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500 DESCRIPTION

The work under this section includes the proportioning, batching, and placing of Portland Cement Concrete in accordance with these specifications and in conformity with the lines, grades, and dimensions as shown on the plans or established.

501 PORTLAND CEMENT CONCRETE

Concrete shall be manufactured, produced, delivered, tested, and placed in accordance with all current editions of the applicable ASTM, ACI, and AASHTO specifications unless expressly modified herein.

502 MATERIALS

Concrete shall be composed of cement, fly-ash supplementary cementitious material as needed for ASR mitigation and Class 2 sulfate resistance, fine and coarse aggregates, water, and chemical admixtures. The concrete shall meet the specifications for air-entrained Portland Cement (ASTM C-175 or C-595) and shall be Type IIA (Air-Entrained Cement). The materials are specified in the following sections. All sources of mined manufactured materials listed shall be approved annually by the City as having met the appropriate materials performance specifications. This approval is a condition of using those material sources for construction within the City right-of-way or for a City project.

502.1 Cementitious Materials

The total cementitious material shall be the minimum required to produce a 28-day compressive strength of 4,000 to 4,500 psi, depending on the usage, in accordance with the American Concrete Institutes (ACI) 301/(ACI) 318 specifications for the weathering region which the State of Colorado occupies. The range of total cementitious materials in a mix design shall be between 564 lbs. and 705 lbs, depending on usage.

502.2 Cement

Portland Cement shall conform to the current published specifications for ASTM C150 (Standard Specification for Portland Cement).

1. Type I, Type II, or Type V cements
2. Type I, Type II, or Type V low alkali cements (with a maximum alkali content of 0.6%)

Blended Portland Cement shall conform to the current published specifications for ASTM C595 (Standard Specification for Portland Cement).

1. Type IL - Portland-limestone cement
2. Type IP - Portland-pozzolan cement may only be used with the prior approval of the Project Engineer.

502.3 Fly Ash

Fly ash shall conform to the current published requirements of ASTM C 618, Class F (Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete). All chemical requirements of ASTM C 618 Table 1-A shall apply, except for footnote A.

Fly-ash/pozzolan/supplementary cementitious material shall be limited to a maximum of 20 percent by weight of total cementitious material, when used with Portland cement for ASR mitigation or Class 2 Sulfate Resistance, unless approved by City Engineering.

502.4 Water

Water for use in concrete shall be potable. Potable water shall not require chemical testing before use in concrete. Water from other sources shall be sampled and tested for chemical content before use in concrete, and shall be free from oils, acids, organic matter and other deleterious substances, and shall not contain more than 1,000 parts per



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million of chlorides (as CL) or more than 1,000 parts per million of sulfates (as SO₄). Tests shall be made in accordance with AASHTO T 26 (Standard Method of Test for Quality of Water to Be Used in Concrete).

502.5 Aggregates

The amounts and proportions of fine and coarse aggregates shall be such as to produce a plastic, workable mix which can be readily placed into the corners and angles of the forms and around reinforcement and other embedded fixtures without undue accumulation of water or laitance on the surface, and such that there will be no honeycombing in the structure after the concrete forms have been removed.

Proportions of fine and coarse aggregates shall be such that the ratio of the coarse to the fine aggregate shall not be less than one (1) nor more than two (2). Concrete aggregates shall consist of sand, gravel, crushed stone, or limestone. Aggregate particles shall be clean, hard, tough, durable, of uniform quality, and free of any soft, thin, or elongated pieces, disintegrated stone, dirt, organic or other injurious materials. All aggregate must be supplied from a source approved by City Engineering and shall be tested annually by an independent testing laboratory with its own independent certification in accordance with ASTM C 1077. Aggregate test results shall be no more than six months old at the time of a mix design submittal.

502.6 Fine Aggregates

Fine aggregate shall consist of durable particles of gravel, crushed stone, or combinations thereof. Aggregate shall be washed and free of frozen material, salt, alkalis, organic matter, or any other deleterious matter. Fine aggregates shall conform to the requirements of ASTM C-33 (Standard Specification for Concrete Aggregates) and adhere to the following:

Specific Gravity (Gsb) (ASTM C 128):	2.5 min
Absorption (ASTM C 128):	1.40% by weight or less.
Potential Alkali-Silica Reactivity:	less than 0.10% at 14 days in accordance with ASTM C 1260

In the event the fine aggregate has the potential for ASR Reactivity as measured per ASTM C 1260, the material shall be tested in accordance with ASTM C 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method). The materials tested shall adhere to the following:

Potential Alkali-Silica Reactivity:	less than 0.10% at 14 days in accordance with ASTM C 1567
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502.6.1 *Deleterious Substances*

The amount of deleterious substances in the washed fine aggregate shall not exceed the following values:

Deleterious Substance	ASTM	Max Percentage by mass
Sum of Clay Lumps, Friable Particles, and Chert	ASTM C 33	3.0%
Lightweight Particles	ASTM C 123	0.5%
Material Finer than 75-um (No. 200 sieve)	ASTM C 117	0.0 – 3.0% ^{1,2}
Coal and Lignite	ASTM C 123	0.5% - 1.0% ³
Degradation of Fine Aggregates Micro Deval	ASTM D 7428	15.0%
Sand Equivalent Value	ASTM D 2419	75 min
Sodium Sulfate Soundness (5 cycles) or Magnesium Sulfate Soundness	ASTM C 88	10.0% 15.0%
Organic Impurities in Fine Aggregate	ASTM C 40	Plate 3
Fineness Modulus	ASTM C 33	2.3 – 3.1



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- Note 1: For concrete not subject to abrasion, the limit for material finer than the 75- μ m (No. 200) sieve shall be 5.0 % maximum.
 Note 2: For manufactured fine or other recycled aggregate, if the material finer than the 75- μ m (No. 200) sieve consists of the dust of fracture, essentially free of clay or shale, this limit shall be 5% for concrete subject to abrasion, and 7% maximum for concrete not subject to abrasion.
 Note 3: Dependent on the importance of the concrete's appearance.
 Note 4: Aggregate tests results shall be completed within six (6) months old at the time of mix design submittal.

502.6.2 Grading

Fine aggregate shall be regularly graded from coarse to fine when test in accordance with ASTM C 136 and ASTM C117. The fine aggregate shall have not more than 45% passing any sieve and retained on the next consecutive sieve. The fine aggregate shall conform to the following requirements expressed as percentages by weight:

Sieve Size	Percent Passing
3/8"	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	5 - 30
No. 100	0 - 10
No. 200	0 - 3.0**

**Test results submitted shall be less than 1 month old at the time of mix design submittal.

502.7 Coarse Aggregate

Coarse aggregate shall consist of durable particles of gravel, crushed stone, or combinations thereof. Aggregate shall be washed and free of frozen material, salt, alkalis, organic matter, or any other deleterious matter, including wood. Wood or wood waste is defined as all material which, after drying to constant weight, has a specific gravity less than 1.0. Coarse aggregates shall conform to the requirements of ASTM C-33 (Standard Specification for Concrete Aggregates) and adhere to the following:

Specific Gravity (ASTM C 128)	2.6 min
Absorption (ASTM C 128):	1.40% by weight or less.
Potential Alkali-Silica Reactivity	less than 0.10% at 14 days in accordance with ASTM C 1260

In the event one or more of the coarse aggregate(s) has the potential for ASR Reactivity as measured per ASTM C 1260, the materials shall be tested in accordance with ASTM C 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method). The materials tested shall adhere to the following:

Potential Alkali-Silica Reactivity	less than 0.10% at 14 days in accordance with ASTM C 1567
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502.8 Combined Fine and Coarse Aggregates

In the event one or more of the fine/coarse aggregate(s), has the potential for ASR Reactivity as measured per ASTM C 1260, the fine and coarse aggregate materials shall be combined and tested in the same proportion(s) as those found in the submitted mix design, in accordance with ASTM C 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method). The combined materials tested shall adhere to the following:

Potential Alkali-Silica Reactivity	less than 0.10% at 14 days in accordance with ASTM C 1567
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502.8.1 Deleterious Substances

The quantity of deleterious substances in the coarse aggregate shall not exceed the following values:

Deleterious Substance	ASTM	Max Percentage by mass
Clay Lumps and Friable Particles	ASTM C 33	3.0%
Material Finer than 75-um (No. 200 sieve)	ASTM C 117	1.5%
Lightweight Pieces less than 2.40 specific gravity SSD	ASTM C 123	5.0%
L.A. Abrasion	ASTM C 131 or ASTM C 535 based on grading	50%
Sodium Sulfate Soundness (5 cycles) or Magnesium Sulfate Soundness	ASTM C 33	10% 15%

502.8.2 Grading

Coarse aggregate, when tested in conformity with ASTM C-136 and ASTM C 117, shall conform to one or more of the following gradations or as called for elsewhere in the specifications, special provisions, or on the plans.

Sieve size	Percent Passing or Test Requirement		
	Flat Work (Sidewalk, curb & gutter) No. 57	Median Cover No. 8	Structural No. 67
2 1/2"	-	-	--
2"	-	-	--
1 1/2"	100	-	--
1"	95 - 100	-	100
3/4"	--	100	90 - 100
1/2"	25 - 60	90 - 100	--
3/8"	--	40 - 70	25 - 55
No. 4	0 - 10	0 - 15	0 - 10
No. 8	0 - 5	0 - 5	0 - 5
No. 200	*1.0 MAX.	*1.0 MAX.	*1.0 MAX.

*This number may be increased to 1.5 maximum if the material is essentially free of clay or shale fines.

502.9 Admixtures

Admixtures for air entrainment, water reducers, or other uses shall be in a liquid state and conform to the requirements of ASTM C 260 (Standard Specifications for Air-Entraining Admixtures for Concrete) or ASTM C 494 (Standard Specification for Chemical Admixtures for Concrete).

502.9.1 Air-Entraining Admixtures

Air-entrainment is required for all concrete exposed to weather, de-icing agents, and within three feet of the ground surface.



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502.9.2 Accelerating Admixtures

Calcium Chloride may be used as an accelerating agent in amounts not to exceed 1.0% by total weight of cementitious materials with approval of the Engineer and shall not be used in reinforced concrete.

Non-Calcium Chloride may be used as an accelerating agent in amounts up to 2.0% by weight of cement in concrete flatwork, curb-and gutter, paving or structural applications. Amounts greater than 2.0% may only be used with approval of the Engineer.

502.9.3 Hydration Stabilizer/Set-Retarding Admixtures

Hydration stabilization/set-retarding admixtures may be added to an approved mix design when approved by City Engineering with the following documentation:

The manufacturer's Letter of Certification/Certificate of Compliance and/or Data Sheets which display the manufacturer's recommended dosage rate(s) of the admixture.

A letter/document signed or stamped by the product Manufacturer or the Concrete Mix Design Engineer approving the changes to the existing mix.

502.9.4 Fiber Reinforcement

When Fiber-Reinforced Concrete is specified, polyolefin fibers may be added to an approved mix design except when Macro Fiber-Reinforced Concrete is specified. When Macro-Reinforced Concrete is specified, a new trial mix will be required if the manufacturer's recommended dosage rate is exceeded.

When polyolefin fibers are added to an approved concrete mix design, the Contractor shall submit a letter/document signed or stamped by the Concrete Mix Design Engineer approving the changes.

The stamped letter shall include the following and will be reviewed and approved by City Engineering:

3. The mix design number
4. The brand and type of fiber reinforcement
5. The specified/recommended dosage of fiber reinforcement in pounds per cubic yard
6. Adjustments to the fine aggregate batch weight (if any)



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503 PROPORTIONING OF PORTLAND CEMENT CONCRETE

The proportions of materials to be used for mix designs and field placement shall produce a workable Portland Cement Concrete Mix having:

Concrete Class or Type	Trial Mix 28 day Compressive Strength	Required 28 day Field Compressive Strength	Cementitious Materials Content (minimum) (lbs/yd) ¹	W/C Materials Ratio (maximum)	Slump (inch) (maximum)	Air Entrainment (%)
	ASTM C 39 (psi)	ASTM C 39 (psi)		ASTM C 566	ASTM C 143	ASTM C 231
City Exterior Mix	5,000	4,000	564 to 705	0.45	Hand Placement 5" Max	5-8
					Machine Placement 2" Max	
City Structural Mix	5,500	4,500	564 to 705	0.45	3-5	5-8
City Median Mix	4,000	3,000	564 to 705	0.45	3-5	6-10

Note 1: Maximum cementitious material content shall be 705 lbs/cubic yard

504 TRIAL MIX DESIGN, PERFORMANCE HISTORY, AND AGGREGATES SUBMITTALS

The contractor shall submit a laboratory Trial Mix Design (proportions, material sources, and strength data), aggregate data, and certifications for cementitious materials and admixtures for each class of PCC being placed. The trial mix design test data shall show the mix design material sources and proportions, fresh concrete properties including slump, air content, and unit weight, water/cement ratio, and laboratory 7 and 28-day compressive strength results. *The laboratory Trial Mix Design proportions must produce at least 1,000 psi over-design compressive strength at 28 days.*

In lieu of laboratory Trial Mix Design data, a Field Performance History may be accepted as proof of potential for performance, provided it meets the strength criteria set forth in ACI 301 for acceptance of concrete mixes. Each Field Performance History shall include tested fresh properties (field strength, slump, air content, temperature, and unit weight) of the proposed concrete and shall establish the mix proportions and sources of all components.

Trial batches or Field Performance History shall be submitted annually by April 1st of each year.

Aggregate test data shall include gradations, minus No. 200, sand equivalent, fineness modulus, specific gravity, absorption, soundness, Alkali-Silica Reactivity (ASR), and LA abrasion.

Any aggregate tested by ASTM C 1260 with an expansion of 0.10 percent or more, or that is known to be reactive, shall not be used unless mitigated measures are included in the mix design.

ASTM C 1293 may be substituted for ASTM C 1260 test results. The ASTM C 1293 test shall be run on individual source of aggregate. The ASTM C 1293 test shall not use fly ash or slag as part of the cementitious material content.

Mitigative measures shall be tested using ASTM C 1567 and exhibit an expansion of less than 0.10 percent by one of the following methods:



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Combined Aggregates - The mix design source of aggregates, cement, and mitigated measures shall be tested. The proportions of aggregate, cement, and mitigative measures shall be those used in the mix design.

Individual Aggregates - Each source and size of individual aggregates shall be tested. The source of cement and mitigated measures shall be those used in the mix design. The highest level of mitigated measures for any individual aggregate shall be the minimum used in the mix design.

The supplier shall be responsible for the design mix proportions and subsequent adjustments necessary to produce the specified concrete.

A new trial mix design shall be submitted when changes occur in either the mix proportions, source, or type of cement, fly ash or aggregate, or failure of field tests to meet the specifications. All Trial Mix Designs or Performance Histories shall be stamped and dated by a Professional Engineer licensed in the State of Colorado. All such Designs or Histories shall be updated or re-confirmed each calendar year.

505 PRODUCTION AND DELIVERY

The production and delivery of ready-mixed concrete shall be such that placing and finishing shall be continuous in so far as the operations require.

505.1 Time of Haul

Concrete transportation in truck mixers or truck agitators shall be delivered to the site of work and discharge begun within a period of ninety (90) minutes after the cementitious material comes in contact with the mixing water or with the combined aggregates when the combined aggregates contain free moisture in excess of 2% by weight (herein after referred to as the "Batch Time"). The contractor may continue with concrete placement after the ninety (90) minute period has elapsed providing the concrete maintains its workability and plasticity. No water may be added to the concrete on-site after the ninety (90) minute period has elapsed and the w/c ratio shall be strictly enforced. The concrete must be completely discharged within a period of one hundred twenty (120) minutes of the Batch Time.

If during hot weather concrete placement the concrete arrives on-site with the temperature of the concrete above ninety degrees Fahrenheit (90° F), then the ninety (90) minute time identified above shall be reduced and concrete placement begun within a period of seventy-five (75) minutes. The contractor may continue with concrete placement after the seventy-five (75) minute period has elapsed providing the concrete maintains its workability and plasticity. No water may be added to the concrete on-site after the seventy-five (75) minute period has elapsed and the maximum w/c ratio shall be strictly enforced. The concrete must be completely discharged within a period of ninety (90) minutes of the Batch Time if the concrete temperature is above ninety degrees Fahrenheit (90° F).

In the event the concrete exhibits behavior consistent with "flash-setting," the concrete shall be rejected. Flash-setting can be identified as when the concrete mix is rapidly becoming rigid and losing plasticity and workability. Re-tempering the concrete with water has little to no effect, and the concrete is setting up and cannot be discharged from the mixer truck without difficulty.

505.2 Mixing and Placement

505.2.1 *Preparation of Equipment and Placing of Deposit*

Before any concrete is placed, all equipment for mixing and transporting the concrete shall be cleaned. All debris and ice shall be removed from the places occupied by the concrete.

505.2.2 *Conveying*

Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of materials. Concrete shall not free fall more than four (4) feet.



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Tremie, chuting, and pumping equipment shall be of such size and design as to insure a practically continuous flow of concrete at the delivery end without separation of materials.

505.2.3 Placing

Concrete shall be deposited in its final position to avoid segregation. Concrete shall be placed at such a rate as to always keep it in a plastic state. The practice of moving concrete from one point to another using vibrators is prohibited. Vibrators shall be used to consolidate the concrete, not to transport it.

No concrete that has partially hardened or been contaminated by foreign materials shall be deposited on the job site. All concrete shall be thoroughly consolidated during placement. It shall be thoroughly worked around reinforcement and embedded fixtures and into the corners of forms.

Concrete placed for vertical structures (walls) shall be placed in equal lifts (not to exceed 12 inches) around the structure. Concrete shall not freefall greater than four feet.

505.3 Cold Weather Placement

Concrete shall not be placed by free fall greater than four (4) feet and/or where there is greater than 3-inches of water. Cold Weather is defined by the current version of ACI 306R (Guide to Cold Weather Concreting) as a period of more than three successive days where the average daily outdoor temperature drops below 40 degrees F. The average daily temperature is determined by averaging the highest and lowest temperature during the day (midnight to midnight).

For placement of concrete during Cold Weather:

- Subgrade shall be unfrozen (above 32 degrees F), free of snow, ice, and standing water before placement. A temperature probe shall be inserted into the ground and left undisturbed for a minimum of 3 minutes prior to determining the temperature of the subgrade.
- The surface temperature of metal form work shall not be less than 35° F.
- Ambient Air Temperature shall be 35° F and rising, measure in the shade, prior to concrete placement.

Placing of concrete may be started in the morning when the temperature reaches 35° F and shall be discontinued at 3:00 p.m. of the same day if freezing weather is forecast for that evening.

During periods of cold weather, the contractor shall provide additional controls for concrete placement. The contractor shall submit a Cold Weather Concrete Plan to include the following:

- Procedure for protecting the subgrade from freezing, frost, and accumulation of ice and/or snow on forms and reinforcement.
- Concrete production and transportation modifications; including heating of the aggregate and/water.
- Method for maintaining temperatures between 50° to 80° F during placement and curing periods.
- Types of coverings, insulation, housing, and/or heating to be provided.
- Procedure for measuring and recording concrete temperatures during placement and curing period.
- Procedure for preventing drying and moisture loss during windy conditions.

The Cold Weather Concrete Plan (Plan) shall be submitted to and approved by the City Engineer prior to placing concrete in Cold Weather as defined above. This Plan can be provided once per season prior to temperatures dropping into the Cold Weather range. Any concrete placed in Cold Weather conditions prior to the Plan being submitted and approved shall be removed and replaced at the Contractor's expense regardless of compressive strength testing results.

The minimum temperature of concrete as placed and maintained during the production period shall be 55° F. The concrete surfaces will be enclosed and heated with artificial heat maintaining a minimum of 50° F and a maximum of 75° F until concrete has reached a compressive strength of 3,500 psi, based on the average of two field cure cylinders, unless otherwise approved by the project engineer.

All cold weather protection required to perform work shall not be paid for separately but shall be included in the unit price of the work being performed.

505.4 Hot Weather Placement

Hot weather is defined by ACI 305R-10 (Guide to Hot Weather Concreting), is any combination of the following conditions that impairs the quality of freshly mixed concrete or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results:

- High Ambient Temperature
- High Concrete Temperature
- Low Relative Humidity
- High Wind Speed
- Solar Radiation

505.4.1 *Ambient Air Temperature*

Concrete shall not be placed when the ambient air temperature is greater than 100° F.

505.4.2 *Concrete Temperature Control*

All concrete deposited in hot weather shall have the proper temperature control. The concrete temperature shall be between 50-89 degrees F.

In hot weather the Contractor may use ice or chilled water in the mixing water to reduce the temperature of the concrete in the mixer. There shall be no ice in the concrete when it is discharged from the mixer on site.

505.4.3 *Evaporation Reducers*

The contractor may use evaporation reducers to reduce moisture loss. Evaporation reducers are not a “finishing aid” and shall not be used as such. Finishing operations shall not be started until the evaporation reducers have dissipated so the liquid is not worked into the mortar during finishing operations.

505.4.4 *Curing and Protecting*

All concrete shall be cured/protected for a period of seven days. Concrete shall be kept moist for at least five days after placement. The curing medium used shall be applied to prevent checking and cracking of the finish surface of the concrete immediately after the finishing operation is completed, and it shall be maintained to prevent loss of water from the surface and edges of the concrete for the entire duration of the curing period. The contractor shall use one of the following methods:

505.4.5 *Burlap or Mat Curing*

Cotton mats or burlap (AASHTO M 182, Class 2) made from jute or kenaf weighting approximately 9 oz/sq.yd. (dry) shall be kept continuously (not periodically) moist for the duration of the curing period. After the forms are removed, the cotton mats or burlap shall be folded down over the back of the curb to subgrade. All mats or burlap covering material shall be approved by the Engineering.

505.4.6 *Curing Compounds*

If curing compounds are used, they shall be thoroughly agitated during use and shall be uniformly sprayed in a single coat and completely cover the concrete with no surface of the newly placed concrete exposed and visible (100 percent coverage – no gray concrete). Application shall be on all concrete surfaces at a rate not to exceed 150 square feet per gallon in place. Application shall be made as soon as all surface water sheen has disappeared from the concrete surface.

If concrete surfaces become partially dry, they shall be thoroughly moistened with water immediately, with a mister, prior to the application of the compound.



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If in the opinion of the Engineer pinholes exist, or the surface of the concrete is, in their opinion, exposed and not covered completely, a second coat shall be immediately applied at right angles to the first in the affected area. Under no circumstances shall curing compound be used on surfaces to which new concrete is to be bonded. All curing compounds shall conform to ASTM C-309.

If, at any time during the curing period any of the forms are removed, a coat of curing compound shall be applied immediately to the exposed surface.

Concrete curing compound shall be white for all “grey” concrete (ASTM C 309, Type 2, Class B) and clear curing/sealing compound shall be use for all colored concrete (ASTM C 309, Type 1). Clear cure shall not be applied to “grey” concrete.

506 INSPECTION AND TESTING

Concrete Form Inspections are required prior to placing concrete. This in no way relieves the Contractor of responsibility to construct work in accordance with the Contract Documents and/or Construction Drawings. It is the Contractor’s responsibility to complete the required work and to schedule inspections during normal working hours Monday through Friday. Any work that is approved by the Project Manager to be performed on Saturdays, Sundays, or holidays, shall be requested at least 48 hours in advance. This work can only occur if an inspector is available for those days requested. There is no guarantee of the inspector’s availability. It is the responsibility of the on-site representative/inspector to perform the necessary inspections and verify all party’s conformance with the specifications for a project.

It is the Contractor’s responsibility to adhere to the grade and line requirements set forth in the Contract Documents and/or Construction Drawings for all concrete installations. Inspection and approval of form work shall not relieve the Contractor from achieving these requirements. The Contractor shall be responsible for removing and replacing any work installed that does not meet the required line, grade, and specifications. There will be no additional payment for this removal and replacement work. It is recommended the Contractor’s personnel should have a two-foot smart level onsite to verify grades of all work being performed.

The City does not provide quality control for the contractor. It is the contractor’s responsibility to provide Process Control (PC).

506.1 Testing of Material

All concrete testing shall be performed by independently certified testing agencies/laboratories. Testing agencies/laboratories which perform testing services for the City of Colorado Springs shall be accredited in accordance with the current requirements of ASTM C1077 and shall not use the certification of their respective corporate branch or any affiliated organization to bypass this certification requirement. Ready-mix concrete suppliers shall be NRMCA Certified and possess a certification for each facility which provides concrete to the City of Colorado Springs.

All personnel performing concrete testing shall be ACI Concrete Field Testing Technician – Grade I certified. In the event an individual is not ACI Concrete Field Testing Technician – Grade I certified, this individual may perform this testing under the supervision and direction of an individual employed by the same organization, if the person supervising is ACI Concrete Field Testing Technician – Grade I certified, has at least one year of applicable experience, and is on-site at the time of testing.

Testing agencies/laboratories/ready-mix suppliers shall use the latest version of each referenced method, or the most recent version within one year of its publication. All testing equipment shall be in proper working order and satisfy the ASTM minimum requirements for each standard.

- All testing equipment shall be verified to be in proper working order before being placed in service on site.
- Slump testing equipment shall be clean and free of concrete on the interior of the slump cone. The apparatus shall be inspected annually. While on-site, if the apparatus appears dirty, damaged, or out of round, the apparatus shall be inspected and if it is out of compliance shall be removed from service.



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- Air Content testing equipment shall be clean and free of concrete on the interior of air pot. The dial gauge shall be clean, legible, and functioning properly, with the gauge needle moving freely and without hesitation when the air content is measured. If the apparatus appears dirty, damaged, or not working properly, the apparatus shall be inspected, tested for calibration, and if it is out of compliance, shall be removed from service unless it can be repaired/calibrated on site.
- Scales shall be independently certified/calibrated annually.
- Compressive strength testing machines shall be independently certified/calibrated annually.

506.2 Frequency of Testing

Portland Cement Concrete shall be tested in accordance with the table below, unless otherwise directed by the City Engineer.

Schedule of Minimum Sampling and Testing for each corresponding concrete test of material.

Description	Standards	Frequency
Air Content	ASTM C231	Minimum of once per day and/or every 50 cy
Slump	ASTM C 143	Minimum of once per day and/or every 50 cy
Temperature	ASTM C1064	Minimum of once per day and/or every 50 cy
Unit Weight	ASTM C138	Minimum of once per day and/or every 50 cy
Compressive Strength Testing	ASTM C 39	Minimum of once per day and/or every 50 cy

The City of Colorado Springs provides on-site Inspection and Owner Acceptance (OA) testing. This testing is not to be considered as PC testing. The contractor/supplier shall provide PC testing it shall be at the contractor's expense. All individuals/companies representing each party shall be certified in accordance with the requirements of this specification.

The contractor's/ready-mix supplier's PC can test the concrete prior to, or in conjunction with, the City's OA performing their test to verify compliance with the project's specifications. If the contractor or the ready-mix supplier elects not to perform PC testing, the City's OA test results shall determine on-site acceptance. When the PC and OA air content measurements differ by more than 0.5%, both the PC and OA air meters shall be checked (not calibrated) in accordance with ASTM C 231 using a 5.0% air void. If either air meter differs from the 5.0% reading by more than 0.3%, the air meter shall be removed from service unless it can be repaired/calibrated on site. The air content test results of the air meter found to be working properly and in accordance with this paragraph, shall be used for the concrete's acceptance. The City's on-site representative shall document all parties test results, deviations/out-of-specification occurrences.

The City's OA, at their discretion, may check the air content and slump any time after water or air content adjustments have been made to the load. All slump and air content adjustments shall be performed in accordance with ASTM C 94 specifications. After an adjustment has been made, the concrete load must be mixed at high-speed for a minimum of 30 revolutions. The City's Inspector may reduce the mixing evolutions at their discretion.

506.3 Strength of Feature

A minimum of four cylinders (4x8 inch cylinders) shall be cast for compressive strength testing in accordance with ASTM C31 (Standard Practice for Making and Curing Concrete Test Specimens in the Field). One cylinder shall be strength tested at the age seven days of curing time and three cylinders shall be strength tested at the age of 28 days of curing time. Compressive strength testing shall be in accordance with C39 (Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens).

In the event, the initial 28-day cylinder should not meet the required compressive strength, the remaining two cylinders shall be reserved, and strength tested after 56 days of curing time.



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If the 56-day cylinder(s) fail(s) to meet the required compressive strength, the associated concrete shall be removed and replaced at the contractor's expense.

Additionally, the strength and durability of the concrete will be considered deficient if any of the following conditions or a combination of the following conditions have been identified:

- The concrete failed to meet the required 28-day/56-day compressive strength requirements.
- Reinforcement does not conform to the specified requirements.
- Thickness, dimensions, or location differs from those specified in such a manner as to reduce strength.
- Concrete curing and protection of concrete against extremes of temperature during curing and not conforming to the requirements specified.
- Concrete has previously been subjected to damaging mechanical disturbances, load stresses, heavy shock, and excessive vibration prior to achieving the minimum strength requirements.
- Poor workmanship, which is likely to result in deficient strength of durability.

When there is evidence that the compressive strength of the concrete structure in-place does not satisfy the specification requirements, the contractor has the option to obtain concrete core samples drilled from the hardened concrete in question for compressive strength testing. Core samples shall be obtained in accordance with the current ASTM C42/C42M specifications as follows:

- A 3rd party testing agency, provided by the Contractor and not affiliated with the testing in question, shall be used to extract the core samples. The parties involved shall agree on the testing agency from the City's on-call list used to extract the core samples.
- Take at least three representative cores from each member or area of concrete-in-place that is considered potentially deficient. More cores may be taken to allow for additional testing. Location of cores will be determined by the City/Project Engineer.
- Test cores after moisture conditioning in accordance with ASTM C42/C42M if concrete they represent is more than superficially wet under service. Air dry cores, (60 to 80 degrees F with relative humidity less than 60 percent) for seven days before test and test dry if concrete they represent is dry under service conditions.
- Strength of cores from each member or area are considered satisfactory if their average is equal to or greater than 85 percent of the 28-day design compressive strength of the class of concrete.
- Fill core holes solid with concrete or an equivalent patching material and finish to match adjacent concrete surfaces.
- If the results of core tests indicate that the concrete compressive strength do not conform to the compressive strength specifications, the cost of such tests and restoration required must be borne by the contractor.

If there is evidence the testing agency/laboratory testing procedures and methods deviated from ASTM Standards, the test results and their effect on compressive strength shall be evaluated by all the parties involved with the project. A remediation/resolution plan shall be drafted by the parties involved for the concrete in question. A mitigation plan shall also be drafted to establish procedures to prevent future deviations from standard which can affect concrete strength performance.

507 PORTLAND CEMENT CONCRETE FLATWORK

507.1 General

This section of the specification provides for the operations and construction of concrete curbs, gutters, medians, curb ramps and sidewalks, and concrete pavement including cross pans and driveway approaches to be constructed within street right-of-way of the form and dimensions shown on the standard details.

The contractor shall mark sidewalks, curb, and gutter, every 100 feet, and every crossspan, driveway, and curb ramp by stamping their company name and the year of construction. The stamped letters shall be 1 inch high and ¼ inch deep.



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507.2 Earthwork

The subgrade shall be constructed true to the grade and cross section as shown on the plans or determined by the City. Subgrade shall be thoroughly moisture conditioned and compacted and meet the requirements of Section 200 and 300 of the City Standard Specifications.

All soft and yielding material shall be removed to a depth of not less than 12-inches and the resulting space filled with compacted earth, sand, gravel, or other City approved fill materials. Aggregates and fill materials not native to the soils in this region shall not be used as “fill” material to level the grade, without the approval/onus of the inspection staff.

The completed subgrade shall be tested for grade and cross section by means of a template extending the full depth and supported on the side forms.

The subgrade and forms shall be watered in advance of placing Portland Cement Concrete.

507.3 Materials

Materials shall conform to the applicable requirements of Section 500, Concrete.

507.4 Forms

Forms may be of metal or seasoned shiplap lumber. The depth of forms for curbs shall be equal to the full depth of the work prescribed.

Forms for concrete shall be used for all vertical surfaces, mortar type, true to required lines and grades, and of sufficient strength to maintain shape during the placing of the concrete and the mechanical finishing without springing or settling. Wood forms shall be two inch (2") (nominal) surfaced plant; metal forms shall be approved section and shall have a flat surface on the top of not less than one and three-quarter inches (1-3/4"). Warped forms and forms not having a smooth, straight upper edge shall not be used. Forms shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being used. Unit lengths of forms shall be jointed in advance of the point of placing concrete. Flexible, curved, or wood forms of the proper radii shall be used for curbs having a radius of less than two (200) hundred feet.

Forms shall be carefully set to alignment and grade and to conform to the dimensions required. Forms shall be held rigidly in place using pairs of steel stakes placed at intervals not to exceed three feet. If metal forms are used, steel stakes shall not be spaced more than six feet apart. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms.

Forms shall be equipped with not less than three staking points per 10-foot length with means for securely locking the form to each stake. Flange braces and staking pockets shall extend outward on the base not less than two-thirds (2/3) of the height of the form.

Forms shall not be removed until 12 to 24 hours after concrete placement.

507.5 Slip Forms

Slip-form equipment shall be equipped with traveling side forms of sufficient dimensions, shape, and strength to support laterally for a sufficient length of time during placement to produce the required cross section. No abrupt changes in longitudinal alignment will be permitted. The horizontal deviation shall not exceed ½ inch from the alignment. 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 from adhering to forms.

The subgrade and forms shall be watered in advance of placing Portland Cement Concrete.



SECTION 500 CONCRETE

507.6 Jointing

507.6.1 Expansion Joints - Expansion joints shall be installed when abutting existing concrete or fixed structure. Expansion joint material shall be ½-inch thick and shall extend the full depth of the contract surface and shall meet the requirements of ASTM D 1751 or 8139. The filler for the joint shall be furnished in a single piece for the full depth and width required for the joint. Expansion Joint shall be placed as follows:

- Curb and Gutter - at curb returns or at a maximum of every 100 ft. Expansion joints shall be constructed at right angles to the line of curb and gutter.
- Colored Patterned Concrete – where abutting adjacent concrete (curb) and at a maximum of 50 feet.
- Sidewalk - Maximum of every 100 ft. Expansion joints shall be constructed at right angles to the line of sidewalk.

507.6.2 Joint Sealing - Materials for sealing and for filling all joints and for filling pre-molded expansion joints shall be epoxy type joint seal. Sealing material shall be applied in strict accordance with the manufacturer's directions. All expansion joints shall be sealed.

507.6.3 Contraction Joints - Contraction joints shall be installed at intervals:

- Curb and Gutter shall not exceed ten feet (10') and shall be at least one and one-half (1-1/2") inch in depth.
- Colored Patterned Concrete shall not exceed ten feet (10') and shall be at least one and one-half (1-1/2") inch in depth.
- Sidewalks shall not to exceed five feet (5') and shall be at least one and one-half (1-1/2") inch in depth and shall be no wider than ¼ of an inch.

508 CURB AND GUTTER

General - Curb height shall be either six or eight-inches in height (above grade) and six-inches in width. Gutter pans shall be six-inches thick except for commercial driveway openings where the gutter shall be eight-inches. The curb head shall be transitioned for six or eight inches to 1 and 1/2" at driveway openings and shall be transitioned at curb openings.

Concrete City Exterior Mix

All concrete placed in Parks, or which will maintained by Parks Department, will contain fiber reinforcement.

Reinforcement - Curb and gutter shall be reinforced with reinforcing steel when greater than six inches thick.

Gutter Slope - The gutter in-slope shall be 6.25 percent except for curb cuts for curb ramps where the in-slope shall be five percent or less from PCR to PCR.

Placement and Finish

After placement of the concrete, the concrete shall be consolidated by mechanical vibration resulting in uniform concrete with no honeycomb. Concrete shall be brought to the proper elevation by striking-off the concrete with a straightedge spanning the forms. The combination curb and gutter shall be brought to the proper elevation by striking-off the concrete with a straightedge which spans the steel form templates. After the concrete has been struck-off the surface shall be floated with a wood or magnesium float, and edges worked with an edging tool. The final finish shall be a "medium" broomed surface with a medium to light-bristled broom. Steel trowels shall not be used on exterior flatwork. Immediately after final finishing, a curing compound shall be applied to the concrete surface at 100% coverage and in accordance with the City of Colorado Springs specifications, Section 500, "Curing Compounds," or the manufacturer's instructions and recommended rate of application, whichever is more stringent.

Broom marks shall be in the same direction as water flow for curbs and gutters. Float marks should not be visible in the final finish.



SECTION 500 CONCRETE

Asphalt Patching

Asphaltic Concrete Pavement or Asphalt Paving Material will not be placed adjacent to freshly placed concrete. Asphalt pavement material may be placed adjacent to curb and gutter five-days after placement or when the concrete has reached a minimum compressive strength of 3,200 psi.

Measurement

The quantity of curb and gutter measured for payment will be the number of linear feet along the base of the curb face or along the flow line of the gutter, and such measurements shall be continuous along such line extended across driveways and alley entrance returns.

Curb radius with square returns shall be poured with eight inches of reinforced concrete and measured as curb and gutter.

Transitions between types of curb and gutter shall be measured for both types of curb and gutter. Each type shall be measured to the midway point of the transition.

Curb and gutter through concrete cross pans, around plowable end sections, and across openings for pedestrian ramps shall be included in the measurement for payment.

Curb poured as part of a drainage structure, such as an inlet or curb opening, shall not be measured for payment and shall be included in the cost of the drainage structure.

509 COLORED PATTERNED CONCRETE

General - Colored Patterned concrete may be placed as median cover material or as indicator of a non-traversable surface adjacent to a curb ramps. Colored Patterned Concrete shall be a minimum of four-inches thick.

Per detail for Patterned Concrete Median Paving, the standard Color shall be “Springs Brown” 5 lbs/sack, “Durango Brown” 2.50 lbs/sack, “San Diego Buff” or an approved equivalent.

The standard pattern shall be running bond brick or an approved equivalent.

Other colors/patterns may be approved by City Engineering.

Concrete City Median Mix –
All concrete placed in City Parks, or which will be maintained by Parks Department will contain fiber reinforcement.

Slope - Median Cover use as a non-traversable surface shall have slopes exceeding three percent.

Median - The colored patterned concrete shall be domed and extend six inches above the top back of curb at the center and be a consistent curvature, unless approved by City Engineering.

Non-Traversable Surface - Shall be domed to indicate a non-traversable surface percent slope may vary.

Placement and Finish

After placement of the concrete, the concrete shall be consolidated by mechanical vibration resulting in uniform concrete with no honeycomb. Concrete shall be brought to the proper elevation by striking-off the concrete with a straightedge spanning the forms. Immediately after using the straight edge, the surface shall be floated with a wood or magnesium float, and edges worked with an approved edging tool. Finishing shall be accomplished without adding water to the surface. Excessive water, laitance, or other inert material shall be removed from the surface prior to finishing.

Just before the concrete takes its initial set, the surface shall be stamped with the approved pattern. No additional concrete shall be poured in one day than can be finished before dark, the same day.



SECTION 500 CONCRETE

Immediately after final finishing, a curing compound shall be applied to the concrete surface at 100% coverage and in accordance with the City of Colorado Springs specifications, Section 500, "Curing Compounds," or the manufacturer's instructions and recommended rate of application, whichever is more stringent.

Measurement

Stamped Concrete shall be measured by the square yard.

Areas designated as plowable end sections shall be included in the measurement for payment within the top backs of curb.

510 RAMPS (CURB, PARKING AND BIKE)

General - Curb Ramps and Bike Ramps shall be a minimum of six-inches thick.

Curb Ramps shall be a minimum of five feet in width. In no case shall the clear width of the curb ramp be less than 4-feet.

Bike Ramps shall be a minimum of three feet and be set at a 30-degree angle from the curb line.

Concrete City Exterior Mix –
All concrete placed in City Parks, or which will be maintained by Parks Department, will contain fiber reinforcement.

Slopes - Curb ramp slopes – Running slope of 8.33 or less and a cross slope of 2% or less.

Bike ramps – Must adhere to a cross slope of 2%

510.1 Parking and Curb Ramp

Curb ramps shall have maximum cross slope of two percent when measured perpendicular to the direction of pedestrian travel. Curb ramps shall have a maximum running slope of 8.33% (1 inch vertical per 12 inches horizontal). The counter slope of the gutter or street at the foot of the ramp run shall be five percent maximum. The maximum difference in grades between the curb ramp and the adjacent gutter pan shall be 13.3%. The transition between the two surfaces shall be flush.

Where applicable, turning spaces shall be provided with curb ramps and shall have a maximum cross slope and running slope of two percent.

Forms for curb ramp and turning space construction are recommended to be set with a cross slope of 1.5% to maintain the minimum and maximum tolerances. Forms for ramp construction are recommended to be set to a running slope of 7.5% so as not to exceed the maximum tolerance.

510.2 Bike Ramps

Bike ramps shall have a maximum cross slope of five percent when measured perpendicular to the direction of travel. Bike ramps shall have a maximum running slope of 15% unless otherwise approved by City Engineering.

Detectable Warnings:

Curb Ramps - Curb Ramp Detectable Warnings (Truncated Domes) shall be cast in place and extend a minimum of two feet in the direction of pedestrian travel and extend the entire width of the curb ramp. Detectable warnings for curb ramps shall be selected from the City Approved Product list.

Bicycle Ramps - Bike Ramp Detectable Warnings (Directional Bars) shall be placed at the top of the bike ramp. The warning shall extend a minimum of one foot into the bike ramp and extend the entire width of the bike ramp.



SECTION 500 CONCRETE

Parking Ramps - Parking Ramps Detectable Warnings (Directional Bars) shall be placed at the top of the parking ramp.

Opening: Curb, Parking and Bike Ramps shall not be opened to pedestrian traffic for at least 24 hours after placement.

Placement and Finish

After placement of the concrete, the concrete shall be consolidated by mechanical vibration resulting in uniform concrete with no honeycomb. Concrete shall be brought to the proper elevation by striking-off the concrete with a straightedge spanning the forms. The ramp shall be brought to the proper elevation by striking-off the concrete with a straightedge which spans the steel form templates. After the concrete has been struck-off the surface shall be floated with a wood or magnesium float, and edges worked with an approved edging tool. The final finish shall be a “medium” broomed surface with a medium to light-bristled broom. Steel trowels shall not be used on exterior flatwork. Immediately after final finishing, a curing compound shall be applied to the concrete surface at 100% coverage and in accordance with the City of Colorado Springs specifications, Section 500, “Curing Compounds,” or the manufacturer’s instructions and recommended rate of application, whichever is more stringent.

Broom marks shall be perpendicular to vehicular and pedestrian traffic. Float marks shall not be visible in the final finish.

Measurements

Concrete Ramps shall be measured by the square yard along the horizontal plane and shall include the areas of the flares and ramp between the joints at the top back of curb and top of ramp.

Detectable warnings shall be paid by the surface area of detectable warning installed and measured in square feet.

511 SIDEWALKS/MULTIUSE TRAILS

General - Sidewalks shall be four inches in thickness and a minimum five feet in width. Where a sidewalk crosses a residential driveway, it shall be a minimum of six-inches thick and where a sidewalk crosses a commercial driveway it shall be a minimum of eight-inches thick and be reinforced.

Multi-use trails shall be either six-inches thick or five-inches thick with fiber reinforcement and shall be a minimum of eight-feet wide.

Concrete City Exterior Mix –
All concrete placed in City Parks, or which will be maintained by Parks Department, will contain fiber reinforcement.

Reinforcement - Sidewalks shall be reinforced with reinforced steel when greater than six-inches thick.

Slope - Sidewalks and multiuse trails shall have a cross slope of 1-2 percent when measured perpendicular to the direction of pedestrian travel. Sidewalks and multiuse trails shall have a maximum running slope of street grade when install adjacent to the street or match the surrounding topography when not adjacent to a street.

Placement & Finish

After placement of the concrete, the concrete shall be consolidated by mechanical vibration resulting in uniform concrete with no honeycomb. Concrete shall be brought to the proper elevation by striking-off the concrete with a straightedge spanning the forms. The ramp shall be brought to the proper elevation by striking-off the concrete with a straightedge which spans the steel form templates. After the concrete has been struck-off the surface shall be floated with a wood or magnesium float, and edges worked with an approved edging tool. The final finish shall be a broomed surface with a medium to light-bristled broom. Steel trowels shall not be used on exterior flatwork. Immediately after final finishing, a curing compound shall be applied to the concrete surface at 100% coverage and in accordance with the City of Colorado Springs specifications, Section 500, “Curing Compounds,” or the manufacturer’s instructions and recommended rate of application, whichever is more stringent.



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Broom marks shall be perpendicular to vehicular and pedestrian traffic. Float marks should not be visible in the final finish.

Measurement

Concrete sidewalk (4 inch) shall be measured by the square yard placed.

512 CONCRETE PAVEMENT

Cross pans and Square Returns:

General - Cross pans shall be a minimum of six feet wide. Cross pans and square returns shall be a minimum of eight-inches thick and reinforced.

All concrete placed in Parks, or which will be maintained by Parks Department, will contain fiber reinforcement.

Square returns shall be placed on all corners where the radius is less than 15 feet.

Concrete City Structural Mix –
All concrete placed in City Parks, or which will be maintained by the Parks Department, will contain fiber reinforcement.

Asphalt Patching - Asphaltic Concrete Pavement or Asphalt Paving Material will not be placed adjacent to freshly placed concrete. Asphalt pavement material may be placed adjacent to curb and gutter five-days after placement or when the concrete has reached a minimum compressive strength of 3,200 psi.

Reinforcement - Cross pan and square returns shall be reinforced with a minimum of N0. 4 bar, Grade 60 placed at 18-inches on center, each way.

Slope - Cross pans shall be sloped from edge to the middle at the slope rate of ¼-inch per foot maximum (two percent).

Placement and Finish

After placement of the concrete, the concrete shall be consolidated by mechanical vibration resulting in uniform concrete with no honeycomb. Concrete shall be brought to the proper elevation by striking-off the concrete with a straightedge spanning the forms. The ramp shall be brought to the proper elevation by striking-off the concrete with a straightedge which spans the steel form templates. After the concrete has been struck-off the surface shall be floated with a wood or magnesium float, and edges worked with an edging tool. The final finish shall be a “medium” broomed surface with a medium to light-bristled broom. Steel trowels shall not be used on exterior flatwork. Immediately after final finishing, a curing compound shall be applied to the concrete surface at 100% coverage and in accordance with the City of Colorado Springs specifications, Section 500, “Curing Compounds,” or the manufacturer’s instructions and recommended rate of application, whichever is more stringent.

Broom marks shall be perpendicular to vehicular and pedestrian traffic. Float marks should not be visible in the final finish.

Patching

Asphaltic Concrete Pavement or Asphalt paving material will not be placed adjacent to freshly placed concrete. Asphalt pavement material may be placed adjacent to curb and gutter five-days after placement of when the concrete has reached a compressive strength of 3,200 psi.

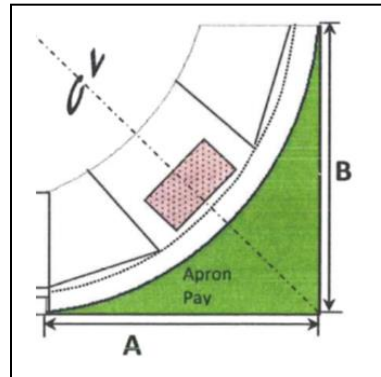
Measurement

Cross Pans: The quantity of cross pan measured for payment will be the number of square yards placed and accepted.

Square Returns: Squared Returns will be measured using the detail below and the formula for a spandrel or fillet.

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A=Square Return Edge Length
B= Square Return Edge Length
Formula= (A*B)*.215



513 DRIVEWAY APRONS

General - Residential Driveways shall be six-inches thick and not exceed 24-feet at opening to the street. Commercial driveways shall be eight-inches thick reinforced and not exceed 30-feet at the opening to the street.

Concrete City Structural Mix –
All concrete placed in City Parks, or which will be maintained by the Parks Department, will contain fiber reinforcement.

Reinforcement - Driveways greater than six-inches thick or designated a commercial driveway shall be reinforced.

Slope - Driveways shall have the following slopes:
Driveways 12% maximum

Measurement

Concrete Driveway Approach shall be measured by the square feet.

Payment

Curb and Gutter, Type___(Section X_)	LF
Gutter, Type___(Section)	LF
Colored Patterned Concrete	SQFT
Ramp, Type (Curb Ramp Type _)	SQFT
Sidewalk/Multiuse Trail	SQYD
Concrete Pavement, (Driveway Cross pan, etc.)	SQFT
Tactile Surface (Bike, Parking, or Curb Ramp)	SQFT