conformance with Table 7.32.01 of these STANDARDS AND SPECIFICATIONS.

(A) Coarse Aggregate for concrete other than pavement:

The coarse aggregate shall consist of broken stone or gravel composed of clean, hard, tough, and durable stone and shall be free from soft, thin, elongated, or laminated pieces, disintegrated stone, clay, loam, vegetable, or other deleterious matter. Coarse aggregate for concrete shall conform to the requirements of AASHTO M 80, except that the percentage of wear shall not exceed forty-five (45) when tested in accordance with AASHTO T 96.

(B) Coarse Aggregate for concrete pavement:

Coarse aggregate shall conform to the requirement of AASHTO M 80, latest edition, except that the percentage of wear shall not exceed forty five (45) when tested in accordance with AASHTO T 96. Coarse aggregate shall conform to the grading in Table 7.38.01 for the grading specified in Table 6.77.04. Sizes 357 and 467 shall each be furnished in two separate sizes and combined in the plant in the proportions necessary to conform to the grading requirements. Size 357 is a combination of No. 3 and No. 57, and Size No. 467 is a combination of No. 4 and No. 67.

(C) Fine Aggregate for concrete other than pavement:

Fine aggregate shall be composed of clean, hard, durable, uncoated particles of sand, free from injurious amounts of clay, dust, soft or flaky particles, loam, shale, alkali, organic matter, or other deleterious matter. Fine aggregate shall be well-graded from course to fine and, when tested by means of laboratory sieves, shall meet the grading requirements of Table 7.38.01 of these STANDARDS AND SPECIFICATIONS.

(D) Fine Aggregate for concrete pavement:

Fine aggregate for shall conform to the requirements of AASHTO M 6, latest edition. The amount of deleterious substances removable by elutriation shall not exceed three percent (3%) by dry weight of fine aggregate when tested in accordance with AASHTO T 11 unless otherwise specified. The minimum sand equivalent, as tested in accordance with AASHTO T 176 shall be eighty (80) unless otherwise specified. The fineness modules shall not be less than 2.50 nor greater than 3.50 unless otherwise approved by the CITY ENGINEER.

TABLE 7.32.01
Concrete Aggregate Gradation Table
Percentages Passing Designated Sieves and Nominal Size Designation

Sieve Size	No. 3*	No. 4*	No. 6	No. 7	No. 8	No. 57*	No. 67*	No. 357*	No. 467*	AASHTO M6
	2" to 1"	1-1/2" to 3/4"	3/4" to 3/8"	1/2" to #4	3/8" to #8	1" to #4	3/4" to #4	2" to #4	1-1/2" to #4	#4 to #100
2-1/2"	100								100	
2"	90-100	100							95-100	
1-1/2"	35-70	90-100				100				
1"	0-15	20-55	100			95-100	100	35-70		
3/4"		0-15	90-100	100			90-100		35-70	
1/2"	0-5		20-55	90-100	100	25-60		10-30		
3/8"		0-5	0-15	40-70	85-100		20-55		10-30	100
#4			0-5	0-15	10-30	0-10	0-10	0-5	0-5	95-100
#8				0-5	0-10	0-5	0-5			
#16					0-5					45-80
#50										10-30
#100										2-10

* Additional primary gradings may be permitted when produced on the project provided the theoretical combination meets the specifications for combined aggregate sizes. Size No. 357 is a combination of No. 3 and No. 57. Size No. 467 is a combination of No. 4 and No.67

7.32.03 Water

Water used in mixing or curing shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetation, organic matter, or other substance injurious to the finished product. Water shall be tested in accordance with and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed to exclude silt, mud, grass, or other foreign materials.

7.32.04 Admixtures

The CONTRACTOR shall use air-entraining admixtures for all concrete that will have exposed surfaces. The CONTRACTOR may elect to use another admixture provided the admixture is specifically approved by the CITY ENGINEER. Documentary evidence of acceptability will be required when new or unknown admixtures are proposed for use. Air-entraining admixtures shall conform to the requirements of ASTM C 260.

Air-entraining admixtures for concrete pavement shall conform to the requirements of AASHTO M 154, latest edition, and ASTM C 260, latest edition.

Chemical admixtures, if permitted by the CITY ENGINEER for concrete, shall conform to the requirements of AASHTO M 194, latest edition.

Admixtures which have been frozen will be rejected.

7.32.05 Fly Ash

Fly ash for concrete, when permitted by the CITY ENGINEER, shall conform to the requirements of ASTM C 618, Table 1-A, latest edition, for Class C or Class F. (The

pozzolanic activity index shall be 85 for Class C and Class F, Fly Ash.) Class C fly ash will not be permitted where sulfate-resistant cement is required.

The CONTRACTOR shall notify the CITY ENGINEER of the source of fly ash for review before using in the project. The fly ash shall be subject to sampling and testing by agents of the CITY. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of fly ash until the necessary corrections have been taken to ensure that the material meets specifications. All costs associated with possible testing of fly ash by the CITY, which do not meet these specifications, shall be paid by the CONTRACTOR. The fly ash for use on the project shall have been tested by the CONTRACTOR for compliance with these specifications and submitted to the CITY ENGINEER for review prior to its use in the project.

7.33.00 REINFORCING STEEL

Reinforcing steel shall conform to the requirements of the following specifications:

- | | | |
|-----|---|--------------|
| (A) | Deformed and plain billet-steel bars for concrete reinforcement | ASTM A615 |
| (B) | Axle-steel deformed and plain bars for concrete reinforcement | ASTM A996 |
| (C) | Fabricated steel bar or rod mats for concrete reinforcement | ASTM A706 |
| (D) | Welded steel-wire fabric plain for concrete reinforcement | AASHTO M 55 |
| (E) | Welded deformed steel wire fabric for concrete reinforcement | AASHTO M 221 |
| (F) | Epoxy coated rebar | AASHTO A 775 |

Unless otherwise designated, bars conforming to ASTM A615 & ASTM A996 shall be furnished in Grade 60 for No. 5 bars and larger and Grade 40 or 60 for bars smaller than No. 5. In ASTM A184, bar material conforming to ASTM A616 will not be permitted.

7.34.00 CURING MATERIALS

7.34.01 General

- (A) Sheet materials for curing concrete shall conform to AASHTO M 171.
- (B) Burlap cloth made from Jute or Keaff shall conform to AASHTO M 182.
- (C) Straw used for curing shall consist of threshed straw or oats, barley, wheat, or rye. Clean field or marsh hay may be substituted when approved by the CITY ENGINEER. Old, dry straw or hay which breaks readily in the spreading process will not be permitted.

7.34.02 Liquid Curing Compound (Pigmented)

Liquid white-pigmented membrane-forming compounds shall conform to AASHTO M 148.

7.34.03 Liquid Curing Compound (Clear)

During the winter months of October to May, clear curing compound shall be utilized. The compound shall meet ASTM C 1315 Type I, Class A (clear, non-yellowing). The compound must be an acrylic copolymer type, non-freezing solvent based, with a minimum of 25% solids content. Compound must be VOC compliant in accordance with EPA 40 CFR Part 59. The final gloss appearance will serve as proof of application.

The CONTRACTOR shall use a sealer that when applied according to manufacturer's recommendations will not adversely affect the skid resistance of the pavement. The use of cure-sealer shall not be a substitute for best cold weather curing practices according to ACI 308.

7.35.00 FORM WORK

7.35.01 Forms for Structures, Curb and Sidewalks

Whenever necessary, forms shall be used to confine the concrete and shape it to the required lines. Forms shall have sufficient strength to withstand, without deformation, the pressure resulting from placement and vibration of the concrete. Forms shall be constructed so that the finished concrete will conform to the shapes, lines, grades, and dimensions indicated on the approved plans. Any form which is not clean and has not had the surface prepared with a commercial form oil that will effectively prevent bonding and that will stain or soften concrete surfaces shall not be used. Plywood forms, plastic coated plywood forms, or steel forms shall be used for all surfaces requiring forming which are exposed to view, whether inside or outside any structure. Forms shall be true and straight and free of any defects that would cause imperfections in the final surface. Surfaces against backfilled earth, interior surfaces, of covered channels, or other places permanently obscured from view may be formed with forms having substandard surfaces.

7.35.02 Removal of Forms

The forms for any portion of the structure shall not be removed until the concrete is strong enough to withstand damage when the forms are removed.

Unless specified in the plans, forms shall remain in place for members that resist dead load bending until concrete has reached a compressive strength of at least eighty percent (80%) of the required twenty-eight (28) day strength, $0.80f'_c$. Forms for columns shall remain in place until concrete has reached a compressive strength of at least one thousand (1,000) psi. Forms for sides of beams, walls or other members that do not resist dead load bending shall remain in place until concrete has reached a compressive strength of at least five hundred (500) psi.

Forms and supports for cast-in-place concrete box culverts (CBCs) shall not be removed until the concrete compressive strength exceeds $0.6f'_c$ for CBCs with spans up to and including twelve feet (12'), and $0.67f'_c$ for CBCs with spans exceeding twelve feet (12') but not larger than twenty feet (20'). Forms for CBCs with spans larger than twenty feet (20') shall not be removed until after all concrete has been placed in all spans and has attained a compressive strength of at least $0.80f'_c$. Backfill shall not occur until the top slab has attained a compressive strength of $1.0f'_c$.

Concrete compressive strength shall be determined by maturity meters in accordance with CDOT CP 69. At the Pre-Pour Conference, the CONTRACTOR shall submit the location where maturity meters will be placed.

The CONTRACTOR shall provide maturity meters and all necessary wires and connectors. The CONTRACTOR shall be responsible for the placement and maintenance of the maturity meter and wire. At a minimum a maturity meter shall be placed at the mid-span of beams and at support locations. Placement shall be as directed by the CITY ENGINEER.

For structures with multiple maturity meters, the lowest compressive strength shall determine when the forms can be removed.

Acceptance cylinders shall not be used for determining compressive strength to remove forms. When field operations are controlled by maturity meters, the removal of forms, supports and housing and the discontinuance of heating and curing may begin when the concrete is found to have the required compressive strength.

Forms for barrier, railing, or curbs may be removed at the convenience of the CONTRACTOR after the concrete has hardened.

All forms shall be removed except permanent steel bridge deck forms and forms used to support hollow abutments or hollow piers when no permanent access is available into the cells. When permanent access is provided into box girders, all interior forms, falsework, and loose material shall be removed, and the inside of box girders shall be cleaned with an industrial vacuum.

7.35.03 Forms for Concrete Pavement

Straight side forms shall be made of a metal having a thickness of not less than seven-thirty-seconds of an inch ($7/32''$) and shall be furnished in sections not less than ten feet (10') in length. Forms shall have a depth equal to the prescribed edge thickness of the concrete, without horizontal joint, and a base width equal to or greater than the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of one-hundred-foot (100') radius or less. Flexible or curved forms shall be of a design acceptable to the CITY ENGINEER. Forms shall be provided with adequate devices for secure setting so when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than two-thirds ($2/3$) the height of the form. Forms with battered top surfaces and bent, twisted, or broken forms shall be removed from the site. Repaired forms shall not be used until accepted by the CITY ENGINEER. Built-up forms shall not be used except where the total area of pavement of any specified thickness on the project is less than two thousand (2000) square yards. The top face of the form shall not vary from a true plane more than one-eighth inch ($1/8''$) in ten feet (10'), and the upstanding leg shall not vary more than one-quarter inch ($1/4''$). The forms shall contain provisions for locking the ends of abutting form sections together tightly and for secure setting.

Forms for bridge approach slabs or for pavement areas with irregular dimensions shall be made of metal or straight, sound timber. Forms shall be free from warp and of sufficient strength to resist springing out of shape. Forms shall be staked securely to line and grade to the satisfaction of the CITY ENGINEER. All mortar and dirt shall be removed from the forms that have been previously used.

Commercial quality, colorless mineral oil, free of kerosene and of a suitable viscosity, shall be used as form oil.

7.35.04 Slip-Formed Concrete Pavement

Slip-form paving equipment shall be equipped with traveling side forms of sufficient dimensions, shape, and strength to support the concrete pavement laterally for a sufficient length of time during placement to produce pavement of the required cross section.

No abrupt changes in longitudinal alignment of the pavement will be permitted. The horizontal deviation shall not exceed 0.04 foot from the designed alignment or as established by the CITY ENGINEER. All forms shall be cleaned thoroughly each time they are used and coated with a light oil as often as necessary to prevent the concrete pavement from adhering to them.

7.36.00 JOINTING MATERIAL

7.36.01 General Joint Materials

Joint materials will conform to specifications according to type as follows:

- | | | |
|-----|---|--------------|
| (A) | Concrete joint sealer, hot-poured elastic | AASHTO M 173 |
| (B) | Performed expansion joint filler
(bituminous type) | AASHTO M 33 |
| (C) | Performed expansion joint fillers (non-extruding and resilient bit) | AASHTO M 213 |
| (D) | Self-Leveling joint sealant
(Sika Concrete Sealer) | ASTM C920 |
| (E) | Bond-breaker joint
(plastic sheeting) | ASTM C171 |

7.36.02 Concrete Pavement Joint Materials

(A) Joint Sealing Compound:

Material for filling all types of pavement joints shall be a hot-poured elastomeric-type sealant specifically manufactured for sealing joints in concrete. The material shall not crack or break its bond when exposed to a temperature of zero degrees Fahrenheit (0°F). Joint sealing compounds shall meet the requirements of ASTM D 6690.

(B) Expansion Joints:

Expansion joint material shall be non-extruding and resilient bituminous types and shall conform to AASHTO M 213. The filler shall be furnished in a single piece for the depth and thickness required for the joint.

(C) Cold Joint Sealer:

Cold-applied joint sealer material for concrete slab joints shall conform to the requirements of ASTM D 5893 and be on the CDOT Approved Products List for concrete joint sealers.

(D) **Steel Spacers:**

Metal chairs used to support longitudinal, tie, or reinforcing bar shall be channel shaped, pressed out of sheet steel of not less than twelve (12) gauge (U.S. Standard) metal.

(E) **Dowel Baskets:**

Pre-formed, continuous dowel expansion joint material supports shall be eighteen (18) gauge (U.S. Standard) metal or three- (3) gauge wire chairs with ten- (10) gauge tie wires or heavier spaced no further than eighteen inches (18") along the axis of the expansion joint.

(F) **Expansion Tubes:**

Metal dowel caps or tubes shall be manufactured from thirty-two- (32) gauge sheet metal or heavier, shall not be less than five inches (5") in length, shall be indented to provide a limiting stop for the dowel bars, and shall provide unobstructed expansion space of not less than one inch (1") to permit movement of the dowel bar. The inside diameter shall be one-sixteenth inch (1/16") larger than the diameter of the specified dowel bars and the closed end shall be watertight. Caps made from bituminous-treated paper or other similar material shall not be used.

(G) **Epoxy:**

Epoxy used for bonding new or wet concrete to old concrete shall be an acceptable product and shall be of the type specifically intended for bonding wet concrete to existing concrete and shall be submitted to the CITY ENGINEER for review prior to use.

7.37.00 BATCHING AND MIXING

7.37.01 General

All concrete shall be thoroughly mixed in a batch mixer of an approved type and capacity for a period of not less than two (2) minutes after all the materials, including the water, have been placed in the drum. During the period of mixing, the drum shall be operated at the speed specified by the manufacturer of the equipment. The entire contents of the mixer shall be discharged before recharge, and the mixer shall be cleaned frequently. The concrete shall be mixed only in such quantities that are required for immediate use. No retempering of concrete will be permitted. Hand-mixed concrete will not be permitted except by written approval of the CITY ENGINEER and then in only very small quantities or in case of an emergency.

7.37.02 Proportioning the Mix

Proportioning the dry constituents of all concrete mixtures shall be accomplished by weighing. The supplier shall provide adequate and accurate scales for this work. There shall be no variance permitted in the minimum cement factor (sacks per cubic yard) as specified for the classes of concrete. The total quantity of mixing water per sack of cement, including free water in the aggregate, shall not exceed the minimum specified herein. The supplier shall be responsible for

developing the proper proportions of aggregates, cement, and water that will conform to the various requirements of these STANDARDS AND SPECIFICATIONS.

7.37.03 Ready-Mixed Concrete

The use of ready-mixed concrete in no way relieves the CONTRACTOR or DEVELOPER of the responsibility for proportion, mix, delivery, or placement of concrete. All concrete shall conform to all requirements of these STANDARDS AND SPECIFICATIONS and ASTM C 94 and AASHTO M 157.

The CITY shall have free access to the mixing plant at all times. 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 CITY 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) DOH mix design number
- (H) Type, brand, and amount of cement and fly ash
- (I) Brand and amount of any admixture
- (J) Weights of fine and coarse aggregates
- (K) Moisture content of fine and coarse aggregates
- (L) Gallons of batch water (including ice)
- (M) Gallons of water added by truck operator.
- (N) Allowable water to add

Provide the following titles with blank space to record information:

- (O) Discharge time
- (P) Water-cement ratio
- (Q) Air content
- (R) Slump
- (S) Revolutions