SECTION 500 - STREET AND PARKING FACILITIES CONSTRUCTION
TABLE OF CONTENTS

TABLES

DETAIL DRAWINGS

THIS PAGE IS A BLANK PLACEHOLDER FOR DOUBLE-SIDED PRINTING.

SECTION 500 - STREET AND PARKING FACILITIES CONSTRUCTION

501 GENERAL PROVISIONS

501.1 Purpose

This section contains minimum criteria to be met on newly designed and constructed public and private (open to general public) streets and parking lots in the City. Roadway design shall meet or exceed these Standards and Specifications. Policies and technical criteria not specifically addressed in this document shall follow the provisions of the American Association of State Highway and Transportation Officials (AASHTO), CDOT Standard Specifications for Road and Bridge Construction (CDOT S&S), Highway Capacity Manual, Manual on Uniform Traffic Control Devices (MUTCD), and the Colorado Department of Transportation's Standard Plans ("M-Standards"). Improvements shall also be in conformance with the Development Code.

502 DESIGN CRITERIA

502.1 Geometric Cross Section

A. Street cross sectional elements shall conform to the detail drawing as determined by the Development Engineering Manager. Collector and arterial streets shall be constructed whenever the alignment of the proposed street is generally the same as the collector and arterial streets shown on the Comprehensive Plan, Transportation Plan, or whenever a traffic engineering analysis of the future traffic volumes indicates the need of a cross section greater than that of a local residential street. These cross sections can be found in Details 500-1 through 500-4.

B. Additional ROW may be required to satisfy other criteria contained in these Standards and Specifications. Areas outside the ROW shall be contour graded, compacted, and sloped, as required for proper drainage, soil stability, and maintenance accessibility.

502.2 Curb Radii

Curb radii criteria for various intersections are listed on Table 500-1:

TABLE 500–1
CURB RADII CRITERIA

Classification	Major Arterial	Minor Arterial	Collector	Local
Major Arterial	45 feet	45 feet	45 feet	N/A
Minor Arterial	45 feet	40 feet	35 feet	N/A
Collector	45 feet	35 feet	30 feet	25 feet
Local	N/A	N/A	25 feet	20 feet

502.3 Horizontal Alignment

Streets shall intersect or connect to other streets at right angles, and intersections shall be constructed so that lanes are not offset through the intersection. If a street approaching another street is at an oblique angle, then the design shall have the intersecting streets at right angles for 100 linear feet from the intersecting flowlines. Horizontal and vertical alignment and ROW limits shall be coordinated so as not to obstruct sight distance at intersections, in accordance with City Code.

502.4 Street Design Criteria

Street design criteria for various street types are listed on Table 500-2. The requirements of the City of Thornton Development Code, the City Transportation Plan, and the City's Comprehensive Plan shall be adhered to.

TABLE 500-2
STREET DESIGN CRITERIA

Design Element	Major Arterial	Minor Arterial / Parkway Collector	Major& Minor Collectors****		Local Streets	Parking Lots & Private Streets
Cross Section	Refer to Details 500-1 through 500-4					N/A
Street Light Spacing*	150' (+/- 50')	150' (+/- 50')	200' (+/- 40)		200' (+/- 40')	
Right & Left Turn Lanes***	Required at all accesses along arterials. May be required at accesses along collectors but shall be determined at time of development by the Development Engineering Manager. Minimum dimensions: 150' storage, 100' taper, with the exception of arterial/arterial intersections which shall be design to accommodate 200' storage and 100' taper.**					
Cross Slope without Super Elevation	Maximum 4% - Minimum 2%					Max 4% – Min 1%
Maximum Curb Line Grade Break without Vertical Curve	1% at Curb Returns, 0.5% at Other Locations					1%
Super Elevation Maximum	4%	4%	4%		N/A	N/A
Minimum Degree Curve	7 (820'R)	8.5 (675'R)	Minor 10 (575' R)	Major 22 (260'R)	38.2 (150' R)	N/A
Maximum Street Grade	5%	5%	5%	7%	7%	7%
Minimum Street Grade	0.75%	0.75%	0.75%		0.75%	.75%
Maximum Grade at Intersection	2% for 400'	2% for 300'	3% for 300'	4% for 150'	4% for 50'	4% for 50% when approaching ROW
Tangents between Horizontal Curves	500'	400'	300'	150'	N/A	N/A
Design Speed	50	45	40	35	30	N/A
Posted Speed	45	40	35	30	25	N/A
K-Values Sag Crest	 96 84	 79 61	 64 44	 37 19	 37 19	N/A

* A photometric design is required to be submitted for street lights. Spacing indicated is per same side of the roadway.

** Turn lanes shall be designed to have the larger of either the 95 %ile queue utilizing the long range future scenario as required in the Traffic Impact Analysis, or the requirements of Table 500-2. Refer to Section 100 for all Traffic Impact Analysis requirements.

*** Turn lanes should be avoided on curves.

**** Major collector designation shall be utilized if there will be commercial development on both sides, or the roadway connects several developments.

502.5 Cul-De-Sacs – Details 500-6 & 500-7

A. Hammerhead cul-de-sacs, as shown in Detail 500-7, require approval of the Development Engineering Manager. Lengths of cul-de-sacs are required to be no greater than 500 feet.

B. Surface drainage shall be directed toward the intersecting street, or if this is not reasonably practical, a drainage structure and 20 foot easement shall be provided at the end of the cul-de-sac.

502.6 Requirements of Improvements Adjacent to Existing Roadways

A. Where proposed street construction will widen existing roadways or add a right turn lane, then the following requirements shall apply:

1. Existing cross slope of adjacent lanes shall be maintained. Where this is not possible, the change in cross slope for the new lane shall not exceed 2.0%.

2. The removal limits shall be sawcut in a clean straight line and shall not be in the traveled wheel path.

3. The entire adjacent lane along the new improvements shall be roto-milled two (2) inches and overlayed with the final lift of the new improvements. Geosynthetic fabric may be required at the joint to prevent the pavements from reflective cracking.

4. A geotechnical investigation shall be conducted on all roadways adjacent to the development to evaluate the condition of the asphalt. The investigation shall consist of borings or other suitable method of sampling, at spacing of no more than 250 feet unless otherwise accepted by the Development Engineering Manager. The results of this investigation shall be submitted to the City for determination of what, if any, existing asphalt may be utilized to meet the requirements of the Developer's Agreement.

502.7 Off-Site Design

A. The design grade, and existing ground at that design grade, of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued in the same plan and profile as the proposed design for at least three hundred feet (300') or to its intersection with an arterial roadway.

B. If the off-site roadway adjacent to the proposed development is not fully improved, the Responsible Party is responsible for the design and construction of a transition for the safe conveyance of traffic from the improved section to the existing roadway. The following formula shall be applied to the taper of lane change necessary for this transition:

For roadways with speeds less than 45 mph:

$L = WS^2/60$

For roadways greater than or equal to 45 mph:

$L=WS$

Where:

L = Length of Transition in Feed
W = Width of Offset in Feet
S = Posted Speed Limit

C. Type 4 object markers shall be accompanied by a "future street extension" sign for the entire cross section of the roadways if it is planned for the street to be continued in the future.

503 PAVEMENT DESIGN ANALYSIS

503.1 General

This subsection provides the basic criteria and design procedure for roadway pavements. Recommended design methodologies for asphalt and Portland cement concrete are addressed and essentially follow the CDOT and AASHTO methodology. Some standardization of criteria has been made in design procedures.

503.2 Minimum Pavement Section

The following table provides the minimum acceptable pavement sections for each roadway classification. Final pavement designs shall be based on subgrade support test results.

TABLE 500-3
MINIMUM ACCEPTABLE PAVEMENT SECTIONS

Classification	Composite Section Asphalt Inches	 Roadbase Inches	Full Depth Asphalt Inches	Portland Cement Concrete Inches
1-Local,Private streets and parking lots	4	6	5	6
2-Collector A-Minor B-Major	 5 5	 6 7	 5 6	 6 7
3-Minor Arterial	7	11	8	8
4-Major Arterial	7	12	9	8
5 – Emergency Access Only	4	6	5	6

503.3 Pavement Design Reports

A. Prior to any roadway construction, the Responsible Party shall provide a pavement design report that recommends typical pavement structural sections based on the known site soil conditions. The report shall consist of the following:

B. The report shall be prepared by or under the supervision of and signed by a PE registered in the State of Colorado and shall include the following information:

1. Vicinity map to locate the investigated area.

2. Scaled drawings showing the location of borings.

3. Scaled drawings showing the estimated extent of subgrade soil types and EDLA/ESAL for each street.

4. Pavement design alternatives for each street on a scaled drawing.

5. Tabular listing of sample designation, sample depth, Group Number, Liquid Limit, Plasticity Index, % passing the No. 200 sieve, Group Index, Unified and AASHTO Classification, and soil description.

6. Proctor Compaction Curves.

7. Subgrade support testing of each soil type used in the design. (see 503.6.(c))

8. Pavement design computer printouts or nomographs properly drawn to show soil support, EDLA/ESAL, and structural number.

9. Design calculations. Include for all phases of project.

10. Design coefficient used for asphalt, base course, etc.

11. A discussion regarding potential subgrade soil problems including, but not limited to:

    a. Heave or settlement prone soils,

    b. Frost susceptible soils,

    c. Ground water,

    d. Drainage considerations (surface and subsurface),

    e. Cold weather construction (if appropriate), and

f. Other factors, properties, or fill areas which could affect the design or performance of the pavement system.

12. Recommendations to alleviate or mitigate the impact of problems discussed in item 11 above.

503.4 Equivalent 18 Kip Daily Load Applications (EDLA) / Equivalent Single Axle Load (ESAL)

The pavement design procedure in this chapter provides for a 20 year service life of pavement, given that normal maintenance is provided to keep the roadway surface in an acceptable condition. EDLA/ESAL and design traffic number (DTN) are considered equivalent units based on 20 year design criteria and an 18 kip axle loading. Data is based on the EDLA/ESAL units for pavement loading repetitions. EDLA/ESAL criteria for each roadway classification are given in Table 500-4.

TABLE 500-4
EDLA/ESAL Criteria

CLASSIFICATION	CLASS MODIFIER	EDLAVALUES (1)	ESALVALUES
Local	All Others	10	73,000
Collector	MinorMajor	50 75	365,000 547,500
Minor Arterial	All	465	3,394,500
Major Arterial	All	620	4,526,000

Alternatively higher EDLA/ESAL values may be considered with justification provided by the Traffic Impact Study, proposed land uses, and traffic analysis that defines proportion of truck vehicles.

503.5 Design Serviceability and Reliability

TABLE 500-5
SERVICEABILITY/RELIABILITY INDEX

Roadway Classification	SI	R
Arterials (minor, major)	2.5	90
Collectors		
Major	2.5	85
Minor	2.0	85
Local	2.0	75

503.6. Subgrade Investigation Requirements

A. Field Investigation

The geotechnical investigation shall consist of borings or other suitable method of sampling subgrade soils to a depth of at least five (5) feet below proposed subgrade elevation, with a 10 foot boring every third hole, at spacings of no more than 250 feet unless otherwise accepted by the Development Engineering Manager. Samples shall be taken after grading is completed and the subgrade is rough cut.

B. Classification Testing

Each subgrade sample shall be tested to determine liquid limit, plastic limit, plasticity index and the %age passing the U.S. Standard No. 200 sieve. Samples of sands and gravels may require gradation analysis for classification determination. These data shall be determined using the following methods:

Liquid Limit - AASHTO T 89
Plastic Limit - AASHTO T 90
% Passing No.200 - AASHTO T II
Gradation - AASHTO T 27

The results of these tests shall be used to calculate the AASHTO Classification and Group Index using AASHTO M 145.

C. Subgrade Support Testing

1. Individual subgrade samples shall be tested to determine the subgrade support value using Hveem Stabilimeter (R-value), or California Bearing Ratio (CBR) and Unconfined Compressive Strength (Qu) testing, or direct measurement of resilient modulus of soil AASHTO T-307. These values shall be used in the design of pavement sections in accordance with the procedures outlined below. Tests shall be conducted in accordance with this procedure.

2. R-Value Tests - Hveem Stabilimeter tests shall be conducted in accordance with AASHTO T 190. The design R-value shall be at 300 psi exudation pressure. The reported data shall consist of:

   a. Dry density and moisture content for each sample.

   b. Expansion pressure for each sample.

   c. Exudation Pressure - corrected R-value curve showing the 300 psi design R-value.

3. CBR Tests: California Bearing Ratio Tests shall be conducted in accordance with AASHTO T193 with the following modifications:

   a. Note 4 of AASHTO T193 shall not apply. A 3-point CBR evaluation is required.

   b. The compaction method used for the CBR test shall be determined by the soil classification.

   c. Surcharge shall be calculated using a unit weight of 140 pcf for HMA and 135 pcf for ABC.

   d. The design CBR value shall be determined from the CBR dry density curve and shall be the CBR value at 95 % compaction.

   e. In addition to the values requested in AASHTO T193 Stress Penetration curves for each sample, a CBR dry density curve and Proctor compaction test results shall be reported.

503.7 Pavement Design Procedures

A. Flexible Pavements

1. The following procedure should be used in determining the Structural Number (SN) of the pavement being designed:

   a. Determine roadway classification and corresponding EDLA/ESAL (Table 500-4)

   b. Determine the Serviceability Index (SI) of the roadway classification (Table 500-5)

   c. Determine the reliability (R) of the roadway classification (Table 500-5)

   d. Approved proper nomographs

   e. Determine the required structural number using AASHTO pavement design software or nomographs from AASHTO or CDOT along with soil support test results and EDLA/ESAL values previously determined. If used, copies of the nomograph determinations must be included with the design submittal.

   f. Once the Structural Number (SN) has been determined, the design thicknesses of the pavement structure can be determined by the general equation:

      SN = a(1)D(1) + a(2)D(2) + a(3)D(3) + ...

      where

      A(1), Aa(2), Aa(3), Aa(n) = strength coefficients

      D(1),D(2),D(3),D(n) = thickness of pavement component sections

      The strength coefficients for various components of the pavement structure are given in Table 500-6.

   g. The component thickness selected must meet two (2) conditions:

      i. Total thickness selected cannot be less than the minimum specified in Table 500-1 for the roadway classification.

ii. The base course thickness selected cannot exceed two and one-half (2.5) times the asphalt thickness selected in Table 500-3.

h. Pavement section calculations shall be rounded up to the next thickness one-half (½) -inch increment.

i. The standard deviation for design of asphalt pavements shall be 0.44

j. The design must reference any mitigation measures required when the subgrade contains swelling soils. Design reports recommending alternative methods or materials to address swelling soils (i.e. base course, lime, cement, etc) must present the measures to be used to ensure adequate drainage of such layers and to maintain separation of the layers from the swelling soils. Swell tests shall be conducted for samples with probable expansion (volume change estimate) greater than two (2)% based on actual tests. Surcharge pressure shall be 150 psf, or as specified by the Development Engineering Manager.

k. Alternative methods and materials shall be approved specifically in writing by the Development Engineering Manager prior to any construction of the roadway. With this approval, Table 500-6 shall be utilized for appropriate strength coefficients. Also, if approved in writing, minimum design requirements for composite sections can be found in Table 500-3.

B. Rigid Pavement

1. Rigid pavements are those that possess a high bending resistance and distribute loads over a large area of foundation soil. Examples include Portland cement concrete pavement or Portland cement concrete surfaced with asphalt. Rigid pavement shall only be utilized as specifically authorized by the Development Engineering Manager.

2. The design of rigid pavements is a function of support characteristics of the subgrade soil (R-value, CBR, or resilient modulus), traffic (EDLA/ESAL), and the strength of the concrete (working stress). In comparison to the strength of the concrete slab, the structural contributions of underlying layers to the capacity of the pavement are relatively insignificant. Therefore, the use of thick bases or subgrades under concrete pavement to achieve greater structural capacity is considered to be uneconomical and is not recommended.

3. Use the following procedure to obtain required thickness:

a. Determine roadway classification and corresponding EDLA/ESAL (Table 500-4).

b. Determine design Serviceability Index (SI) of the roadway (Table 500-5).

c. The working stress of the concrete (F_t) used in the design shall be 75% of that provided by third-point beam loading, which shall have a minimum laboratory 28-day strength of 600 psi based on actual tests of materials to be used .

d. The reliability factor for design of all concrete pavements shall be 90%.

e. The standard deviation for design of concrete pavements shall be between 0.30 and 0.40.

f. Determine the structural numbers using AASHTO pavement design software. Nomographs of the AASHTO or CDOT parameters may be used instead. If used, copies of the nomograph determinations must be included with the design submittal.

f. Using EDLA/ESAL and working stress data, locate point on the pivot line; connect this point to the R-value or CBR value on the soil support scale to determine slab thickness.

g. Use slab thickness from step f. (rounded upward to the nearest one-half (1/2) inch) or the minimum thickness from Table 500-5.

h. For swelling soils (swell potential greater than two (2)%, under 200 psf surcharge pressure) concrete paving shall not be permitted without subgrade treatment.

i. Pavement joint detail plans. With rigid pavement designs, the construction plans shall include a joint pattern layout for each street, alley or intersection. All joints and joint filling in rigid pavements shall be designed and detailed in accordance with the current CDOT M&S Standards.

TABLE 500-6
STRENGTH COEFFICIENTS

Pavement Component	Strength Coefficients	(Limiting Test Criteria)
Conventional Materials		
Hot Mix Asphalt	0.44	(Rt 90+)
Aggregate Base Course	0.14	(CBR 80+ or R 78+)
Granular Subgrade Course	0.07	(CBR 15+ or R 50+)
Recycled Asphalt/Concrete Pavement Subgrade Course	0.07	(CBR 15+ or R 50+)
Treated Materials		
Cement Treated Aggregate Base	0.23	(7 day 650-1000 psi) *
Lime Treated Subgrade	0.14	(7 day, 160 psi, PI <6) *

* 100 degree moist oven

504 HOT MIX ASPHALT (HMA)

504.1 General

A. The intent of this section is to specify materials and methods to be used for the construction, overlaying, seal coating and pavement rejuvenating of streets, parking lots, walks, and other miscellaneous work requiring the use of aggregates. The work covered shall include general requirements that are applicable to aggregate base course, bituminous base and pavements of the plant mix type, bituminous prime coat, bituminous tack coat, rejuvenating applications, and asphalt concrete overlay. Workmanship and material shall be in accordance with requirements of these Standards and Specifications and in conformity with the lines, grades, depths, quantity requirements, and the typical cross section shown on the plans or as directed by the Development Engineering Manager.

B. These specifications include general requirements applicable to all types of plant mixed hot mix asphalt (HMA). Also included are requirements for Stone Matrix Asphalt (SMA). Reference to HMA shall also mean SMA is Included. This work consists of one (1) or more courses of asphalt mixture constructed on a prepared foundation in accordance with specifications. The design intent is to provide pavement with adequate thickness and quality to provide a serviceable life of at least 20 years. It is also the intent to provide construction in accordance with these specifications with a high standard of practice. This item shall include all labor, equipment, and materials to manufacture, place and compact asphaltic concrete for pavement purposes.

C. TEST PROCEDURE DEFINITIONS

1. CP-## Colorado Department of Transportation: Field Materials Manual (Colorado Testing Procedures)
2. ASTM American Society for Testing & Materials
3. AASHTO American Association of State Highway & Transportation Officials
4. CP-L #### Colorado Department of Transportation: Laboratory Manual of Test Procedures (Lab Testing Procedures)

D. When references to both an AASHTO and either a CP or CP-L and test procedure are given, CP or CP-L shall be used, unless the Development Engineering Manager has stipulated to ONLY use and require AASHTO test procedures

504.2 Materials

A. Pavement shall be hot mix asphalt plant mix type unless otherwise approved in writing by the Development Engineering Manager. Materials and construction shall be in accordance with the CDOT S&S, Section 403, and the following requirements:

1. The hot mix asphalt shall be composed of a mixture of aggregate, filler, hydrated lime and asphalt binder. Some mixes may require polymer modified asphalt binder. Some mixes may allow up to 20%

reclaimed asphalt pavement (RAP) as approved by the Development Engineering Manager. All RAP introduced shall meet the requirements of section 504.2 F. Stone Mastic Asphalt (SMA) mixtures are to be used in the top lift only, and are required at intersections per Detail 500-16.

2. Experimental materials such as Warm Mix Asphalt shall be approached as a variance and is subject to the approval of the Development Engineering Manager.

NOTE: SMA specifications are adapted from the CDOT S&S and incorporated throughout other sections of this specification.

B. Aggregate

Aggregates for HMA shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. Excess of fine material shall be wasted before crushing. The material shall not contain clay balls, vegetable matter, or other deleterious substances and shall meet the following requirements:

TABLE 500-7
AGGREGATE PROPERTIES

Aggregate Test Property	Coarse: Retained on #4	Fine: Passing the #4
Fine Aggregate Angularity, CP-L 5113 Method A or AASHTO T 304 Note: Fine aggregate angularity does not apply to RAP aggregates		45% Min
Two Fractured Faces, CP-45 or ASTM D 5821 SG Mixtures Top and Middle Lifts Bottom Lifts SMA Mixtures	 90% Min. 80% Min. 70% Min. 100% required	
LA Abrasion, AASHTO T 96	45% Max.	
Flat and Elongated (Ratio 5:1) %, AASHTO M 283	10% Max.	
Adherent Coating (Dry Sieving) ASTM D 5711	0.5% Max.	
Sand Equivalent. AASHTO-T 176		45% Min.
Micro Deval CP-L 4211 or AASHTO T 327	18% Max	

1. Reclaimed Asphalt Pavement material (RAP) shall be used only where specifically allowed and shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. Mixes shall not contain more than 25% RAP.

2. The Proposed Design Job Mix Formula (PDJMF) gradation shall be wholly within the control point gradation range set forth in the following applicable Table 500-7 for dense graded mix designs or Table 500-8 for Stone Matrix Asphalt (SMA). The Allowable Job Mix Formula (AJMF) gradation for production shall be the PDJMF gradation with the tolerances of section 504.14 B. applied. The PDJMF and the final AJMF gradation for production shall report all sieve sizes listed in the applicable Table 500-7 or Table 500-8.

3. Mineral filler for the Stone Matrix Asphalt pavement shall be limestone dust and shall meet the requirements of this subsection and have a maximum Plasticity Index (AASHTO T90) of four (4)%.

4. The Responsible Party shall submit hydrometer analysis (AASHTO T88) for the gradation of mineral filler used in the SMA mixture.

TABLE 500-8
DENSE GRADED HMA GRADATION RANGE
(% by Weight Passing Square Mesh Sieves, CP-31, AASHTO T 11 & T 27)

Mixture Grading	SX (1/2" nominal)		S (3/4" nominal)		SG (1" nominal)	
Sieve Size	Control Points	Caution Zone*	Control Points	Caution Zone*	Control Points	Caution Zone*
11/2"					100	
1"			100		90-100	
3/4"	100		90-100		@	
1/2"	90-100		@		@	
3/8"	@		@		@	
#4	@		@		@	39.5
#8	28-58	39.1	23-49	34.6	19-45	26.8-30.8
#16	@	25.6-31.6	@	22.3-28.3	@	18.1-24.1
#30	@	19.1-23.1	@	16.7-20.7	@	13.6-17.6
#50	@	15.5	@	13.7	@	11.4
#200**	2.0-8.0		2.0-7.0		1.0-7.0	

* The caution zone is a guideline only. It is recommended that mix design gradations go above the caution zone boundaries, on the "fine" side.
** These limits shall include the required one (1)% of lime by weight.
@ These sieve sizes used only to determine the final Allowable Job Mix Formula (JMF) in accordance with Section 500.

TABLE 500-9
SMA AGGREGATE GRADATION RANGE PROPERTIES
(% by Weight Passing Square Mesh Sieves, CP-31, AASHTO T 11 & T 27)
(Ref: CDOT Table 703-5)

Sieve Size	Stone Mastic Grading Designation (% by Weight Passing Square Mesh Sieves)			
	#4 Nominal	3/8" Nominal	½" Nominal	¾" Nominal
1"				100
3/4"			100	90-100
1/2"	100	100	90-100	50-88
3/8"	100	90-100	50-80	25-60
#4	90-100	26-60	20-35	20-28
#8	28-65	20-28	16-24	16-24
#16	22-36			
#30	18-28	12-18	12-18	12-18
#50	15-22	10-15		
#200	12-15	8-12	8-11	8-11

C. Performance Graded Asphalt Binders

1. The Responsible Party shall provide to the Development Engineering Manager acceptable 'Certifications of Compliance' of each applicable asphalt binder grade from the supplier. Upon non-conformance with the specifications, the asphalt binder may be rejected as directed by the Development Engineering Manager. When production begins, the Responsible Party shall, upon request, provide to the Development Engineering Manager a one (1) quart can of each specified asphalt binder. Additionally, when requested, the Responsible Party shall provide the refinery test results that pertain to the asphalt binders used during production.

2. Asphalt binder shall meet the requirements of the Superpave Performance-Graded Binders (PG) as presented in Table 500-10 below.

TABLE 500-10
PROPERTIES OF PERFORMANCE GRADED BINDERS

Usage for each Binder Grade	PG 58-28	PG 64-22	PG 76-28
Traffic Loading, Total 18 kip ESALs Over Design Life (Usually 20 Years)***	Low Volume (0-100,000)	100,000 to <10.0 Million	3.0 Million to <10 Million
Superpave Compactor Design gyrations Recommended Usage	N_{design} = 50	N_{design} = 75	N_{design} = 100
Property of Binder Grade	PG 58-28	PG 64-22	PG 76-28
Flash Point Temperature, ºC, AASHTO T 48	230 Min.	230 Min.	230 Min.
Viscosity at 135 ºC, Pas, ASTM D 4402	3 Max.	3 Max.	3 Max.
Dynamic Shear, Temperature ºC, where C*/Sin δ @ 10 rad/sec. ≥ 1.00 Kpa, AASHTO TP 5	58 º C	64 º C	76 º C
Rolling Thin Film Oven Residue Properties, AASHTO T 240			
Mass Loss, %, AASHTO T 240	1.00 Max.	1.00 Max.	1.00 Max.
Dynamic Shear, Temperature ºC, where G*/Sin δ @ 10 rad/sec. ≥ 2.20 Kpa, AASHTO TP 5	58 º C	64 º C	76 º C
Elastic Recovery1, 25°C, % Min.*	N/A	N/A	50 Min.
Pressure Aging Vessel Residue Properties, Aging Temperature 100 ºC AASHTO PP1			
Dynamic Shear, Temperature ºC, where G*/Sin δ @ 10 rad/sec. ≤ 5,000 Kpa, AASHTO TP 5	19 º C	25 º C	28 º C
Creep Stiffness, @ 60 sec. Test Temperature in ºC, AASHTO TP 1	-18 º C	-12 º C	-18 º C
S, Mpa, AASHTO TP 1	300 Max.	300 Max.	300 Max.
m-value, AASHTO TP 1	0.300 Min.	0.300 Min.	0.300 Min.
**Direct Tension Temperature in ºC, @ 1.0 mm/min., Where Failure Strain >1.0%, AASHTO TP 3	-18 º C	-12 º C	-18 º C

* Elastic Recovery by Task Force 31, Appendix B Method.
** Direct tension measurements are required when needed to show conformance to AASHTO MP.1.
*** Development Engineering Manager is to determine PG Binder.
*** Use PG Binder 76-28 for all Major Arterial surface course.

D. Additives – Hydrated Lime**.**

Lime shall be added at the rate of one (1)% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve. Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C 207, Type N. In addition, the residue retained on a 200-mesh sieve shall not exceed 10% when determined in accordance with ASTM C 110. Drying of the test residue in an atmosphere free from carbon dioxide will not be required.

E. Tack Coat

When tack coat is specified on the plans or required by the Development Engineering Manager, the materials and construction shall be in accordance with the requirements of the CDOT S&S, Section 702. The emulsified asphalt, for Tack Coat shall be CSS-1h or SS-1h and conform to AASHTO M208 or M140.

F. Reclaimed Asphalt Pavement

1. Reclaimed Asphalt Pavement (RAP) may be allowed in the HMA mixture by the Development Engineering Manager. It shall be of uniform quality and gradation with a maximum size particle no greater than the maximum size allowed in the HMA mixture. HMA mixtures containing RAP shall meet the same gradation requirements as a virgin HMA mix. The Development Engineering Manager may allow mixtures with a maximum of 25% RAP of any HMA pavement. RAP is not allowed in Stone Mastic Asphalt Mixtures, except by agreement by the Development Engineering Manager.

2. The reclaimed asphalt pavement shall meet all the requirements for HMA pavement, as contained herein. The Responsible Party shall have an approved mix design for the amount of RAP to be used prior to placement.

3. The Development Engineering Manager may require the Responsible Party to maintain separate stockpiles for each type of RAP material. All processed material shall be free of foreign materials and segregation shall be minimized. Any RAP material that cannot be readily broken down in the mixing process, and/or affects the paving operation, shall be processed prior to mixing with the virgin material.

4. Fine Aggregate Angularity requirements shall not apply to any RAP aggregate. The RAP will not contain clay balls, vegetable matter, or other deleterious substances.

5. Verification testing for asphalt content and gradation will be performed on RAP at the frequencies listed in section 504.2 G, below. The Development Engineering Manager may request the mix supplier's testing results on RAP at any time. In addition, the mixture shall be tested for properties as listed in Table 500-10

6. When the use of RAP is allowed, the following additional conditions shall apply:

a) The processed RAP must be 100% passing the one and one-fourth inch (1¼) inch sieve. The aggregate obtained from the processed RAP shall be 100% passing the one (1) inch sieve. The aggregate and binder obtained from the processed RAP shall be uniform in all the measured parameters in accordance with the following schedule:

TABLE 500-11
RAP AGGREGATE UNIFORMITY TOLERANCES

Element	Uniformity*
Binder Content	0.5
% Passing ¾"	4.0
% Passing ½"	4.0
% Passing 3/8"	4.0
%Passing #4	4.0
% Passing #8	4.0
% Passing #30	3.0
% Passing #200	1.5

* Uniformity is the Maximum allowable Standard Deviation of test results of processed RAP.

b. The Responsible Party shall have an approved RAP Quality Control (QC) Plan that details how the RAP will be processed and controlled. The QC plan must address the following:

i. RAP Processing Techniques. This requires a schematic diagram and narrative that explains the processing (crushing, screening, and rejecting) and stockpile operation for normal plant operation or a specific project.

ii. Control of RAP Asphalt Binder Content: - Minimum Testing Frequency: 1/1,000 tons of processed RAP material (minimum 3 tests) for recent production of the mix type.

iii. Control of RAP Gradation (CP31 or AASHTO T-30): Minimum Testing Frequency: 1/1,000 tons of processed RAP material (minimum 3 tests) for recent production of the mix type.

iv. Process Control Charts shall be maintained for binder content and each screen listed, during addition of any RAP material to the stockpile. The Responsible Party shall maintain separate control charts for each RAP stockpile. The control charts shall be displayed and shall be made available to the Development Engineering Manager upon request.

G. Example of RAP QUALITY CONTROL PLAN

1. Initial quality control of the reclaimed asphalt pavement shall be performed prior to and during crushing. Material for reclamation shall be separated by quality and source before being accepted for processing. Reclaimed asphalt must be free of concrete, dirt and organic materials. These stockpiles shall be built from the ground up, completely mixing all loads as they come in.

2. Crushing of the reclaimed asphalt pavement shall be accomplished by means of a cone crusher and a screen deck. Oversize material shall be rejected on a three-fourths (¾) inch scalping material, which reprocesses the material through the cone additional times. The processed material shall be stockpiled at the crushing facility and kept in separate piles and separate from other products to prevent intermingling of products, as well as the feed bins to prevent intermingling of the aggregates.

3. The reclaimed asphalt pavement material shall be sampled during the crushing operations according to AASHTO T 2 at frequencies greater than 1/1000 tons and tested for gradation and asphalt content in accordance with AASHTO T 27 AND T11, and AASHTO T 308. Testing shall be done randomly on a daily basis to ensure conformance to specifications.

4. The reclaimed asphalt pavement material at the asphalt plant shall be again sampled and tested according to the appropriate procedures to ensure that the asphalt content and gradation meet specifications and represent initial quality control data. Once data is collected, a statistical analysis shall be performed to determine the blend for the asphalt mixture design. This analysis shall be provided with the Asphalt Mixture Design submittal. The RAP will meet the Uniformity Specification of Table 500-11 above.

5. The RAP system at the asphalt plant consists of a feed bin with a variable speed motor controlled by the plant computer, which ensures the proper quantity of RAP material called for by the mix design. Material is delivered to the asphalt-mixing chamber of the asphalt plant by means of conveyor belts. The RAP material falls from one conveyor to another through a shaker screen that serves to break up any RAP material that has recompacted. Any oversize material shall be rejected at the shaker screen. While in production, the front-end loader shall works the full face of the stockpile, to ensure a representative batch is being produced.

6. Prior to starting a project and at any other time necessary, the RAP feed system shall be calibrated by placing an amount of RAP measured by certified external scales into the feed bin. That measured material is fed from the RAP bin across the belt scales. The weights are compared and, if outside of accepted tolerances for the blending system, adjustments are made by the plant-blending computer. This process is the same for all other components of the mix design.

504.3 Mix Design and Plant Produced Mixture Requirements

The mix design materials shall be those listed in Section 504.3 and used for the project. No substitutions are allowed during production, unless approved by the Development Engineering Manager.

The Responsible Party shall indicate on Detail 500-19 the project specific criteria concerning mix design method, traffic level, asphalt binder type, mixture grading, and maximum amount of RAP allowed. This information shall be provided on Detail 500-19, or other construction documents.

Grading SG (1-inch nominal aggregate) shall only be designed using the 150 mm Superpave molds. Hveem Stability and Lottman test are not required for Grading SG mixtures. Grading S and SX shall be designed using 100 mm Superpave molds.

A. Superpave Mixture Design Method

1. The Responsible Party shall submit a Proposed Design Job Mix Formula (PDJMF) for each mixture required by the Contract. The mixture design shall be determined using AASHTO T-312 or Colorado Procedure CP-L 5115 for the Superpave Method of Mixture Design. Guidance is provided in "Superpave Level 1 Mix Design" SP-2 published by the Asphalt Institute. Mixture design and field control testing shall meet the following requirements of Table 500-12 for Dense Graded HMA.

2. Mixture design and field control testing of SMA shall meet the following requirements of Table 500-12.

TABLE 500-12
SUPERPAVE MIXTURE PROPERTIES FOR DENSE GRADED HMA

Property or Test	Traffic Levels (ESALs)		
Traffic Loading, Total 18 kip ESALs Over Design Life (Usually 20 Years)	Low (0-100,000)	Medium (100,000 to <3.0 Million)	High (3.0 Million to <30 Million)
Design gyrations, N_{design} (Air Void: 3.5% to 4.5%) (See Note 1,2)	50	75	100
Air Voids in Total Mix (VTM) CPL 5115 or AASHTO T 312	(See Note 1)	(See Note 1)	(See Note 1)
Hveem Stability CP-L 5106 or AASHTO T 246 (Grading S & SX only) (See Note 3)	N/A	28 Min.	30 Min.
Voids Filled with Asphalt (VFA), MS-2	70-80	65-78	65-75
Lottman, Tensile Strength Ratio, % Retained, CP-L 5109 or AASHTO T 283, Method B	80 Min.	80 Min.	80 Min.
Lottman, CP-L 5109 or AASHTO T 283 Dry Tensile Strength, psi	30 Min.	30 Min.	30 Min.
VMA %. CP-48 or AASHTO PP 19 (See notes 2,3,4)	Minimum VMA criteria applies to the mix design only (Table 500-7). The minimum VMA criteria shall be linearly interpolated based on actual air voids. See 504.14 B for production tolerances		

Note 1: Select the target Job Mix Optimum Binder Content for HMA gradings as close to 4.0% air voids as possible (3.5% to 4.5% air voids). VTM is also referred to as Pax in CPL 5115, and %Gmmx in T 312
Note 2: Maximum Theoretical Specific Gravity of mix by CP-51 or AASHTO T 209.
Note 3: Refer to Section 504.13 B for production tolerances.
Note 4: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (CP-L 5103 or AASHTO T 166) and Aggregate (AASHTO T 84 & T 85), and calculated according to CP-48 or AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 500-14, below.

TABLE 500-13
SUPERPAVE MIXTURE PROPERTIES FOR OPEN GRADED SMA

Property	Test Method	Value for SMA
Lab compaction (Revolutions) N_{Design}	CPL 5115 or AASHTO T 312	100
Air Voids, % at: N_{Design} (See Note 1)	AASHTO T 312	3.0 – 4.0
Hveem Stability	CP-L 5106 or AASHTO T 246	30 Min.
Accelerated Moisture Susceptibility, tensile strength Ratio, (Lottman)	CPL 5109 or AASHTO T 283, Method B	80 Min.
Dry Split Tensile Strength, psi	CPL 5109 or AASHTO T 283, Method B	30 Min.
Grade of Asphalt Binder	n/a	PG 76-28
Voids in the Mineral Aggregate (VMA) %, minimum (see note 2)	CP 48 or AASHTO PP 19	17
Draindown at Production Temperature	AASHTO T 305	0.3 maximum
% VCA_{MIX} (See Note 3)	AASHTO PP 41-02	Less than VCA_{DRC} (See Note 4)

General Note: Copies of AASHTO PP 41-02 and MP 8-02 (for designing SMA mixes) can be obtained from the CDOT Region Materials or the Development Engineering Manager.

Note 1: Select the target Job Mix Optimum Binder Content for SMA grading at 3.0% to 4.0% air voids.

Note 2: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (CP-L 5103 or AASHTO T-166) and Aggregate (AASHTO T 84 & T 85), and calculated according to CP-48 or AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 500-14, below.

TABLE 500-14
MINIMUM VOIDS IN MINERAL AGGREGATE (VMA) for Dense Graded HMA & Open Graded SMA, %

Nominal Maximum* Particle Size	Air Voids **		
	3.5%	4.0%	4.5%
1"	12.2	12.7	13.2
¾"	13.2	13.7	14.2
½"	14.2	14.7	15.2
SMA	17.0	17.0	17.0

* Nominal Maximum Particle Size is defined as one (1) sieve size larger than the first sieve to retain more than 10%, but shall not exceed the 100% passing size. The Nominal Maximum Particle Size can vary during mix production even when the 100% passing size is constant.

** Minimum VMA criteria apply to the mix design only. The minimum VMA criteria shall be linearly interpolated based on actual air voids. See Section 504.14 for tolerances.

504.4 Mix Design Submittals

A. General Requirements

1. The Responsible Party shall submit all mixture designs, Certificates of Compliance, and laboratory data to the Development Engineering Manager for approval at least seven (7) calendar days before construction is to begin. The mix design (Proposed Design Job Mix) must be approved by the Development Engineering Manager prior to the start of construction.

2. Mixture designs shall be performed in a materials laboratory under the direct supervision of and shall be stamped and signed by a Professional Engineer licensed in the State of Colorado and practicing in this field. In addition, the Responsible Party shall submit, as part of the mixture design, laboratory data documents to verify the following:

   a. Source of materials.

   b. Gradation, specific gravity, source and description of individual aggregates and the final blend.

   c. Aggregate physical properties.

   d. Source and Grade of the Performance Graded Binder (PG Binder).

   e. Proposed Design Job Mix: aggregate and additive blending, final gradation shown on 0.45 power graph, optimum asphalt content.

   f. Mixing and compaction temperatures used.

   g. Mixture properties determined at a minimum of four (4) asphalt contents and interpolated at optimum and graphs showing mixture properties versus asphalt content.

3. Development Engineering Manager approval of any mix design for HMA or SMA must be given prior to placement,

4. The Development Engineering Manager reserves the right to verify the Responsible Party's mix design for each hot mix asphalt grading utilizing materials actually produced and stockpiled. If requested, the Responsible Party shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and additive for the required laboratory tests, by the Development Engineering Manager. The Development Engineering Manager may request a Certificate of Conformance or Certificate of Compliance at any time on any material used. The Development Engineering Manager may request the mix supplier’s testing results on RAP at any time.

B. Change in Source or Grade

Should a change in the source of Lime occur, or more than one temperature grade change on either the high or low end of Performance Graded Asphalt Binders - (PG Binder) occur, a one point verification test (at optimum asphalt content) of the mix must be performed to verify that the applicable criteria shown on Table 500-12 (Dense Graded HMA)) or Table 500-13 (SMA), and Table 500-14 (VMA), is still met. If this testing shows noncompliance, a new Design Job Mix will be established and approved by the Development Engineering Manager before the new Performance Graded Asphalt Binders (PG Binder) or Lime source is used. Any change in aggregate type or source will require a new mix design. The one point verification test may be performed on lab mixed samples or on plant mixed samples

C. Mix Production Verification

Production verification shall occur prior to the start of the project. The production verification shall be performed by LABCAT Level C certified technicians with current Certification to verify the volumetric properties of the mix. If the mix has been produced for another project within the last 90 days, data from that project can be submitted for this verification. Volumetric properties of the mix verification testing shall be within the following tolerances compared to the Proposed Design Job Mix. The mix verification test reports shall be submitted to the Development Engineering Manager prior to mix placement.

TABLE 500-15
MIX DESIGN VERIFICATION TOLERANCES

Air Voids	+/- 1.2%
VMA	+/- 1.2%
Asphalt Binder Content	+/-0.3%
Stability	Applicable minimum

The tolerances in this table are for mix design verification only.
See section 504.13 for production tolerances.

D. Pre-paving Meeting

1. Development Engineering Manager may require a pre-paving meeting of all parties involved in supply, haul, laydown inspection, quality control and quality acceptance of HMA. Areas of responsibility and contact names and numbers should be shared. A construction (joint) plan will be submitted at the pre-paving meeting, see Section 504.9 and 504.10 for joint requirements.

2. A minimum of two (2) weeks prior to the proposed use of any Stone Matrix Asphalt pavement on the project, a pre-paving conference will be conducted. Prior to that time, the Responsible Party shall submit to the Development Engineering Manager, a mix design meeting the appropriate specification requirements for the items in Table 500-13.

504.5 HMA Equipment

A. Mixing Plant

1. The mixing plant shall be capable of producing a uniform material, have adequate capacity, and be maintained in good mechanical condition. Defective parts shall be replaced or repaired immediately if they adversely affect the proper functioning of the plant or plant units, or adversely affect the quality of the HMA.

2. Dust, smoke, or other contaminants shall be controlled at the plant site to meet all air quality requirements in the "Colorado Air Quality Control Act," Title 25, Article 7, CRS and regulations promulgated there under.

3. Acceptable safety equipment, approved by the Development Engineering Manager, shall be provided by the Responsible Party to accommodate sampling and testing.

B. Hauling Equipment

Trucks used for hauling HMA material shall have tight, clean, smooth beds, or functional and maintained conveyor belt bottom that is thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. Petroleum distillates such as kerosene or fuel oil will not be permitted. Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather and excessive temperature loss or cooled layers of mix in truck as covered in 504.6 C. Hauling, later in this specification.

C. Bituminous Pavers

1. Self-propelled pavers shall be provided for full lane width paving capable of spreading and finishing the HMA, material in full lane widths applicable to the typical section and thicknesses shown in the Contract and shall be equipped with:

   a. Anti-segregation devices.

   b. A vibratory screed assembly capable of being heated.

2. Pavers used for shoulders, patching and similar construction, not requiring fine grade control, shall be capable of spreading and finishing courses of HMA material in widths shown in the Contract without segregation.

3. The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place and spread the mixture uniformly in front of the screed.

4. The paver shall be capable of operating at forward speeds consistent with uniform and continuous laying of the mixture. Stop and go operations of the paver shall be avoided. The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture. Self-propelled pavers shall be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line, and maintaining the screed at the specified longitudinal grade and transverse slope. The sensors may be contact or non-contact type devises. The sensor shall be constructed to operate from either or both sides of the paver and shall be capable of working with the following devices when they are required for the situation:

    a. Grade control device at least 30 feet in length.

    b. Joint matching device.

    c. Adequate length of control line and stakes, if no other type of geometric control is present.

    d. A straight edge at least 10 feet in length will be available to verify the crown on the screed, at the request of the Development Engineering Manager.

5. The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 %. Automatic mode should be used where possible. If the automatic controls fail or malfunction, the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

6. If the Responsible Party fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

7. Placement of HMA on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering.

504.6 Manufacture

A. Preparation of Aggregates

1. Heating and drying of the aggregates shall be accomplished without damaging the aggregate. Hydrated lime shall be added to achieve complete and uniform coating of the aggregate, in accordance with one of the following methods:

    a. Lime Slurry Added to Aggregate: The hydrated lime shall be added to the aggregate in the form of slurry and then thoroughly mixed in an approved pugmill. The slurry shall contain a minimum of 70% water by weight.

    b. Dry Lime Added to Wet Aggregate: The dry hydrated lime shall be added to wet aggregate (a minimum of three (3)% above saturated surface dry) and then thoroughly mixed in an approved pug mill.

2. The lime-aggregate mixture may be fed directly into the hot plant after mixing or it may be stockpiled for not more than 90 days before introduction into the plant for mixing with the asphalt binder. The hydrated lime may be added to different sized aggregates and stockpiled by adding 75% of the lime to the aggregate passing the No.4 sieve and 25% to the aggregate retained on the No. 4 sieve.

3. A minimum of one (1)% hydrated lime by weight of the combined aggregate shall be added to the aggregate for all Dense Graded and Open Graded Stone Matrix Asphalt mixtures.

B. Mixing

1. The dried aggregates and asphalt binder shall be combined in the mixer in the quantities required to meet the design job mix. The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt binder is uniformly distributed throughout the aggregate, Baghouse fines shall be fed back to the mixing plant in a uniform and continuous manner to maintain uniformity in the mixture. The Baghouse, fines feeder, auger, and related equipment, shall be in good working condition and operated in accordance with manufacturer's recommendation. If the Development Engineering Manager determines that non-uniform operation of the equipment is detrimental to the mixture, it may suspend all paving operations until the Responsible Party takes appropriate action.

2. The minimum temperature of the mixture when discharged from the mixer shall be as shown in the following table:

TABLE 500-16
MIXTURE DISCHARGE TEMPERATURES

Asphalt Grade	Minimum Discharge Temperature	Maximum Discharge Temperature
PG 58-28	275º F	310º F
PG 64-22	290º F	325º F
PG 76-28*	318º F	326º F

* Contractor or Binder supplier must supply production temperature as required by their product

3. The Responsible Party may provide refinery information that recommends revised discharge temperatures depending on the base binder grade or source being used. HMA mix shall be produced at the lowest temperature within the specified temperature range that produces a workable mix and provides for uniform coating of aggregates (95 % minimum in accordance with AASHTO T 195), and that allows the required compaction to be achieved.

4. HMA mix may be stored provided that any and all characteristics of the mixture are not altered by such storage. If storing or holding of the mixture causes segregation, excessive heat loss, or adversely affects the quality of the finished product, corrective action shall be taken. Unsuitable mixture shall be disposed of at the Responsible Party's expense.

5. When placing hot mix asphalt over bridge decks covered by waterproofing membrane, the minimum temperature of the mixture, when rolling operations begin, shall be 250° F. The job mix temperature may be increased up to 30° F to obtain this temperature.

6. The mineral filler for SMA shall be stored in a separate silo and added automatically in the correct proportion. The mineral filler addition equipment shall be electronically or mechanically interlocked to the aggregate feed sensors so that the proper amount of mineral filler is added whenever SMA is produced.

7. The SMA mineral filler shall be added at the same point the asphalt binder is added to the aggregate.

C. Hauling

Each truck shall use full covers (tarps) to completely protect the mix during transport at all times. The Development Engineering Manager can reject any mix, which shows an excess or deficiency of asphalt cement, damage due to burning or overheating, an improper gradation, or thermal segregation with cold areas 10° F below the minimum discharge temperature.

504.7 Tack Coat

A. Prior to placement of HMA, a tack coat shall be applied to all existing concrete and asphalt surfaces. The material shall be in accordance with 504.2 E. The emulsified asphalt shall be diluted 1:1 with water and applied at 0.10 ± 0.01 gallons per square yard of diluted material. The Development Engineering Manager may direct other application rates to match the age of condition of the surface. The surface prior to receiving the tack coat shall be dry and cleaned by sweeping, or other approved method, until dust, debris, and foreign matter are removed. The tack coat shall then be applied uniformly by squeegee, brooms, or distributor. Prior to paving, all water must have evaporated from the tack coat. Contaminated areas shall be cleaned and tack coat shall be reapplied.

B. Prior to placement of SMA, tack coat between the existing pavement and Stone Matrix Asphalt pavement shall be placed at a rate between 0.03 and 0.05 gallons per square yard

504.8 Placement

A. Hot mix asphalt shall be placed only on approved, properly constructed surfaces that are free from loose material, water, frost, snow or ice. The hot mix asphalt and tack coat shall be placed in accordance with the temperature limitations of Table 500-16 and only when weather conditions permit the pavement to be properly placed and finished as determined by the Development Engineering Manager. Placement temperature as stated shall be increased by 5° F for each 10 miles per hour wind velocity to a maximum increased minimum placement temperature of 70 ° F.

TABLE 500-17
MINIMUM AIR AND SURFACE TEMPERATURES
LIMITATIONS FOR MIX PLACEMENT (HMA)

Compaction Layer Thickness	Top Layer of Pavement*		Lower Layers *	
	PG 58-28 PG 64-22	PG 76-28	PG 58-28 PG 64-22	PG 76-28
<2 inches (not recommended)	60º F	75º F	N/A	N/A
2 inches to <3 inches	50º F	65º F	40º F	50º F
> 3 inches	50ºF	50º F	40º F	40º F
SG mix only	N/A	N/A	38º F	38º F

* Air temperature is taken in the shade. Surface temperature is taken on the subgrade or base. The Development Engineering Manager may not waive the above temperature limitations for PG 76-28.

B. The mixture shall not be placed at a temperature lower than 245° F for mixes containing PG 58-28 or PG 64-22 asphalt, and 290° F for mixes containing polymer modified asphalt binder. Mix which is too cold or damaged by weather will be rejected.

C. The mixture shall be placed on an approved surface, spread and struck off to obtain the required grade and elevation after compaction. The minimum lift thickness shall be at least three (3) times (preferably four (4) times) the nominal particle size. The un-compacted mixture should be placed approximately 10-25 % thicker than the existing surrounding mat to account for compaction based on the materials being placed. Raking is discouraged and will not be allowed except to correct major problems of grade and elevation. Casting or raking that causes any segregation will not be permitted.

D. On areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be carefully dumped, spread, raked, screeded, and luted by hand tools to the required compacted thickness plus approximately 25 % based on the materials being placed. Carefully move or minimally work the HMA mix with the use of rakes, lutes, or shovels to avoid segregation. Mixtures made with modified asphalt binder require more rapid completion of handwork areas than for normal mixtures. Hauling and placement sequences shall be coordinated so that the paver is in constant motion. Excessive starting and stopping shall not be allowed. A construction joint shall be placed any time the paver stops, and the screed drops enough to cause a surface dip in violation of section 504.13, Production Tolerances; or the mat temperature falls below that allowed in section 504.12, Compaction. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable. Echelon paving will be permitted.

E. SMA PI & Compaction

A Roller Pass Study (RPS) for Density and 1000 foot demonstration control strip are required for placement of lifts less than or equal to 1.5 inch thick, optional for thicker lifts.

1. For Thin Lift SMA less than or equal to 1.5 inch thick:

   a. In-place density shall be determined through the completion of a Roller Pass Study (RPS) to be conducted during placement of the required 1000-foot demonstration control strip. The RPS will determine the necessary roller compaction process needed to produce a minimum pavement density of 94 % of theoretical maximum density (RICE). During the RPS, a minimum of three (3) sets of three (3) four (4) inch diameter cores each shall be taken to measure SMA mat density for the various sections of the RPS. All coring shall be completed by the Responsible Party and submitted to the Development Engineering Manager. The densities of the three (3) cores will be averaged to produce the density for each RPS section tested.

   b. Full production of the thin SMA shall not begin until density test results are determined and the project compaction process is established by the Responsible Party and approved by the Development Engineering Manager. The approved compaction process established from the RPS shall be used for the duration of the thin SMA paving. Changes to the thin SMA mixture will be reviewed and a new RPS may be required.

   c. Using the same method for determining density during the RPS, density will be determined daily for each day of full production and tested to confirm pavement density. If a daily density check

shows density below 92 % of RICE, the Responsible Party shall stop production and the Responsible Party will again complete a RPS to establish the necessary compaction process. The Responsible Party will be allowed two (2) daily density checks below 92 % of RICE to be addressed in this manner during the project. All subsequent daily checks that identify locations having density below 92 % of RICE shall be removed and replaced and a new RPS shall be completed and approved prior to again beginning production. Thin SMA density requirements will be enforced when the SMA mix design gradation and specified lift thickness are in accordance with or exceed the 3:1 requirements for the ratio of nominal maximum aggregate size to lift thickness.

d. The Responsible Party shall submit a plan for a Roller Pass Study (RPS) to the Development Engineering Manager for approval. Upon approval by the Development Engineering Manager, the Responsible Party shall perform a RPS. The plan for the RPS shall include, but is not limited to the following:

   i. Number, size, and type of rollers.

   ii. Amplitude, frequency, size and speed of vibratory rollers.

   iii. Temperature of mixture being compacted.

   iv. Roller patterns.

e. The method of measuring density will be by roller passes. If a density element is based on a RPS.

2. For SMA lifts greater than 1.5 inch thick:

   a. If in the opinion of the Development Engineering Manager, the roller pass study presented by the Responsible Party is inadequate, then the Responsible Party shall modify the compaction procedures as directed.

   b. Before Proceeding with SMA placement,

      i. The Responsible Party shall demonstrate the ability to produce and place a satisfactory mix.

      ii. The actual work may proceed when a full lane width demonstration control strip, having a minimum length of 1000 feet has been successfully placed. The Responsible Party shall determine properties (Superpave Air voids, VMA, in-place density, and Hveem Stability) of the project produced mix that is used in the demonstration control strip and provide the results to the Development Engineering Manager. No other SMA production or placement will be allowed until densities are determined. If the material in the demonstration control strip is not in close conformity with the specifications, the demonstration control strip will be removed and replaced at the Responsible Party‘s expense. The Development Engineering Manager will designate the location of the control strip.

      iii. SMA mixture shall be transported and placed on the roadway without drain-down or flushing. All flushed areas behind the paver shall be removed immediately upon discovery. If more than 50 square feet of flushed SMA pavement is ordered removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the flushing has been found and corrected. The Development Engineering Manager will designate the depth and area of all flushed areas requiring removal and replacement. All costs associated with the removal and replacement of the flushed areas shall be at the Responsible Party’s expense.

      iv. Stone Matrix Asphalt Pavement shall be placed and compacted in accordance with the temperatures listed in Table 500-16 or as revised for the project.

      v. The relative compaction for all SMA mixtures will be measured from roadway cores in accordance with CDOT-CP 44 or AASHTO T-166, Method B, unless the SMA mixture is being placed on a structure (bridge deck) in which case the Development Engineering Manager may specify that nuclear gauge measurements be used.

      vi. When cores are used, the Responsible Party shall provide all labor and equipment for the coring operation and filling the core holes. When nuclear density gauges are used, the tests will be performed in accordance with CDOT-CP 81 or ASTM D 2950 and CDOT-CP 82 or AASHTO T 230.

vii. In-place density for SMA shall be 95 ± 2 % of the SMA Mix maximum specific gravity as measured according to Maximum theoretical value (Rice) (CDOT-CP 51 or AASHTO T 209).

504.9 Longitudinal Joints

A. The longitudinal joints in both a new pavement and an overlay pavement layer shall offset the joint in the layer immediately below by a minimum of six (6) inches. The joints in any pavement layer shall not fall in a wheel track or path. The joints in the top layer of new pavement, not built on top of an existing pavement, shall be located on lane lines, or as shown on the plans. Longitudinal joints shall be minimized, where feasible, with wide paving pulls or echelon paving. Joints shall be parallel to the flow of traffic and shall not cross any centerline, lane line, or edge line unless approved by the Development Engineering Manager. The Responsible Party shall submit, prior to paving, a joint plan and pavement marking plan showing locations and the methods to establish a field control line. The Development Engineering Manager must approve such plans prior to paving. The Responsible Party shall use a continuous string line to delineate longitudinal joints during paving as shown on the joint plan. All string lines shall be removed at the end of each day's paving.

B. The free edge of the paved pass shall be laid as straight as possible, to the satisfaction of the Development Engineering Manager. This joint, if cold, shall be tack coated prior to placement of adjacent paving.

C. The new compacted mat shall overlap the previously placed mat no more than one and one-half (1.5) inches. Excess overlap or thickness shall not be raked or cast onto the new mat, but shall be wasted by pulling back and removing. The hot edge shall be blocked or bumped in a smooth line consistent with the previous longitudinal edge. Minor raking will only be allowed to correct major grade problems or provide mix around manholes and meter covers. The longitudinal joint shall be rolled from the hot side and overlap the joint by approximately six (6) inches on the cold side.

504.10 Transverse Joints

A. The Responsible Party shall submit, prior to paving, a joint plan showing locations and the methods to be used to construct transverse joints. The Development Engineering Manager must approve such plans prior to paving. Placing of the HMA shall be continuous with a minimum of transverse joints, and rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. Tack coat material shall be applied to contact surfaces of all joints just before additional mixture is placed against the previously compacted material.

B. The end of transverse joints shall be located so they will be constructed with a full head of mix in front of the screed. When butt joints are constructed, runoff boards shall be used to support the roller on the downstream side of the joint. All tapered sections, rounded edges and segregated areas shall be removed to achieve a vertical face at the butt joint before paving is restarted.

C. When a temporary tapered joint is required for temporary traffic access, the ramp shall be removed back to a full depth section before paving is restarted.

D. When restarting paving operations, the paver screed shall be placed on the starter block on the completed side of the transverse joint. The starter block should be approximately 25% greater than the thickness of the existing completed mat, so that adequate grade and compaction can be achieved on starting the paving operation. The screed should be nulled (angle removed) when on starting blocks and an up angle of attack set. Proper head of mix should be introduced into the paver prior to starting. The new compacted (downstream) side of the joint may be up to 3/16 inches higher than the old (upstream) side. Raking of this joint shall not be allowed except to correct major grade problems. The surface tolerance at the transverse joint must be verified by the Responsible Party with a 10-foot straight edge before the paver is more than 100 feet from the joint. If the surface tolerance is not within 3/16 inches, the Responsible Party shall make corrections before proceeding

504.11 Segregation

A. The asphalt mixture shall be transported and placed on the roadway without segregation. All segregated areas shall be removed immediately and replaced with specification material before the initial rolling. If more than 50 square feet of segregated pavement is removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the segregation has been determined and corrected.

B. The Development Engineering Manager will visually determine areas that are segregated, and may also use density and gradation measures to help in this determination. The Development Engineering Manager will visually determine the extent of the segregation. The Responsible Party will not be allowed additional compensation for correction of segregated areas.

504.12 Compaction

A. The temperature of the mixture immediately behind the screed shall be sufficient to allow for proper compaction of the HMA layer and at least 245° F for PG 58-28 or PG 64-22 binder and between 297° F and 305° F for PG 76-28 binder. The breakdown compaction should be completed as quickly as possible after placement occurs.

B. The HMA shall be compacted by rolling. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density and surface texture while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and be continued until the required density is obtained. Final compaction shall be obtained using steel wheel rollers.

C. Pavement operations shall be suspended when density requirements are not met and the surface temperature falls below 185° F, or there is obvious surface distress or breakage, the problem shall be resolved prior to continuing paving operations. The criteria for mixtures containing PG 76-28 asphalt cements shall be 235° F. The minimum compaction temperatures may be adjusted according to the asphalt binder supplier recommendations. Adjusted minimum compaction temperatures must be shown on the approved mix design or on other asphalt binder supplier documents, and be available on the job site.

D. All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted on bridge decks.

E. The Responsible Party shall establish a rolling pattern or procedure during the beginning of paving operations, which will achieve the required compaction and surface tolerances. This procedure may be re-evaluated by the Responsible Party and Development Engineering Manager throughout the paving operations.

F. All HMA paving shall be compacted to 94.0 ± 2% of Maximum Theoretical (RICE) Density, (CP-51 or AASHTO T-209: Maximum Specific Gravity of Bituminous Paving Mixtures) as determined by ASTM D 2950. RICE values shall be used in calculating Relative Compaction according to CP-44 or .AASHTO T 166. The Responsible Party shall determine the proper RICE value to use for the initial day's placement. Subsequent day's RICE value(s) will be based on the current day's production. The Responsible Party shall provide the producer's RICE value, which shall be used for production until the actual day's RICE value is determined by the testing firm of record for the project as approved by the Development Engineering Manager.

G. All joints shall be compacted to 92.0 ± 2% of RICE, taken fully on each side of joint, every 200 Linear Feet. RICE values shall be used in calculating Relative Compaction according to AASHTO T 166, Cores if need will be used to verify compaction results.

H. The Responsible Party shall core the pavement, as required by the Development Engineering Manager, for field density tests in accordance with Colorado Procedure 44 or AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with the ASTM D 2950 or Appendix of Colorado Procedure 81. At a minimum, cores for nuclear density equipment calibration shall be taken at the beginning of placement of each pavement layer or change of mixture materials or gradation. Untested areas during placement will also require cores to be taken to verify compaction.

I. Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers.

J. Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with fresh hot mixture and compacted to conform to the surrounding area.

K. Compaction requirements for SMA are covered in Section 504.8 E. Rollers shall not be used in a vibratory mode on SMA unless they are first used successfully in the demonstration control strip. Pneumatic wheel rollers shall not be used on SMA Mix.

504.13 Production Tolerances

A. Top Lift Surface Tolerances

The surface variation between any two (2) contacts shall not exceed three-sixteenths (3/16) inch in 10 feet for full lane width paving. For patching surface tolerances, the variation shall not exceed three-eighths (3/8) inch in 10 feet. Irregularities exceeding the specified tolerance shall be corrected at the Responsible Party's expense. Transverse measurements for variations shall exclude breaks in the crown sections.

B. Job Mix Formula Tolerances

Production test results that deviate from the design job mix by more than shown in the following table are subject to Section 504.13 C:

TABLE 500-18
JOB MIX FORMULA TOLERANCES

Item	Tolerances
Passing No. 3/8" and Larger (note 1)	± 6%
Passing No. 4 and No.8	± 5%
Passing No. 30 to No. 50	± 4%
Passing No. 200 (note 2)	± 2%
Air Voids	± 1.2%
VMA (note 4)	± 1.2%
Hveem Stability	(note 3)
Asphalt Content	± 0. 3%

Note 1 There is one (1.0)% tolerance for the maximum sieve size.
Note 2 Mixes with passing No. 200 sieve material produced over seven (7.0)% are allowed only when the above Air Voids and VMA tolerances are still met.
Note 3 Hveem Stability must meet the minimum value specified in Table 500-13.
Note 4 When calculating VMA, use the most current aggregate specific gravity $G_{sb,}$

C. When disagreements concerning determination of specification compliance occur, only valid tests from both the Development Engineering Manager and Responsible Party will be considered. The Development Engineering Manager shall determine validity. Generally, valid tests are those in which sampling and testing have been performed according to referenced procedures and the results are within stated precision statements. When disagreements occur with asphalt content and gradation tests results, solvent extracted aggregate testing shall take precedence over burn off oven extracted aggregate, which shall take precedence over cold feed belt testing.

505 CONCRETE PAVEMENT

A. The installation of concrete pavement, including materials, equipment, foundation and construction methods shall be in conformance with Section 412, "Portland Cement, Concrete Pavement" of the CDOT S&S, except as modified herein or as modified by the approval of the Development Engineering Manager.

B. Section 600 of these Standards and Specifications must be followed for concrete work. Concrete pavements shall only be designed where approved by the Development Engineering Manager. It shall be installed as shown on the approved plans. When concrete pavement is constructed on a curve, flexible forms shall be used having a radius of 200 feet or less, unless otherwise directed by the Development Engineering Manager. The Responsible Party shall furnish steel pins to use in setting grades for concrete pavement.

505.1 Portland Cement Concrete Pavement

This material shall consist of a mixture of coarse and fine aggregates, Portland cement, water and other materials or admixtures as required. CDOT Class "D" mix shall be used.

A. Portland cement shall comply with the CDOT requirements. The type of cement shall be Type II or Type II Modified unless sulfate conditions dictate otherwise. Table 2.2.3 in Chapter 2.2 of ACI 201 indicates recommendations for sulfate resistance.

B. Fine aggregates shall meet CDOT S&S, Section 703.01 requirements.

C. Coarse aggregates shall meet CDOT S&S, Section 703.02 requirements.

D. Fly Ash shall comply with CDOT S&S, Section 701.02 if use is approved by Development Engineering Manager.

E. Water shall meet the requirements of CDOT S&S, Section 712.01.

F. Air entraining and chemical admixtures shall meet the requirements of CDOT S&S, Section 711.02 and 711.03. No chloride containing additives shall be permitted.

G. Curing materials shall be white pigmented liquefied membrane curing compound and meet the requirements of AASHTO M 148.

H. Reinforcing steel shall meet the requirements of CDOT S&S, Section 709.01, grade 40 minimum.

I. Minimum compressive strength shall be 4000 psi; minimum modulus of rupture or flexural strength shall be 600 psi.

505.2 Aggregate Base Course Material

A. This material shall consist of hard, durable particles or fragments of stone or gravel, crushed to required sizes, containing an appropriate quantity of sand or other finely-divided mineral matter which conform to the requirements of AASHTO M 147, and to Section 703.03, CDOT S&S. In addition, the material shall have an R-value of 78 or greater or a CBR of 80 or greater and shall be moisture stable. Moisture stability is determined by R-value testing which shows a drop of 12 points or less in R-value between exudation pressures of 300 psi and 100 psi.

B. Only aggregate from approved sources shall be used. Approval of sources shall be at the discretion of the Development Engineering Manager and submissions shall, at a minimum, consist of supplying documented gradation, Atterberg limits and CBR/R-value testing on an annual basis. Only two (2) types of crushed aggregate base course are acceptable. The gradation specifications for these two types of base course are listed below:

TABLE 500-19
AGGREGATE BASE COURSE MATERIALS
AND CDOT SPECIFICATIONS

Sieve Designation	% Passing By Weight	
	Class 5	Class 6
1½"	100	---
1"	95-100	---
3/4"	---	100
No. 4	30-70	30-65
No. 8	---	25-55
No.200	3-15	3-12
Liquid Limit (LL)	30, Maximum	30, Maximum

505.3 Cement Treated Aggregate Base Course

A. This material shall consist of a mixture of aggregate materials, Portland cement and water as outlined in Section 308 of the CDOT S&S. Acceptable aggregates include CDOT Classes 4, 5, and 6. Other aggregates may be used, if previously approved by the Development Engineering Manager.

B. The materials to be used in construction shall be tested and a mix design submitted to the Engineer. As a minimum, the mix design report shall contain a description of material sources, gradations and Atterberg limits of aggregates, cement type, Proctor compaction curves and unconfined compressive strength results for each mix, strength versus cement content curves, a design mix and special construction procedures recommended. Testing shall be in accordance with appropriate AASHTO specification.

C. To be approved, the mix shall have a seven (7) day compressive strength of at least 650 psi and no more than 1,000 psi. The minimum acceptable cement content shall be five (5)% by weight. Only mix designs approved by the engineer shall be used.

505.4 Lime Treated Subgrade

A. This material consists of a mixture of native or imported soils, hydrated or quick lime and water as outlined by Section 307 of CDOT S&S.

B. The materials to be used in construction shall be tested and a mix design submitted to the Engineer for approval. As a minimum, the mix design report shall contain a description of material sources, gradation (-200) and Atterberg limits of native soils, Atterberg limits and seven (7) day unconfined compressive test results for each mix and special construction procedures are recommended. Testing shall be in accordance with appropriate AASHTO methods.

C. To be approved, the mix shall have a minimum seven (7) day compressive strength of 160 psi. In addition, the plasticity index of the treated soil shall not exceed six (6). The minimum acceptable hydrated lime content shall be four (4)% by weight.

D. Only mix designs approved by the Development Engineering Manager shall be used. Approvals are required on a project basis prior to issuing construction permits. Minimum in-place thickness for this material shall be six (6) inches.

506 MATERIALS AND CONSTRUCTION PRACTICES

506.1 General

Refer to Section 100 for excavation, testing, backfill, and compaction requirements.

506.2 Heating and Scarifying

When heating and scarifying treatment is specified on the approved construction plans or required by the Development Engineering Manager, the equipment, materials and construction shall be in accordance with requirements of the CDOT S&S, Section 405.

506.3 Grinding

A. Grinding shall consist of "milling", "grinding", or "cold planing" the existing pavement surface to establish a new surface profile and cross section in preparation for a bituminous overlay. After grinding, the surface shall have a grooved or ridged finish, uniform and resistant to raveling or traffic displacement. This textured surface shall have grooves of one-fourth (¼) inch plus or minus one-eighth (1/8) inch. The existing surface to be ground shall include bituminous pavement, concrete utility patches, and a small amount of concrete pavement.

B. "Wedge cut" grinding shall consist of grinding the existing pavement surface a minimum of four (4) feet wide at the existing concrete gutter. The edge of the gutter end of the finished wedge cut shall be one and one-half (1½) inches below the edge of the existing concrete gutter. The center line of street edge of the wedge cut shall be cut one-eighth (1/8) inch. The depth of cut shall be determined by measuring to the top of the ridges by placing a five (5) foot straight edge perpendicular to the grooving pattern. "Full width" grinding shall consist of grinding the existing pavement surface from edge of gutter to edge of gutter to a minimum depth of two (2) inches, unless otherwise directed by the Development Engineering Manager.

C. Grinding around utility castings to the depth of cut before and after encountering the castings shall be included in the area of the pavement surface ground. The Responsible Party may choose to remove the entire existing bituminous pavement around the castings where grinding is not completed, and replace it with bituminous surface course placed and compacted in three (3) inch lifts. The Responsible Party shall vertically cut the limits of the area to be patched, mechanically compact the existing base course, and prime the bottom and vertical edges before backfilling.

D. The grinding machine shall be a power operated, self-propelled machine, having a cutting drum with lacing patterns that shall attain a grooved surface and produce grinding chips of less than one (1) inch in size. The grinding machine shall be equipped with a pressurized watering system for dust control. The equipment shall be a type that has successfully performed similar work.

E. The Responsible Party shall remove the cuttings immediately behind the grind machine by belt loader, end loader, power sweeper and/or by hand. The removed material shall be disposed of as approved by the Development Engineering Manager.

F. The cleaning equipment shall be a type which shall efficiently remove loosened material, load it into trucks for hauling and spreading, and utilize a watering system for dust control. Because of the nature of the streets to be ground and the traffic restrictions, a beltloader followed by a power sweeper and manual sweeper is the most desirable method. Flushing into the City's storm sewer system as a means of cleanup shall not be allowed.

506.4 Geosynthetics

A. General

Any proposed Geosynthetic used in paving applications must be accompanied with a letter stating the purpose for use, and include the stamp of a licensed PE in the State of Colorado.

B. Fabric

Geotextile fabric shall meet criteria for the proper application and that set forth by the CDOT S&S, Sections 420 & 712, and subject to the approval of the Development Engineering Manager. This includes, but not limited to those geotextile fabrics for paving, weed control, and erosion control.

C. Geogrids

Geogrids shall meet the pavement or soil report criteria and are subject to the approval of the Development Engineering Manager.

507 APPURTENANT CONCRETE STRUCTURES

507.1 General

Curb, curb ramps, gutter, sidewalk, cross pan, and driveway construction shall conform to Section 600 of these Standards and Specifications.

508 ROADWAY INSPECTION AND TESTING

508.1 General

Work performed inside ROW and associated easements shall be tested by a materials testing firm which employs a full time PE, registered in the State of Colorado, who directly supervises work of the firm. Concrete technicians must be ACI or equivalent Level I technicians. The costs of testing and associated reporting shall be paid by the Responsible Party. Test and inspection results performed by the testing firm in the employment of the Responsible Party shall be submitted to the Development Engineering Manager at the time of testing or within 15 working days after the testing or retesting date.

508.2 Roadway Subgrade Preparation

A. Compaction

The subgrade shall be free of organic material and shall be scarified to a minimum depth of six (6) inches, or as stated in the Pavement Design Report, moisture treated to within two (2) % of optimum moisture content, or as otherwise specified in the approved geotechnical report, and compacted. Table 500-20 shall be used to determine the compaction.

B. Testing

Field moisture-density tests using methods acceptable to the Development Engineering Manager shall be required at random locations at the rate of one (1) for each 250 lineal feet of paving for each travel lane.

TABLE 500-20
MOISTURE-DENSITY CONTROL

Soil Classification (AASHTO M 145)	AASHTO T 99 Minimum Relative Compaction %	AASHTO T 180 Minimum Relative Compaction %
A-1, A-3, A-2-4, A-2-5	100	95
All Other	95	90

C. Final Proof-Rolling

After the subgrade has been compacted, tested and found to meet specifications, the entire subgrade shall be proof-rolled with a heavily loaded vehicle. The vehicle shall have a certified loaded GVW of 50,000 pounds with a loaded single axle weight of at least 18,000 pounds and a tire pressure of 90 psi. Subgrade which is pumping or deforming must be reworked, replaced or otherwise modified to form a smooth, stable, non-yielding base for subsequent paving courses. The Development Engineering Manager shall be notified at least 48 hours before final proof-rolling.

D. Acceptance

The results of field density tests and proof-rolling shall be submitted and reviewed by the Development Engineering Manager. Provided test results are acceptable, compaction shall be approved for the placement of the next paving course. Should testing indicate unsatisfactory work, the necessary reworking, compaction or replacement shall be required prior to continuation of the paving process. The approval is valid for 24 hours. Changes in weather, such as freezing or precipitation, shall require re-approval of the subgrade.

508.3 Lime Treated Subgrade

A. Materials

Lime treated subgrade shall be used only where a mix design has been previously submitted and approved by the Development Engineering Manager. Refer to Section 307 of the CDOT specifications for construction requirements.

B. Construction

Construction of lime treated subgrade shall be in accordance with the requirements of Section 307 of the CDOT S&S, except that the curing period shall be a minimum of 48 hours.

C. Testing

Lime treated subgrade shall be observed and tested on a full-time basis and paid for by the Responsible Party. Field moisture-density tests shall be taken at the rate of one (1) for each 250 lineal feet of travel lane for each lift. Compaction curves (AASHTO T 220) shall be required for each soil type and field density shall be compared to the appropriate curve for percentage compaction determinations. Field compacted seven (7) day strength and lime content (AASHTO T 232) determinations shall be required for each 500 tons of subgrade treated, with a minimum of one (1) per project.

D. Acceptance

The results of field density, lime content and strength tests shall be submitted and reviewed by the Development Engineering Manager. Provided test results are acceptable, the subgrade shall be approved and the next paving course can be placed. Should these tests fail to meet project specifications, the strength reduction shall be used to calculate increased pavement layer or overlay thicknesses required for the design section.

508.4 Aggregate Base Course

A. Materials

Aggregate base course materials shall be from a source approved by the Development Engineering Manager. The Responsible Party shall, upon request, provide verification of material properties.

B. Placement and Compaction

1. Materials shall be placed on an approved subgrade which has been proof-rolled within the past 24 hours and found to be stable and non-yielding. Should weather conditions change, such as freezing, precipitation, etc., aggregate base materials shall not be placed until the subgrade is reapproved.

2. Aggregate base materials shall be placed, moisture treated and compacted as outlined in Section 304 of the CDOT S&S.

C. Testing

1. At least one (1) sample of aggregate base course for each 1,000 tons of material placed shall be tested to determine gradation and Atterberg limits. Should these tests indicate the material does not meet specifications, the material shall be removed and replaced.

2. During placement and compaction, Compaction Curves shall be required for each material used. Field moisture-density tests shall be taken of each lift of material at random locations, at approximate intervals of 250 feet in each travel lane. At least 20% of the tests shall be taken within one (1) foot of manholes, valves and curbs.

D. Approval

The results of field density tests shall be submitted and reviewed by the Development Engineering Manager provided the tests are acceptable, the aggregate base course materials, placement and compaction shall be approved and the next paving course can be placed. Should testing indicate unsatisfactory work, the necessary reworking, compaction or replacement shall be required prior to continuation of the paving process.

508.5 Cement Treated Aggregate Base Course

A. Materials

Aggregate and cement materials shall be from a currently approved source, and shall be approved by the Development Engineering Manager. The Responsible Party shall provide verification of material properties and an approved mix design.

B. Placement and Compaction

Materials shall be placed on a subgrade approved by the Development Engineering Manager and which has been proof-rolled within the past 24 hours and found to be stable and non-yielding. Should weather conditions change, such as freezing, precipitation, etc., materials shall not be placed until the subgrade is reapproved.

C. Testing

1. At least one (1) sample of cement treated aggregate base course for each 1,000 tons of material placed shall be tested to determine cement content, gradation and Atterberg limits. Six (6) field prepared Proctor mold samples shall be taken for each 500 tons placed and tested at seven (7) and 28 days to determine unconfined compressive strength.

2. During placement and compaction, Compaction Curves shall be required for each material used in accordance with AASHTO T 134. Field moisture-density tests shall be taken of each lift of material at random locations at approximate intervals of 250 feet in each travel lane. At least 20% of the tests shall be taken within one (1) foot of manholes, valves, and curbs.

D. Approval

The results of laboratory tests and field density tests shall be submitted and reviewed by the Engineer. Provided test results are acceptable, the cement treated aggregate base course materials, placement and compaction shall be approved and the next paving course can be placed. Should testing indicate unsatisfactory work, necessary adjustments shall be made to the pavement section to comply with original strength requirements.

508.6 Asphalt Prime and Tack Coats

A. Materials

See Subsection 504.2 E of these Standards and Specifications

B. Application

1. Prior to prime coat application, the surface shall be allowed to dry to approximately 80% of optimum moisture. The asphalt material shall be applied in the range of 0.05 to 0.15 gallons/square yard.

2. Tack coat shall be applied where additional HMA is to be placed over existing asphaltic or Portland cement surfaces. Tack coats shall not be required where HMA is less than 24 hours old and remains free of dust, dirt or debris. A 1:1 dilution shall be applied at 0.10 gallon per square yard and shall be used for a tack coat on existing pavement. A wand, or hand spray nozzle attached to the spray bar can be used for applying tack to gutter faces, valve boxes, manholes and rings.

C. Curing

Curing shall be required for prime and tack coats. The prime or tack coat shall be sticky, or tacky, when cured. The length of time required for curing shall depend on the air temperature, humidity and wind conditions and shall be black when cured.

D. Approval

Prime or tack coat shall be approved by the Development Engineering Manager upon acceptance of mill certifications, visual approval and verification of application rate. Dust or contamination of prime or tack coats shall require brooming and reapplication.

508.7 Plant Mix Bituminous Pavement

A. Materials

Asphalt, aggregate, fillers and additives shall be combined to form a mix design. The mix design shall be submitted to the Development Engineering Manager for approval.

B. Placement and Compaction

1. Materials shall be placed upon a City approved subgrade or previous paving course in accordance with Section 400 of the CDOT Standard Specifications. Prime or tack coats shall be applied in accordance with Subsection 504.2 E and 508.6 of these Standards and Specifications.

2. When more than one lift of pavement is required, the joints or seams between lifts shall be staggered so that joints are separated by at least two (2) feet in the horizontal direction. Joints in the final wearing course shall not be located in probable wheel paths.

3. The HMA mix shall be compacted to at least 95% of the mix specified density from Hveem testing to achieve design strength.

C. Testing

1. During placement and compaction of Hot Mix Asphalt pavement, observation and testing by City personnel shall be on a full-time basis at the expense of the Responsible Party.

2. If any materials furnished or work performed by the Responsible Party fails to fulfill the specification requirements, such deficiencies shall be reported to the Development Engineering Manager and the Responsible Party immediately. Preliminary written field reports of all tests taken and observation results shall be given to the Responsible Party and Development Engineering Manager within one (1) business day after samples were obtained or density testing performed. Field reports shall be forwarded to the Project Manager no later than one (1) week following the testing.

3. Reports of all tests taken, including failing tests, shall be reported to the Development Engineering Manager and to the Responsible Party no later than one (1) week following the sampling. Density test results will be given in writing at the time the testing occurs.

4. Testing of Hot Mix Asphalt Pavement shall be performed in accordance with Table 500-21. The tests shall be performed under the general supervision of and signed by a Professional Engineer registered in the State of Colorado. Laboratories shall be inspected by either AASHTO or accredited A2LA or equivalent in the elements listed below. Technicians taking samples and conducting compaction tests must have a LABCAT Level A certification or equivalent. Technicians conducting tests of asphalt content and gradation must have a LABCAT Level B certification or equivalent. Technicians performing volumetric testing must have a LABCAT Level C certification or equivalent.

TABLE 500-21
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING
FOR HMA -PAVEMENT

Test	Standard*	Minimum Frequency
Sampling	AASHTO T 168, ASTM D 979 and ASTM D3665	One test for each day
Density	AASHTO T 166, T 238, T 230 Or CP-44, CP-81, CP-82	One test for each 250 lineal feet per Lane
Thickness (Core)	ASTM D 3549	One test for each 1000 lineal feet per Lane,
Air Voids & VMA	AASHTO T 166 & AASHTO PP 19 or CP-48	One test for each day (See note 4, Table 9.13.2)
Gradation	AASHTO T 27, T 11 or CP-31A, CP-31B	One test for each day
Hveem/Marshall Stability As Applicable	AASHTO T 245, AASHTO T 246 or CP-L 5106	One test for each day
Asphalt (AC) Content	AASHTO T 164 or CP-L 5120 or other methods agreed upon between Development Engineering Manager and Responsible Party	One test for each day
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209 or CP-51	One test for each day
Lottman Stripping, TSR & Dry Density	AASHTO T 283 or CP-L 5109, Method B	As requested by the Development Engineering Manager.
Micro Deval	AASHTO T 327 or CP-L 4211	One per 5000 tons or 1 per project minimum

* Development Engineering Manager may determine the method used (CP vs. AASHTO).

5. Inspectors shall be responsible for checking temperatures of mix in the truck and on pavement, segregation, rolling patterns and other construction means and methods that affect the performance of the pavement system. The Responsible Party shall provide assistance in sampling and testing at all facilities and at the job site.

6. The HMA or SMA mix design must be approved by the Development Engineering Manager before any pavement is placed on the project. In addition, the Responsible Party shall provide field control testing during production of the SMA mix and for the demonstration control strip. The Responsible Party shall perform the tests described in Table 500-22 and provide the results to the Development Engineering Manager during production:

7. If a SuperPave SMA mix design is used, the Responsible Party shall perform the tests described in Table 500-22 and provide the results to the Development Engineering Manager during production:

TABLE 500-22
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING
HMA/SMA PAVEMENT

Superpave Mix Property	Frequency
Draindown (AASHTO T 305)	1/1000 tons or fraction thereof
% Voids in the total mix @ $N_{(design)}$	1/1000 tons or fraction thereof
VMA (% Voids in the Mineral Aggregate) @ $N_{(design)}$	1/1000 tons or fraction thereof
Lottman, CPL 5109 or AASHTO T 283, Method B	1/5000 tons or fraction thereof
Dry Tensile Strength, CPL 5109 or AASHTO T 283	1/5000 tons or fraction thereof
% AC & Aggregate Gradation CP 5120 or AASHTO T 308	1/1000 tons or fraction thereof

D. Approval

1. The results of field density and laboratory tests shall be submitted and reviewed by the Development Engineering Manager. Provided test results are acceptable, the HMA materials, placement and compaction shall be approved. Acceptable results shall be in compliance with tolerances for gradation and extraction. Should testing indicate unsatisfactory work, removal and replacement or overlay work shall be required.

2. Criteria used to determine satisfactory work shall be the following and shall be in compliance with the Pavement Evaluation Report:

   a. 90% of core tests shall meet or exceed design HMA thickness;

   b. Average of core tests shall meet or exceed design HMA thickness;

   c. Core test thicknesses shall exceed design HMA thickness, minus one-half (½) inch.

508.8 Portland Cement Concrete

A. Construction Requirements

Materials shall be proportioned, handled, measured, batched, placed and cured in accordance with Section 600 of these Standards and Specifications and Section 412 of CDOT S&S.

B. Placement

During placement of Portland cement concrete pavement, observation and testing by City personnel shall be on a full-time basis. For each day of production or 1,000 square yards placed, aggregate samples shall be obtained for gradation of both the coarse and fine aggregates.

C. Interval

Slump, air content, unit weight and mix temperature shall be tested three (3) times for every 1,000 square yards of pavement placed. Tests for slump and air content shall be on a random basis.

D. Cylinders

Four (4) compressive strength cylinders shall be cast for each 50 cubic yards, or for each day of pour placed. Cylinders shall be tested as follows:

1. one (1) at seven (7) days,
2. two (2) at 28 days
3. one (1), at 56 days, if 28-day test fails, otherwise discard.

E. Fly Ash

Portland cement and fly ash shall be accepted on the basis of certificates of compliance and pretesting by CDOT and subject to approval of Development Engineering Manager. Reinforcing steel, dowels and tie bars shall be accepted by certificate of compliance and mill reports. Only CDOT approved brands of air entraining agents, chemical admixtures and curing materials shall be used and shall be documented.

F. Thickness Check

Thickness of fresh concrete shall be checked every 300 linear feet in each traffic lane. Any noted deficient areas shall be corrected at that time. Surface smoothness shall be tested and corrected as necessary according to CDOT S&S, Section 412.

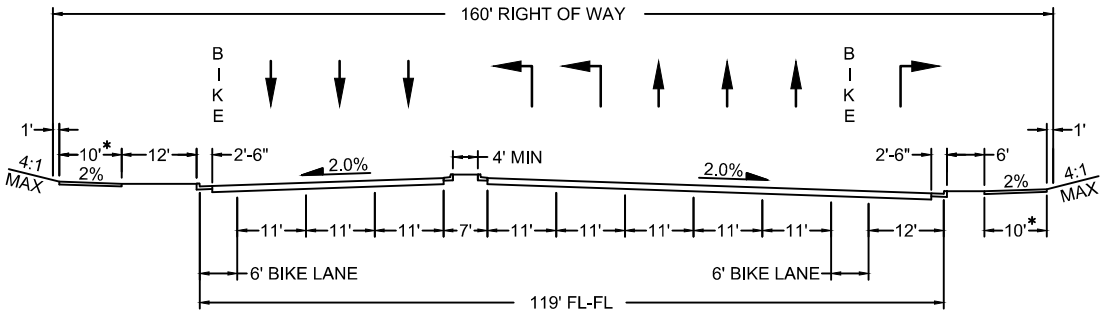
G. Approval

Test results shall be submitted and reviewed by the Development Engineering Manager. Provided test results are acceptable, the pavement shall be accepted. Should testing indicate unsatisfactory work, removal and replacement or grinding shall be required.

508.9 Test Listing

The testing of materials and construction shall be in conformance with the appropriate AASHTO or ASTM specifications. A partial list of approved testing methods includes those listed in Table 500-21.

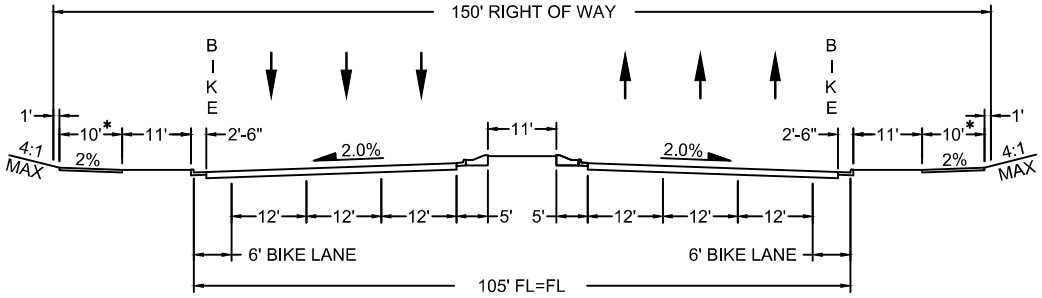
THIS PAGE IS A BLANK PLACEHOLDER FOR DOUBLE-SIDED PRINTING.



MAJOR ARTERIAL
INTERSECTION W/MAJOR OR MINOR ARTERIAL

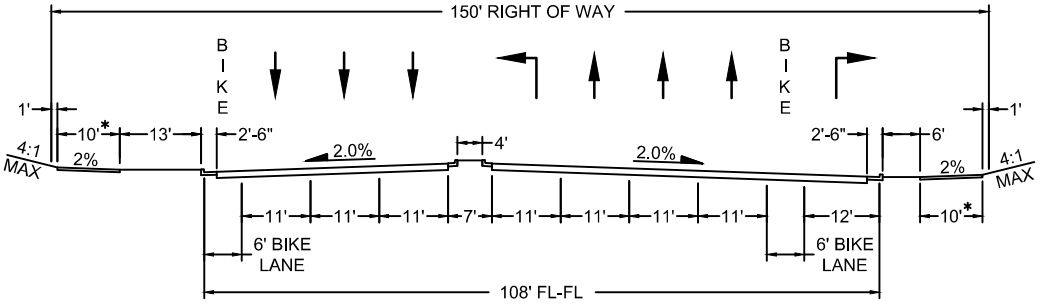
(A1) 6 LANES W/ DUAL LEFT TURN LANES, 2 BIKE LANES, AND RIGHT TURN LANE

* ONE (1) 10 FOOT WIDE SIDEWALK IS REQUIRED ON ALL MAJOR ARTERIALS. THE SECOND SIDEWALK MAY BE EIGHT (8) FEET WIDE.



(A2) MAJOR ARTERIAL
6 LANE STRAIGHT SECTION WITH 2 BIKE LANES

* ONE (1) 10 FOOT WIDE SIDEWALK IS REQUIRED ON ALL MAJOR ARTERIALS. THE SECOND SIDEWALK MAY BE EIGHT (8) FEET WIDE.



MAJOR ARTERIAL
INTERSECTION W/ COLLECTOR

(A3) 6 LANES W/ RT TURN, LT TURN, AND 2 BIKE LANES

* ONE (1) 10 FOOT WIDE SIDEWALK IS REQUIRED ON ALL MAJOR ARTERIALS. THE SECOND SIDEWALK MAY BE EIGHT (8) FEET WIDE.

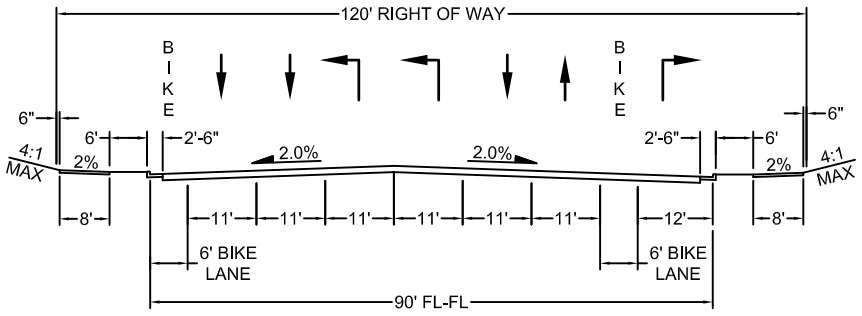
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

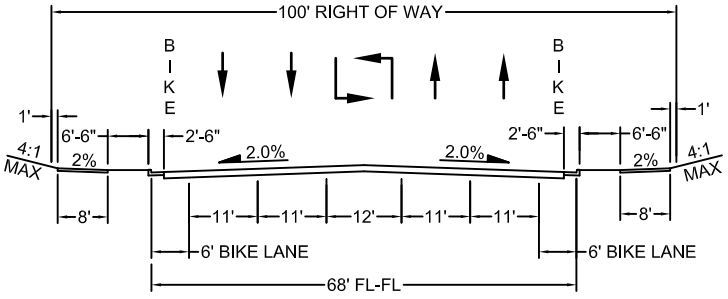
TYPICAL THOROUGHFARE CROSS SECTIONS – MAJOR ARTERIAL

ISSUED: APRIL 2010
REVISED: AUG 2012

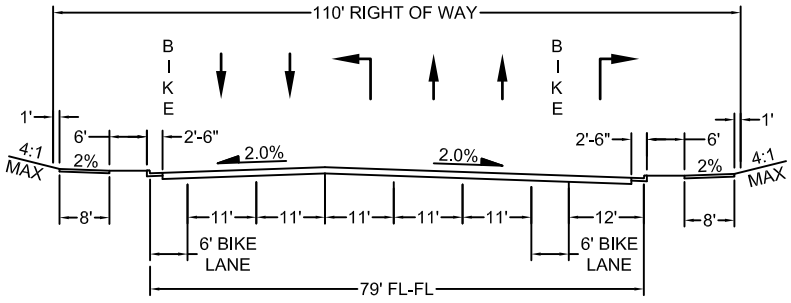
DRAWING NO. 500–1



MINOR ARTERIAL
INTERSECTION W/MAJOR OR MINOR ARTERIAL
(A4) 4 LANES W/ DUAL LEFT TURN LANES, 2 BIKE LANES, AND RIGHT TURN LANE



(A5) MINOR ARTERIAL
4 LANE STRAIGHT SECTION WITH 2 BIKE LANES



MINOR ARTERIAL
INTERSECTION W/ COLLECTOR
(A6) 4 LANES W/ RT TURN, LT TURN, AND TWO BIKE LANES

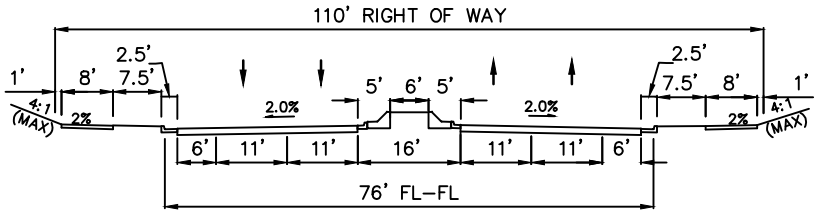
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPICAL THOROUGHFARE CROSS SECTIONS – MINOR ARTERIAL

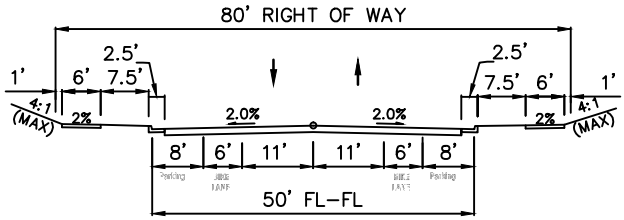
ISSUED:
APRIL 2010
REVISED:
AUG 2012

DRAWING NO.
500–2



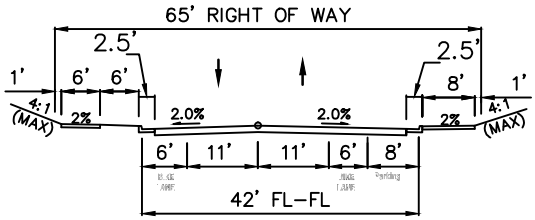
PARKWAY COLLECTOR
4 LANE STRAIGHT SECTION W/ BIKE LANES

(PC)



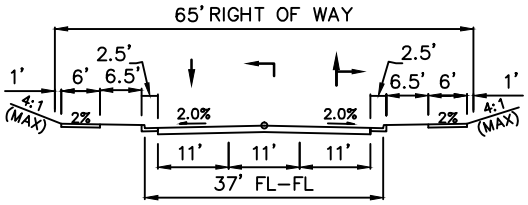
COLLECTOR
2 LANES W/ BIKE LANES
AND PARKING

(C1)



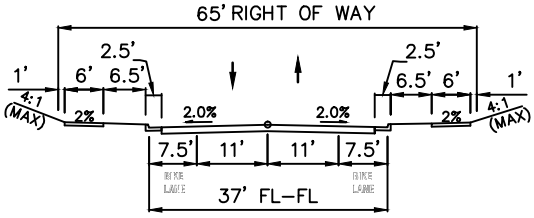
COLLECTOR
2 LANES W/ BIKE LANES
AND PARKING ALONG PARKS

(C2)



COLLECTOR
AT INTERSECTION

(C3)



COLLECTOR
2 LANES W/ BIKE LANES

(C4)

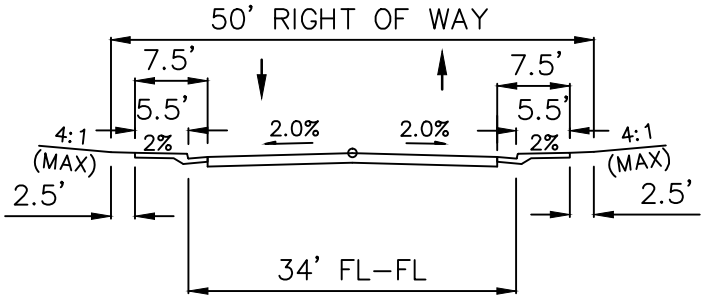
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

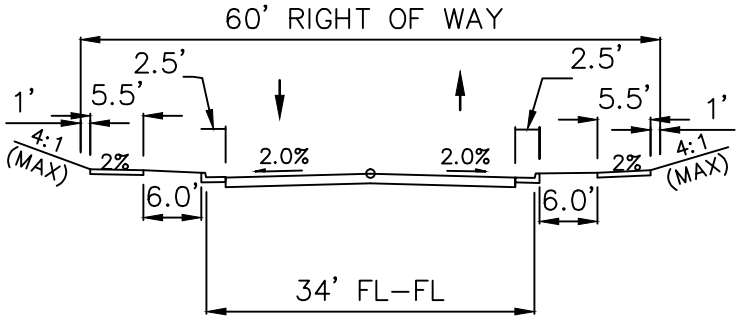
TYPICAL THOROUGHFARE CROSS SECTIONS – COLLECTOR

ISSUED:
APRIL 2010
REVISED:
SEPT 2012

DRAWING NO.
500–3



(L1) LOCAL RESIDENTIAL
2 LANE ATTACHED WALK
TYPE II INTEGRAL SIDEWALK



(L2) LOCAL RESIDENTIAL
2 LANE DETACHED WALK

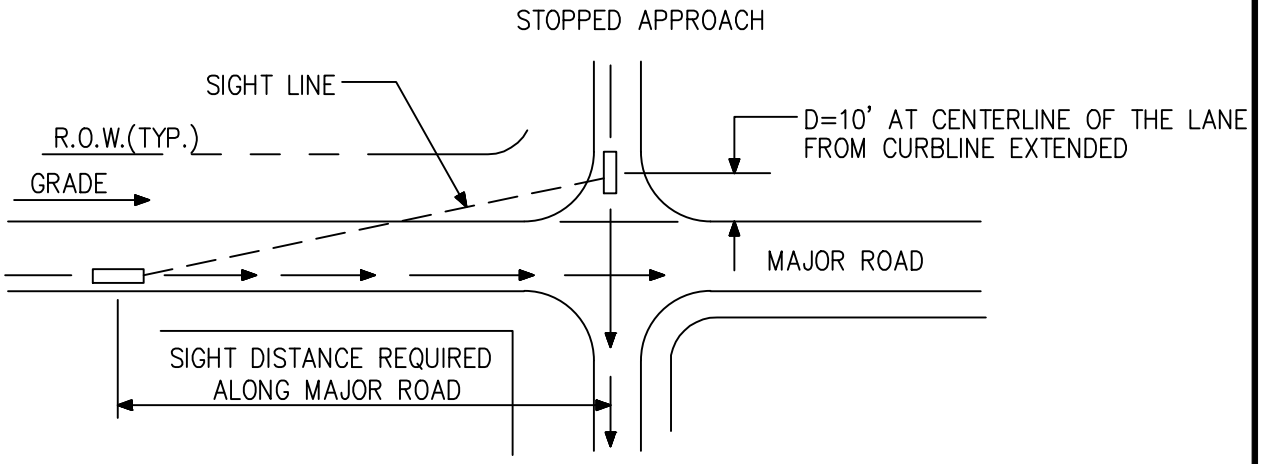
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPICAL THOROUGHFARE CROSS SECTIONS – LOCAL

ISSUED:
APRIL 2010
REVISED:

DRAWING NO.
500–4



DESIGN SPEED OF THRU ROADWAY (MPH)	MINIMUM SIGHT DISTANCE FOR STOPPED VEHICLE (FT.)	GRADE CORRECTION DISTANCE (FT.)				
		SPEED	UPGRADE TO		FOR DOWNGRADES	
			3%	6%	3%	6%
25	250					
30	300	25	0	−10	+10	+20
		30	0	−10	+10	+20
35	350	35	−10	−15	+10	+25
		40	−10	−20	+10	+30
40	400	45	−15	−25	+15	+40
45	450					
50	500					
55	550					

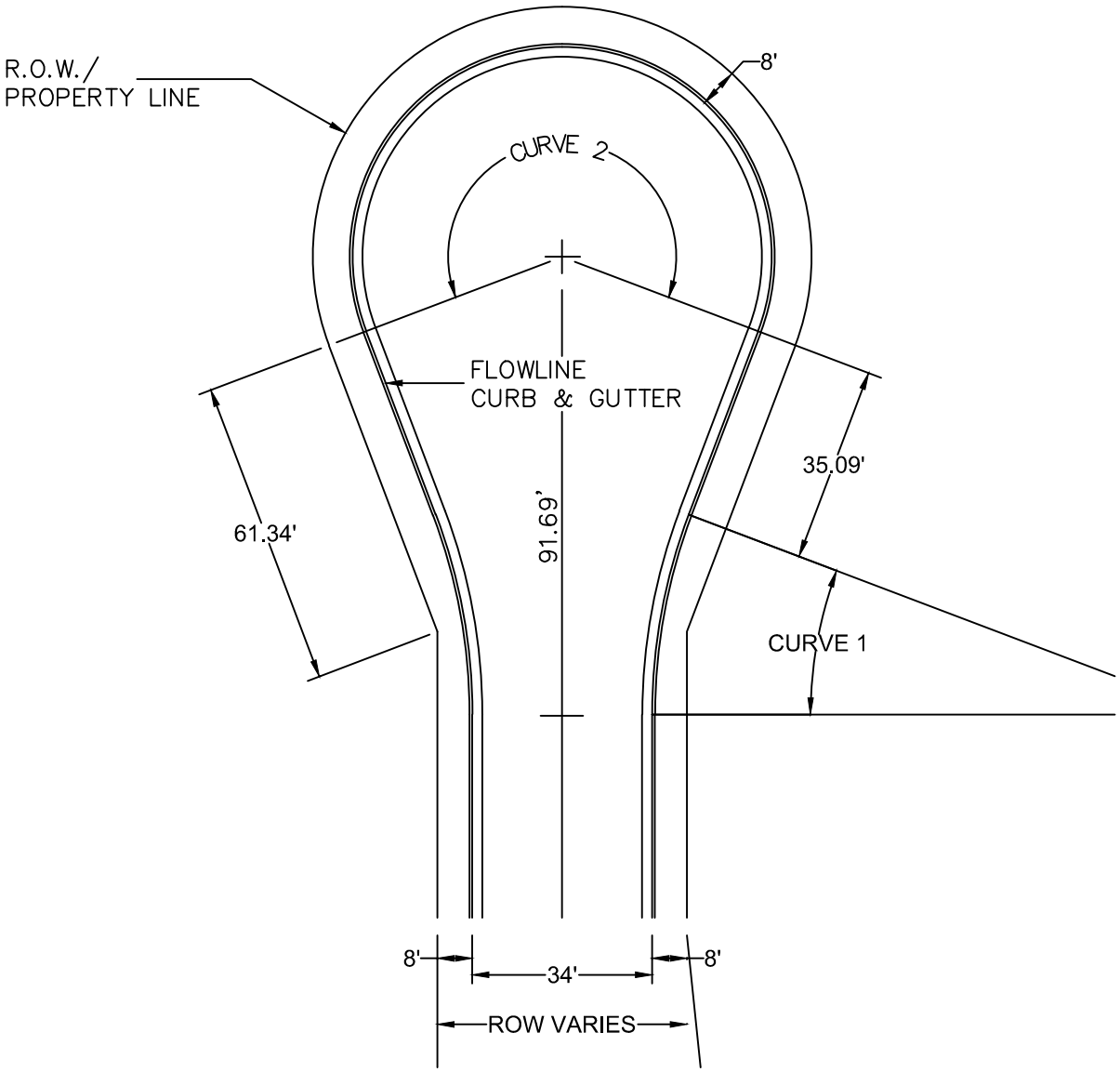
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

SIGHT DISTANCE

ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500−5



CURVE 1				CURVE 2				
△	CURB FLOWLINE			△	CURB FLOWLINE		R.O.W./PROP.	
	RADIUS	LENGTH	TANGENT		RADIUS	LENGTH	RADIUS	LENGTH
22° 18' 40"	113'	44.00'	22.28'	224° 37' 20"	43'	168.58'	50'	193.33'

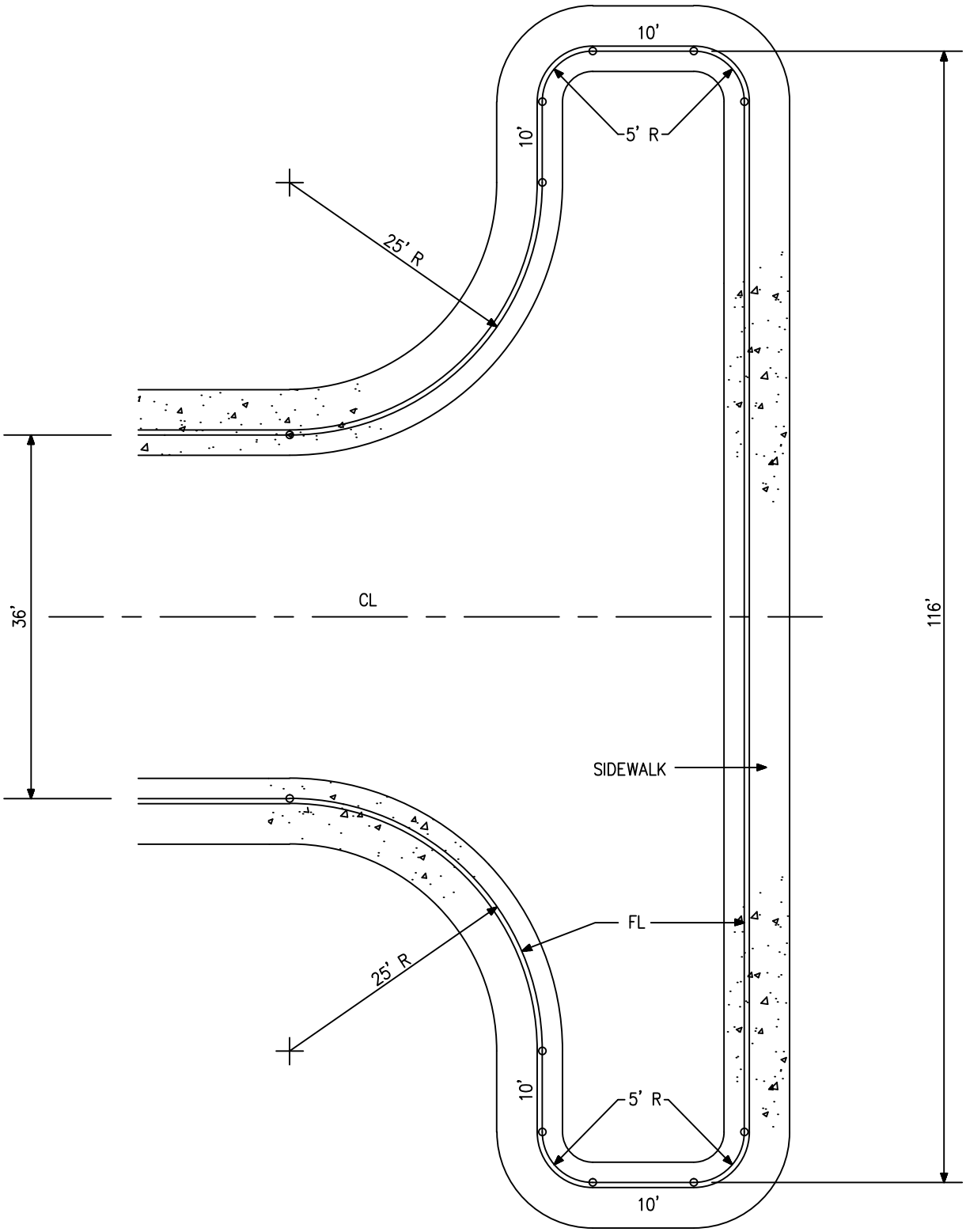
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

CUL-DE-SACS

ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500-6



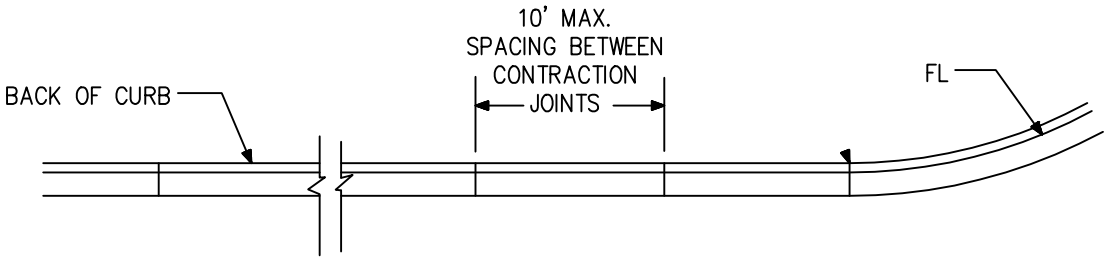
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

CUL-DE-SACS
HAMMERHEAD (PRIVATE)

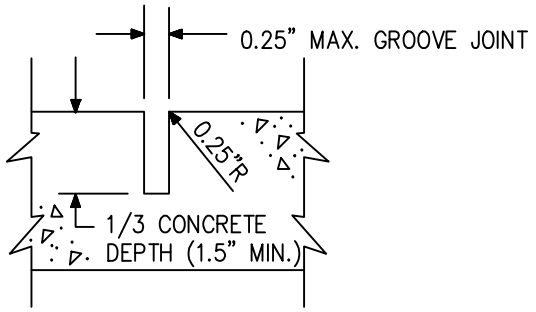
ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500-7

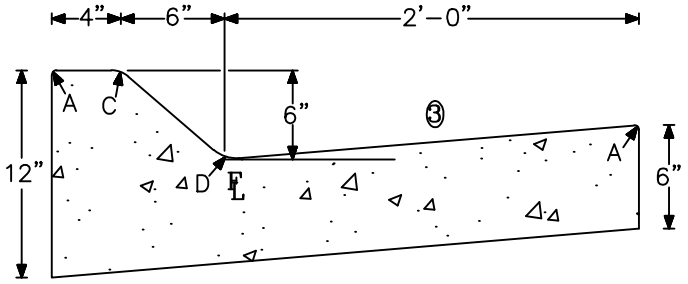


LAYOUT

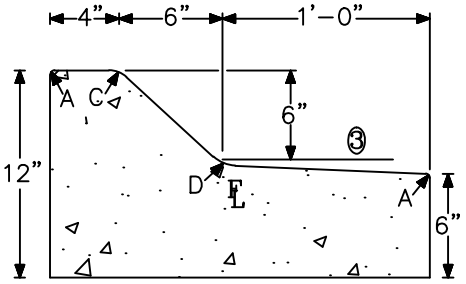
LEGEND FOR RADII
A = 1/8" TO 1/4"
B = 1"
C = 1-1/2"
D = 1-1/2" TO 2"



CONTRACTION JOINT



TYPE 2 CURB & GUTTER
(SECTION IIM)



TYPE 2 CURB & GUTTER
(SECTION IM)

NOTES:

1. ANY OVER-EXCAVATION SHALL BE REPLACED WITH GRANULAR BACKFILL COMPACTED TO 95% MAXIMUM DRY DENSITY AS DETERMINED BY ASTM D-698.
2. TYPE 2 SPILL CURB MAY BE REQUIRED FOR SPECIAL CONDITIONS.
3. GUTTER CROSS SLOPES SHALL BE 1/2"/FT. WHEN DRAINING AWAY FROM CURB AND 1"/FT. WHEN DRAINING TOWARD CURB.
4. CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

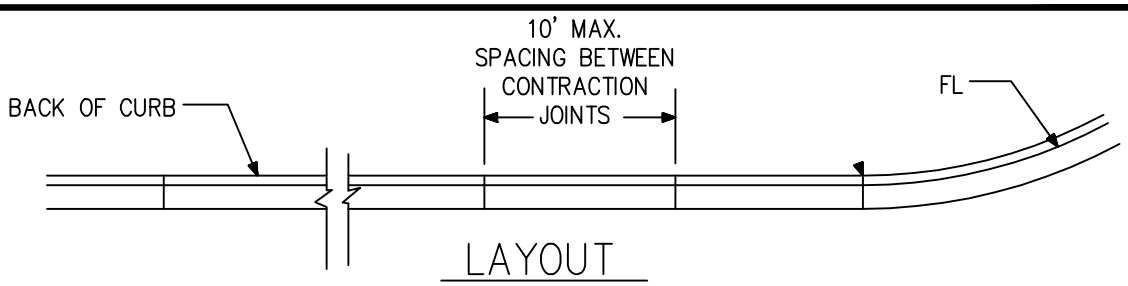
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

CURB AND GUTTER
TYPE 2 (SECTION IM)
TYPE 2 (SECTION IIM)

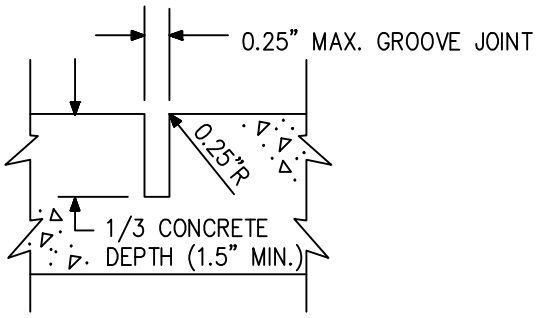
ISSUED:
DECEMBER 1998
REVISED:
APRIL 2010

DRAWING NO.
500-8

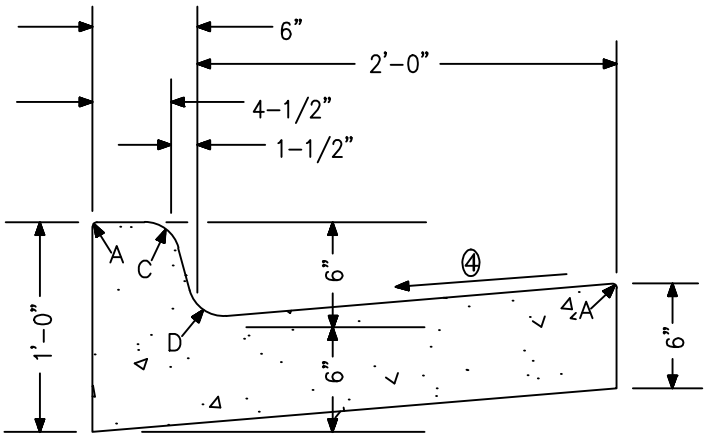


LAYOUT

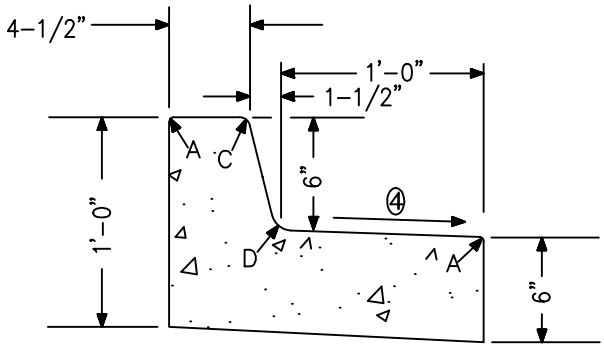
LEGEND FOR RADII
A = 1/8" TO 1/4"
B = 1"
C = 1-1/2"
D = 1-1/2" TO 2"



CONTRACTION JOINT



TYPE 2 CURB & GUTTER
SECTION IIB



TYPE 2 CURB & GUTTER
SECTION I B

NOTES:

1. TYPE 2 CURB & GUTTER IS FOR USE IN COMMERCIAL, ARTERIALS AND COLLECTOR STREETS.
2. ANY OVER-EXCAVATION SHALL BE REPLACED WITH GRANULAR BACKFILL COMPACTED TO 95% MAXIMUM DRY DENSITY AS DETERMINED BY ASTM D-698.
3. TYPE 2 SPILL CURB MAY BE REQUIRED FOR SPECIAL CONDITIONS.

④ GUTTER CROSS SLOPE SHALL BE 1/2" /FT. WHEN DRAINING AWAY FROM CURB AND 1" /FT. WHEN DRAINING TOWARD CURB.

5. CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

N.T.S.

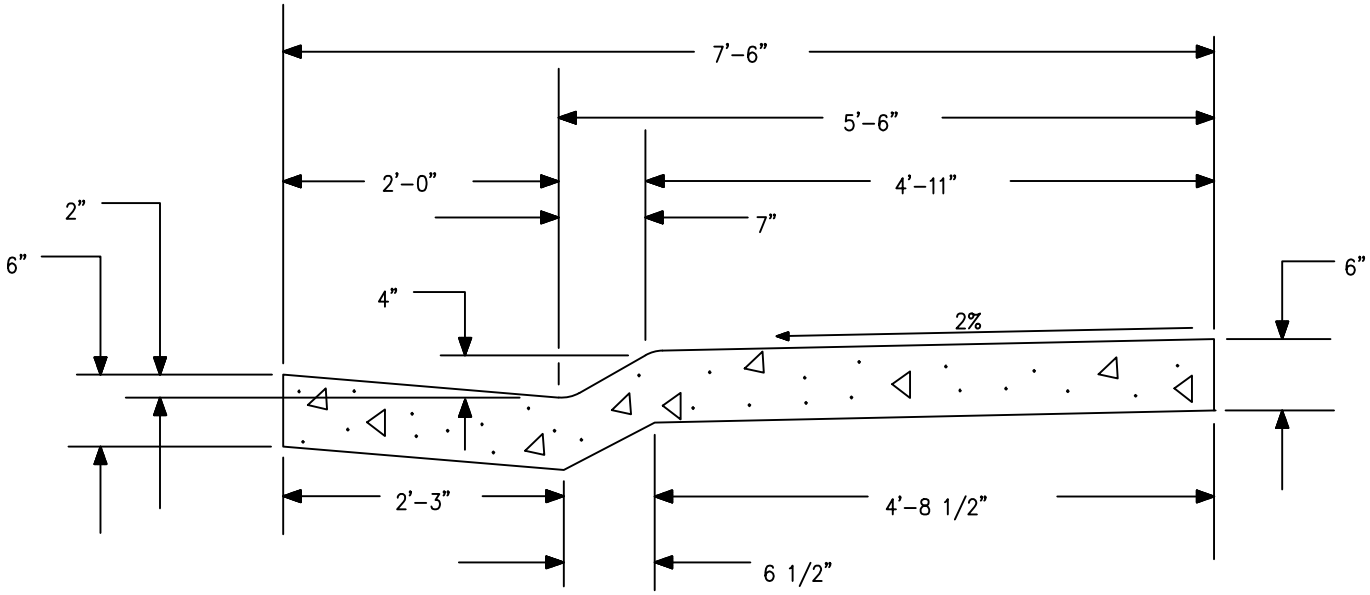
CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

CURB AND GUTTER
TYPE 2 (SECTION IB)
TYPE 2 (SECTION IIB)

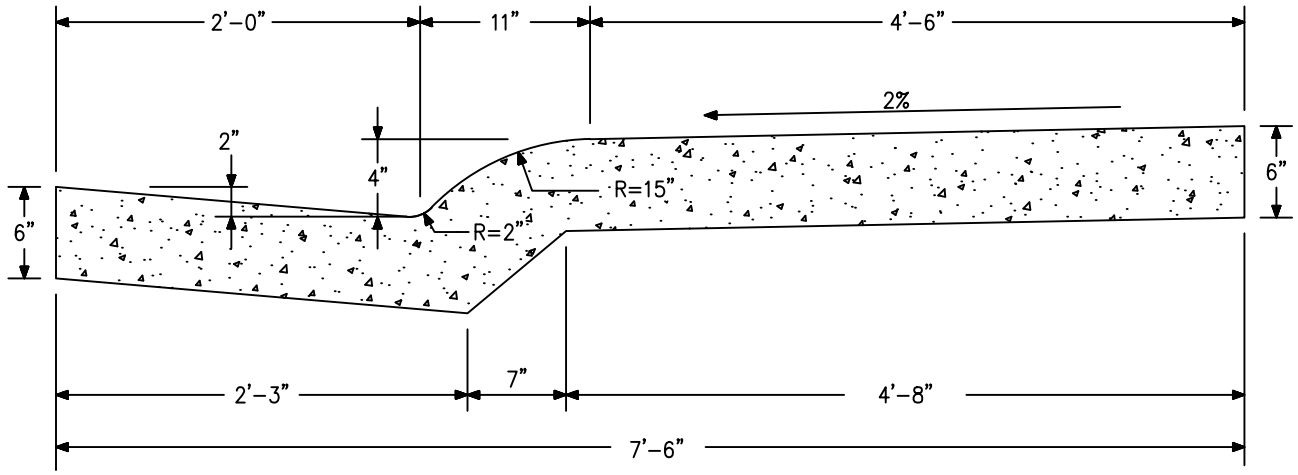
ISSUED:
DECEMBER 1998
REVISED:
APRIL 2010

DRAWING NO.
500-8A

NOTE:
CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600–CONCRETE.
4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT



LOCAL ATTACHED SECTION 1



LOCAL ATTACHED SECTION 2

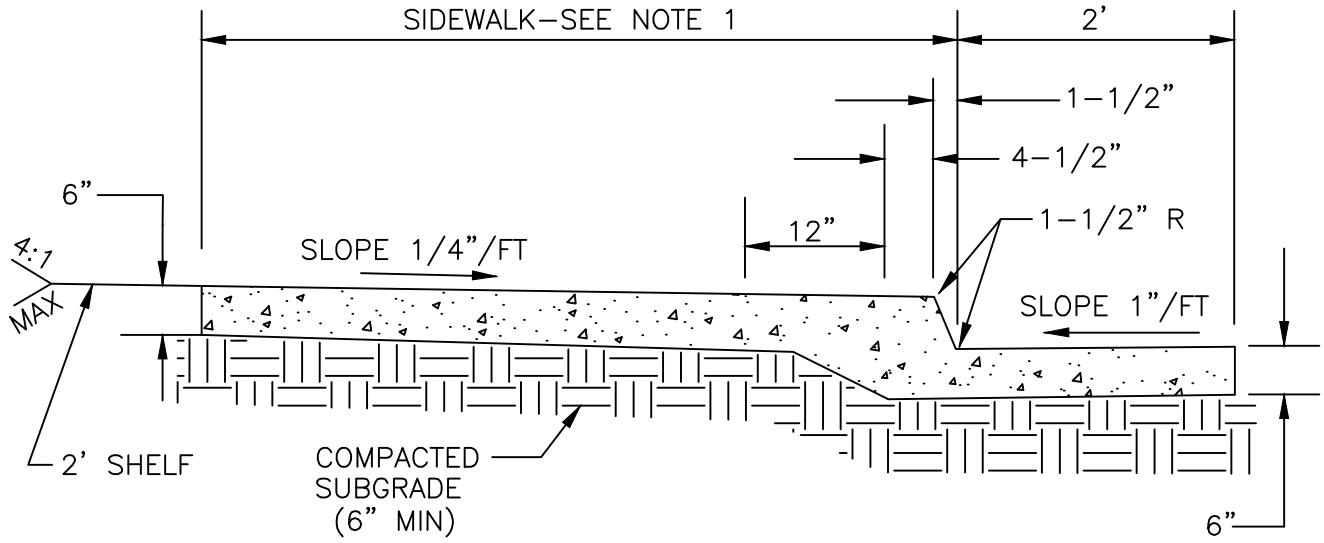
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPE 1 COMBINATION CURB, GUTTER AND SIDEWALK

ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500–9



NOTES

1. WIDTHS ARE TO BE 5'–6" IF STREET CLASSIFICATION IS LOCAL, 6'–6" IF STREET IS A COLLECTOR, 8'–6" IF STREET IS AN ARTERIAL OR 10'–6" IF SIDEWALK IS TO FUNCTION AS A BIKE TRAIL. DIMENSIONS ARE TO BE INCLUDED IN DETAILED CONSTRUCTION PLANS.
2. CONCRETE SHALL INCLUDE FIBER MESH.
3. SIDEWALK, CURB AND GUTTER SHALL BE POURED MONOLITHICALLY.
4. SEE DETAIL 500–8 FOR JOINT DETAILS AND COMPACTION NOTES.
5. CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600–CONCRETE. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

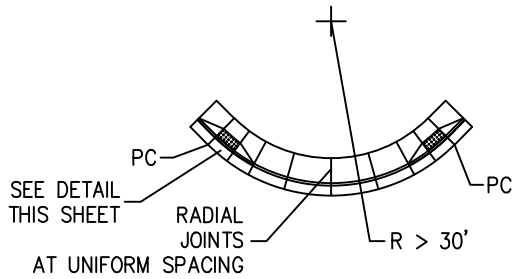
N.T.S.

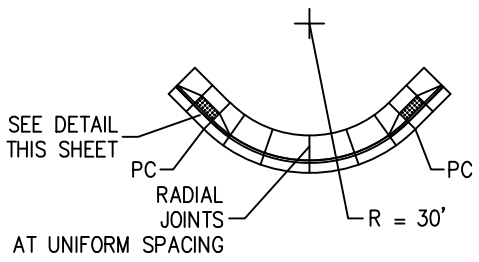
CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPE IIB INTEGRAL SIDEWALK AND BIKE PATH

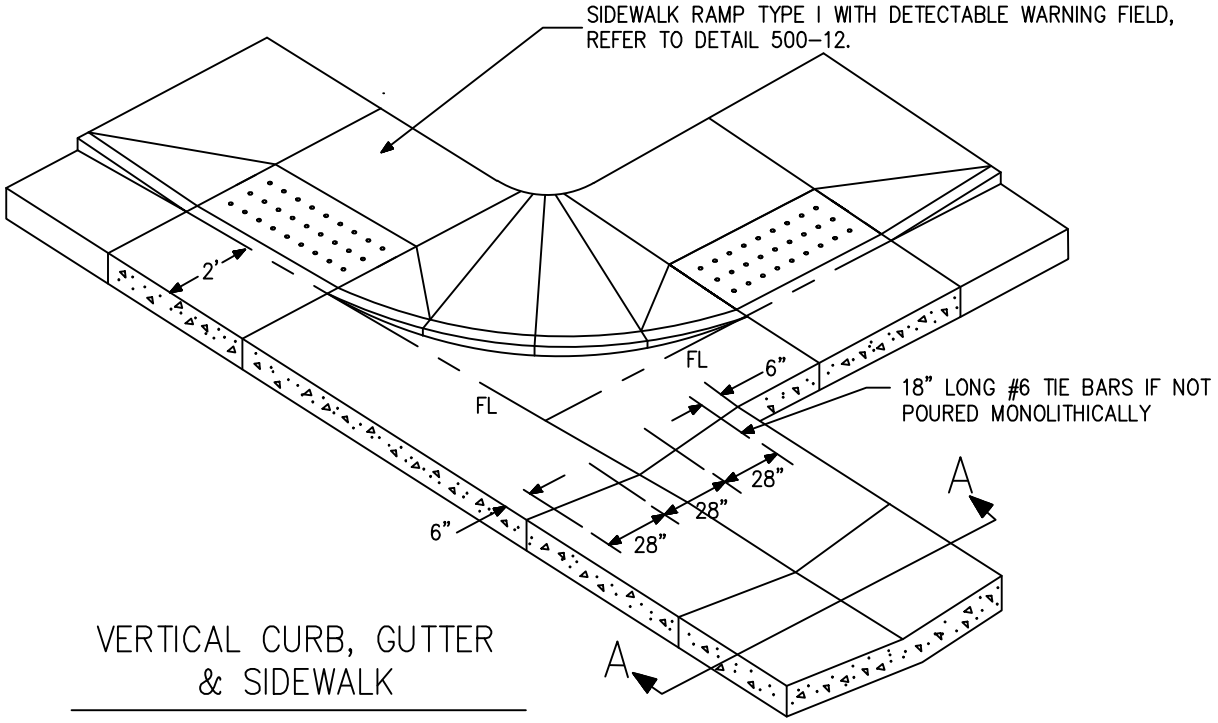
ISSUED:
JUNE 1995
REVISED:
APRIL 2010

DRAWING NO.
500–9A

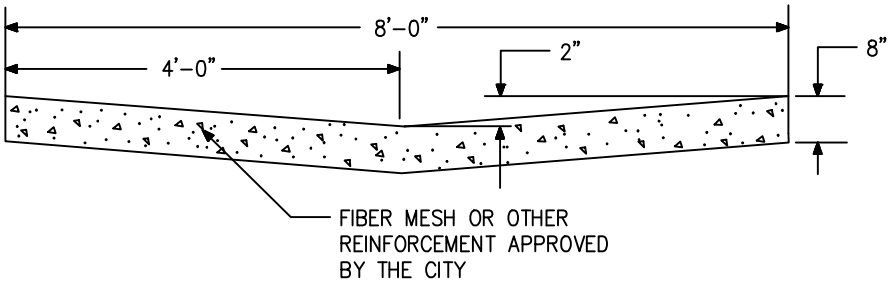




DIRECTIONAL RAMP LOCATIONS WITH ATTACHED SIDEWALK



VERTICAL CURB, GUTTER & SIDEWALK



SECTION A-A

NOTE:
CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE.
4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

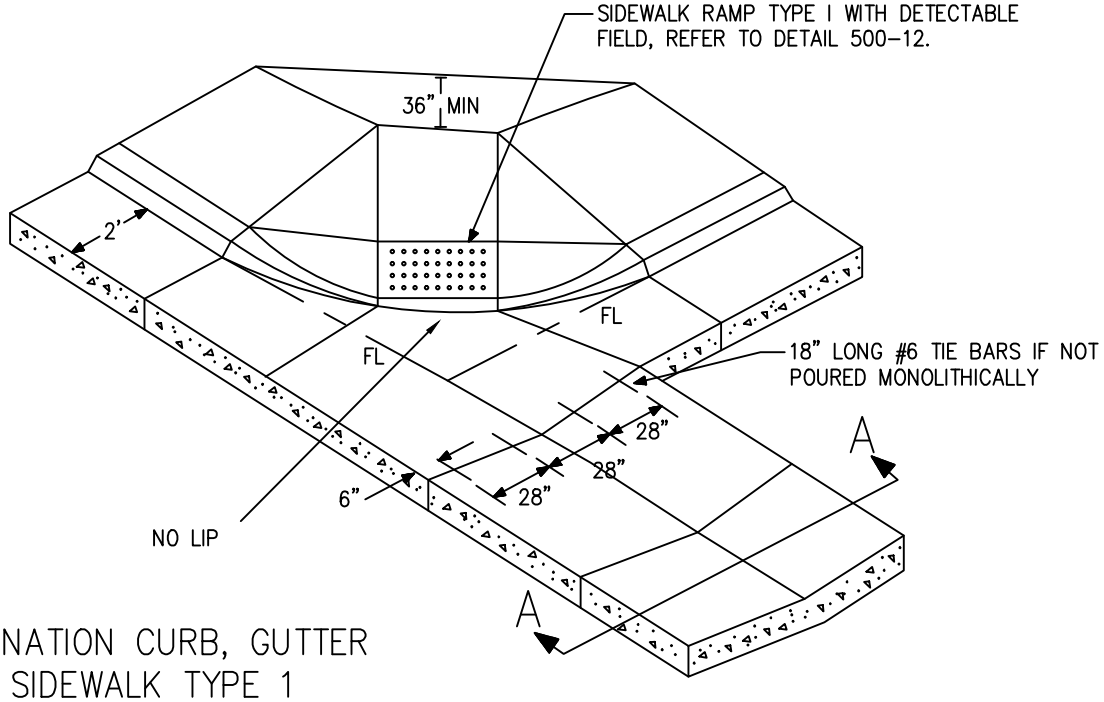
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

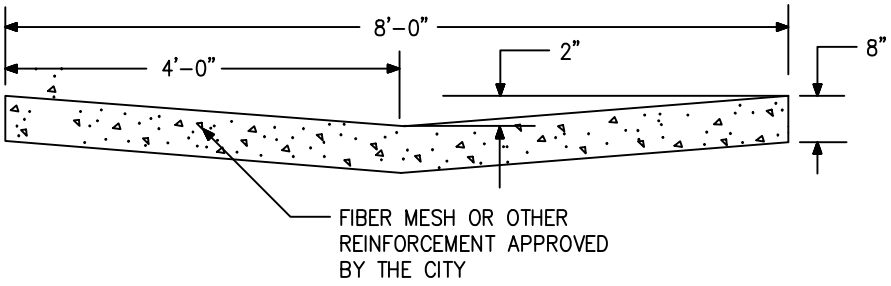
SQUARED RADIUS WITH CROSS PAN FOR ARTERIALS AND COLLECTORS

ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500-10



COMBINATION CURB, GUTTER & SIDEWALK TYPE 1



SECTION A-A

NOTE:
CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE.
4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

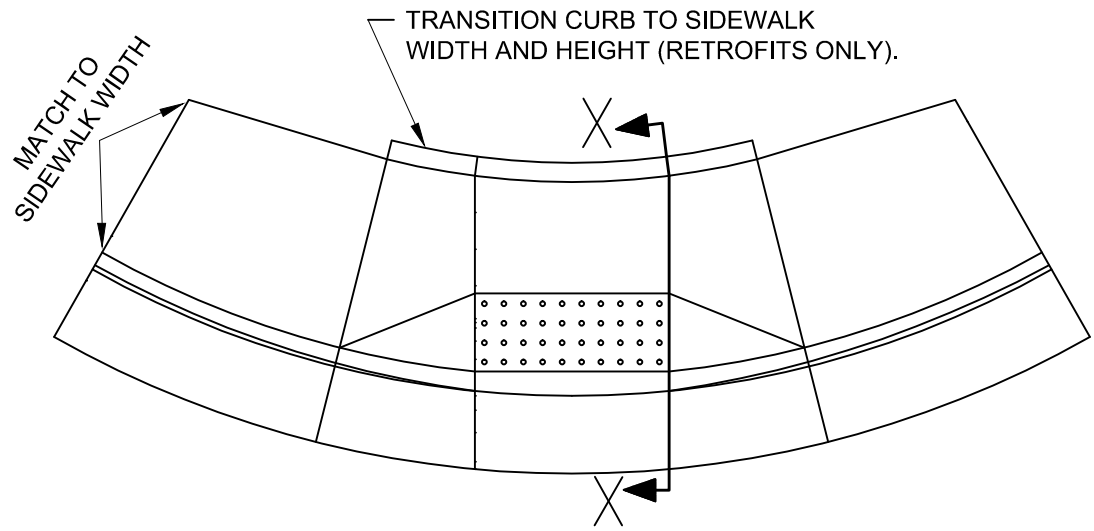
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

SQUARED RADIUS WITH CROSS PAN FOR LOCAL STREETS

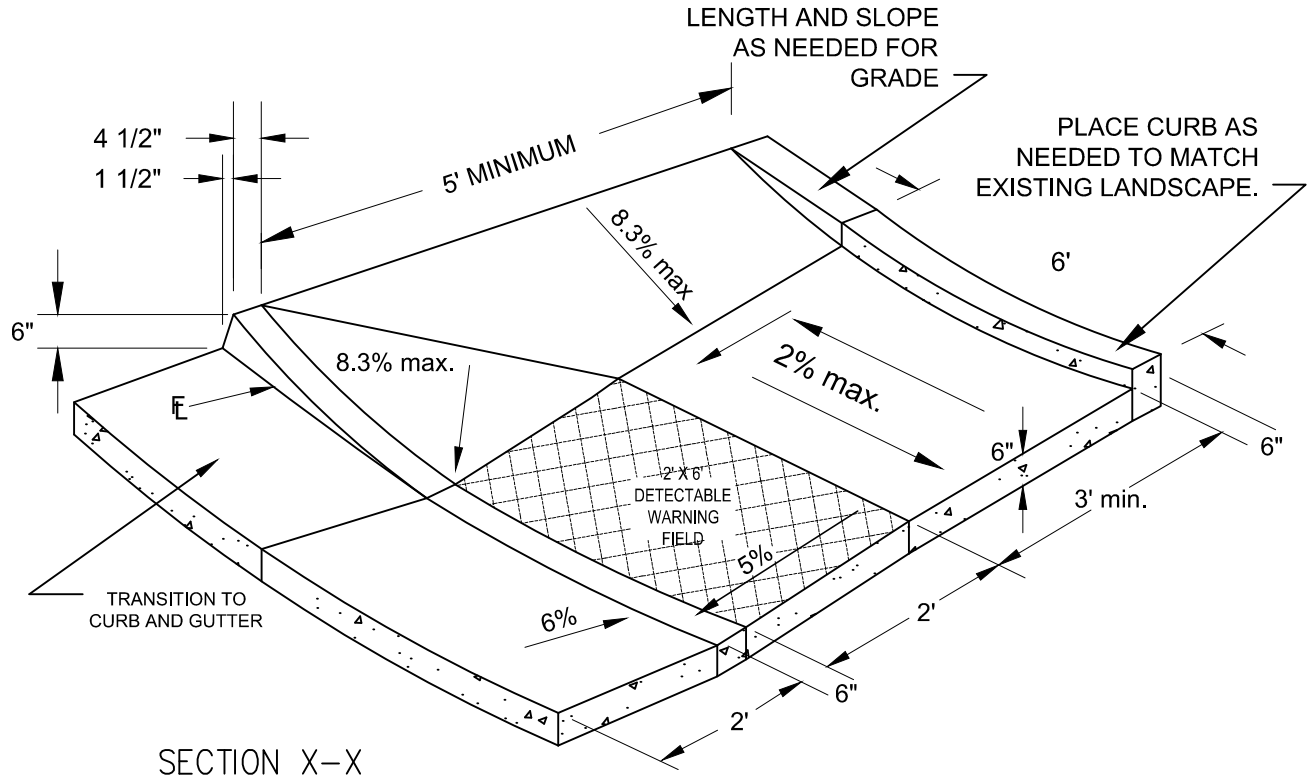
ISSUED:
APRIL 1992
REVISED:
APRIL 2010

DRAWING NO.
500-11



NOTES

1. DETECTABLE WARNING FIELD SHALL BE CAST-IN-PLACE RED EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. CONCRETE SHALL CONFORM TO THE STANDARDS AND SPECIFICATIONS SECTION 600-CONCRETE WORK. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT
3. CHANGES IN GRADE SHALL NOT EXCEED 11%.



SECTION X–X

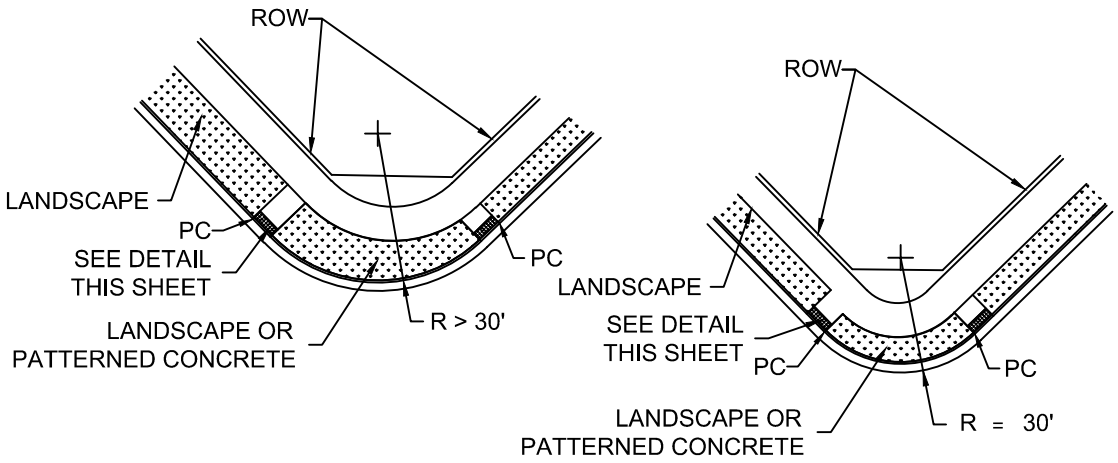
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPE I SIDEWALK RAMP – LOCAL STREETS (APEX)

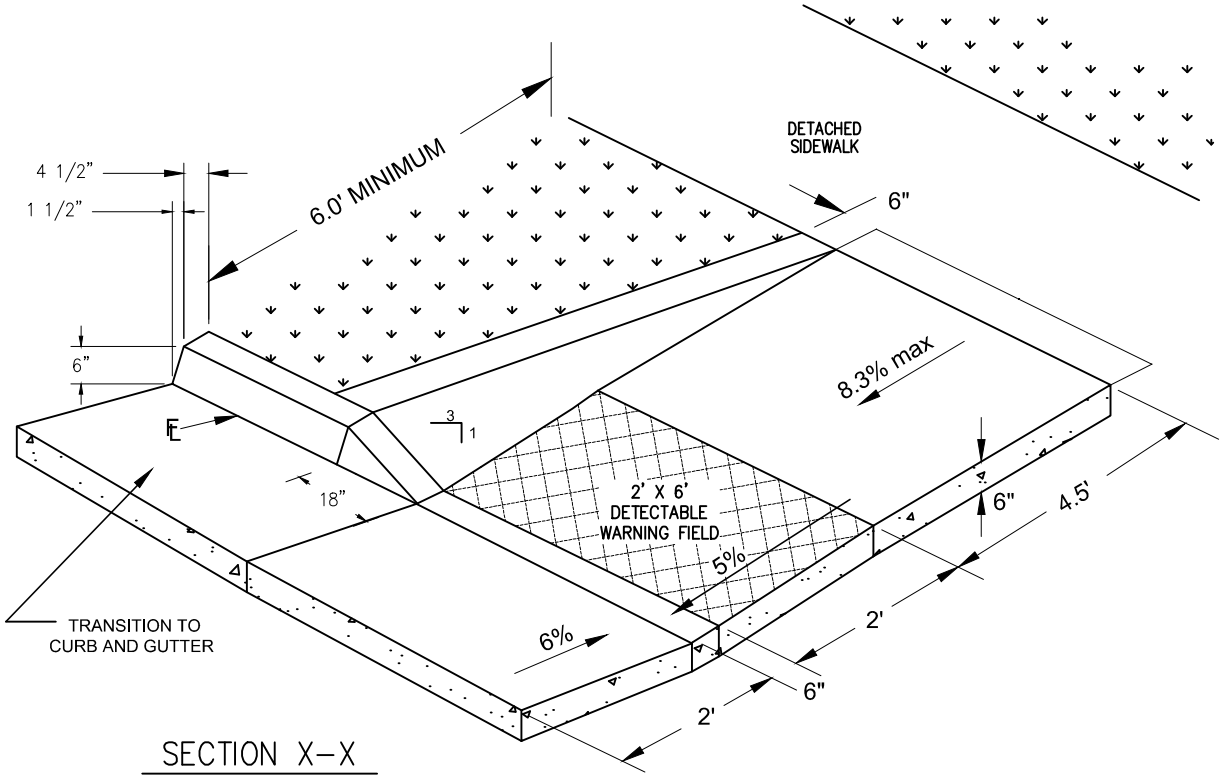
ISSUED:
APRIL 2010
REVISED:

DRAWING NO.
500–12



NOTES

1. DETECTABLE WARNING FIELD SHALL BE CAST-IN-PLACE RED EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. CONCRETE SHALL CONFORM TO THE STANDARDS AND SPECIFICATIONS SECTION 600-CONCRETE WORK. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT
3. CHANGES IN GRADE SHALL NOT EXCEED 11%.



SECTION X–X

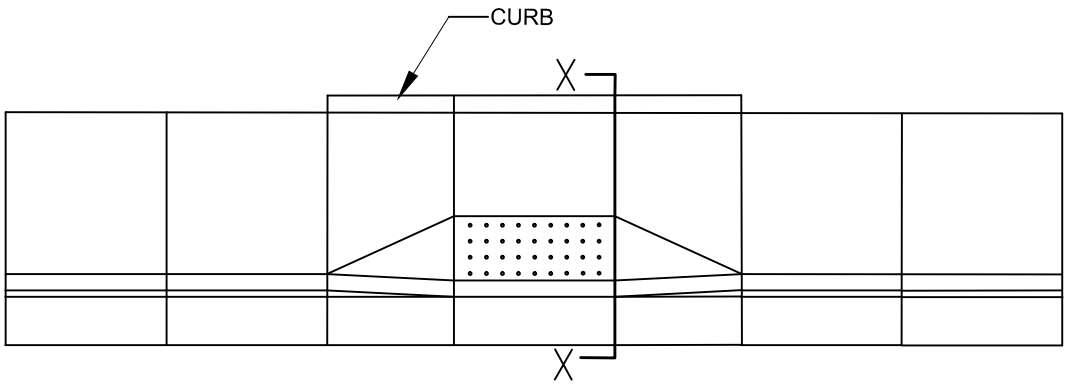
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPE II SIDEWALK RAMP – COLLECTOR/ARTERIAL (DIRECTIONAL)

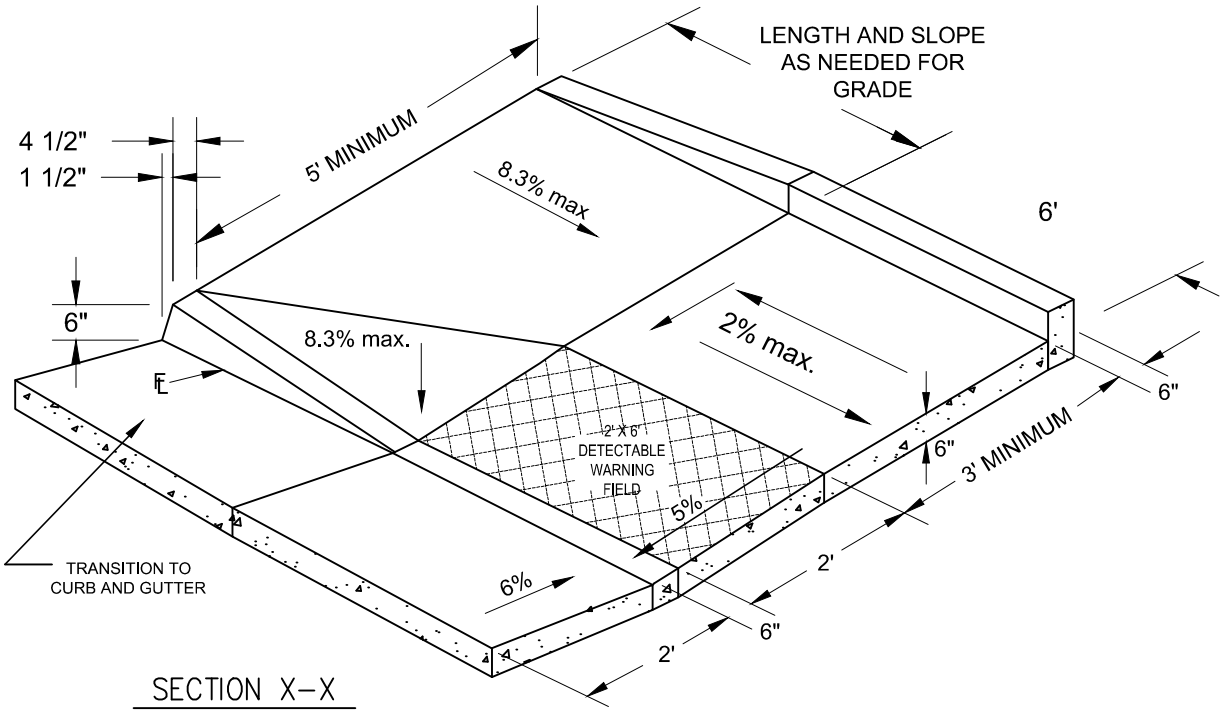
ISSUED:
APRIL 2010
REVISED:

DRAWING NO.
500–13



NOTES

1. DETECTABLE WARNING FIELD SHALL BE CAST-IN-PLACE RED EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. CONCRETE SHALL CONFORM TO THE STANDARDS AND SPECIFICATIONS SECTION 600-CONCRETE WORK. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT
3. CHANGES IN GRADE SHALL NOT EXCEED 11%.



SECTION X–X

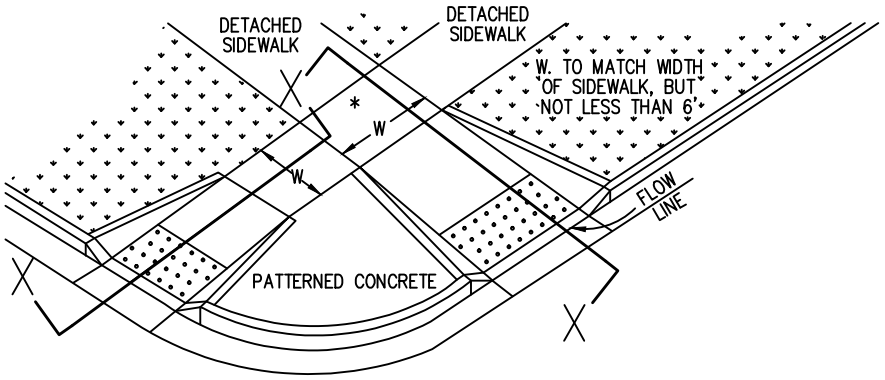
N.T.S.

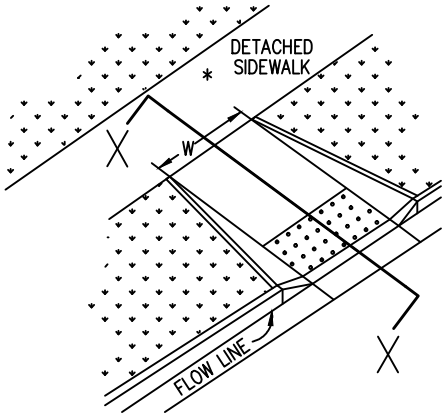
CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TYPE III SIDEWALK RAMP (TEE)

ISSUED:
APRIL 2010
REVISED:

DRAWING NO.
500–14

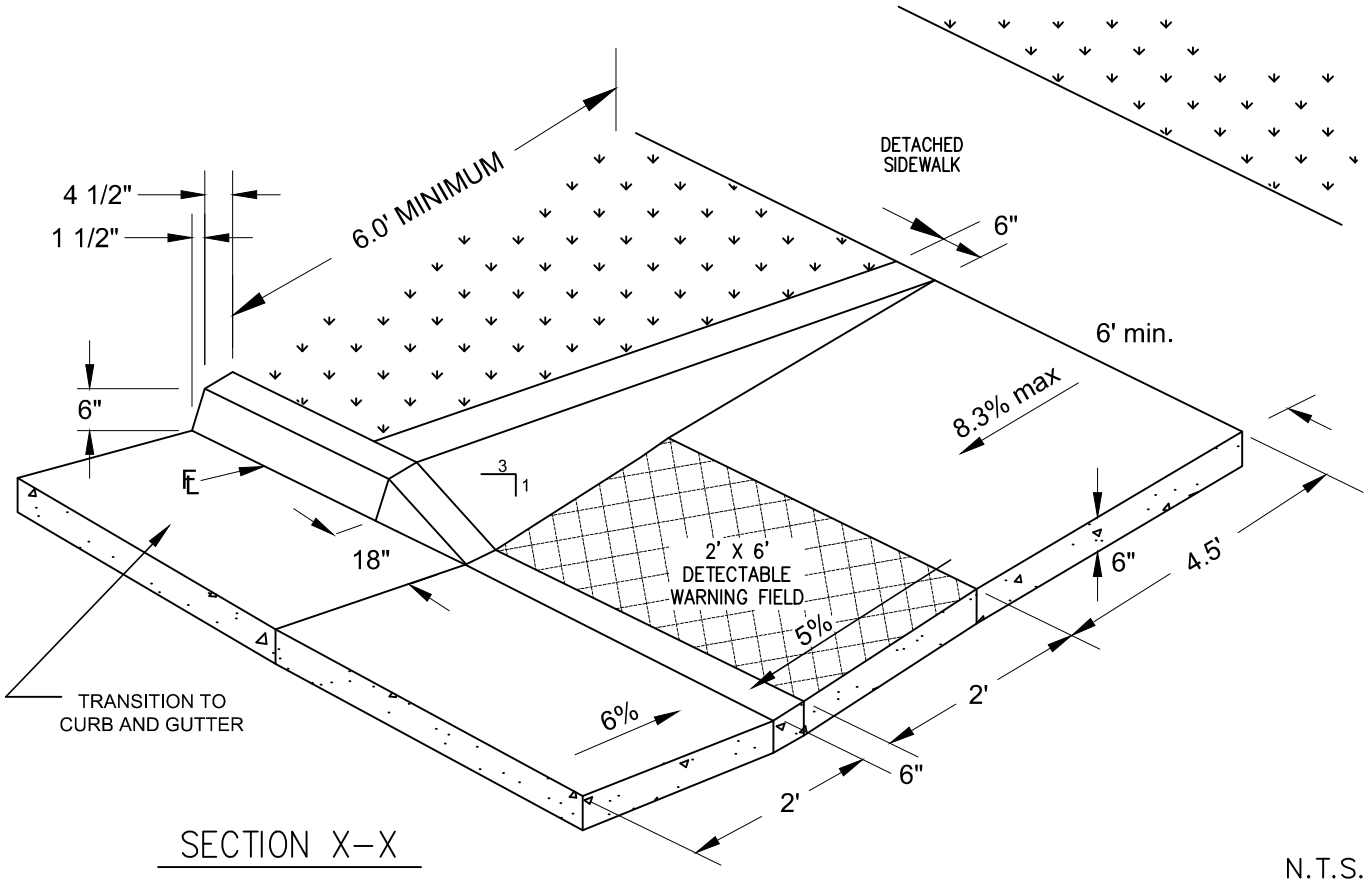




* SLOPE MUST BE < 2.0% IN BOTH DIRECTIONS

NOTES

1. DETECTABLE WARNING FIELD SHALL BE CAST-IN-PLACE RED EAST JORDAN IRON WORKS OR APPROVED EQUAL.
2. CONCRETE SHALL CONFORM TO THE STANDARDS AND SPECIFICATIONS SECTION 600-CONCRETE WORK. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT
3. CHANGES IN GRADE SHALL NOT EXCEED 11%.



SECTION X–X

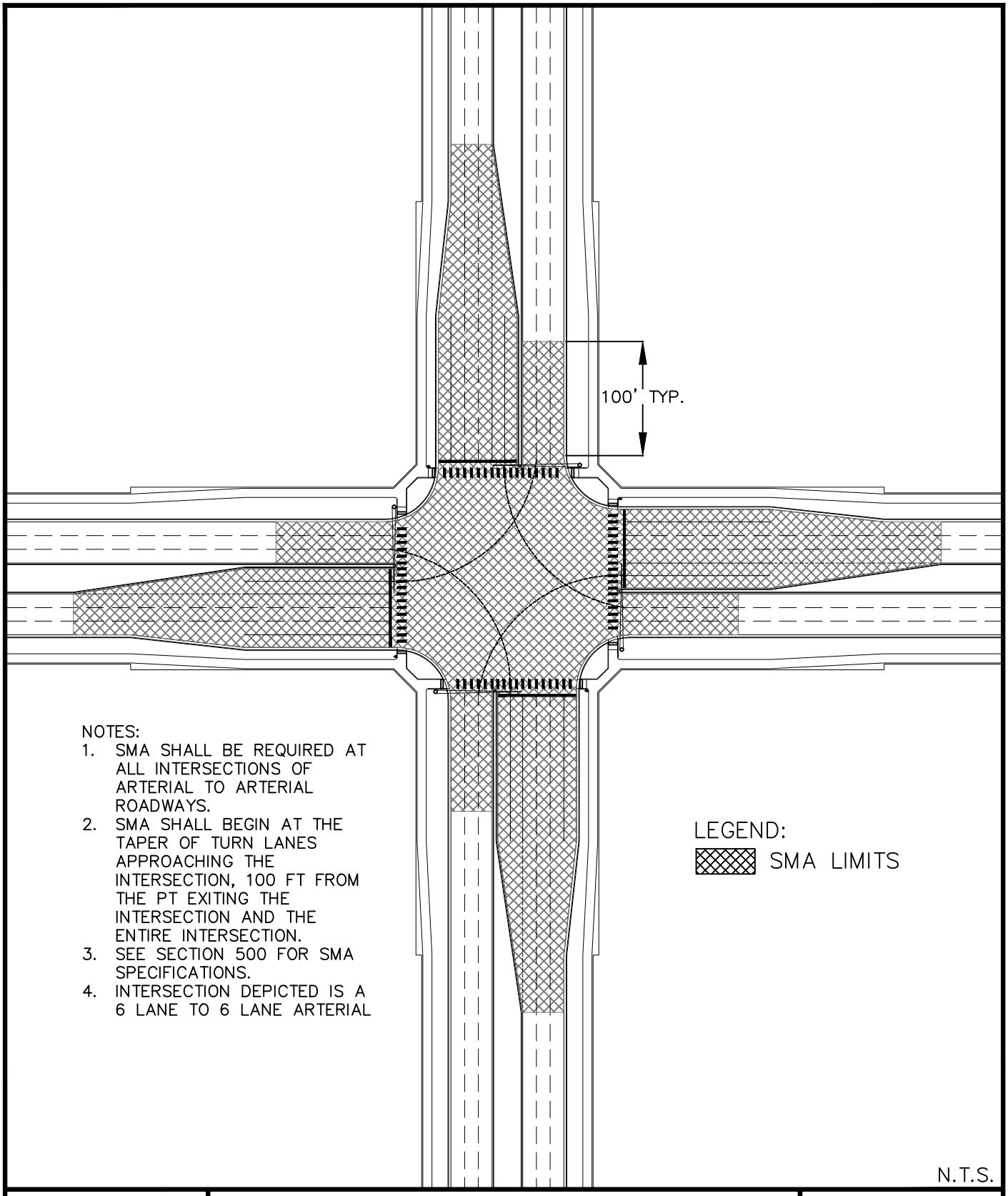
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

DIRECTIONAL SIDEWALK RAMP – DETACHED SIDEWALK

ISSUED: APRIL 2010
REVISED:

DRAWING NO. 500–15



NOTES:
1. SMA SHALL BE REQUIRED AT ALL INTERSECTIONS OF ARTERIAL TO ARTERIAL ROADWAYS.
2. SMA SHALL BEGIN AT THE TAPER OF TURN LANES APPROACHING THE INTERSECTION, 100 FT FROM THE PT EXITING THE INTERSECTION AND THE ENTIRE INTERSECTION.
3. SEE SECTION 500 FOR SMA SPECIFICATIONS.
4. INTERSECTION DEPICTED IS A 6 LANE TO 6 LANE ARTERIAL

LEGEND:
SMA LIMITS

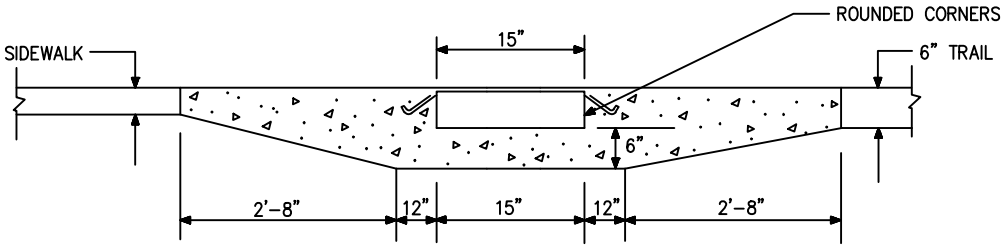
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

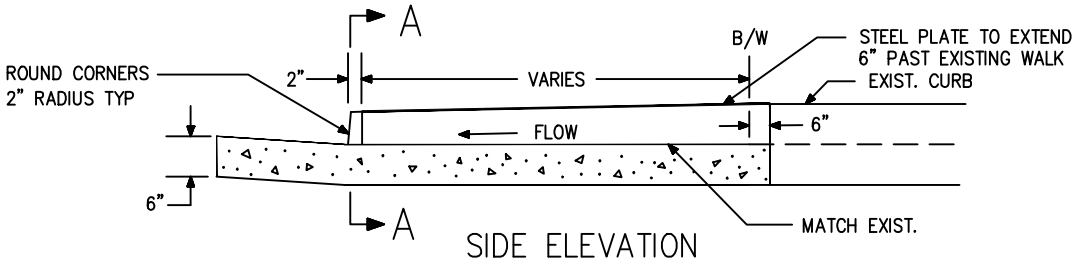
STONE MASTIC ASPHALT (SMA) TOP LIFTS

ISSUED:
APRIL 2010
REVISED:

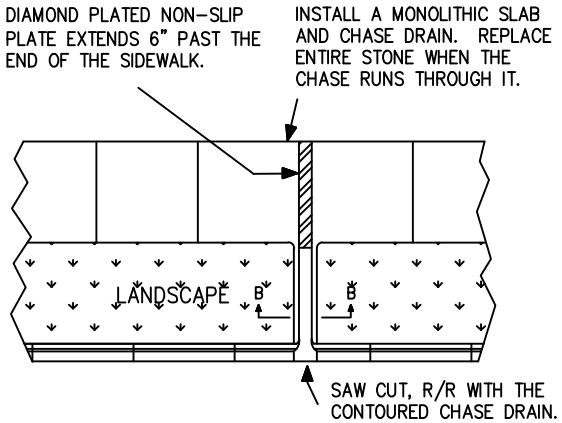
DRAWING NO.
500–16



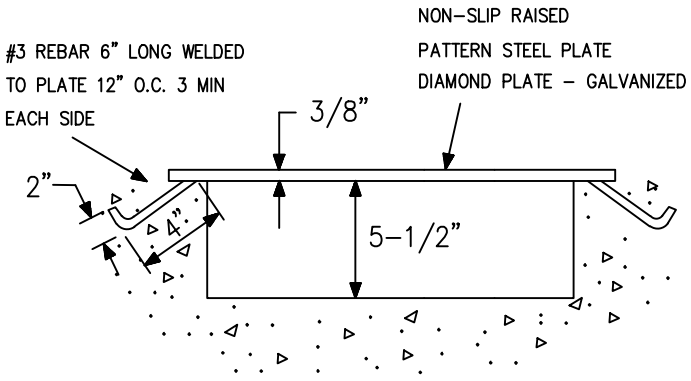
FRONT ELEVATION



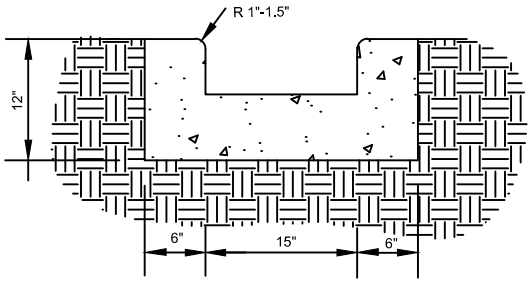
SIDE ELEVATION



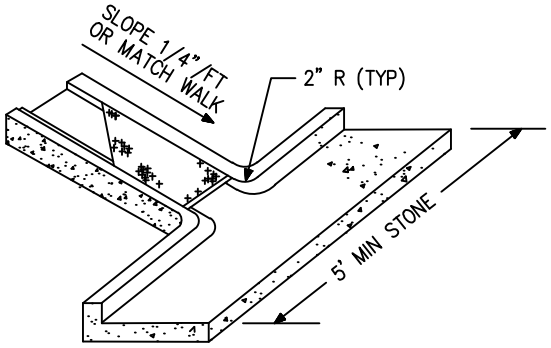
LANDSCAPE BUFFER
PLAN VIEW



SECTION A-A



LANDSCAPE BUFFER
SECTION B-B



NOTE:
CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE.
4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

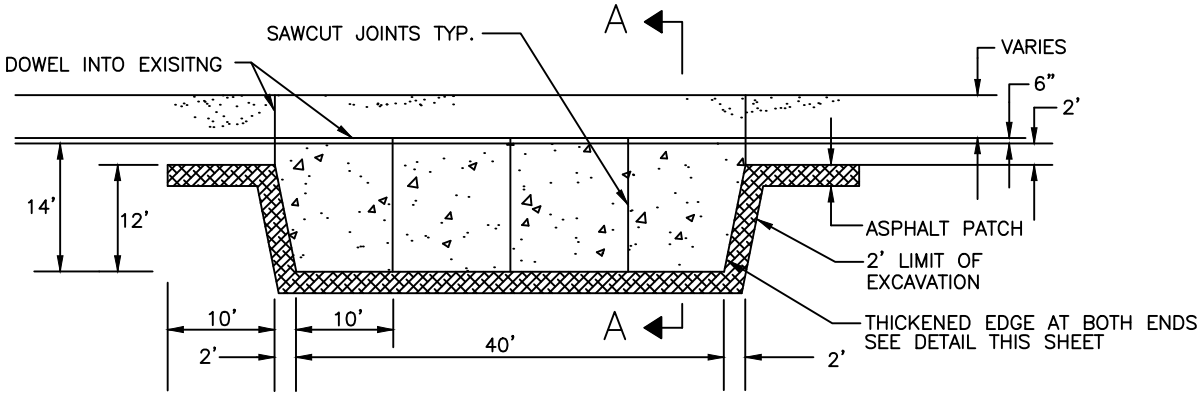
N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

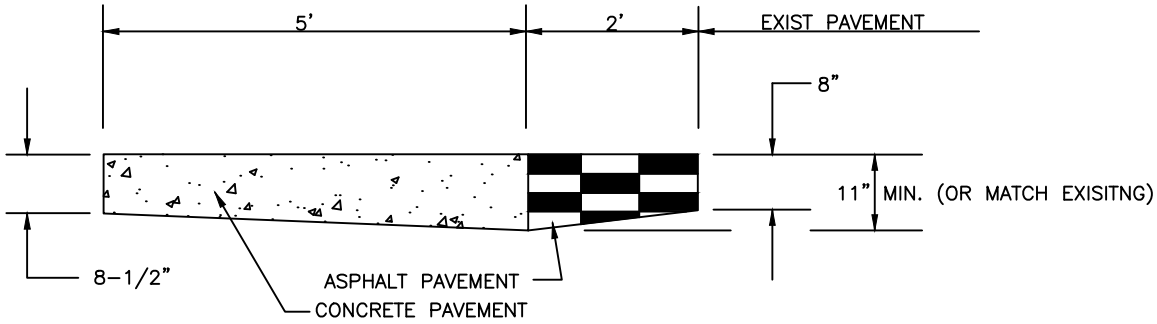
CONCRETE SIDEWALK CHASE DRAIN (FOR COMMERCIAL, COMMON AREAS, AND DETACHED)

ISSUED:
APRIL 1992
REVISED:
MAY 2010

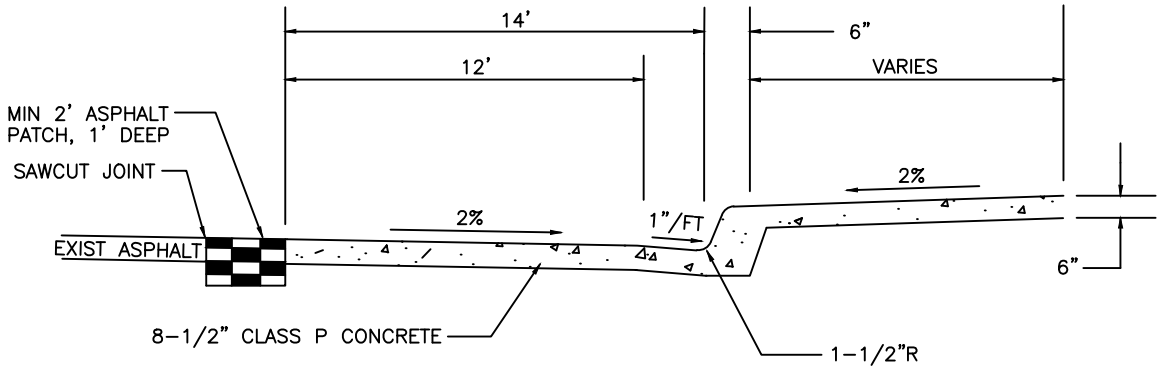
DRAWING NO.
500-17



PLAN



THICKENED EDGE



SECTION A-A

NOTE:
CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE.
4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT

N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

CONCRETE BUS PAD

ISSUED:
MAY 1995
REVISED:
APRIL 2010

DRAWING NO.
500-18

Form 500-19

• Mixture Design Requirements for Hot Mix Asphalt Pavements (HMA)

Developer/Owner: _____ Paving Contractor: _____

Date: _____ Subdivision/Project Name: _____

- Project Special Provision Sheet for Hot Mix Asphalt Pavements (HMA)

Roadway Classification: _____
(examples: Local , Collector, Arterial, Parking Lot or actual name for Project)

Construction Application: ❑ Top Lift ❑ Intermediate Lift(s) ❑ Bottom Lift
❑ Patching ❑ Other _____

Aggregate Gradation:
- ❑ Grading SX (2.0" to 2.5" lifts)
- ❑ Grading S (2.5" to 3.5" lifts)
- ❑ Grading SG (3.5" to 5.0" lifts) - for lower lift(s) only, may need approval of surface texture by Agency
- ❑ SMA (2.5" to 3.5") - Top Lift Only
  The SMA gradation for this project shall be _____

RAP Quantity, Maximum: ❑ 0% ❑ 15% ❑ 20% ❑ 25%

Notes: A quality control plan for RAP will be required when RAP is used
Top lift Maximum RAP content allowed is 20%

Superpave Gyratory Mix Design Compaction Level usage and binder(s):

Design Level	Traffic Levels	PG Binder(s)	
❑ N_{design}=50	Low volume	❑ PG 58-28	❑ PG 64-22
❑ N_{design}=75	0 to <3 million ESALs	❑ PG 64-22	❑ PG 58-28
❑ N_{design}=100	3 million to <30 million ESALs	❑ PG 64-22	❑ PG 76-28

Notes:
- The binders are shown in order they should be considered.
- PG 76-28 polymer modified PG Binders are required in the top lift only on arterial roadways
- PG 58-28 Binder recommended for residential developments with less than 100,000 ESAL's

- Target Job Mix Optimum Binder Content for HMA gradings as close to 4.0% air voids as possible (3.5% to 4.5% air voids)
- Target Job Mix Optimum Binder content for SMA gradings at 3.0% to 4.0% air voids

---

A completed Form 500-19 shall supplement the City of Thornton Standards and Specifications for the Design of Public and Private Improvements defining the project specific requirements of Hot Mix Asphalt Pavement (HMA) and Stone Matrix Asphalt (SMA). Refer to the Standards and Specifications Section 504 for details.

N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

HOT MIX ASPHALT (HMA) PAVEMENT MIX DESIGN

ISSUED: APRIL 2010
REVISED:

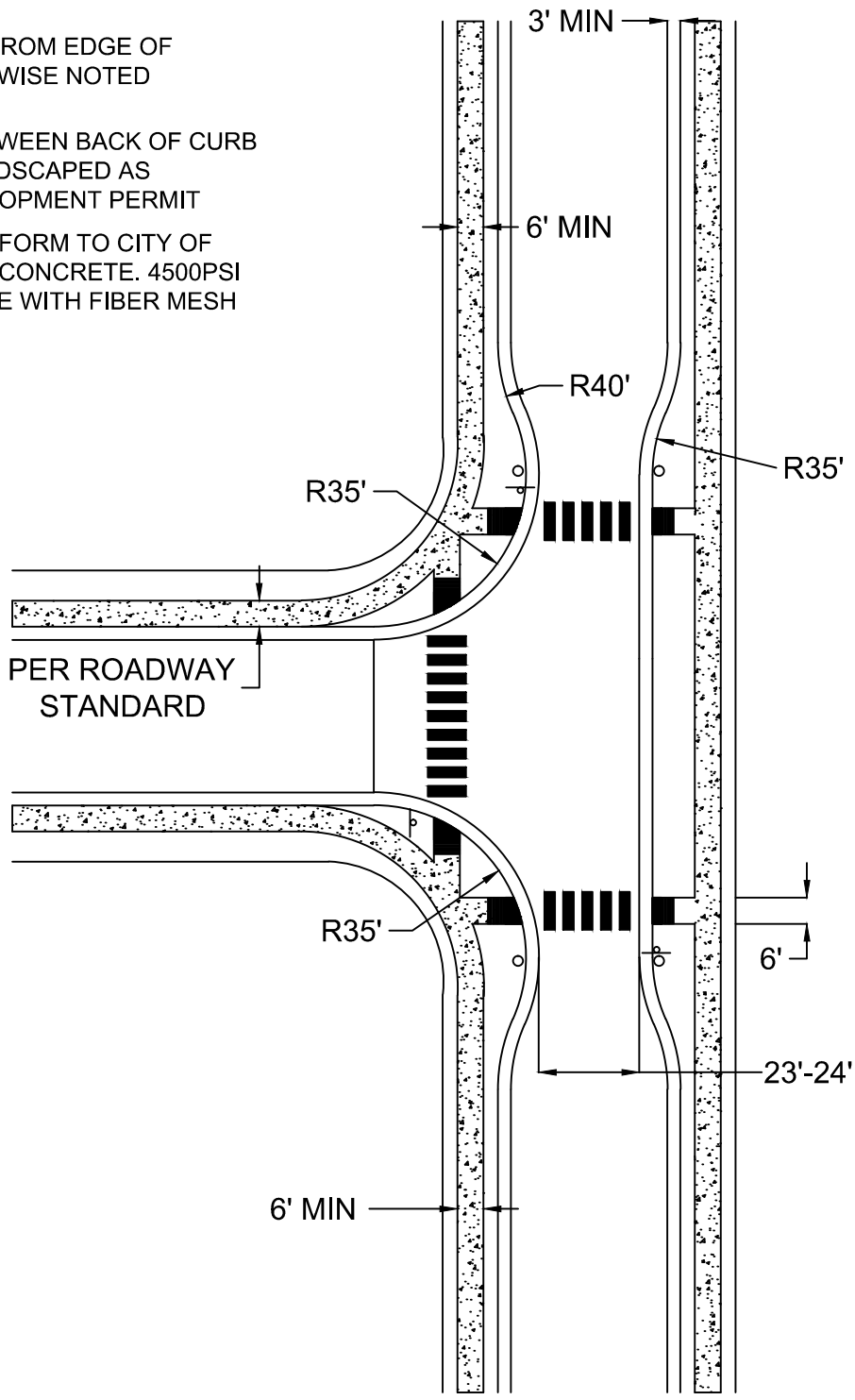
DRAWING NO. 500-19

NOTES:
1 RADIUSES ARE MEASURED TO FLOW LINE

2. MEASUREMENTS ARE FROM EDGE OF ASPHALT UNLESS OTHERWISE NOTED

3. MEDIAN AND AREA BETWEEN BACK OF CURB AND WALK SHALL BE LANDSCAPED AS APPROVED IN THE DEVELOPMENT PERMIT

4. CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT



N.T.S.

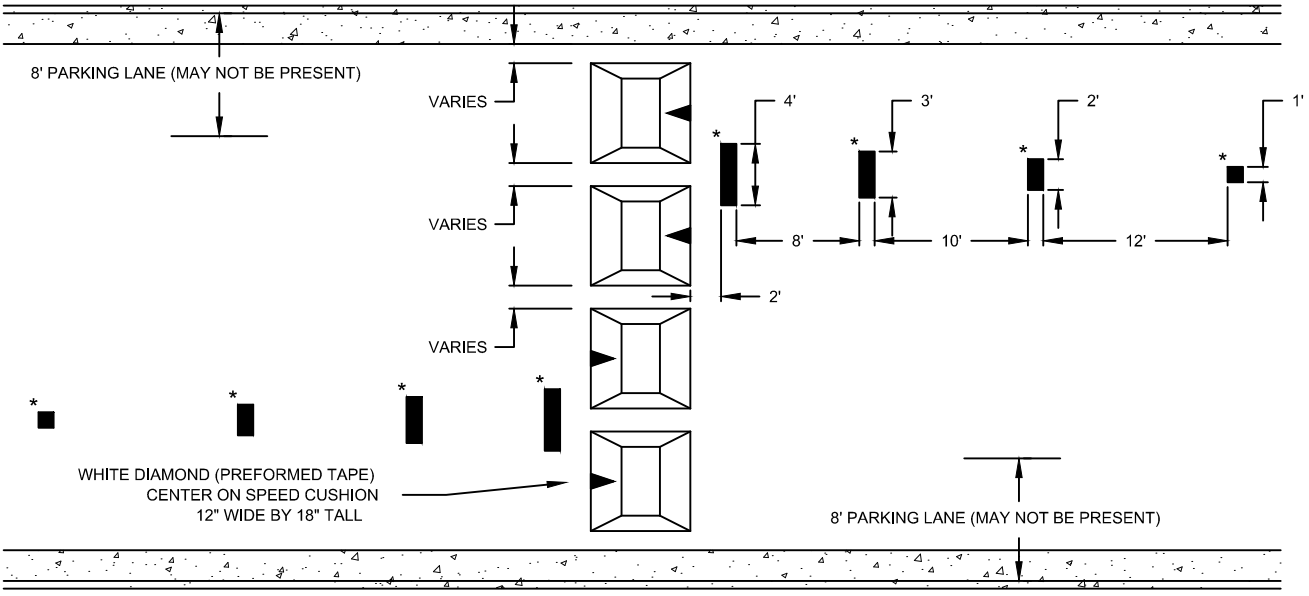
CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

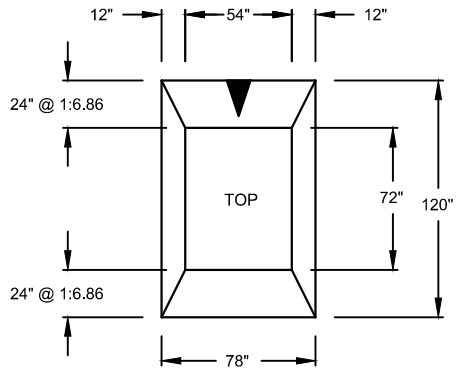
TRAFFIC CALMING
CURB EXT. @ T-INTERSECTION

ISSUED:
AUG 2012
REVISED:

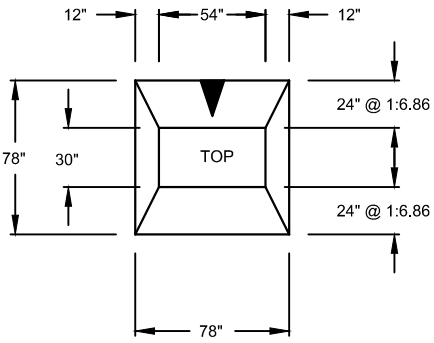
DRAWING NO.
500-20

* 12" WHITE STRIPE (PREFORMED PLASTIC TAPE)
CENTER ON SPACE BETWEEN SPEED CUSHIONS (4 CUSHION LOCATIONS)
CENTER ON OUTSIDE SPEED CUSHION (3 CUSHION LOCATIONS)





TYPICAL EXTENDED SPEED CUSHION
(3.5" HIGH)



TYPICAL SPEED CUSHION
(3.5" HIGH)

N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

SPEED CUSHION AND PAVEMENT MARKINGS LAYOUT

ISSUED:
AUG 2012
REVISED:

DRAWING NO.
500-21

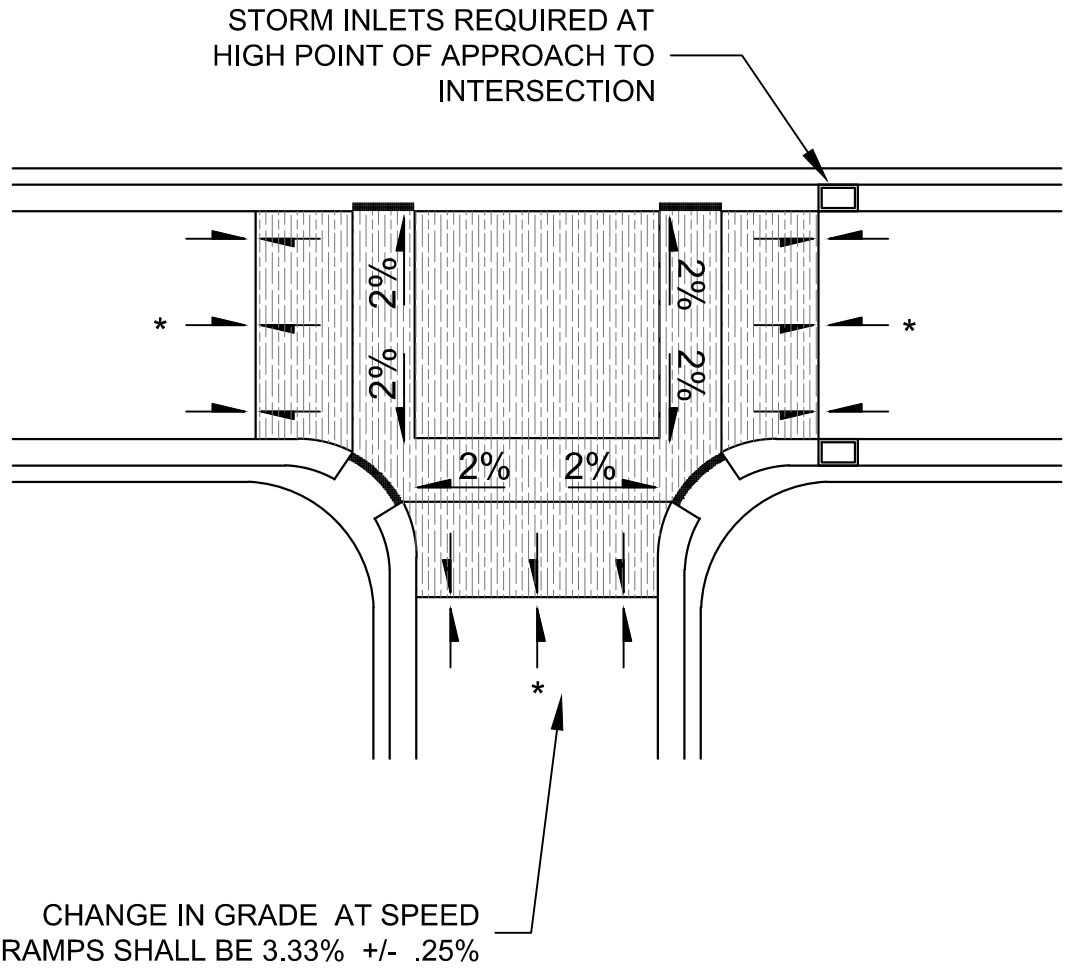
1. COLORADO PATTERN CONCRETE SHALL BE DAVIS FLAGSTAFF BROWN.

2. CONTRACTOR IS RESPONSIBLE FOR PROVIDING FINAL JOINTING AND REINFORCEMENT LAYOUT TO CITY FOR APPROVAL.

3. INLETS SHALL BE CONSTRUCTED WITH A 4" OPENING INSTEAD OF THE TYPICAL 6" OPENING DEPTH.

4. THE INSPECTION OF FORMS IS REQUIRED BY THE CITY PRIOR TO POURING / PLACEMENT OF CONCRETE.

5. CONCRETE SHALL CONFORM TO CITY OF THORNTON SECTION 600-CONCRETE. 4500PSI CDOT CLASS D CONCRETE WITH FIBER MESH REINFORCEMENT



N.T.S.

CITY OF THORNTON, COLORADO
STANDARDS & SPECIFICATIONS

TRAFFIC CALMING SPEED TABLE

ISSUED: AUG 2012
REVISED:

DRAWING NO. 500–22