ITEM 2

EXCAVATION

2.1 DESCRIPTION

This Item shall consist of furnishing all materials, equipment, labor and necessary items for the excavation of the required material in the areas shown on the plans and cross sections to the lines, grades and typical sections as specified. Excavation shall include all materials encountered regardless of their nature or of the manner in which they are removed except rock.

2.2 EQUIPMENT

The **CONTRACTOR** shall provide equipment in good operating condition that is specifically designed and manufactured for the purpose of excavating soil and rock. Equipment shall be available to perform the work specified within the time frames needed and to be coordinated with the other work activities. The equipment shall be operated by skilled workman.

Excavating and hauling equipment shall be approved by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

2.3 CONSTRUCTION METHODS

All excavation shall be performed as specified herein and the completed excavation shall conform to the alignment, grades and typical sections as shown on the plans or project cross sections or as established by the **AGENCY**.

Unsuitable excavation and excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the **CONTRACTOR** and shall be disposed of in accordance with local, State and Federal regulations. Unsuitable material encountered below subgrade elevation in roadway cuts, when declared "Waste" by the **AGENCY**, shall be replaced with material from the roadway excavation or with other suitable material as approved by the **AGENCY**. This work shall be done in accordance with the provisions in Item 3, Embankment.

The **CONTRACTOR** shall maintain excavation to be used for construction in stockpile over a clean site and prevent contamination.

During construction, the roadbed and ditches shall be maintained in such condition as to ensure proper drainage at all times. Ditches and channels shall be constructed and maintained to avoid damage to the roadway section. Silt protection shall be provided by

the **CONTRACTOR**. During construction, channels shall be kept drained. All slopes shall be accurately shaped and care shall be taken that no material is loosened below or outside the required slopes. Exceptions shall be those slopes in rock or other material where, in the judgement of the **AGENCY**, some variation may be permitted. All breakage and slides shall be removed and disposed of in a manner acceptable to the **AGENCY**, at no cost to the **AGENCY**.

A. Rock Cuts

Rock shall be defined as a substance naturally occurring in the ground which, when struck soundly by a hammer does not fracture and emits a "ping" sound. For neat excavations shown on the plans, the **CONTRACTOR** shall have the following options:

1. Excavate to finish subgrade elevation, manipulate and compact the subgrade in accordance with the method specified under Embankment, Item 3, without removal.

2.Excavate below grade (undercutting) and replace with embankment material approved by the **AGENCY**. Compaction shall be in accordance with the method specified under Embankment, Item 3

3.Homogenous rock may be excavated to finish subgrade elevation. The slopes of all rock cuts shall be scaled and dressed to a safe, stable condition by removing all loose spalls and rock not firmly keyed to the rock slope. Overhanging rock shall be removed when it may be a hazard, in the opinion of the **AGENCY**.

B. Earth Cuts

When base and/or pavement structure is placed within this project, all earth cuts shall be scarified to a uniform depth of at least 12 inches below the required finished subgrade elevation for the entire roadbed width. The material shall be thoroughly mixed, moisture conditioned and compacted in accordance with the method specified under Embankment, Item 3 or as shown on the plans.

C. Subgrade Tolerance

Any deviation in excess of 0.1 feet in cross section and 0.1 feet in 16 feet measured longitudinally shall be corrected by loosening, adding or removing soil, reshaping, moisture conditioning, and recompacting.

~~**2.4 MEASUREMENT**~~

~~This Item will be measured by the cubic yard in its original position as computed by the method of average end areas with no allowances made for curvature. If for any reason, it is impossible or impractical to measure quantities by average end areas, the **AGENCY** will compute the quantities by a method, which, in the **AGENCY's** opinion, is best suited to obtain an accurate determination.~~

~~This is a plan quantity Item and the quantity will be that shown on the plans. When changes are made during construction, measurements for payment shall be made by the **AGENCY**. If no adjustment of quantities is required, additional measurements or calculations will not be required.~~

~~Shrinkage or swellage factors will not be considered in determining the calculated quantities. When a slide, not due to the **CONTRACTOR's** negligence or operation, occurs, the **CONTRACTOR** and **AGENCY** shall negotiate in each case the relative difficulty of work and payment for removal and disposal of the slide material. Only those quantities of slide and slipout material, which are authorized and actually removed, will be measured for payment.~~

~~2.5 PAYMENT~~

~~Excavation to be wasted or otherwise not used on the project shall be paid at a unit rate basis per cubic yard. Only the volume of excavation on the plans shall be paid. No payment shall be made for miscellaneous excavations or any other quantities not specifically noted as excavation on the plans. The quantities of excavation used elsewhere on the project, shall be paid for at the contract unit price bid for Item 3, Embankment.~~

~~Item~~	~~Description~~	~~Payment~~
~~2.5-1~~	~~Excavation (wasted)~~	~~$/yd^3~~
	~~Excavation used as fill complete in place*~~	
~~2.5-2~~	~~Excavation (rock)~~	~~$/yd^3~~

~~* No charge - paid under Item 3~~

End of MGPEC Item 2

ITEM 3

EMBANKMENT

3.1 DESCRIPTION

This work consists of the placement and compaction of all materials necessary for the construction of a pavement structure including foundation preparation, dikes, ditch berms, and approaches within or outside of the right-of-way or any designated section of the roadway.

3.2 MATERIAL

Materials may be furnished from required excavation of the areas shown in the plans or from off right-of-way sources obtained by the **CONTRACTOR** and meeting the requirements shown on the plans. All materials used in embankments shall be free from vegetation, objectionable matter, and other deleterious material. Frozen material will not be allowed.

Rock fill is only allowed where shown on the plans. Rock fill shall consist of sound, durable stones, boulders or broken rock not less than 6 inches in least dimension or greater than 24 inches in the greatest dimension. Material must be graded and placed so as to not have significant voids in the matrix. Where rock fill is used in the embankment, the upper 5 feet of the roadbed shall be formed of approved embankment material. A stabilization fabric (Item 10) shall be placed between the rock fill and A-6 and A-7-6 embankment subgrade. Claystone or non-durable shale, shall not be treated as sound rock and shall be broken, placed and compacted as embankment material. Rock shall be defined as in Item 2.3A.

If the **CONTRACTOR** desires to use borrow material from off-site sources, the material shall meet the requirements shown on the plans and shall be free from vegetation, objectionable matter, and other deleterious material. The **AGENCY** shall be notified 14 days in advance of opening any material source to allow performance of any required testing.

Water shall be furnished by the **CONTRACTOR** and shall be clean and free from industrial wastes and other objectionable matter.

3.3 EQUIPMENT

The **CONTRACTOR** shall provide equipment in good operating condition that is specifically designed and manufactured for the purpose of excavating, hauling, leveling and compacting embankment materials. Compaction equipment shall be adequately designed to obtain compaction requirements without adverse shoving, rutting, displacement or loosening of embankment material. The equipment shall be available to perform the work specified within the time frames required and to be coordinated with the other work activities. The equipment shall be operated by skilled workman at a normal production rate for the specified type of work.

Hauling and compacting equipment shall be approved by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

3.4 CONSTRUCTION METHODS

A. General

Prior to placing any embankment, the right-of-way shall have been prepared by the removal and disposal of all obstructions in the areas, which the embankment is to be placed. Tree stump holes or other excavations in the limits of the embankment shall be backfilled with material described in Item 3.2 and compacted in accordance with Table 3.4-B1 before commencing embankment construction. The surface of the ground, including disk loosened ground or any surface roughened, shall be restored to its original slope by blading or other methods. Where shown on the plans or required by the **AGENCY**, the ground surface thus prepared shall be compacted by moisture conditioning and compaction (Item 3.4B4).

1. Subgrade Preparation

Unless otherwise shown on the plans, the surfaces of unpaved areas (except rock) which are to receive embankment shall be loosened by scarifying to a depth of at least 12 inches, moisture conditioned and compacted in accordance with Table 3.4B-1.

2. Benching

Embankment material that is to be placed and compacted adjacent to existing embankment or existing slopes steeper than 5:1 shall be continuously benched as the new embankment material is placed up in layers. Each bench shall be keyed a minimum of 3 feet (0.9 m) into the existing ground and shall begin at the intersection of existing ground and the vertical sides of the previous cut. The configuration of the benches shall be as shown on the plans or at least 4 feet in height. Materials from the benching shall be compacted with the embankment material. Placement of embankment materials shall begin at the low point of slopes. Materials, which have been loosened, shall be recompacted with the embankment materials.

B. Construction of Embankments

Embankments shall be constructed to the grade and sections shown on the plans or as established by the **AGENCY**. Each section of the embankment shall correspond to the detailed section or slopes established by the **AGENCY**. After completion of the roadway, it shall be continuously maintained to its finished section and grade until the project is accepted.

1. Earth Embankments

Earth embankments shall be defined as those composed principally of soil or soil-like material other than rock, and shall be constructed of acceptable material from approved sources. Trees, stumps, roots, vegetation or other unsuitable materials shall not be placed in embankment. Material shall not be placed in embankment when either the foundation or the embankment is frozen. Unless otherwise shown on the plans, all embankment shall be constructed in layers parallel to the finished grade of the roadbed and not more than 8 inches in loose thickness.

Unless otherwise specified, earth embankments shall be constructed in successive layers for the full width of the individual roadway cross section and in such lengths as are best suited to the moisture conditioning and compaction methods utilized.

Layers of embankment shall be formed by utilizing equipment and methods, which will evenly distribute the material.

Rock or broken concrete encountered in the construction of this project may be incorporated in the lower layers of the embankment with prior approval of the **AGENCY**. Rock or broken concrete may also be placed in deep fills in accordance with the requirements for the construction of rock embankments, provided such placement of rock is not immediately adjacent to structures or in areas where foundations are to be constructed. Any rock or broken concrete within the right-of-way may not exceed 6 inches in any dimension. Also, rock or broken concrete may be placed in the portions of embankments outside the limits of the completed roadbed width where the size of the rock or broken concrete prohibits its incorporation in the normal embankment layers. Exposed reinforced steel shall be cut and removed from the broken concrete.

Each layer of embankment shall be uniform material at or above optimum moisture content prior to compaction. Where layers of unlike materials abut, each layer shall be featheredged for at least 100 feet, or the materials shall be mixed as to prevent abrupt changes in the soil. No material placed in the embankment by dumping in a pile or windrow shall be incorporated without mixing and moisture conditioning prior to compaction. Clods or lumps of material shall be broken and the embankment material mixed by blading, harrowing, disking or similar methods until a uniform material is achieved in each layer.

The water used to achieve the moisture content necessary for compaction shall be provided by the **CONTRACTOR**. If a pay item is included for the water, it shall be paid for separately; otherwise, it shall be included in the cost of the work. It

shall be the responsibility of the **CONTRACTOR** to secure a uniform, optimum or higher, moisture content throughout the layer by such methods as may be necessary. In order to facilitate uniform moisture conditioning of the embankment material, the **CONTRACTOR** may apply water at the material source. Such procedures shall be subject to the approval of the **AGENCY**. Cost of necessary water is included in this item.

2. Rock Embankments

Rock embankments shall be defined as those composed principally of rock as defined in Item 2.3A, and shall be constructed of acceptable material.

Unless otherwise specified, rock embankments normally shall be constructed in successive layers for the full width of the individual roadway cross section and 18 inches or less in depth. When, in the opinion of the **AGENCY**, the rock sizes necessitate a greater depth of layer, the layer depth may be increased as necessary, but in no case shall the depth of layer exceed 30 inches. Each layer shall be constructed in such a manner that the interstices between the stones are filled with smaller stones and soils. As placed material shall be relatively uniform in moisture and shall not contain voids in the opinion of the **AGENCY**.

The maximum dimension of any rock used in embankment shall be less than the depth of the embankment layer, and in no case shall any rock over 24 inches in its greatest dimension be placed in the embankment unless otherwise approved by the **AGENCY**. The upper or final 5 feet of the embankment shall be composed of material as specified for the subgrade as shown on the plans.

Each layer shall be compacted to the required density as outlined in Item 3.4B4. In rock layers when density testing is inappropriate, the **AGENCY** shall require the layer to be proof rolled to ensure proper compaction.

3. Embankment Adjacent to Culverts and Bridges

Embankments adjacent to culverts and bridges shall be compacted to the same standards as earth embankments. Embankment material placed adjacent to any portion of any structure and in the first two layers above the top of any culvert or similar structure shall be free of any appreciable amount of gravel or stone particles more than 3 inches in greatest dimension. The percentage of fines shall be sufficient to fill all voids and ensure a uniform and thoroughly compacted mass of proper density. Where the culvert is within 3 feet of the finished subgrade elevation and for all bridge abutments, the upper 5 feet shall consist of Flowable Backfill as described within Item 19. The material and placement shall be as discussed in Item 19, Utility Cuts.

4. Compaction

Each layer shall be moisture conditioned and compacted to the required density by any method, type and size of equipment, which will give the required compaction. The maximum depth of each layer, prior to compaction, shall be 8 inches (loose). Prior to and in conjunction with the rolling operation, each layer shall be brought to the required moisture content and shall be kept level with suitable equipment to ensure uniform compaction over the entire layer.

Each layer shall be moisture conditioned and be compacted to provide the density and moisture specified below, unless otherwise shown on the plans.

TABLE 3.4B-1

SOIL TYPE	COMPACTION	MOISTURE %
A-1, A-2-5, A-2-7, A-3, A-4, & A-5	95% Min. of AASHTO T 180	-2 to +2
A-2-4, A-2-6, A-6	95% Min. of AASHTO T 99	0 to +2

Note: Layers shown on the plans as "moisture treated" shall be placed and compacted in accordance with Item 4, Moisture Treatment.

5. Embankment Testing and Proof Roll

After each layer of earth, embankment is complete, tests may be made by the **AGENCY**. If the material fails to meet the moisture or density requirements or should the material lose the required density or moisture before accepted, the layer shall be reworked as necessary.

The **CONTRACTOR** may be required to excavate an area of the layer in order to facilitate the taking of density tests. Excavation, replacement and compaction of the removed material in the area shall be at the **CONTRACTOR's** expense.

The **CONTRACTOR** shall proof roll the completed embankment to determine if any soft, yielding or otherwise unacceptable areas exist. The **AGENCY** may require a witness be present during the proof roll. These areas shall be removed and replaced without additional payment. The proof roller shall be a pneumatic tired vehicle with tire pressures of at least 100 psi capable of applying ground loads of not less than 18,000 pounds per axle, provided by the **CONTRACTOR**. Complete

coverage of the proof roller will be required. Rollers shall be operated at between 2 and 6 miles per hour.

3.5 TOLERANCES

The tolerances shall be as follows:

A. Grade Tolerances

Any deviation in excess of 1.0 inches in cross section and 1.0 inches in 16 feet measured longitudinally shall be corrected by loosening, adding or removing the material, reshaping, moisture conditioning and recompacting. Deviations in excess of this tolerance shall be corrected by the **CONTRACTOR**, at the **CONTRACTOR'S** expense, in a manner satisfactory to the **AGENCY**.

B. Density Tolerances

Density below the specified minimum or moisture contents outside of the required deviation set in Item 3.4B4 shall be corrected. Inadequate compaction shall be corrected by the **CONTRACTOR**, at the **CONTRACTOR's** expense, in a manner satisfactory to the **AGENCY**.

3.6 MEASUREMENT

This Item will be measured as follows:

Shrinkage or swell factors will not be considered in determining the calculated quantities.

Embankment will be measured by the cubic yard in its final position as the volume of embankment computed in place between (1) the original ground surfaces or the surface or cut elevation shown on the plans, and (2) the lines, grades and slopes of the accepted embankment, using the average end area method.

This is a plan quantity measurement Item and the quantity to be paid for will be that quantity shown on the contract plans. If no adjustments of quantities, as required by the **AGENCY**, are required, additional measurements or calculations will not be required.

3.7 TESTING AND INSPECTION

Testing of embankment shall be performed in accordance with Table 3.7-1.

TABLE 3.7-1

SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING

In Place Soil Density and Moisture Content	AASHTO T 191, ASTM D 2167, AASHTO T 238, ASTM D 2216, AASHTO T 191, and ASTM D 2216	One test for each 200 lane feet, each layer (not less than one test per day)
	AASHTO T 239	Shall be performed every tenth nuclear method density test
Liquid Limit	AASHTO T 89	One test per soil type
Plastic Limit	AASHTO T90	One test per soil type
Moisture-Density Relationships	AASHTO T99 AASHTO T180	One test per soil type

3.8 PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit bid price for “Embankment". This price will be full compensation for all excavation, including blading, scarifying, shaping, dragging and finishing of subgrade; for hauling and disposing of excess excavated material; for all manipulations, labor, tools, equipment and incidentals necessary to complete the work. Proof rolling will be considered a part of this Item. When subgrade is constructed under this project, correction of soft or yielding areas in the subgrade will be at the **CONTRACTOR's** expense.

Item	Description	Payment
3.8-1	Embankment	$/yd^3
3.8-2	Water	$/gal

End of MGPEC Item 3

ITEM 6

MECHANICAL STABILIZED SUBGRADE

6.1 DESCRIPTION

Item includes mechanically stabilized subgrade of base/subbase course and/or subgrade improvement in the construction of paved or unpaved roadways. Design details for geogrid reinforcement, such as geogrid type, fill thickness, pavement cross-section and associated details, shall be as shown on the contract drawings. Work consists of:

A. Purpose

The purpose of the work shall be to provide a stabilized paving platform section on which paving materials can be placed. This Item shall not be used to retain moisture in subgrades unless retaining moisture in the section can be assured. This specification shall be used for a construction platform and not as a means of mitigating swell.

6.2 MATERIALS

A. Definitions

Mechanically Reinforced: Placement of a geogrid immediately over a soft subgrade soil in order to improve the bearing capacity and mitigate deformation of the subgrade soil. The goal of this application may be to reduce deeper excavation requirements, improve construction efficiency, reduce the amount of aggregate subbase/base material required, provide a stiff working platform for pavement construction, or combination of these.

Geogrid: A biaxial polymeric grid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth to function primarily as reinforcement.

Multi-Layer Geogrid: A geogrid product consisting of multiple layers of grid which are not integrally connected throughout.

Extruded Geogrid: A geogrid product formed by extrusion of a polypropylene or polypropylene/polyethylene copolymer sheet followed by its perforation with a precise arrangement of holes and subsequent stretching, or drawing, into the finished product.

Woven Geogrid: A geogrid product formed by weaving discrete strips of polymer into a network. These geogrids usually require a protective coating to protect the polymer from pre-mature degradation.

Minimum Average Roll Value (MARV): Value based on testing and determined in accordance with ASTM D4759-92.

True Initial Modulus in Use: The ratio of tensile strength to corresponding zero strain. The tensile strength is measured via ASTM D6637 at a strain rate of 10 percent per minute. Values shown are MARVs. For multi-layer geogrid products, rib tensile testing shall be performed on the multi-layer configurations, as prescribed by ASTM D6637

Junction Strength: Breaking tensile strength of junctions when tested in accordance with GRI-GG2 as modified by AASHTO Standard Specification for Highway Bridges, 1997 Interim, using a single rib having the greater of 3 junctions or a minimum 8 inch machine direction sample and tested at a strain rate of 10 percent per minute based on this gauge length. Values shown are MARVs. For multi-layer geogrid products, junction strength testing shall be performed across junctions from each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.

Flexural Stiffness (also known as Flexural Rigidity): Resistance to bending force measured via ASTM D1388-96, Option A, using specimen dimensions of 864 millimeters in length by 1 aperture in width. Values shown are MARVs. For multi-layer geogrid products, flexural stiffness testing shall be performed directly on the multi-layer configuration without using any connecting elements other than those used continuously throughout the actual product, and results shall not be assumed as additive from testing performed on a single layer of the multi-layer product.

Aperture Stability Modulus (also known as Torsional Rigidity or Torsional Stiffness): Resistance to in-plane rotational movement measured by applying a 20 kg-cm (2.0 m-N) moment to the central junction of a 9-inch by 9-inch specimen restrained at its perimeter. Values shown are MARVs. For multi-layer geogrid products, torsional stiffness testing shall be performed on each layer of grid individually, and results shall not be assumed as additive from single layers to multiple layers.

Granular Fill Material: The preferred gradation for base reinforcement application is well-graded crushed aggregate fill with a maximum particle size (100 percent passing) of 1 ½ inches, and less than 10% fines (passing the #200 sieve). Recycled concrete may be used only with polypropylene geogrids in accordance with FHWA 2001.

6.3 MANUFACTURERS

All manufacturers will be considered provided they meet the submittal process as per Item 6.6 and per Table 6.4-1.

6.4 GEOGRID MATERIAL PROPERTIES

A. Structural Soil Reinforcement Geogrid: The geogrid shall be integrally formed and deployed as a single layer having the following characteristics according to Table 6.4-1 (ALL VALUES ARE MINUMUM AVERAGE ROLL VALUES UNLESS A RANGE OR CHARACTERISTIC IS INDICATED):

TABLE 6.4-1 GEOGRID STRUCTURAL PROPERTIES

Property	Test Method	Units	Type 1	Type 2
Aperture Stability Modulus at 20 cm-kg (2.0 m-N)	Kinney (2001)	m-N/deg	0.32	0.65
Rib Shape	Observation	N/A	Rectangular or Square	Rectangular or Square
Rib Thickness	Calipered	In	0.03	0.05
Nominal Aperture Size	I.D. Calipered	In	1.0 to 1.5	1.0 to 1.5
Junction Strength	GRI-GG2-2000 [1]	ratio	NOTE 1	NOTE 1
Flexural Rigidity	ASTM D1388-96 [2]	Mg-cm	250,000	750,000
Minimum Tensile Strength @ 2% Strain:	ASTM D6637-01 [4]			
- MD[3]		Lb./ft	280	410
- CMD[3]		Lb./ft	450	620
Minimum Tensile Strength @ 5% Strain:	ASTM D6637-01 [4]			
- MD[3]		Lb./ft	580	810
- CMD[3]		Lb./ft	920	1,340

NOTES:

1. The ratio of Junction Strength/Ultimate Tensile Strength must meet or exceed 75%.
2. Resistance to bending force measured via ASTM D-5732-95, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a “ladder”), and of length sufficiently long to enable measurement of the overhang dimension.
3. MD = machine direction (along roll length); CMD = cross-machine direction (across roll width).
4. True resistance to elongation when initially subjected to a load determined in accordance with ASTM D6637 without deforming test materials under load before measuring such resistance or employing “secant” or “offset” tangent methods of measurement so as to overstate tensile properties.

B. Geotextile materials shall not be considered as an alternate to geogrid materials for subgrade improvement or base/sub-base reinforcement applications. A geotextile may be used in the cross-section to provide separation, filtration or drainage; however, no structural contribution shall be attributed to the geotextile.

6.5 EXECUTION

A. Examination

The **CONTRACTOR** shall check the geogrid upon delivery to verify that the proper material has been received. The geogrid shall be inspected by the **CONTRACTOR** to be free of flaws or damage occurring during manufacturing, shipping, or handling.

6.6 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection

Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.

Store at temperatures above -20 degrees F (-29 degrees C).

Rolled materials may be laid flat or stood on end.

Geogrid materials should not be left directly exposed to sunlight for a period longer than the period recommended by the manufacturer (as per ASTM D4355).

B. Preparation

The subgrade soil elevation shall be prepared at the proper elevation and alignment as directed by the engineer or as indicated on the construction drawings.

C. Installation

The geogrid shall be installed in accordance with the installation guidelines provided by the manufacturer or as directed by the engineer.

The geogrid may be temporarily secured in place with ties, staples, pins, sandbags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the engineer.

D. Granular Fill

Compaction – Standard compaction methods may be used unless the soils are very soft. In these cases, static instead of vibratory compaction is prudent, particularly over silty subgrades. Compaction is then achieved using a light roller. Keeping fill moisture content near optimum will make compaction more efficient. Water spray is most effective with sand fill. Compact aggregate fill to project specifications, after it has been graded smooth and before it is subject to accumulated traffic.

Vehicle Operation Over Geogrids- A minimum loose fill thickness of 6 inches is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid. When underlying substrate is trafficable with minimal rutting, rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) when integrally-formed geogrids are used. This shall

not be allowed with coated geogrids and sharp turning movements shall be avoided.

E. Inspection

The owner or owner's representative may randomly inspect geogrid before, during and after (using test pits) installation.

Any damaged or defective geogrid (i.e. frayed coating, separated junctions, separated layers, tears, etc.) will be repaired/replaced in accordance with Item 6.6F.

F. Repair

Any roll of geogrid damaged before, during and after installation shall be replaced by the **CONTRACTOR**.

Proper replacement shall consist of replacing the affected area adding 3ft (1m) of geogrid to either side of the affected area.

6.7 SUBMITTALS

A. Submittal Procedure – 15 days prior to bid letting.

1. Submit geogrid product sample approximately 4 inches by 7 inches or larger three days prior to installation.
2. Submit geogrid product data sheet, certification, and/or independent full scale laboratory testing from the manufacturer that the geogrid product supplied meets the requirements of Table 6.4-1
3. Submit manufacturer's installation instructions and general recommendations.
4. A list of 5 comparable projects that are similar in terms of size and application, within the state of Colorado, and where the results of using the specific geogrid material can be verified after a minimum of 1 year of service life.
5. Additional information as requested by the engineer to fully evaluate the product.

B. Quality Assurance

Pre-Construction Conference - Prior to the installation of the geogrid, the **CONTRACTOR** shall arrange a meeting at the site with the geogrid material supplier and, where applicable, the geogrid installer. The **OWNER** and the **ENGINEER** shall be notified at least 3 days in advance of the time of the meeting. A representative of the geogrid supplier shall be available on an "as needed" basis during construction.

6.8 CONSTRUCTION PLATFORM DESIGN

Construction platform design shall be performed under supervision of and signed by a Professional Engineer registered in the State of Colorado. The recommended procedure shall be derived by the Giroud-Han, Method (ASCE, August 2004).

Appropriate partial safety factors shall be applied to results obtained using geogrids having properties or characteristics outside the range of rigorous model validation (Giroud and Han, 2004). This method has been endorsed by numerous Department of Transportations and Government Agencies such as the Federal Highway Administration and Army Corps of Engineers.

For general guidance purposes only, Table 6.8-1 and 6.8-2 present a guide for estimating subgrade soil strength and minimum construction platform recommendations based on a range of subgrade strengths, respectively. A piping ratio analysis (D15fill/D85subgrade) shall be performed to determine the need of a separation fabric. If the piping ratio is less than 5 then no separation fabric is required. If the piping ratio is greater than 5 then a separation fabric is required below the geogrid. Final determination of construction platform shall be approved by the engineer.

TABLE 6.8-1

Guide for Estimating Subgrade Soil Strengths (Fine Grained Soils)

Estimate Consistency by:		Test by:				Correlates to:			
Feel	Equipment/Visual	Standard Penetration Test (blows/ft)	Dynamic Cone Penetrometer (mm/blow)			Shear Strength c_u		R Value	CBR
			SC, SM, SP	CL	CH	(kPa)	(tsf)		
Very Soft	Man standing sinks > 3"	< 2	—	—	—	< 12	< 0.125	—	< 0.4
Soft	Man walking sinks ≈ 2 - 3"	2 - 4	—	—	—	12 - 24	0.125 - 0.25	< 0.36	0.4 - 0.8
Medium	Man walking sinks ≈ 1"	4 - 8	—	> 66	—	24 - 48	0.25 - 0.50	0.36 - 2.5	0.8 - 1.6
Stiff	Pickup truck ruts ≈ 1/2 - 1"	8 - 15	> 100	66 - 46	—	48 - 96	0.50 - 1.0	2.5 - 6.8	1.6 - 3.2
Very Stiff	Loaded dump truck ruts ≈ 1 - 3"	15 - 30	100 - 56	46 - 33	> 109	96 - 193	1.0 - 2.0	6.8 - 15.5	3.2 - 6.4
Hard	Insignificant rutting by loaded dump truck	> 30	56 - 27	33 - 23	109 - 54	> 193	> 2.0	> 15.5	> 6.4

References: After Portland Cement Association, E.I. Dupont Literature and McCarthy, David F., "Essentials of Soil Mechanics and Foundations," 1977, and Tensar 1998. Webster, Personal Communication 2001, "DCP vrs. CBR Correlations".
AASHTO, "1993 Guide for Design of Pavement Structures," Van Till et. al. NCHRP 128.

TABLE 6.8-2

Recommended Aggregate Fill Thickness Feel / CBR Value with Geogrid Mechanical Reinforcement				
Soil Strength [1]	CBR	Aggregate Fill Thickness (in.) [2]		
Feel	approx.	Type 1 Geogrid [3]	Type 2 Geogrid [3]	*Unreinforced*
Very Soft	< 0.4	37"	34"	52"
Soft	0.6	30"	26"	42"
Medium	1.2	20"	16"	29"

Stiff	2.5	14"	9"	22"
Very Stiff	4	12"	6"	20"

Notes:

1. Soil Strength is based in Table 6.8-1. The soil strength used is general for these purposes.
2. Results of aggregate fill thickness were derived using the published Giroud-Han (2004) Methodology. Average values for fill thickness are used. Aggregate fill was assumed to have a minimum R-value of 30.
3. Type 1 and Type 2 geogrid structural properties used were a minimum as derived from Table 6.4-1

~~6.9 PAYMENT~~

~~Payment shall be made at the contract unit price per square yard based upon plan quantities for the stabilization. The price shall be full compensation for furnishing all material and for all preparation of the subgrade, delivering, installation, and incidentals necessary to complete this item. Paving platform found deficient shall be removed and replaced. At the option of the **AGENCY**, the pavement structural section shall be adjusted to compensate for any deficiency in the paving platform thickness and strength at the **CONTRACTOR's** expense as noted in Item 6.6F. Granular fill will be paid for at the contract unit price per ton. Unit price will be held constant regardless of deviation from actual quantities.~~

~~Item~~	~~Description~~	~~Payment~~
~~6.9-1~~	~~Geogrid~~	~~$/yd^2~~
~~6.9-2~~	~~Separation fabric~~	~~$/yd^2~~
~~6.9-3~~	~~Granular fill~~	~~$/ton~~

6.10 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO)
   1. AASHTO Recommended Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures, AASHTO PP46-01, April 2001 Interim Edition of the AASHTO Provisional Standards.
   2. Standard Specification for Highway Bridges (1997 Interim)
   3. AASHTO Guide for Design of Pavement Structures (1993)

B. American Society for Testing and Materials (ASTM)
   1. D1388-96 - Standard Test Method for Stiffness of Fabrics, Option A
   2. D6637-01- Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-rib Tensile Method
   3. D4354-96 - Practice for Sampling of Geosynthetics for Testing
   4. D4759-92 - Practice for Determining the Specification Conformance of Geosynthetics
   5. D5818-95 - Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage

C. Geosynthetic Research Institute (GRI)
1. GRI-GG2 - Standard Test Method for Geogrid Junction Strength

D. U.S. Department of Transportation – Federal Aviation Administration (FAA)
1. Specification for Geogrid Reinforced Base Courses, Engineering Brief No. 49 (1994).

E. U.S. Department of Transportation – Federal Highway Administration (FHWA)
1. Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earthen Walls and Reinforced Soil Slopes, Publication No. FHWA-NHI-00-044, March 2001, pages 59-60.

F. U.S. Environmental Protection Agency (U.S. EPA)
1. EPA 9090 - Compatibility Test for Wastes and Membrane Liners

G. U.S. Army Corps of Engineers (U.S. CoE)
1. Draft Specification for Grid Aperture Stability by In-Plane Rotation
2. CW-02215 Determination of Percent Open Area.

H. American Society of Civil Engineers (ASCE)
1. Giroud, J.P., and Han, J. (2004). "Design Method for Geogrid-Reinforced Unpaved Roads. Part I – Development of Design Method." Journal of Geotechnical and Geoenvironmental Engineering, 130 (8), 775-786.
2. Giroud, J.P., and Han, J. (2004). "Design Method for Geogrid-Reinforced Unpaved Roads. Part II – Calibration and Applications." Journal of Geotechnical and Geoenvironmental Engineering, 130 (8), 787-797.

I. Thomas C. Kinney, P.E., PhD
1. Determining the Aperture Stability Modulus of a Geogrid (2001).

End of MGPEC Item 6

ITEM 12

SEPARATION FABRIC

12.1 DESCRIPTION

This work consists of furnishing and placing a fabric as a separator between the subgrade and aggregate base. This applies to fabric membranes used for the entire width of the roadway in accordance with these specifications and as shown on the plans.

12.2 MATERIALS

A. Fabric

The fabric shall be a woven fabric resistant to chemical attack, mildew and rot and shall meet the following physical requirements.

TABLE 12.2-1

Apparent Opening Size	ASTM D 4751	No. 30 to 70 U.S. Standard Sieve
Grab Tensile	ASTM D 4632	200 Ibs. Min
Elongation at Break	ASTM D 4632	30% Max.

The minimum roll width shall be 10 feet. The **CONTRACTOR** shall submit the certification for the stabilization fabric.

12.3 EQUIPMENT

Mechanical or manual laydown equipment shall be used for laying the fabric smoothly. Stiff bristle brooms shall be used to smooth the fabric; scissors or blades to cut the fabric are also required.

Equipment shall be approved by the **AGENCY**. AII equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

12.4 CONSTRUCTION

Fabric rolls shall be wrapped for protection against moisture and extended ultra-violet exposure prior to placement. Fabric rolls shall be stored and protected from the weather. If stored outdoors, the rolls shall be elevated and protected with a waterproof cover.

Any ruts, holes, defects or soft yielding places which occur in the subgrade for any cause whatsoever shall be corrected and compacted to require density and stability before fabric is placed. The fabric shall be stretched, aligned and placed with no wrinkles that lap. The

test for lapping shall be made by gathering together the fabric in a wrinkle. Lap in excess of 2 inches shall be removed.

Overlap of fabric joints shall be sufficient to ensure full closure of the joint and shall be a minimum of 18 inches and not exceed 36 inches. Transverse joints shall be lapped in the direction of aggregate base laydown to prevent edge pickup.

Hauling units shall be operated so that braking, turning movements and reversing direction of travel do not cause wrinkling, folding or displacement of the fabric. Damaged fabric shall be replaced. The aggregate shall be backdumped on to the fabric, taking care not to drive directly on the fabric.

~~12.5 MEASUREMENT~~

~~Fabric will be measured for payment by the square yard of surface area, complete, in place, with no allowance for overlaps. Payment shall be based upon plan quantities. The fabric unit price will be full compensation for preparation of the application surface, furnishing and placing the fabric, and all labor, equipment, tools and incidentals necessary to complete the fabric placement.~~

12.6 TESTING AND INSPECTION

Testing of stabilization fabric shall be performed in accordance with Table 12.6-1

TABLE 12.6-1
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING

Fabric	One certificate of compliance for each lot of stabilization fabric.

~~12.7 PAYMENT~~

~~Payment shall be made at the Contract Unit Price for "Separation Fabric" measured in square yard of surface area. The price shall be full compensation for furnishing all material, and for all preparation of the subgrade, delivering, placing, and all labor, equipment, tools and incidentals necessary to complete this Item.~~

~~Item~~	~~Description~~	~~Payment~~
~~12.7-1~~	~~Stabilization Fabric~~	~~$/yd^2~~

End of MGPEC Item 12

ITEM 13

AGGREGATE BASE COURSE

13.1 DESCRIPTION

This work shall consist of furnishing, placing and compacting aggregate base courses constructed in accordance with this specification and conformity with the lines, grades, thickness and cross sections shown on the plans or established by the **AGENCY**.

13.2 MATERIALS

The base material shall be crushed to meet the requirements herein and shall consist of durable coarse aggregate particles and binding material. The aggregates shall conform to the following requirements:

TABLE 13.2-1

3/4 inch	95-100
No. 4	30 to 65
No. 8	25 to 55
No.200	3 to 12
R-Value * AASHTO T 190	Min. 78 at 300 psi
Plastic Index AASHTO T 90	6 Max.
Liquid Limit AASHTO T 89	30 Max.
Resilient Modulus, psi AASHTO T 294	20,000 psi Min.

* Must have less than a 10 point difference between 100 psi and 300 psi exudation pressure. The aggregate base material shall be pre-qualified on an annual basis by an independent laboratory capable of performing the tests listed in this section. The annual report shall be prepared under the supervision of, stamped and signed by a Colorado registered Professional Engineer. Supplier must certify the material meets the requirements listed above.

13.3 EQUIPMENT

The **CONTRACTOR** shall provide equipment in good operating condition that is specifically designed and manufactured for the purpose of excavating, hauling, leveling and compacting base course materials. Compaction equipment shall be adequately designed to obtain compaction requirements without adverse shoving, rutting, displacement or loosening of base course material. The equipment shall be available to perform the work specified within the time frames required and to be coordinated with the other work activities. The equipment shall be operated by skilled staff at a normal production rate for the specified type of work. Equipment shall be approved by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

13.4 CONSTRUCTION METHODS

A. Subgrade Preparation

Any ruts, holes, defects or soft yielding areas which occur in the subgrade for any cause whatsoever shall be corrected and compacted to require density and stability before an aggregate base course is placed. These repairs shall be made at the expense of the **CONTRACTOR**. Subsequent pavement layers shall be placed within 24 hours of the approval of the subgrade or moisture and density shall be reconfirmed at no cost. A separation fabric (Item 12) shall be placed after A-6 and A-7 subgrades have been approved, but before placement of any base as shown on the plans.

B. Spreading and Moisture Conditioning

The aggregate shall be uniformly deposited on the approved subgrade by means of the hauling vehicle with or without spreading devices. Aggregate shall be distributed over the surface to the depth specified on the plans or established by the **AGENCY**. The maximum loose lift thickness shall be no thicker than 8 inches.

After base course material has been deposited, it shall be thoroughly blade-mixed to full depth of the layer by alternately blading the entire layer to the center and back to the edges of the road. It shall then be spread and finished to the required cross section by means of a self-propelled pneumatic tired motor grader.

Water shall be applied prior to and during all blading and processing operations to moisten the material sufficiently to prevent segregation of the fine and coarse particles. Water shall be applied during the compaction in sufficient amounts to assist in compaction and prevent raveling.

C. Compaction

Compaction shall be immediately following the spreading operation. If the compacted depth of the base exceeds 6 inches, the course shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches.

Each layer shall be compacted to a density of not less than 95 percent of maximum density in accordance with AASHTO T 180. Field in-place density tests will be in accordance with schedule of testing in Section 13.8. The finished surface of each layer shall have a uniform texture. Water shall be uniformly applied over the materials during compaction in the quantity necessary for compaction. Moisture conditions shall be within 1 percent of optimum moisture content. It is to be expected that a loss of density in the upper portions of the material may occur due to a lapse in time, elements or other reasons. Moisture conditioning and recompaction to the specified density will be required prior to placement of any subsequent layer and no additional compensation will be allowed for such work. Testing shall be completed within 24 hours of the placement of the next paving course. Base shall be retested if the next paving course is delayed beyond 24 hours.

D. Proof Roll

The **CONTRACTOR** shall proof roll the completed base course material to determine any soft, yielding or otherwise unacceptable areas. These areas shall be removed and replaced without additional payment. The proof roller shall be a pneumatic tired roller or pneumatic tired compactor weighing not less than 45 tons and capable of applying ground loads of not less than 18,000 pounds per axle. All tires shall be of equal size and diameter and shall have a tire pressure of at least 100 pounds per square inch. They shall be kept uniformly inflated so that the difference in the pressure in any two tires shall never exceed 5 pounds per square inch and means shall be provided by the **CONTRACTOR** for checking the tire pressure on the job at any time.

Complete coverage of the proof roller will be required. Rollers shall be operated at between 2 and 6 miles per hour.

13.5 TOLERANCES

The tolerances shall be as follows:

A. Grade Tolerances

Any deviation in excess of 1/2 inch in cross section and 1/2 inch in 16 feet measured longitudinally shall be corrected by loosening, adding or removing the material, reshaping and recompacting by sprinkling and rolling. Deviations in excess of this tolerance shall be corrected by the **CONTRACTOR**, at the **CONTRACTOR's** expense, in a manner satisfactory to the **AGENCY**.

B. Density Tolerances

Density below the specified minimum set in Item 13.4C shall be corrected by loosening, reshaping, moisture conditioning and recompacting. Inadequate compaction shall be corrected by the **CONTRACTOR**, at the **CONTRACTOR's** expense, in a manner satisfactory to the **AGENCY**.

C. Thickness Tolerances

In any areas where the thickness is deficient by more than 1/2 inch in thickness, the deficiency shall be corrected by scarifying, adding material as required, reshaping, recompacting and refinishing by the **CONTRACTOR**, at the **CONTRACTOR's** expense, in a manner satisfactory to the **AGENCY**.

D. Material Properties

Gradation and Atterberg Limits shall be performed on random samples taken from each lift placed at the project. The aggregate base course shall conform to the following range of tolerances from the approved gradation.

TABLE 13.5D-1

Passing No. 8 and larger sieves	± 8%
Passing No. 30 sieve	± 6%
Passing No. 200 sieve	± 2%
Plastic Index	± 3

Should there be a change in source of materials or material placed at the project is not in conformance with the tolerances in Table 13.5D-1, the **AGENCY** shall suspend the use of such material until laboratory tests indicate the resilient modulus is acceptable. Material, which exceeds the tolerances, shall be removed and replaced by the **CONTRACTOR** at no expense to the **AGENCY**.

13.6 PRICE REDUCTIONS

Resilient modulus values less than 20,000 psi shall be price reduced in accordance with fatigue life reductions based upon a 20-year design as calculated using CHEVPC, MICHPAVE, DAMA or TTIPAVE. Values less than 15,000 psi shall be cause for removal and replacement. Insufficient thickness shall be for a lot size of 1,000 yd^2 and shall be priced reduced at the following rates:

TABLE 13.6-1

> 1 inch thickness	6%
> 2 inch thickness	8%
> 3 inch thickness	remove and replace

Price Reduction is equal to the full price of the entire pavement system. Price Reductions reflect reduced fatigue life as a result of the deficiency.

13.7 MEASUREMENT

Aggregate base course will be measured by the ton based upon plan quantities and density measurements at 95 percent Modified Proctor density per Table 13.8-1.

13.8 TESTING AND INSPECTION

Testing aggregate base course shall be performed in accordance with Table 13.8-1.

TABLE 13.8-1

SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING

In Place Soil Density and Moisture Content	AASHTO T 191 ASTM D 2167	One test for each 1,000 square yards (not less than one test per day).
	AASHTO T 239 AASHTO T 238 ASTM D 2216 AASHTO T 191 and ASTM D 2216	Shall be performed every tenth nuclear method density test
Atterberg Limits	AASHTO T89 & T90	One test per 2,000 tons
Moisture-Density Relationships	AASHTO T180	One test per soil type
Gradation	AASHTO T27 and T11	One test per 2,000 tons
Thickness		One test per 5,000 square yards
Resilient Modulus	AASHTO T 294	Upon request by the Agency

13.9 PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement'' will be paid for at the unit bid price for “Aggregate Base Course". This price will be full compensation for shaping and fine grading the roadbed, for spreading, mixing, blading, compacting, shaping and finishing the base material and for all labor, tools, equipment and incidentals necessary to complete the work. Proof rolling will be considered part to this Item. When base is constructed under this item, correction of soft spots in the base will be at the **CONTRACTOR'S** expense.

Item	Description	Payment
13.9-1	Aggregate Base Course	$/ton

End of MGPEC Item 13

ITEM 19

UTILITY CUT, BACKFILL AND PATCHING

19.1 DESCRIPTION OF WORK

This work shall consist of the excavation and rapid backfill of trenches for the installation or repair of utility and underground features. The work also includes utilizing temporary pavement patching materials, and final permanent pavement surfaces. The work requires the use of removable, controlled low-strength materials (CLSM) for the backfill material, as an alternative to traditional compacted soil, for trenches and cuts too small for traditional soil compaction and safe human entry for testing. Various temporary pavement materials may also be utilized, prior to permanent pavement repairs.

A. Description of removable, flowable, controlled low strength materials CLSM

The term CLSM used in this item shall mean the same as Removable CLSM or flowable backfill. This material is covered in detail due to the many time saving and engineering benefits of this type of backfill material. CLSM does not need compacting, nor moisture density compaction testing. Only a few physical tests of the CLSM properties are needed to assure durability and future removability with light excavating equipment. A low strength is desired so that surrounding utilities or structures will be accessible without causing damage if the CLSM must be removed in the future. Air entrainment is required to prevent damage and heave displacement of trench patches due to freeze-thaw damage.

In addition, CLSM may be used for other applications apart from trench or street cut backfill. These include filling voids due to pipe abandonment or undercutting of excavation in caving or normal soils. CLSM offers quick restoration of the trench and improving other subgrade conditions for roadway or structure support in a rapid time frame without the need for traditional soil backfill testing requirements or when a quick strength is needed to support upper layers. These benefits may outweigh the extra costs vs. using traditional methods that require compaction and testing.

Other applications include: backfilling behind retaining walls and abutments, filling void areas including pipe abandonment, annular spaces, undercut areas and other approved void filling applications. Other suitable applications include structural support for utilities and replacement of unstable subgrade during pavement repairs.

Utility types that can utilize CLSM include: conduits or pipes for electrical, wired or fiber optic communications, traffic signal or other utilities such as gas and water lines, sanitary and storm sewer lines, and other types of utility under existing pavements or ground surfaces to be built upon or improved later.

B. Objectives for Required Use of CLSM

The objectives of requiring the use of the CLSM specified below, instead of reusing excavated soils, is to provide a self-leveling, frost heave-resistant, non-settling, controlled low-strength material (defined by American Concrete Institute in ACI 229 as a CLSM), that does not normally require compactive effort and compaction testing. Traditional use of compacted soil or aggregate materials for backfill will require AGENCY approval and testing for acceptance.

C. Requirements for CLSM – Flow-Fill or Flashfill

This item further specifies two distinct CLSM material products: The Flashfill products will allow trench to backfill, temporary or permanent pavement restoration and traffic access to occur more quickly than Flow-Fill. The term 'CLSM' in this item shall mean either or both.

A high slump is required to aid in the self-leveling and void filling objective. The visual consistency may appear to range in appearance from thin batter or mud, to thick water. It must be foremost removable with light machinery in the future, and also quickly stable to support paving operations and traffic.

Minimum air contents are required in the top 4 feet of CLSM fill to limit permanent frost heave. This air content requirement should be used for the entire depth, to aid in the ability to remove or excavate CLSM in the future. The air content requirement may be forbidden by some utility agencies, such as for thrust blocks or for pipe bedding normally used for lateral support of pressurized pipes.

A Removability Modulus (RE) is specified at a maximum 1.5, and is based on compressive strength and unit weight of the CLSM Backfill. Refer to section 19.2C.

19.2 CLSM MATERIALS

A. Flow-Fill

Flow-Fill shall consist of a controlled low-strength, self-leveling concrete material composed of various combinations of cement, fly ash, aggregates, water, chemical admixtures and/or cellular foam for air-entrainment. Generally, the **CONTRACTOR** may place Flow-Fill in approximate 3 feet thick layers, allow bleed water to rise and divert away from placement before another layer may be added. Refer to section 19.4E for more information,

The Flow-Fill shall be limited to a maximum Removability Modulus (RE, as described in section 19.2C) of 1.5 to ensure ability to excavate in the future. Slumps of less than 7 inches will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond specified removability limits.

The **CONTRACTOR** shall submit a mix design for approval by the **AGENCY**, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

TABLE 19.2A-1

Flow-Fill Property	Flow-Fill Specification
Air Content, ASTM C231	6% Minimum
Compressive Strength, ASTM D4832	50psi – 150psi at 28 days
Slump, ASTM C143	7” – 10”
Removability Modulus, RE	1.5 Maximum

B. Flashfill

Flashfill shall consist of a controlled low-strength, self-leveling cementitious material composed of various combinations of fly ash, water, chemical admixtures and/or cellular foam for air-entrainment. No aggregate or sand is usually needed. It shall have a minimum specified air content to provide suitable resistance to frost-heave. Flashfill may generally be placed without lift thickness limits.

Higher strengths may be permitted over Flow-Fill; however, the Flashfill shall still be limited to a maximum Removability Modulus (RE) of 1.5. Slumps of less than 8 inches or spreads of less than 8 inches will not be permitted for placement, since the flowability to fill voids and avoid future settlement is impaired, and strengths may increase beyond removability limits.

The **CONTRACTOR** shall submit a mix design for approval by the **AGENCY**, prior to placement. The mix design shall be supported by laboratory test data verifying compliance with air content, slump, strength and removability (RE) requirements.

TABLE 19.2B-1

Flashfill Property	Flashfill Specification
Air Content, ASTM C231, or by Section 19.2D volumetric calculations (recommended)	15% Minimum
Compressive Strength, ASTM D4832	100psi – 300psi at 28 days
Slump, ASTM C143 (one lift, no rodding)	8” – 11”
Spread, ASTM D6103 (recommended)	8” – 12”, or greater
Removability Modulus, RE	1.5 Maximum

C. Removability Modulus

The Removability Modulus* ,RE , is a value calculated by

$$RE = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

where: W = in-situ unit weight (pcf) and C = 28-day compressive strength

*RE was developed & is used by Hamilton County, Ohio; per the NCHRP #597 CLSM Report. A lower RE means CLSM is easier to excavate or remove.

Some examples of RE based on strength and unit weights are shown below:

TABLE 19.2C-1
Removability Modulus (RE)

	Unit Weight, pcf [W]										
Compressive strength, psi [C]	50	60	70	80	90	100	110	120	130	140	150
25	0.18	0.24	0.30	0.37	0.44	0.52	0.60	0.68	0.77	0.86	0.96
50	0.26	0.34	0.43	0.53	0.63	0.74	0.85	0.97	1.09	1.22	1.35
75	0.32	0.42	0.53	0.64	0.77	0.90	1.04	1.18	1.33	1.49	1.65
100	0.37	0.48	0.61	0.74	0.89	1.04	1.20	1.37	1.54	1.72	1.91
125	0.41	0.54	0.68	0.83	0.99	1.16	1.34	1.53	1.72	1.93	2.14
150	0.45	0.59	0.75	0.91	1.09	1.27	1.47	1.67	1.89	2.11	2.34
175	0.49	0.64	0.81	0.98	1.17	1.38	1.59	1.81	2.04	2.28	2.53
200	0.52	0.68	0.86	1.05	1.26	1.47	1.70	1.93	2.18	2.44	2.70
RE less than or equal to 1.50 indicates Removable							1.70	Shading indicates Not Readily Removable			

D. Air Content Volumetric Calculation

Air content can be calculated as follows (using wet unit weights before and after foaming or entraining air):

$$\text{Air Content} = \frac{(\text{Unit Weight not Air-Entrained} - \text{Unit Weight Air-Entrained}) \times 100\%}{\text{Unit Weight not Air-Entrained}}$$

E. Flow Consistency of CLSM

Flow shall be measured by ASTM D6103, which utilizes a moistened 3" diameter, 6" high open-ended cylinder, filled with the flashfill. When the cylinder is lifted, the resulting "pancake" is measured at its longest and shortest dimensions and averaged.

19.3 MATERIAL CONSTITUENTS

A. Cement

Cement shall meet the standard chemical requirements of Type II or Type IP, ASTM C150 or ASTM C595, respectively.

B. Fly Ash

Fly ash shall meet the requirements of ASTM C618 Type C or Type F. Fly ash not meeting the requirements of ASTM C618 may be used if prior testing indicates acceptable, consistent results for strength and air content.

C. Water

Potable water or reasonably clean and free of chemicals injurious to the final product are to be used.

D. Chemical Admixtures

Air-entraining admixtures shall conform to ASTM C260 requirements; other chemical admixtures shall conform to ASTM C494 requirements.

E. Foaming Agents

Foaming agents shall conform to ASTM C869 and C796, or as approved by the **AGENCY**.

F. Suitability of CLSM Constituents

CLSM materials may not contain any material deemed toxic or hazardous. Material Safety Data Sheets (MSDS) must be available for any cement, flyash or admixture component of the mixture upon request. Flowable Backfill shall be compatible with bedding materials, electrochemically and otherwise if used as a metal pipe backfill application. Thermal compatibility with plastic pipes should be considered for direct contact of the CLSM with the pipe; heat generation of the mix must not exceed the softening point of the pipe material.

G. Aggregates

The final blend of aggregates for CLSM, including rock, gravel or sand, shall conform to the following gradations:

TABLE 19.3G-1

Sieve Size	% Passing
1 inch (25 mm)	100
No. 200	0 to 10

When coarse aggregate is used, 100 percent shall pass the 1 inch sieve, and it shall comprise not more than 40 percent of the total aggregate content. Other aggregate products such as aggregate base, crushed rock, pea gravel, or reject sand which has no more than 20 percent passing the No. 200 sieve and is free of organic material and other deleterious substances, may be accepted by the **AGENCY** if a flowable, workable mix can be produced without segregation of the aggregate.

~~19.4 CONSTRUCTION METHODS~~

~~A. Cutting Streets~~

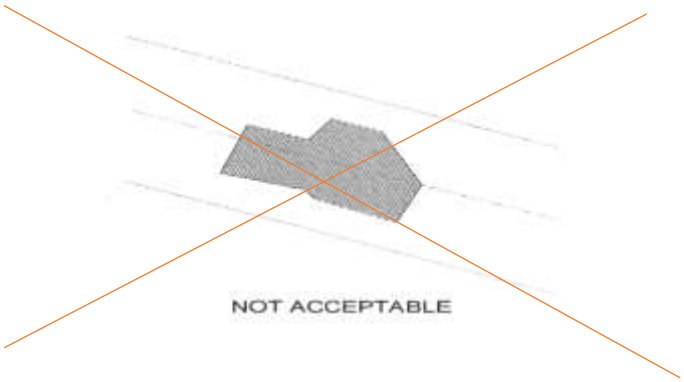
~~Prior to beginning work within any public right-of-way, or cutting any street surface, an encroachment permit and traffic control or barricade plan approval shall be obtained from the government entity or **AGENCY** having jurisdiction over that right - of - way. The barricading and traffic control devices shall be in place, and shall be in compliance with the **AGENCY** approved traffic control and barricade plan and the most current Manual on Uniform Traffic Control Devices (MUTCD).~~

~~Permit fees and construction restrictions shall be in accordance with the rules, regulations, and ordinances of the entity or **AGENCY** having jurisdiction.~~

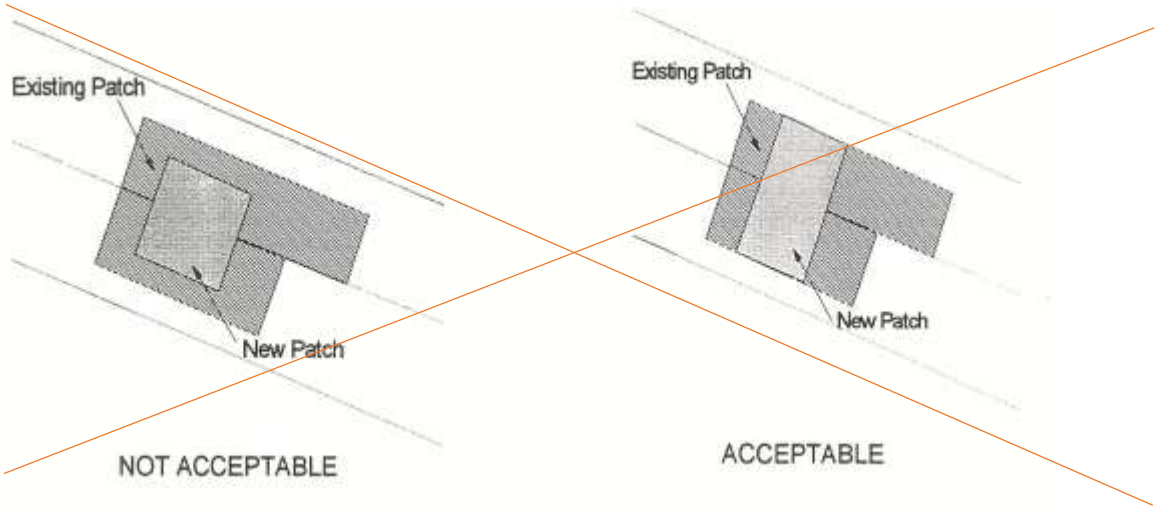
~~While undergoing improvements, all streets upon or within which any work is being done shall be kept open to all traffic by the **CONTRACTOR** unless otherwise approved by the **AGENCY**.~~

~~Existing pavements shall be removed to clean, straight lines, parallel and perpendicular to the flow of traffic. Asphalt and concrete pavements shall be removed by saw cutting, without damaging adjacent surfaces. Final removal of concrete will be to normal or AGENCY approved full panel longitudinal and transverse joint lines.~~

~~Patches with angled sides and irregular shapes will not be accepted as depicted below.~~



~~Patches surrounded by 3 or more sides within existing patches will generally not be accepted. Boundaries of the patches shall coincide. The **CONTRACTOR** shall get direction from the contracting **AGENCY** or utility when existing patches are not stable.~~



~~Existing pavement shall not leave strips of pavement less than one-half lane in width from the edge of the new patch or the lip of the gutter for commercial, industrial or non-residential streets. In the case of residential streets, strips shall not be less than 8 feet in width from the existing patches or the lip of the gutter.~~

~~Avoid breaking away the edges of the existing pavement or damaging the remaining pavement with heavy construction equipment.~~

~~B. Trench Excavation. General~~

~~Excavation including the manner of supporting excavation and provisions for access to trenches shall comply with the current regulations as determined by OSHA for bracing and safe conditions. Excavation shall include, without classifications, the removal of all materials of whatever nature encountered, including all obstructions of any nature that would interfere with the proper execution and completion of the work. The removal of said materials shall conform to the lines and grade shown. Excavation for pipe, wire, or conduits shall be by open trench unless otherwise specified or shown on the plans. However, the **CONTRACTOR** shall first obtain approval from the **AGENCY** prior to using tunnel or jacking methods on any portion.~~

~~The **CONTRACTOR** shall furnish, place, and maintain all supports and shoring that may be required for the sides of the excavation, and all pumping, ditching, or other approved measures for the removal or exclusion of water, including storm~~

water and waste water reaching the site of the work from any source as to prevent damage to the work or adjoining property. The **CONTRACTOR** shall be responsible for any damage to persons or property due to interruption or diversion of potable, storm or wastewater on account of his operations. If due to delays in delivery of materials or for other reasons, and the **CONTRACTOR** is not able to fully complete the work within any excavated area in a reasonable length of time as determined by the **AGENCY**, the **AGENCY** may require the **CONTRACTOR** to backfill the excavation and re-excavate when the work can be completed expeditiously.

Except as otherwise shown or provided herein, excavation shall be open cut trenches with vertical sides up to the top of the pipe, and from the top of the pipe to the ground surface. The bottom of the trench shall have a maximum width equal to the outside diameter of the pipe plus 24 inches or as shown on the plans. If the maximum trench width is exceeded, the **CONTRACTOR** shall provide either; additional bedding, another type of bedding, or a higher strength of pipe if required by the **AGENCY**.

Except when otherwise specified or ordered by the **AGENCY**, the bottom of the trench shall be excavated uniformly to the grade or depth indicated on the drawings. The maximum amount of open trench permitted in any one location shall be 500 feet, or the length necessary to accommodate the amount of pipe installed in a single day, whichever is greater, unless otherwise limited by the **AGENCY**. Trench shall be considered open until backfilled to finish surface. Trenches across streets shall be completely backfilled as soon as possible after pipe, wire, or conduit installation.

Substantial bridging, properly anchored, capable of carrying the legal limit loading, in addition to adequate trench bracing, shall be used to bridge across trenches at street crossings where trench backfill and temporary patches have not been completed during regular working hours. Safe and convenient passage for pedestrians and access to all properties shall be provided.

C. Trench Over-Excavation

Wherever the excavation is made below the grade shown on the drawings, or below the grade ordered by the **AGENCY**, it shall be refilled to the required grade with CLSM; or using Agency approved methods and specifications and verified with materials and compaction testing.

D. Disposal of Unsuitable and Excess Excavated Materials

Excess material and excavated material unsuitable for backfill, shall be removed from the site of the work by the end of each working day unless otherwise approved by the **AGENCY** and disposed of by the **CONTRACTOR**.

E. Trench Backfill with CLSM

Except as otherwise provided or approved by the AGENCY, after the pipe or conduit is laid, trenches shall be backfilled with CLSM in the pipe zone as defined in the following table:

~~TABLE 19.4E-1~~

~~Pipe or Conduit~~	~~Pipe Zone~~
~~2-inch or less diameter~~	~~6 inches above the top of the pipe up to subgrade~~
~~Greater than 2-inch diameter, except vitrified clay pipe~~	~~12 inches above the top of the pipe up to subgrade~~
~~Vitrified clay pipe~~	~~24 inches above the top of the pipe up to subgrade~~

~~CLSM should be well mixed and discharged directly from the truck into the space to be filled, or by other methods approved by the AGENCY. The mix may be placed part depth or full depth as conditions at the site and CLSM type dictate. When used as backfill in the pipe zone, care should be taken to prevent flotation or misalignment of the pipe by means of straps, soil anchors or other approved means of restraint. Material may be placed in stages with initially lesser flowability, to prevent movement or flotation of pipe. Refer to Section 19.26 for thermal compatibility when using CLSM directly against plastic pipe materials. CLSM shall not be placed when the trench bottom or walls are frozen or contain frozen materials.~~

~~Compaction of CLSM will not be normally required. Some external pushing and hand tamping may be required to help fill voids around tightly spaced utilities or obstacles.~~

~~The maximum layer thickness for Flow-Fill shall be 3 feet at one time. Additional layers shall not be placed until the backfill has lost sufficient moisture to be walked on without indenting more than 2 inches. Allow bleed water to rise and divert away from placement area before another layer may be added. Do not place CLSM on top of bleed water or on any water above the bearing layer. Any damage resulting from placing Flow-Fill in layers that are too thick or from not allowing sufficient strength gain time between placement of layers shall be repaired at the **CONTRACTOR's** expense.~~

~~The maximum layer thickness for Flashfill is not restricted except to prevent flowing or running into undesired areas.~~

19.5 ~~STREET SURFACING AND PATCHING~~

~~Placement of pavement materials for vehicle traffic shall not be allowed until the removable CLSM backfill has cured 24 hours (Flow-Fill only) or achieved sufficient resistance to allow paving. CLSM (either type) should be subjected to standard proofroll~~

criteria, or penetration resistance tests. CLSM should achieve a penetration resistance of at least 3.6 tsf (tons per square foot) (equivalent to 50 psi) using a hand-held soil penetrometer, typically pushed to ¼" depth, in accordance with the penetrometer manufacturer's instructions. Alternately, penetration resistance shall be considered achieved when a person weighing 100 pounds by use of their body weight as an axial load, cannot penetrate the CLSM backfill with the square cut end of a ½" diameter (#4) steel reinforcing bar.

A. Temporary Pavement Selection

Whenever permanent pavement patches are not constructed immediately following trench backfilling operations, temporary pavement patch construction consisting of:

- A minimum of 3 inches of hot mix asphalt (or approved warm mix if allowed) or cold plant mix asphalt on Flashfill or cured Flow-Fill CLSM , or
- A thickness of Flash-Patch equal to existing pavement thickness on CLSM, or
- Steel plates per the **AGENCY** requirements on CLSM,must be utilized to provide the required number of paved travel lanes. Sufficient excavation of backfill shall be done to allow the temporary surfacing to be level with surrounding pavement. Use of steel plates may be left in place for a short duration as approved by the **AGENCY**. Temporary pavement patches may be left in place for a maximum of 30 working days following completion of backfilling operations unless otherwise approved by the **AGENCY**.

When Flow-Fill is used as backfill material on collector or arterials streets needed to be opened within 24 hours, it must fill the excavation, using 3 feet maximum lifts as required in section 19.4E, up to the existing pavement surface grade, less enough thickness to provide for steel plates. The **CONTRACTOR** must then plate the excavation with heavy duty steel plates adequate to carry heavy traffic and wait at least 24 hours for the Flow-Fill to cure prior to applying the Permanent Patch or another Temporary Patch. Steel plates should be set below the street surface to avoid lateral displacement; the patch size may be increased to accommodate side support and a smooth height transition. Some Agencies may not allow steel plates on arterials during snow plow operation season. Alternately, Flash-Patch may be placed as a temporary patch and driving surface over CLSM, and shall match the existing pavement thickness.

Neither Flow-Fill nor Flashfill shall be allowed for a driving surface, except for very low traffic conditions and only when allowed by the **AGENCY**.

B. Temporary Pavement Patching Materials

Various materials for temporary patching options can be selected, and include:

- **Hot Mix** (HMA) or **Warm Mix Asphalt** (WMA) conforming to MGPEC Item 20 specifications. These may be used for either concrete or asphalt streets.

- **Cold-mix** asphalt materials (with cut-back asphalt cements only allowed from October 1 to February 28 (29)). This may only be used for asphalt streets.

- **VOC compliant** Cold-mix asphalt materials, (conforming to CDPHE Regulation No. 7, 5CCR 1001-9, Section XI, required from March 1 through September 30). This may only be used for asphalt streets.
- **Flash-Patch** materials (consisting of cementitious fly ash, water and cellular foam) and shall include approximately 10 to 15% air content. This may be used for either concrete or asphalt streets. Flash-Patch can be produced with the same volumetric-mixing truck as delivers and produces the Flashfill CLSM material. Flash-Patch materials will exceed CLSM strengths, but are limited in thickness to the existing pavement thickness to allow removal.
    - Flash-Patch usage on arterial roadways will require that **Small Aggregate topping** be used. Gradations shall meet ASTM C33 for size #9, and be crushed stone or natural gravels, with gradations requirements listed below:

TABLE 19.5B-1

Sieve	3/8"	#4	#8	#16	#50
% Passing	100	85 – 100	10 - 40	0 - 10	0 - 5

C. Temporary Pavement Patch Placement

Asphalt should ideally be placed according to MGPEC Item 20 requirements. Any temporary asphalt pavement patch shall be placed and compacted and shall be maintained by the **CONTRACTOR** so that the patched surface and the surrounding area remain a single even (smooth) unbroken plane, suitable to handle the traffic, for the duration of Temporary Patch.

Flash-Patch usage on arterial roadways will require that the Small Aggregate shall be broadcast on and embedded into the surface, for increased skid-resistance. Aggregate application will occur on patches within 100 feet of approaching stop signs or signal lights on other city streets. This aggregate shall be applied at approximately 5 lb. per SY of patch surface, before the Flash-Patch hardens. The **CONTRACTOR** shall be responsible to apply and embed the surface aggregate in a timely manner before set occurs.

The following surface tolerance for any temporary patches shall be observed. When a 10 foot straight edge is laid across the temporary patch parallel to the centerline of the street and in the direction transverse to the centerline, there shall be no more than a 3/4 inch rut, hump, or depression evident. Deteriorated temporary patches exhibiting ruts, humps, or depressions shall be repaired or replaced immediately. If the existing street exceeded the above tolerances prior to patching, then the temporary patch shall be equal to or better than the condition of the surrounding pavements.

Temporary patches with hot or cold mix asphalt may be opened to traffic after proper compaction and clean-up of the adjacent areas has occurred. Temporary patches of Flash-Patch may be opened to traffic usually within 1-1/2 hours after placement on arterial roadways, and usually within one hour on other streets.

D. Permanent Pavement Materials

Asphalt for replacement of Asphalt Pavement streets, shall be HMA (Hot Mix Asphalt), or WMA (Warm Mix Asphalt) if allowed by **AGENCY**, and shall meet the material requirements in MGPEC Item 20 for Grading S or SX with PG 64-22 binder, unless specified otherwise. Completion of the permanent patch in areas where an open graded surface course (SMA) exists shall include placement of a surface course to match the existing surface texture.

Concrete for replacement of Concrete Pavement Streets shall meet MGPEC Item 30, CDOT Class P specifications, or **AGENCY** standards as they require. Refer to the applicable specification for restoring tie bars, smooth dowel bars, expansion joint and joint seal materials.

E. Permanent Pavement Construction

Prior to placing the permanent patch, the existing cuts made for trenches shall be properly prepared for final pavement patching.

1. Existing Asphalt Pavement

Existing asphalt pavement shall be saw cut to a neat straight line and to a minimum 9 inches outside of the trench area. The AGENCY may require just the top lift be outside the trench edges. The resulting "T patch" edges shall not fall within existing wheel paths. Patches parallel to the direction of traffic and encompassing the wheel path shall extend to lane lines.

The asphalt thickness shall be the thicker of the existing depth, or the by **AGENCY** standards, except that the minimum depth shall be at least 4 inches.

A tack coat shall be applied to all edges to the existing freshly cut and/or approved well cleaned edges of asphalt pavement prior to placing new pavement.

Compaction of each lift shall be between 92 and 96 percent of T 209 using maximum theoretical (Rice) density. Average compaction of less than 92 percent of T 209 will be cause for rejection.

2. Existing Concrete Pavement

Existing concrete pavement shall be prepared by saw cutting and removal of partial panels back to existing joint lines to achieve full panels for new replacement panels or per **AGENCY** requirements. The **CONTRACTOR**

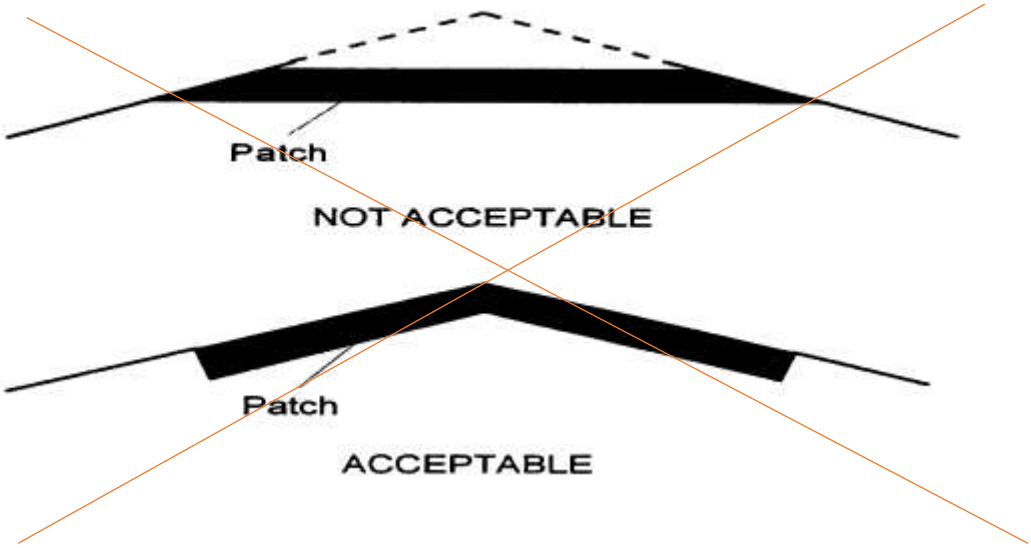
~~shall provide CLSM to the top of subgrade/bottom of the final Concrete Pavement level or base course level. The top of loose CLSM shall be moisture adjusted and compacted and proof-rolled to a tight condition prior to adding base course and/or concrete for pavement. Jointing layout and the use of tie bars and smooth dowel bars shall be constructed according to applicable specific Agency, CDOT 'M' standards or MGPEC Item 30 specifications. Generally, deformed tie bars shall be used in longitudinal joints, and smooth load-transfer dowels in transverse joints regardless if the existing PCCP had or has them. Alignment tolerances of the dowel bars shall be followed to assure natural lateral movement and proper performance.~~

~~The top of CLSM placed for temporary paving or for steel plates in section 19.4A shall be excavated to the top of subgrade/bottom of the final asphalt or concrete pavement level. The depth of excavation shall allow for the permanent pavement section to be equal to, or greater than, the existing section, or the section required by the **AGENCY**.~~

~~Any improvements in the right-of-way or on private property disturbed or damaged during construction shall be replaced prior to placement of the permanent pavement patch. Damaged sections of concrete sidewalk shall be removed and replaced to the nearest expansion joint or score line. Damaged concrete curb and gutter shall be removed and replaced to the nearest contraction joint. Replacement of less than a standard length of curb and gutter will not be permitted. Integral curb, gutters, and/or sidewalk shall be replaced in their entirety.~~

~~The following surface tolerance for permanent pavement patch for asphalt (or concrete), including any surface treatment before stripping, shall be observed. The surface shall be thoroughly compacted (leveled), smooth (broomed), and free from ruts, humps, depressions, or irregularities. When a 10 foot straight-edge is laid across the permanent patch parallel to the centerline of the street and in a direction transverse to the centerline, the surface shall not vary more than 1/4 inch from the lower edge of the straight edge. Patches exhibiting deviations greater than 1/4 inch shall be replaced prior to acceptance of the patch. If the existing street exceeds the above tolerances, then the patch shall be equal or better than the condition of the surrounding pavement.~~

~~Patches shall also have a cross slope or cross section consistent with the design of the existing roadway.~~



~~**F. Traffic Control Devices**~~

~~All traffic control devices removed or disturbed during construction must be replaced upon completion of the permanent patch including but not limited to delineation, paint, thermoplastic pavement markings, and traffic signal detector loops. Temporary lane lines and other markings used during construction shall be permanently removed, to the satisfaction of the AGENCY, prior to placing the new traffic stripes or markings.~~

~~19.6 MEASUREMENT~~

~~The following measurement items shall be followed, unless the **AGENCY** or utility contracting the work uses or requires their own methods.~~

~~**A. Length of Trench**~~

~~The length of trench will be measured by the **CONTRACTOR** and verified and approved by the **AGENCY**. The dimensions shall be the centerline length dimension or an average of both trench side lengths; and shall be no more than previously agreed upon by the **AGENCY**. This length shall include all **CONTRACTOR** costs for traffic control, excavations regardless of width, material removal and disposal, shoring, dewatering, utility materials and installation, and materials and installation of pavement materials, and final striping.~~

~~**B. Cubic Yard Volume of CLSM Materials**~~

~~The cubic yard volume of CLSM materials shall include all **CONTRACTOR** costs to supply and install CLSM backfill previously planned and agreed upon by the **AGENCY**, and will include overages for void filling accepted by the **AGENCY**. The~~

~~volume shall be only for actual materials installed for the work in the trench or cut area, as approved by the **AGENCY**.~~

~~19.7 PAYMENT~~

~~When any trench over-excavation below the specified level of bedding material and additional backfill material is ordered or approved by the **AGENCY** because unsuitable materials are encountered, payment shall be made separately by the appropriate contract item.~~

~~In the event that changes in elevation of the trench of less than 6 inches (150 mm) are ordered by the **AGENCY**, no changes in the contract amount will be allowed. When such changes in elevation are more than 6 inches or changes in alignment are made that change the character of the work required, the work shall be performed as specified by the **AGENCY** and agreed upon with the **CONTRACTOR**.~~

~~Item~~	~~Description~~	~~Payment~~
~~19.7-1~~	~~Utility Cut & Installation, Pavement, Striping~~	~~linear feet (LF)~~
~~19.7-2~~	~~CLSM Backfill(Materials and Installation)~~	~~cubic yards (CY)~~

End of MGPEC Item 19

ITEM 20
ASPHALT PAVEMENT MATERIALS

20.1 DESCRIPTION

This work shall consist of providing an Asphalt Paving Mixture (APM) to be placed as shown on the plans, or as directed by the **AGENCY**. The **CONTRACTOR** shall be responsible for Process Control (PC) of the APM; including the design, and control of the quality of the material incorporated into the project. The **AGENCY** will be responsible for Owners Acceptance (OA); including testing, to assure the quality of the material incorporated into the project meet design parameters. The following specifications include general requirements applicable to all types of plant mixed asphalt pavements. The work shall meet the requirements within the contract documents and in conformity with the lines, grades, thickness, and design cross sections as shown on the plans or established by the **AGENCY's** representative.

This specification is to maximize the service life of APM. It is also the intent of this document to provide construction requirements in accordance with these specifications to the standard of practice. This item shall include all labor, equipment, and materials to produce, place, and compact asphalt pavement.

A. Definition of Terms

Wherever the following abbreviations are used in the specifications or other contract documents, the intent and meaning will be interpreted as shown below:

AASHTO	American Association of State Highway & Transportation Officials
ASTM	American Society for Testing & Materials\
APM	Asphalt Paving Mixture
RAP	Reclaimed Asphalt Pavement
SMA	Stone Matrix Asphalt
WMA	Workability Mixture Additive (formerly known as Warm Mix Asphalt)

B. Contractor Process Control

At least 10 calendar days prior to placing any mixture on the project, the **CONTRACTOR** shall submit a mix design for acceptance.

The **CONTRACTOR** shall assume full responsibility for controlling all operations and processes to meet the Specifications. The **CONTRACTOR** shall perform all tests necessary for process control purposes and maintain a log of all process control testing. Owners Acceptance (OA) and/or Process Control (PC) test results will be evaluated to determine acceptability.

Prior to use on the project the **CONTRACTOR** shall submit a quality control plan that addresses production, sampling, testing, qualifications of testing personnel, timing, and methods for making adjustments to meet the specifications. The **CONTRACTOR** will provide a process or schedule for making corrections for material that was placed but does not meet specifications as well as obtain a follow

up sample immediately after corrective actions are taken to assess the adequacy of the corrections. In the event the follow-up process control sample also fails to meet Specification requirements; the **CONTRACTOR** shall cease production of the asphalt mixture until the problem is adequately resolved to the satisfaction of the **AGENCY**.

20.2 MATERIALS

Asphalt mixtures may consist of aggregate, filler, anti-strip agent, Recycled Asphalt Pavement (RAP), Workability Mixture Additive (WMA) and asphalt binder.

A. Aggregate

The Aggregate shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel. The material shall not contain clay balls, vegetable matter, rounded aggregate, or other deleterious substances, and shall meet the following requirements:

TABLE 20.2A-1
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 (Does not apply to RAP aggregate)		45% Min
Two Fractured Faces, ASTM D 5821 SG Mixtures Top and Middle Lifts Bottom Lifts SMA Mixtures	 90% Min. 80% Min. 70% Min. 100% required	
Flat and Elongated (Ratio 5:1) %, AASHTO M 283	10% Max.	
Sand Equivalent. AASHTO-T 176		45% Min.
Micro Deval (for combined samples) AASHTO T 327	18% Max for design 20% Max. for production	

TABLE 20.2A-2
Dense Graded Mixture Gradation
(AASHTO T 11 & T 27)

	ST (3/8" nominal)	SX (1/2" nominal)	S (3/4" nominal)	SG (1" nominal)**
	Leveling, Maintenance, Bike Path, Sidewalk	Top and Bottom Lifts, Patching	Lower Lifts	Lower Lifts
Sieve Size				
1.5"				100
1"			100	90-100
3/4"		100	90-100	
1/2"	100	90-100		
3/8"	90-100			
#4				
#8	28-58	28-58	23-49	19-45
#16				
#30				
#50				
#200*	2.0-10.0	2.0-8.0	2.0-7.0	1.0-7.0

*Shall include 1% by total weight if lime is used as the anti-strip agent.

TABLE 20.2A-3
SMA Mixture Gradation
(AASHTO T 11 & T 27)

Sieve Size	½"	¾"
(1")		100
(3/4")	100	90-100
(1/2")	90-100	50-88
(3/8")	50-80	25-60
(#4)	20-35	20-28
(#8)	16-24	16-24
(#16)		
(#30)	12-18	12-18
(#50)		
(#100)		
(#200)	8-11	8-11

B. Reclaimed Asphalt Pavement (RAP)

Allowable percentages of RAP in APM are shown in Table 20.2B-1.

TABLE 20.2B-1
RAP Allowed in APM Mixtures

Mix Grading	Max % RAP allowed
ST (3/8")	25%
SX (1/2")	25%
S (3/4")	25%
SG (1")	35%
SMA (1/2" & 3/4")	Not Allowed

1. Quality of RAP

RAP may be used where allowed and shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. RAP shall not contain clay balls, vegetable matter, or other deleterious substances.

Asphalt mixtures containing RAP shall meet the same gradation and physical requirements as in Table 20.2A-1 and Table 20.2B-1.

Verification testing for asphalt content and gradation will be performed on RAP at the frequencies listed on Table 20.2B-2.6, below. The **CONTRACTOR** shall provide testing results on RAP mixtures daily for properties listed in this specification.

The aggregate obtained from the processed RAP shall be based on the required gradation limits for the mixture being used. The aggregate and binder obtained from the processed RAP shall meet the tolerances provided in Table 20.2B-2a.

Table 20.2B-2a

RAP Binder & Aggregate Uniformity Tolerances

Element	Standard Deviation
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

2. Process Control (PC) Plan for RAP

A PC plan detailing how the RAP will be processed and controlled shall be developed and followed by the **ASPHALT PRODUCER/ CONTRACTOR** and shall address the following:

A plan that explains the **CONTRACTOR'S** processing techniques for crushing, screening, rejecting, and stockpile operation.

RAP shall be tested as shown in Table 20.2B-26.

Table 20.2B-26
Test Frequency of Processed RAP

Test	Minimum testing frequency (minimum 3 tests)
Asphalt Binder Content (AASHTO T-164)	1/1,000 tons
Gradation (AASHTO T-30)	1/1,000 tons

Process control charts shall be maintained for binder content and each screen when RAP material is added to the stockpile. Separate control charts for each RAP stockpile shall be maintained. These charts shall be displayed and shall be provided upon request.

C. WMA Technology:

The **CONTRACTOR** may choose to use a WMA Technology that is included on the CDOT approved products list (https://www.codot.gov/business/apl/asphalt-warm-mix.html).

WMA technologies (additive or foaming) used shall be identified on the mix design submitted and approved by the **AGENCY** for use on a project.

If a WMA technology is used, the discharge temperatures may be lowered during production at the discretion of the **CONTRACTOR** provided all specifications are achieved.

D. Mineral Filler

Mineral filler for use with Stone Matrix Asphalt (SMA) pavement may consist of limestone dust or any other material filler that will meet the requirements of this subsection and have a maximum Plasticity Index (AASHTO T 90) of less than or equal to 4.0 %.

The **CONTRACTOR** shall submit hydrometer analysis (AASHTO T 88) for the gradation of mineral filler used in the SMA mixture.

E. Performance Graded Asphalt Binders

The **CONTRACTOR** shall provide to the **AGENCY** acceptable 'Certifications of Compliance' of each applicable asphalt binder grade from the supplier. Should testing or certificate show nonconformance with the specifications, the asphalt binder may be rejected. When production begins, the **CONTRACTOR** shall, upon request, provide to the **AGENCY** a one quart can of each specified asphalt binder for analysis. Additionally, the **CONTRACTOR** shall provide the refinery test results that pertain to the asphalt binders used during production.

F. Asphalt Binder

Asphalt binder shall meet the requirements of the Performance-Graded Binders (PG) as presented in Table 20.2E-1 and consult www.LTTPbind.com when special circumstances arise.

TABLE 20.2E-1
Properties of Performance Graded Binders

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 R 28***			
Dynamic Shear, Temperature ºC, where $G^*/\sin\delta$ @ 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.

G. Anti-Strip Additives

Anti-Strip shall be added into the APM. Anti-Strip agents may be liquids (added to the binder), lime (added to the aggregates) or other products, and shall be submitted for approval by the **AGENCY**.

The minimum value for Tensile Strength Ratio (TSR) shall be 80% for the mix design and 70% during production.

Liquid Anti-Strip

There are various types of liquid Anti-Strips. Amine and Organo-silane type liquid Anti-Strip additives are physically mixed with the asphalt binder.

Liquid Anti-Strip agents shall be added per the manufacture's recommendations. Typical product dosages are provided in Table 20.2F-1.

TABLE 20.2F-1
Liquid Anti-Strip Dosage Rates

Type	Typical Dosage Rate
Amine	0.4% to 0.8%
Organo-silane	0.05% to 0.15%

WMA chemical products which display Anti-Stripping characteristics will be classified as a liquid Anti-Strip additive.

When a liquid Anti-Strip additive is used, the **CONTRACTOR** shall include the following information with the mix design submission:

- Information on the type of liquid Anti-Strip additive to be supplied, including product name, product manufacturer/supplier
- Additive rate
- TSR values for the treated mixes
- The proposed method for incorporating the additive into the plant produced mix.

Hydrated Lime

The hydrated lime for APM shall conform to the requirements of AASHTO M 303, Type I. In addition, the particle size requirements shall conform to AASHTO M 303 when tested in accordance with CP-L 4209 Physical Testing of Quicklime, Hydrated Lime, and Limestone. Hydrated Lime shall be added at the rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve.

20.3 MIX DESIGN AND PRODUCTION REQUIREMENTS

There shall be no substitutions of materials allowed during production. All substitutions will require checkpoint verification. If the checkpoint differs from the Job Mix Formula (JMF), a new mix design will be required. Upon request of the **AGENCY**, the binder grade may be changed by one available binder grade level without requiring a new mix design.

Grading SG (1-inch nominal aggregate) shall only be designed using the 150mm molds. Hveem Stability is not required for Grading SG mixtures. Lottman test is required for Grading S or SX in-lieu of Lottman for Grading SG. Grading ST, SX, and S shall be designed using 100mm molds.

A. Mixture Design Method

A Job Mix Formula (JMF) design shall be submitted for each mixture required, at least 10 calendar days prior to construction, for review by the **AGENCY.** The JMF design shall be determined using AASHTO T-312 for the Method of Mixture Design.

Mixture design and field control testing of dense graded asphalt mixes shall meet the requirements of Table 20.3A-1. For mixes requiring a design gyration of 100 (ESALs greater than 3 million) the Project Special Conditions should be used. This gyration is not recommended for the majority of roads within MGPEC agencies.

Mixture design and field control testing of SMA shall meet the requirements of Table 20.3A-2.

TABLE 20.3A-1
Mixture Properties for Dense Graded Asphalt Mixtures

Property	Traffic Level (ESALs)

	Paths, Parking Lots ~~<100,000~~	≥**50,000** to 3 Million
Design gyrations, N_{design}	50	75
Air Voids (V_a) % at N_{design} (AASHTO T-132)	3.0 – 4.0	3.0 – 4.0
Hveem Stability (AASHTO T-246) (Grading ST, SX & S only)	28 Min.	28 Min.
Voids Filled with Asphalt (V_a), MS-2	70-80	65-80
Accelerated Moisture Susceptibility, tensile strength ratio, (Lottman) (AASHTO T-283 Method B)(for S,SX,SG mixes)	80 Min.	80 Min.
Dry Tensile Strength, psi (AASHTO T-283)	30 Min.	30 Min.
Voids in Mineral Aggregates (VMA) % (AASHTO PP-19)	Table 20.3A-3	

Note: Table 20.3A-1 has been modified by Douglas County

TABLE 20.3A-2
Mixture Properties for SMA

Property	Test Method	Value
Lab compaction (Gyrations) N_{Design}	AASHTO T-312	75
Air Voids (V_a) % at N_{Design}	AASHTO T-312	3.0 – 4.0
Accelerated Moisture Susceptibility, tensile strength Ratio, (Lottman)	AASHTO T-283, Method B	80 Min.
Dry Split Tensile Strength, psi	ASHTO T-283, Method B	30 Min.
Grade of Asphalt Binder	N/A	PG 76-28
Voids in the Mineral Aggregate (VMA) %, minimum	AASHTO PP19	17
Drain Down at Production Temperature	AASHTO T-305	0.3 Max.

TABLE 20.3A-3
Minimum Voids in Mineral Aggregate (VMA)
Dense Graded & SMA mixes

Nominal Maximum	Minimum VMA (%)

Particle Size	3.0% V_a	3.5% V_a	4.0% V_a
3/8" (ST)	15.5	15.6	15.7
½"(SX)	14.5	14.6	14.7
¾" (S)	13.5	13.6	13.7
1" (SG)	12.5	12.6	12.7
SMA - ½"	17.0	17.0	17.0
SMA - ¾"	17.0	17.0	17.0

B. Mixture Design Submittals

The **CONTRACTOR** shall submit all mix designs, Certificates of Compliance, and laboratory data to the **AGENCY** for approval at least 10 calendar days before construction is to begin.

Designs shall be developed and performed in a materials laboratory that meets the requirements set forth by AASHTO Materials Reference Laboratory (AMRL) for all testing procedures. , The design shall be stamped and signed by a Professional Engineer licensed in the State of Colorado. In addition, the **CONTRACTOR** shall submit, as part of the mixture design, laboratory data documents to verify the following:

- Gradation, specific gravity, source and description of individual aggregates and the final blend.
- Aggregate physical properties.
- Source and Grade of the Performance Graded Binder.
- Proposed Design Job Mix: aggregate and additive blending, final gradation, optimum binder content.
- Mixing and compaction temperatures used.
- Mixture properties shall be determined with a minimum of four binder contents.

The **AGENCY** reserves the right to verify the asphalt supplier's mix design for each APM design utilizing materials produced and stockpiled. The asphalt supplier shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and additive for the required laboratory tests, as well as all Certificates of Conformance/ Compliance at any time on any material used. The Asphalt Supplier shall provide copies of quality control testing results during the production of APM used within three business day from the sampling date.

C. Change in Source or Grade

Should a change in the source of any material used in the production of APM (aggregate, mineral filler, lime, or performance graded asphalt binder) occur, a one point verification test (at optimum binder content) of the mix must be performed to verify that the applicable criteria shown on Table 20.3A-1 (dense graded APM),

Table 20.3A-2 (SMA), and Table 20.3A-3 (VMA), is still met. If this testing shows noncompliance, the **CONTRACTOR** shall establish a new job mix design and obtain approval by the **AGENCY** before the new APM is used.

D. Mix Production Verification

Production verification shall occur prior to the start of the project. Volumetric properties of the mix shall be verified by LabCAT Level C certified Technicians. If the mix was produced for another project within the last 90 days, data from that project can be submitted for verification. Volumetric properties for mix verification testing shall be within the tolerances in Table 20.12B-1. The mix verification test reports shall be submitted to the **AGENCY** prior to mix placement.

Verification testing for binder content, gradation and physical properties shall be performed at the frequencies listed in Table 20.14-1.

E. Pre-Paving Meeting

The AGENCY may require a pre-paving meeting of all parties that are directly involved in the project. Traffic control, transport, sequence of paving and construction plans may be reviewed and discussed.

20.4 PRODUCTION

A. Preparation of Aggregates

Heating and drying of the aggregates shall be accomplished without damaging the aggregate. An Anti-Strip additive shall be added to achieve uniform coating of the aggregate, in accordance with Section 20.2G Anti-Strip Additives.

B. Mixing

The dried aggregates and asphalt binder shall be combined in the mixer in the quantities required to meet the design job mix formula. The materials shall be mixed until the aggregate is uniformly coated, and the asphalt binder is uniformly distributed throughout the aggregate. Baghouse fines may be fed back to the mixing plant in a continuous manner to maintain uniformity in the mixture at the discretion of the producer.

Discharge temperatures are shown in Table 20.4B-1.

TABLE 20.4B-1
Mixture Discharge Temperatures

Binder Grade	Minimum Discharge Temperature	Maximum Discharge Temperature
PG 58-28	275º F	305º F
PG 64-22	290º F	320º F
PG 76-28	320º F	330º F
Workability Mixture Additive (WMA)	If a WMA technology (additive or foaming) is used, the discharge temperatures may be lowered during production at the discretion of the **CONTRACTOR** provided all specifications are achieved.	

To protect the properties of the binder, APM shall be produced at the lowest temperature within the specified range that produces a workable mix and provides for uniform coating of aggregates, and that allows the **CONTRACTOR** to achieve the required compaction.

C. Transportation

Colorado Statutes require that each truck shall be covered. This will also help protect the mix during transport from contamination and weathering. The **AGENCY** may reject any uncovered APM which demonstrates it has been impacted by contamination and/or weather.

20.5 TACK COAT

Prior to placement of APM, a tack coat shall be applied to all existing concrete and asphalt surfaces.

The tack coat shall meet the specification for emulsified asphalt, consisting of CSS-1h or SS-1h and conform to AASHTO M208 or M140.

The tack coat shall be applied at a rate of 0.1 to 0.3 gallons per square yard. The surface receiving the tack coat shall be dry and clean, and dust, debris, and foreign matter shall be removed. Tack coat shall be applied uniformly. The **CONTRACTOR** shall allow the tack coat to cure (dehydrate) prior to the placement of APM. If the tack becomes contaminated during construction, it shall be cleaned, and if necessary, additional tack coat shall be reapplied and allowed to cure before paving resumes.

TABLE 20.5-1
Tack Coat Application Rates

Pavement Condition	Application Rate (gal/yd^2)		
	Residual	Undiluted	Diluted (1:1)
New asphalt	0.03 - 0.04	0.05 – 0.07	0.10 – 0.13
Oxidized asphalt	0.04 – 0.06	0.07 – 0.10	0.13 – 0.20
Milled Surface (asphalt)	0.06 – 0.08	0.10 – 0.13	0.20 – 0.30
Milled Surface (PCC)	0.06 – 0.08	0.10 – 0.13	0.20 – 0.30
Portland Cement Concrete	0.04 – 0.06	0.07 – 0.10	0.13 – 0.20

20.6 EQUIPMENT

A. Transport Equipment

Trucks used for transporting APM shall be free of debris, and should be treated with approved release agents. Petroleum distillates such as kerosene or fuel oil will not be permitted as a release agent. The **AGENCY** may reject any APM which demonstrates it has been contaminated from a petroleum distillate release agent.

B. Material Transfer

Placement of SMA shall require the use of a Material Transfer Vehicle (MTV) or Material Transfer Device (MTD). The MTV shall be a self-propelled unit with on board storage of material. An MTD is a non-self-propelled unit. Both MTV and MTD are capable of receiving material from trucks or from the ground, transferring the material from the unit to a paver hopper insert via a conveyor system.

C. APM Pavers

Self-propelled pavers shall be capable of placing the APM to the desired width, thickness and a satisfactory mat texture.

Pavers shall be equipped with automatic screed controls; the sensors may be contact or non-contact type devices. The controls shall be capable of maintaining the screed at the specified transverse slope within ±0.1%.

20.7 PLACEMENT

APM shall be placed on properly constructed surfaces that are free from debris, frost, snow, or ice. APM shall be placed in accordance with the temperature limitations of Table 20.7A-1. In-place density for APM shall be 94% of maximum theoretical specific gravity (Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

A. Temperature

Surface temperatures shall be used to determine placement of APM. APM produced with documented WMA will be allowed a reduction in minimum surface temperatures for placement as provided in Table 20.7A-1. Ambient temperatures shall be 40 degrees and rising. ~~and other weather conditions shall be considered prior to placement.~~

TABLE 20.7A-1
Minimum Surface Temperatures for placement of APM

Compacted Layer Thickness (in.)	Minimum Surface Temperature (ºF)			
	Top Layer		Layers Below the Top Layer	
Product	APM	with WMA	APM	with WMA
<1½	60	50	50	40
1½ - <3	50	45	40	35
3 or more	45	40	35	35

If the **CONTRACTOR** modifies the placement and compaction processes when ambient temperatures are below minimum surface temperatures in Table 20.7A-1, they shall demonstrate to the **AGENCY** the required in-place density has been achieved. APM cooling software such as PaveCool, or MultiCool can be used to determine placement and compaction times available.

B. SMA Placement

The **CONTRACTOR** shall establish and document a roller pattern for the SMA being placed. The roller pattern shall include, but is not limited to the following:

- Number, size, and type of rollers
- Amplitude, frequency, and speed of rollers
- Temperature of mixture being compacted during each process (break down, intermediate and finish)
- Number of roller passes for each phase

The in-place density shall be determined during placement of the first 1,000 feet with a minimum of 95% of Theoretical Maximum Density (Rice). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

SMA mixture shall be placed with the assistance of an MTV or MTD. The **CONTRACTOR** should minimize flushing and drain down during the transport and placement of SMA. If more than 50 square feet of flushed area is observed, the **CONTRACTOR** shall provide a remedy to address the flushing and/or drain down.

In place density may be determined by nuclear gauge measurements in accordance with ASTM D 2950 and AASHTO T 230, or based on cores in accordance with AASHTO T 166, Method B. When cores are used, the **CONTRACTOR** shall provide all labor and equipment for the coring and repair of the holes.

When the material being placed is on a structure (bridge deck), nuclear gauge measurements shall be used.

C. WMA Technology

WMA technologies (additive or foaming) may be used as a compaction aid and may allow for workability of the APM at lower temperatures.

The addition of WMA additives during production, including foaming, shall be controlled by a calibrated metering system interlocked with the plant's controls per the manufacturers' recommendation.

Additives may be added at the asphalt terminal at the dosage rate recommended by the WMA technology provider. The dosage rate and additive name shall be printed on the Bill of Lading for the asphalt binder.

The foaming process mixes water and binder to create microscopic steam bubbles. Typical water injection rate is ≤ 2% of binder flow rate or per manufacturers' recommendation.

20.8 LONGITUDINAL JOINTS

The **CONTRACTOR** shall submit a joint plan and pavement marking plan showing the location of and the methods to establish the paving control lines. The plan shall be approved by the **AGENCY**. The **CONTRACTOR** shall use a method to delineate longitudinal joints during paving.

The longitudinal joint on the top lift shall match the crown. Longitudinal joints in all pavement layers shall offset the joint in the layer immediately below by a minimum of six inches. The joint in any pavement layer shall not fall in or between wheel paths. Joints in the top layer of new pavement shall be located on lane lines unless otherwise shown on the plans. Longitudinal joints shall be minimized with wide paving pulls. Joints shall be parallel to the flow of traffic and shall not cross any centerline, lane line, or edge line.

All paving shall be placed parallel to the roadway centerline and as straight as possible**.** All joints shall receive a coat of tack prior to placement of adjacent paving.

20.9 TRANSVERSE JOINTS

The **CONTRACTOR** shall submit a joint plan. The plan shall be approved by the **AGENCY**. The **CONTRACTOR** shall use an approved plan to delineate transverse joints during paving. 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 before additional mixture is placed against the previously compacted material.

The surface tolerance at the transverse joint shall be verified by the **CONTRACTOR** with a 10 foot straight edge. If the surface tolerance exceeds 3/16" across the joint, measured in at least three locations, the **CONTRACTOR** shall make corrections to the joint before proceeding.

20.10 SEGREGATION

Visually segregated areas shall be corrected before the initial compaction process is applied. Segregated areas may be determined visually or by other acceptable means. The **CONTRACTOR** shall correct segregated areas to the satisfaction of the **AGENCY**.

20.11 COMPACTION

Equipment used for compaction of the APM will be at the discretion of the **CONTRACTOR**. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density and surface texture.

When the mixture contains unmodified asphalt binder (PG 58-28 or PG 64-22), and the surface temperature falls below 180°F, further compactive effort shall not be applied unless the **CONTRACTOR** can demonstrate that there is no damage to the finished mat.

If the mixture contains modified asphalt binder (PG 76-28) and the surface temperature falls below 230°F, further compactive effort shall not be applied unless the **CONTRACTOR** can demonstrate that there is no damage to the finished mat.

Use of rollers with the vibrator on will not be permitted on bridge decks covered with waterproofing membrane.

In-place density for APM shall be 94% of maximum theoretical specific gravity (Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number. Rice values will be based on a three production day's average. The **CONTRACTOR** 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.

In place density for SMA shall be determined during placement of the first 1,000 feet with a minimum of 95% of theoretical maximum specific gravity Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

All joints shall be compacted to 92% of Rice, taken six inches offset from the joint, at a minimum of one every 1000 linear feet or fraction thereof. The allowable variance shall be ±2%. Test results shall be reported to the nearest whole number.

Cores may be used to verify compaction results. The **CONTRACTOR** shall core the pavement, as required by the **AGENCY;** in accordance with AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with the ASTM D 2950. At a minimum, cores for nuclear density equipment correlation shall be taken at the beginning of placement of each pavement layer or change of mixture materials or gradation.

Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall meet all project compaction specifications. Any mixture that is defective, shall be corrected to meet the project specifications at the expense of the **CONTRACTOR**.

20.12 PRODUCTION TOLERANCES

A. Wearing Course

Surface variation shall not exceed 3/16 inch in 10 feet for full lane width paving. For patching, the variation shall not exceed 3/8 inch in 10 feet. The final pavement

surface shall not vary from the specified cross section by more than one inch at any point. Transverse measurements for variations shall exclude breaks in the crown sections. Corrections shall be made at the **CONTRACTOR's** expense.

The final surface pavement adjacent to curb and gutter shall be finished from 1/8-inch to 3/8-inches above the lip for catch curb and shall not extend above the lip for spill curb.

The **CONTRACTOR** shall adjust all manholes, valve boxes, and survey range boxes 1/8 to 1/2- inch below final grade and adjusted to match the slope of the roadway. Valve boxes and manholes are to be maintained fully accessible at all times for emergency and maintenance operations. The cost of adjusting valve boxes, manholes, and survey range boxes shall be included in the work, unless otherwise specified. The **CONTRACTOR** shall be responsible for any cost incurred by the **AGENCY** to provide access to the covered manholes or valve boxes. Final adjustment of all utility access points shall be completed within seven days of from the time the APM was placed.

B. Job Mix Formula

Tolerances for gradation are presented in Table 20.2A-2 and Table 20.2A-3. APM volumetric tolerances are presented in Table 20.12B-1.

TABLE 20.12B-1
Production Mix Tolerances

Property	Tolerance
Air Voids	± 1.2%
VMA	± 1.2%
Asphalt Binder Content	± 0.3%

20.13 CONFORMITY WITH PLANS AND SPECIFICATIONS

A. Materials

Materials shall be sampled by and tested by a LabCAT certified technician(s) in an AMRL accredited testing laboratory in accordance with Section 20.14.

Test results that have sampling or testing errors shall not be used.

B. Pavement Thickness

A minimum of 90% of all the pavement thickness cores must equal or exceed the required thickness shown on plans or pavement design report.

If the pavement thickness deficiency is greater than 0.25 inches for individual cores, two additional cores will be taken by the **CONTRACTOR** 50 feet before and

after each deficient core. The three core results will be averaged to determine if the results meet the required thickness.

When individual core thickness deviates from the target thickness by more than 0.25 inch but not more than 0.50 inch, remedial action will be required. The **CONTRACTOR** shall present proposed remedial measures for consideration by the **AGENCY**. The **AGENCY** will review the proposal within 10 working days to accept or modify the remedial measures. The remedial measures will be performed by the **CONTRACTOR** at no additional cost to the **AGENCY**.

When individual core thickness deviates from the target thickness by more than 0.50 inch, corrective action shall be required. The deficient area will be overlaid with no less than one inch thick lift to meet the design thickness. The **CONTRACTOR** will mill to match existing facilities prior to corrective overlay. The mixture proposed shall be approved by the **AGENCY**. Corrective action will be performed by the **CONTRACTOR** within 15 working days.

If the **AGENCY** does not want the top lift cored, they may require the **CONTRACTOR** to use non-destructive survey techniques to determine APM thickness.

C. Smoothness

Smoothness criteria is typically not applicable for local agency roads. Impacts of curb and gutter, utilities, cross streets, and intersections will cause deviation from plane making smoothness measurements inaccurate.

However, if the **AGENCY** elects to set smoothness criteria it should only be established for roadways with speed limits 35 mph or greater. When specified, the **CONTRACTOR** shall profile the roadway prior to the work taking place and immediately after the work has ended. The **CONTRACTOR** will be required to maintain or improve the ride quality. If the ride quality decreases, the **CONTRACTOR** will be required to restore the ride to the levels it was prior to the work taking place.

D. Acceptance

If the **CONTRACTOR** does not meet the project specifications, but acceptable work has been produced, the **AGENCY** shall determine the extent of the work to be accepted. If the **AGENCY** determines the work is not acceptable, the **CONTRACTOR** shall correct the work, as approved by the **AGENCY**, at the expense of the **CONTRACTOR**.

20.14 TESTING AND INSPECTION

If any materials furnished or work performed fails to meet the specification requirements, such deficiencies shall be documented and reported to the **AGENCY**. Field reports shall be delivered to the **AGENCY** within three business days. Test results that cannot be

completed within three days shall be provided to the **AGENCY** no later than one week after the sample was obtained.

Testing of APM shall be performed in accordance with Table 20.14-1. Laboratories shall be accredited by AASHTO Materials Reference Laboratory (AMRL) for the tests being performed. Technicians obtaining samples and conducting compaction tests must have a LabCAT Level A certification. Technicians conducting tests of asphalt content and gradation must have a LabCAT Level B certification. Technicians performing volumetric testing must have a LabCAT Level C certification. Inspectors on APM projects shall be LabCAT Inspector Certified (Level I).

TABLE 20.14-1
Minimum Materials Sampling and Testing for Process Control and Owners Acceptance

Test	Standard	Minimum Frequency
Sampling	AASHTO T168, ASTM D 979 and ASTM D3665	1/1000 tons or fraction thereof (not less than one test per day)
Density	AASHTO T 166, T 238, T 230	One test for each 250 lineal feet per lane;
Thickness (Core)	ASTM D3549	One test for each 1000 lineal feet per lane
Air Voids & VMA	AASHTO T 166 & AASHTO PP 19	1/1000 tons or fraction thereof (not less than one test per day)
Gradation	AASHTO T 27, T 11	1/1000 tons or fraction thereof (not less than one test per day)
Hveem/Marshall Stability As Applicable	AASHTO T 245, AASHTO T-246	1/1000 tons or fraction thereof (not less than one test per day)
Binder Content	AASHTO T 164 or other methods agreed upon between Agency and Contractor	1/1000 tons or fraction thereof (not less than one test per day)
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209	1/1000 tons or fraction thereof (not less than one test per day)
Lottman Stripping, TSR & Dry Density	AASHTO T 283	One per project per mix used.

~~**20.15 PAYMENT**~~

~~Accepted quantities of APM shall be paid at the contract price when complete and in place according to the Plans and Specifications. The contract price per contract and shall include labor, materials, and equipment necessary to complete the work.~~

~~TABLE 20.15-1~~
~~Payment~~

~~Description~~	~~Payment~~
~~Asphalt Pavement Material~~	~~$ / Ton Placed~~
~~Emulsified Tack Coat – (measured prior to the addition of water)~~	~~$ / Gallon~~
~~Stone Matrix Asphalt~~	~~$ / Ton Placed~~

End of MGPEC Item 20

ITEM 23
CRACK SEAL

23.1 DESCRIPTION

This item shall consist of furnishing all materials, equipment, labor, cleaning and clean up, traffic control and incidental items necessary for sealing or filling cracks of asphalt pavements. The purpose of crack sealing and crack filling is to prevent the intrusion of water and incompressibles. Crack sealing shall be applicable for cracks 1/4" to 3/4" wide or as recommended by manufacturer. Crack filler is recommended for cracks that are 1" or wider and / or exhibit edge deterioration.

Crack **Sealer** is used for working cracks, cracks that have more than ¼" seasonal movement. Both hot and cold materials are currently available for crack sealing; however, this specification is meant to only apply to hot applied materials.

Crack **Filler** should be used for nonworking cracks. Non-working cracks are cracks that have annual movement less than ¼". Non working crack types may include wide transverse cracks. If a crack exhibits edge deterioration it should be filled not sealed.

23.2 MATERIALS

Materials used for crack sealing shall meet or exceed requirements of ASTM D 6690 Type II and be listed on the CDOT approved products list. Crack sealers are typically viscous at high temperatures and applied with a wand and excess material is spread with a squeegee. The **CONTRACTOR** shall provide material certifications and manufacturer's instructions for heating and application.
http://www.coloradodot.info/business/apl

Materials used for crack filling shall be a premixed blend of polymer modified asphalt binder and wear resistant aggregates heated and mixed in a specialized melter. They are usually spread using a specialized device and smoothed with a heated float. The **CONTRACTOR** shall provide material certifications and manufacturer's instructions for heating and application. Material shall be listed on the CDOT approved products list.

NOTE:
If CDOT approved crack filler is not available see MGPEC website for product recommendations made by other municipalities.

23.3 EQUIPMENT

Equipment shall be as specified by the sealant manufacturer and approved by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

An oil jacketed type melting unit equipped with both agitation and recirculation systems shall be used to heat the sealant. Direct Fire Melters will not be allowed. The unit shall

be equipped with separate thermometers for both the oil bath and the crack sealing material. Thermometers shall be calibrated on a weekly basis to ensure the proper heating of the material.

Materials shall be heated according to the manufacturer's specifications. Fresh material shall not be added to material that was overheated in an attempt to make it acceptable. Material that has been overheated shall be discarded.

23.4 CONSTRUCTION REQUIREMENTS

Prior to sealing, all loose material shall be blown out of cracks using a heat lance. Care shall be taken not to burn of scorch the pavement. Torches shall not be used. The **CONTRACTOR** shall ensure that blown debris shall not strike pedestrians, workers, or cause damage to vehicles and/or private property during cleaning and sealing operations. The **CONTRACTOR** shall clean debris from streets and sidewalks as soon as sealant has hardened sufficiently.

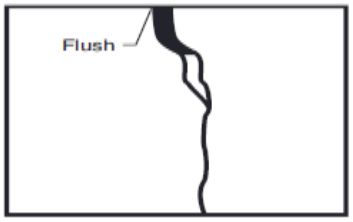
Cracks shall be free of moisture, residue from deicing chemicals, vegetation and loose matter prior to sealing. If sealant boils when applied additional drying is required before sealing resumes.

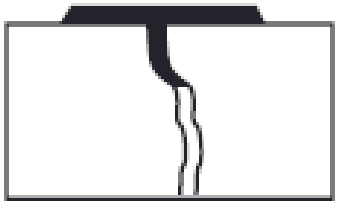
Cracks shall be sealed to a minimum depth equal to 2 X crack width or the full thickness of the pavement. Overband, if used, shall not exceed 3" in width and ⅛" in height above the pavement surface. Over band width is critical when sealing longitudinal cracks or in stopping zones to avoid creating hazards for cyclists or reducing the tire friction.

When the **AGENCY** specifies routing of cracks, routing shall precede blowing out cracks.

AGENCY shall specify if routing is required prior to placement of Crack Seal:

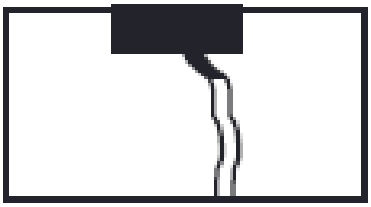
Flush Fill

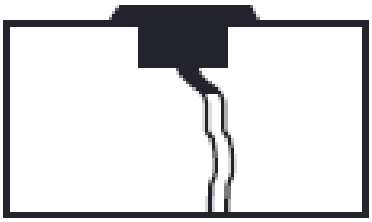




Routed and flush filled

Overband (Slang "Band Aid")





Routed and Overband

The finished level of **Crack Seal** or **Crack Filler** shall be **flush to 1/8" above the asphalt surface**. Excess material shall be removed by the **CONTRACTOR**.

The **CONTRACTOR** shall apply the sealant material according to manufacturer's recommendations with approval by the **AGENCY**. The **CONTRACTOR** shall be solely responsible for safety during all operations and making sure material is placed only in cracks with or without overband as shown above.

Traffic shall be kept off sealant until sufficiently hard to not be picked up by traffic. Cooling of sealant can be accelerated using a commercial solution or water. Blotting with sand or paper is not acceptable.

NOTE FOR ASPHALT OVERLAYS:
According to CDOT Research Report 2009-9, bumps caused by crack sealant under an overlay can be prevented by using a pneumatic roller for the breakdown roll. Age of crack seal is not a factor in the development of bumps from crack seal material.

QUALITY CONTROL REQUIREMENT CHECKLIST

Climatic Conditions

- Surface temperature is at least 45°F and rising or per manufacturer's recommendations.
- No moisture, fog or dew is present.
- Early morning operations should be performed in direct sunlight.

Routing

- Cutting tips are sufficiently sharp to minimize spalling and cracking.
- Proper safety garments are worn (hard hat, reflective vest, long-sleeved shirt, pants, steel toed boots, safety goggles, and hearing protection).
- Guards and safety mechanisms on equipment work properly.
- Router follows cracks without difficulty.
- Routed cracks do not exhibit spalling.

Material Preparation

- Proper safety garments are worn (hard hat, reflective vest, long-sleeved shirt, pants, steel toed boots, safety goggles, and hearing protection).
- Heating oil in melter jacket is not fuming and level is adequate.
- Temperature gauge on the melter has been calibrated to the satisfaction of the AGENCY.
- If the temperature gauge has not been calibrated:
- Measure sealant temperature with a thermometer.
- Ensure that the reading on the thermometer is the same as the reading on the melter temperature gauge.
- Sealant is never reheated above the manufacturer's recommended pouring temperature.
- Material safety data sheet (MSDS) is available on-site.

Cleaning of Cracks and Routs

- Proper safety garments are worn (hard hat, reflective vest, long-sleeved shirt, pants, steel toed boots, safety goggles, and hearing protection).
- A power sweeper or vacuum cleaner is being used to remove dirt and debris from the pavement surface.
- Compressor for high-pressure air provides at least 100 psi.
- Oil and moisture filters on compressor work properly.
- Temperature of the hot-air lance is below 930°F and the tip is 2 to 4 inches from the crack or rout.
- The cleanliness of the crack or rout is being checked every 30 minutes.
- The crack or rout is dry.
- No deicing chemical residue is present.

Sealant Application

- Hot-pour sealant is poured at the manufacturer's recommended temperature.
- The material is applied to the inside of the cracks.
- Insure that sealant is placed up to the asphalt surface.
- There is sufficient sealant to allow for overband (if applicable).
- There are no bubbles due to moisture present.

Overbanding of Sealant (if applicable)

- Over band is not more than 3 inches wide.
- Over band is not more than 1/8 inch above the pavement surface.
- Over band is formed during, or immediately after, sealant application.
- Excess sealant is removed before hardening.

Sealant Protection

- Traffic is rerouted until sealant is set.

~~23.5 MEASUREMENT~~

~~Crack sealant shall be measured and paid by the ton complete in place and accepted. If routing is specified it will not be measured and paid separately but shall be included in the cost of material.~~

~~The **CONTRACTOR** shall measure and the inspector verify the following:~~

~~Before work starts each day:~~

- ~~Amount of material in melter~~
- ~~Number and weight of containers of material on site~~
- ~~All containers are clearly marked with manufacturer's information.~~

~~At the end of work each day:~~

- ~~Amount of material in melter.~~
- ~~Number of containers of material not used.~~

~~The **CONTRACTOR** shall certify that material in the melter is per the specifications and has not been overheated.~~

~~Measurement will not begin before inspector arrives.~~

~~Inspector shall be given adequate notice if material is to be delivered during the work day and have the opportunity to verify quantity.~~

~~Counting or delivering boxes or lids shall not be an acceptable method of verifying quantity of material.~~

23.6 TESTING AND INSPECTION - GUIDANCE

When pulled vertically using a flattened sharp tipped ¼" rod bent at 90° the bond between the sealant and asphalt should be stronger than the sealant or the asphalt. Sealant or existing asphalt pavement should fail before the bond is broken.

~~23.7 PAYMENT~~

~~Payment shall include all equipment, supervision, labor, material, traffic control; clean up including sweeping of streets and other areas where debris may have traveled and any other items necessary to perform the work. Payment for crack seal and / or crack filler shall be made for material placed and accepted at the unit prices provided in the bid schedule. Crack seal and crack filler shall be paid at the contract unit price per ton of material placed and accepted.~~

~~Item Description~~	~~Payment~~
~~23.7-1 Joint and Crack Sealant~~	~~$/Ton~~
~~23.7-2 Joint and Crack Filler~~	~~$/Ton~~

End of MGPEC Item 23

ITEM 30

PORTLAND CEMENT CONCRETE MATERIALS
(2019 version)

30.1 DESCRIPTION

The concrete shall be composed of fine and coarse aggregates, portland/hydraulic cement, supplementary cementitious materials, admixtures, and water. The ingredients are specified in Sections 30.2A through 30.2F. Reference documents ACI 301 and ACI 318.

30.2 MATERIALS

All materials used in concrete shall be the same materials used in the concrete represented by the field test records or trial batch mixtures. Materials substitution shall be approved by the AGENCY.

A. Aggregate

Aggregate is defined as granular material, such as sand, gravel, crushed stone, and iron blast-furnace slag, used with a cementing medium to form hydraulic-cement concrete or mortar as per ASTM C125. Other materials that are significantly detrimental to the concrete mix should be excluded from the aggregate or aggregate blend utilized.

1. Alkali-Silica Reactivity

Aggregates containing certain ingredients can react with the cement in concrete causing expansion of the concrete. The following tests shall be performed to help produce concrete resistant to alkali-silica reaction. Individual aggregates shall be tested and considered innocuous if it complies with the following:

- ASTM C1260 14-day expansion less than or equal to 0.10%, or
- ASTM C1293 1-year expansion less than or equal to 0.040%

For aggregates that do not meet these criteria, mitigation measures shall be demonstrated in accordance with the below to meet the minimum requirements:

- ASTM C1567 14-day expansion less than or equal to 0.10%*, or
- ASTM C1293 2-year expansion less than or equal to 0.040%*

**Tested with submitted concrete mix design cement, supplementary cementitious materials, and aggregate(s)*

Individual aggregate proportions or the aggregate blends which shall be used in the mix design shall be tested. Alternative mitigation measures will be considered case by case (see Table 30.2A-3).

2. Fine Aggregate

Fine aggregate shall meet the requirements in ASTM C33, except as follows.
The gradation shall meet the requirements in Table 30.2A-1.

Table 30.2A-1
Fine Aggregate Gradation

Sieve	Percent Passing, %
3/8 inch	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	5 – 30
No. 100	0 – 10
No. 200	0 – 3*

**Manufactured sand that consists of over 50% crushed particles limits No. 200 to a maximum of 5%.*

Sulfate soundness loss by weight (ASTM C88) shall not exceed 10% (Sodium Sulfate,) or 15% (Magnesium Sulfate.)

The maximum deleterious substances and organic impurities shall not exceed the limits listed in ASTM C33 (Table 30.2A-2).

Table 30.2A-2
Fine Aggregate Deleterious Substances and Organic Impurities

Material	ASTM	Limit
Material finer than 200 mesh sieve	C117	3% by weight
Shale	Petrographic analyses	1% by weight
Coal and lignite	C123	0. 5% by weight
Clay lumps and friable particles	C142	3% by weight
Organic Impurities	C40	Plate 3

The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

3. Coarse Aggregate

Coarse aggregate gradation shall meet the requirements in ASTM C33 (Table 30.2A-3).

Table 30.2A-3
Coarse Aggregate Gradation

Sieve Size	No. 8 (3/4" Nominal) % Passing	No. 67 (3/4" Nominal) % Passing	No. 57 (1" Nominal) % Passing	No. 467 (Combined Grading) % Passing
2 inch		--	--	100
1-1/2 inch		--	100	95 to 100
1 inch		100	95 to 100	--
¾ inch		90 to 100	--	35 to 70
½ inch	100	--	25 to 60	--
3/8 inch	85 to 100	20 to 55	--	10 to 30
No. 4	10 to 30	0 to 10	0 to 10	0 to 5
No. 8	0 to 10	0 to 5	0 to 5	--
No. 16	0 to 5	--	--	--

Note: Grading No. 57 or 67 shall be used when the concrete section thickness is six (6)-inches or less, unless otherwise specified.

Wear shall not exceed 50% as tested in accordance with ASTM C131/C535 (based on nominal maximum aggregate size). Sulfate soundness loss by weight (ASTM C88) shall not exceed 12% (Sodium Sulfate), or 18% (Magnesium Sulfate).
The maximum percentage of deleterious substances shall not exceed the limits in ASTM C33 (Table 30.2A-4).

Table 30.2A-4
Coarse Aggregate Deleterious Substances

Material	ASTM	Limit
Material finer than 200 mesh sieve	C117	1% by weight
Lightweight fragments (specific gravity < 2.4)	C123	3% by weight
Coal and lignite (specific gravity < 2.4)	C123	0.5% by weight
Clay lumps and friable particles	C142	3% by weight

Non-aggregate material such as wood, sealant, and backer-rod are considered deleterious substances. The sum of the percentages of the above deleterious substances shall not exceed 5% by weight.

4. Combined Aggregate Blends

Combined aggregate blends will be allowed. Individual aggregates that do not meet the gradations in Table 30.2A-3 may be blended to achieve the gradations in Table 30.2A-3. Intermediate aggregates may also be added to improve fresh and hardened properties of concrete.

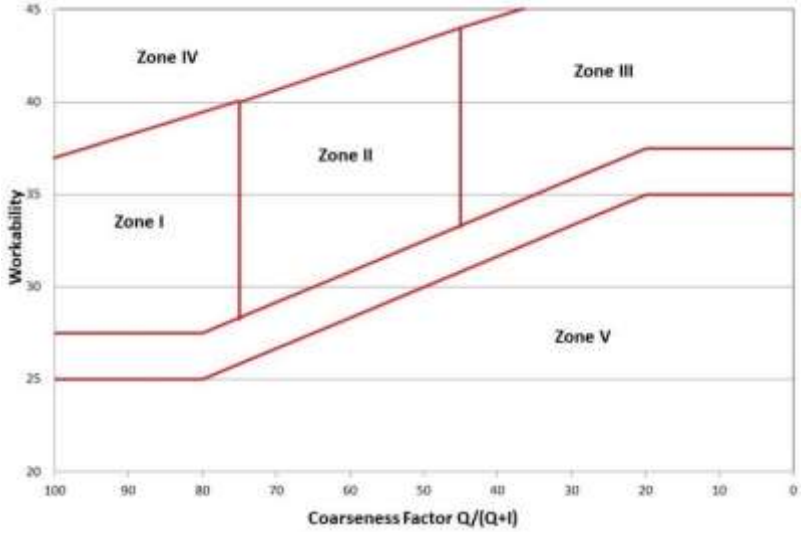
Optimized gradations may be used by following a Shilstone, KU Mix, or similar method. The combined aggregate gradation usually falls within Zone II of Figure 30.2 but is not required to be within this Zone. Coarseness factor and workability factor shall be computed as follows:

$$Q\ (Quality)\ =\ \%\ combined\ aggregate\ retained\ on\ {}^{3}/_{8}\ inch\ sieve$$
$$I\ (Intermediate) =$$
$$\%\ combined\ aggregate\ passing\ {}^{3}/_{8}\ inch\ sieve\ and\ retained\ on\ \#8\ sieve$$
$$W\ (Workability)\ =\ \%\ combined\ aggregate\ passing\ \#8\ sieve$$
$$CF\ (Coarseness\ Factor\ -\ X\ axis)\ =\ \frac{Q}{(Q+I)}$$
$$WF\ (Workability\ Factor - Y\ axis)\ =\ W$$

The workability factor should be adjusted based on the total cementitious content (cement plus any supplementary cementitious materials) prior to plotting using the following equation:

$$WF_{adj}\ (Adjusted\ Workability\ Factor)\ =\ W\ +\ \left(\frac{wt.\ cementitious}{94\ lbs.} - 6\right) * 2.5$$

Figure 30.2A-1
Shilstone Coarseness Factor Chart



B. Cement

Portland/hydraulic cement shall conform to the following specifications:

Table 30.2B-1
Cement Types

Description	Specification	Type
Portland Cement[1]	ASTM C150	I, II, or V [2]
Blended Hydraulic Cement	ASTM C595	IL(MS), IL(HS), IP, IP(MS), IP(HS) or IT
Hydraulic Cement[3]	ASTM C1157	GU, MS, HS, shall be limited to a maximum of 15% limestone

[1] ASTM C150 Type III may be allowed for fast track applications.
[2] ASTM C150 Type II cement meeting the optional limits in accordance with ASTM C452 may be substituted for ASTM C150 Type V cement. ASTM C452 documentation shall be valid for two (2) years.
[3] ASTM C1157 Type HE may be allowed for fast track applications.

C. Supplementary Cementitious Materials

1. Fly Ash

Fly ash or natural pozzolans shall conform to ASTM C618, for Class C, F, N, or AASHTO M321 for High Reactivity Pozzolans.

2. Slag Cement

Slag cement shall conform to ASTM C989, Grade 100 or Grade 120.

D. Admixtures

Air-entraining admixtures shall conform to ASTM C260.

Chemical admixtures shall conform to ASTM C494, according to the following types:

Type A – Water-reducing
Type B – Retarding
Type C – Accelerating
Type D – Water-reducing and retarding
Type E – Water-reducing and accelerating
Type F – Water-reducing, high range admixtures
Type G – Water-reducing, high range, and retarding
Type S – Specific performance

Calcium chloride shall not be used ~~for exterior concrete~~ **on Douglas County projects**. Written approval by the Agency shall be obtained prior to the use of any ~~Type S~~ admixtures **in Douglas County**. Application of admixtures shall be per manufacturer's recommendations.

Corrosion inhibiting admixtures shall meet ASTM C1582.

Pigments for integrally coloring concrete shall meet ASTM C979.

E. Water

Water shall be potable or qualified by conforming to ASTM C1602.

F. Fibers

Fibers shall be allowed and must conform to ASTM C1116:

Type I	Steel fiber-reinforced concrete or shotcrete. Contains stainless steel, alloy steel, or carbon steel fibers.
Type II	Glass fiber-reinforced concrete. Contains alkali-resistant glass fibers.
Type III	Synthetic fiber-reinforced concrete. Contains virgin homopolymer polypropylene fibers or other synthetic fibers.
Type IV	Natural fiber-reinforced concrete that contains cellulose fibers.

G. Reinforcing Steel

All steel shall meet the requirements as noted or as shown in the project plans.

Mesh reinforcement shall meet ASTM A1064 for plain and deformed welded wire.

1. **Tie Bars for Pavement**
   Tie bars shall be **epoxy coated and shall meet** ASTM A615 Grade 60 deformed steel bars and conform to the requirements of ASTM A775, except that ends need not be patched, and frames are not required to be epoxy coated. Tie bars fabricated with ASTM A615 Grade 40 steel may be used for construction requiring bent bars.

2. **Dowel Bars for Pavement**
   Dowel bars shall be **epoxy coated and shall meet** ASTM A615 Grade 60 plain steel bars conforming to ASTM A775, except that ends and frames need not be epoxy coated. Dowel bars shall be free from burring or other deformation restricting slippage in the concrete. The dowels shall be coated with a bond-breaker recommended by the manufacturer.

H. Curing Materials

Curing materials shall conform to one of the following:

Table 30.2H-1
Curing Materials

Material	Specification
Liquid membrane-forming curing compounds	ASTM C309, Type 2, Class A, or Class B
Liquid membrane-forming compounds having special properties for curing and sealing concrete	ASTM C1315, Type I or II, Class A
White polyethylene film	ASTM C171
White burlap-polyethylene sheeting	ASTM C171
Waterproof paper	ASTM C171

I. Joint Sealant, Backer Rod & Expansion Joint Materials

The joint sealant for all sawed longitudinal and transverse joints shall be a silicone joint sealant meeting ASTM D5893. ASTM C1193 provides guidance for use of joint sealants.

Blocking medium shall be an expanded closed cell polyethylene foam backer rod or non-plastic rope that is compatible with the joint sealant material and meets ASTM C1330, Type C or ASTM D5249.

Polyethylene expansion joint materials shall be flexible, low density, expanded extruded polyethylene plank formed by the expansion of polyethylene base resin, extruded as a multicellular, closed cell, homogeneous foamed polyethylene. Laminations shall not be permitted. The joint material shall conform to ASTM D1751, ASTM D1752, or ASTM D8139.

J. Miscellaneous Additional Products

Use of additional products and or special ingredients may be approved by the Agency on a project specific basis.

30.3 CONCRETE MIXTURE PROPORTIONING

The following criteria is for general use exterior flatwork and concrete pavement, both of which may be exposed to deicing chemicals, as detailed in the application types in Table 30.3A-1.

A. Mixture Requirements

Jobsite, placement size, and exposure conditions may require modifications to these general criteria.

Table 30.3A-1
Mix Design Criteria

		EXTERIOR - General, Deicer Resistant	PAVING - Deicer Resistant
MIX SELECTION BY USE	**Designation**	EXT-DR	P-DR
	Acceptable CDOT Mix Substitution Class	D, B, S35	P
	Typical Application Type	Flatwork, sidewalk, curb and gutter, curb ramps, bridge structure and decks, other structures	Concrete pavement, bus pullouts, curb and alley cuts or pans
	Typical Cure Environment	Year-Round	Year-Round
STRENGTH REQUIREMENTS	**Minimum Design Compressive Strength (f'_c)* at 28 Days**	4,500 psi	4,500 psi
	Minimum Lab Mix Design Compressive Strength at 28 Days	5,200 psi	5,200 psi
	~~**Minimum Design Flexural Strength at 28 Days**~~	~~Not Required~~	~~650 psi~~
	Minimum Opening Compressive Strength	2,000 psi (before construction traffic) 2,500 psi (before normal traffic) *All opening strengths must be verified with maturity methods. Alternative mitigation measures will be reviewed individually*	
MIX COMPONENTS	**Allowable Cement Types**	Refer to Table 30.6	
	Allowable Supplementary Cementitious Materials	ASTM C618 Class F Fly Ash, Class C Fly Ash, or other approved pozzolans (**20%** ~~20-30%~~ replacement of cement) ASTM C989 Slag Cement, Grade 100 or 120 (**20%** ~~20-50%~~ replacement of cement) *Supplementary cementitious materials are required to mitigate deicer impacts*	
	Minimum Cementitious Material Content (cement + supplementary cementitious materials)	550 ~~520~~ lbs./cy (flatwork) 550 ~~565~~ lbs./cy ~~(structures; inlets,~~	550~~520~~ lbs./cy

		EXTERIOR - General, Deicer Resistant	PAVING - Deicer Resistant
	~~buried sewer box culverts, vaults)~~		
	Maximum Water-to-Cementitious Material (W/CM) Ratio [water/(cement + supplementary cementitious materials)]	0.45	0.44
	Sulfate Resistance	Subject to the limits in CDOT 601.04 Sulfate Resistance	
SLUMP	**Lab Mix Design Slump Range**	Slump requirements will vary based on application (hand vs. machine placement or other) *Slump acceptance is based on approved supplier mix design and set limits*	
TEMPERATURE	**Fresh Concrete Temperature (for placement)**	Between 50°F and ~~95~~ 90°F	
	In-Place Concrete Temperature (during curing)	A minimum of 50°F for at least ~~48 hours~~ 5 days, or until it reaches ~~2,000~~ 2,700 psi compressive strength *Use curing blankets as needed and verify using temperature monitoring devices, such as a min-max thermometer or maturity logger*	

**f'c = Minimum Specified Compressive Strength*

The concrete mixture shall include a supplementary cementitious material to mitigate winter deicer impacts, and the type(s) of supplementary cementitious materials allowed are dependent on sulfate contents in the subgrade soils.

The supplier should have available a range of mixtures that will work with various placing temperatures, slumps, climates, and need to adhere to required setting and opening time to pedestrian and vehicular traffic.

Allowable air content ranges for concrete mixture shall be according to the following table:

Table 30.3A-2
Air Content Requirements for Mix Design
(ACI 318, 19.3.3.1)

Nominal maximum aggregate size, inches	Air content, %
All	5.0 - 8.0
~~3/8~~	~~6.0 – 9.0~~
~~1/2~~	~~5.5 – 8.5~~
~~3/4~~	~~4.5 – 7.5~~
~~1~~	~~4.5 – 7.5~~
~~1-1/2~~	~~4.0 – 7.0~~
~~2~~	~~3.5 – 6.5~~
~~3~~	~~3.0 – 6.0~~

Nominal maximum size (of aggregate) is defined in ASTM C125 as the smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

Application and performance requirements will dictate the maximum nominal aggregate size.

B. Mix Design Submittal

Mix Design submittals will follow ACI 318 and include the following items at a minimum:

- Certified material test reports for aggregate, including all tests required; reporting each test, test method, test result, and other requirement specified (criteria).
- Aggregate gradations and analysis.
- Reactivity test results.
- Coarse aggregate quality test results, including deleterious materials.
- Fine aggregate quality test results, including deleterious materials.
- Mill certificates for cement and supplementary cementitious materials.
- Certified test results or certifications for all admixtures.
- Specified strength, slump, air content and maximum water-cementitious materials (w/cm) ratio.
- Recommended proportions, weights/volumes for proposed mixture and trial water-cementitious materials (w/cm) ratio, including actual slump and air content. Include material supplier and location of materials (pit name, cement plant, etc.)
- Compressive (and flexural when required) strength summaries and plots, including all individual beam and cylinder break results. Maturity Method data and curves showing the basis of criteria for allowing the opening of traffic on pavement.
- Submit a new design mix based on the above requirements when a significant change occurs in the mix proportions, source or type of cement, fly ash, or aggregate, or failure of field tests to meet specifications.
- The limits to possible field added weights for air, water, slump, other materials shall be clearly shown on individual dispatch tickets during production. The mix design

shall be reviewed and stamped by a Professional Engineer registered in the State of Colorado. Alternatively, a mix design on the current CDOT Approved Products List (APL,) may be submitted for use.
Review of the design mix by the AGENCY does not constitute acceptance of the concrete delivered.

C. Field Acceptance

1. Fresh Properties

Concrete may be placed when slump, air content, **temperature**, and water to cementitious materials ratio are determined to be in accordance with the AGENCY approved mix design parameters. Use Tables 30.3A-1 and 30.3A-2, and maximum water added dictated by the supplier in the mix design or delivery batch ticket when the AGENCY has no parameters. Concrete may be placed when batch tolerances are in accordance with ASTM C94, including the onsite addition of water and admixtures, and discharge time limits.

2. Strength

The strength level of standard or field cured concrete mixture specimen shall be acceptable if:

- The arithmetic average of any three consecutive strength tests equals or exceeds the Minimum Specified Compressive Strength, f'_c, and,
- No strength test falls below f'_c by more than 500 psi if f'_c is 5,000 psi or less; or by more than $0.10f'_c$ if f'_c exceeds 5,000 psi.

If either of these requirements are not satisfied, steps shall be taken to increase the average of subsequent strength results. Evaluation of strength test results, and investigation of low strength-test results shall be in accordance with ACI 301 and ACI 318. When 28 day strength test results are below the minimum specified strength, 56 day cylinders can be evaluated to verify minimum specified strength. Otherwise, if concrete **flatwork** is determined to not meet required compressive strength, in-place coring can be performed for material evaluation up to 65 **days** after placement. If the average of three core specimens achieve at least 85% of f'_c, the concrete placement is considered acceptable. Core specimens must be obtained following ASTM C42. **Coring will not be allowed on concrete structures.**

D. Testing

Testing of Concrete shall be performed in accordance with Table 30.3D-1

. **TABLE 30.3D-1**
Contractor's QC SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING

Test Type	Test Standard	Minimum Frequency (General Use)	~~Minimum Frequency (Pavement)~~
Strength	ASTM C31 ASTM C39	One set* per 100 cubic yards (minimum of one set per day)	~~One set* per 500 CY (minimum of one set per day)~~
Air Content	ASTM C231	One test per each first three trucks, then one for every **100 CY** ~~five trucks**~~ and with each set of strength samples	~~One test per each first three trucks, then one for every 500 CY** and with each set of strength samples~~
Slump	ASTM C143	One test per each first three trucks, then one for every five trucks** and with each set of strength samples	~~One test per each first three trucks, then one for every 500 CY** and with each set of strength samples~~
Temperature	ASTM C1064	One test with every air and slump test	~~One test with every air and slump test~~
Unit Weight	ASTM C138	One per air content test	~~One per air content test~~
Thickness	ASTM C174	--	~~One core per 1,500 LF per lane or utilize MIT Scan T3 or equivalent~~
Joint Sealant Pull Test	ASTM C1521 CDOT CP-67	--	~~One per 1,000 linear feet of joints~~

+QA testing may be less frequent than that required for QC testing.
One set consists of at least ~~5~~ **6 cylinders, with a minimum of 3 cylinders tested at 28 days. One* cylinder *may be tested at 7 days and ~~one~~ **two** held for compressive strength testing at 56 days, in case compressive strength tests do not meet requirements at 28 days.*

***If out of specification, test each truck until within specification*

Testing shall be performed by ACI Concrete Field Testing Technician Grade I certified technicians. The AGENCY shall determine who is responsible for performing QA testing, and the CONTRACTOR shall be responsible for QC testing.

The CONTRACTOR shall provide and maintain onsite facilities that will allow for the initial curing of test specimens to meet the requirements of ASTM C31. The AGENCY, CONTRACTOR, TESTING LABORATORY, AND CONCRETE SUPPLIER shall meet to discuss the adequacy and location of the on-site initial curing facilities location. Test results will be distributed by the TESTING LABORATORY to the AGENCY, CONTRACTOR, CONCRETE SUPPLIER, and any other appropriate representatives after specified project break dates of compressive strength specimen.

Laboratories performing tests shall be accredited by a nationally recognized accrediting organization. The laboratory will meet the requirements of ASTM C1077 and E329 for Aggregates and Concrete. Temporary field laboratories shall meet the same requirements, but the principal laboratory shall be accredited. Testing shall be performed by individuals certified in the testing conducted or under the direct observation of certified individuals while in training and in pursuit of certification (within 3 months). Results of tests determined to have not been performed in

accordance with applicable ASTM standards or criteria stated here shall not be used in the determination of acceptance. (Note: Records of technician certifications, and equipment calibrations and verifications shall be maintained and made available for review.)

30.4 MATURITY (TIME-TEMPERATURE) METHOD AND ESTIMATING CONCRETE STRENGTH

The Maturity Method may be used to make reliable estimates of the in-place strength of concrete, particularly when early opening is desired or required by the AGENCY. This is a two-step procedure:

- First, a relationship must be established between the maturity values and the concrete strength as measured by destructive methods in a laboratory in order to determine the Maturity Index. The development of the maturity curve shall be done prior to beginning construction and shall use the approved materials and mix design for the project.
- The second step is the instrumentation of the concrete to be measured. Maturity loggers are installed in the concrete and measured at predetermined intervals. By comparing those maturity readings to the laboratory curve, the in-place strength can be estimated. The contractor and the agency shall jointly develop a plan for performing the maturity testing.

A. Terminology

Datum Temperature	"The datum temperature is a selected temperature value at which it is assumed that no reactions occur to contribute to strength." (TIP 15)
Maturity Logger	A device required to monitor and record the concrete temperature as a function of time and compute the Maturity Index.
Maturity Method	"A technique for estimating concrete strength that is based on the assumption that samples of a given concrete mixture attain equal strengths if they attain equal values of the maturity index." (ASTM C1074)
Strength-Maturity Relationship	"An empirical relationship between concrete strength and maturity index that is obtained by testing specimens whose temperature history up to the time of test has been records." (ASTM C1074) In this document the Strength-Maturity Relationship is referred to as the Maturity Curve.
Temperature-Time Factor	"The maturity index computed as the area between the concrete temperature and the datum temperature from the plot of measured concrete temperature versus time, expressed in units of degree-days or degree hours." (ASTM C125) In this document the Temperature-Time Factor is referred to as the Maturity Index.

B. Laboratory Curve Development

Maturity curves should be developed in a laboratory with the same concrete mix design that will be used on the project. It is acceptable to use concrete produced at the ready mix plant, and delivered to the laboratory, for development of the maturity curve.

Determine test cylinder size according to ASTM C192. Prepare a minimum of 15 cylinders for testing in addition to cylinders that will contain the maturity loggers.

The maturity logger should be placed in the center of the cylinder with the lead exposed. Use two maturity loggers, in separate cylinders, for curve development. Activate the maturity loggers, input datum temperature, and record the logger activation time immediately after molding is complete.

Moist cure cylinders in a water bath, or a moist room, following the requirements of ASTM C511.

For conditions when maximum accuracy of strength estimation is desired the appropriate datum temperature can be determined experimentally. For convenience, 0 degrees Celsius is an industry standard datum temperature selection in the absence of verification testing.

For high early applications, the recommended cylinder curing environment is described in ASTM C1758. Several field and laboratory observations have indicated that concrete mixtures with rapid strength development generate increased early age heat that cannot be replicated through standard curing. Standard curing of this type of concrete slows the hydration reaction and restricts the early age heat which would otherwise occur. This restriction in early age heat and strength development may yield an inaccurate maturity curve. In all cases, cure cylinders for maturity curve development in a manner that closely mimics the expected jobsite curing conditions.

Determine measurement ages based on the type of cylinder curing environment that will be utilized. Take a minimum of three measurements prior to reaching the target strength for the project, and two afterwards. Record the averages of the maturity values, temperatures and at least two compressive strengths at each measurement age. If the range of compressive strength of the two specimens exceeds 10% of their average compressive strength, test another cylinder and compute the average of the three tests. If a low test result is due to an obviously defective specimen, discard the low test result.

Input the recorded data into the maturity software system that is being utilized. Provide a report that summarizes the following data from the trial:

- Batch Date
- Batch time
- Logger activation time
- Datum temperature
- Mix Code
- Concrete slump, air content, unit weight, temperature and water to cementitious ratio at the time of testing

- Minimum and maximum temperatures recorded
- At each test age list averages of the maturity values, temperature and compressive strengths
- What size cylinder or beam that was used as a specimen type
- The time-temperature factor for the target compressive strength
- The appropriate equation from ASTM C1074 Section 6 used
- Plotted maturity curve with the maturity value on the X axis and the strength listed on the Y axis

If specified, a flexural strength maturity relationship is permitted. Use the same procedures found in Section 30.4B above to develop the flexural maturity curve.

Development of a new maturity curve due to material source, or proportion changes, in a concrete mix may be waived by use of the verification procedure found in Section 30.4D.

C. Field Measurement

The AGENCY is responsible for the maturity determination of in-place concrete such as designating the location and quantity of maturity sensors and verifying the required maturity index for the project.

Prior to concrete placement, install maturity loggers at locations in the structure that are critical in terms of exposure conditions and structural requirements. Sensors should be surrounded by concrete and not be in direct contact with metallic embedment or other features that are partially exposed to the environment. For pavements, insert the maturity loggers into the concrete until the probe is at approximately the slab mid-depth, and at least two feet from the edge. Consult the AGENCY for smaller sections of pavement where this is not possible.

D. Determination of In-Place Strength

The field placement will likely reach the target maturity index faster than the cylinder specimens did during the development of the maturity curve. This is more accentuated when using high early concrete. A plan should be developed for each pour as to when maturity readings in the field will begin based on the anticipated rate of strength gain of the concrete placement. Consult with the Ready-Mix supplier to understand this in more detail.

When the strength at a location is to be estimated, read the maturity index from the logger.

Verification of the strength maturity relationship is performed when safety critical elements are identified by the AGENCY. Cast at least three field-molded cylinders. A maturity logger will be placed in the center mass of one cylinder. Activate the maturity logger immediately after molding is complete. Subject these cylinders to the same curing method used during maturity curve development. When the logger reads 90-100% of the target maturity index, transport all cylinders, including the one with the logger, to the testing location. Prior to testing any cylinders, record the temperature, maturity index and elapsed time of the embedded logger. Test at least two cylinders to determine the average compressive

strength. If the average compressive strength of the cylinders is more than 10% below the strength indicated by the maturity curve at that time, a new strength maturity relationship should be developed. If the average compressive strength of the cylinders is more than 10% over the strength indicated by the maturity curve at that time, it is not necessary to develop a new curve unless more accuracy is deemed necessary by the AGENCY.

E. Factors Requiring a New Curve

Changes in material sources, proportions, and mixing equipment all affect the maturity value of a given concrete mixture. If the w/c ratio of the production concrete exceeds the w/c ratio of the concrete used to develop the strength-maturity curve by more than 0.02, a new curve shall be developed. Therefore, development of a new maturity curve is generally required for any change to a concrete mix.

Development of a new maturity curve due to material source or proportion changes in a concrete mix may be waived by use of the validation procedure. If the average strength is greater than the original maturity curve at the TTF the validation beams were tested, a new curve shall not be required. A new curve shall be required if the average strength is less than the original curve at the TTF the validation beams were tested.

30.5 REFERENCES

The following standards and procedures are noted for reference as needed:

Standard or Procedure	Name	Description or Significance
AASHTO M321	Standard Specification for High-Reactivity Pozzolans for Use in Hydraulic-Cement Concrete, Mortar, and Grout	This specification covers high-reactivity pozzolans for use as a mineral admixture in Portland cement concrete and mortar to fill small voids and/or where pozzolanic action is desired. High-reactivity pozzolans are microsilica products with a particle size typically one to two orders of magnitude smaller than portland cement. These materials are usually supplied in undensified or densified dry form. If the material is supplied in a densified form, the tests should be performed on the as-collected undensified material before being processed into densified form.
AASHTO T104	Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate	This method covers the procedure to be followed in testing aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate or magnesium sulfate. This is accomplished by repeated immersion in saturated solutions of sodium or magnesium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in permeable pore spaces. The internal expansive force, derived from the rehydration of the salt upon reimmersion, simulates the expansion of water on freezing. This test method furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions. Attention is called to the fact that test results by the use of the two salts differ considerably and care must be exercised in fixing proper limits in any specifications that may include requirements for these tests.

Standard or Procedure	Name	Description or Significance
ACI 301	Specifications for Structural Concrete	This is a Reference Specification that the Architect/Engineer can apply to any construction project involving structural concrete by citing it in the Project Specifications. A mandatory requirements checklist and an optional requirements checklist are provided to assist the Architect/Engineer in supplementing the provisions of this Specification as required or needed by designating or specifying individual project requirements.
ACI 308	Guide to External Curing of Concrete	This guide reviews and describes practices, procedures, materials, and monitoring methods for the external curing of concrete and provides guidance for specifying curing procedures. Current curing techniques are presented, and commonly accepted methods, procedures, and materials are described. Methods are given for curing structures and buildings, pavements and other slabs-on-ground, and for mass concrete. Curing methods for several specific categories of cement-based products are discussed in this document.
ACI 318	Building Code Requirements for Structural Concrete and Commentary	The “Building Code Requirements for Structural Concrete” (“Code”) provides minimum requirements for the materials, design, and detailing of structural concrete buildings and, where applicable, nonbuilding structures. This Code addresses structural systems, members, and connections, including cast-in-place, precast, plain, non-prestressed, prestressed, and composite construction. Among the subjects covered are: design and construction for strength, serviceability, and durability; load combinations, load factors, and strength reduction factors; structural analysis methods; deflection limits; mechanical and adhesive anchoring to concrete; development and splicing of reinforcement; construction document information; field inspection and testing; and methods to evaluate the strength of existing structures.
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement	This specification covers deformed and plain carbon-steel bars for concrete reinforcements in cut lengths and coils. Materials considered under this specification are available in Grades 40 [280], 60 [420] and 75 [520].
ASTM A706	Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement	This specification covers deformed and plain low-alloy steel bars in cut lengths or coils for concrete reinforcement intended for applications. Restrictive mechanical properties and chemical composition are required for compatibility with controlled tensile property applications or to enhance weldability.
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars	This specification covers deformed and plain steel reinforcing bars with protective epoxy coating applied by the electrostatic spray method. The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to near-white metal. The number and frequency of tests for coating thickness, continuity, flexibility and adhesion are specified. If the specimen for coating thickness or flexibility fails to meet the specified requirements, two retests on random samples shall be conducted for each failed test.
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete	This specification covers carbon-steel wire and welded wire reinforcement produced from hot-rolled rod to be used for the reinforcement of concrete. The steel wire is cold-worked, drawn or rolled, plain (non-deformed, as-drawn or galvanized), or deformed. Welded wire reinforcement is made from plain or deformed wire, or a combination of plain and deformed wire.

Standard or Procedure	Name	Description or Significance
ASTM A1078	Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement	This specification covers plain steel dowel bars with protective fusion-bonded epoxy coating for use in concrete pavements.
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field	This practice provides standardized requirements for making, curing, protecting, and transporting concrete test specimens under field conditions.
ASTM C33	Standard Specification for Concrete Aggregates	This specification defines the requirements for grading and quality of fine and coarse aggregate for use in concrete. Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof. Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled blast furnace slag, or crushed hydraulic-cement concrete, or a combination thereof.
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens	This test method covers determination of compressive strength of cylindrical concrete specimens such as molded cylinders and drilled cores. It is limited to concrete having a density in excess of 800 kg/m^3 [50 lb./ft^3].
ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete	This test method provides standardized procedures for obtaining and testing specimens to determine the compressive, splitting tensile, and flexural strength of in-place concrete. Generally, test specimens are obtained when doubt exists about the in-place concrete quality due either to low strength test results during construction or signs of distress in the structure. Another use of this method is to provide strength information on older structures.
ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)	This test method is used to determine the flexural strength of specimens prepared and cured in accordance with Test Methods C42/C42M or Practices C31/C31M or C192/C192M. Results are calculated and reported as the modulus of rupture. For the same specimen size, the strength determined will vary if there are differences in specimen preparation, curing procedure, moisture condition at time of testing, and whether the beam was molded or sawed to size.
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate	This test method provides a procedure for making a preliminary estimate of the soundness of aggregates for use in concrete and other purposes. The values obtained may be compared with specifications, for example Specification C33, that are designed to indicate the suitability of aggregate proposed for use. Since the precision of this test method is poor (Section 12), it may not be suitable for outright rejection of aggregates without confirmation from other tests more closely related to the specific service intended.
ASTM C94	Standard Specification for Ready-Mixed Concrete	This specification covers ready-mixed concrete manufactured and delivered to a purchaser in freshly mixed and unhardened state as hereinafter specified. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchase.
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing	Material finer than the 75-µm (No. 200) sieve can be separated from larger particles much more efficiently and completely by wet sieving than through the use of dry sieving. Therefore, when accurate determinations of material finer than 75 µm in fine or coarse aggregate are desired, this test method is used on the sample prior to dry sieving in accordance with Test Method C136.

Standard or Procedure	Name	Description or Significance
ASTM C125	Standard Terminology Relating to Concrete and Concrete Aggregates	This standard is a compilation of definitions of terms as they are used in standards under the jurisdiction of Committee C09.
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	This test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure.
ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete	This test method covers determination of the density of freshly mixed concrete and gives formulas for calculating the unit weight, yield or relative yield, cement content, and air content of the concrete. Yield is defined as the volume of concrete produced from a mixture of known quantities of the component materials.
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete	This test method is intended to provide the user with a procedure to determine slump of plastic hydraulic-cement concretes.
ASTM C150	Standard Specification for Portland Cement	This specification covers eight types of portland cement: type I, type IA, type II, type IIA, type III, type IIIA, type IV, and type V. The cement covered by this specification shall only contain the following ingredients: portland cement clinker; water or calcium sulfate, or both; limestone; processing additions; and air-entraining addition for air-entraining portland cement.
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores	This test method is used to determine the compliance of concrete construction with design specifications and is commonly used in determining the thickness of pavements and other slab construction. This test method requires that at least one end of the core be a finished or formed surface.
ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory	This practice provides standardized requirements for preparation of materials, mixing concrete, and making and curing concrete test specimens under laboratory conditions.
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method	This test method covers the determination of the air content of freshly mixed concrete. The test determines the air content of freshly mixed concrete exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction factor (see 6.1 and 9.1).
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete	This specification covers materials proposed for use as air-entraining admixtures to be added to concrete mixtures in the field. The air-entraining admixture shall conform to the requirements such as initial and final time of setting, compressive strength, flexural strength, and length change (maximum shrinkage).

Standard or Procedure	Name	Description or Significance
ASTM C272	Standard Test Method for Water Absorption of Core Materials for Sandwich Constructions	Absorbed water affects the characteristic properties of sandwich core materials, such as electrical properties (for example, dielectric constant, loss tangent, and electrical resistance) and mechanical properties (for example, strength and modulus). The mass of absorbed water may also affect the behavior of sandwich structures. It should be noted that in a sandwich panel the presence of facings bonded on two sides of the core may affect the amount of water absorbed by the core.
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete	This specification covers liquid membrane-forming compounds suitable for application to concrete surfaces to reduce the loss of water during the early-hardening period. White-pigmented membrane-forming compounds serve the additional purpose of reducing the temperature rise in concrete exposed to radiation from the sun. The membrane-forming compounds covered by this specification are suitable for use as curing media for fresh concrete, and may also be used for further curing of concrete after removal of forms or after initial moist curing.
ASTM C452	Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate	This test method, which is applicable only to portland cements, covers the determination of the expansion of mortar bars made from a mixture of portland cement and gypsum in such proportions that the mixture has a sulfur trioxide (SO_3) content of 7.0 mass %.
ASTM C494	Standard Specification for Chemical Admixtures for Concrete	This specification covers the materials and the test methods for use in chemical admixtures to be added to hydraulic-cement concrete mixtures in the field. The seven types of admixtures are indicated as follows: Type A—water reducing; Type B—retarding; Type C—accelerating; Type D—water reducing and retarding; Type E—water reducing and accelerating; Type F—water reducing, high range; and Type G—water reducing, high range, and retarding. The materials used in the concrete mixtures shall include Type I or Type II cement, pozzolan, fine and coarse aggregates, and air-entraining admixture.
ASTM C511	Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes	This specification includes requirements for mixing rooms where paste and mortar specimens are prepared; and for moist cabinets, moist rooms, and water storage tanks where paste, mortar, and concrete specimens are stored. This specification includes the requirements for mixing rooms where paste and mortar specimens are prepared and for moist cabinets, moist rooms, and water storage tanks where paste, mortar, and concrete specimens are stored; intended for use in the testing of hydraulic cements and concretes. The system shall be equipped with a temperature recorder and a reference temperature measuring device that are to be placed practically near to each other.
ASTM C535	Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	The test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure.
ASTM C595	Standard Specification for Blended Hydraulic Cements	This specification pertains to blended hydraulic cements for both general and special applications, using slag or pozzolan, or both, with portland cement or portland cement clinker or slag with lime. These cements are classified into two types: Type IS which is portland blast-furnace slag cement and Type IP which is portland-pozzolan cement. They can also be described according to air-entraining, moderate sulfate resistance, moderate heat of hydration, high sulfate resistance, or low heat of hydration properties.

Standard or Procedure	Name	Description or Significance
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	This specification covers coal fly ash and raw or calcined natural pozzolan for use in concrete where cementitious or pozzolanic action, or both, is desired, or where other properties normally attributed to fly ash or pozzolans may be desired, or where both objectives are to be achieved.
ASTM C979	Standard Specification for Pigments for Integrally Colored Concrete	This specification covers the basic requirement for colored and white pigments in powder form to be used as admixtures in concrete for the purpose of producing integrally colored concrete. Where the pigments are a constituent of a multicomponent admixture, this specification applies to the pigment constituent of the admixture.
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars	This specification covers three strength grades of finely ground granulated blast-furnace slag (Grades 80, 100, and 120) for use as a cementitious material in concrete and mortars.
ASTM C1064	Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete	This test method provides a means for measuring the temperature of freshly mixed concrete. The measured temperature represents the temperature at the time of testing and may not be an indication of the temperature of the freshly mixed concrete at a later time. It may be used to verify conformance to a specified requirement for temperature of concrete.
ASTM C1074	Standard Practice for Estimating Concrete Strength by the Maturity Method	This practice can be used to estimate the in-place strength of concrete to allow the start of critical construction activities such as: (1) removal of formwork and reshoring; (2) post-tensioning of tendons; (3) termination of cold weather protection; and (4) opening of roadways to traffic.
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation	The testing and inspection of concrete and concrete aggregates are important elements in obtaining quality construction. A testing agency providing these services shall be selected with care.
ASTM C1116	Standard Specification for Fiber-Reinforced Concrete	This specification covers all forms of fiber-reinforced concrete that are delivered to a purchaser with the ingredients uniformly mixed. This specification may also apply to fiber-reinforced concrete intended for shotcreting by the dry-mix process when sampling and testing is possible at the point of placement. It, however, does not cover the placement, consolidation, curing, or protection of the fiber-reinforced concrete after delivery to the purchaser. Materials are classified according to the type of fiber incorporated, which are: Type I, steel fiber-reinforced concrete that contains stainless, alloy, or carbon steel fibers; Type II, glass fiber-reinforced concrete that contains alkali-resistant glass fibers; Type III, synthetic fiber-reinforced concrete that contains synthetic fibers; and Type IV, natural fiber-reinforced concrete that contains cellulose fibers.
ASTM C1157	Standard Performance Specification for Hydraulic Cement	This performance specification covers hydraulic cements for both general and special applications. There are no restrictions on the composition of the cement or its constituents.

Standard or Procedure	Name	Description or Significance
ASTM C1193	Standard Guide for Use of Joint Sealants	This guide describes the use of a cold liquid-applied sealant for joint sealing applications. Including joints on buildings and related adjacent areas, such as plazas, decks, and pavements for vehicular or pedestrian use, and types of construction other than highways and airfield pavements and bridges. Information in this guide is primarily applicable to a single and multi-component, cold liquid-applied joint sealant and secondarily to a precured sealant when used with a properly prepared joint opening and substrate surfaces.
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)	This test method provides a means of detecting the potential of an aggregate intended for use in concrete for undergoing alkali-silica reaction resulting in potentially deleterious internal expansion. It is based on the NBRI Accelerated Test Method. It is especially useful for aggregates that react slowly or produce expansion late in the reaction. However, it does not evaluate combinations of aggregates with cementitious materials nor are the test conditions representative of those encountered by concrete in service.
ASTM C1293	Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction	Alkali-silica reaction is a chemical interaction between some siliceous constituents of concrete aggregates and hydroxyl ions. The concentration of hydroxyl ion within the concrete is predominantly controlled by the concentration of sodium and potassium.
ASTM C1315	Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete	This specification covers the performance requirements for membrane-forming liquids suitable for use as curing compounds and sealers for fresh and hardened concrete. Each membrane should have good alkali resistance, acid resistance, adhesion-promoting qualities, and resistance to degradation by UV light. The materials are limited to clear or translucent and white pigmented materials, all of which are classified into non-yellowing, moderately yellowing, or yellows or darkens unrestrictedly.
ASTM C1330	Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants	This standard specification covers the basic requirements for cylindrical sealant backing for use with cold liquid-applied sealants. Cylindrical sealant backings are classified into three types: type C, type O, and type B, composed predominantly of closed cell material, open cell material, and bi-cellular material, respectively.
ASTM C1521	Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints	Many parameters contribute to the overall performance of a sealant application. Some of the most significant parameters are sealant bead size and configuration, joint movement, quality of workmanship, the quality of the adhesive bond, and the quality of the sealant material. This method does not evaluate the performance of a sealant joint as a weather seal. It only evaluates the characteristics of the adhesive bond relative to the cohesive strength of the sealant in a particular installation. Since any failures that result from use of this test method are intentionally induced, they do not necessarily mean that the sealant joint will not perform as a weather seal.
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)	This test method provides a means for evaluating the ability of pozzolans and ground granulated blast-furnace slag to control deleterious internal expansion due to alkali-silica reaction when used with an aggregate intended for use in concrete. It is based on the Accelerated Test Method developed at the National Building Research Institute (NBRI) in the Republic of South Africa.

Standard or Procedure	Name	Description or Significance
ASTM C1582	Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete	This specification covers material for use as chloride-corrosion-inhibiting admixtures for concrete. Concrete must meet the physical requirements such as compressive strength and flexural strength. The test admixture must show corrosion-inhibiting performance with the required mean integrated macrocell current of test beams and mean corroded area of test beams as a fraction of control.
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete	This specification covers mixing water used in the production of hydraulic cement concrete. It defines sources of water and provides requirements and testing frequencies for qualifying individual or combined water sources.
ASTM C1758	Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete	This practice covers procedures for fabricating test specimens in the laboratory or field using a representative sample of fresh self-consolidating concrete (SCC). This practice is applicable to SCC with a nominal maximum aggregate size up to 25 mm [1 in.] and a slump flow of 500 mm [20 in.] or greater. If the slump flow is less than 500 mm [20 in.] follow the fabrication procedures described in the standard for which the test specimen is required.
ASTM D1056	Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber	This specification covers flexible cellular rubber products known as sponge rubber and expanded rubber, but does not apply to latex foam rubber or ebonite cellular rubber.
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)	This specification covers preformed expansion joint filler having relatively little extrusion and substantial recovery after release from compression.
ASTM D1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction	This specification covers preformed expansion joint fillers for use in concrete, brick, stone, and other paving and structural construction. The fillers are available in the following types: Type I, sponge rubber, which shall consist of preformed strips of a durable elastic sponge rubber compound using synthetic rubber or natural rubber as a base and containing no reclaim rubber or factice; Type II, cork, and Type III, self-expanding cork, which shall both consist of preformed strips that have been formed from clean granulated cork particles securely bound together by a synthetic resin of an insoluble nature; and Type IV, recycled PVC, which shall consist of preformed strips that have been extruded using scrap PVC material and using either no binder or a synthetic resin of an insoluble nature to securely bind it together.

Standard or Procedure	Name	Description or Significance
ASTM D5893	Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements	This specification covers two types of cold applied, single component, chemically curing silicone sealants that are based on polymers of polysiloxane structures, and are intended for use in sealing joints and cracks in Portland cement concrete highway and airfield pavements. This specification does not address the properties required of sealants for use in areas of Portland cement concrete pavements subject to jet fuel or other fuel spillage, such as vehicle or aircraft refueling and maintenance areas, or a combination thereof. Type NS (non-sag) sealant resists sagging after application in horizontal joints and requires tooling or forming into the joint to achieve the desired application configuration. Type SL (self-leveling) sealant, on the other hand, has sufficient flow characteristics to form a smooth and level surface in horizontal joints without tooling or forming after application.
ASTM D8139	Standard Specification for Semi-Rigid, Closed-Cell Polypropylene Foam, Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction	This specification covers preformed expansion joint fillers made from closed-cell polypropylene foam materials having suitable compressibility, recovery from compression, nonextruding, and weather-resistant characteristics.
ASTM E329	Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection	This specification defines the minimum requirements for inspection agency personnel or testing agency laboratory personnel, or both, and the minimum technical requirements for equipment and procedures utilized in the testing and inspection of construction and materials used in construction.
CDOT CP-67	Standard Method of Test for Determining Adhesion of Joint Sealant to Concrete Pavement	This procedure is designed to test the adhesion of the joint filler to the concrete pavement in sawed joints or routed cracks where backer rod is used.
EPA 40 CFR Part 59	National Volatile Organic Compound Emission Standards for Consumer and Commercial Products	This section identifies the consumer and commercial product categories for which EPA has determined that CTGs will be substantially as effective as regulations in reducing VOC emissions in ozone nonattainment areas: (a) Wood furniture coatings; (b) Aerospace coatings; (c) Shipbuilding and repair coatings; (d) Lithographic printing materials; (e) Letterpress printing materials; (f) Flexible packaging printing materials; (g) Flat wood paneling coatings; (h) Industrial cleaning solvents; (i) Paper, film, and foil coatings; (j) Metal furniture coatings; (k) Large appliance coatings; (l) Miscellaneous metal products coatings; (m) Plastic parts coatings; (n) Auto and light-duty truck assembly coatings; (o) Fiberglass boat manufacturing materials; and (p) Miscellaneous industrial adhesives.

End of MGPEC Item 30

ITEM 31

CONCRETE CURBS, GUTTERS, AND SIDEWALKS

31.1 DESCRIPTION

This work shall consist of constructing curbs, gutters, sidewalks, ramps, local depressions and driveways of the form and dimensions shown on the plans.

31.2 MATERIALS

Materials shall conform to the applicable requirements of Item 30, Portland Cement Concrete Pavement (PCCP).

31.3 EQUIPMENT

A. General

Equipment and tools necessary for handling materials and performing all parts of the work must have adequate capacity and be in good mechanical condition. This equipment shall be on the site, available for inspection and testing, before paving operations are started. All equipment, tools, and machinery shall be maintained in a satisfactory working condition.

Equipment shall be approved by the **AGENCY**. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled. All taxes, licenses and fees shall have been paid and proper licenses and permits shall be posted as required by law.

B. Forms

The depth of forms for curbs shall be equal to the full depth of the curb. The depth of outside forms for concrete gutter shall be equal to the full thickness of the gutter. Timber forms, if used, shall be surfaced on the side placed next to the concrete, shall have a true smooth upper edge, and shall not be less than ~~14/2~~ ½ inches thick after being surfaced. Warped forms and forms not having a smooth, straight upper edge shall not be used. Benders or thin plank forms, rigidly placed, shall be used on curves, grade changes or for curb returns. Steel forms shall not be used on curved sections with radii less than 200 feet. Back forms for curb returns shall be made of a minimum of 1/2-inch benders, for the full height of the curb, cleated together. Forms shall be carefully set to alignment and grade and to conform to the dimensions required. Forms shall be held rigidly in place by the use of pairs of steel stakes placed at intervals not to exceed 4 feet. If metal forms are used, steel stakes shall not be spaced more than 6 feet apart. Clamps, spreaders and braces shall be used where required to ensure rigidity in the forms.

C. Slip Forms

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

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

31.4 CONSTRUCTION

~~Curbs, gutters and sidewalks shall be placed in sections of 90 feet maximum length. Moisture treatment and stabilization of the subgrade will be required where specified on the plans in~~

~~A. Earthwork~~

~~The subgrade shall be constructed true to the grade and cross section as shown on the plans or established by the **AGENCY**. It shall be thoroughly moisture conditioned and rolled or hand tamped until the subgrade from front of curb to back of sidewalk reaches the compaction required for the adjacent roadway. All soft and yielding material shall be removed to a depth of not less than 12 inches and the resulting space filled with compacted earth, sand or gravel.~~

~~The completed subgrade shall be tested for grade and cross section by means of a template extending the full depth and supported on the side forms. The subgrade and forms shall be watered in advance of placing portland cement concrete.~~

B. Existing Curbs. Gutters and Sidewalks

The **CONTRACTOR** shall remove existing curbs, gutters and sidewalks to the limits shown on the plans.

C. Curb and Gutter Expansion Joints

Expansion joints 1/2 inch wide shall be constructed in curbs and gutters at 90-foot intervals, at each side of structures and at the ends of all curb returns; except that expansion joints shall not be installed within 20 feet of an island nose. Expansion joints shall be filled with joint filler strips 1/2 inch thick conforming to ASTM D 1751, Fiber Type. The filler for the joint shall be furnished in a single piece for the full depth and width required for the joint. Expansion joint filler shall be shaped to the cross section of the curb and gutter. Expansion joints shall be constructed at right angles to the line of curb and gutter.

D. Sidewalk Expansion Joints

Transverse expansion joints 1/2 inch wide shall be constructed at all sidewalk returns and in line with expansion joints in adjacent curb. Where curb is not adjacent, expansion joints shall be constructed at intervals of 100 feet. Expansion joints shall coincide where curb and gutter are adjacent, even if not integral. Expansion joints shall be filled with joint filler strips 1/2 inch thick conforming to ASTM D 1751, Fiber Type. The filler for the joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the **AGENCY**.

The joint filler shall be placed with the top edge 1/4 inch below the concrete surface and shall be held in place by means of steel pins driven into the subgrade and spaced sufficiently close to prevent warping of the filler during floating. Upon completion of floating, the pins shall be removed and when finishing operations have been completed, the joint shall be edged with an edging tool having a radius of, 1/8 inch.

E. Curb and Gutter Construction

In constructing curbs, entrances for driveways shall be constructed according to the dimensions shown on the plans. With approval of the **AGENCY**, the curb may be constructed by the use of a curb forming machine.

Where hot mix asphalt pavement (HMAP) or portland cement concrete pavement (PCCP) is to be placed around or adjacent to manholes, drop inlets or catch basins in gutter, local depressions or driveways, such structures shall not be constructed to final grade until after the curbs and gutters have been constructed on each side of the structure in order to maintain a true grade.

The forms shall be filled to the top and the concrete shall be consolidated so that there will be no rock pockets. Concrete shall be consolidated by means of mechanical vibrators approved, by the **AGENCY**. No concrete over 90° F shall be used. Immediately after removing the front curb forms, the face of the curb shall be ~~troweled~~ **floated** smooth to a depth of not less than 2 inches below the flow line or to the flow line of integral curb and gutter, and then finished with a ~~steel trowel~~ **wood, fiberglass, or magnesium float**. The stop shall be finished and the front and back edges rounded as shown on the plans.

After the face of the curb has been ~~troweled~~ **floated** smooth, it shall be given a final fine brush finish with brush strokes parallel to the line of curb. In no case shall the minimum time between placing concrete and removal of forms be less than 12 hours. No dusting or topping of the surface, or sprinkling with water, to facilitate finishing shall be permitted.

The top and face of the finished curb shall be true and straight, and the top surface of curbs and gutters shall be of uniform width, free from humps, sags or other irregularities. When a straightedge 10 feet long is laid on the top or face of the curb or on the surface of the gutters, the surface shall not vary more than 1/8 inch from the edge of the straightedge, except at grade changes or curves. The exposed surface shall be cured for a period of not less than 72 hours in accordance with the requirements in Item 30.

F. Sidewalk Construction

The structures shall be finished to smooth, NOT troweled, and uniform texture by floating with wooden, fiberglass, or magnesium floats, and, if so directed by the **AGENCY**, by cross brooming ~~or burlap finishing~~. No concrete over 90° F shall be used. The surface shall be lightly grooved or marked into squares or other shapes to match other such markings on similar existing structures in the vicinity, or as designated by the **AGENCY**.

No dusting or topping of the surface, or sprinkling with water, or finishing aids to facilitate finishing shall be permitted. The minimum time between placing concrete and removal of forms is at least 12 hours.When a 10-foot straightedge is placed on the sidewalk, the

surface shall not vary more than 1/8 inch from the edge of the straightedge, except at grade changes, and the finished surface shall be free from blemishes.

Immediately after the surface of the sidewalk is finished, the concrete shall be cured for a period of not less than 72 hours in accordance with the requirements of Item 11.

Contraction joints in sidewalks must be placed at a spacing equivalent to width up to 12 feet. All joints in curb and gutter must be continuous through adjacent sidewalk.

G. Cold Weather Protection

Refer to Section 8.7.2.1. ~~When concrete is placed with ambient temperatures below 40° F, the **CONTRACTOR** shall provide satisfactory methods and means to protect the mix from injury by freezing. The aggregates, or water, or both, shall be heated in order to place the concrete at temperatures between 50° and 90° F. Placing of concrete may be started in the morning if the **CONTRACTOR** desires, but shall be discontinued at 3:00 p.m. of the same day if freezing weather threatens.~~

~~The concrete or aggregates shall be protected before and after placing, as directed by the **AGENCY**, to retain all heat possible in the concrete mix. After the concrete has been placed, the **CONTRACTOR** shall provide sufficient protection such as blankets, canvas, framework, heating apparatus, etc., to enclose and protect the structure and maintain the temperature of the concrete at not less than 50° F until at least 60 percent of the 28-day field strength has been attained. Temperatures shall be measured and recorded using a recording thermometer. Except as provided above, cold weather concreting shall be in accordance with ACI 306. If in the opinion of the **AGENCY**, the protection provided is inadequate, concrete placement shall cease until conditions or procedures are satisfactory to the **AGENCY**.~~

H. Hot Weather Concreting

Except by written authorization, concrete shall not be placed if its temperature exceeds 90° F. The placement of concrete in hot weather shall comply with ACI 305.

I. Opening

Walks shall not be opened to pedestrian traffic for at least 24 hours after placement. Curb cuts, curb and gutter and crosspans shall not be opened to vehicular traffic for at least 7 days after placement or until concrete has attained two-thirds of the required 28-day strength. The **CONTRACTOR** shall maintain suitable barricades to comply with these requirements.

31.5 TOLERANCES

Surface irregularities (measured with a 10-foot long straightedge) exceeding 3/16 inch, but less than ~~⅜~~ **1/2** inch, shall be ground by the **CONTRACTOR** at his expense. When surface irregularities exceed the foregoing limits, the **CONTRACTOR** shall remove and replace that portion of work.

If, after stripping of forms, any concrete is found to be not formed as shown on the Plans, or is out of alignment or level, or shows a defective surface, it shall be considered as not conforming to these specifications. The defective area shall be removed and replaced by the **CONTRACTOR** at his expense.

~~31.6 MEASUREMENT~~

~~The quantity of curb and gutter measured for payment will be the number of linear feet along the base of the curb face or along the flow line of the gutter, and such measurement shall be continuous along such line extended across driveway and alley entrance returns. The quantity of sidewalk, ramps and driveway shall be measured for payment by area in square yards. Al1 quantities herein will be complete and in place. These are plan quantities and no separate measurement is required~~.

31.7 TESTING AND INSPECTION

Testing of portland cement concrete pavement shall be performed in accordance with Table 31.7-1.

TABLE 31.7-1
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING

Compressive Strength	ASTM C 39	One set. per 100 cubic yards
Air Content	ASTM C 231	One test per[RB1] each first three trucks, then one for every 100 CY thereafter
Slump	ASTM C 143	One test per each first three trucks, then one for every 100 CY thereafter
Temperature	ASTM C 1064	One test per ~~300 cubic yard~~ **first three trucks, then one for every 100 CY thereafter**
Thickness	ASTM C 174	One test per 500 linear feet. One set consists of at least 4 cylinders

~~31.8 PAYMENT~~

~~All quantities of concrete measured will be paid for at the contract unit price. All excavation or backfill work required other than roadway quantities will be considered subsidiary and no further payment will be made. Saw cutting of existing installations prior to removal will not be paid for directly but the cost shall be considered as included in the contract unit price. The price shall be full compensation for furnishing al materials required and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.~~

~~Item~~	~~Description~~	~~Payment~~
~~31.8-1~~	~~Concrete Curb and Gutter~~	~~$/linear foot~~
~~31.8-2~~	~~Concrete Sidewalk, Ramps, Drives~~	~~$/yd^2~~
~~31.8-3~~	~~Removal~~	~~$/yd^2~~

End of MGPEC Item 31