

10.0 GEOTECHNICAL, ROADWAY PAVEMENTS, AND STRUCTURE FOUNDATIONS

10.1 Design Requirements

10.1.1 Geotechnical Investigations

Geotechnical investigations performed for CDOT in the Project area are provided in Book 3. The Contractor should also be aware that groundwater was encountered during the construction of the intersection at SH-128 and SH-121 (Wadsworth Parkway). The Contractor shall be responsible for any supplemental subsurface investigation necessary to complete the Work. Geotechnical investigations shall comply with the requirements of Section 10 in the AASHTO LRFD Bridge Design Specifications and the CDOT Field Materials Manual.

For non-CDOT roadways, geotechnical investigations by the Contractor shall follow the requirements set forth in the City and County of Broomfield Standards and Specifications.

All supplemental investigations made by the Contractor for CDOT roadways and structures shall be documented in a geotechnical investigation report and submitted to CDOT for Acceptance. All supplemental investigations made by the Contractor for non-CDOT roadways shall be documented in a separate geotechnical investigation report and submitted to CDOT for Acceptance.

10.1.2 Roadway Pavement Analysis and Design

CDOT has performed the pavement design to determine the PCCP thickness and minimum sub-grade stabilization requirements for SH-128 (120th Avenue Connection). The Contractor shall be responsible for all other aspects of pavement design, except as otherwise provided for in the Contract Documents. Design recommendations and substantiating analysis performed by the Contractor shall be documented in a separate Pavement Design Reports for CDOT and non-CDOT roadways, and submitted for Acceptance. These reports may be combined with the Geotechnical Investigation Reports for the Contractor's convenience.

The Contractor shall be responsible for PCCP joint design. PCCP joint design shall comply with the requirements of the Book 3 standards, including but not limited to the CDOT Standard Plans (M & S Standard Plans), and the 2009 CDOT Pavement Design Manual. The PCCP longitudinal and transverse joint designs shall be compatible with lane and shoulder configurations. The Contractor shall submit the pavement joint design to the CDOT Project Director at least 14 Days prior to PCCP construction. PCCP construction shall not commence until the PCCP joint design is Accepted.

The Contractor shall be responsible for pavement designs for detour/temporary pavement and any other pavement identified in the course of this Project. Any pavement design by the Contractor shall follow the requirements set forth in the 2009 CDOT Pavement Design Manual. All flexible pavement shall be designed using the AASHTOWare DARWin pavement design system while all rigid pavement shall be designed using the 1998 AASHTO supplement. Rigid pavements must be structurally sufficient and pass the faulting and corner break checks. Flexible pavement thicknesses shall be rounded up to the nearest ¼ inch. However, rigid

pavements shall include an additional ¼ inch to accommodate grinding at year 22 and shall be subsequently rounded up to the nearest ½ inch.

For non-CDOT roadways, pavement design by the Contractor shall follow the requirements set forth in the City and County of Broomfield Standards and Specifications, including the requirement to obtain soil samples for design of structural section after grading operations are complete and subgrade is rough cut, and requirements for pavement edge drains. The Contractor shall submit pavement designs to the CDOT Project Director and the City and County of Broomfield for review. The pavement design shall include traffic counts / calculations used to arrive at the ADT and 18-k ESALS for the required design period. Construction of paved surfaces shall not commence until the pavement design has been Accepted by the CDOT Project Director. Non-CDOT roadways must be constructed with a composite HMA and ABC pavement section.

10.1.3 Structure Foundation Analysis and Design

The Contractor shall perform additional geotechnical analysis as required for the design of retaining walls, bridges, and other structure foundations. Design recommendations and substantiating analysis shall be documented in foundation design reports, submitted to CDOT for Acceptance, and part of the Preliminary Design packages and/or the In-Process Design Packages for Structures as described in Section 15, Structures.

10.2 Construction Requirements

The Contractor shall construct the Portland Cement Concrete Pavement (PCCP) and Hot Mix Asphalt (HMA) in accordance with the requirements of the Contract Documents.

10.2.1 Roadway Pavement Construction Requirements

The Contractor shall mechanically groove the PCCP per Book 2, Section 19 (Section 412 – Portland Cement Concrete Finishing Consolidating and Finishing).

10.2.2 Roadway Pavement Types and Thickness Requirements

10.2.2.1 Detour Pavement

The Contractor is referred to the plans and requirements of Book 2, Section 19 (Section 621 – Detour Pavement).

10.2.2.2 Full Depth Hot Mix Asphalt

The Contractor shall use Stone Matrix Asphalt (Fibers) (Asphalt) or (SMA) (Fibers) (Asphalt) on the proposed bridge structures and comply with the specifications in this Section.

The Contractor shall use one 3-inch lift of SMA (Fibers) (Asphalt) on the proposed structure:

The nominal maximum aggregate size (NMAS) of the SMA (Fibers) Asphalt shall be ½ inch. Stone Matrix Asphalt (Fibers) (Asphalt) shall not contain any reclaimed asphalt pavement. All references to SMA shall be taken to be Stone Matrix Asphalt (Fibers)(Asphalt) or SMA (Fibers)(Asphalt).

For CDOT roadways, the Contractor shall use HMA (Grading SX) (100) (PG 76-28) and HMA (Grading S) (100) (PG 64-22) for HMA patching and minor widening of US36 and shall comply with the specifications in this Section. Patching shall be to the depth of the surrounding existing pavement as directed by the CDOT Project Director. The top lift must match the overlay depth, if any, and utilize HMA (Grading SX) (100)(PG 76-28). The thickness of lower lifts must be equal to or greater than the lift directly above. Lower lifts may utilize HMA (Grading S) (100) (PG 64-22).

For non-CDOT roadways, asphalt pavement incentive, smoothness incentive, and asphalt cement cost adjustment will not apply.

10.2.2.3 Portland Cement Concrete Pavement

Mainline SH-128 shall utilize PCCP. Eleven inches of PCCP will be required from the intersection of SH 121 / SH 128 to station 35+00 or as directed by the CDOT Project Director. From station 35+00 to the end of the project excluding the top surface of the proposed structure, and including intersections to the outside curb return, 10 inches of PCCP shall be utilized. The PCCP section shall consist of the following:

1. 11 inches of PCCP over 6 inches ABC Class 6 over 4 feet of nonswelling A-2-4 or better soil from the intersection of SH-121 / SH-128 to Station 35+00.
2. 10 inches of PCCP over 6 inches of ABC Class 6 over 4 feet of nonswelling A-2-4 or better soil from Station 35+00 to the end of the project, measured from the bottom of the ABC Class 6.

In areas with unprotected slopes, the ABC Class 6 and the 4 feet of nonswelling A-2-4 or better material shall be extended to the slope. However, in areas with curb and gutter, the ABC Class 6 and the 4 feet of A-2-4 or better material shall extend for a distance of 6 inches minimum beyond the back of the curb.

Pavement edge drains are required in cut areas to keep water levels a minimum 2 feet below the bottom of the nonswelling A-2-4 or better material. The Contractor shall submit the pavement edge drain design with the Release for Construction documents.

10.2.2.4 Pavement Thickness

The Contractor shall construct the PCCP and HMA pavement to the thickness requirements for the Project, as set forth in the Table below:

Location	Subgrade Minimum R-value	Minimum Required Pavement Section Thickness (inches)			Pavement Smoothness Category (i)
		PCCP	Full-Depth SMA	Composite HMA/ over ABC Class 6	
Intersection of SH 121 / SH 128 to Station 35+00	(iii)	11"			N/A
SH 128 excluding bridge structure	(iii)	10"			Category II

Bridge Structure			3"		HRI Category II
Wadsworth Blvd.	(ii)			7" / 15" (ii)	(ii)
Wadsworth Place	(ii)			4" / 9" (ii)	(ii)
Destination Drive	(ii)			5.5" / 12" (ii)	(ii)
Commerce Street	(ii)			5.5" / 12" (ii)	(ii)
120 th Avenue	(ii)			5.5" / 12" (ii)	(ii)
118 th Avenue	(ii)			5.5" / 12" (ii)	(ii)
Frontage Road Access	(ii)			4" / 6" (ii)	(ii)

- (i): Intersections constructed with PCCP are exempt from pavement smoothness requirements except for all 10 foot straightedge requirements shall be met for both longitudinal and transverse smoothness.
- (ii) Design and construction of subgrade and pavement section per City and County of Broomfield Standards.
- (iii) See Section 11 for subgrade requirements.

10.2.3 Project Special Provisions

The following specifications modify and take precedence over the Standard Specifications.

10.2.3.1 Plant Mix Pavement Compaction (Pneumatic Tire Rollers)

Section 401 of the Standard Specifications is hereby revised for this Project as follows:

In Subsection 401.17, first paragraph, delete the second sentence and replace with the following:

Both steel wheel and pneumatic tire rollers shall be required on this Project. If the Contractor can demonstrate to CDOT that all of the manufacturer's recommendations were followed and the pneumatic tire roller is detrimental to the finished surface of the HMA, the Contractor may request CDOT to waive the pneumatic tire roller requirement. Pneumatic tire rollers shall not be used on SMA pavement.

10.2.3.2 Conformity to the Contract of Hot Mix Asphalt

Section 106 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 106.05 shall include the following:

For this project, Contractor process control testing of hot mix asphalt is mandatory.

10.2.3.3 Quality of Hot Mix Asphalt

Section 106 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 106.03 shall include the following:

For this Project, Contractor process control testing is mandatory.

10.2.3.4 Aggregate Base Course

Section 304 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 304.02 shall include the following:

Materials for the base course shall be Aggregate Base Course (Class 6) as shown in subsection 703.03

The aggregate base course (Class 6) must meet the gradation requirements and have a resistance value of at least 78 when tested by the Hveem Stabilometer method.

10.2.3.5 Hot Mix Asphalt Compaction (Steel Wheel Roller)

Section 401 of the Standard Specifications is hereby revised for this Project as follows:

In subsection 401.17, first paragraph, delete the second sentence and replace with the following:

Steel wheel rollers will be required on this Project.

10.2.3.6 Hot Mix Asphalt

Section 403 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 403.02 shall include the following:

The design mix for hot mix asphalt shall conform to the following:

TABLE 403-1

Property	Test Method	Value For Grading			
		S (100)		SX(100)	Patching
Air Voids, percent at: N (initial) [for information only] N (design)	CPL 5115	3.5 – 4.5		3.5 – 4.5	3.5 – 4.5
Lab Compaction (Revolutions): N (initial) [for information only] N (design)	CPL 5115	8 100		8 100	8 100
Stability, minimum	CPL 5106	30		30	30
Aggregate Retained on the 4.75 mm (No. 4) Sieve with at least 2 Mechanically Induced fractured faces, % minimum	CP 45	60		60	60

Property	Test Method	Value For Grading			
		S (100)		SX(100)	Patching
Accelerated Moisture Susceptibility Tensile Strength Ratio (Lottman), minimum	CPL 5109 Method B	80		80	80
Minimum Dry Split Tensile Strength, kPa (psi)	CPL 5109 Method B	205 (30)		205 (30)	205 (30)
Grade of Asphalt Cement, Top Layer				PG 76-28	PG 76-28
Grade of Asphalt Cement, Layers below Top		PG 64-22			PG 64-22
Voids in the Mineral Aggregate (VMA) % minimum	CP 48	See Table 403-2		See Table 403-2	See Table 403-2
Voids Filled with Asphalt (VFA), %	AI MS-2	65-75		65-75	65-75
Dust to Asphalt Ratio Fine Gradation Coarse Gradation	CP 50	0.6 – 1.2 0.8 – 1.6		0.6 – 1.2 0.8 – 1.6	0.6 – 1.2 0.8 – 1.6
<p>Note: AI MS-2 = Asphalt Institute Manual Series 2</p> <p>Note: The current version of CPL 5115 is available from the Region Materials Engineer.</p> <p>Note: Mixes with gradations having less than 40% passing the 4.75 mm (No. 4) sieve shall be approached with caution because of constructability problems.</p> <p>Note: Gradations for mixes with a nominal maximum aggregate size of one-inch or larger are considered a coarse gradation if they pass below the maximum density line at the #4 screen. Gradations for mixes with a nominal maximum aggregate size of ¾ inch or smaller are considered a coarse gradation if they pass below the maximum density line at the #8 screen.</p>					

All mix designs shall be run with a gyratory compaction angle of 1.25 degrees and properties must satisfy Table 403-1. Form 43 will establish construction targets for Asphalt Cement and all mix properties at Air Voids up to 1.0 percent below the mix design optimum.

TABLE 403-2

Minimum Voids in the Mineral Aggregate (VMA)			
Nominal Maximum Size*, mm (inches)	***Design Air Voids **		
	3.5%	4.0%	4.5%
37.5 (1½)	11.6	11.7	11.8
25.0 (1)	12.6	12.7	12.8
19.0 (¾)	13.6	13.7	13.8
12.5 (½)	14.6	14.7	14.8
9.5 (¾)	15.6	15.7	15.8

- * The Nominal Maximum Size is defined as one sieve larger than the first sieve to retain more than 10%.
- ** Interpolate specified VMA values for design air voids between those listed.
- *** Extrapolate specified VMA values for production air voids beyond those listed.

The Contractor shall prepare a quality control plan outlining the steps taken to minimize segregation of HMA. This plan shall be submitted to the Engineer and approved prior to beginning the paving operations. When the Engineer determines that segregation is unacceptable, the paving shall stop and the cause of segregation shall be corrected before paving operations will be allowed to resume.

Hot mix asphalt for patching shall conform to the gradation requirements for Hot Mix Asphalt (Grading SX) (100) (PG 76-28) for the top lift and Hot Mix Asphalt (Grading S) (100) (PG 64-22) for the lower lifts.

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all hot mix asphalt.

Subsection 403.03 shall include the following:

If liquid anti-stripping additive is added at the plant, an approved in-line blender must be used. The blender shall be in the line from the storage tank to the drier drum or pugmill. The blender shall apply sufficient mixing action to thoroughly mix the asphalt cement and anti-stripping additive.

The Contractor shall construct the work such that all roadway pavement placed prior to the time paving operations end for the year, shall be completed to the full thickness required by the plans. The Contractor's Progress Schedule shall show the methods to be used to comply with this requirement.

10.2.3.7 Stone Mastic Asphalt Pavement

Sections 401 and 703 of the Standard Specifications are hereby revised for this Project as follows:

Subsection 401.02 shall include the following:

Recycled Asphalt Pavement (RAP) shall not be used in Stone Matrix Asphalt (SMA) mix.

Subsection 401.09 shall include the following:

Each SMA load shall be completely covered and securely fastened with a full tarp.

Subsection 401.16 shall include the following:

The 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 Contractor is responsible for all expenses associated with removal and replacement of all flushed areas. The Engineer shall designate the depth and area of all flushed areas requiring removal and replacement.

Subsection 401.17 shall include the following:

Rollers shall not be used in a vibratory mode on SMA unless they are first used successfully in the demonstration control strip specified in subsection 403.03. Pneumatic wheel rollers shall not be used on SMA mix.

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

When cores are used, the Contractor 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 CP 81 and CP 82.

In-place density for SMA shall be 93 to 97 percent of the SMA mix maximum specific gravity as measured according to CP 51.

Subsection 401.22 shall include the following:

Acceptance, testing, and pay factors for SMA shall be in accordance with subsections 105.05 and 106.05 as revised for this project for Hot Mix Asphalt.

Section 403 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 403.01 shall include the following:

This Work includes placing a Stone Matrix Asphalt (SMA) pavement.

Subsection 403.02 shall include the following:

The SMA gradation for this project shall be 1/2 inch.

Mixture design and field control testing of SMA shall be performed using either the SuperPave (CPL 5115, 100 Gyrations) or the Marshall Method (AASHTO T245, 50 Blow).

A minimum of two weeks prior to the proposed use of any Stone Matrix Asphalt pavement on the project, a pre-paving conference will be conducted. At that time, the Contractor shall submit to the Engineer, a mix design meeting the appropriate specification requirements for one of the following:

The SuperPave SMA mix design shall conform to the requirements of Table 403-1a:

Table 403-1a

Property	Test Method	Value for SMA
Air Voids, percent at: N(Design)	CPL 5115	3.0 – 4.0
Lab compaction (Revolutions) N(Design)	CPL 5115	100
Accelerated Moisture Susceptibility, tensile strength Ratio, (Lottman), minimum	CPL 5109, Method B	70
Minimum Dry Split Tensile Strength, psi	CPL 5109, Method B	30
Grade of Asphalt Cement		PG 76-28
Voids in the Mineral Aggregate (VMA) %, minimum	CP 48	17
Draindown at Production Temperature	AASHTO T305	0.3 maximum
% VCA ¹ _{MIX}	AASHTO PP41-02	Less than VCA _{DRC} ²

Note: The current version of CPL 5115 is available from the Region Materials Engineer
 Note: Copies of AASHTO PP41-02 and MP8-02 can be obtained from the Region Materials Engineer
 Note: ¹Voids in the Coarse Aggregate
 Note: ²Dry-rodged condition

The Marshall SMA mix design shall conform to the following:

Mix Properties	Value
Stability, Marshall Compactor	1400 lbs., min
% Voids in Total Mix	3 – 4%
VMA (% Voids in the Mineral Aggregate)	17 min.
Lottman, CPL 5109, Method B	70% min
Dry Tensile Strength, (CPL 5109)	30 psi, min.

Regardless of mix design method, a minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all Stone Matrix Asphalt.

The SMA mix design must be approved by the Engineer before any pavement is placed on the Project. In addition, the Contractor shall provide field control testing during production of the SMA mix and for the demonstration control strip. The Contractor shall perform the following tests and provide the results to the Engineer during production:

If a SuperPave SMA mix design is used, the Contractor shall perform the following tests and provide the results to the Engineer during production:

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

If a Marshall SMA mix design is used, the Contractor shall perform the following tests and provide the results to the Engineer during production:

Marshall Mix Property	Frequency
Draindown (AASHTO T 305)	1/1000 tons or fraction thereof
Stability (Marshall)	1/1000 tons or fraction thereof
Percent Voids in the total mix	1/1000 tons or fraction thereof
VMA (Percent Voids in the Mineral Aggregate)	1/1000 tons or fraction thereof
Lottman, CPL 5109, Method B	1/5000 tons or fraction thereof
Dry Tensile Strength, CPL 5109	1/5000 tons or fraction thereof
Percent AC & Aggregate Gradation CP 5120	1/1000 tons or fraction thereof

Subsection 403.03 shall include the following:

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.

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

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.

Before proceeding with SMA placement, the Contractor shall demonstrate the ability to produce and place a satisfactory mix. 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 Contractor shall determine properties (VMA, Voids, in-place density, and Marshall Stability, if required) of the project produced mix that is used in the demonstration control strip and provide the results to the Engineer. 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 Contractor's expense. The Engineer will designate the location of the control strip.

10.2.3.8 Tie-Bar Insertion

Section 412 of the Standard Specifications is hereby revised for this Project as follows:

Subsection 412.13(b) 1 shall include the following:

If tie bars are inserted into plastic concrete with a tie bar insertion machine, tie bar location and concrete consolidation shall be subject to the following additional requirements:

Each 2500 linear feet of longitudinal weakened plane joint resulting from the procedure shall have one random location cored where the core intercepts an inserted tie bar. The core shall be six-inch diameter taken in the presence of the Engineer.

If non-consolidated concrete is evident above the inserted tie bar, the Contractor shall cease paving operations and submit a corrective action plan in writing for approval. Correction of the joint and further paving shall take place only after written approval of the corrective action plan has been provided by the Engineer. Additional coring may be required, as directed by the Engineer.

Further failure to consolidate the concrete over the tie-bars will be justification to preclude the use of automatic tie-bar insertion for the remainder of the Project.

10.2.3.9 Detour Pavement

Section 621 is hereby added to the Standard Specifications for this Project and shall include the following:

DESCRIPTION

621.01 This Work consists of constructing detour pavement.

MATERIALS

621.02 The Contractor shall be responsible for quality control required to assure adequate quality of material used in the pavement.

CONSTRUCTION REQUIREMENTS

621.03 The detour location and dimensions shall be approved by the CDOT Project Director. The detour pavement design shall be provided by the Contractor. These designs shall be submitted to the CDOT Project Director prior to starting construction of the detour. Review does not constitute Acceptance of the designs. Acceptance will be based solely on providing the detour in a satisfactory condition. If the material and thickness furnished result in an inadequate detour structure, the Contractor will provide additional thickness, materials, or other measures necessary to provide a satisfactory pavement for the life of the detour. All necessary signs, pavement markings and other traffic control devices shall be provided in accordance with the Traffic Control Plan. The Contractor shall remove and dispose of the detour pavement when it is no longer needed to maintain traffic.

MAINTENANCE OF DETOUR

The Contractor shall maintain the detour for the entire period that it is required. Any distress which affects the ride, safety, or serviceability of the detour roadway shall be corrected to the satisfaction of the CDOT Project Director.

10.3 Deliverables

At a minimum, the Contractor shall submit the following to CDOT for review, Approval and/or Acceptance:

Deliverable	Acceptance or Approval	Schedule
Geotechnical Investigation Reports	Acceptance	Within 30 Working Days following completion of fieldwork.
Foundation Design Report	Acceptance	Submitted with Preliminary Design Packages and/or In-Process Design Packages for Structures.
Pavement Design Reports	Acceptance	Submitted with Preliminary Design Packages
Paving Quality Control Plan	(None)	Prior to beginning paving operations.
SMA Mix Design	Acceptance	At the Pre-Paving Conference and at least 14 Days prior to the use of any SMA pavement on the Project
PCCP Jointing Plan	Acceptance	At the Pre-Paving Conference and at least 14 Days prior to the use of any PCC pavement on the Project
PCCP Mix Designs	Acceptance	At the Pre-Paving Conference and at least 14 Days prior to the use of any PCC pavement on the Project
Mechanical Grooving Plan	Acceptance	Prior to beginning paving operations.