PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport’s (SFO’s or Airport’s) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for Airfield Civil – Pavement Improvements made at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for Airfield Civil – Pavement Improvements. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport’s discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

GENERAL INFORMATION

Contact SFO Engineering with any questions regarding the specifications provided.

All work in this section must comply with Federal Aviation Administration’s (FAA) Advisory Circular AC 150/5300-13 (current version) Airport Design, AC 150/5320-5 (current version) Airport Drainage Design, AC 150/5320-6 (current version), AC 150-5340-1 (current version) Airport Markings, and AC 150/5370 – 10 (current version) – Standards for Specifying Construction of Airports. Please note that these Standards are in the process of being updated as a result of the release of AC 150/5370-10H dated 12/21/18.

DRAWING REQUIREMENTS

A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport’s Building Information Modeling (BIM) Requirements as described in Document 00 73 87: BIM Requirements, unless waived by the Chief Development Officer.

B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the Chief Development Officer.

C. Refer to technical specifications for As-Built requirements.

D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).
<table>
<thead>
<tr>
<th>Version</th>
<th>Publish Date</th>
<th>Revisions</th>
<th>Reviewed By</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>SECTION 32 01 11.53</td>
<td>AIRFIELD PAVEMENT MARKING REMOVAL</td>
<td>4</td>
</tr>
<tr>
<td>SECTION 32 01 16.71</td>
<td>COLD MILLING ASPHALT PAVEMENT</td>
<td>10</td>
</tr>
<tr>
<td>SECTION 32 01 26.71</td>
<td>SAW-CUT GROOVES</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-621 SAUCUT GROOVES</td>
<td>15</td>
</tr>
<tr>
<td>SECTION 32 11 23</td>
<td>CRUSHED AGGREGATE BASE COURSE</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-209 CRUSHED AGGREGATE BASE COURSE</td>
<td>21</td>
</tr>
<tr>
<td>SECTION 32 11 29.13</td>
<td>SOIL-CEMENT BASE COURSE</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-301 SOIL-CEMENT BASE COURSE</td>
<td>29</td>
</tr>
<tr>
<td>SECTION 32 11 33</td>
<td>CEMENT-TREATED BASE COURSE</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-304 CEMENT-TREATED BASE COURSE</td>
<td>35</td>
</tr>
<tr>
<td>SECTION 32 11 36</td>
<td>LEAN CONCRETE BASE COURSE</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-306 LEAN CONCRETE BASE COURSE</td>
<td>47</td>
</tr>
<tr>
<td>SECTION 32 12 13.13</td>
<td>BITUMINOUS TACK COAT</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-603 BITUMINOUS TACK COAT</td>
<td>60</td>
</tr>
<tr>
<td>SECTION 32 12 13.19</td>
<td>BITUMINOUS PRIME COAT</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-602 BITUMINOUS PRIME COAT</td>
<td>63</td>
</tr>
<tr>
<td>SECTION 32 12 16.13</td>
<td>HOT MIX ASPHALT (HMA) PAVEMENTS</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS</td>
<td>68</td>
</tr>
<tr>
<td>SECTION 32 12 16.14</td>
<td>HOT MIX ASPHALT PAVEMENTS (BASE, LEVELING OR SHOULDER SURFACE COURSE)</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-403 HOT MIX ASPHALT PAVEMENTS (BASE, LEVELING OR SHOULDER SURFACE COURSE)</td>
<td>97</td>
</tr>
<tr>
<td>SECTION 32 12 16.15</td>
<td>HOT MIX ASPHALT PAVEMENTS (CALTRANS MIX)</td>
<td>120</td>
</tr>
<tr>
<td>SECTION 32 12 36.13</td>
<td>EMULSIFIED ASPHALT SEAL COAT</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-608 EMULSIFIED ASPHALT SEAL COAT</td>
<td>123</td>
</tr>
<tr>
<td>SECTION 32 12 73</td>
<td>JOINT SEALANTS FOR CONCRETE PAVEMENTS</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-605 JOINT SEALANTS FOR CONCRETE PAVEMENTS</td>
<td>132</td>
</tr>
<tr>
<td>SECTION 32 13 13</td>
<td>PORTLAND CEMENT CONCRETE PAVEMENT</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT</td>
<td>139</td>
</tr>
<tr>
<td>SECTION 32 13 13.20</td>
<td>SIDEWALK, CURBS, AND ASSOCIATED IMPROVEMENTS</td>
<td>177</td>
</tr>
<tr>
<td>SECTION 32 17 23</td>
<td>RUNWAY AND TAXIWAY MARKINGS</td>
<td>182</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-620, RUNWAY AND TAXIWAY MARKINGS</td>
<td>186</td>
</tr>
<tr>
<td>SECTION 32 23 23.33</td>
<td>CONTROLLED LOW-STRENGTH MATERIAL (CLSM)</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM P-153 CONTROLLED LOW-STRENGTH MATERIAL (CLSM)</td>
<td>195</td>
</tr>
<tr>
<td>SECTION 32 31 13</td>
<td>CHAIN-LINK FENCE</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>FAA ITEM F-162 CHAIN LINK FENCE</td>
<td>201</td>
</tr>
<tr>
<td>SECTION 32 31 15</td>
<td>TEMPORARY AOA FENCE</td>
<td>205</td>
</tr>
<tr>
<td>SECTION 34 73 19</td>
<td>JET BLAST DEFLECTING FENCE</td>
<td>207</td>
</tr>
<tr>
<td>MASTER LIST OF MANUFACTURERS</td>
<td>213</td>
<td></td>
</tr>
</tbody>
</table>
**SECTION 32 01 11.53 – AIRFIELD PAVEMENT MARKING REMOVAL**

**PART 1 – GENERAL**

### 1.1 SUMMARY

A. The Work under this Section shall consist of airfield pavement marking removal as specified herein.

1. The Work under this Section shall be performed by an experienced contractor and operating approved equipment and methods as required by these specifications.

2. Removing airfield pavement markings from specified areas as shown on the drawings or as directed by the Contract Manager.

3. Cleaning miscellaneous airfield pavement and collecting all debris and effluent generated.

4. Storage and segregation of different debris streams and used wash water. Analyzing and profiling, temporarily storing, hauling, documenting and disposing of all waste materials and used wash water created and collected during removal process, maintaining and submitting all chain of custody documentation with all processes in compliance with Airport and California Environmental standards.

5. Contractor shall handle all rubber removal and pavement marking debris and used wash water, until otherwise proven by established testing, as though it is Hazardous Material and or California Regulated waste.

6. Coordinating operation with all other applicable Airport operations.

### 1.2 REFERENCES

A. Section 32 17 23 – Runway and Taxiway Markings (FAA Item P-620).

B. Section 32 12 36.13 – Emulsified Asphalt Seal Coat (FAA Item P-608).

C. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

D. California Regional Water Quality Control Board Rules and Regulations.

E. California BCDC – Bay Conservation and Development Commission.

F. California State Department of Toxic Substance Control (DTSC.)

G. California State and Federal EPA Regulations.

H. California State and Federal OSHA Regulations.

I. SFO WQCP Industrial Waste Discharge and Dilution Criteria.

### 1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following pavement painting and markings removal information:

1. Proposed paint removal method and equipment.
2. Contractor shall, prior to start of work and as requested by Contract Manager, furnish for review and approval, a brief and thorough narrative describing work procedure, process flow and control, compliant with these provisions including debris collection, testing and disposal procedures. This submittal shall become an element of contractor’s work schedule.

3. Sampling Results per Paragraph 1.4.

4. Work Experience per Part 1.5.

1.4 QUALITY CONTROL

A. Contractor shall demonstrate and incorporate procedure to assure that the cleaning process is proceeding without damage to pavement.

B. Contractor shall demonstrate and implement any and all controls or procedures needed to prevent contaminant spills due to equipment failure.

C. Contractor shall demonstrate and implement all necessary controls to prevent effluent runoff into Airport storm water system during pavement cleaning operation.

D. Contractor shall demonstrate and implement controls throughout contract work to assure that wash water discharge into SFO Industrial Waste (IW) system does not cause SFO IW plant to go into violation of current operational permit.

E. The Airport reserves the right to inspect all contractor equipment to assure that it is in compliance with the project requirements.

F. Contractor shall employ services of California Certified Environmental Chemist, Registered Environmental Assessor or Licensed Hazardous Materials Handler to manage proper sampling, characterization and disposal of debris and used wash water. Sampling and analysis of debris and used wash water shall be performed using State of California certified analytical laboratory appropriate for this type of debris profiling. Profile shall be based on need to comply with SFO WQCP standards. Contractor shall perform a minimum of 3 sampling events for each visit until a consistent characterization is achieved for four consecutive samples, at which time one sample per visit shall be required. The Airport reserves the right to perform sampling at its discretion.

G. Contractor shall be responsible for all chain of custody records and manifests for both analytical/characterization task and debris disposal. Copies shall be retained and provided to Contract Manager upon request.

1.5 EXPERIENCE

A. Contractor must have experience performing this work in accordance with these Contract Specifications.

B. Contractor shall be required to perform a test section, in a location as directed by the Contract Manager, to show that they are capable of performing the work to the satisfaction of the Contract Manager and in accordance with these contract specifications. Contractor shall demonstrate and incorporate procedure to assure that the cleaning process is proceeds without damage to pavement.

C. Contractor shall demonstrate the ability to abandon runway, taxiway, and taxilane under emergency direction at a maximum of 3 minutes for all vehicles.
PART 2 – PRODUCTS

2.1 EQUIPMENT

A. Equipment used for paint removal shall meet the following criteria:

1. The equipment shall contain on board and be capable of simultaneous (vacuum) recovery, separation, and containment of residual removed.

2. The equipment shall be the ultra-high pressure water blasting type with a minimum water pressure of 15,000 psi at 90 degrees to the surface. The equipment shall be equipped with variable pressure control and using carefully controlled water blast at pressures that does not damage the existing pavement. Grinding will not be allowed.

3. The equipment shall be truck mounted and shall be self-contained, and when working on the runway, to quickly exit and completely clear the runway when required within 3 minutes’ notice.

4. The equipment shall have a reservoir capacity sufficient for at least 3-hour continuous operation without refilling.

5. The equipment shall be equipped with sufficient lighting for work at night.

6. The equipment and method of cleaning must successfully remove the paint that has partially filled the open pores in the surface without damaging the pavement.

7. The equipment shall be able to recover water, removed paint deposits as they are being generated. The equipment shall be able to recover at least 90% of the water simultaneously with the water blasting and without the use of sweepers or other separate devices. The contractor shall only employ sweepers only be used as a secondary cleanup device to remove debris and water.

8. Should the Contract Manager determine that the contractor’s equipment is not adequately removing rubber or painted markings properly from the pavement, or is damaging the pavement, Contract Manager may require contractor to correct his equipment or procedures, or both, to adequately perform the work. The Airport reserves the right to inspect the contractor’s equipment and the contractor shall provide for access and assistance during the inspection.

9. Contractor shall operate reliable, productive equipment for the life of the contract. If contractor experiences more than three breakdowns in any shift or four breakdowns during a job or task, Airport reserves the right to require contractor to have on site an additional functioning service unit, in compliance with these specifications, to perform the work. A breakdown shall be considered to be the condition when, working on runway during a shift, a contractor’s equipment does not function for one hour due to mechanical, electrical or operational failure. After the first breakdown, multiple failures of less than an hour each during a shift will be counted individually. Contractor shall perform all routine maintenance prior to beginning pavement cleaning.

10. Cleaning vehicles shall be capable of maintaining constant speed independent of operator to assure continuous smooth operation. Each operator shall be able to immediately interrupt process when unacceptable operating conditions or equipment failure occurs.

11. Cleaning vehicles shall have continuous process monitoring instrumentation and full operational control within the operator compartment.
12. In addition to recovering all debris, each cleaning vehicle shall be capable of recovering 90% of the wash water discharged during the cleaning process and shall be able to return used wash water to storage tank for sampling and eventual discharge.

PART 3 – EXECUTION

3.1 PAVEMENT MARKING REMOVAL

A. The contractor shall conduct his operation without damage to the pavement surface and drainage grooves, pavement lights, joint sealers and kerf sealants. The contractor, at its expense and to the satisfaction of the Airport, shall immediately repair any damage to the foregoing caused by its operation. Grinding will not be allowed.

B. Equipment, tools, and machines to be used shall be safe, in satisfactory working order.

C. Contractor’s employees shall be properly informed of all safety and operational procedures through routine “tailgate meetings.” These notifications shall be in writing, with a copy submitted to Contract manager at end of shift work.

D. Contractor shall see that all employees have personal protective equipment consistent with contractor’s safety plan.

E. Water nozzles shall be mounted on rotating heads to ensure uniform pavement marking removal. Contractor shall routinely monitor nozzle condition to service malfunctioning nozzles.

F. Each cleaning vehicle shall be equipped with a mounted or towed water tank. Water used shall be continuously recovered along with paint debris, separated, filtered and recycled. The water tanks shall hold an adequate amount of water required for this work.

G. Water pressure shall be carefully and continuously monitored and field adjustable to provide adequate pavement marking removal without damage to the pavement.

H. Contractor shall not clear runway work area until all loose debris is recovered.

I. Water may be obtained from Airport water hydrants designated by the Contract Manager. For details regarding fees, adapters, water service locations and availability of water meters, contact the Michael Watson at (650) 821-7874. Contractor shall be responsible to use SFO water meter to monitor, conserve and manage wash water consumption. Data from water meter shall be used to accurately maintain service log.

J. The use of chemicals, solvents, acids, bases, detergents, salt water, brackish water, or water containing undesirable matter will not be permitted in the cleaning process. Any variation from this rule will require written authorization from Contract Manager.

K. Contractor shall furnish all necessary equipment including pumps, hoses, fittings, water trucks, and labor for delivering water from the water hydrants to the work site.

L. Contractor shall yield usage of water hydrant to the Airport Fire Department when ordered or in the event of an emergency.

M. Waste materials (pavement marking debris and used wash water) shall be continuously and immediately collected throughout the cleaning operation. Neither the waste material nor the used wash water shall be allowed to flow off the airfield pavement and into the adjacent unpaved field area or the Airport’s storm drainage collection system.
N. Contractor shall be able to discharge used wash water only into SFO IW system at predetermined location and only within dilution rate as determined by analytical results. Used wash water shall be stored in acceptable container prior to discharge. If wash water does not meet SFO WQCP IW standards, contractor shall dispose of off-site at compliant facility and shall provide all chain of custody documentation.

O. Contractor shall notify Contract Manager in writing 24 hours prior to discharge of any used wash water. Airport Staff must be present during used wash water discharge.

P. The waste material shall be safely consolidated, staged, analyzed, consolidated and hauled off Airport property for disposal at a properly classified landfill. All related costs, including laboratory tests, temporary storage, hauling, documentation, and disposal fees shall be the contractor’s responsibility.

Q. Contractor shall be responsible for the security and removal of whatever debris containerization is used.

R. All work shall comply with all applicable environmental requirements. All penalties and citations incurred for improper handling and disposal shall be borne by the contractor.

S. Contractor shall provide and use all necessary barricading, signage and lighting as required by SFO Airfield Operations. This equipment shall be considered incidental to the work.

3.2 CLEAN UP

A. The contractor, during paving operation, shall continuously clean-up the site and haul routes and remove all excess material and equipment from the site immediately after the work for the shift is completed.

3.3 PAVEMENT SEALANT

A. Unless otherwise indicated, in areas where paint has been removed and will not receive overlay improvements, contractor shall apply seal coat to larger areas around the paint removal area as shown on the plans.

B. “Paintovers” – obliteration of existing markings by covering with black paint or bituminous material will not be allowed.

C. Seal coat shall be applied to the surfaces of pavement in accordance with Section 32 12 36.13 Emulsified Asphalt Seal Coat – FAA Item P-608.

3.4 INCLUDED FAA SPECIFICATIONS

A. Not applicable

3.5 MEASUREMENT AND PAYMENT

A. The quantity of pavement markings and striping removal shall be measured for payment by lump sum as a single complete unit of Work, and accepted by the Contract Manager.

B. Payment shall be made at the contract unit price of lump sum for pavement markings and striping removed, whether markings are permanent or temporary, at the contract unit price. Surface Preparation-cleaning shall be considered incidental to the other bid items and no separate payment will be made. No additional payment shall be made for difficulties encountered when the marking removals are in areas of night, weekend, or other limited-time construction or in other areas subject to construction phasing restrictions.
C. This price shall be full compensation for furnishing all materials, including application of pavement sealant as required, and for all labor, equipment, tools, and incidentals necessary to complete the item.

END OF SECTION 32 01 11.53
SECTION 32 01 16.71 – COLD MILLING ASPHALT PAVEMENT

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consists of removal of existing pavement by cold milling method, as shown on the plans, as specified herein or as directed by the Engineer.

B. The work under this section includes the following:
   1. Milling or cold-milling of existing pavement.
   2. Clean-up and removal of residue material and water after the milling process.
   3. Removal of film and loose material attached on milled surface.
   4. Collecting, hauling, and disposing of residue, liquid, debris, slurry, and milled material to accepting site outside Airport property. (A copy of approval from the California Regional Water Quality Control Board shall be submitted to the Contract Manager before disposing residue to the site).

1.2 REFERENCES

A. Caltrans Standard Plans and Specifications.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. California Regional Water Quality Control Board Rules and Regulations.

1.3 SUBMITTALS

A. Not used.

1.4 QUALITY CONTROL

A. The contractor shall perform work in accordance with all applicable codes, rules and regulations, and San Francisco International Airport Rules and Regulations/Airport Building Regulations.

B. Visual inspection will be done by the Airport Inspector at time requested by the contractor. No material shall be constructed on the milled area without prior approval by the Inspector.

C. Shovel test, with the presence of the Airport Inspector, shall be performed to insure no loose material or thin film is attached to the milled surface.

D. Tolerances: The finished milled surface shall not have any deviation in excess of ½” from design grade.

E. If the milled depth is more than ½” shallower than the design grade, the surface will have to be milled again to comply with the allowable tolerance. Such repeated milling will not be compensated. If the milled depth is more than ½” deeper than the design grade, the quantity of the excessive fill material (e.g., asphalt concrete, Portland Cement concrete, etc.), will be computed and deducted from the payment to contractor.
PART 2 – PRODUCTS
   A. Not used

PART 3 – EXECUTION
3.1 EXAMINATION
   A. Verify site conditions.

3.2 SURVEY
   A. Verify survey references provided by Airport surveyors.
   B. Provide grade checkers for the construction work.
   C. Airport surveyors will perform quality assurance survey to check contractor’s work.

3.3 PREPARATION
   A. Identify required lines, levels, contours, and datum.
   B. Protect taxiway and runway centerline and edge lights to remain, from damage.
   C. Provide measures to protect passengers, vehicles, and aircraft traffic in the vicinity of work site.
   D. Be familiar with the Airport's procedures for construction, safety, emergencies, and utility shutdowns.

3.4 MILLING EQUIPMENT
   A. The cold-milling equipment shall include at least one self-propelled machine of proven design and standard manufacture designed and built especially for milling, grinding and scarifying pavements without gouging or damaging the underlying pavement.
   B. The machine shall not soften the pavement by any device specifically designed to emit heat.
   C. The machine shall incorporate a cutting drum not less than 60” in width with carbide or diamond tipped cutting teeth capable of producing variable textured patterns to depths below existing surfaces. The drum shall be suspended on a carrier unit with minimum wheel base of 20’ and shall not be closer than 7’ to either axle. Drum lacing patterns shall permit a grooved or smooth surface finish as selected by the Engineer and the drum shall be totally enclosed in a shroud to prevent discharge of any loosened material into adjacent work areas.
   D. The machine shall operate at speeds from 10 to 50’-per-minute and shall be designed so that the operator can observe all operations while at the controls of the machine.
   E. The machine shall be adjustable as to the crown and depth by tilting the drum axis.
   F. A dust suppression system with 750-gallon minimum water storage tanks and two high-pressure spray bars with spiral nozzles shall be standard equipment.
   G. The equipment shall be demonstrated to be successful on similar work completed.
   H. The equipment shall be equipped with a guidance system (e.g., laser-grade control system and/or sonic tracer system) to ensure accurate depth of pavement removal, and to assist operator to control grade and match adjacent pavement or cuts.
I. The machine shall meet all requirements of legally-empowered regulatory agencies including the noise and air pollution standards set by the Air Quality Act.

J. The contractor’s equipment on the job shall also include truck loaders and other auxiliary equipment in quantities sufficient to maintain the progress schedule.

3.5 MILLING PROCESS

A. The exact locations and areas to be milled are subject to adjustments in the field and as work progresses. The contractor shall accurately record locations and areas of milled surfaces with horizontal dimensions and elevations and shall provide such record to the Contract Manager for payment.

B. The milled depths shall be as shown in the plans, but are subject to minor adjustment in the field and as work progresses, and shall conform to the allowable tolerance.

C. The contractor shall make a cross-pass along the edges of the milled area so the edges are clean and sharply cut.

D. After milling, contractor shall collect and remove all film, liquid, slurry, residual and loose material attached to the milled surface by brushing, shoveling, spading, chiseling, vacuuming, sweeping or other methods.

E. The contractor shall obtain the approval of the condition of the cleaned, milled surface from the Airport Inspector prior to construction of any fill material or new pavement thereon.

F. Milling and repaving of an area shall be performed within the same work shift. Exceptions must be obtained from the Contract Manager before work begins.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Not applicable

PART 5 – MEASUREMENT AND PAYMENT

A. The quantity of pavement removed by cold mill shall be measured by the number of square yards of pavement, removed at variable depths of 0” to 6” and also at variable depths of greater than 6” to 12” as indicated in the contract bid items and accepted by the Contract Manager.

B. Payment shall be made at the contract unit price per square yard for pavement removed at various depths of 0” to 6” and also at variable depths of greater than 6” to 12” by cold milling method.

C. This price shall be full compensation for furnishing all materials, and for all preparation and for all labor, equipment, tools, and incidentals necessary to perform all work related to milling of existing pavement, clean-up and removal of residue material and water after the milling process, removal of film and loose material attached on milled surface, and hauling and disposal of material from Airport property.

END OF SECTION 32 01 16.71
SECTION 32 01 26.71 – SAW-CUT GROOVES

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consists of providing a skid resistant surface by transverse grooves saw-cut grooves in the pavement as shown on the plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

B. FAA Specification Item P-621, Saw-Cut Grooves, and as modified herein.

C. California State Water Quality Control Board Requirements.

1.3 SUBMITTALS

A. The contractor shall submit the following saw-cut grooves information.

1. Saw-cut grooving equipment as indicated in FAA Item P-621.

1.4 QUALITY CONTROL

A. The contractor shall perform work in accordance with all applicable codes, rules and regulations, and San Francisco International Airport Rules and Regulations/Airport Building Regulations.

PART 2 – PRODUCTS

A. Not used

PART 3 – EXECUTION

A. The contractor shall perform saw-cut grooving in accordance with FAA Specification Item P-621, and as modified herein.

B. Extreme care shall be exercised when grooving near runway lighting fixtures and kerf wireways. Grooves shall be sawed no nearer than 6” from the light fixtures.

C. Clean-up shall be continuous throughout the grooving operation. The waste material (used water and solid residue) resulting from grooving operations shall be collected by either sweeping or vacuuming. No solid residue shall be left on the pavement surfaces as to do so can create hazardous conditions to aircraft operations.

D. Work shall be performed during work hours specified by the Engineer.

E. Centerline lights are located about 2’ from centerline of runway (Centerline of paint). Location of any kerf wireways should be verified in field.

F. All excessive waste material at the end of each grooving pass must be swept up and that waste water marks running to the sides of the runways and taxiway shall also be cleaned to avoid any staining of the runway or taxiway surface. All residue and waste water collected shall become the contractor's property and shall be hauled off the Airport.
G. Grooving shall be performed a minimum of 30 days after placement of pavement and/or slurry seal, or as directed by the Engineer.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-621, Saw-Cut Grooves.

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-621, and as modified herein.
FAA ITEM P-621 SAW-CUT GROOVES

PART 1 – DESCRIPTION

- 621-1.1 – This item consists of providing a skid resistant surface that prevents hydroplaning during wet weather in accordance with these specifications and at the locations shown on the plans, or as directed by the Engineer.

PART 2 – CONSTRUCTION METHODS

- 621-2.1 – Procedures. The contractor shall submit to the Engineer the grooving sequence and method of placing guide lines to control grooving operation. Transverse grooves saw-cut in the pavement must form a 1/4" (+1/16", -0") wide by 1/4" (±1/16") deep by 1-1/2" (-1/8", +0") center-to-center configuration. The grooves must be continuous for the entire runway length. They must be saw-cut transversely (perpendicular to centerline) in the runway and high-speed taxiway pavement to not less than 10' (3 m) from the runway pavement edge to allow adequate space for equipment operation.

A. The saw-cut grooves must meet the following tolerances. The tolerances apply to each day’s production and to each piece of grooving equipment used for production. The contractor is responsible for all controls and process adjustments necessary to meet these tolerances.

1. **Alignment Tolerance.** The grooves shall not vary more than ±1-1/2" (38 mm) in alignment for 75’ (23 m) along the runway length, allowing for realignment every 500’ (150 m) along the runway length.

2. **Groove Tolerance. Depth.** The standard depth is ¼" (6 mm). At least 90% of the grooves must be at least 3/16" (5 mm), at least 60% of the grooves must be at least ¼" (6 mm), and not more than 10% of the grooves may exceed 5/16" (8 mm).

3. **Width.** The standard width is ¼" (6 mm). At least 90% of the grooves must be at least 3/16" (5 mm), at least 60% of the grooves must be at least ¼" (6 mm), and not more than 10% of the grooves may exceed 5/16" (8 mm).

4. **Center-To-Center Spacing.** The standard spacing is 1-1/2" (38 mm). Minimum spacing 1-3/8" (34 mm). Maximum spacing 1-1/2" (38 mm)

B. Saw-cut grooves must not be closer than 3" (8 cm) or more than 9" (23 cm) from transverse paving joints in concrete pavements. Grooves must not be closer than 6" (150 mm) and no more than 18" (0.5 m) from in-pavement light fixtures. Grooves may be continued through longitudinal construction joints. Where neoprene compression seals have been installed and the compression seals are recessed sufficiently to prevent damage from the grooving operation, grooves may be continued through the longitudinal joints. Where neoprene compression seals have been installed and the compression seals are not recessed sufficiently to prevent damage from the grooving operation, grooves must not be closer than 3" (8 cm) or more than 5" (125 mm) from the longitudinal joints. Where lighting cables are installed, grooving through longitudinal or diagonal saw kerfs shall not be allowed.

- 621-2.2 – Environmental Requirements. Grooving operations will not be permitted when freezing conditions prevent the immediate removal of debris and/or drainage of water from the grooved area. Discharge and disposal of waste slurry shall be the contractor’s responsibility.
- **621-2.3 – Test Section.** Groove a test section in an area of the pavement outside of the trafficked area, as approved by the Engineer. The area shall be 100’ long by two lanes wide. Demonstrate the setup and alignment process, the grooving operation, and the waste slurry disposal.

- **621.2.4 – Existing Pavements.** Bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement shall not be grooved until such areas are adequately repaired or replaced.

- **621-2.5 – New Pavements.** If it can be demonstrated that grooves are stable with no spalling along or tearing or raveling of the groove edges, then grooving sooner than 30 days may be allowed upon approval by the Engineer; otherwise, new asphalt concrete pavements shall be allowed to cure for a minimum of 30 days before grooving, to allow the material to become stable enough to prevent closing of the grooves under normal use. Permit new Portland cement concrete pavements to cure for a minimum of 28 days before grooving. Spalling along or tearing or raveling of the groove edges shall not be allowed.

- **621-2.6 – Grooving Machine.** Provide a grooving machine that is power driven, self-propelled, specifically designed and manufactured for pavement grooving, and has a self-contained and integrated continuous slurry vacuum system as the primary method for removing waste slurry. The grooving machine shall be equipped with diamond-saw cutting blades, and capable of making at least 18” (0.5 m) in width of multiple parallel grooves in one pass of the machine. Thickness of the cutting blades shall be capable of making the required width and depth of grooves in one pass of the machine. The cutting head shall not contain a mixture of new and worn blades or blades of unequal wear or diameter. Match the blade type and configuration with the hardness of the existing airfield pavement. The wheels on the grooving machine shall be of a design that will not scar or spall the pavement. Provide the machine with devices to control depth of groove and alignment.

- **621-2.7 – Water Supply.** Water for the grooving operation shall be provided by the contractor.

- **621-2.8 – Clean-Up.** During and after installation of saw-cut grooves, the contractor must remove from the pavement all debris, waste, and by-products generated by the operations to the satisfaction of the Engineer. Cleanup of waste material must be continuous during the grooving operation. Flush debris produced by the machine to the edge of the grooved area or pick it up as it forms. The dust coating remaining shall be picked up or flushed to the edge of the area if the resultant accumulation is not detrimental to the vegetation or storm drainage system. Accomplish all flushing operations in a manner to prevent erosion on the shoulders or damage to vegetation. Waste material must be disposed of in an approved manner. Waste material must not be allowed to enter the Airport storm sewer system. The contractor must dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

- **621-2.9 – Repair of Damaged Pavement.** Grooving must be stopped and damaged pavement repaired at the contractor’s expense, when in the opinion of the Engineer, the result of the grooving operation will be detrimental to aircraft tires.

- **621-2.10 – Production Rate.** The contractor must furnish sufficient equipment to groove the surface of pavement at a production rate as required to complete the grooving within the construction phasing schedule indicated in the Contract.
PART 3 – ACCEPTANCE

621-3.1 – **Acceptance Testing.** Grooves will be accepted based on results of zone testing. All acceptance testing necessary to determine conformance with the groove tolerances specified will be performed by the Engineer.

A. Instruments for measuring groove width and depth must have a range of at least 0.5” (12 mm) and a resolution of at least 0.005” (0.13 mm). Gauge blocks or gauges machined to standard grooves width, depth, and spacing may be used.

B. Instruments for measuring center-to-center spacing must have a range of at least 3” (8 cm) and a resolution of at least 0.02” (0.5 mm).

C. The Engineer will measure grooves in five zones across the pavement width. Measurements will be made at least three times during each day’s production. Measurements in all zones will be made for each cutting head on each piece of grooving equipment used for each day’s production.

D. The five zones are as follows:

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centerline to 5’ (1.5 m) left or right of the centerline.</td>
</tr>
<tr>
<td>2</td>
<td>5’ (1.5 m) to 25’ (7.5 m) left of the centerline.</td>
</tr>
<tr>
<td>3</td>
<td>5’ (1.5 m) to 25’ (7.5 m) right of the centerline.</td>
</tr>
<tr>
<td>4</td>
<td>25’ (7.5 m) to edge of grooving left of the centerline.</td>
</tr>
<tr>
<td>5</td>
<td>25’ (7.5 m) to edge of grooving right of the centerline.</td>
</tr>
</tbody>
</table>

E. At a random location within each zone, five consecutive grooves sawed by each cutting head on each piece of grooving equipment will be measured for width, depth, and spacing. The five consecutive measurements must be located about the middle blade of each cutting head ±4” (100 mm). Measurements will be made along a line perpendicular to the grooves.

F. Width or depth measurements less than 0.170” (4 mm) shall be considered less than 3/16” (5 mm).

G. Width or depth measurements more than 0.330” (8 mm) shall be considered more than 5/16” (8 mm).

H. Width or depth measurements more than 0.235” (6 mm) shall be considered more than 1/4” (6 mm).

I. Production must be adjusted when more than one groove on a cutting head fails to meet the standard depth, width, or spacing in more than one zone.

PART 4 – METHOD OF MEASUREMENT

621-4.1 – The quantity of grooving to be paid for shall by the number of square yards (square meters) of grooving performed in accordance with the specifications and accepted by the Engineer per paragraph 621-3.1.

PART 5 – BASIS OF PAYMENT

621-5.1 – Payment for Saw-Cut Grooving. Payment for saw-cut grooving will be made at the contract unit price per square yard for saw-cut pavement grooving.
A. This price shall be full compensation for furnishing all materials, and for all preparation, delivering, and application of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

END OF SECTION 32 01 26.71
SECTION 32 11 23 – CRUSHED AGGREGATE BASE COURSE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of furnishing and placing Crushed Aggregate Base Course as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.

B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

C. FAA Specification Item P-209, Crushed Aggregate Base Course, and as modified herein.

D. Section 31 23 00 – Excavation and Embankment FAA Item P-152.

E. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-209.

1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following Aggregate Base Course information:

1. Test Results: The contractor shall submit all copies of certified test results to the Engineer for review. These shall include retests for items that failed initial testing.

2. Samples of aggregates and materials used, including test reports, as specified.

3. Contractor shall submit ASCII file of grade checks performed for section 209-3.6 and 3.7, for the Engineer’s review and approval, before proceeding to subsequent material layers.

1.4 QUALITY ASSURANCE

1.5 The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-209, and as modified herein.

PART 2 – PRODUCTS

2.1 AGGREGATES

A. Aggregates shall conform to FAA Specification Item P-209, and as modified herein.

PART 3 – EXECUTION

A. Prior to placing aggregate base, the contractor shall compact the subgrade as required per Section 31 23 00 FAA Item P-152.

B. The contractor shall place crushed aggregate base course in accordance with FAA Specification Item P-209, and as modified herein.
PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-209 Crushed Aggregate Base Course.

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-209 and as modified herein.
FAA ITEM P-209 CRUSHED AGGREGATE BASE COURSE

PART 1 – DESCRIPTION

- 209-1.1 This item consists of a base course composed of crushed aggregate base constructed on a prepared course in accordance with these specifications and in conformity to the dimensions and typical cross-sections shown on the plans.

PART 2 – MATERIALS

- 209-2.1 Crushed aggregate base. Crushed aggregate shall consist of clean, sound, durable particles of crushed stone, crushed gravel, or crushed slag and shall be free from coatings of clay, silt, organic material, or other objectionable materials. Aggregates shall contain no clay lumps or balls. Fine aggregate passing the No. 4 (4.75 mm) sieve shall consist of fines from the coarse aggregate crushing operation. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel, or slag that meet the coarse aggregate requirements for wear and soundness.

  A. The crushed slag shall be an air-cooled, blast furnace slag and shall have a unit weight of not less than 70 pounds per cubic foot (1120 kg/cubic meter) when tested per ASTM C29.

  B. The coarse aggregate portion, defined as the material retained on the No. 4 (4.75 mm) sieve, shall not have a loss of greater than 45% when tested per ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. The aggregate shall contain no more than 15%, by weight, of flat, elongated, or flat and elongated particles per ASTM D4791. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. The aggregate shall have at least 90% by weight of particles with at least two fractured faces and 100% with at least one fractured face per ASTM D5821. The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

1. **Sampling and Testing for Initial Aggregate Base Requirements.** Samples shall be taken by the contractor in the presence of the Engineer. Material shall meet the requirements in paragraph 209-2.1 and 209-2.2. This sampling and testing will be the basis for approval of the aggregate base quality requirements.

   a) Aggregates for preliminary testing shall be furnished by the contractor prior to the start of production. All tests for initial aggregate submittals necessary to determine compliance with the specification requirements will be made by the Engineer at no expense to the contractor.

   b) Samples of aggregates shall be furnished by the contractor at the start of production and at intervals during production.

   c) In lieu of testing, the Engineer may accept certified state test results indicating that the aggregate meets specification requirements. Certified test results shall be less than 6 months old.
d) Samples of aggregates to check gradation shall be taken by the Engineer at least two per lot. The lot will be consistent with acceptable sampling for density. The samples shall be taken from the in-place, compacted material. Sampling shall be in accordance with ASTM D 75, and testing shall be in accordance with ASTM C 136 and ASTM C 117.

- 209-2.2 – Gradation Requirements. The gradation of the aggregate base material shall meet the requirements of the gradation given in the following table when tested per ASTM C117 and ASTM C136. The gradation shall be well graded from coarse to fine as defined by ASTM D2487 and shall not vary from the lower limit on one sieve to the high limit on an adjacent sieve or vice versa. The fraction of material passing the No. 200 (0.075 mm) sieve shall not exceed one-half the fraction passing the No. 40 (0.45 mm) sieve.

A. The material finer than 0.02 mm shall be limited to a maximum of 3% and the maximum allowable material passing the No. 200 sieve shall be reduced from 0-8% to 0-5%. Testing per ASTM D422 will be required for the percentage passing the 0.02 mm particle size once per lot.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Design Range Percentage by Weight</th>
<th>Contractor’s Final Gradation [To be Filled in by Contractor During Construction]</th>
<th>Job Control Grading Band Tolerances for Contractor’s Final Gradation Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2” (50 mm)</td>
<td>100</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1-1/2” (38 mm)</td>
<td>95-100</td>
<td></td>
<td>±5</td>
</tr>
<tr>
<td>1” (25 mm)</td>
<td>70-95</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>3/4” (19 mm)</td>
<td>55-85</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>30-60</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>No. 40 (0.45 mm)</td>
<td>10-30</td>
<td></td>
<td>±5</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>0-8</td>
<td></td>
<td>±3</td>
</tr>
</tbody>
</table>

B. The “Job Control Grading Band Tolerances for Contractor’s Final Gradation” in the table shall be applied to “Contractor’s Final Gradation” to establish a job control grading band. The full tolerance still applies if application of the tolerances results in a job control grading band outside the design range.

C. Sampling and testing for gradation. Gradation tests shall be performed by the Engineer per ASTM C136 and sieve analysis on material passing the No. 200 sieve (75 mm) per ASTM C112. The Engineer shall take at least two aggregate base samples per lot to check the final gradation. Sampling shall be per ASTM D75. The lot will be consistent with the lot size used for density. The samples shall be taken from the in-place, un-compacted material in the presence of the Engineer. Sampling points and intervals will be designated by the Engineer.

PART 3 – CONSTRUCTION METHODS

- 209-3.1 – Preparing underlying subgrade and/or subbase. The underlying subgrade and/or subbase shall be checked and accepted by the Engineer before base course placing and spreading operations begin. Re-proof rolling of the subgrade or proof rolling of the subbase in accordance with P-152, at the
contractor's expense, may be required by the Engineer if the contractor fails to ensure proper drainage or protect the subgrade and/or subbase. Any ruts or soft, yielding areas due to improper drainage conditions, hauling, or any other cause, shall be corrected before the base course is placed. To ensure proper drainage, the spreading of the base shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

209-3.2 - Production. The aggregate shall be uniformly blended and, when at a satisfactory moisture content per paragraph 209-3.4, the approved material may be transported directly to the spreading equipment.

209-3.3 - Placing. The aggregate base material shall be placed on the prepared underlying subgrade and/or subbase and compacted in layers to the thickness shown on the plans. Work shall progress without interruption. The material shall be deposited and spread in lanes in a uniform layer without segregation to such loose depth that, when compacted, the layer shall have the specified thickness. The aggregate base course shall be constructed in layers of uniform thickness of not less than 3” (75 mm) nor more than 6” (150 mm) of compacted thickness. The aggregate as spread shall be of uniform grading with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the Engineer, shall not be spread more than 2,000 square yards (1700 sq m) in advance of the rolling. Any necessary sprinkling shall be kept within these limits. Care shall be taken to prevent cutting into the underlying layer during spreading. No material shall be placed in snow or on a soft, muddy, or frozen course. The aggregate base material shall be spread by spreader boxes or other approved devices. This equipment shall have positive thickness controls that spread the aggregate in the required amount to avoid or minimize the need for hand manipulation. Dumping from vehicles that require re-handling shall not be permitted. Hauling over the uncompacted base course shall not be permitted.

A. When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

209-3.4 - Compaction. Immediately after completion of the spreading operations, compact each layer of the base course, as specified, with approved compaction equipment. The number, type, and weight of rollers shall be sufficient to compact the material to the required density within the same day that the aggregate is placed on the subgrade. The moisture content of the material during placing operations shall be within ±2 percentage points of the optimum moisture content as determined by ASTM D6938 using Procedure A, the direct transmission method and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated per ASTM D6938.

209-3.5 - Acceptance Sampling and Testing for Density. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day’s production if it does not exceed 2,400 square yards (2000 sq m). A lot will consist of one-half day’s production if a day’s production consists of between 2,400 and 4,800 square yards (2000 and 4000 sq m). The Engineer shall perform all density tests.

A. Each lot shall be divided into two equal sublots. One test shall be made for each sublot and shall consist of the average of two random locations for density determination. Sampling locations will be determined by the Engineer on a random basis per ASTM D3665.

B. Each lot will be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens. The specimens shall be compacted and tested per ASTM D1557. The in-place field density shall be determined per ASTM D1556. Test in accordance with ASTM D4718 if greater than 30% is retained on the ¾” sieve; or ASTM D2167; or ASTM D6938 using Procedure A, the
direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material.

C. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made at the contractor's expense. This procedure shall be followed until the specified density is reached.

- **209-3.6 – Surface Tolerances.** After the course has been compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3" (75 mm), reshaped and recompacted to grade. Until the required smoothness and accuracy are obtained and approved by the Engineer. Any deviation in surface tolerances shall be corrected by the contractor at the contractor's expense. The smoothness and accuracy requirements specified here apply only to the top layer when base course is constructed in more than one layer.

  A. **Smoothness.** The finished surface shall not vary more than 3/8" (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

  B. **Accuracy.** The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +0 and -1/2" (12 mm) of the specified grade.

- **209-3.7 – Thickness Control.** The thickness of the base course shall be within +0 and -1/2" (12 mm) of the specified thickness as determined by depth tests taken by the contractor in the presence of the Engineer. Tests shall be taken at intervals representing no more than 300 square yards (250 sq m) per test. Sampling locations will be determined by the Engineer per ASTM D3665. Where the thickness is deficient by more than 1/2" (12 mm), the contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3" (75 mm), adding new material of proper gradation, and the material shall be blended and recompacted to grade. Additional test holes may be required to identify the limits of deficient areas. The contractor shall replace, at his expense, base material where depth tests have been taken.

  A. In lieu of depth tests, contractor may elect to survey the placed material and provide ASCII file for review by the Engineer. In order to employ this method, contractor shall hire the services of a licensed surveyor to survey prior to placement and after placement. Survey interval shall be no greater than a 25' x 25' and shall capture all grade breaks. ASCII files shall be provided for review by the Engineer. At the engineer's discretion, supplemental survey and or the use of the aforementioned depth tests may be required.

- **209-3.8 – Protection.** Perform construction when the atmospheric temperature is above 35°F (2°C). When the temperature falls below 35°F (2°C), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements. When the aggregates contain frozen materials or when the underlying course is frozen or wet, the construction shall be stopped. Hauling equipment may be routed over completed portions of the base course, provided no damage results. Equipment shall be routed over the full width of the base course to avoid rutting or uneven compaction. The Engineer will stop all hauling over completed or partially completed base course when, in the Engineer's opinion, such hauling is causing damage. Any damage to the base course shall be repaired by the contractor at the contractor's expense.
209-3.9 – Maintenance. The contractor shall maintain the base course in a satisfactory condition until the full pavement section is completed and accepted by the Engineer. The surface shall be kept clean and free from foreign material and properly drained at all times. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

A. Equipment used in the construction of an adjoining section may be routed over completed base course, if no damage results and the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

B. The contractor shall remove all survey and grade hubs from the base courses prior to placing any bituminous surface course.

PART 4 – METHOD OF MEASUREMENT

209-4.1 – The quantity of crushed aggregate base course will be determined by measurement by the number of cubic yards of material actually constructed and accepted by the Engineer, whether in the production work or in the test section, as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

209-4.2 – The quantity of high early strength crushed aggregate base course will be determined by the measurement of the number of cubic yards of material actually constructed for use in the high early strength pavement section or test section and accepted by the Engineer as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

PART 5 – BASIS OF PAYMENT

209-5.1 – Payment shall be made at the contract unit price per cubic yard of crushed aggregate base course. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, and incidentals necessary to complete the item.

209-5.2 – Payment shall be made at the contract unit price of per cubic yard of crushed aggregate base course placed in conjunction with the high early strength concrete. This price shall be full compensation for furnishing all materials, for preparing and placing these materials as used in the high early strength pavement section, for all labor, equipment tools, and incidentals necessary to complete the item.

TESTING REQUIREMENTS

<p>| ASTM C 29 | Unit Weight of Aggregate |
| ASTM C 88 | Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| ASTM C 117 | Materials Finer than 75 mm (No. 200) Sieve in Mineral Aggregates by Washing |
| ASTM C 131 | Resistance to Degradation of Small-Size Coarse Aggregate by abrasion and impact in the Los Angeles Machine |
| ASTM C 136 | Sieve Analysis of Fine and Coarse Aggregates |
| ASTM D 75 | Sampling Aggregate |
| ASTM D 422 | Particle Size Analysis of Soils |</p>
<table>
<thead>
<tr>
<th>ASTM D 698</th>
<th>Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12 in (305 mm) Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D 1556</td>
<td>Density of Soil in Place by the Sand-Cone Method</td>
</tr>
<tr>
<td>ASTM D 1557</td>
<td>Test for Laboratory Compaction Characteristics of Soil Using Modified Effort</td>
</tr>
<tr>
<td>ASTM D 2167</td>
<td>Density and Unit Weight of Soil in Place by the Rubber Balloon Method</td>
</tr>
<tr>
<td>ASTM D 2419</td>
<td>Sand Equivalent Value of Soils and Fine Aggregate</td>
</tr>
<tr>
<td>ASTM D 6938</td>
<td>In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods</td>
</tr>
<tr>
<td>ASTM D 3665</td>
<td>Random Sampling of Construction Materials</td>
</tr>
<tr>
<td>ASTM D 4718</td>
<td>Correction of Unit Weight and Water Content for Soils Containing Oversize Particles</td>
</tr>
<tr>
<td>ASTM D 4791</td>
<td>Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM D 5821</td>
<td>Determining the Percentage of Fractured Particles in Coarse Aggregate</td>
</tr>
</tbody>
</table>

END OF SECTION 32 11 23
SECTION 32 11 29.13 – SOIL-CEMENT BASE COURSE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of soil-cement base (SCB) by constructing one or more courses of a mixture of soil, Portland cement, and water in accordance with this specification, and in conformity with the lines, grades, thickness, and typical cross sections shown on the plans and as specified herein.

1.2 REFERENCES

A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. Section 31 23 00 – Excavation and Embankment FAA Item P-152.
D. FAA Specification Item P-301, Soil-Cement Base Course, and as modified herein.
E. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-301.

1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following SCB treated base course information:

1. Test Results: The contractor shall submit all copies of certified test results for the soil gradation, Plasticity Index, Liquid Limit, Sulfate content, In-Place Field Density and Test of laboratory Compaction Characteristics of Soil, as required by Item P-301, to the Engineer for review. These shall include retests for items that failed initial testing.

2. Source of cement material and certified test results.

3. Source of bituminous material and certified test results

4. List of equipment to be inspected and approved by the Engineer at the job site.

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-301, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Soil-cement base course material shall conform to FAA Specification Item P-301, and as modified herein.
PART 3 – EXECUTION

A. The contractor shall mix, place and compact SCB treated base course in accordance with FAA Specification Item P-301, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-301 Soil-Cement Base Course

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-301 and as modified herein.
FAA ITEM P-301 SOIL-CEMENT BASE COURSE

PART 1 – DESCRIPTION

- 301-1.1 – This item shall consist of constructing a base course by uniformly mixing soil, Portland cement, and water. The mixed material shall be spread, shaped, and compacted in accordance with these specifications and in conformity to the dimensions and typical cross-section shown on the plans. Tests shall be required for each approved soil included within the treated layer.

A. Runway, taxiway, or apron pavements shall be built in a series of parallel lanes using a plan that reduces the number of longitudinal and transverse joints to a minimum.

PART 2 – MATERIALS

- 301-2.1 – Portland Cement. Portland cement shall conform to the requirements of ASTM C150, Type I or Type II.

- 301-2.2 – Water. Water used for mixing or curing shall be potable, reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product.

- 301-2.3 – Soil. The soil shall consist of an approved select soil. The soil shall be free of roots, sod, weeds, and shall not contain gravel or stone retained on a 2” (50-mm) sieve or more than 45% retained on a No. 4 (4.75 mm) sieve, as determined by ASTM C136.

- 301-2.4 – Bituminous material. The types, grades, controlling specifications, and application temperatures for the bituminous materials used for curing the soil-cement shall be SS-1.

<table>
<thead>
<tr>
<th>BITUMINOUS MATERIALS</th>
</tr>
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<tbody>
<tr>
<td>Type and Grade</td>
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<td></td>
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<tr>
<td>Emulsified Asphalt</td>
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</table>

PART 3 – Mix Design

- 301-3.1 – Proportions. Before the start of base course construction, tests shall be made on the soil or soil-aggregate material to be stabilized to determine the quantity of cement required for the mix design.

A. Test specimens containing various amounts of cement shall be compacted per ASTM D558, and the optimum moisture determined for each test specimen. Samples at the optimum moisture shall be subjected to the wet-dry and the freeze-thaw test in accordance with American Association of State Highway and Transportation Officials (AASHTO) T135 and AASHTO T136, respectively.

B. The specified cement content for construction shall be the cement content of the test specimen which has a weight loss of 14% or less for granular soils, 10% for the more plastic granular and silty soils, and 7% for clay soils after 12 cycles of the durability test.

C. The compressive strength of soaked specimens should increase with both age and increase in cement content.

PART 4 – CONSTRUCTION METHODS

- 301-4.1 – Weather limitations. The soil-cement base shall not be mixed or placed while the atmospheric temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 40°F.
(4°C) within 24 hours, or when the weather is foggy or rainy, or to soils that are frozen or contain frost, or when the underlying material is frozen.

- **301-4.2 – Equipment.** The soil-cement may be constructed with any equipment that will meet the requirements for soil pulverization, cement application, mixing, water application, incorporation of materials, compaction, finishing, and curing specified here.

- **301-4.3 – Preparation.** The area to be stabilized shall be graded and shaped to conform to the lines, grades and cross-section shown on the plans. Any soft or yielding areas in the subgrade shall be removed and replaced with acceptable soil and compacted to the specified density.

- **301-4.4 – Pulverization.** After completion of moist-mixing, the soil for the base course shall be pulverized so that 100% by dry weight passes a 1” (25 mm) sieve and a minimum of 80% passes a No. 4 (4.75 mm) sieve.

- **301-4.5 – Cement application, mixing, and spreading.** Mixing of the soil, cement, and water shall be accomplished by the mixed-in-place method. Approximately shape pulverized material to the cross-section indicated. Cement shall be applied so that when uniformly mixed with the soil, the specified cement content is obtained, and a sufficient quantity of cement-treated soil is produced to construct a compacted cement-treated course conforming to the lines, grades, and cross-section indicated. Immediately after the cement has been distributed, it shall be mixed with the soil. The cement shall not be mixed below the required depth. Continue mixing until the cement has been sufficiently blended with the soil to prevent the formation of cement balls when water is applied. Determine moisture content of the mixture immediately after completion of mixing of the soil and cement. Provide water supply and pressure distributing equipment that will permit the application within 3 hours of all mixing water on the section being processed. Incorporate water in the mix so that concentration of water near the surface does not occur. After all mixing water has been applied, continue mixing until the water is uniformly distributed throughout the full depth of the mixture. Do not apply cement if the soil moisture content exceeds the optimum moisture content specified for the cement-treated mixture. After mixing is complete, the proportions of the mixture shall be in accordance with the approved mix design.

- **301-4.6 – Compaction.** Immediately after spreading, the mixture shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density.

  A. The field density of the compacted mixture shall be at least 98% of the maximum density of laboratory prepared specimens compacted and tested in accordance with ASTM D558. The in-place field density shall be determined in accordance with ASTM D1556 or ASTM D2167. No portion of the mixture shall remain undisturbed during mixing and before compaction for more than 30 minutes. The moisture content of the mixture at the start of compaction shall be within ±2 percentage points of the optimum moisture content. The optimum moisture content shall be determined in accordance with ASTM D558. All testing shall be done by the contractor’s laboratory in the presence of the Engineer and density test results shall be furnished upon completion to the Engineer for acceptance determination.

- **301-4.7 – Finishing.** Finishing operations shall be completed during daylight hours. The completed base course shall conform to the required lines, grades, and cross-section. If necessary, the surface shall be lightly scarified to eliminate any imprints made by the compacting or shaping equipment. The surface shall then be recompacted to the required density. The finishing operations shall be complete within 2 hours after completion of mixing operations.

- **301-4.8 – Construction Joints.** At the end of each day’s construction, a straight transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true vertical face free of loose material.
A. The protection provided for construction joints shall permit the placing, spreading, and compacting of base material without injury to the previous work. Where it is necessary to operate or turn any equipment on the completed base course, sufficient protection and cover shall be provided to prevent damage to the finished surface. A supply of mats or wooden planks shall be maintained and used as approved and directed by the Engineer.

B. Care shall be exercised to ensure thorough compaction of the base material immediately adjacent to all construction joints. When spreading or compacting base material adjacent to a previously constructed lane, care shall be taken to avoid damaging the previous work.

301-4.9 – Protection and Curing. After the base course has been finished to grade and compacted as specified, it shall be protected against drying for a period of 7 days by the application of bituminous material. The curing method shall begin as soon as possible, but no later than 24 hours after the completion of finishing operations. The finished base course shall be kept moist continuously until the curing material is placed.

A. The bituminous material specified shall be uniformly applied to the surface of the completed base course at the rate of approximately 0.2 gallons per square yard (0.91 l/m²) with approved heating and distributing equipment. The exact rate and temperature of application to give complete coverage without excessive runoff shall be as specified.

B. At the time the bituminous material is applied, the surface shall be dense, free of all loose and extraneous material, and shall contain sufficient moisture to prevent penetration of the bituminous material. Water shall be applied in sufficient quantity to fill the surface voids immediately before the bituminous curing material is applied.

C. The curing material shall be maintained and applied as needed by the contractor during the 7-day protection period.

D. Completed portions of the cement-treated soil area may be opened to light traffic, if approved by the Engineer, and provided the curing is not impaired. Sufficient protection from freezing shall be provided to the soil-cement for 7 days after its construction and until it has hardened.

301-4.10 – Construction Limitations. When any of the operations after the application of cement are interrupted for more than 30 minutes or when the uncompacted soil-cement mixture is wetted by rain so that the moisture content is exceeded by a small amount, the decision to reconstruct the portion affected shall rest with the Engineer. If the uncompacted, rain-wetted mixture exceeds the specified moisture content tolerance, the contractor shall reconstruct the affected portion at the contractor’s expense the portion affected. All material along the longitudinal or transverse construction joints not properly compacted shall be removed and replaced, at the contractor’s expense, with properly moistened and mixed soil-cement compacted to specified density.

301-4.11 – Surface Tests. The finished surface shall not vary more than 3/8” (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with, or at right angles to, the longitudinal axis of the pavement. Any variations in excess of this tolerance shall be corrected by the contractor, at the contractor’s expense, in a manner satisfactory to the Engineer.

301-4.12 – Thickness. The completed thickness of the stabilized course shall be within 1/2” (12 mm) of the thickness indicated. Where the measured thickness is more than 1/2” (12 mm) deficient, such areas shall be corrected by scarifying, adding mixture of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2” (12 mm) thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 1/4” (6 mm) of the thickness indicated. The thickness of the stabilized course shall be measured at intervals which ensure
one measurement for each 500 square yards of stabilized course. Measurements shall be made in 3-inch (75 mm) diameter test holes penetrating the stabilized course. Where the average thickness shown by the measurements made in one day’s construction is not within the tolerance given, the Engineer shall evaluate the area and determine if, in the Engineer’s opinion, it shall be reconstructed at the contractor’s expense or the deficiency deducted from the total material in place.

- **301-4.13 – Maintenance.** The contractor shall be required to maintain, at the contractor’s expense, the entire base course within the limits of the contract in a condition satisfactory to the Engineer until all the work has been completed. Maintenance shall include immediate repairs of any defects that may occur either before or after the cement is applied. The work shall be repeated as often as necessary to keep the area intact at all times. Repairs shall be made to ensure restoration of a uniform surface and the durability of the area repaired. Faulty work shall be replaced for the full depth of treatment. Adding a thin layer of soil-cement to the completed work to remedy low areas shall not be permitted.

**PART 5 – BASIS OF PAYMENT**

- **301-5.1 – Payment** shall be made at the contract unit per square yards (square meters) for soil-cement base course. This price shall be full compensation for furnishing all materials, except Portland cement, and for all preparation, delivering, placing, and mixing of these materials; and for all labor, equipment, tools and incidentals necessary to complete the item.

- **301-5.2 – Payment** shall be made at the contract unit price hundred (kg) for cement. This price shall be full compensation for furnishing this material and for all delivery, placing, and incorporation of this material, and for all labor, equipment, tools, and incidentals necessary to complete the item.

**TEST REQUIREMENTS**

| ASTM C136 | Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates |
| ASTM D558 | Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures |
| ASTM D1556 | Standard Test Method for Density and Unit Weight of Soil In-Place by the Sand Cone Method |
| ASTM D2167 | Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method |
| AASHTO T135 | Standard Method of Test for Wetting-and-Drying Test of Compacted Soil-Cement Mixtures |
| AASHTO T136 | Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures |

**MATERIAL REQUIREMENTS**

| ASTM C150 | Standard Specification for Portland Cement |
| ASTM D977 | Standard Specification for Emulsified Asphalt |
| ASTM D2027 | Standard Specification for Cutback Asphalt (Medium-Curing Type) |
| ASTM D2028 | Standard Specification for Cutback Asphalt (Rapid-Curing Type) |
| ASTM D2397 | Standard Specification for Cationic Emulsified Asphalt |

**END OF SECTION 32 11 29.13**
SECTION 32 11 33 – CEMENT-TREATED BASE COURSE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consists of a cement-treated base (CTB) course composed of mineral aggregate and cement, uniformly blended and mixed with water. The mixed material shall be spread and shaped with a mechanical spreader, and compacted with rollers in accordance with these specifications and in conformance to the lines, grades, dimensions, and cross-sections shown on the plans as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. FAA Specification Item P-304, Cement-Treated Base Course, and as modified herein.
D. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-304.

1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following cement-treated base course material and equipment information:

1. Test Results: The contractor shall submit all copies of certified test results on aggregates, cement, admixtures, curing, and bond breaking materials to the Engineer for review. These shall include retests for items that failed initial testing.

2. The contractor shall submit to the Engineer a mix design including the proportions and source of materials, admixtures, and Compressive Strength.

3. Source of materials, samples of aggregates and materials used, as specified.

4. List of equipment to be inspected and approved by the Engineer at the job site.

5. Contractor shall submit an ASCII file of all grades checked before the placement of P-304 and at completion of P-304, for the Engineer’s review and approval as described in 304-6.

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-304, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Aggregate, Portland cement, water, admixtures, curing, and bond breaking materials shall conform to FAA Specification Item P-304, and as modified herein.
B. Water shall be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

PART 3 – EXECUTION

A. The contractor shall mix, place and compact CTB in accordance with FAA Specification Item P-304, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-304, Cement-Treated Base Course.

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-304 and as modified herein.
FAA ITEM P-304 CEMENT-TREATED BASE COURSE

PART 1 – DESCRIPTION

- 304-1.1 – This item shall consist of a cement-treated base (CTB) course composed of mineral aggregate and cement, uniformly blended and mixed with water. The mixed material shall be spread and shaped with a mechanical spreader, and compacted with rollers in accordance with these specifications and in conformance to the lines, grades, dimensions, and cross-sections shown on the plans.

PART 2 – MATERIALS

- 304-2.1 – Aggregate. The aggregate shall be select granular materials, comprised of crushed or uncrushed gravel and/or stone, or recycled crushed and graded Portland cement concrete (PCC). The material shall be free of roots, sod, and weeds. The crushed or uncrushed aggregate shall consist of hard, durable particles of accepted quality, free from an excess of soft, flat, elongated, or disintegrated pieces, and objectionable matter. The method used to produce the aggregate shall ensure the finished product is as consistent as practicable. All inferior quality stones and rocks shall be wasted. If recycled PCC is used as the aggregate, it must meet the requirements for virgin aggregate.
  
  A. The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 10%, or the magnesium sulfate soundness loss shall not exceed 15%, after five cycles, when tested in accordance with ASTM C88.
  
  B. When tested in accordance with ASTM C136, the aggregate shall conform to the gradation(s) shown in the table below (titled Aggregate Gradation for CTB Material). An aggregate blend that meets the requirements of the table shall be selected by the contractor and used in the final mix design. The final aggregate blend shall be well graded from coarse to fine within the limits designated in the table and shall not vary from the low limit on one sieve to the high limit on adjacent sieves, or vice versa. The portion of final aggregate blend passing the No. 40 (425 µm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with ASTM D4318.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage by Weight Passing Sieves</th>
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<tbody>
<tr>
<td></td>
<td>Gradation A</td>
</tr>
<tr>
<td>2 in</td>
<td>100 ¹</td>
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<tr>
<td>No. 4</td>
<td>45 - 100</td>
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<tr>
<td>No. 10</td>
<td>37 - 80</td>
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<tr>
<td>No. 40</td>
<td>15 - 50</td>
</tr>
<tr>
<td>No. 80</td>
<td>0 - 25</td>
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</tbody>
</table>

  ¹ Maximum size of aggregate is 1" when used as a base course under Item P-501, Portland Cement Concrete Pavement.

- C. All aggregate samples required for testing shall be furnished by the contractor at the expense of the contractor. Sampling shall be performed by the contractor in accordance with ASTM D75.

- 304-2.2 – Cement. Cement shall conform to the requirements of ASTM C150 Type II.

- 304-2.3 – Cementitious Additives. Pozzolanic and slag cement may be added to the CTB mix. If used, each material must meet the following requirements:
A. **Pozzolan.** Pozzolanic materials must meet the requirements of ASTM C618, Class F, or N with the exception of loss of ignition, where the maximum shall be less than 6%.

B. **Slag Cement.** Slag shall conform to ASTM C989, Grade 80, 100, or 120.

- **304-2.4 – Water.** Water used in mixing or curing shall be potable, clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product.

- **304-2.5 – Curing Materials.**
  
  A. For curing CTB placed under PCC pavement, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class A or Class B (wax-based).
  
  B. For curing CTB placed under HMA pavement, use emulsified asphalt conforming to ASTM C977 or ASTM D2397 (Table 2).

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<thead>
<tr>
<th>Type and Grade</th>
<th>Specification</th>
<th>Application Temperature</th>
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<tbody>
<tr>
<td>Emulsified Asphalt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS-1, SS-1</td>
<td>ASTM D977</td>
<td>75 – 130 °F</td>
</tr>
<tr>
<td>CRS-1</td>
<td>ASTM D2397</td>
<td>75 – 130 °F</td>
</tr>
</tbody>
</table>

- **304-2.6 – Sand Blotter.** Sand shall be applied, when required, to prevent tracking of the emulsion curing materials. The sand material shall be clean, dry, and non-plastic.

**PART 3 – COMPOSITION OF MIXTURE**

- **304-3.1 – General.** The CTB material shall be composed of a mixture of aggregate, cementitious material, and water. Fly ash or slag cement may be used as a partial replacement for Portland cement.

- **304-3.2 – Mix Design.** The mix design shall use a cement content that, when tested in the laboratory per ASTM D1633 produces a:
  
  1. 7-day compressive strength between 400 pounds per square inch (2758 kPa) minimum and 800 pounds per square inch (5516 kPa) maximum, and
  
  2. 28-day strength that shall not exceed 1000 pounds per square inch (6895 kPa).

  A. The mix design shall include a complete list of materials, including type, brand, source, and amount of cement, fine aggregate, coarse aggregate, water, and cementitious additives.

  B. Should a change be made in aggregate sources or type of cement, or if cementitious additives are added or deleted from the mix, production of the CTB mix shall be stopped and a new mix design shall be submitted.

- **304-3.3 – Submittals.** At least 30 days prior to the placement of the CTB, the contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the CTB material. Tests older than six (6) months shall not be used. The certification shall show the ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:
1. Source(s) of materials, including aggregate, cement, cementitious additives, curing, and bond-breaking materials.


3. Mix design:
   a) Mix identification number
   b) Aggregate gradation
   c) Cement content
   d) Water content
   e) Cementitious materials content

4. Laboratory test results:
   a) Compaction and strength testing procedures
   b) Laboratory compaction characteristics (maximum dry density and optimum moisture content)
   c) Compressive strength at 7 days
   d) Wet-dry and/or freeze-thaw weight loss, if applicable

A. No CTB material shall be placed until the submittal is accepted in writing by the Engineer.

B. During production, the contractor shall submit batch tickets for each delivered load.

PART 4 – EQUIPMENT

- All equipment necessary to mix, transport, place, compact, and finish the CTB material shall be furnished by the contractor. The equipment shall be inspected and approved by the Engineer at the job site prior to the start of construction operations.

- **304-4.1 – Mixing.** The mixer shall be a batch or continuous-flow type stationary mixer. The mixer shall be equipped with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities. If necessary, a screening device shall be used to remove oversized material greater than 2” (50 mm) from the raw aggregate feed prior to mixing.

  A. The Engineer shall have free access to the plant at all times for inspection of the plant’s equipment and operation and for sampling the CTB mixture and its components.

- **304-4.2 – Hauling.** The mixed CTB material shall be transported from the plant to the job site in trucks or other hauling equipment having beds that are smooth, clean, and tight. Truck bed covers shall be provided and used to protect the CTB from rain. CTB material that becomes wet during transport shall be rejected.

- **304-4.3 – Placing.** CTB material shall be placed using a mechanical spreader or a machine capable of receiving, spreading, and shaping the mixture without segregation into a uniform layer or lift. The equipment shall be equipped with a strike-off plate capable of being adjusted to the specified layer thickness. It shall also be equipped with two end gates or cut off plates, so that the CTB may be spread in widths varying up to lane width.
304-4.4 – **Compaction.** Compaction of the CTB layer shall be accomplished using one or a combination of the following pieces of equipment:

1. Tamping or grid roller
2. Steel-wheeled roller
3. Vibratory roller
4. Pneumatic-tire roller
5. And/or vibrating plate compactor (for areas inaccessible to rollers).

A. The number, type, and weight of rollers and/or compactors shall be sufficient to compact the mixture to the required density.

304-4.5 – **Finishing.** Final trimming of the compacted CTB to meet surface requirements shall be accomplished using a self-propelled grader or trimming machine, with a mold board cutting edge, which is at least 12’ (3.7 m) wide and is automatically controlled by sensors in conjunction with an independent grade control from a taut stringline. Stringline will be required on both sides of the sensor controls for the pilot lane. For all other lanes, a single stringline on the outside and grade matching with previously completed adjacent lanes is permissible.

PART 5 – CONSTRUCTION METHODS

304-5.1 – Weather Limitations.

304-5.1.1 – **Cold Weather.** Do not construct base when weather conditions will detrimentally affect quality of the finished course. Apply cement when the ambient temperature is a minimum of 40 °F (4 °C) and rising. Do not apply cement to aggregate materials that are frozen or contain frost. If ambient temperature falls below 40 °F (4 °C), protect completed cement-treated areas against freezing. Reprocess, reshape, and recompact damaged material. The CTB shall not be placed on frozen surfaces. Provide drainage to prevent water from collecting or standing on stabilized areas, and on the pulverized, mixed, or partially mixed materials.

304-5.1.2 – **Rain.** The CTB may not be placed when it is raining. If unexpected rain occurs during placement, the layer should be quickly compacted. CTB material that becomes wet by rain during transport or placement shall be evaluated by the Engineer, and may be rejected.

304-5.2 – **Preparation of Underlying Course.** The underlying course shall be checked by the Engineer before placing and spreading operations are started, to ensure that it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places shall be corrected before the CTB mixture is placed. The underlying course shall be wetted in advance of placing the CTB layer. The final prepared grade prior to placing the CTB should be in a firm and moist condition free of frost. Use of chemicals to eliminate frost will not be permitted.

A. To ensure proper drainage, placement of the base shall begin along the centerline of the pavement on a crowned section or on the highest elevation contour of a pavement with variable cross slope.

304-5.3 – **Grade Control.** Grade control between the edges of the CTB shall be accomplished at intervals of 50’ (15 m) or less on the longitudinal grade and at 25’ (7.5 m) or less on the transverse grade.

304-5.4 – **Handling, Measuring, and Batching.** The continuous flow central plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Aggregate stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials. Aggregates that are segregated or mixed with earth or foreign material will not be accepted.
A. Continuous flow plants shall be equipped with feeders to automatically and accurately proportion aggregates and bulk cement, by weight. When bulk cement is used, the contractor shall use a suitable method of handling the cement such as a chute, boot or other device, to prevent loss of cement between the weigh hopper and mixer. The device shall provide positive assurance that the specified cement content is present in each batch.

- **304-5.5 – Mixing.** Aggregate and cement may be proportioned either by weight or volume, and shall be mixed sufficiently to prevent the forming of cement balls when water is added. The mixing time shall be that required to secure a well-blended, uniform mixture of aggregate, cement, water, and pozzolan (if used). The minimum mixing time will be based on the uniformity and consistency of the mixture.

- **304-5.6 – Placing.** The CTB mixture shall be deposited on the moistened subgrade or subbase and spread into a uniform layer of specified width and thickness that, when compacted and trimmed, conforms to the required line, grade, and cross-section. The contractor may install the CTB layer in single or multiple compacted lifts; however, each compacted lift must be no greater than 6” (150 mm) thick. In multi-lift construction, the surface of the compacted lift shall be kept moist until covered with the next lift. Successive lifts shall be placed and compacted so that the required total depth of the CTB layer is completed within 12 hours.

A. A single spreader may be used, provided it is capable of placing a uniform, full-depth layer of material across the full width of the base in one pass. Otherwise, two or more spreaders will be required, and shall be operated so that spreading progresses along the full width of the base in a uniform manner.

- **304-5.7 – Compaction.** Immediately upon completion of the spreading operations, the CTB material shall be thoroughly compacted using approved compaction equipment. At the start of compaction, the moisture content shall be within ±2 percentage points of the specified optimum moisture.

- **304-5.8 – Finishing.** After completing compaction, the surface of the CTB layer shall be shaped to the specified lines, grades, and cross-section. During the finishing process, the surface shall be kept moist by means of fog-type sprayers. Compaction and finishing shall produce a smooth, dense surface, free of ruts, cracks, ridges, and loose material. All placement, compaction, and finishing operations shall be completed within 2 hours from the start of mixing. Material not completed within the 2-hour time limit shall be removed and replaced at the contractor’s expense.

A. CTB layer limits that extend beyond the edges of the new PCC surface course shall be rolled down or shaped to ensure the drainage is away from the new PCC surface course edge.

- **304-5.9 – Construction Joints.** At the end of each day’s construction, a transverse construction joint shall be formed that is a true vertical face (perpendicular to the centerline) and is free of loose material.

A. Longitudinal construction joints (parallel to the centerline) shall be formed to a consistent, well-defined vertical edge that is free of loose material. The longitudinal joints shall be located so there is a 2-foot (0.6-m) minimum offset from planned joints in any overlying layer.

B. While forming construction joints, the contractor shall make sure the material in the joint area is adequately compacted and that the joints are finished level and even with the remainder of the CTB layer.

- **304-5.10 – Curing.** The compacted and finished CTB shall be cured with the approved curing agents as soon as possible and in no case later than 2 hours after completion of the finishing operations. The layer shall be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied.
A. When asphalt emulsion is used as the curing agent, the entire surface of the CTB layer shall be uniformly sprayed with the emulsion at a rate of between 0.15 and 0.30 gallons per square yard (0.7 and 1.4 l/m²); the exact temperature and rate of application being that required to achieve complete and uniform coverage without runoff. Apply sand at 3 pounds per square yard (kg/m²) to treated surfaces requiring protection from traffic.

B. When a liquid membrane-forming curing compound is used as the curing agent, the surface of the CTB layer shall be uniformly sprayed with the curing compound at the rate of one gallon (3.8 liters) to not more than 200 square feet (18.6 m²) to obtain a uniform cover over the surface. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. The curing compound shall be thoroughly and uniformly mixed with the pigment in the storage tank. During application, the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and CTB surfaces exposed by the removal of forms is permitted.

C. The curing seal shall be maintained and protected until the pavement is placed. If the surface of the finished CTB and/or the curing seal becomes damaged, additional curing material shall be applied at the time it is damaged or when the damage is first observed.

304-5.11 – Protection. Completed portions of the cement-stabilized area may be opened to local traffic provided the curing process is not impaired and to other traffic after the curing period has elapsed, provided that the cement-stabilized course has hardened sufficiently to prevent surface marring or distortion by equipment or traffic. Do not permit construction equipment on the area during protection and curing periods. Necessary cement and water may be hauled over the area with pneumatic-tired equipment on approval of the Engineer. Protect finished portions of cement stabilized base from traffic of equipment used in constructing adjoining sections in a manner to prevent marring or damaging completed work. The CTB shall also be protected from freezing at all times.

304-5.12 – Bond-Breaker. When the CTB is to be placed directly beneath PCC, the entire surface of the CTB shall be coated with a de-bonding compound applied in a quality sufficient to prevent bonding of the PCC pavement to the base course. If an impervious membrane or asphalt emulsion is used as a curing material, additional applications of curing materials may be required. The contractor shall be responsible for selecting the de-bonding compound and determining the necessary application rate. The de-bonding compound shall be approved by the Engineer prior to being incorporated into the work.

PART 6 – MATERIAL ACCEPTANCE

304-6.1 – Acceptance Sampling and Testing. All acceptance sampling and testing, with the exception of thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The contractor shall provide the required CTB samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

A. Testing organizations performing these tests shall meet the requirements of ASTM D3666. All test equipment in contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

B. The CTB layer shall be tested for density, thickness, grade, and surface tolerance on a lot basis, with a lot consisting of either:

1. One (1) day’s production not to exceed 2,000 square yards (1,700 sq m), or

2. A half (1/2) day’s production, where a day’s production consists of 2,000 to 4,000 square yards (1675 to 3,350 m²)
C. Each lot shall be divided into four equal sublots. Within each sublot, one density test, one thickness measurement, and continuous surface straightedge tests (surface tolerance testing) shall be performed, as described below. Sampling locations shall be determined by the Engineer per ASTM D3665.

D. If only 3 sublots are produced, the 3 sublots shall constitute a complete lot. If one (1) or two (2) sublots are produced for the same reason, they shall be incorporated into the next or previous lot, and the total number of sublots shall be used in the acceptance criteria calculation.

E. End-of-production sublots (that is, sublots associated with the final placement of CTB for the project and are less than a complete lot) shall be handled as:
   1. Three (3) sublots shall constitute a lot, or
   2. One or two (1 or 2) sublots shall be incorporated into the previous lot.

\[304-6.1.1 – \textbf{Density Testing.} \] CTB samples shall be taken from each sublot and used to create laboratory test specimens representing the various sublots. The specimens shall be compacted and tested for density and moisture content per ASTM D558. The density for each sublot comprising a lot, shall be used to determine an average density for the lot, which will serve as the basis for acceptance of the lot for density.

A. Within each sublot in the field, one in-place density test shall be performed in accordance with ASTM D1556, ASTM D2167, or ASTM D6938. The location of the test shall be randomly selected per ASTM D3665. The in-place density for each sublot comprising the lot shall be averaged and compared with the corresponding average lot density. Acceptance criteria for CTB density are provided in paragraph 304-6.2.1. All testing shall be done by the Engineer.

\[304-6.1.2 – \textbf{Thickness Testing.} \] The CTB shall be tested for thickness using the same lot and sublots established for density testing. After three (3) days of curing, one 3-inch (75 mm) diameter core per sublot shall be obtained from a random location, per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures provided in ASTM C174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for CTB thickness are provided in paragraph 304-6.2.2. At all locations where cores have been drilled, the resulting core holes shall be filled by the contractor with CTB or non-shrink grout.

\[304-6.1.3 – \textbf{Grade Testing.} \] The elevations of the finished CTB shall be surveyed every 25’ (7.5 m) on both sides of the CTB lane as soon as it has hardened sufficiently. Acceptance criteria for CTB grade are provided in paragraph 306-6.2.3.

\[304-6.1.4 – \textbf{Surface Tolerance Testing.} \] After the CTB has hardened sufficiently, it shall be tested for surface tolerance with a 12-foot (3.7-m) straightedge or other approved measuring device for tolerances outlined in paragraph 304-6.2.4.

\[304-6.1.5 – \textbf{Compressive Strength Testing.} \] CTB samples shall be taken from each sublot and used to create laboratory test specimens representing the various sublots. Samples shall be tested in the laboratory per ASTM D1633 to establish a 7-day compressive strength.

\[304-6.2 – \textbf{Acceptance Criteria.} \] Acceptance of CTB will be based on density, thickness, grade, and surface tolerance, as described in the paragraphs below.

\[304-6.2.1 – \textbf{Density Requirements.} \] For density, each lot of compacted material will be accepted without adjustment if the average in-place density of the lot is equal to or greater than 98% of the average
laboratory density determined for the lot. Each lot of compacted CTB shall be accepted and payment adjusted in accordance with the table below.

Table 3 Sliding Pay Scale Factors for Density

<table>
<thead>
<tr>
<th>Average Dry Density (%)</th>
<th>Payment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.0 and greater</td>
<td>100</td>
</tr>
<tr>
<td>97.0 - 97.9</td>
<td>95</td>
</tr>
<tr>
<td>96.0 - 96.9</td>
<td>90</td>
</tr>
<tr>
<td>95.0 - 95.9</td>
<td>75</td>
</tr>
<tr>
<td>Less than 95.0</td>
<td>Reject</td>
</tr>
</tbody>
</table>

A. If the average density is below 95%, the lot will be rejected and shall be removed and replaced at the contractor’s expense. In multi-layer construction, density shall be tested for each lift, and all lifts within a rejected lot shall be removed and replaced. No payment shall be made for removed lifts. Replacement lifts shall be paid in accordance with this section.

- **304-6.2.2 – Thickness Requirements.** The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than 1/2” (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1” (25 mm), it shall be removed and replaced at the contractor’s expense. When such measurement is deficient by more than 1/2” (12 mm) but less than 1” (25 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new average lot thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. If the recomputed average lot thickness is not deficient by more than 1/2” (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1/2” (12 mm) from the plan thickness, the entire lot shall be removed and replaced at the contractor’s expense or shall be permitted to remain in-place at an adjusted payment of 75% of the contract unit price.

A. When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed CTB layer is within the established grade and surface tolerance requirements.

- **304-6.2.3 – Grade Requirements.** When the completed surface is higher than 1/2” (12 mm) above the grade shown in the plans, the surface shall be trimmed, at the contractor’s expense, with an approved grinding machine to an elevation that falls within a tolerance of 1/4” (6 mm) or less.

- **304-6.2.4 – Surface Tolerance Requirements.** The finished surface shall not vary more than 3/8” (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with, or at right angles to, the centerline of the CTB area. Areas in the CTB showing high spots greater than 3/8” (9 mm) over 12’ (3.7 m) shall be marked and immediately trimmed with an approved grinding machine. Such trimming shall be at the contractor’s expense.

**PART 7 – METHOD OF MEASUREMENT**

- **304-7.1 – Cement-Treated Base Course.** The quantity of cement-treated base course will be determined by the measurement of the number of square yards of CTB actually constructed and accepted by the Engineer as complying with the plans and specifications.

**PART 8 – BASIS OF PAYMENT**

- **304-8.1 – Cement-Treated Base Course.** Payment shall be made at the contract unit price per square yard for each thickness specified for cement-treated base course. This price shall be full compensation for
furnishing all materials, including cement; for all preparation, manipulation, placing, and curing of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

A. Each lot of CTB material will be accepted for density at the full contract price adjusted in accordance with Table 3 in paragraph 304-6.2.1.

### TESTING REQUIREMENTS

<table>
<thead>
<tr>
<th>ASTM Code</th>
<th>Test Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C88</td>
<td>Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
</tr>
<tr>
<td>ASTM C136</td>
<td>Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM C174</td>
<td>Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores</td>
</tr>
<tr>
<td>ASTM D75</td>
<td>Standard Practice for Sampling Aggregates</td>
</tr>
<tr>
<td>ASTM D558</td>
<td>Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures</td>
</tr>
<tr>
<td>ASTM D1556</td>
<td>Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method</td>
</tr>
<tr>
<td>ASTM D1633</td>
<td>Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders</td>
</tr>
<tr>
<td>ASTM D2167</td>
<td>Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method</td>
</tr>
<tr>
<td>ASTM D6938</td>
<td>Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)</td>
</tr>
<tr>
<td>ASTM D3665</td>
<td>Standard Practice for Random Sampling of Construction Materials</td>
</tr>
<tr>
<td>ASTM D3666</td>
<td>Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials</td>
</tr>
<tr>
<td>AASHTO T135</td>
<td>Standard Method of Test for Wetting-and-Drying Test of Compacted Soil-Cement Mixtures</td>
</tr>
<tr>
<td>AASHTO T136</td>
<td>Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures</td>
</tr>
<tr>
<td>ASTM C88</td>
<td>Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
</tr>
</tbody>
</table>

### MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>ASTM Code</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C150</td>
<td>Standard Specification for Portland Cement</td>
</tr>
<tr>
<td>ASTM C309</td>
<td>Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete</td>
</tr>
<tr>
<td>ASTM C595</td>
<td>Standard Specification for Blended Hydraulic Cements</td>
</tr>
<tr>
<td>ASTM C618</td>
<td>Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete</td>
</tr>
<tr>
<td>Standard Specification</td>
<td>Reference</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ASTM C989</td>
<td>Standard Specification for Slag Cement for Use in Concrete and Mortars</td>
</tr>
<tr>
<td>ASTM D977</td>
<td>Standard Specification for Emulsified Asphalt</td>
</tr>
<tr>
<td>ASTM D2397</td>
<td>Standard Specification for Cationic Emulsified Asphalt</td>
</tr>
</tbody>
</table>

END OF SECTION 32 11 33
SECTION 32 11 36 – LEAN CONCRETE BASE COURSE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of Lean Concrete Base (LCB), herein termed lean concrete, that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross sections shown on the plans and as specified herein.

1.2 REFERENCES

A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation
B. FAA Specification Item P-306, Lean Concrete Base Course, and as modified herein.
C. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-306.

1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following lean concrete base course information:
   1. Test Results: The contractor shall submit all copies of certified test results on aggregates, cement, admixtures, curing, and bond breaking materials to the Engineer for review. These shall include retests for items that failed initial testing.
   2. The contractor shall submit, to the Engineer, a mix design including the proportions and source of materials, admixtures, and Compressive Strength.
   3. Source of materials, samples of aggregates, and materials used, as specified.
   4. List of equipment to be inspected and approved by the Engineer at the job site.

1.4 QUALITY ASSURANCE

1.5 The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-306, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Aggregate, Portland cement, water, admixtures, curing, and bond breaking materials shall conform to FAA Specification Item P-306, and as modified herein.

PART 3 – EXECUTION

A. The contractor shall mix and place lean concrete base course in accordance with FAA Specification Item P-306, and as modified herein.
PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-306, Lean Concrete Base Course.
FAA ITEM P-306 LEAN CONCRETE BASE COURSE

PART 1 – DESCRIPTION

- 306-1.1 – This item shall consist of a subbase material, herein termed lean concrete, that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross-sections shown on the plans.

PART 2 – MATERIALS

- 306-2.1 – **Aggregate.** The coarse aggregate fraction shall be crushed stone, crushed or uncrushed gravel, crushed and adequately seasoned, air-cooled, iron blast furnace slag, crushed recycled concrete, or a combination thereof. The fine aggregate fraction may be part of the natural aggregate blend as obtained from the borrow source or it may be natural sand that is added at the time of mixing.

  A. The aggregate shall consist of hard, durable particles, free from an excess of flat, elongated, soft, or disintegrated pieces, or objectionable matter such as roots, sod, weeds, organic impurities, etc. A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than 5.

  B. The design aggregate blend shall conform to the gradation(s) shown in the table below, when tested in accordance with ASTM C136. The aggregates shall be within the limits for deleterious material contained in ASTM C33 Table 3 type 4S. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement, except as permitted in ASTM C33.

<table>
<thead>
<tr>
<th>Sieve Size (square openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gradation A</td>
</tr>
<tr>
<td>2” (50 mm)</td>
<td>–</td>
</tr>
<tr>
<td>1-1/2” (38 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1” (25 mm)</td>
<td>70 - 95</td>
</tr>
<tr>
<td>3/4” (19 mm)</td>
<td>55 - 85</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>30 - 60</td>
</tr>
<tr>
<td>No. 40 (425 µm)</td>
<td>10 - 30</td>
</tr>
<tr>
<td>No. 200 (75 µm)</td>
<td>0 – 15</td>
</tr>
</tbody>
</table>

- 306-2.2 – **Cement.** Cement shall conform to the requirements of ASTM C 150 Type II

- 306-2.3 – **Cementitious Additives.** Pozzolanic and slag cement may be added to the lean concrete mix. If used, each material must meet the following requirements:

  A. **Pozzolan.** Pozzolanic materials must meet the requirements of ASTM C618, Class N, F, or C Fly Ash, except the loss on ignition shall be 6% for Class N and F.

  B. Ground granulated blast furnace slag (slag cement). Slag shall conform to ASTM C989, Grade 120.

- 306-2.4 – **Chemical Admixtures.** The contractor shall submit certificates indicating that the material to be furnished meets all the requirements listed below. In addition, the Engineer may require the contractor
to submit complete test data showing that the material to be furnished meets all the requirements of the cited specification.

A. **Air-entraining admixtures.** Air-entraining admixtures shall meet the requirements of ASTM C260.

B. **Water-reducing admixtures.** Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, D, E, F, or G. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer’s printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

C. **Retarding admixtures.** Retarding admixtures shall meet the requirements of ASTM C494, Type B or D.

D. **Accelerating admixtures.** Accelerating admixtures shall meet the requirements of ASTM C494, Type C.

- 306-2.5 – **Water.** Water used in mixing or curing shall be potable, clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product.

- 306-2.6 – **Curing materials.** For curing lean concrete, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class B, or clear or translucent Type 1-D, Class B with white fugitive dye.

**PART 3 – COMPOSITION OF MIXTURE**

- 306-3.1 – **Mix Design.** The lean concrete mix design shall be based on trial batch results conducted in the laboratory. The lean concrete shall be designed to meet the criteria in this section.

  - 306-3.1.1 – **Compressive Strength.** Compressive strength shall not be less than 500 pounds per square inch (3,445 kPa) nor greater than 800 pounds per square inch (5,516 kPa) at seven (7) days. Three-day and seven-day strengths shall be taken as the average of two compressive strength test results. All compressive strength specimens shall be prepared and tested in accordance with ASTM C192 and ASTM C39, respectively.

    A. If the 3-day strength is greater than 500 pounds per square inch (3,447 kPa), the contractor shall construct transverse joints in the lean concrete layer in accordance with paragraph 306-5.10.2.

    B. If there is a change in aggregate sources, type of cement used, or pozzolanic materials, a new mix design must be submitted.

  - 306-3.1.2 – **Air Content.** The percentage of air entrainment shall be 6%, ±1/2%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

  - 306-3.2 – **Submittals.** At least 30 days prior to the placement of the lean concrete, the contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the lean concrete material. Tests older than six (6) months shall not be used. The certification shall show the appropriate ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

    1. Sources of materials, including aggregate, cement, admixtures, and curing and bond breaking materials.
2. Physical properties of the aggregates, cement, admixtures, curing and bond breaking materials.

3. Mix design:
   a) Mix identification number
   b) Weight of saturated surface-dry aggregates (fine and coarse)
   c) Combined aggregate gradation
   d) Cement factor
   e) Water content
   f) Water-cementitious material ratio (by weight)
   g) Volume of admixtures and yield for one cubic yard (cubic meter) of lean concrete

4. Laboratory test results:
   a) Slump
   b) Air content
   c) Compressive strength at 3, 7, and 28 days (average values)
   d) Freeze-thaw weight loss (when applicable)

   A. In addition, where applicable, the contractor shall submit for approval by the Engineer a jointing plan for transverse joints in the lean concrete layer.

   B. During production, the contractor shall submit batch tickets for each delivered load.

PART 4 – EQUIPMENT

- 306-4.1 – All equipment necessary to mix, transport, place, compact, and finish the lean concrete material shall be furnished by the contractor. The equipment shall be subject to inspection and approval by the Engineer.

- 306-4.2 – Mixing. Lean concrete may be mixed in a stationary mixer (central batch plant or at the site), or in a truck mixer. The mixer type and capacity shall be inspected and approved by the Engineer before production begins. Each mixer shall have attached in a prominent place a manufacturer’s nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

- 306-4.2.1 – Stationary plant mixer. The batch plant and equipment shall conform to the requirements of ASTM C94. The Engineer shall have unrestricted access to the plant at all times for inspection of the plant’s equipment and operation and for sampling the lean concrete mixture and its components.

   A. The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades.

- 306-4.2.2 – Truck mixers. Truck mixers used for mixing lean concrete shall conform to the requirements of ASTM C94. Lean concrete may be entirely mixed in a truck mixer or partially mixed in a stationary mixer with mixing completed in a truck mixer. Truck mixers shall be equipped with an accurate continuous registering electronically or mechanically activated revolution counter, to verify the number of drum revolutions.

- 306-4.3 – Hauling. Mixed lean concrete shall be hauled from the stationary plant to the job site in a truck agitator, a truck mixer operating at agitating speed, or a non-agitating truck. All equipment shall conform to the requirements of ASTM C94. When truck mixers are used to mix lean concrete, they may be transported to the job site in the same truck operating at agitating speeds, truck agitators, or a non-
agitating truck. The bodies of non-agitating trucks shall be smooth, metal containers and shall be capable of discharging the concrete at a controlled rate without segregation.

- **306-4.4 – Placing and finishing.**

  - **306-4.4.1 – Forms.** Straight side forms shall be made of steel and shall be furnished in sections not less than 10’ (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100’ (30 m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer.

    A. The top face of the form shall not vary from a true plane more than 1/8” (3 mm) in 10’ (3 m), and the upstanding leg shall not vary more than 1/4” (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when accepted by the Engineer.

- **306-4.4.2 – Fixed form or slip-form pavers.** Lean concrete can be placed using fixed form or slip-form pavers. The paver shall be fully energized, self-propelled and capable of spreading, consolidating, and finishing the lean concrete material, true to grade, tolerances, and cross-sections. The paver shall be capable of finishing the surface so that hand finishing is not required. The paver shall be of sufficient weight and power to construct the maximum specified concrete paving lane width, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The slip-form paver shall be equipped with electronic or hydraulic horizontal and vertical control devises using guide wires or stringlines on both sides of the machine. Slope control will not be allowed.

    A. **Concrete pavers.** Concrete pavers are approved as paver-finishing machines for lean concrete, providing they are capable of handling the amount of lean concrete required for the full-lane width specified, and consolidating the lean concrete full depth. A concrete paver is a power-driven machine with augers, strike-off and tamper bars ahead of a pan screed, with at least one trailing oscillating screed or belt finisher.

    B. **Bridge deck pavers.** Bridge deck pavers are approved as paver-finishing machines for lean concrete, providing they are capable of handling the amount of lean concrete required for the full-lane width specified, and consolidating the lean concrete full depth. A bridge deck paver is an automatic truss paving machine, with paving carriage that strikes off, vibrates, paves, and textures the lean concrete with augers, internal vibration, paving rollers, and drag pan.

- **306-4.5 – Consolidation.** For side-form construction, vibrators may be either the surface pan type for pavements less than 8” (200 mm) thick or the internal type with either immersed tube or multiple spuds for the full width of the slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms.

    A. For slip-form construction, the paver shall vibrate the lean concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators.

    B. The number, spacing, frequency, and eccentric weights of vibrators shall be provided to achieve acceptable consolidation without segregation and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the lean concrete.
C. The contractor shall constantly monitor the frequency of each of the individual vibrators and shall provide constant monitoring of the consolidation process to avoid honeycombing or segregation. Areas that are visually determined to be honeycombed or segregated shall be corrected at the contractor’s expense.

D. The vibrators and tamping elements shall be automatically controlled so that they stop operation as forward motion ceases. Any override switch shall be of the spring-loaded, momentary-contact type.

E. Hand held vibrators may be used in irregular areas.

- **306-4.6 – Jointing.** The contractor shall provide sawing equipment adequate in number of units and power to produce contraction or construction joints of the required dimensions as shown on the plans. The contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

### PART 5 – CONSTRUCTION METHODS

- **306-5.1 – Weather Limitations.**
  - **306-5.1.1 – Cold Weather.** Unless authorized by the Engineer, the temperature of the mixed lean concrete shall not be less than 50°F (10 °C) at the time of placement. In addition, the lean concrete shall not be placed when the ambient temperature is below 40 °F (4 °C) or when conditions indicate that the temperature may fall below 35 °F (2 °C) within 24 hours. Under no circumstances shall the lean concrete be placed on frozen underlying courses or mixed when the aggregate is frozen.

    A. When mixing and placing is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to not less than 70 °F (21 °C) nor more than 150 °F (66 °C). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials. The contractor shall adhere to the practices recommended in American Concrete Institute (ACI) 306R, Guide to Cold Weather Concreting.

    - **306-5.1.2 – Hot Weather.** To prevent rapid drying of newly constructed lean concrete, the lean concrete temperature from initial mixing through final cure shall not exceed 90°F (32 °C). The aggregates and/or mixing water shall be cooled as necessary to maintain the lean concrete temperature at or not more than the specified maximum. Ice or ice water may be substituted for the mixing water for this purpose. The contractor shall adhere to the practices recommended in ACI 305R.

      A. In addition, during periods of warm weather when the maximum daily air temperature exceeds 85°F (30°C), the forms and/or the underlying material shall be sprinkled with water immediately before placing the lean concrete.

    - **306-5.1.3 – Rain.** All mixing and batching operations should be halted during rain showers and any plastic lean concrete placed should be covered immediately. The lean concrete shall be kept covered with plastic sheeting or other waterproof material until such time that the rain does not make any surface indentation on the lean concrete layer. Areas damaged by rain shall be refinished or replaced at the expense of the contractor.

    - **306-5.2 – Form Setting.** Forms shall be set sufficiently in advance of the lean concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than 3 pins for each 10’ (3 m) section. A pin shall be placed at each side of every joint.
A. Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4" (6 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of lean concrete.

B. The alignment and grade elevations of the forms shall be checked and corrections made by the contractor immediately before placing the lean concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

- 306-5.3 – Preparation of Underlying Course. The underlying course shall be checked by the Engineer before placing and spreading operations are started, to ensure it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places in the underlying course shall be corrected at the contractor’s expense before the lean concrete mixture is placed. The underlying course should be wetted down in advance of placing the lean concrete to ensure a firm, moist condition at the time of lean concrete placement. The underlying course shall be protected from frost. Usage of chemicals to eliminate frost is not permissible.

- 306-5.4 – Grade Control. Grade control between the edges of the pavement shall be accomplished at intervals of 50' (15 m) or less on the longitudinal grade and at 25' (7.5 m) or less on the transverse grade. To protect the underlying course and ensure proper drainage, the lean concrete paving shall begin along the centerline of the pavement on a crowned section or on the greatest contour elevation of a pavement with variable cross slope.

- 306-5.5 – Handling, Measuring, and Batching Material. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

  A. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours’ transit will be accepted as adequate binning if the car bodies permit free drainage.

  B. Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using approved interlocked proportioning devises. When bulk cement is used, the contractor shall use a suitable method such as a chute, boot or other device approved by the Engineer to handle the cement between the weighing hopper and the transporting container or into the batch itself for transportation to the mixer, to prevent loss of cement. The device shall provide positive assurance that each batch has the specified cement content.

- 306-5.6 – Mixing. All lean concrete shall be mixed and delivered to the site per the requirements of ASTM C94. The mixing time should be adequate to produce lean concrete that is uniform in appearance, with all ingredients evenly distributed. Mixing time shall be measured from the time all materials are emptied into the drum (provided all the water is added before one-fourth the preset mixing time has elapsed) and continues until the time the discharge chute is opened to deliver the lean concrete.

  A. If mixing in a plant, the mixing time shall not be less than 50 or greater than 90 seconds. If mixing in a truck, the mixing time shall not be less than 70 or more than 125 truck-drum revolutions at a mixing speed of not less than 6 or more than 18 truck-drum revolutions per minute.

  B. Re-tempering lean concrete by adding water or by other means will not be permitted, except when lean concrete is delivered in truck mixers. With truck mixers, additional water may be added to the batch materials and additional mixing performed to allow proper placement of the material,
provided (a) the addition of water is performed within 45 minutes after the initial mixing operations and (b) the slump and water/cementitious ratio specified in the mix design is not exceeded.

- **306-5.7 – Hauling.** The elapsed time from the addition of cementitious material to the mix until the lean concrete is deposited in place at the work site shall not exceed 45 minutes when the concrete is hauled in nonagitating trucks, or 90 minutes when it is hauled in truck mixers or truck agitators.

- **306-5.8 – Placing, Consolidating, and Finishing.** Prior to placement of the lean concrete layer, the prepared underlying course shall be moistened with water, without saturating, to prevent rapid loss of moisture from the lean concrete. In cold weather, the underlying course shall be protected so that it will be entirely free of frost when lean concrete is placed.

  A. The contractor has the option of side-form or slip-form paving. Either option shall require the hauled lean concrete material to be discharged onto the prepared underlying course such that segregation of the mix is minimized and minimum handling of the mix is needed. The lean concrete shall be placed continuously at a uniform rate without unscheduled stops except for equipment failure or other emergencies. Avoid contamination of plastic lean concrete with foreign material on construction equipment, workman’s footwear, or any other sources. Lean concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate artificial lighting system is provided.

  - **306-5.8.1 – Side-Form Construction.** For side-form placement, the contractor shall verify the elevations of the fixed forms so the thickness and finished grade of the lean concrete layer will be in accordance with the requirements of the project plans and specifications. The lean concrete shall be spread uniformly between the forms immediately after it is placed using a spreading machine. Necessary hand spreading shall be done with shovels. Rakes shall not be allowed for spreading lean concrete.

    A. The spreading shall be followed immediately by thorough consolidation using vibrating screeds or spud vibrators. Vibrators may be external or internal type, depending on the thickness of the lean concrete layer. The surface vibrators may be attached to the spreader or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms. When spud vibrators are used, the lean concrete shall be thoroughly consolidated against and along the faces of all forms and previously placed lean concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the lean concrete.

    B. Hand finishing will not be permitted except in areas where the mechanical finisher cannot operate.

  - **306-5.8.2 – Slip-Form Construction.** For slip-form construction, the contractor shall verify the elevations of the guide wires controlling slip-form pavers such that the thickness and finished grade of the lean concrete will be in accordance with the requirements of the project plans and specifications. The slip-form paver should spread, consolidate, and shape the freshly placed lean concrete in one complete pass of the machine. The machine shall vibrate and finish the lean concrete for the full width and depth of the layer.

  - **306-5.9 – Final Finishing.** Final finishing shall be accomplished while the lean concrete is still in the plastic state. Limited surface refinishing by hand is acceptable to meet the grade and surface tolerance established in paragraphs 306-6.2.3 and 306-6.2.4, after strike off and consolidation.

    A. If the overlying layer is to be PCC pavement, the surface of the lean concrete shall not be textured. If the overlying layer is to be HMA pavement, and if the bond between the HMA layer and the lean concrete is considered important for pavement performance, tining or scarifying the surface to provide a coarse texture may be permitted.
306-5.10 – **Joints.** Joints shall be constructed as shown on the plans.

306-5.10.1 – **Construction Joints.** Locate all longitudinal and transverse construction joints as shown on the plans. If longitudinal joints are not shown, locate longitudinal joints within 6” (150 mm) from planned joints in the PCC to be placed over the lean concrete.

306-5.10.2 – **Contraction Joints.** If required by paragraph 306-5.10.1 or if shown on the plans, transverse contraction joints shall be constructed by sawing the hardened lean concrete to a depth of at least one-third the thickness of the lean concrete base. These joints shall match within 3” (75 mm) the planned joints of the overlying concrete surface.

306-5.10.3 – **Concrete Saws.** When sawing of joints are specified, the contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The contractor shall provide adequate artificial lighting facilities for night sawing. All equipment shall be on the job at all times during lean concrete placement.

306-5.11 – **Curing.** Immediately after the finishing operations are complete and within 2 hours of placement of the lean concrete, the entire surface and edges of the newly placed lean concrete shall be sprayed uniformly with white pigmented, liquid membrane forming curing compound. The layer should be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied. The curing compound shall not be applied during rainfall.

A. The curing material shall be applied at a maximum rate of 200 square’ per gallon (5.0 m²/l) using pressurized mechanical sprayers. The spraying equipment shall be a fully atomizing type equipped with a tank agitator. At the time of use, the curing compound in the tank shall be thoroughly and uniformly mixed with the pigment. During application the curing compound shall be continuously stirred by mechanical means.

B. Hand spraying of odd widths or shapes and lean concrete surfaces exposed by the removal of forms is permitted.

C. If the film of curing material becomes damaged from any cause, including sawing operations, within the required 7-day curing period or until the overlying course is constructed, the damaged portions shall be repaired immediately with additional compound or other approved means as quickly as practical.

D. Edges of the lean concrete layer shall be sprayed with curing compound immediately following placement with slip-form pavers or when side-forms are removed.

306-5.11.1 – **Curing in Cold Weather.** The lean concrete shall be maintained at a temperature of at least 50 °F (10 °C) during curing. Cover lean concrete and provide with a source of heat sufficient to maintain 50 °F (10 °C) minimum while curing. The contractor shall adhere to the practices recommended in ACI 306R. The contractor shall be responsible for the quality and strength of the lean concrete placed during cold weather, and any lean concrete injured by frost action shall be removed and replaced at the contractor’s expense.

306-5.11.2 – **Curing in Hot Weather.** Lean concrete temperature from initial mixing through final cure shall not exceed 90 °F (32 °C). Shade the fresh lean concrete and start curing as soon as the surface is sufficiently hard to permit curing without damage. The contractor shall adhere to the practices recommended in ACI 305R.
306-5.12 – **Protection.** The contractor shall protect the lean concrete from injurious action by sun, rain, flowing water, frost, or mechanical injury. Protect lean concrete surfaces from foot and vehicular traffic and other sources of abrasion for a minimum of 72 hours. The Engineer shall decide when the pavement shall be opened to traffic. Traffic shall not be allowed on the pavement until test specimens made per ASTM C31 have attained a compressive strength of 350 psi (2,413 kPa) when tested per ASTM C39. The contractor shall maintain continuity of applied curing method for the entire curing period.

306-5.13 – **Bond-breaker.** When the lean concrete is placed directly beneath PCC pavement, a bond-breaker shall be used. The entire surface of the lean concrete shall be coated with a de-bonding compound applied in a sufficient quantity to prevent bonding between the PCC pavement and the lean concrete. The contractor shall be responsible for selecting the de-bonding compound and determining the appropriate application rate. This application shall be made at least eight (8) hours and not more than 24 hours before placement of the PCC pavement. If an impervious membrane is used as a bond breaker, a second application of curing materials is required and shall be placed no more than 24 hours prior to placement of the PCC pavement. After application of the bond-breaker coat, traffic will be limited to that required for placement of the PCC pavement.

**PART 6 – MATERIAL ACCEPTANCE**

306-6.1 – **Acceptance Sampling and Testing.** All acceptance sampling and testing, with the exception of coring for thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The contractor shall provide the required lean concrete samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

A. The lean concrete layer shall be tested for air content, strength, thickness, grade, and surface tolerance. Sampling and testing for air shall be as specified in paragraph 306-6.1.1. Sampling and testing for strength, thickness, grade, and surface tolerance shall be on a lot basis, with a lot consisting of either: (1) one day’s production not to exceed 2,000 square yards (1700 sq m), or (2) a half day’s production, where a day’s production is expected to consist of between 2,000 and 4,000 square yards (1675 and 3350 m2).

B. Each lot will be divided into four equal sublots. In the event that only three sublots are produced, the three sublots shall constitute a complete lot. If only one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation.

C. End-of-production sublots (sublots associated with the final placement of lean concrete for the project which are less than a complete lot) shall be handled as (1) three sublots shall constitute a lot, or (2) one or sublots shall be incorporated into the previous lot.

306-6.1.1 – **Air Content Testing.** Air content tests shall be performed on the first three truckloads of lean concrete produced at the start of operations each day and the first three truckloads produced after any scheduled or non-scheduled shutdown. Additional tests shall be performed each time a sample is taken for a strength test and when requested by the Engineer.

A. Air content tests shall be made in accordance with ASTM C231. Air content test results shall be between 4% and 8%.

B. If the first test on a truckload of lean concrete is not within the specification limits, a second test on the same truckload shall be made. If the second test is within the specification limits, the lean concrete will be accepted with respect to entrained air content. If the second test is not within the specification limits, the truckload shall be rejected.
306-6.1.2 – **Compressive Strength Testing.** One sample of freshly delivered lean concrete shall be taken from each sublot for compressive strength testing. The lean concrete shall be sampled in accordance with ASTM C172. Sampling locations shall be determined per ASTM D3665.

A. At least 2 test cylinders shall be made from each sample per ASTM C31. The 7-day compressive strength of each cylinder shall be determined per ASTM C39.

B. The contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80 °F (16 to 27 °C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

C. The compressive strength for each sublot shall be computed by averaging the 7-day compressive strengths of the two test cylinders representing that sublot. The compressive strength of the lot shall be the average compressive strength of the individual sublots comprising the lot.

D. Specimens that are noticeably defective shall not be considered in the determination of the strength. If the test specimens fail to conform to the requirements for strength, the Engineer shall request changes in the lean concrete mixture to increase the strength to meet the requirements.

E. If the maximum 7-day compressive strength values exceed the maximum strength requirements when evaluated in accordance with paragraph 306-6-2.1, the contractor shall propose a jointing plan for approval by the Engineer.

306-6.1.3 – **Thickness Testing.** After the lean concrete base has cured for 3 days, one 4-inch (100 mm) diameter core per sublot shall be obtained per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures per ASTM C174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for lean concrete thickness are provided in paragraph 306-6.2.2.

A. When such measurement is deficient more than 1/2” (12 mm) and not more than 1” (25 mm) from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. The thickness of the cores shall be determined by average caliper measurement of cores tested in accordance with ASTM C174.

B. At all locations where cores have been drilled, the resulting holes shall be filled with lean concrete or non-shrink grout material, as approved by the Engineer.

306-6.1.4 – **Grade Testing.** The elevations of the finished lean concrete shall be surveyed on both sides of the lean concrete lane, every 25’ (7.5 m).

306-6.1.5 – **Surface Tolerance Testing.** After the lean concrete has hardened sufficiently, it shall be tested for surface tolerance with a 12’ (3.7 m) straightedge provided by the contractor.

306-6.2 – **Acceptance Criteria.** Acceptance of lean concrete will be based on compressive strength, thickness, grade, and surface tolerance, as described in the paragraphs below.

306-6.2.1 – **Compressive Strength Requirements.** The lean concrete shall meet all of the following compressive strength requirements on a lot basis:

A. The compressive strength of the lot, tested at 7 days, shall be greater than 500 pounds per square inch (3,445 kPa). When a given lot of lean concrete fails to meet the minimum compressive strength requirements, the entire lot shall be replaced at the contractor’s expense.
B. Not more than 20% of the individual cylinders in a given lot, tested at 7 days, shall have a compressive strength greater than 800 pounds per square inch (5,512 kPa). When greater than 20% of the individual cylinders in a given lot have 7-day compressive strengths in excess of 800 pounds per square inch (5,512 kPa), and transverse joints have not been constructed, a bond-breaker shall be used.

- 306-6.2.2 – Thickness Requirements. The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than 1/2” (12 mm) from the plan thickness, full payment shall be made. If the lot average thickness is deficient by more than 1” (25 mm), it shall be removed and replaced at the contractor’s expense. When such measurement is deficient more than 1/2” (12 mm) and not more than 1” (25 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new lot average thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. When the recomputed average lot thickness is not deficient by more than 1/2” (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1/2” (12 mm) from the plan thickness, the entire lot shall be removed and replaced at the contractor’s expense or shall be permitted to remain in place at an adjusted payment of 75% of the contract unit price.

A. When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed lean concrete layer is within the established grade and surface tolerance requirements.

- 306-6.2.3 – Grade Requirements. When the completed surface is more than 1/2” (12 mm) above the grade shown in the plans, the surface shall be trimmed at the contractor’s expense using an approved grinding machine to an elevation that falls within a tolerance of 1/4” (6 mm).

- 306-6.2.4 – Surface Tolerance Requirements. Surface deviations shall not exceed 3/8” (9 mm) from a 12-foot (3.7-m) straightedge laid in any location parallel with or at right angles to the longitudinal axis of the centerline (includes along all edges of the paving lane). Any high spots of more than 3/8” (9 mm) in 12-foot (3.7-m) shall be marked and immediately trimmed with an approved grinding machine. If the overlying layer is PCC pavement, the ground surface shall be sprayed with a double application of the curing compound at the specified rate prior to paving.

PART 7 – METHOD OF MEASUREMENT

- 306-7.1 – The quantity of lean concrete (LCB) to be paid for will be determined by the number of square yards of lean concrete (LCB) whether for the production run or in the test section for each thickness specified actually constructed and accepted by the Engineer as complying with the plans and specifications.

PART 8 – BASIS OF PAYMENT

- 306-8.1 – The accepted quantities of lean concrete (LCB) will be paid for at the contract unit price per square yard for each thickness specified for lean concrete base (LCB). The price and payment shall be full compensation for furnishing and placing all materials, provided; however, for any pavement found deficient in thickness as specified in paragraph 306-6.2.2, the reduced unit price shall be paid.

### TESTING REQUIREMENTS

<table>
<thead>
<tr>
<th>ASTM C 31</th>
<th>Making and Curing Concrete Test Specimens in the Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C 39</td>
<td>Compressive Strength of Cylindrical Concrete Specimens</td>
</tr>
<tr>
<td>ASTM C 136</td>
<td>Sieve or Screen Analysis of Fine and Course Aggregates</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ASTM C 172</td>
<td>Sampling Freshly Mixed Concrete</td>
</tr>
<tr>
<td>ASTM C 173</td>
<td>Air Content of Freshly Mixed Concrete by the Volumetric Method</td>
</tr>
<tr>
<td>ASTM C 174</td>
<td>Measuring Length of Drilled Concrete Cores</td>
</tr>
<tr>
<td>ASTM C 192</td>
<td>Making and Curing Concrete Test Specimens in the Laboratory</td>
</tr>
<tr>
<td>ASTM C 231</td>
<td>Air Content of Freshly Mixed Concrete by the Pressure Method</td>
</tr>
<tr>
<td>ASTM D 560</td>
<td>Standard Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures</td>
</tr>
<tr>
<td>ASTM D 3665</td>
<td>Random Sampling of Paving Materials</td>
</tr>
<tr>
<td>AASHTO T 26</td>
<td>Quality of Water to be Used in Concrete</td>
</tr>
<tr>
<td>AASHTO T 136</td>
<td>Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures</td>
</tr>
</tbody>
</table>

### MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C 33</td>
<td>Specification for Concrete Aggregates</td>
</tr>
<tr>
<td>ASTM C 94</td>
<td>Specification for Ready-Mixed Concrete</td>
</tr>
<tr>
<td>ASTM C 150</td>
<td>Specification for Portland Cement</td>
</tr>
<tr>
<td>ASTM C 260</td>
<td>Specification for Air-Entraining Admixtures for Concrete</td>
</tr>
<tr>
<td>ASTM C 309</td>
<td>Specification for Liquid Membrane-Forming Compounds for Curing Concrete</td>
</tr>
<tr>
<td>ASTM C 494</td>
<td>Specification for Chemical Admixtures for Concrete</td>
</tr>
<tr>
<td>ASTM C 595</td>
<td>Standard Specification for Blended Hydraulic Cements</td>
</tr>
<tr>
<td>ASTM C 618</td>
<td>Specification for Fly ash and Raw and Calcined Natural Pozzolans for Use in Portland Cement Concrete</td>
</tr>
<tr>
<td>ASTM C 989</td>
<td>Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars</td>
</tr>
<tr>
<td>ACI 305R</td>
<td>Guide to Hot Weather Concreting</td>
</tr>
<tr>
<td>ACI 306R</td>
<td>Guide to Cold Weather Concreting</td>
</tr>
</tbody>
</table>

END OF SECTION 32 11 36
SECTION 32 12 13.13 – BITUMINOUS TACK COAT

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consist of application of bituminous tack coat on the existing pavement surface as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. Section 32 12 16.13 – Hot Mix Asphalt (HMA) Pavements (FAA Item P-401).
B. Section 32 12 16.14 – Hot Mix Asphalt Pavements (Base, Leveling or Shoulder Surface Course) (FAA Item P-403).
C. San Francisco International Airport Rules and Regulations/Airport Building Regulations
D. FAA Specification Item P-603, Bituminous Tack Coat, and as modified herein.
E. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-603.

1.3 SUBMITTALS

A. The contractor shall submit the following bituminous tack coat information:

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-603, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Bituminous material shall conform to FAA Specification Item P-603, and as modified herein.

PART 3 – EXECUTION

A. The contractor shall apply bituminous tack coat to the surface of pavement in accordance with FAA Specification Item P-603, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-603, Bituminous Tack Coat.

PART 5 – MEASUREMENT AND PAYMENT

A. Unless otherwise indicated in FAA Specification Item P-603 and as modified herein, there will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.
FAA ITEM P-603 BITUMINOUS TACK COAT

PART 1 – DESCRIPTION

- 603-1.1 – This item shall consist of preparing and treating a bituminous or concrete surface with bituminous material in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

PART 2 – MATERIALS

- 603-2.1 – **Bituminous Materials.** The bituminous material shall be emulsified asphalt indicated in ASTM D3628 as a bituminous application for tack coat appropriate to local conditions or as designated by the Engineer.

PART 3 – CONSTRUCTION METHODS

- 603-3.1 – **Weather Limitations.** The tack coat shall be applied only when the existing surface is dry and the atmospheric temperature is 50°F or above; the temperature has not been below 35°F for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Engineer.

- 603-3.2 – **Equipment.** The contractor shall provide equipment for heating and applying the bituminous material.
  
  A. Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than ±5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shut off valve, the tack operations shall be started and stopped on building paper. The contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the owner.
  
  B. A power broom and/or blower suitable for cleaning the surfaces to which the bituminous tack coat is to be applied shall be provided.

- 603-3.3 – **Application of Bituminous Material.** Immediately before applying the tack coat, the full width of surface to be treated shall be swept with a power broom and/or power blower to remove all loose dirt and other objectionable material.
  
  A. Emulsified asphalt shall be diluted by the addition of water when directed by the Engineer and shall be applied a sufficient time in advance of the paver to ensure that all water has evaporated before the overlying mixture is placed on the tacked surface.
  
  B. The bituminous material including vehicle shall be uniformly applied with a bituminous distributor at the rate of 0.05 to 0.10 gallons per square yard depending on the condition of the existing surface.
The type of bituminous material and application rate shall be approved by the Engineer prior to application.

C. After application of the tack coat, the surface shall be allowed to cure without being disturbed for the period of time necessary to permit drying and setting of the tack coat. This period shall be determined by the Engineer. The contractor shall protect the tack coat and maintain the surface until the next course has been placed.

- **603-3.4 – Bituminous Material Contractor’s Responsibility.** The contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted and approved by the Engineer before any shipment of bituminous materials to the project.

   A. The contractor shall furnish the vendor’s certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The tests reports shall be provided to and approved by the Engineer before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the contractor’s expense. Furnishing the vendor’s certified test report for the bituminous material shall not be interpreted as a basis for final acceptance.

- **603-3.5 – Freight and Weigh Bills.** The contractor shall submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Engineer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

PART 4 – METHOD OF MEASUREMENT

- **603-4.1 –** There will be no separate measurement and payment for work under this section. All work shall be considered incidental to the respective contract bid items.

PART 5 – BASIS OF PAYMENT

- **603-5.1 –** There will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.

**MATERIAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D633</td>
<td>Volume Correction Table for Road Tar</td>
</tr>
<tr>
<td>ASTM D977</td>
<td>Emulsified Asphalt</td>
</tr>
<tr>
<td>ASTM D1250</td>
<td>Use of the Petroleum Measurement Tables</td>
</tr>
<tr>
<td>ASTM D2028</td>
<td>Cutback Asphalt (Rapid-Curing Type)</td>
</tr>
<tr>
<td>ASTM D2397</td>
<td>Cationic Emulsified Asphalt</td>
</tr>
<tr>
<td>ASTM D3628</td>
<td>Selection and Use of Emulsified Asphalts</td>
</tr>
</tbody>
</table>

END OF SECTION 32 12 13.13
SECTION 32 12 13.19 – BITUMINOUS PRIME COAT

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consist of application of bituminous prime coat on the prepared base course as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. Section 32 12 16.13 – Hot Mix Asphalt (HMA) Pavements (FAA Item P-401).
B. Section 32 12 16.14 – Hot Mix Asphalt Pavements (Base, Leveling or Shoulder Surface Course) (FAA Item P-403).
C. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
D. FAA Specification Item P-602, Bituminous Prime Coat, and as modified herein.
E. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-602.

1.3 SUBMITTALS

A. The contractor shall submit the following bituminous prime coat information:


1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-602, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Bituminous material shall conform to FAA Specification Item P-602, and as modified herein.

PART 3 – EXECUTION

A. The contractor shall apply bituminous prime coat to the surface of prepared base course in accordance with FAA Specification Item P-602, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-602, Bituminous Prime Coat.

PART 5 – MEASUREMENT AND PAYMENT

A. Unless otherwise indicated in FAA Specification Item P-602 and as modified herein, there will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.
FAA ITEM P-602 BITUMINOUS PRIME COAT

PART 1 – DESCRIPTION

602-1.1 – This item shall consist of an application of bituminous material on the prepared base course in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

PART 2 – MATERIALS

602-2.1 – Bituminous Material. The bituminous material shall be an emulsified asphalt indicated in ASTM D3628 as a bituminous application for prime coat appropriate to local conditions or as designated by the Engineer.

PART 3 – CONSTRUCTION METHODS

602-3.1 – Weather Limitations. The prime coat shall be applied only when the existing surface is dry; the atmospheric temperature is 50°F or above, and the temperature has not been below 35°F for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Engineer.

602-3.2 – Equipment. The equipment shall include a self-powered pressure bituminous material distributor and equipment for heating bituminous material.

A. Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than ±5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shut off valve, the prime operations shall be started and stopped on building power. The contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Owner.

B. A power broom and power blower suitable for cleaning surfaces to which the bituminous coat is to be applied shall be provided.

602-3.3 – Application of Bituminous Material. Immediately before applying the prime coat, the full width of the surface to be primed shall be swept with a power broom to remove all loose dirt and other objectionable material.

A. The bituminous material shall be uniformly applied with a bituminous distributor at the rate of 0.15 to 0.30 gallons per square yard depending on the base course surface texture. The type of bituminous material and application rate shall be approved by the Engineer prior to application.

B. Following application of the bituminous material and prior to application of the succeeding layer of pavement, allow the bituminous coat to cure and to obtain evaporation of any volatiles or moisture. Maintain the coated surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure
without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up and cure excess bituminous material. Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

- **602-3.4 – Trial applications.** Before providing the complete bituminous coat, the contractor shall apply three lengths of at least 100’ for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied with the equipment. Apply three different trial application rates of bituminous materials within the application range specified in paragraph 602-3.3. Other trial applications will be made using various amounts of material as deemed necessary by the Engineer.

- **602-3.5 – Bituminous Material Contractor’s Responsibility.** The contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted to and approved by the Engineer before any shipment of bituminous materials to the project. The contractor shall furnish vendor’s certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The test reports shall be provided to and approved by the Engineer before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the contractor’s expense. Furnishing the vendor’s certified test report for the bituminous material shall not be interpreted as basis for final acceptance.

- **602-3.6 – Freight and Weigh Bills.** The contractor shall submit waybills and delivery tickets during the progress of the work. Before the final estimate is allowed, file with the Engineer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

**PART 4 – METHOD OF MEASUREMENT**

- **602-4.1 –** There will be no separate measurement and payment for work under this section. All work shall be considered incidental to the respective contract bid items.

**PART 5 – BASIS OF PAYMENT**

- **602-5.1 –** There will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.

**TESTING REQUIREMENTS**


**MATERIAL REQUIREMENTS**

| ASTM D977   | Emulsified Asphalt   |
| ASTM D2028  | Cutback Asphalt (Rapid-Curing Type) |
| ASTM D2397  | Cationic Emulsified Asphalt |
| ASTM D3628  | Selection and Use of Emulsified Asphalts |

END OF SECTION 32 12 13.19
SECTION 32 12 16.13 – HOT MIX ASPHALT (HMA) PAVEMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of hot mix asphalt pavement courses constructed to the depth, typical section, and elevation required by the plans, and as specified herein.

1.2 REFERENCES

A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. FAA Specification Item P-401 Plant Mix Bituminous Pavements and as modified herein.
D. Section 02 41 19 – Surface Preparation FAA Item P-101.
E. Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603.
F. Section 32 12 13.19 – Bituminous Prime Coat FAA Item P-602.
G. Section 32 01 26.71 – Saw-cut Grooves FAA Item P-621.
H. American Association of State Highway and Transportation Officials (AASHTO) standards and tests, as referenced in FAA Item P-401.
I. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-401.
J. The Asphalt Institute as referenced in FAA Item P-401.
K. California Department of Transportation (Caltrans).

1.3 SUBMITTALS

A. Prior to commencing Work in this Section and delivery of materials to the job site, the contractor shall submit the following plant mix bituminous pavement information:

1. Certified Test Reports of coarse aggregate, fine aggregate, mineral filler and bituminous material in conformance with FAA Specification Item P-401 Article 401-2.4.

2. Bituminous Concrete Surface Course Quality Control (BCSCQC) Project Plan: The BCSCQC Project Plan shall include all testing procedures to be used for quality control and shall conform to FAA Specification Item P-401.

3. Job Mix Formula and Test Results: Bituminous Concrete Surface Course job mix formula in conformance with FAA Specification Item P-401, with test reports of the parameters listed in Article 401-3.2, including calibration results for the Ignition Furnace test in Article 401-6.3A.

B. Bituminous Concrete Surface Course samples of aggregates and bituminous materials, quantity as required by testing laboratory, including test reports as required.

C. Bituminous Concrete Surface Course Paving Plan.
1. Prior to the start of paving, the contractor shall submit a Paving Plan for asphalt milling, pavement repair work, and for the placement of hot mix asphalt (HMA) leveling and overlay courses as required for the work. The Paving Plan shall indicate milling, leveling, and laydown operations on a daily basis by project phase and shall be submitted to the Engineer for acceptance a minimum of 14 calendar days prior to the start of paving.

2. The Paving Plan shall specify the sequence of paving, paving widths, lift thickness, longitudinal and transverse joint spacing, grade and slope control, and paving equipment which will be used to accomplish the work and meet all the requirements specified in this specification. The contractor’s Paving Plan shall be designed to achieve these goals by proposing the use of wide, single unit pavers, and echelon paving meeting the requirements of this specification.

3. Review of the Paving Plan will take into consideration the ability of the contractor to minimize the number of transverse and cold joints. Acceptance of this plan by the Engineer shall not relieve the contractor of the responsibility to meet the requirements specified in this specification.

4. As a minimum, the Paving Plan shall include:

   a. Sketches showing the location of milling, leveling, paving lanes, and the sequence of paving for each phase.

   b. Anticipated roller pattern and equipment.

   c. Anticipated equipment haul pattern and routing.

   d. Average tonnage and pull length per shift, for each phase and course.

   e. Anticipated weather outlook during paving days.

D. The contractor shall also furnish the Engineer with production and paving drawings at each weekly construction meeting for the following work week. These drawings shall include a five to fourteen-day look-ahead paving schedule.

E. During the Work of this Section, periodic Bituminous Concrete Surface field test results to the Engineer for review. These results shall include the results of retests for items that failed initial testing.

F. Testing laboratory accreditation, testing personnel qualifications and lab manager certification.

G. The recorded batch weights or truck scale weights (certified tags) shall be submitted to the Contract Manger or Inspector within 24 hours of completion.

1.4 QUALITY ASSURANCE

A. The Airport will perform Quality Assurance (QA) testing for acceptance, measurement, and payment of the Work. The contractor is responsible for hiring an approved, independent testing firm to perform standard bituminous concrete pavement testing Quality Control (QC) testing.

B. The contractor shall develop Quality Control Program and perform Quality Control testing and inspection to meet the requirement of FAA Specification Item P-401, and as modified herein.

PART 2 – PRODUCTS

2.1 HIGH STABILITY BITUMINOUS SURFACE COURSE
A. High Stability Bituminous Surface Course shall conform to FAA Specification Item P-401, and as modified herein.

PART 3 – EXECUTION

3.1 SURVEY

A. Project control points will be provided by SFIA Surveyor. The contractor shall provide Grade Setters and Checkers for the construction work.

3.2 HIGH STABILITY BITUMINOUS SURFACE COURSE

A. The contractor shall prepare, spread, and compact the high stability surface course in accordance with FAA Specification Item P-401, and as modified herein.

3.3 TACK COAT

A. The contractor shall apply tack coat in accordance with Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603, and as modified herein, to all existing pavement surfaces both horizontal and at vertical interfaces, and between lifts of asphalt pavement.

3.4 PRIME COAT

A. The contractor shall apply prime coat in accordance with Section 32 12 13.19 – Bituminous Prime Coat FAA Item P-602, and as modified herein, to base course surface where shown on the plans.

3.5 JOINT SEALING FILLER

A. The contractor shall prepare all joints and cracks to be overlaid and filled in accordance with Section 02 41 19 – Surface Preparation FAA Item P-101, and as modified herein.

3.6 CLEAN-UP

A. The contractor, during paving operation, shall continuously clean-up the site and haul routes and remove all excess material and equipment from the site immediately after the work for the shift is completed.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-401, Plant Mix Bituminous Pavements.

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-401 and as modified herein.
FAA ITEM P-401 HOT MIX ASPHALT (HMA) PAVEMENTS

PART 1 – DESCRIPTION

401-1.1 – This item shall consist of pavement courses composed of mineral aggregate and asphalt cement binder (asphalt binder) mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

PART 2 – MATERIALS

401-2.1 – Aggregate. Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. The portion retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

A. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from films of matter that would prevent thorough coating and bonding with the bituminous material and free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. Clay lumps and friable particles shall not exceed 1.0% when tested in accordance with ASTM C142.

1. Aggregate shall contain at least 75% by weight of individual pieces having two or more fractured faces and 85% by weight having at least one fractured face. The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be achieved by crushing.

2. The aggregate shall not contain more than a total of 8%, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D4791 with a value of 5:1.

3. Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C29.

B. Fine Aggregate. Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter.

1. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

2. The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

3. Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with ASTM C142.
a) Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. The fine aggregate shall not contain more than 15% natural sand by weight of total aggregates. If used, the natural sand shall meet the requirements of ASTM D1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

4. The aggregate shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D2419.

C. Sampling. ASTM D75 shall be used in sampling coarse and fine aggregate, and ASTM C183 shall be used in sampling mineral filler.

- 401-2.2 – Mineral Filler. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242.

- 401-2.3 – Asphalt Cement Binder. Asphalt cement binder shall conform to ASTM D6373 Performance Grade (PG) 76-22. A certificate of compliance from the manufacturer shall be included with the mix design submittal.

A. The supplier’s certified test report with test data indicating grade certification for the asphalt binder shall be provided to the Engineer for each load at the time of delivery to the mix plant. A certified test report with test data indicating grade certification for the asphalt binder shall also be provided to the Engineer for any modification of the asphalt binder after delivery to the mix plant and before use in the HMA.

- 401-2.4 – Preliminary Material Acceptance. Prior to delivery of materials to the job site, the contractor shall submit certified test reports to the Engineer for the following materials:

1. Coarse Aggregate.
   a) Percent of wear
   b) Soundness
   c) Clay lumps and friable particles
   d) Percent fractured faces
   e) Flat and elongated particles
   f) Unit weight of slag

2. Fine Aggregate.
   a) Liquid limit and Plasticity Index
   b) Soundness
   c) Clay lumps and friable particles
   d) Percent natural sand
   e) Sand equivalent


4. Asphalt Binder. Test results for asphalt binder shall include temperature/viscosity charts for mixing and compaction temperatures.
A. The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

B. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

- 401-2.5 - Anti-Stripping Agent. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the California Department of Transportation (Caltrans).

PART 3 – COMPOSITION

- 401-3.1 – Composition of Mixture. The HMA mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and asphalt binder. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

- 401-3.2 – Job Mix Formula (JMF). No hot-mixed asphalt (HMA) for payment shall be produced until a JMF has been approved in writing by the Engineer. The asphalt mix-design and JMF shall be prepared by an accredited laboratory that meets the requirements of paragraph 401-3.4. The HMA shall be designed using procedures contained in

  A. Asphalt Institute MS-2 Mix Design Manual, 7th Edition. ASTM D6926 shall be used for preparation of specimens using the manually held and operated hammer for the mix design procedure. ASTM D6927 shall be used for testing for Marshall stability and flow.

  B. If material variability exceeds the standard deviations indicated, the JMF and subsequent production targets shall be based on a stability greater than shown in Table 1 and the flow shall be targeted close to the mid-range of the criteria in order to meet the acceptance requirements.

  C. The design criteria in Table 1 are target values necessary to meet the acceptance requirements contained in paragraph 401-5.2B. The criteria is based on a production process which has a material variability with the following standard deviations:

    1. Stability = 270 lbs (1200 N)
    2. Flow (0.01” (0.25 mm)) = 0.015” (.38 mm)
    3. Air Voids = 0.65%.

  D. Tensile strength ratio (TSR) of the composite mixture, as determined by ASTM D4867, shall not be less than 75 when tested at a saturation of 70-80% or an anti-stripping agent shall be added to the HMA, as necessary, to produce a TSR of not less than 75 when tested at a saturation of 70-80%. If an anti-strip agent is required, it shall be provided by the contractor at no additional cost to the Owner.

  E. The JMF shall be submitted in writing by the contractor at least 30 days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates currently being produced.

  F. The submitted JMF shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

    1. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.
    2. Percent of asphalt cement.
3. Asphalt performance grade, and type of modifier if used.
4. Number of blows per side of molded specimen.
5. Laboratory mixing temperature.
6. Laboratory compaction temperature.
7. Temperature-viscosity relationship of the PG asphalt cement binder showing acceptable range of mixing and compaction temperatures; and for modified binders include supplier recommended mixing and compaction temperatures.
8. Plot of the combined gradation on a 0.45 power gradation curve.
9. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.
10. Specific Gravity and absorption of each aggregate
11. Percent natural sand.
12. Percent fractured faces.
13. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).
14. Tensile Strength Ratio (TSR).
15. Anti-strip agent (if required).

G. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.

H. The contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the JMF requirements specified in Tables 1 and 3.

I. When the project requires asphalt mixtures of differing aggregate gradations, a separate JMF and the results of JMF verification testing shall be submitted for each mix.

J. The JMF for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new JMF must be submitted within 15 days and approved by the Engineer in writing before the new material is used. After the initial production JMF has been approved by the Engineer and a new or modified JMF is required for whatever reason, the subsequent cost of the Engineer’s approval of the new or modified JMF will be borne by the contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified JMF.

Table 1 Marshall Design Criteria

<table>
<thead>
<tr>
<th>Test Property</th>
<th>Pavements Designed for Aircraft Gross Weights of 60,000 Lb. or More or Tire Pressures of 100 PSI or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Blows</td>
<td>75</td>
</tr>
<tr>
<td>Stability, pounds (Newtons) minimum</td>
<td>2150 (9560)</td>
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<tr>
<td>Flow1, 0.01&quot;. (0.25 mm)</td>
<td>10-16</td>
</tr>
<tr>
<td>Target Air Voids (percent)</td>
<td>3.5</td>
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<tr>
<td>Percent Voids in Mineral Aggregate (minimum)</td>
<td>See Table 2</td>
</tr>
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</table>
Table 2 Minimum Percent Voids in Mineral Aggregate

<table>
<thead>
<tr>
<th>Maximum Particle Size</th>
<th>Minimum Voids in Mineral Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation 3</td>
<td>16%</td>
</tr>
<tr>
<td>Gradation 2</td>
<td>15%</td>
</tr>
<tr>
<td>Gradation 1</td>
<td>14%</td>
</tr>
</tbody>
</table>

K. The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C136 and ASTM C117.

L. The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply; be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa.

M. The maximum aggregate size should be no greater than 1/4 the lift thickness to be constructed except where otherwise shown on the plans or ordered by the Engineer.

N. Surface course for runways – one inch (1") maximum sieve size.

O. The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition.

Table 3 Aggregate - HMA Pavements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Gradation 1</th>
<th>Gradation 2</th>
<th>Gradation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; (25 mm)</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3/4&quot; (19 mm)</td>
<td>76-98</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>1/2&quot; (12 mm)</td>
<td>66-86</td>
<td>79-99</td>
<td>100</td>
</tr>
<tr>
<td>3/8&quot; (9 mm)</td>
<td>57-77</td>
<td>68-88</td>
<td>79-99</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>40-60</td>
<td>48-68</td>
<td>58-78</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>26-46</td>
<td>33-53</td>
<td>39-59</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>17-37</td>
<td>20-40</td>
<td>26-46</td>
</tr>
<tr>
<td>No. 30 (0.600 mm)</td>
<td>11-27</td>
<td>14-30</td>
<td>19-35</td>
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<tr>
<td>No. 50 (0.300 mm)</td>
<td>7-19</td>
<td>9-21</td>
<td>12-24</td>
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<tr>
<td>No. 100 (0.150 mm)</td>
<td>6-16</td>
<td>6-16</td>
<td>7-17</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>3-6</td>
<td>3-6</td>
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<table>
<thead>
<tr>
<th>Asphalt Percent</th>
<th>Gradation 1</th>
<th>Gradation 2</th>
<th>Gradation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone or gravel</td>
<td>4.5-7.0</td>
<td>5.0-7.5</td>
<td>5.5-8.0</td>
</tr>
<tr>
<td>Slag</td>
<td>5.0-7.5</td>
<td>6.5-9.5</td>
<td>7.0-10.5</td>
</tr>
</tbody>
</table>

- **401-3.3 – Reclaimed Asphalt Pavement (RAP).** Recycled asphalt concrete will not be permitted for high stability surface courses.

- **401-3.4 – Job mix formula (JMF) laboratory.** The contractor’s laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.
401-3.5 – **Test Section.** Prior to full production, the contractor shall prepare and place a quantity of HMA according to the JMF. The amount of HMA shall be sufficient to construct a test section 300’ long and 25’ wide, placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint for this test section is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160 °F (71°C). The cold joint must be cut back using the same procedure that will be used during production in accordance with 401-4.13. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

A. The test section shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 401-5.1 and 401-5.2. The test section shall be divided into equal sublots. As a minimum the test section shall consist of 3 sublots.

B. The test section shall be considered acceptable if:
   1. Stability, flow, mat density, air voids, and joint density are 90% or more within limits
   2. Gradation and asphalt content are within the action limits specified in paragraphs 401-6.5A, and
   3. The voids in the mineral aggregate are within the limits of Table 2.

C. If the initial test section should prove to be unacceptable, the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the contractor’s expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the contractor’s expense. Full production shall not begin until an acceptable test section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 401-8.1.

D. Job mix control testing shall be performed by the contractor at the start of plant production and in conjunction with the calibration of the plant for the JMF. If aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum asphalt content determined in the same manner as for the original JMF tests.

E. Contractor will not be allowed to place the test section until the Contractor Quality Control Program, showing conformance with the requirements of Paragraph 401-6.1, has been approved, in writing, by the Engineer.

**PART 4 – CONSTRUCTION METHODS**

401-4.1 – **Weather Limitations.** The HMA shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

<table>
<thead>
<tr>
<th>Mat Thickness</th>
<th>Base Temperature (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in. or greater</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 4 Base Temperature Limitations
A. Requirements for all plants include:

1. **Truck scales.** The HMA shall be weighed on approved scales furnished by the contractor, or on certified public scales at the contractor’s expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, subsection 90-01.

   a) In lieu of scales, and as approved by the Engineer, HMA weight may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the Engineer.

2. **Testing facilities.** The contractor shall ensure laboratory facilities are provided at the plant for the use of the Engineer. The lab shall have sufficient space and equipment so that both testing representatives (Engineer’s and contractor’s) can operate efficiently. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, calibrations, current reference standards to comply with the specifications and a masonry saw with diamond blade for trimming pavement cores and samples.

   a) The plant testing laboratory shall have a floor space area of not less than 200 square’ (18.5 sq m), with a ceiling height of not less than 7-1/2’ (2 m). The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70°F ±5°F (21°C ±2.3°C). The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials. In addition, the facility shall include the minimum:

   1) Adequate artificial lighting.
   2) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.
   3) A minimum of 2 Underwriter’s Laboratories approved fire extinguishers of the appropriate types and class.
   4) Work benches for testing.
   5) Desk with chairs and file cabinet.
   6) Sanitary facilities convenient to testing laboratory.
   7) Exhaust fan to outside air.
   8) Sink with running water.

   b) Failure to provide the specified facilities shall be sufficient cause for disapproving HMA plant operations.

   c) Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the contractor’s laboratory facility and witness quality control activities. The Engineer will advise...
the contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

3. **Inspection of plant.** The Engineer, or Engineer’s authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

4. **Storage bins and surge bins.** The HMA stored in storage and surge bins shall meet the same requirements as HMA loaded directly into trucks and may be permitted under the following conditions:
   1) Stored in non-insulated bins for a period of time not to exceed 3 hours.
   2) Stored in insulated bins for a period of time not to exceed 8 hours.

   a) If the Engineer determines that there is an excessive amount of heat loss, segregation, or oxidation of the HMA due to temporary storage, no temporary storage will be allowed.

   ➢ **401-4.3 – Hauling equipment.** Trucks used for hauling HMA shall have tight, clean, and smooth metal beds. To prevent the HMA from sticking to the truck beds, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other material approved by the Engineer. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

   ➢ **401-4.3.1 – Material transfer vehicle (MTV).** Material transfer vehicles used to transfer the material from the hauling equipment to the paver, shall use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

   ➢ **401-4.4 – HMA Pavers.** HMA pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of HMA that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

   A. The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the HMA uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

   B. If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the contractor.

   ➢ **401-4.4.1 – Automatic grade controls.** The HMA paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at
the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

A. The controls shall be capable of working in conjunction with any of the following attachments:
   1. Ski-type device of not less than 30’ (9 m) in length.
   2. Taut string-line (wire) set to grade.
   3. Short ski or shoe.
   4. Laser control.

- **401-4.5 – Rollers.** Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the HMA. The number, type, and weight of rollers shall be sufficient to compact the HMA to the required density while it is still in a workable condition.

   A. All rollers shall be specifically designed and suitable for compacting HMA concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the contractor at their own expense.

   B. The use of equipment that causes crushing of the aggregate will not be permitted.

- **401-4.6 – Density device.** The contractor shall have on site a density gauge during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The contractor shall also supply a qualified technician during all paving operations to calibrate the gauge and obtain accurate density readings for all new HMA. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

- **401-4.7 – Preparation of asphalt binder.** The asphalt binder shall be heated in a manner that will avoid local overheating and provide a continuous supply of the asphalt binder to the mixer at a uniform temperature. The temperature of unmodified asphalt binder delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325°F (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than 350°F (175°C) when added to the aggregate.

- **401-4.8 – Preparation of mineral aggregate.** The aggregate for the HMA shall be heated and dried. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350°F (175°C) when the asphalt binder is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

- **401-4.9 – Preparation of HMA.** The aggregates and the asphalt binder shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the contractor, based on the procedure for determining the percentage of coated particles described in ASTM D2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture.
delivered per second by the mixer. The moisture content of all HMA upon discharge shall not exceed 0.5%.

401-4.10 – **Preparation of the Underlying Surface.** Immediately before placing the HMA, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, and as shown on the plans or as required by these specifications.

A. The existing pavement surfaces to be overlaid shall be prepared, and cracks and joints shall be filled in accordance with Item P-101 and as shown on the plans. Payment will be made under respective bid items as indicated in Section 02 41 19 – Surface Preparation.

401-4.11 – **Laydown Plan, Transporting, Placing, and Finishing.** Prior to the placement of the HMA, the contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

A. The HMA shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-4.3. Deliveries shall be scheduled so that placing and compacting of HMA is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

B. The contractor shall use a material transfer vehicle to deliver mix to the paver for the final surface course lift and any underlying lifts unless otherwise directed by the Engineer.

C. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose for the first lift of all runway and taxiway pavements. Successive lifts of HMA surface course may be placed using a ski, or laser control per paragraph 401-4.4.1, provided grades of the first lift of HMA surface course meet the tolerances of paragraphs 401-5.2B(6) as verified by a survey. Contractor shall survey each lift of HMA surface course and certify to Engineer that every lot of each lift meets the grade tolerances of paragraph 401-5.2B6 before the next lift can be placed.

D. The initial placement and compaction of the HMA shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250°F.

E. Edges of existing HMA pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and coated with asphalt tack coat before new material is placed against it.

F. Upon arrival, the HMA shall be placed to the full width by a HMA paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the HMA mat. Unless otherwise permitted, placement of the HMA shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The HMA shall be placed in consecutive adjacent strips having a minimum width of 10’ (m) except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1’ (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10’ (3 m) from transverse joints in the previous course.

G. Transverse joints in adjacent lanes shall be offset a minimum of 10’.
H. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the HMA may be spread and luted by hand tools.

I. Areas of segregation in the surface course, as determined by the Engineer, shall be removed and replaced at the contractor's expense. The area shall be removed by saw cutting and milling a minimum of 2" (50 mm) deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10' (3 m) long.

401-4.12 – Compaction of HMA. After placing, the HMA shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the HMA has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

A. Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross-section, and the required field density is obtained. To prevent adhesion of the HMA to the roller, the wheels shall be equipped with a scraper and kept properly moistened but excessive water will not be permitted.

B. In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds (125 kg), have a tamping plate width not less than 15" (38 cm), be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

C. Any HMA that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the contractor's expense. Skin patching shall not be allowed.

401-4.13 – Joints. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

A. The roller shall not pass over the unprotected end of the freshly laid HMA except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be coated with an asphalt tack coat before placing any fresh HMA against the joint.

B. Longitudinal joints which have been left exposed for more than four (4) hours; the surface temperature has cooled to less than 175°F (80°C); or are irregular, damaged, uncompacted or otherwise defective shall be cut back 3" (75 mm) to 6" (150 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material shall be removed from the project. Asphalt tack coat or other product approved by the Engineer shall be applied to the clean, dry joint, prior to placing any additional fresh HMA against the joint. Any laitance produced from cutting joints shall be removed by vacuuming and washing. The cost of this work shall be considered incidental to the cost of the HMA.

401-4.14 – Saw-Cut Grooving. Saw-cut grooving shall be performed in accordance with Section 32 01 26.71 FAA Item P-621, where shown on the plans.
401-4.15 – **Diamond Grinding.** When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12" (300 mm) of cutting head width; the actual number of blades will be determined by the contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3’ (0.9 m) wide. Equipment that causes raveling, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2" (13mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. Areas that have been ground will be sealed with a P608 surface treatment as directed by the Engineer. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

401-4.16 – **Nighttime paving requirements.** Paving during nighttime construction shall require the following:

1. All paving machines, rollers, distribution trucks and other vehicles required by the contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

2. Minimum illumination level shall be 20 horizontal foot-candles and maintained in the following areas:
   a) An area of 30’ (9 m) wide by 30’ (9 m) long immediately behind the paving machines during the operations of the machines.
   b) An area 15’ (4.5 m) wide by 30’ (9 m) long immediately in front and back of all rolling equipment, during operation of the equipment.
   c) An area 15’ (4.5 m) wide by 15’ (4.5 m) long at any point where an area is being tack coated prior to the placement of pavement.

3. As partial fulfillment of the above requirements, the contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000-watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

4. A lighting plan must be submitted by the contractor and approved by the Engineer prior to the start of any nighttime work.

A. If the contractor places any out of specification mix in the project work area, the contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the contractor has to continue placing non-payment HMA, as directed by the Engineer, to make the surfaces safe for aircraft operations, the contractor shall do so to the satisfaction of the Engineer. It is the contractor’s responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs.

**PART 5 – MATERIAL ACCEPTANCE**

401-5.1 – **Acceptance Sampling and Testing.** Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be
performed by the Engineer at no cost to the contractor except that coring as required in this section shall be completed and paid for by the contractor.

A. Testing organizations performing these tests shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations at the contractor’s expense.

1. **Hot Mixed Asphalt.** Plant-produced HMA shall be tested for air voids and stability and flow on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D979.

   1) A standard lot shall be equal to:

      a) One day’s production or 2000 tons (1814 metric tons) whichever is smaller.

      b) If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production.

      c) If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

   2) Where more than one plant is simultaneously producing HMA for the job, the lot sizes shall apply separately for each plant.

   a) **Sampling.** Each lot will consist of four equal sublots. Sufficient HMA for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D3665. Samples will be taken in accordance with ASTM D979.

      1) The sample of HMA may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the JMF.

   b) **Testing.** Sample specimens shall be tested for stability and flow in accordance with ASTM D6927. Air voids will be determined by the Engineer in accordance with ASTM D3203. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D6926 at the number of blows required by paragraph 401-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test specimens prepared from the same sample. The manual hammer in ASTM D6926 shall be used.

      1) Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 6752, whichever is applicable, using the procedure for laboratory-prepared thoroughly dry specimens for use in computing air voids and pavement density.

      2) For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each sublot in accordance with ASTM D2041. The value used in the air voids computation for each sublot shall be based on theoretical maximum specific gravity measurement for the sublot.
3) The stability and flow for each sublot shall be computed by averaging the results of all test specimens representing that sublot.

c) Acceptance. Acceptance of plant produced HMA for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 401-5.2.

2. In-place HMA. HMA placed in the field shall be tested for mat and joint density on a lot basis. A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

a) Mat Density. The lot size shall be the same as that indicated in paragraph 401-5.1 and shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. Cores for mat density shall not be taken closer than 1” (30 cm) from a transverse or longitudinal joint.

b) Joint Density. The lot size shall be the total length of longitudinal joints constructed by a lot of HMA as defined in paragraph 401-5.1. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. All cores for joint density shall be taken centered on the joint. The minimum core diameter for joint density determination shall be 5” (125 mm).

c) Sampling. Samples shall be neatly cut with a diamond core drill bit. Samples will be taken in accordance with ASTM D979. The minimum diameter of the sample shall be 5” (125 mm). Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling. Laitance produced by the coring operation shall be removed immediately.

1) The top most lift of HMA shall be completely bonded to the underlying layer. If any of the cores reveal that the surface is not bonded to the layer immediately below the surface, then additional cores shall be taken as directed by the Engineer in accordance with paragraph 401-5.1 to determine the extent of any delamination. All delaminated areas shall be completely removed by milling to the limits and depth and replaced as directed by the Engineer at no additional cost.

d) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 6752, whichever is applicable. Samples will be taken in accordance with ASTM D979. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 401-5.1. The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

e) Acceptance. Acceptance of field placed HMA format density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2B1. Acceptance for joint density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2B3.
3. **Partial Lots.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

   a) The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, \( n = 5 \) or \( n = 6 \), for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, \( n = 3 \).

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401-5.2 ‒ Acceptance Criteria.

A. **General.** Acceptance will be based on the following characteristics of the HMA and completed pavement as well as the implementation of the contractor Quality Control Program and test results:

   a) Air voids
   b) Mat density
   c) Joint density
   d) Thickness
   e) Smoothness
   f) Grade
   g) Stability
   h) Flow

   1. Mat density and air voids will be evaluated for acceptance in accordance with paragraph 401-5.2B1. Stability and flow will be evaluated for acceptance in accordance with paragraph 401-5.2B2. Joint density will be evaluated for acceptance in accordance with paragraph 401-5.2B3.

   2. Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 401-5.2B4. Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2B5. Acceptance for grade will be based on the criteria contained in paragraph 401-5.2B6.

   3. The Engineer may at any time, reject and require the contractor to dispose of any batch of HMA which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

B. **Acceptance Criteria.**

   1. **Mat Density and Air Voids.** Acceptance of each lot of plant produced material for mat density and air voids shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment shall be determined in accordance with paragraph 401-8.1.

   2. **Stability and Flow.** Acceptance of each lot of plant produced HMA for stability and flow shall be based on the PWL. If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. If
the PWL is less than 90%, the contractor shall determine the reason and take corrective action. If
the PWL is below 80%, the contractor must stop production until the reason for poor stability
and/or flow has been determined and adjustments to the HMA are made.

3. **Joint Density.** Acceptance of each lot of plant produced HMA for joint density shall be based on
the PWL. If the PWL of the lot is equal to or exceeds 90%, the lot shall be considered acceptable.
If the PWL is less than 90%, the contractor shall evaluate the reason and act accordingly. If the
PWL is less than 80%, the contractor shall cease operations and until the reason for poor
compaction has been determined. If the PWL is less than 71%, the pay factor for the lot used to
complete the joint shall be reduced by 5 percentage points. This lot pay factor reduction shall be
incorporated and evaluated in accordance with paragraph 401-8.1.

4. **Thickness.** Thickness of each lift of surface course shall be evaluated by the Engineer for
compliance to the requirements shown on the plans. Measurements of thickness shall be made
by the Engineer using the cores extracted for each subplot for density measurement. The
maximum allowable deficiency at any point shall not be more than 1/4” (6 mm) less than the
thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than
the indicated thickness. Where the thickness tolerances are not met, the lot or subplot shall be
corrected by the contractor at his expense by removing the deficient area and replacing with
new pavement. The contractor, at his expense, may take additional cores as approved by the
Engineer to circumscribe the deficient area.

5. **Smoothness.** The final surface shall be free from roller marks. After the final rolling, but not later
than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and
transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances
specified. The contractor shall furnish paving equipment and employ methods that produce a
surface for each pavement lot having an average profile index meeting the requirements of
paragraph 401-8.1d when evaluated with a profilograph; and the finished surface course of the
pavement shall not vary more than 1/4” (6mm) when evaluated with a 12-foot (3.7m)
straightedge. When the surface course smoothness exceeds specification tolerances which
cannot be corrected by diamond grinding of the surface course, full depth removal and
replacement of surface course corrections shall be to the limit of the longitudinal placement.
Corrections involving diamond grinding will be subject to the final pavement thickness
tolerances specified. The contractor shall apply a surface treatment per Item P-608 or P-609 to
to all areas that have been subject to grinding as directed by the Engineer.

a) **Transverse measurements.** Transverse measurements will be taken for each lot placed.
Transverse measurements will be taken perpendicular to the pavement centerline each 50’
(15m) or more often as determined by the Engineer.

1) Testing shall be continuous across all joints, starting with one-half the length of the
straightedge at the edge of pavement section being tested and then moved ahead one-
half the length of the straightedge for each successive measurement. Smoothness
readings will not be made across grade changes or cross slope transitions; at these
transition areas, the straightedge position shall be adjusted to measure surface
smoothness and not design grade or cross slope transitions. The amount of surface
irregularity shall be determined by placing the freestanding (unleveled) straightedge
on the pavement surface and allowing it to rest upon the two highest spots covered by
its length, and measuring the maximum gap between the straightedge and the
pavement surface in the area between these two high points. High spots on final surface
course > 1/4” (6mm) in transverse direction shall be corrected with diamond grinding
per paragraph 401-4.15 or by removing and replacing full depth of surface course.
Grinding will be tapered in all directions to provide smooth transitions to areas not
requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

2) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50’ (15m) or more often if directed by the Engineer. Deviations on final surface course > 1/4” (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

b) **Longitudinal measurements.** Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20’ (6m); and at the third points of paving lanes when widths of paving lanes are 20’ (6m) or greater.

1) **Longitudinal Short Sections.** Longitudinal Short Sections are when the longitudinal lot length is less than 200’ (60m) and areas not requiring a profilograph. When approved by the Engineer, the first and last 15’ (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4” (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4” (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

2) **Profilograph Testing.** Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2” (5 mm) blanking band. The bump template must span 1” (25 mm) with an offset of 0.4” (10 mm). The profilograph must be calibrated prior to use and operated by a factory or Caltrans approved operator. Profilograms shall be recorded on a longitudinal scale of 1” (25 mm) equals 25’ (7.5 m) and a vertical scale of 1” (25 mm) equals 1” (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.

(a) The pavement must have an average profile index meeting the requirements of paragraph 401-8.1D. High spots, or “must grind” spots, on final surface course in
longitudinal direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(b) Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15” (38 cm) per mile or less. If the initial average profile index was less than 15” (38 cm), only those areas representing greater than 0.4” (10 mm) deviation will be re-profiled for correction verification.

3) Final profilograph of runway. Final profilograph, full length of runway, shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of paragraph 401-8.1D. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2” (5 mm) blanking band. The bump template must span 1” (25 mm) with an offset of 0.4” (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of 1” (25 mm) equals 25’ (7.5 m) and a vertical scale of 1” (25 mm) equals 1” (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed 1’ right and left of runway centerline and 15’ (4.5 m) right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the Engineer.

(a) Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 24 hours of placement of material. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours of paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions, then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

6. Grade. Grade shall be evaluated on the first day of placement and then as a minimum, every lot to allow adjustments to paving operations if measurements do not meet specification requirements. The contractor must submit the survey data to the Engineer by the following day after measurements have been taken. The finished surface of the pavement shall not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2” (12 mm). The finished grade of each lot will be determined by running levels at intervals of 50’ (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50’ (15 m)) to determine the elevation of the completed pavement. The contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the contractor to the Engineer. The lot size shall be 2,000 square yards (m2). When more than 15% of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates 3/4” (19 mm) or more from planned grade, the contractor shall remove the deficient area to the depth of the final course plus 1/2” (12 mm) of pavement and replace with new material. Skin patching shall not be
permitted. Isolated high points may be ground off provided the course thickness complies with the thickness specified on the plans. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130" (2 and 3.5 mm) wide. The peaks and ridges shall be approximately 1/32" (1 mm) higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. High point grinding will be limited to 15 square yards (12.5 m²). Areas in excess of 15 square yards (12.5 m²) will require removal and replacement of the pavement in accordance with the limitations noted above. The contractor shall apply a surface treatment per P-608 to all areas that have been subject to grinding.

C. **Percentage of Material within Specification Limits (PWL).** The PWL shall be determined in accordance with procedures specified in Division 01 Specification Section in the contract associated with Quality Control FAA Section 110. The specification tolerance limits (L) for lower and (U) for upper are contained in Table 5.

<table>
<thead>
<tr>
<th>TEST PROPERTY</th>
<th>Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Blows</td>
<td>75 blows</td>
</tr>
<tr>
<td></td>
<td>Specification Tolerance Limits</td>
</tr>
<tr>
<td>Stability, minimum (lbs)</td>
<td>L: 1800</td>
</tr>
<tr>
<td></td>
<td>U: --</td>
</tr>
<tr>
<td>Flow, 0.01-in</td>
<td>L: 8</td>
</tr>
<tr>
<td></td>
<td>U: 18*</td>
</tr>
<tr>
<td>Air Voids Total Mix (%)</td>
<td>L: 2</td>
</tr>
<tr>
<td></td>
<td>U: 5</td>
</tr>
<tr>
<td>Surface Course Mat Density (%)</td>
<td>L: 96.3</td>
</tr>
<tr>
<td></td>
<td>U: 101.3</td>
</tr>
<tr>
<td>Base Course Mat Density (%)</td>
<td>L: 95.5</td>
</tr>
<tr>
<td></td>
<td>U: 101.3</td>
</tr>
<tr>
<td>Joint density (%)</td>
<td>L: 93.3</td>
</tr>
<tr>
<td></td>
<td>U: --</td>
</tr>
</tbody>
</table>

*DUpper flow limit requirements do not apply for any mix with a polymer-modified binder (where the difference between the upper and lower temperature number is 90°F (32°C) or greater).

D. **Outliers.** All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the PWL shall be determined using the remaining test values. The criteria in Table 5 is based on production processes which have a variability with the following standard deviations:

1. Surface Course Mat Density (%), 1.30
2. Base Course Mat Density (%), 1.55
3. Joint Density (%), 2.1
4. The contractor should note that (1) 90 PWL is achieved when consistently producing a surface course with an average mat density of at least 98% with 1.30% or less variability, (2) 90 PWL is achieved when consistently producing a base course with an average mat density of at least 97.5% with 1.55% or less variability, and (3) 90 PWL is achieved when consistently producing joints with an average joint density of at least 96% with 2.1% or less variability.

➤ **401-5.3 – Resampling Pavement for Mat Density.**

A. **General.** Resampling of a lot of pavement will only be allowed for mat density, and then, only if the contractor requests same, in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1 and 401-5.2. Only one resampling per lot will be permitted.
1. A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.

2. The cost for resampling and retesting shall be borne by the contractor.

B. Payment for Resampled Lots. The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

C. Outliers. Check for outliers in accordance with ASTM E178, at a significance level of 5%.

401-5.4 – Leveling Course. Any course used for trueing and leveling shall meet the aggregate gradation in Table 3, paragraph 401-3.2. The trueing and leveling course shall meet the requirements of paragraph 401-3.2, 401-5.2B1 for air voids and 401-5.2B2 for stability and flow, but shall not be subject to the density requirements of paragraph 401-5.2B1 for mat density and 401-5.2B3 for joint density. The leveling course shall be compacted with the same effort used to achieve density of the test section. The trueing and leveling course shall not exceed the maximum lift thickness associated with each gradation in Table 3, paragraph 401-3.2. The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.

PART 6 – CONTRACTOR QUALITY CONTROL

401-6.1 – General. The contractor shall develop a Quality Control Program. The program shall address all elements that affect the quality of the pavement including, but not limited to:

1. Mix Design
2. Aggregate Grading
3. Quality of Materials
4. Stockpile Management
5. Proportioning
6. Mixing and Transportation
7. Placing and Finishing
8. Joints
9. Compaction
10. Surface Smoothness
11. Personnel
12. Laydown Plan

A. The contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 401-6.3. As a part of the process for approving the contractor’s plan, the Engineer may require the contractor’s technician to perform testing of samples to demonstrate an acceptable level of performance.

B. No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

401-6.2 – Contractor Testing Laboratory. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications.

401-6.3 – Quality Control Testing. The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in
the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program per Division 01 Specification Section in the contract associated with Quality Control.

A. **Asphalt Content.** A minimum of two asphalt content tests shall be performed per lot in accordance with ASTM D6307 or ASTM D2172 if the correction factor in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

B. **Gradation.** Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444, ASTM C136, and ASTM C117.

C. **Moisture Content of Aggregate.** The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

D. **Moisture Content of HMA.** The moisture content shall be determined once per lot in accordance with ASTM D1461.

E. **Temperatures.** Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the asphalt binder in the storage tank, the HMA at the plant, and the HMA at the job site.

F. **In-Place Density Monitoring.** The contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.

G. **Additional Testing.** Any additional testing that the contractor deems necessary to control the process may be performed at the contractor’s option.

H. **Monitoring.** The Engineer reserves the right to monitor any or all of the above testing.

- **401-6.4 – Sampling.** When directed by the Engineer, the contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the contractor. All sampling shall be in accordance with standard procedures specified.

- **401-6.5 – Control Charts.** The contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each sublot will be calculated and monitored by the Quality Control laboratory.

A. Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the contractor’s test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor’s projected data during production indicates a problem and the contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

1. **Individual Measurements.** Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation, asphalt content, and VMA. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:
2. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of \( n = 2 \). Should the contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for \( n = 3 \) and by 1.27 for \( n = 4 \).

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Action Limit</th>
<th>Suspension Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; (19 mm)</td>
<td>±6%</td>
<td>±9%</td>
</tr>
<tr>
<td>1/2&quot; (12 mm)</td>
<td>±6%</td>
<td>±9%</td>
</tr>
<tr>
<td>3/8&quot; (9 mm)</td>
<td>±6%</td>
<td>±9%</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>±6%</td>
<td>±9%</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>±5%</td>
<td>±7.5%</td>
</tr>
<tr>
<td>No. 50 (0.30 mm)</td>
<td>±3%</td>
<td>±4.5%</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>±2%</td>
<td>±3%</td>
</tr>
<tr>
<td>Asphalt Content</td>
<td>±0.45%</td>
<td>±0.70%</td>
</tr>
<tr>
<td>VMA</td>
<td>-1.00%</td>
<td>-1.50%</td>
</tr>
</tbody>
</table>

3. Corrective Action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

a) One point falls outside the Suspension Limit line for individual measurements or range; or

b) Two points in a row fall outside the Action Limit line for individual measurements.

- 401-6.6 – Quality Control Reports. The contractor shall maintain records and shall submit reports of quality control activities daily.

PART 7 – METHOD OF MEASUREMENT

- 401-7.1 – Measurement. HMA shall be measured by the weight of HMA used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

PART 8 – BASIS OF PAYMENT

- 401-8.1 – Payment. Payment for a lot of HMA meeting all acceptance criteria as specified in paragraph 401-5.2 shall be made based on results of tests for smoothness, mat density and air voids. Payment for
acceptable lots shall be adjusted according to paragraph 401-8.1C for mat density and air voids and 401-8.1E for smoothness, subject to the limitation that:

A. The total project payment for HMA pavement shall not exceed 100% of the product of the contract unit price and the total number of units of weight of HMA used in the accepted work (See Note 1 under Table 6).

B. The prices shall be full compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, including tack coat and prime coat as required, and for all labor, equipment, tools, and incidentals necessary to complete the item.

C. **Basis of Adjusted Payment.** The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100%. If PWL for joint density is less than 71% then the lot pay factor shall be reduced by 5% but be no higher than 95%.

1. For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 401-8.1. Payment in excess of 100% for accepted lots of HMA shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100%.

Table 6. Price Adjustment Schedule

<table>
<thead>
<tr>
<th>Percentage of Material Within Specification Limits (PWL)</th>
<th>Lot Pay Factor (Percent of Contract Unit Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>96 – 100</td>
<td>106</td>
</tr>
<tr>
<td>90 – 95</td>
<td>PWL + 10</td>
</tr>
<tr>
<td>75 – 89</td>
<td>0.5 PWL + 55</td>
</tr>
<tr>
<td>55 – 74</td>
<td>1.4 PWL – 12</td>
</tr>
<tr>
<td>Below 55</td>
<td>Reject ²</td>
</tr>
</tbody>
</table>

²Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment above 100% shall be subject to the total project payment limitation specified in paragraph 401-8.1.

²The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.

D. **Profilograph Smoothness.** When the final average profile index (subsequent to any required corrective action) does not exceed 7” per mile (18 cm per 1.6 km), payment will be made at the contract unit price for the completed pavement. If the final average profile index (subsequent to any required corrective action) exceeds 7” per mile (18 cm per 1.6 km), but does not exceed 15” per mile (38 cm per 1.6 m), the contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

E. **Basis of Adjusted Payment for Smoothness.** Price adjustment for pavement smoothness will be made in accordance with Table 7. The adjustment will apply to the total tonnage of HMA within a lot of pavement and shall be applied with the following equation:
1. \( \text{(Tons of asphalt concrete in lot)} \times \text{(lot pay factor)} \times \text{(unit price per ton)} \times \text{(smoothness pay factor)} = \text{payment for lot} \)

<table>
<thead>
<tr>
<th>Inches/miles per 1/10 mile</th>
<th>Short Sections</th>
<th>Pay Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 - 7</td>
<td>00.0 - 15.0</td>
<td>100%</td>
</tr>
<tr>
<td>7.1 - 9</td>
<td>15.1 – 16</td>
<td>98%</td>
</tr>
<tr>
<td>9.1 - 11</td>
<td>16.1 – 17</td>
<td>96%</td>
</tr>
<tr>
<td>11.1 - 13</td>
<td>17.1 – 18</td>
<td>94%</td>
</tr>
<tr>
<td>13.1 - 14</td>
<td>18.1 – 20</td>
<td>92%</td>
</tr>
<tr>
<td>14.1 - 15</td>
<td>20.1 – 22</td>
<td>90%</td>
</tr>
<tr>
<td>15.1 and up</td>
<td>22.1 and up</td>
<td>Corrective work required(^1)</td>
</tr>
</tbody>
</table>

\(^1\) The contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay should be at least 3 times the maximum aggregate size (approximately 4 times the nominal maximum aggregate size). The corrective overlay shall not violate grade Criteria and butt joints shall be constructed by sawing and removing the original pavement in compliance with the thickness/ maximum aggregate size ratio. Skin patching shall not be permitted.

2. HMA placed above the specified grade and below the specified milled depth shall not be included in the quantities for payment.

**TESTING REQUIREMENTS**

<table>
<thead>
<tr>
<th>ASTM Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C29</td>
<td>Standard Test Method for Bulk Density (&quot;Unit Weight&quot;) and Voids in Aggregate</td>
</tr>
<tr>
<td>ASTM C88</td>
<td>Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
</tr>
<tr>
<td>ASTM C117</td>
<td>Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing</td>
</tr>
<tr>
<td>ASTM C127</td>
<td>Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM C136</td>
<td>Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates</td>
</tr>
<tr>
<td>ASTM C183</td>
<td>Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement</td>
</tr>
<tr>
<td>ASTM C566</td>
<td>Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying</td>
</tr>
<tr>
<td>ASTM D75</td>
<td>Standard Practice for Sampling Aggregates</td>
</tr>
<tr>
<td>ASTM D979</td>
<td>Standard Practice for Sampling Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D1073</td>
<td>Standard Specification for Fine Aggregate for Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2172</td>
<td>Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D1461</td>
<td>Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2041</td>
<td>Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2489</td>
<td>Standard Practice for Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures</td>
</tr>
<tr>
<td>ASTM D2726</td>
<td>Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures</td>
</tr>
<tr>
<td>ASTM D2950</td>
<td>Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods</td>
</tr>
<tr>
<td>ASTM D3203</td>
<td>Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D3665</td>
<td>Standard Practice for Random Sampling of Construction Materials</td>
</tr>
<tr>
<td>ASTM D3666</td>
<td>Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials</td>
</tr>
<tr>
<td>ASTM D4791</td>
<td>Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM D4867</td>
<td>Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D5444</td>
<td>Standard Test Method for Mechanical Size Analysis of Extracted Aggregate</td>
</tr>
<tr>
<td>ASTM D6307</td>
<td>Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method</td>
</tr>
<tr>
<td>ASTM D6926</td>
<td>Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus</td>
</tr>
<tr>
<td>ASTM E11</td>
<td>Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves</td>
</tr>
<tr>
<td>ASTM E178</td>
<td>Standard Practice for Dealing with Outlying Observations</td>
</tr>
<tr>
<td>ASTM E1274</td>
<td>Standard Test Method for Measuring Pavement Roughness Using a Profilograph</td>
</tr>
<tr>
<td>AASHTO T030</td>
<td>Standard Method of Test for Mechanical Analysis of Extracted Aggregate</td>
</tr>
<tr>
<td>AASHTO T110</td>
<td>Standard Method of Test for Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)</td>
</tr>
<tr>
<td>AASHTO T275</td>
<td>Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens</td>
</tr>
</tbody>
</table>
### AASHTO M156

### AASHTO T329
Standard Method of Test for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

### Asphalt Institute Handbook MS-26
Asphalt Binder

### Asphalt Institute MS-2
Mix Design Manual, 7th Edition

## MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D946</td>
<td>Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction</td>
</tr>
<tr>
<td>ASTM D4552</td>
<td>Standard Practice for Classifying Hot-Mix Recycling Agents</td>
</tr>
<tr>
<td>ASTM D6373</td>
<td>Standard Specification for Performance Graded Asphalt Binder</td>
</tr>
</tbody>
</table>

END OF SECTION 32 12 16.13
SECTION 32 12 16.14 – HOT MIX ASPHALT PAVEMENTS (BASE, LEVELING OR SHOULDHER SURFACE COURSE)

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of plant mix bituminous concrete base, leveling and shoulder surface courses constructed to the depth, typical section, and elevation required by the plans, and as specified herein.

1.2 REFERENCES

1. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.
2. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
3. FAA Specification Item P-403 Plant Mix Bituminous Pavements (Base, Leveling or Shoulder Surface Course) and as modified herein.
4. Section 02 41 19 – Surface Preparation FAA Item P-101.
5. Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603.
7. American Association of State Highway and Transportation Officials (AASHTO) standards and tests, as referenced in FAA Item P-403.
9. The Asphalt Institute as referenced in FAA Item P-403.
10. California Department of Transportation (Caltrans)

1.3 SUBMITTALS

A. Prior to commencing Work in this Section and delivery of materials to the job site, the contractor shall submit the following plant mix bituminous pavement information

1. Certified Test Reports of coarse aggregate, fine aggregate, mineral filler and bituminous material in conformance with FAA Specification Item P-403 Article 403-2.4.
2. Bituminous Concrete Base and Leveling Course Quality Control (BCBLCQC) Project Plan: The BCBLCQC Project Plan shall include all testing procedures to be used for quality control and shall conform to FAA Specification Item P-403.
3. Job Mix Formula and Test Results: Bituminous Concrete Base and Leveling Course job mix formula in conformance with FAA Specification Item P-403, with test reports of the parameters listed in Article 403-3.2.
4. Bituminous Concrete Base and Leveling Course samples of aggregates and bituminous materials, including test reports as required.
5. Bituminous Concrete Base and Leveling Course Paving Plan.

6. Reclaimed Asphalt Concrete: The contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

7. During the Work of this Section, periodic Bituminous Concrete Base and Leveling Course field test results to the Engineer for review. These results shall include the results of retests for items that failed initial testing.

8. Testing laboratory accreditation, testing personnel qualifications and lab manager certification.

9. Contractor shall provide ASCII file for grade check of each lift of P-403 for Engineer’s review before continuing with successive lifts.

1.4 QUALITY ASSURANCE

A. The Airport will perform Quality Assurance (QA) testing for acceptance, measurement, and payment of the Work. The contractor is responsible for hiring an approved, independent testing firm to perform standard bituminous concrete pavement testing Quality Control (QC) testing.

B. The contractor shall perform Quality Control testing and inspection to meet the requirement of FAA Specification Item P-403, and as modified herein.

PART 2 – PRODUCTS

2.1 BITUMINOUS CONCRETE

A. Bituminous Concrete Base and Leveling Course shall conform to FAA Specification Item P-403, and as modified herein.

PART 3 – EXECUTION

3.1 SURVEY

A. Project control points will be provided by SFIA Surveyor. The contractor shall provide Grade Setters and Checkers for the construction work.

3.2 BITUMINOUS CONCRETE PLACEMENT

A. The contractor shall prepare, spread, and compact the surface course for bituminous concrete in accordance with FAA Specification Item P-403, and as modified herein.

B. Bituminous pavement deep patches and underlying layers shall be placed to the full width by a bituminous paver with a material transfer vehicle.

C. The contractor shall not be allowed to broadcast aggregate back onto the mat. Raking along the joints should be kept to a minimum.

3.3 TACK COAT

A. The contractor shall apply tack coat in accordance with Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603, and as modified herein, to all existing pavement surfaces both horizontal and at vertical interfaces, and between lifts of asphalt pavement.
3.4 **PRIME COAT**
   A. The contractor shall apply prime coat in accordance with Section 32 12 13.19 – Bituminous Prime Coat FAA Item P-602, and as modified herein, to base course surface where shown on the plans.

3.5 **JOINT SEALING FILLER**
   A. The contractor shall prepare all joints and cracks to be overlaid and filled in accordance with Section 02 41 19 – Surface Preparation FAA Item P-101, and as modified herein.

3.6 **AGGREGATE**
   A. Sources of Aggregates. Sources of aggregates shall be selected well in advance of the time the materials are required in the work. When the aggregates are obtained from a previously approved source or an existing source producing aggregates that has a satisfactory service record in airport bituminous pavement construction for at least five years, samples shall be submitted 14 days prior to start of production. An inspection of the producer’s operation will be made by the Engineer. When new sources are to be developed, the contractor shall indicate the sources and shall submit a plan for operation 30 days in advance of starting production. Samples from test pits, boring, and other excavations, shall be submitted at the same time. Approval of the source of aggregate does not relieve the contractor in any way of the responsibility for delivery at the job site of aggregates that meet the requirements specified herein. Any change of materials shall require a new mix design by a certified lab, at the cost of the contractor, and shall be approved by the Engineer prior to use of the material in the job.
   
   B. Samples of Aggregates. Samples of aggregates shall be furnished by the contractor at the start of production and at intervals during production of bituminous mixtures. The sampling points and intervals will be designated by the Engineer. The samples will be the basis of approval of specific lots of aggregates from the standpoint of the quality requirements of this section.

3.7 **CLEAN-UP**
   A. The contractor, during paving operation, shall continuously clean-up the site and haul routes and remove all excess material and equipment from the site immediately after the work for the shift is completed.

**PART 4 – INCLUDED FAA SPECIFICATIONS**

A. FAA Item P-403, Hot Mix Asphalt Pavements (Base, Leveling or Shoulder Surface Course).

**PART 5 – MEASUREMENT AND PAYMENT**

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-403 and as modified herein.
FAA ITEM P-403 HOT MIX ASPHALT PAVEMENTS (BASE, LEVELING OR SHOULDER SURFACE COURSE)

PART 1 – DESCRIPTION

- 403-1.1 – This item shall consist of a base, leveling or shoulder surface course composed of mineral aggregate and asphalt cement binder (asphalt binder) mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

PART 2 – MATERIALS

- 403-2.1 – **Aggregate.** Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause "rust" staining that can bleed through pavement markings. The portion retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

A. **Coarse Aggregate.** Coarse aggregate shall consist of sound, tough, durable particles, free from films of matter that would prevent thorough coating and bonding with the bituminous material and free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after 5 cycles, when tested in accordance with ASTM C88. Clay Lumps and friable particles shall not exceed 1.0% when tested in accordance with ASTM C142.

1. Aggregate shall contain at least 75% by weight of individual pieces having two or more fractured faces and 85% by weight having at least one fractured face. The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be achieved by crushing.

2. The aggregate shall not contain more than a total of 8%, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D4791 with a value of 5:1.

3. Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C29.

B. **Fine Aggregate.** Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter.

1. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

2. The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.
3. Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with ASTM C142.

4. Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. The fine aggregate shall not contain more than 15% natural sand by weight of total aggregates. If used, the natural sand shall meet the requirements of ASTM D1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

5. The aggregate shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D2419.

C. **Sampling.** ASTM D75 shall be used in sampling coarse and fine aggregate, and ASTM C183 shall be used in sampling mineral filler.

   - 403-2.2 – **Mineral Filler.** If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.
   - 403-2.3 – **Asphalt Cement Binder.** Asphalt cement binder shall conform to ASTM D6373 Performance Grade (PG) 76-22. A certificate of compliance from the manufacturer shall be included with the mix design submittal

   A. The supplier's certified test report with test data indicating grade certification for the asphalt binder shall be provided to the Engineer for each load at the time of delivery to the mix plant. A certified test report with test data indicating grade certification for the asphalt binder shall also be provided to the Engineer for any modification of the asphalt binder after delivery to the mix plant and before use in the HMA.

   - 403-2.4 – **Preliminary Material Acceptance.** Prior to delivery of materials to the job site, the contractor shall submit certified test reports to the Engineer for the following materials:

     1. Coarse Aggregate:
        a) Percent of wear.
        b) Soundness.
        c) Clay lumps and friable particles
        d) Percent fractured faces
        e) Flat and elongated particles
        f) Unit weight of slag.

     2. Fine Aggregate:
        a) Liquid limit and Plasticity index
        b) Soundness
        c) Clay lumps and friable particles
        d) Percent natural sand
        e) Sand equivalent


     4. Asphalt Binder. Test results for asphalt binder shall include temperature/viscosity charts for mixing and compaction temperatures.

   A. The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.
B. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

- 403-2.5 – **Anti-Stripping Agent.** Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the California Department of Transportation (Caltrans).

**PART 3 – COMPOSITION**

- 403-3.1 – **Composition of Mixture.** The HMA plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and asphalt binder. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

- 403-3.2 – **Job Mix Formula.** No hot-mixed asphalt (HMA) for payment shall be produced until a JMF has been approved in writing by the Engineer. The asphalt mix design and JMF shall be prepared by an accredited laboratory that meets the requirements of paragraph 403-3.4. The HMA shall be designed using procedures contained in Asphalt Institute MS-2 Mix Design Manual, 7th Edition. ASTM D6926 shall be used for preparation of specimens using the manually held and operated hammer for the mix design procedure. ASTM D6927 shall be used for testing for Marshall stability and flow.

  A. If material variability exceeds the standard deviations indicated, the JMF and subsequent production targets shall be based on a stability greater than shown in Table 1 and the flow shall be targeted close to the mid-range of the criteria in order to meet the acceptance requirements.

  B. Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867, shall not be less than 75 when tested at a saturation of 70-80% or an anti-stripping agent shall be added to the HMA, as necessary, to produce a TSR of not less than 75 when tested at a saturation of 70-80%. If an anti-strip agent is required, it shall be provided by the contractor at no additional cost to the Owner.

  C. The JMF shall be submitted in writing by the contractor at least 30 days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates currently being produced.

  D. The submitted JMF shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

    1. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the JMF.

    2. Percent of asphalt cement.

    3. Asphalt performance, grade, and type of modifier if used.

    4. Number of blows per side of molded specimen

    5. Laboratory mixing temperature.

    6. Laboratory compaction temperature.

    7. Temperature-viscosity relationship of the PG asphalt cement binder showing acceptable range of mixing and compaction temperatures and for modified binders include supplier recommended mixing and compaction temperatures.

    8. Plot of the combined gradation on the 0.45 power gradation curve

    9. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.
10. Specific gravity and absorption of each aggregate.
11. Percent natural sand.
12. Percent fractured faces.
13. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).
14. Tensile Strength Ratio (TSR).
15. Anti-strip agent (if required).
16. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.

E. The contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the JMF requirements specified in Tables 1 and 3.

F. When the project requires asphalt mixtures of differing aggregate gradations, a separate JMF and the results of JMF verification testing shall be submitted for each mix.

G. The JMF for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new JMF must be submitted within 15 days and approved by the Engineer in writing before the new material is used. After the initial production JMF has been approved by the Engineer and a new or modified JMF is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified JMF will be borne by the contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified JMF.

<table>
<thead>
<tr>
<th>Test Property</th>
<th>Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Blows</td>
<td>75</td>
</tr>
<tr>
<td>Stability, pounds (Newtons) minimum</td>
<td>1800 (8006)</td>
</tr>
<tr>
<td>Flow, 0.01&quot; (0.25 mm)</td>
<td>8-16</td>
</tr>
<tr>
<td>Air Voids (percent)</td>
<td>3.5</td>
</tr>
<tr>
<td>Percent Voids in Mineral Aggregate (minimum)</td>
<td>See Table 2.</td>
</tr>
</tbody>
</table>

1. The flow requirement is not applicable for Polymer Modified Asphalts.

Table 2 Minimum Percent Voids in Mineral Aggregate (VMA)

<table>
<thead>
<tr>
<th>Maximum Particle Size</th>
<th>Minimum VMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation 3</td>
<td>16%</td>
</tr>
<tr>
<td>Gradation 2</td>
<td>15%</td>
</tr>
<tr>
<td>Gradation 1</td>
<td>14%</td>
</tr>
</tbody>
</table>

H. The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C136 and ASTM C117.
I. The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply, be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa.

J. The maximum aggregate size should be no greater than 1/4 the lift thickness to be constructed except where otherwise shown on the plans or ordered by the Engineer.

K. Use the following sieve sizes unless otherwise specified or directed by the Engineer:
   1. Leveling Course – one inch (1") maximum sieve size
   2. Base course for runways and taxiways – ¾" maximum sieve size
   3. Surface course for shoulders – one inch (1") maximum sieve size

L. The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition.

Table 3 Aggregate - Bituminous Pavements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Gradation 1</th>
<th>Gradation 2</th>
<th>Gradation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&quot; (25 mm)</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3/4&quot; (19 mm)</td>
<td>76-98</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>1/2&quot; (12 mm)</td>
<td>66-86</td>
<td>79-99</td>
<td>100</td>
</tr>
<tr>
<td>3/8&quot; (9 mm)</td>
<td>57-77</td>
<td>68-88</td>
<td>79-99</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>40-60</td>
<td>48-68</td>
<td>58-78</td>
</tr>
<tr>
<td>No. 8 (2.36 mm)</td>
<td>26-46</td>
<td>33-53</td>
<td>39-59</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>17-37</td>
<td>20-40</td>
<td>26-46</td>
</tr>
<tr>
<td>No. 30 (0.600 mm)</td>
<td>11-27</td>
<td>14-30</td>
<td>19-35</td>
</tr>
<tr>
<td>No. 50 (0.300 mm)</td>
<td>7-19</td>
<td>9-21</td>
<td>12-24</td>
</tr>
<tr>
<td>No. 100 (0.150 mm)</td>
<td>6-16</td>
<td>6-16</td>
<td>7-17</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>3-6</td>
<td>3-6</td>
<td>3-6</td>
</tr>
</tbody>
</table>

Asphalt Percent:

| Stone or gravel | 4.5-7.0 | 5.0-7.5 | 5.5-8.0 |
| Slag            | 5.0-7.5 | 6.5-9.5 | 7.0-10.5 |

- 403-3.3 – **Reclaimed Asphalt Concrete (RAP).** Reclaimed HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. Recycled asphalt shingles (RAS) shall not be allowed. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 1-1/2" (38 mm). The reclaimed asphalt concrete mix shall be designed using procedures contained in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition. The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D2172 using the appropriate dust correction procedure. The JMF shall meet the requirements of Paragraph 403-3.2. RAP should only be used for shoulder surface course mixes and for any intermediate courses. The use of RAP containing Coal Tar shall not be allowed. Coal Tar surface treatments must be removed prior to recycling underlying asphalt material. The amount of RAP shall be limited to 30%.

A. In addition to the requirements of paragraph 403-3.2, the JMF shall indicate the percent of reclaimed asphalt pavement and the percent and grade of new asphalt binder.

B. For the PG graded asphalt binder selected in 403-2.3, adjust as follows:
1. For 0-20% RAP, there is no change in virgin binder content.
2. For >20 to 30% RAP, select binder one grade softer, i.e., PG 64-22 would soften to PG 58-28.

- **403-3.4 – Job mix formula (JMF) laboratory.** The contractor’s laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

- **403-3.5 – Test Section.** Prior to full production, the contractor shall prepare and place a quantity of HMA according to the JMF. The amount of HMA shall be sufficient to construct a test section 300’ long and 25’ wide, placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint for this test section is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160°F (71ºC). The cold joint must be cut back using the same procedure that will be used during production in accordance with 403-4.12. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

  A. The test section shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 403-5.1 and 403-5.2. The test section shall be divided into equal sublots. As a minimum the test section shall consist of 3 sublots.

  B. The test section shall be considered acceptable if the average mat density of the test section cores is greater than or equal to 96% and the average joint density of the test section cores is greater than or equal to 94%

  C. If the initial test section should prove to be unacceptable, the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the contractor’s expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the contractor’s expense. Full production shall not begin until an acceptable test section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 403-8.1.

  D. Job mix control testing shall be performed by the contractor at the start of plant production and in conjunction with the calibration of the plant for the JMF. If the aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum asphalt content determined in the same manner as for the original JMF tests.

  E. Contractor will not be allowed to place the test section until the contractor Quality Control Program, showing conformance with the requirements of paragraph 403-6.1, has been approved, in writing, by the Engineer.

**PART 4 – CONSTRUCTION METHODS**

- **403-4.1 Weather Limitations.** The HMA shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may
be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

Table 4 Surface Temperature Limitations of Underlying Course

<table>
<thead>
<tr>
<th>Mat Thickness</th>
<th>Base Temperature (Minimum) Deg. F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” (7.5 cm) or greater</td>
<td>40</td>
</tr>
<tr>
<td>Greater than 2” (50 mm) but less than 3” (7.5 cm)</td>
<td>45</td>
</tr>
</tbody>
</table>

➢ 403-4.2 – HMA Plant. Plants used for the preparation of HMA shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M156 with the following changes:

A. Requirements for all plants include:

1. **Truck Scales.** The HMA shall be weighed on approved scales furnished by the contractor, or on certified public scales at the contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the Contract specifications.

   a) In lieu of scales, and as approved by the Engineer, HMA weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the Engineer.

2. **Testing Facilities.** The contractor shall ensure laboratory facilities are provided at the plant for the use of the Engineer. The lab shall have sufficient space and equipment so that both testing representatives (Engineer’s and contractor’s) can operate efficiently. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications and masonry saw with diamond blade for trimming pavement cores and samples. The plant testing laboratory shall have a floor space area of not less than 200 square feet (18.5 sq m), with a ceiling height of not less than 7-1/2' (2 m). The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70°F ±5°F (21°C ±2.3°C). The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials. In addition, the facility shall include the minimum:

   1) Adequate artificial lighting.
   2) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.
   3) A minimum of 2 Underwriter’s Laboratories approved fire extinguishers of the appropriate types and class.
   4) Work benches for testing.
   5) Desk with chairs and file cabinet.
   6) Sanitary facilities convenient to testing laboratory.
   7) Exhaust fan to outside air.
   8) Sink with running water.
a) Failure to provide the specified facilities shall be sufficient cause for disapproving HMA plant operations.

b) Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the contractor’s laboratory facility and witness quality control activities. The Engineer will advise the contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

3. **Inspection of Plant.** The Engineer, or Engineer’s authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

4. **Storage Bins and Surge Bins.** The HMA stored in storage and surge bins shall meet the same requirements as HMA loaded directly into trucks and may be permitted under the following conditions:
   1) Stored in non-insulated bins for a period of time not to exceed 3 hours.
   2) Stored in insulated storage bins for a period of time not to exceed 8 hours.

   a) If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the HMA due to temporary storage, no temporary storage will be allowed.

   ➢ **403-4.3 – Hauling Equipment.** Trucks used for hauling HMA shall have tight, clean, and smooth metal beds. To prevent the HMA from sticking to the truck beds, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other material approved by the Engineer. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

   ➢ **403-4.3.1 – Material Transfer Vehicle (MTV).** Material transfer Vehicles shall be required due to the improvement in smoothness and decrease in both physical and thermal segregation. To transfer the material from the hauling equipment to the paver, use a self-propelled, material transfer vehicle with a swing conveyor that can deliver material to the paver without making contact with the paver. The MTV shall be able to move back and forth between the hauling equipment and the paver providing material transfer to the paver, while allowing the paver to operate at a constant speed. The Material Transfer Vehicle will have remixing and storage capability to prevent physical and thermal segregation.

   ➢ **403-4.4 – HMA Pavers.** HMA pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of HMA that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

   A. The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the HMA uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

   B. If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by
the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the contractor.

- **403-4.4.1 – Automatic Grade Control.** The HMA paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

  A. The controls shall be capable of working in conjunction with any of the following attachments:

     1. Ski-type device of not less than 30' (9 m) in length
     2. Taut stringline (wire) set to grade
     3. Short ski or shoe
     4. Laser control

- **403-4.5 – Rollers.** Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the HMA. The number, type, and weight of rollers shall be sufficient to compact the HMA to the required density while it is still in a workable condition.

  A. All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the contractor at their own expense.

  B. The use of equipment that causes crushing of the aggregate will not be permitted.

- **403-4.5.1 – Density Device.** The contractor shall have on site a density gauge during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The contractor shall also supply a qualified technician during all paving operations to calibrate the density gauge and obtain accurate density readings for all new HMA. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

- **403-4.6 – Preparation of Asphalt Binder.** The asphalt binder shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the unmodified asphalt binder delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325°F (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than 350°F (175°C) when added to the aggregate.

- **403-4.7 – Preparation of Mineral Aggregate.** The aggregate for the HMA shall be heated and dried. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350°F (175°C) when the asphalt binder is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

- **403-4.8 – Preparation of HMA.** The aggregates and the asphalt binder shall be weighed or metered and introduced into the mixer in the amount specified by the JMF.
A. The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the contractor, based on the procedure for determining the percentage of coated particles described in ASTM D2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all HMA upon discharge shall not exceed 0.5%.

- **403-4.9 – Preparation of the Underlying Surface.** Immediately before placing the HMA, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, and as shown on the plans or as required by these specifications.

- **403-4.10 – Laydown Plan, Transporting, Placing, and Finishing.** Prior to the placement of the HMA, the contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

A. The HMA shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 403-4.3. Deliveries shall be scheduled so that placing and compacting of HMA is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

B. The contractor shall use a material transfer vehicle to deliver HMA to the paver.

C. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose for the first lift of all runway and taxiway pavements. Successive lifts of HMA surface course may be placed using a ski, or laser control per paragraph 403-4.4.1, provided grades of the first lift of bituminous surface course meet the tolerances of paragraphs 403-5.2B as verified by a survey. Contractor shall survey each lift of HMA surface course and certify to Engineer that every lot of each lift meets the grade tolerances of paragraph 403-5.2B5 before the next lift can be placed.

D. The initial placement and compaction of the HMA shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250°F (121°C).

E. Edges of existing HMA pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and coated with asphalt tack coat before new material is placed against it.

F. Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the HMA mat. Unless otherwise permitted, placement of the HMA shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The HMA shall be placed in consecutive adjacent strips having a minimum width of 10’ except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1” (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10’ (3 m) from transverse joints in the previous course.
G. Transverse joints in adjacent lanes shall be offset a minimum of 10’ (3 m).

H. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the HMA may be spread and luted by hand tools.

I. Areas of segregation in the course, as determined by the Engineer, shall be removed and replaced at the contractor’s expense. The area shall be removed by saw cutting and milling a minimum of 2” (50 mm) deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10’ (3 m) long.

- 403-4.11 – Compaction of HMA. After placing, the HMA shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

A. Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross-section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened using a water soluble asphalt release agent approved by the Engineer.

B. In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds (125 kg), have a tamping plate width not less than 15” (38 cm), be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

C. Any HMA that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the contractor’s expense. Skin patching shall not be allowed.

- 403-4.12 – Joints. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade. The roller shall not pass over the unprotected end of the freshly laid HMA except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be coated with an asphalt tack coat before placing any fresh HMA against the joint.

A. Longitudinal joints which have been left exposed for more than 4 hours; the surface temperature has cooled to less than 175°F (80°C); or are irregular, damaged, uncompacted or otherwise defective shall be cut back 6” (150 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material shall be removed from the project. A asphalt tack coat or other product approved by the Engineer shall be applied to the clean, dry joint prior to placing any additional fresh HMA against the joint. Any laitance produced from cutting joints shall be removed by vacuuming and washing. The cost of this work shall be considered incidental to the cost of the HMA.

- 403-4.13 – Diamond grinding. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting
head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12” (300 mm) of cutting head width; the actual number of blades will be determined by the contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3’ (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2” (13mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. Areas that have been ground will be sealed with a P-608 surface treatment as directed by the Engineer. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

- **403-4.14 – Nighttime Paving Requirements.** Paving during nighttime construction shall require the following:

  1. All paving machines, rollers, distribution trucks and other vehicles required by the contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

  2. Minimum illumination level shall be 20 horizontal foot-candles and maintained in the following areas:

     a) An area of 30’ (9 m) wide by 30’ (9 m) long immediately behind the paving machines during the operations of the machines.

     b) An area 15’ (4.5 m) wide by 30’ (9 m) long immediately in front and back of all rolling equipment, during operation of the equipment.

     c) An area 15’ (4.5 m) wide by 15’ (4.5 m) long at any point where an area is being tack coated prior to the placement of pavement.

  3. As partial fulfillment of the above requirements, the contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000-watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

  4. A lighting plan must be submitted by the contractor and approved by the Engineer prior to the start of any nighttime work.

A. If the contractor places any out of specification mix in the project work area, the contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the contractor has to continue placing non-payment HMA, as directed by the Engineer, to make the surfaces safe for aircraft operations, the contractor shall do so to the satisfaction of the Engineer. It is the contractor's responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs.

**PART 5 – MATERIAL ACCEPTANCE**

- **403-5.1 – Acceptance Sampling and Testing.** Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the contractor except that coring as required in this section shall be completed and paid for by the contractor.
A. Testing organizations performing these tests shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations.

1. Hot Mixed Asphalt. Plant-produced HMA shall be tested for air voids and stability and flow on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D979.

1) A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

2) Where more than one plant is simultaneously producing HMA for the job, the lot sizes shall apply separately for each plant.

   a) **Sampling.** Each lot will consist of four equal sublots. Sufficient HMA for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D3665. Samples will be taken in accordance with ASTM D979.

      1) The sample of HMA may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the JMF.

   b) **Testing.** Sample specimens shall be tested for stability and flow in accordance with ASTM D6927. Air voids will be determined by the Engineer in accordance with ASTM D3203. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D6926 at the number of blows required by paragraph 403-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test specimens prepared from the same sample. The manual hammer in ASTM D6926 shall be used.

      1) Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D2726 or ASTM D6752 using the procedure for laboratory-prepared thoroughly dry specimens for use in computing air voids and pavement density.

      2) For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each sublot in accordance with ASTM D2041. The value used in the air voids computation for each sublot shall be based on theoretical maximum specific gravity measurement for the sublot.

      3) The stability and flow for each sublot shall be computed by averaging the results of all test specimens representing that sublot.

   c) **Acceptance.** Acceptance of plant produced HMA for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 403-5.1.
2. In-place HMA. HMA placed in the field shall be tested for mat and joint density on a lot basis. A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

   a) **Mat Density.** The lot size shall be the same as that indicated in paragraph 403-5.1a The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. Cores for mat density shall not be taken closer than 1’ (30 cm) from a transverse or longitudinal joint.

   b) **Joint Density.** The lot size shall be the total length of longitudinal joints constructed by a lot of HMA as defined in paragraph 403-5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. All cores for joint density shall be taken centered on the joint. The minimum core diameter for joint density determination shall be 5” (125 mm).

   c) **Sampling.** Samples shall be neatly cut with a diamond core drill bit. Samples will be taken in accordance with ASTM D979. The minimum diameter of the sample shall be 5” (125 mm). Samples that are defective, as a result of sampling, shall be discarded and another sample taken. The contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling. Laitance produced by the coring operation shall be removed immediately. The top most lift of bituminous material shall be completely bonded to the underlying layers of bituminous material. If any of the cores reveal that the surface is not bonded to the bituminous layer immediately below the surface, then additional cores shall be taken as directed by the Engineer in accordance with paragraph 403-5.1b to determine the extent of any delamination. All delaminated areas shall be completely removed by milling to the limits and depth and replaced as directed by the Engineer at no additional cost.

   d) **Testing.** The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D2726 or ASTM D6752. Samples will be taken in accordance with ASTM D979. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each subplot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 403-5.1a(2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

   e) **Acceptance.** Acceptance of field placed HMA for mat density will be determined by the Engineer in accordance with the requirements of paragraph 403-5.2B1. Acceptance for joint density will be determined by the Engineer in accordance with the requirements of paragraph 403-5.2B2.

3. **Partial Lots HMA.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.
a) The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, n = 5 or n = 6, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, n = 3.

403-5.2 – Acceptance Criteria.

A. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement and test results:
   a) Air Voids
   b) Mat density
   c) Joint density
   d) Thickness
   e) Smoothness
   f) Grade
   g) Stability
   h) Flow

1. Mat density will be evaluated for acceptance in accordance with paragraph 403-5.2B1. Stability and flow will be evaluated for acceptance in accordance with paragraph 403-5.1. Joint density will be evaluated for acceptance in accordance with paragraph 403-5.2B2.

2. Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 403-5.2B3. Acceptance for smoothness will be based on the criteria contained in paragraph 403-5.2B4. Acceptance for grade will be based on the criteria contained in paragraph 403-5.2B5.

3. The Engineer may at any time reject and require the contractor to dispose of any batch of HMA which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

B. Acceptance Criteria.

1. Mat Density. Acceptance of each lot of plant produced material for mat density shall be based on the average of all of the densities taken from the sublots. If the average mat density of the lot so established equals or exceeds 96%, the lot shall be acceptable. If the average mat density of the lot is below 96%, the lot shall be removed and replaced at the contractor’s expense.

2. Joint Density. Acceptance of each lot of plant produced HMA for joint density shall be based on the average of all of the joint densities taken from the sublots. If the average joint density of the lot so established equals or exceeds 94%, the lot shall be acceptable. If the average joint density of the lot is less than 94%, the contractor shall stop production and evaluate the method of
compacting joints. Production may resume once the reason for poor compaction has been determined and appropriate measures have been taken to ensure proper compaction.

3. **Thickness.** Thickness of each course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each subplot for density measurement. The maximum allowable deficiency at any point shall not be more than 1/4" (6 mm) less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where thickness deficiency exceeds the specified tolerances, the lot or subplot shall be corrected by the contractor at his expense by removing the deficient area and replacing with new pavement. The contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

4. **Smoothness.** The final surface shall be free from roller marks. After final rolling, but not later than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The contractor shall furnish paving equipment and employ methods that produce a surface for each pavement lot such that the finished surface course of the pavement shall not vary more than 1/4" (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface course smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the surface course, full depth removal and replacement of surface course corrections shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified. The contractor shall apply a surface treatment per Item P-608 to all areas that have been subject to grinding as directed by the Engineer.

   a) **Transverse measurements.** Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50' (15m) or more often as determined by the Engineer.

      1) Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4" (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 403-4.13 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

      2) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50' (15m) or more often if directed by the Engineer. Deviations on final surface course >
1/4” (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 403-4.13 or by removing and replacing full depth of surface course. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

3) **Longitudinal measurements.** Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20’ (6m); and the third points of paving lanes when widths of paving lanes are 20’ (6m) or greater. The finished surface shall not vary more than 1/4” (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4” (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 403-4.13 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions, then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

5. **Grade.** Grade shall be evaluated on the first day of placement and then every lot to allow adjustments to paving operations if measurements do not meet specification requirements. The contractor must submit the survey data to the Engineer by the following day after measurements have been taken. The finished surface of the pavement shall not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2” (12 mm). The finished grade of each lot will be determined by running levels at intervals of 50’ (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50’ (15 m)) to determine the elevation of the completed pavement. The contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the contractor to the Engineer. The lot size shall be 2,000 square yards (square meters). When more than 15% of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates 3/4” (19 mm) or more from planned grade, the contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 square yard (12.5 sq m). The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130” (2 and 3.5 mm) wide. The peaks and ridges shall be approximately 1/32” (1 mm) higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. Areas in excess of 15 square yard (12.5 sq m) will require removal and replacement of the pavement in
accordance with the limitations noted above. Contractor shall apply a surface treatment per P-608 to all areas that have been subject to grinding.

C. **Density Outliers.** If the tests within a lot include a very large or a very small value that appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E178, at a significance level of 5%, to determine if this value should be discarded.

- **403-5.3 – Resampling Pavement for Mat Density.**
  A. **General.** Resampling of a lot of pavement will only be allowed for mat density and then, only if the contractor requests same in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 403-5.1. Only one resampling per lot will be permitted.
    1. A redefined mat density shall be calculated for the resampled lot. The number of tests used to calculate the redefined mat density shall include the initial tests made for that lot plus the retests.
    2. The cost for resampling and retesting shall be borne by the contractor.
  B. **Payment for Resampled Lots.** The redefined mat density for a resampled lot shall be used to evaluate the acceptance of that lot in accordance with paragraph 403-5.2.
  C. **Outliers.** Check for outliers in accordance with ASTM E178, at a significance level of 5%

- **403-5.4 – Leveling Course.** Any course used for trueing and leveling shall meet the aggregate gradation in Table 3, paragraph 403-3.2. The trueing and leveling course shall meet the requirements of paragraph 403-3.2, 403-5.1 for air voids and for stability and flow, but shall not be subject to the density requirements of paragraph 403-5.1. The leveling course shall be compacted with the same effort used to achieve density of the test section. The trueing and leveling course shall not exceed the maximum lift thickness associated with each gradation in Table 3, paragraph 403-3.2. The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.

**PART 6 – CONTRACTOR QUALITY CONTROL**

- **403.6.1 – General.** The contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 403-6.3, including but not limited to:
  1. Mix Design
  2. Aggregate Grading
  3. Quality of Materials
  4. Stockpile Management
  5. Proportioning
  6. Mixing and Transportation
  7. Placing and Finishing
  8. Joints
  9. Compaction
  10. Surface smoothness
  11. Personnel
  12. Laydown plan
A. The contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 403-6.3. As a part of the process for approving the contractor’s plan, the Engineer may require the contractor’s technician to perform testing of samples to demonstrate an acceptable level of performance.

B. No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

- 403-6.2 – Contractor Testing Laboratory. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications.

- 403-6.3 – Quality Control Testing. The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

A. Asphalt Content. A minimum of two asphalt content tests shall be performed per lot in accordance with ASTM D6307 or ASTM D2172 if the correction factor in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

B. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444 and ASTM C136, and ASTM C117.

C. Moisture Content of Aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

D. Moisture Content of HMA. The moisture content of the HMA shall be determined once per lot in accordance with ASTM D1461.

E. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the asphalt binder in the storage tank, the HMA at the plant, and the HMA at the job site.

F. In-Place Density Monitoring. The contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.

G. Additional Testing. Any additional testing that the contractor deems necessary to control the process may be performed at the contractor’s option.

H. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

- 403-6.4 – Sampling. When directed by the Engineer, the contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the contractor. All sampling shall be in accordance with standard procedures specified.

- 403-6.5 – Control Charts. The contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each sublot will be calculated and monitored by the Quality Control laboratory.
A. Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the contractor's test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor's projected data during production indicates a problem and the contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

1. **Individual Measurements.** Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation, asphalt content, and VMA. The control charts shall use the JMF target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

<table>
<thead>
<tr>
<th>Control Chart Limits For Individual Measurements</th>
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<tbody>
<tr>
<td><strong>Sieve</strong></td>
</tr>
<tr>
<td>3/4&quot; (19 mm)</td>
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<tr>
<td>1/2&quot; (12 mm)</td>
</tr>
<tr>
<td>3/8&quot; (9 mm)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
</tr>
<tr>
<td>No. 50 (0.30 mm)</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
</tr>
<tr>
<td>Asphalt Content</td>
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<tr>
<td>VMA</td>
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</tbody>
</table>

2. **Range.** Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

<table>
<thead>
<tr>
<th>Control Chart Limits Based On Range</th>
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<tbody>
<tr>
<td><strong>Sieve</strong></td>
</tr>
<tr>
<td>1/2&quot; (12 mm)</td>
</tr>
<tr>
<td>3/8&quot; (9 mm)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
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<tr>
<td>No. 50 (0.30 mm)</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
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<tr>
<td>Asphalt Content</td>
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</tbody>
</table>

3. **Corrective Action.** The contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

a) One (1) point falls outside the Suspension Limit line for individual measurements or range; or
b) Two (2) points in a row fall outside the Action Limit line for individual measurements.

- **403-6.6 – Quality Control Reports.** The contractor shall maintain records and shall submit reports of quality control activities daily.

**PART 7 – METHOD OF MEASUREMENT**

- **403-7.1 – Measurement.** HMA pavement shall be measured by the number of tons (kg) of HMA used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

**PART 8 – BASIS OF PAYMENT**

- **403-8.1 – Payment.** Payment for a lot of HMA meeting all acceptance criteria as specified in paragraph 403-5.2 shall be made at the contract unit price per ton (kg) for HMA. The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

**TESTING REQUIREMENTS**

<table>
<thead>
<tr>
<th>AASHTO M156</th>
<th>Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C29</td>
<td>Standard Test Method for Bulk Density (&quot;Unit Weight&quot;) and Voids in Aggregate</td>
</tr>
<tr>
<td>ASTM C88</td>
<td>Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
</tr>
<tr>
<td>ASTM C117</td>
<td>Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing</td>
</tr>
<tr>
<td>ASTM C127</td>
<td>Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM C136</td>
<td>Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates</td>
</tr>
<tr>
<td>ASTM C183</td>
<td>Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement</td>
</tr>
<tr>
<td>ASTM C566</td>
<td>Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying</td>
</tr>
<tr>
<td>ASTM D75</td>
<td>Standard Practice for Sampling Aggregates</td>
</tr>
<tr>
<td>ASTM D979</td>
<td>Standard Practice for Sampling Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D1073</td>
<td>Standard Specification for Fine Aggregate for Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D1074</td>
<td>Standard Test Method for Compressive Strength of Bituminous Mixtures</td>
</tr>
<tr>
<td>ASTM D1461</td>
<td>Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2041</td>
<td>Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM Standard</td>
<td>Description</td>
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<tr>
<td>ASTM D2172</td>
<td>Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D2489</td>
<td>Standard Practice for Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures</td>
</tr>
<tr>
<td>ASTM D2726</td>
<td>Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures</td>
</tr>
<tr>
<td>ASTM D2950</td>
<td>Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods</td>
</tr>
<tr>
<td>ASTM D3203</td>
<td>Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D3665</td>
<td>Standard Practice for Random Sampling of Construction Materials</td>
</tr>
<tr>
<td>ASTM D3666</td>
<td>Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials</td>
</tr>
<tr>
<td>ASTM D4125</td>
<td>Standard Test Methods for Asphalt Content of Bituminous mixtures by the Nuclear Method</td>
</tr>
<tr>
<td>ASTM D4791</td>
<td>Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate</td>
</tr>
<tr>
<td>ASTM D4867</td>
<td>Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures</td>
</tr>
<tr>
<td>ASTM D5444</td>
<td>Standard Test Method for Mechanical Size Analysis of Extracted Aggregate</td>
</tr>
<tr>
<td>ASTM D6307</td>
<td>Standard Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method</td>
</tr>
<tr>
<td>ASTM D6926</td>
<td>Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus</td>
</tr>
<tr>
<td>ASTM E11</td>
<td>Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves</td>
</tr>
<tr>
<td>ASTM E178</td>
<td>Standard Practice for Dealing with Outlying Observations</td>
</tr>
<tr>
<td>AASHTO T030</td>
<td>Standard Method of Test for Mechanical Analysis of Extracted Aggregate</td>
</tr>
<tr>
<td>AASHTO T110</td>
<td>Standard Method of Test for Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)</td>
</tr>
<tr>
<td>AASHTO T275</td>
<td>Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens.</td>
</tr>
<tr>
<td>Reference</td>
<td>Description</td>
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<tr>
<td>Asphalt Institute Handbook MS-26</td>
<td>Asphalt Binder</td>
</tr>
<tr>
<td>Asphalt Institute MS-2</td>
<td>Mix Design Manual, 7th Edition</td>
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### MATERIAL REQUIREMENTS

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<tbody>
<tr>
<td>ASTM D946</td>
<td>Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction</td>
</tr>
<tr>
<td>ASTM D4552</td>
<td>Standard Practice for Classifying Hot-Mix Recycling Agents</td>
</tr>
<tr>
<td>ASTM D6373</td>
<td>Standard Specification for Performance Graded Asphalt Binder</td>
</tr>
</tbody>
</table>

END OF SECTION 32 12 16.14
SECTION 32 12 16.15 – HOT MIX ASPHALT PAVEMENTS
(CALTRANS MIX)

PART 1 – GENERAL

1.1 SUMMARY
A. The Work under this section shall conform to Section 39 Hot Mix Asphalt Caltrans Standard Specifications, latest version as contracted, and as modified herein.
B. The Work under this Section consist of providing plant mix bituminous pavements for surface course of airfield shoulders, access roads, perimeter roads, stabilized base courses under Portland Cement Concrete Pavement, FAA Item P-501, and other pavements not subject to aircraft loading, as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES
A. FAA AC No. 150/5320-6 (current version), Airport Pavement Design and Evaluation.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. Section 02 41 19 – Surface Preparation FAA Item P-101.
D. Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603.
E. Section 32 12 13.19 – Bituminous Prime Coat FAA Item P-602.
F. Caltrans Standard Specifications, latest version as contracted.

1.3 SUBMITTALS
A. The contractor shall submit the following Plant Mix Bituminous Pavements information:
   1. Perform Hot Mix Asphalt Mix Design for HMA Type A, and submit Job Mix Formula and test results in accordance with Section 39 of Caltrans Standard specifications latest version as contracted, article 39-2.01A(3).
   2. Samples of aggregate and asphalt binder, quantity as required by testing laboratory including certified test results of aggregates and asphalt binder.
   3. Surface course hot mix asphalt paving plan for shoulders.

1.4 QUALITY CONTROL
A. The contractor shall be responsible for hiring an approved independent testing firm to perform HMA pavement Quality Control (QC) testing.
B. The contractor shall perform Quality Control testing and inspection to meet the requirement of Section 39 of the Caltrans Standard Specifications, latest version as contracted, and as modified herein.

PART 2 – PRODUCTS

2.1 AGGREGATE
A. Aggregate gradation shall conform to Section 39 Caltrans Standard Specifications, latest version as contracted, Article 39-2.02B(4)(b), 1” HMA Type A.

B. Aggregate quality shall conform to Section 39 Caltrans Standard Specifications, latest version as contracted, Article 39-2.02B(4)(a), HMA Type A.

2.2 ASPHALT BINDER

A. Asphalt binder shall be PG 70-10 and shall comply with the requirements of Section 39-2.01B(3) Asphalt Binder of Caltrans Standard Specifications, latest version as contracted.

PART 3 – EXECUTION

3.1 HOT MIX ASPHALT PLACEMENT

A. The contractor shall prepare, spread and compact the paving courses in accordance with Section 39 of Caltrans Standard Specifications, latest version as contracted, and as modified herein.

3.2 TACK COAT

A. The contractor shall apply tack coat in accordance with Section 32 12 13.13 – Bituminous Tack Coat FAA Item P-603, and as modified herein, to all existing pavement surfaces both horizontal and at vertical interfaces, and between lifts of asphalt pavement.

3.3 PRIME COAT

A. The contractor shall apply prime coat in accordance with Section 32 12 13.19 – Bituminous Prime Coat FAA Item P-602, and as modified herein, to base course surface where shown on the plans.

3.4 JOINT SEALING FILLER

A. The contractor shall prepare all joints and cracks to be overlaid and filled in accordance with Section 02 41 19 – Surface Preparation FAA Item P-101.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. FAA Specifications as referenced in this section are included in Contract specifications.

PART 5 – MEASUREMENT AND PAYMENT

A. HMA surface course pavement shall be measured by the number of tons of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage. The recorded batch weights or truck scale weights (certified tags) shall be submitted to the Contract Manager or Inspector within 24 hours of completion of each paving shift, to receive payment.

B. Payment for HMA course pavement shall be made at the contract unit price per ton. The price shall be full compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, including tack coats and prime coat as required, and for all labor, equipment, tools, and incidentals necessary to complete the item.

C. Payment for existing joints and cracks preparation and filling will be made under respective bid items of Section 02 41 19 FAA Item P-101.

END OF SECTION 32 12 16.15
SECTION 32 12 36.13 – EMULSIFIED ASPHALT SEAL COAT

PART 1 – GENERAL

1.1 SUMMARY
   A. The Work under this Section consist of application of asphalt sealer on the existing bituminous pavement surface as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES
   A. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
   B. FAA Specification Item P-608, Bituminous Sealer, and as modified herein.
   C. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-608.

1.3 SUBMITTALS
   A. The contractor shall submit the following bituminous sealer information:

1.4 QUALITY ASSURANCE
   A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-608, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS
   A. Bituminous material shall conform to FAA Specification Item P-608, and as modified herein.

PART 3 – EXECUTION

   A. The contractor shall apply bituminous sealer to the surface of existing bituminous pavement in accordance with FAA Specification Item P-608, and as modified herein.

   B. INCLUDED FAA SPECIFICATIONS
   C. Item P-608, Bituminous Pavement Sealer.

PART 4 – MEASUREMENT AND PAYMENT

   A. Bituminous pavement sealer shall be measured and paid for in accordance with FAA Specification Item P-608 and as modified herein.
FAA ITEM P-608 EMULSIFIED ASPHALT SEAL COAT

PART 1 – DESCRIPTION

- 608-1.1 – This item shall consist of the application of an emulsified asphalt surface treatment composed of an emulsion of natural and refined asphalt materials, water and, if specified, a polymer additive, for taxiways and runways with the application of a suitable aggregate to maintain adequate surface friction; and airfield secondary and tertiary pavements including low-speed taxiways, shoulders, overruns, roads, parking areas, and other general applications with or without aggregate applied. Emulsified Asphalt Seal Coat products assist in pavement preservation through reducing the rate of pavement oxidation. The emulsified asphalt surface treatment shall be applied in accordance with these specifications, and as shown on the plans or as directed by the Engineer.

- 608-1.2 – Quantities of materials per square yard (square meter). The approximate amounts of materials per square yard (square meter) for the asphalt surface treatment shall be as provided in the table for the treatment area(s) at the specified dilution rate(s) as noted on the plans. The actual application rates will vary within the range specified to suit field conditions and will be recommended by the manufacturer’s representative and approved by the Engineer from the test area/sections evaluation.

<table>
<thead>
<tr>
<th>Application Rate</th>
<th>Dilution Rate</th>
<th>Quantity of Emulsion gal/yd² (l/m²)</th>
<th>Quantity of Aggregate lb/yd² (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:1</td>
<td>0.10-0.15 (0.45-0.68)</td>
<td>0.20-0.50 (0.11-0.27)</td>
</tr>
</tbody>
</table>

PART 2 – MATERIALS

- 608-2.1 – Aggregate. The aggregate material shall be a dry, clean, dust and dirt free, sound, durable, angular shaped manufactured specialty sand, such as that used as an abrasive, with a Mohs hardness of 6 to 8. The contractor shall submit manufacturer’s technical data and a manufacturer’s certification indicating that the specialty sand meets the requirements of the specification to the Engineer prior to start of construction. The sand must be approved for use by the Engineer and shall meet the following gradation limits when tested in accordance with ASTM C136 and ASTM C117:

<table>
<thead>
<tr>
<th>Aggregate Material Gradation Requirements</th>
<th>Sieve Designation (square openings)</th>
<th>Percentage by Weight Retained Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. 8 (2.38 mm)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No. 16 (1.19 mm)</td>
<td>0-8</td>
</tr>
<tr>
<td></td>
<td>No. 20 (0.84 mm)</td>
<td>0-28</td>
</tr>
<tr>
<td></td>
<td>No. 30 (0.60 mm)</td>
<td>20-50</td>
</tr>
<tr>
<td></td>
<td>No. 40 (0.42 mm)</td>
<td>10-55</td>
</tr>
<tr>
<td></td>
<td>No. 50 (0.30 mm)</td>
<td>0-30</td>
</tr>
<tr>
<td></td>
<td>No. 70 (0.21 mm)</td>
<td>0-5</td>
</tr>
<tr>
<td></td>
<td>No. 100 (0.15 mm)</td>
<td>0-2</td>
</tr>
<tr>
<td></td>
<td>No. 200 (0.07 mm)</td>
<td>0-2</td>
</tr>
</tbody>
</table>

1 The terms seal coat and sealer binder and asphalt material are interchangeable throughout this specification. The term emulsified asphalt means an emulsion of natural and refined asphalt materials.
A. The contractor shall provide a certification showing particle size analysis and properties of the material delivered for use on the project. The contractor’s certification may be subject to verification by testing the material delivered for use on the project.

608-2.2 – Asphalt material. The contractor shall furnish the vendor’s certified test reports for the emulsified asphalt, in its concentrated form, to the Engineer, showing that the material meets the following properties:

Concentrated Asphalt Material Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Specification</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saybolt Furol Viscosity at 77°F (25°C)</td>
<td>ASTM D244</td>
<td>20 – 100 seconds</td>
</tr>
<tr>
<td>Residue by Distillation or Evaporation</td>
<td>ASTM D244</td>
<td>57% minimum</td>
</tr>
<tr>
<td>Sieve Test</td>
<td>ASTM D244</td>
<td>0.1% maximum</td>
</tr>
<tr>
<td>24-hour Stability</td>
<td>ASTM D244</td>
<td>1% maximum</td>
</tr>
<tr>
<td>5-day Settlement Test</td>
<td>ASTM D244</td>
<td>5.0% maximum</td>
</tr>
<tr>
<td>Particle Charge ¹</td>
<td>ASTM D244</td>
<td>Positive 6.5 maximum pH</td>
</tr>
</tbody>
</table>

¹ pH may be used in lieu of the particle charge test which is sometimes inconclusive in slow setting, asphalt emulsions.

A. The asphalt material concentrate must be diluted with heated water prior to application. The asphalt material, when diluted in the volumetric proportion of one part concentrated asphalt material to one-part hot water shall have the following properties:

One-to-One Dilution Emulsion Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Specification</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Ready-to-Apply Form, one part concentrate to one part water, by volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saybolt Furol Viscosity at 77°F (25°C)</td>
<td>ASTM D244</td>
<td>10 – 50 seconds</td>
</tr>
<tr>
<td>Residue by Distillation or Evaporation</td>
<td>ASTM D244</td>
<td>28.5% minimum</td>
</tr>
<tr>
<td>Pumping Stability ¹</td>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</table>

¹ Pumping stability is tested by pumping one pint (475 ml) of seal coat diluted one (1) part concentrate to one (1) part water, at 77°F (25°C), through a 1/4-inch (6 mm) gear pump operating 1750 rpm for 10 minutes with no significant separation or coagulation.

B. The asphalt material base residue shall contain not less than 20% gilsonite, or uintaite and shall not contain any tall oil pitch or coal tar material. The material shall be compatible with asphaltic concrete, and have a 5-year minimum proven performance record at airports with similar climatic conditions. Curing time, under recommended application conditions, shall not exceed eight (8) hours.
Emulsion Residue by Distillation or Evaporation Tests

<table>
<thead>
<tr>
<th>Properties</th>
<th>Specification</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity at 275°F (135°C)</td>
<td>ASTM D4402</td>
<td>1750 cts maximum</td>
</tr>
<tr>
<td>Solubility in 1, 1, 1 trichloroethylene</td>
<td>ASTM D2042</td>
<td>97.5% minimum</td>
</tr>
<tr>
<td>Penetration</td>
<td>ASTM D5</td>
<td>50 dmm minimum</td>
</tr>
<tr>
<td>Asphaltenes</td>
<td>ASTM D2007</td>
<td>15% minimum</td>
</tr>
<tr>
<td>Saturates</td>
<td>ASTM D2007</td>
<td>15% maximum</td>
</tr>
<tr>
<td>Polar Compounds</td>
<td>ASTM D2007</td>
<td>25% minimum</td>
</tr>
<tr>
<td>Aromatics</td>
<td>ASTM D2007</td>
<td>15% minimum</td>
</tr>
</tbody>
</table>

C. The contractor shall furnish vendor’s certified test reports showing that the material is the type, grade and quality specified for each load of asphalt material delivered to the project. The certification shall also show the shipment number, refinery, consignee, destination, contract number and date of shipment. The test reports and certification shall be delivered to the Engineer before permission is granted to use the material. The furnishing of the vendor’s certified test report for the asphalt material shall not be interpreted as a basis for final acceptance. The manufacturer’s material test report certification may be subject to verification by testing the material delivered for use on the project.

D. The asphalt material storage and handling temperature shall be between 50°F - 160°F (10°C - 70°C) and the material shall be protected from freezing, or whenever outside temperature drops below 40°F (4°C) for prolonged time periods.

➢ 608-2.3 – Water. Water used in making the emulsion shall be potable, free from harmful soluble salts and chemicals, and at least 100°F (38°C).

PART 3 – APPLICATION RATE

➢ 608-3.1 – Material performance for runway and high-speed taxiway projects. The contractor shall submit to the Engineer friction tests, from previous airport projects which used the seal coat materials in a similar environment, in accordance with AC 150/5320-12, at 40 or 60 mph (65 or 95 km/h) wet, showing, as a minimum; friction value of pavement surface prior to sealant application; two values, tested between 24 and 96 hours after application, with a minimum of 24 hours between tests; and one value tested at no less than 180 days or greater than 360 days after the application. The results of the two tests between 24 and 96 hours shall indicate friction is increasing at a rate to obtain similar friction value of the pavement surface prior to application, and the long term test shall indicate no apparent adverse effect with time relative to friction values and existing pavement surface. The contractor shall submit to the Engineer a list of airports which meet the above requirements, as well as technical details on application rates, aggregate rates, and point of contact at these airports to confirm use and success of sealer with aggregate. Friction tests shall be submitted from no less than one of the airports on the list and each set of tests described above, must be from one project.

A. Seal coat material submittal without required friction performance will not be approved. Friction tests performed on this project cannot be used as a substitute of this requirement.

➢ 608-3.2 – Test areas and test sections. A qualified manufacturer’s representative shall be present in the field to assist the contractor in applying test areas and/or test sections to determine the optimum application rate of both emulsion and sand.
A. A test area and/or section shall be applied for each differing HMA pavement surface identified in the project. The test area(s) and/or test section(s) shall be used to determine the material application rate(s) of both emulsion and sand prior to full production. The same equipment and method of operation shall be utilized on the test area(s) and/or test section(s) as will be utilized on the remainder of the work.

1. **For taxiway, taxilane and apron surfaces.** Prior to full application, the contractor shall place test areas at varying application rates as specified by the manufacturer’s representative and Engineer to determine appropriate application rate(s). The test areas will be located on representative section(s) of the pavement to receive the asphalt surface treatment designated by the Engineer.

2. **For runway and high speed exit taxiway surfaces.** Prior to full application, the contractor shall place a series of test sections a minimum of 300’ (90 m) long by 12’ (3.6 m) wide, or width of anticipated application, whichever is greater, at varying application rates as stipulated by the manufacturer’s representative and Engineer to determine appropriate application rate(s). The area to be tested will be located on a representative section of the pavement to receive the asphalt surface treatment designated by the Engineer. Before beginning the test section(s), the skid resistance of the existing pavement shall be determined for each test section with a continuous friction measuring equipment (CFME). The skid resistance test after application shall be at approximately the same location as the test done on the existing pavement. The contractor may begin testing the skid resistance of runway and high speed exit taxiway test sections after application of the asphalt surface treatment has fully cured. Aircraft shall not be permitted on the runway or high speed exit taxiway test sections for a minimum of 24 hours and until such time as the contractor validates that its surface friction meets AC 150/5320-12. The results of the friction evaluation meet or exceed the Maintenance Planning levels provided in Table 3-2, “Friction Level Classification for Runway Pavement Surfaces,” in AC 150/5320-12, Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces, when tested at speeds of 40 and 60 mph (65 and 95 km/h) wet with approved CFME.

B. If the test section should prove to be unsatisfactory, necessary adjustments to the application rate, placement operations, and equipment shall be made. Additional test sections shall be placed and additional skid resistance tests performed and evaluated. Full production shall not begin without the Engineer’s approval of an appropriate application rate(s). Acceptable test sections shall be paid for in accordance with paragraph 608-8.1.

**PART 4 – CONSTRUCTION METHODS**

- **608-4.1 – Worker safety.** The seal coat product shall be handled with caution. The contractor shall obtain a Material Safety Data Sheet (MSDS) for both the asphalt emulsion product and sand and require workmen to follow the manufacturer’s recommended safety precautions.

- **608-4.2 – Weather limitations.** The asphalt emulsion shall be applied only when the existing pavement surface is dry and when the weather is not foggy, rainy, or when the wind velocity will prevent the uniform application of the material. No material shall be applied when dust or sand is blowing or when rain is anticipated within 8 hours of application completion. The atmospheric temperature and the pavement surface temperature shall both be above 60°F (16°C) and rising. During application, account for wind drift. Cover existing buildings, structures, runway edge lights, taxiway edge lights, informational signs, retro-reflective marking and in-pavement duct markers as necessary to protect against overspray before applying the emulsion. Should emulsion get on any light or marker fixture, promptly clean the fixture. If cleaning is not satisfactory to the Engineer, the contractor shall replace any light, sign or marker with equal equipment at no cost to the Owner.
608-4.3 – **Equipment and tools.** The contractor shall furnish all equipment, tools, and machinery necessary for the performance of the work.

**A. Pressure distributor.** The emulsion shall be applied with a manufacturer-approved computer rate-controlled asphalt distributor. The equipment shall be in good working order and contain no contaminants or diluents in the tank. Spreader bar tips must be clean, free of burrs, and of a size to maintain an even distribution of the emulsion. Any type of tip or pressure source is suitable that will maintain predetermined flow rates and constant pressure during the application process with application speeds under 8 miles per hour (13 km per hour) or 700’ per minute (213 m per minute). Test the equipment under pressure for leaks and to ensure it is in good working order before use.

1. The distributor truck shall be equipped with a 12-foot (3.7-m), minimum, spreader bar with individual nozzle control. The distributor truck shall be capable of specific application rates in the range of 0.05 to 0.25 gallons per square yard (0.15 to 0.80 liters per square meter). These rates shall be computer-controlled rather than mechanical. The distributor truck shall have an easily accessible thermometer that constantly monitors the temperature of the emulsion, and have an operable mechanical tank gauge that can be used to cross-check the computer accuracy.

2. A distributor truck shall be provided, if necessary, equipped to effectively heat and mix the material to the required temperature prior to application. Heating and mixing shall be done in accordance with the manufacturer's recommendations. Care shall be taken not to overheat or over mix the material.

3. The distributor shall be equipped to hand spray the emulsion in areas identified either on the plans or by the Engineer.

**B. Aggregate spreader.** The asphalt distributor truck will be equipped with an aggregate spreader mounted to the distributor truck that can apply sand to the emulsion in a single pass operation without driving through wet emulsion. The aggregate spreader shall be equipped with a variable control system capable of uniformly distributing the sand at the specified rate at varying application widths and speeds. The sander shall have a minimum hopper capacity of at least 3,000 pounds (1361 kg) of sand. Push-type hand sanders will be allowed for use around lights, signs and other obstructions.

**C. Power broom/blower.** A power broom and/or blower shall be provided for removing loose material from the surface to be treated.

**D. Equipment calibration.** The contractor shall calibrate the equipment using either of the following procedures:

1. **First procedure.** The contractor shall furnish a State Calibration Certification for the emulsified asphalt distributor, from any state providing that service, or other acceptable agency certification approved by the Engineer, and the calibration date shall have been within 6 months of the contract award, or up to 12 months if supporting documents substantiate continuous work using the same distributor.

2. **Second procedure.** The contractor shall furnish all equipment, materials and labor necessary to calibrate the emulsified asphalt distributor and the aggregate spreader. Perform all calibrations with the approved job materials and prior to applying the specified coatings to the prepared surface. Perform calibration of the emulsified asphalt distributor in accordance with ASTM D2995. Perform work to calibrate the tank and measuring devices of the distributor. Perform inspection and calibration at the beginning of the work and at least once a day during construction.
608-4.4 – **Preparation of asphalt pavement surfaces.** Clean pavement surface immediately prior to placing the seal coat by sweeping, flushing well with water leaving no standing water, or a combination of both, so that it is free of dust, dirt, grease, vegetation, oil or any type of objectionable surface film. Remove oil or grease that has not penetrated the asphalt pavement by scraping or by scrubbing with a detergent, then wash thoroughly with clean water. After cleaning, treat these areas with the oil spot primer. Any additional surface preparation, such as crack repair, shall be performed in accordance 02 41 19, Surface Preparation P-101.

A. **New asphalt pavement surfaces.** Allow new asphalt pavement surfaces to cure so that there is no concentration of oils on the surface. A period of at least 30 days at 70°F (21°C) daytime temperatures shall elapse between the placement of a hot mixed asphalt concrete surface course and the application of the surface treatment.

   1. Perform a water-break-free test to confirm that the surface oils have degraded and dissipated. (Cast approximately one gallon (4 liters) of clean water out over the surface. The water should sheet out and wet the surface uniformly without crawling or showing oil rings.) If signs of crawling or oil rings are apparent on the pavement surface, additional time must be allowed for additional curing and retesting of the pavement surface prior to treatment.

608-4.5 – **Emulsion mixing.** The application emulsion shall be obtained by blending asphalt material concentrate, water and polymer, if specified. Always add heated water to the asphalt material concentrate, never add asphalt material concentrate to heated water. Mix one-part heated water to one-part asphalt material concentrate, by volume.

A. If polymer is required, add 1% polymer, by volume, to the emulsion mix. If the polymer is added to the emulsion mix at the plant, submit weigh scale tickets to the Engineer. As an option, the polymer may be added to the emulsion mix at the job site provided the polymer is added slowly while the circulating pump is running. The mix must be agitated for a minimum of 15 minutes or until the polymer is mixed to the satisfaction of the Engineer.

608-4.6 – **Application of asphalt emulsion.** The asphalt emulsion shall be applied using a pressure distributor upon the properly prepared, clean and dry surface at the application rate recommended by the manufacturer’s representative and approved by the Engineer from the test area/sections evaluation for each designated treatment area. The asphalt emulsion should be applied at a temperature between 130°F (54°C) and 160°F (70°C) or in accordance with the manufacturer’s recommendation.

A. Pavement surfaces which have excessive runoff of seal coat due to excessive amount of material being applied or excessive surface grade shall be treated in two or more applications to the specified application rate at no additional cost to the Owner. Each additional application shall be performed after the prior application of material has penetrated into the pavement.

B. If low spots and depressions greater than 1/2" (12 mm) in depth in the pavement surface cause ponding or puddling of the applied materials, the pavement surface shall be broomed with a broom drag. Brooming shall continue until the pavement surface is free of any pools of excess material. Ponding and/or puddling shall not cause excessive pavement softening and/or additional distress. The Engineer shall inspect and approve areas after brooming.

C. During all applications, the surfaces of adjacent structures shall be protected to prevent their being spattered or marred. Asphalt materials shall not be discharged into borrow pits or gutters or on the airport area.

608-4.7 – **Application of aggregate material.** Immediately following the application of the asphalt emulsion or as directed by the Engineer, sand at the rate recommended by the manufacturer’s representative and approved by the Engineer from the test area/sections evaluation for each designated...
application area, shall be spread uniformly over the asphalt emulsion. The aggregate shall be spread to
the same width of application as the asphalt material and shall not be applied in such thickness as to
cause blanketing.

A. Sprinkling of additional aggregate material, and spraying additional asphalt material over areas that
show up having insufficient cover or bitumen, shall be done by hand whenever necessary. In areas
where hand work is necessitated, the sand shall be applied before the sealant begins to break.

B. Sanding shall be performed to prevent excessive amounts of sand from accumulating on the
pavement prior to the emulsion being applied. The contractor shall clean areas with excess or loose
sand and dispose of off airport property.

PART 5 – QUALITY CONTROL

- **608-5.1 – Manufacturer’s representation.** The manufacturer’s representative shall have knowledge of
  the material, procedures, and equipment described in the specification and shall be responsible for
determining the application rates and shall oversee the preparation and application of the seal coat
product. Documentation of the manufacturer representative’s experience and knowledge for applying
the seal coat product shall be furnished to the Engineer a minimum of 10 work days prior to placement
of the test sections. The cost of the manufacturer’s representative shall be included in the bid price.

- **608-5.2 – Contractor qualifications.** The contractor shall provide the Engineer contractor qualifications
  for applicators, personnel and equipment. The contractor shall also provide, from the seal coat
manufacturer, documentation that the contractor is certified to apply the seal coat and to have made at
least 3 applications similar to this project in the past 2 years.

PART 6 – MATERIAL ACCEPTANCE

- **608-6.1 – Friction tests.** Friction tests in accordance with AC 150/5320-12, Measurement, Construction,
  and Maintenance of Skid-Resistant Airport Pavement Surfaces, shall be accomplished on all runway and
  high-speed taxiways that have received a seal coat. The contractor shall coordinate testing with the
Engineer. Each test includes performing friction tests at 40 mph and 60 mph (65 or 95 km/h) both wet,
15’ (4.5 m) to each side of runway centerline. Friction test shall be run within 30 days prior to application
of the seal coat to runway and/or high-speed taxiways and after application of the seal coat. The Engineer
shall be present for testing. The contractor shall provide a written report of friction test results.

PART 7 – METHOD OF MEASUREMENT

- **608-7.1 – Asphalt surface treatment.** The quantity of asphalt surface treatment shall be measured by
  the square yards of material applied in accordance with the plans and specifications and accepted by the
Engineer.

  A. The contractor must furnish the Engineer with the certified weigh bills when materials are received
for the asphalt material used under this contract. The contractor must not remove material from the
tank car or storage tank until initial amounts and temperature measurements have been verified.

PART 8 – BASIS OF PAYMENT

- **608-8.1 – Payment.** Payment shall be made at the contract unit price per square yards for the asphalt
  surface treatment applied and accepted by the Engineer, and the contract unit price sum for runway
friction testing. This price shall be full compensation for all surface preparation, furnishing all materials,
delivery and application of these materials, for all labor, equipment, tools, and incidentals necessary to
complete the item, and any costs associated with furnishing a qualified manufacturer’s representative to
assist with test strips.
## TESTING REQUIREMENTS

<table>
<thead>
<tr>
<th>ASTM C117</th>
<th>Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D5</td>
<td>Standard Test Method for Penetration of Bituminous Materials</td>
</tr>
<tr>
<td>ASTM D244</td>
<td>Standard Test Methods and Practices for Emulsified Asphalts</td>
</tr>
<tr>
<td>ASTM D2995</td>
<td>Standard Practice for Estimating Application Rate of Bituminous Distributors</td>
</tr>
<tr>
<td>ASTM D5340</td>
<td>Standard Test Method for Airport Pavement Condition Index Surveys</td>
</tr>
<tr>
<td>AC 150/5320-12</td>
<td>Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces</td>
</tr>
<tr>
<td>AC 150/5320-17</td>
<td>Airfield Pavement Surface Evaluation and Rating (PASER) Manuals</td>
</tr>
<tr>
<td>AC 150/5380-6</td>
<td>Guidelines and Procedures for Maintenance of Airport Pavements</td>
</tr>
</tbody>
</table>

END OF SECTION 32 12 36.13
SECTION 32 12 73 – JOINT SEALANTS FOR CONCRETE PAVEMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consist of providing and installing a resilient and adhesive joint sealing filler capable of effectively sealing joints and cracks in pavements as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
B. FAA Specification Item P-605, Joint Sealants for Concrete Pavements, and as modified herein.
C. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item P-605.

1.3 SUBMITTALS

A. The contractor shall submit the following resilient and adhesive joint sealing filler information:
   1. Test results from a certified laboratory for Joint sealing material as required by plans and these specifications.
   2. Manufacturer’s certificate of compliance for backup and bond breaker as required by plans and these specifications.

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-605, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Joint sealing, backup, and bond breaker material shall conform to FAA Specification Item P-605, and as modified herein.

PART 3 – EXECUTION

A. The contractor shall install joint sealers in accordance with FAA Specification Item P-605, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-605, Joint Sealants for Concrete Pavements.

PART 5 – MEASUREMENT AND PAYMENT

A. Unless otherwise indicated in FAA Specification Item P-605 and as modified herein, there will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.
FAA ITEM P-605 JOINT SEALANTS FOR CONCRETE PAVEMENTS

PART 1 – DESCRIPTION

- 605-1.1 – This item shall consist of providing and installing a resilient and adhesive joint sealing material capable of effectively sealing joints and cracks in rigid pavements.

PART 2 – MATERIALS

- 605-2.1 – Joint Sealers. Joint Sealant for Concrete pavement. Joint sealing material shall meet the requirements of:

  A. Each lot or batch of sealant shall be delivered to the jobsite in the manufacturer’s original sealed container. Each container shall be marked with the manufacturer’s name, batch or lot number, the safe heating temperature, and shall be accompanied by the manufacturer’s certification stating that the sealant meets the requirements of this specification.

- 605-2.2 – Backer Rod. The material furnished shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant. The material shall have a water absorption of not more than 5% when tested in accordance with ASTM C509. The backer-rod material shall be 25% ± 5% larger in diameter than the nominal width of the crack.

- 605-2.3 – Backup Materials. Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5% of the sample weight when tested in accordance with ASTM C509. The backup material shall be 25 ±5% larger in diameter than the nominal width of the crack.

- 605-2.4 – Bond Breaking Tapes. Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8” (3 mm) wider than the nominal width of the joint and shall not bond to the joint sealant.

- 605-2.5 – Primer. Primer shall be as recommended by the manufacturer of the proposed sealant material.

PART 3 – CONSTRUCTION METHODS

- 605-3.1 – Time of Application. Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be above 50 °F at the time of installation of the poured joint sealing material. Do not apply sealant if moisture is observed in the joint.

  A. When used with P-606, such as light can installation, P-605 shall not be applied until the P-606 has fully cured.
B. If the pavement must be opened to traffic prior to placement of the sealant the contractor shall temporarily fill the joint with a jute or nylon rope immediately after the joint is sawed. The rope should be slightly larger than the joint and should be forced into the joint so that the top of the rope is 1/8" (3 mm) below the pavement surface. The rope shall be removed immediately prior to cleaning.

605-3.2 – Equipment. Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 15 days prior to use on the project.

A. Tractor-mounted routing tool. Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

B. Concrete saw. Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

C. Sandblasting Equipment. Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening should not exceed 1/4" (6 mm). The air compressor shall be portable and capable of furnishing not less than 150 cfm (71 L/s) and maintaining a line pressure of not less than 90 psi (621 kPa) at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1" (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

D. Waterblasting Equipment. Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1" (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi (kPa) at which the equipment is operating.

E. Hand Tools. Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces. Where spalled joint edges have not been repaired prior to any previous sealing, it may be necessary for contractor to employ other types of small tools for the repair work. Such tools should be carefully evaluated for potential spalling effects prior to approval for use.

F. Hot-poured Sealing Equipment. The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.
G. Two-component, Cold-applied, Machine Mix Sealing Equipment. Provide equipment used for proportioning, mixing, and installing Federal Specification SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of one (1) to one (1) by volume using pumps with an accuracy of ±5% for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 90°F (32°C). Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 10 to 60 gallons (37.8 to 189 L) per hour and through a range of application pressures from 50 to 1500 psi (345 kPa to 10.3 MPa) as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier’s instructions, and unaltered in any way without obtaining prior approval.

H. Two-component, Cold-applied, Hand-mix Sealing Equipment. Mixing equipment for Federal Specification SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer’s recommendations. Submit printed copies of manufacturer’s recommendations 30 days prior to use on the project where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

I. Cold-applied, Single-component Sealing Equipment. The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier’s instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications. Some ASTM D5893 sealants cure when exposed to moisture. When the sealant is moisture sensitive it is necessary to use Teflon-lined hoses to prevent the sealant from curing in the hoses.

605-3.3 – Preparation of Joints.

A. Sawing. All joints shall be sawed in accordance with specifications and plan details. Immediately after sawing the joint, the resulting slurry shall be completely removed from joint and adjacent area by flushing with a jet of water, and by use of other tools as necessary.

B. Sealing. Immediately before sealing, the joints shall be thoroughly cleaned of all remaining laitance, curing compound, filler, protrusions of hardened concrete, old sealant and other foreign material from the sides and upper edges of the joint space to be sealed. Cleaning shall be accomplished by sandblasting as specified in paragraph 605-3.2. The newly exposed concrete joint faces and the pavement surface extending a minimum of 1/2” (12 mm) from the joint edge shall be sandblasted clean. Sandblasting shall be accomplished in a minimum of two passes. One pass per joint face with the nozzle held at an angle directly toward the joint face and not more than 3” (75 mm) from it.
final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. The joint faces shall be surface dry when the seal is applied.

C. **Back-up Material.** When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

D. **Bond-breaking Tape.** Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond-breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

**605-3.4 – Installation of Sealants.** Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the Engineer before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

A. Immediately preceding, but not more than 50’ (15 m) ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/8” ±1/16” below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

B. The use of a backup material or bond breaker in the bottom of the joint to be filled is to control the depth of the sealant, to achieve the desired shape factor, and to support the sealant against indentation and sag. Backup materials and bond breakers should be compatible with the sealant should be compressible without extruding the sealant, and should recover to maintain contact with the joint faces when the joint is open

**605-3.5 – Inspection.** The contractor shall inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified at no additional cost to the airport.

**605-3.6 – Clean-up.** Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

**PART 4 – METHOD OF MEASUREMENT**

**605-4.1 – Measurement.** There will be no separate measurement for work under this section. All work shall be considered incidental to the respective contract bid items.

**PART 5 – BASIS OF PAYMENT**

**605-5.1 – Payment.** There will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.

**TESTING REQUIREMENTS**
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D 412</td>
<td>Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension</td>
</tr>
<tr>
<td>ASTM C 509</td>
<td>Elastomeric Cellular Preformed Gasket and Sealing Material</td>
</tr>
<tr>
<td>ASTM C 920</td>
<td>Standard Specification for Elastomeric Joint Sealants</td>
</tr>
<tr>
<td>ASTM D 1644</td>
<td>Test Methods for Nonvolatile Content of Varnishes</td>
</tr>
</tbody>
</table>

**MATERIAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 150/5340-30</td>
<td>Design and Installation Details for Airport Visual Aids</td>
</tr>
<tr>
<td>ASTM D 789</td>
<td>Standard Test Method for Determination of Relative Viscosity of Polyamide (PA)</td>
</tr>
<tr>
<td>ASTM D 1854</td>
<td>Jet-Fuel-Resistant Concrete Joint Sealer, Hot-Applied Elastic Type</td>
</tr>
<tr>
<td>ASTM D 3406</td>
<td>Joint Sealants, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements</td>
</tr>
<tr>
<td>ASTM D 3569</td>
<td>Joint Sealant, Hot-Applied, Elastometric, Jet-Fuel-Resistant Type, for Portland Cement Concrete Pavements</td>
</tr>
<tr>
<td>ASTM D 3581</td>
<td>Joint Sealant, Hot-Applied, Jet-Fuel-Resistant Type, for Portland Cement Concrete and Tar-Concrete Pavements</td>
</tr>
<tr>
<td>ASTM D 5893</td>
<td>Standard Specifications for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements</td>
</tr>
<tr>
<td>ASTM D 6690</td>
<td>Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements</td>
</tr>
<tr>
<td>FED SPEC SS-S-200E(2)</td>
<td>Sealants, Joint, Two-Component, Jet-Blast Resistant, Cold Applied</td>
</tr>
</tbody>
</table>

END OF SECTION 32 12 73
SECTION 32 13 13 – PORTLAND CEMENT CONCRETE PAVEMENT

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of Portland cement concrete (PCC) pavement with or without reinforcement prepared and constructed as shown on the Plans and as specified herein.

1.2 REFERENCES

A. Section 32 12 73 – Joint Sealing Filler (FAA Item P-605).
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. FAA Specification Item P-501 Portland Cement Concrete Pavement, and as modified herein.
D. American Society for Testing and Materials (ASTM) standards and tests, as referenced in P-501.

1.3 SUBMITTALS

A. Prior to commencing Work in this Section and delivery of materials to the job site, the contractor shall submit the following structural Portland cement concrete material information:

1. Test Results: The contractor shall submit all copies of certified test results on aggregates, cement, admixtures, joint material, steel reinforcement and curing material to the Engineer for review. These shall include retests for items that failed initial testing.
2. Reactivity test results of coarse and fine aggregate for deleterious reactivity with alkalis in the cement.
3. The contractor shall submit, to the Engineer, a concrete mix design including the proportions and source of materials, admixtures, and Flexural Strength.
4. PCC pavement Paving Plan.
5. Pre-cast panel shop drawings

1.4 QUALITY CONTROL

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-501, and as modified herein.

b. The number of days for minimum strength requirements is subject to change in order to meet the construction schedule requirements, as specified in this contract. The contractor may select to use additives or additional cement to achieve high early strength to meet the construction schedule requirements at no additional cost to the Airport.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Course and fine aggregate, Portland cement, water, admixtures, joint material and steel reinforcement shall conform to FAA Specification Item P-501, and as modified herein.
B. In order to permit the installation of HES Concrete over nightly shifts, the contractor shall manufacture pre-cast concrete panels per the plans. Panels shall be constructed of material conforming to FAA Item P-501 as modified herein. Contractor shall manufacture the panels in sufficient quantity and size to permit the progression of work as shown in the plans. Contractor shall submit for approval shop drawings denoting the size and number of pre-cast panels and include the installation and relocation of panels in the HES Paving Plan Submittal.

PART 3 – EXECUTION

A. The contractor shall provide Portland cement concrete pavement in accordance with FAA Specification Item P-501, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-501 Portland Cement Concrete Pavement.
FAA ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

PART 1 – DESCRIPTION

- 501-1.1 – This work shall consist of pavement composed of Portland cement concrete, with reinforcement or without reinforcement constructed on a prepared underlying surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the plans.

PART 2 – MATERIALS

- 501-2.1 – Aggregates.

  A. Reactivity. Fine and Coarse aggregates to be used in all concrete shall be evaluated and tested by the contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Aggregate and mix proportion reactivity tests shall be performed for each project.

  1. Coarse and fine aggregate shall be tested separately in accordance with ASTM C1260. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.10% at 28 days (30 days from casting).

  2. Combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662. If lithium nitrate admixture is used, it shall be nominal 30% ±0.5% weight lithium nitrate in water.

  3. If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C1567, modified for combined aggregates, or COE CRD C662, does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion of the proposed combined materials test specimens is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

  B. Fine Aggregate. Fine aggregate shall conform to the requirements of ASTM C33. Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33 and shall have a fineness modulus of not less than 2.50 nor more than 3.40. The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

Gradation for Fine Aggregate (ASTM C 33)

<table>
<thead>
<tr>
<th>Sieve Designation (Square Openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 in.</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 8</td>
<td>80-100</td>
</tr>
<tr>
<td>No. 16</td>
<td>50-85</td>
</tr>
<tr>
<td>No. 30</td>
<td>25-60</td>
</tr>
<tr>
<td>No. 50</td>
<td>10-30</td>
</tr>
<tr>
<td>No. 100</td>
<td>2-10</td>
</tr>
</tbody>
</table>
1. The amount of deleterious material in the fine aggregate shall not exceed the following limits:

<table>
<thead>
<tr>
<th>Deleterious material</th>
<th>ASTM</th>
<th>Percentage by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Lumps and friable particles</td>
<td>ASTM C142</td>
<td>1.0</td>
</tr>
<tr>
<td>Material finer than 0.075mm (No. 200 sieve)</td>
<td>ASTM C117</td>
<td>3.0</td>
</tr>
<tr>
<td>Lightweight particles</td>
<td>ASTM C123 using a medium with a density of Sp. Gr. of 2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Total of all deleterious Material</td>
<td></td>
<td>3.0</td>
</tr>
</tbody>
</table>

C. **Coarse Aggregate.** Gradation, within the separated size groups, shall meet the coarse aggregate grading requirements of ASTM C33 when tested in accordance with ASTM C136. When the nominal maximum size of the aggregate is greater than 1” (25 mm), the aggregates shall be furnished in two size groups.

1. Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, air-cooled iron blast furnace slag, crushed recycled concrete pavement, or a combination. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. Steel blast furnace slag shall not be permitted. The aggregate shall be composed of clean, hard, uncoated particles. Dust and other coating shall be removed from the aggregates by washing.

2. The percentage of wear shall be no more than 40 when tested in accordance with ASTM C131.

3. The quantity of flat, elongated, and flat and elongated particles in any size group coarser than 3/8 sieve (9 mm) shall not exceed 8% by weight when tested in accordance with ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 5. An elongated particle is one having a ratio of length to width greater than 5.

4. The soundness loss shall not exceed 12% when sodium sulfate is used or 18% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

5. The amount of deleterious material in the coarse aggregate shall not exceed the following limits:

<table>
<thead>
<tr>
<th>Deleterious material</th>
<th>ASTM</th>
<th>Percentage by Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Lumps and friable particles</td>
<td>ASTM C142</td>
<td>1.0</td>
</tr>
<tr>
<td>Material finer than No. 200 sieve</td>
<td>ASTM C117</td>
<td>1.0</td>
</tr>
<tr>
<td>Lightweight particles</td>
<td>ASTM C123 using a medium with a density of Sp. Gr. of 2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Chert (less than 2.40 Sp Gr.)</td>
<td>ASTM C123 using a medium with a density of Sp. Gr. of 2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Total of all deleterious Material</td>
<td></td>
<td>3.0</td>
</tr>
</tbody>
</table>
Gradation for Coarse Aggregate

( ASTM C 33)

<table>
<thead>
<tr>
<th>Sieve Designations (square openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From 1-1/2&quot; to No. 4 (38 mm - 4.75 mm)</td>
</tr>
<tr>
<td></td>
<td>#4 1-1/2&quot; - 3/4&quot;</td>
</tr>
<tr>
<td>inch</td>
<td>mm</td>
</tr>
<tr>
<td>2-1/2</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>1-1/2</td>
<td>38</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
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<td>9</td>
</tr>
<tr>
<td>No. 4</td>
<td>4.75</td>
</tr>
<tr>
<td>No. 8</td>
<td>2.36</td>
</tr>
</tbody>
</table>

a) Aggregate susceptibility to durability (D) cracking. Aggregates that have a history of D-cracking shall not be used.

1) Coarse aggregate may be accepted from sources that have a 20-year service history for the same gradation to be supplied with no durability issues. Aggregates that do not have a record of 20 years of service without major repairs (less than 5% of slabs replaced) in similar conditions without D-cracking shall not be used unless it meets the following:

(a) Material currently being produced shall have a durability factor of 95 using ASTM C666 procedure B. Coarse aggregates that are crushed granite, calcite cemented sandstone, quartzite, basalt, diabase, rhyolite or trap rock are considered to meet the D-cracking test but must meet all other quality tests. Aggregates meeting State Highway Department material specifications may be acceptable.

(b) The contractor shall submit a current certification that the aggregate does not have a history of D-cracking and that the aggregate meets the state specifications for use in PCC pavement for use on interstate highways. Certifications, tests and any history reports must be for the same gradation as being proposed for use on the project. Certifications which are not dated or which are over one (1) year old or which are for different gradations will not be accepted. Test results will only be accepted when tests were performed by a State Department of Transportation (DOT) materials laboratory or an accredited laboratory.

b) Combined aggregate gradation. If substituted for the grading requirements specified for coarse aggregate and for fine aggregate and when approved by the Engineer, the combined aggregate grading shall meet the following requirements:

1) The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

2) The CF shall be determined from the following equation:
(a) \( CF = \frac{\text{cumulative percent retained on the 3/8 in. sieve}}{100} \times \frac{\text{cumulative percent retained on the No. 8 sieve}}{100} \)

3) The Workability Factor WF is defined as the percent passing the No. 8 (2.36 mm) sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds (42 kg) of cementitious material per cubic meter yard greater than 564 pounds per cubic yard (335 kg per cubic meter).

4) A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.

- **501-2.2 – Cement.** Cement shall conform to the requirements of ASTM C150 Type II or ASTM C1157 HE.
  
  A. If aggregates are deemed innocuous when tested in accordance with paragraph 501-2.1.A.1 and accepted in accordance with paragraph 501-2.1.A.2, higher equivalent alkali content in the cement may be allowed if approved by the Engineer and FAA. If cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

- **501-2.3 – Cementitious Materials.**
  
  A. Fly ash or Natural Pozzolan. Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash for use in mitigating alkali-silica reactivity shall have a Calcium Oxide (CaO) content of less than 13% and a total available alkali content less than 3% per ASTM C311. Fly ash produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the mix design, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Engineer.

  B. Slag cement (ground granulated blast furnace (GGBF). Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.

  C. **Raw or calcined natural pozzolan.** Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6%. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total available alkali content less than 3%.

  D. **Ultrafine fly ash and ultrafine pozzolan.** UltraFine Fly Ash (UFFA) and UltraFine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

    1. The strength activity index at 28 days of age shall be at least 95% of the control specimens.
    2. The average particle size shall not exceed 6 microns.

- **501-2.4 – Joint Seal.** The joint seal for the joints in the concrete pavement shall meet the requirements of Item P-605 and shall be of the type specified in the plans.
501-2.5 – **Isolation Joint Filler.** Premolded joint filler for expansion joints shall conform to the requirements of ASTM D 1751 and shall be where shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer. Joint filler must be compatible with joint sealants.

501-2.6 – **Steel Reinforcement.** Reinforcing shall consist of bar mats conforming to the requirements of ASTM A184 or A704.

501-2.7 – **Dowel and Tie Bars.** Dowel bars shall be plain steel bars conforming to ASTM A615 and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the construction site each dowel bar shall be epoxy coated per ASTM A1078. The dowels shall be coated with a bond-breaker recommended by the manufacturer. Dowel sleeves or inserts are not permitted. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the grout hardens.

A. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615. Tie bars designated as Grade 60 in ASTM A615 or ASTM A706 shall be used for construction requiring bent bars.

501-2.8 – **Water.** Water used in mixing or curing shall be potable, clean, free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602.

501-2.9 – **Material for Curing Concrete.** Curing materials shall conform to one of the following specifications:

A. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309, Type 2, Class B, or Class A if wax base only.

B. White polyethylene film for curing concrete shall conform to the requirements of ASTM C171.

C. White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C171.

D. Waterproof paper for curing concrete shall conform to the requirements of ASTM C171.

501-2.10 – **Admixtures.** The contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

A. **Air-Entraining Admixtures.** Air-entraining admixtures shall meet the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and any water reducer admixture shall be compatible.

B. **Water-Reducing Admixtures.** Water-reducing admixture shall meet the requirements of ASTM C494, Type A, B, or D. ASTM C494, Type F and G high range water reducing admixtures and ASTM C1017 flowable admixtures shall not be used.
C. **Other admixtures.** The use of set retarding, and set-accelerating admixtures shall be approved by the Engineer. Retarding shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

D. **Lithium Nitrate.** The lithium admixture shall be a nominal 30% aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon (1.2 kg/L), and shall have the approximate chemical form as shown below:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Limit (Percent by Mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiNO₃ (Lithium Nitrate)</td>
<td>30 ±0.5</td>
</tr>
<tr>
<td>SO₄ (Sulfate Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>Cl (Chloride Ion)</td>
<td>0.2 (max)</td>
</tr>
<tr>
<td>Na (Sodium Ion)</td>
<td>0.1 (max)</td>
</tr>
<tr>
<td>K (Potassium Ion)</td>
<td>0.1 (max)</td>
</tr>
</tbody>
</table>

1. Provide a trained manufacturer’s representative to supervise the lithium nitrate admixture dispensing and mixing operations.

- **501-2.11 – Epoxy-Resin.** All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

  A. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

  B. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

  C. Material for use for injecting cracks shall be Type IV, Grade 1.

  D. Material for bonding freshly mixed Portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

- **501-2.12 – Material Acceptance.** Prior to use of materials, the contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test for each material, the test results, and a statement that the material passed or failed.

  A. The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

**PART 3 – MIX DESIGN**

- **501-3.1 – General.** No concrete shall be placed until the mix design has been submitted to the Engineer for review and the Engineer has taken appropriate action. The Engineer’s review shall not relieve the contractor of the responsibility to select and proportion the materials to comply with this section.

- **501-3.2 – Proportions.** The laboratory preparing the mix design shall be accredited in accordance with ASTM C1077. The mix design for all Portland cement concrete placed under P-501 shall be stamped or sealed by the responsible professional Engineer of the laboratory. Concrete shall be proportioned to achieve a 7-day flexural strength that meets or exceeds the acceptance criteria contained in paragraph 501-5.2 for a flexural strength of 650 psi per ASTM C78. The mix shall be developed using the procedures...
A. The minimum cementitious material shall be adequate to ensure a workable, durable mix. The minimum cementitious material (cement plus fly ash, or slag cement) shall be 470 pounds per cubic yard (280 kg per cubic meter). The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.45 by weight.

B. Flexural strength test specimens shall be prepared in accordance with ASTM C192 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a maximum allowable slump between 1” and 2” (25mm and 50 mm) as determined by ASTM C143. For slip-form concrete, the slump shall be between 1/2” (12 mm) and 1-1/2” (38 mm). At the start of the project, the contractor shall determine a maximum allowable slump for slip-form pavement which will produce in-place pavement to control the edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

C. Before the start of paving operations and after approval of all material to be used in the concrete, the contractor shall submit a mix design showing the proportions and flexural strength obtained from the concrete at 7 and 28 days. The mix design shall include copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. The mix design shall be submitted to the Engineer at least 30 days prior to the start of operations. The submitted mix design shall not be more than 90 days old. Production shall not begin until the mix design is approved in writing by the Engineer.

D. If a change in sources is made, or admixtures added or deleted from the mix, a new mix design must be submitted to the Engineer for approval.

E. The results of the mix design shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard (meter) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in PCA’s publication, Design and Control of Concrete Mixtures, modified as necessary to accommodate flexural strength.

F. The submitted mix design shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

1. Coarse, fine, and combined aggregate gradations and plots including fineness modulus of the fine aggregate.
2. Reactivity Test Results.
3. Coarse aggregate quality test results, including deleterious materials.
4. Fine aggregate quality test results, including deleterious materials.
5. Mill certificates for cement and supplemental cementitious materials.
6. Certified test results for all admixtures, including Lithium Nitrate if applicable.
7. Specified flexural strength, slump, and air content.
8. Recommended proportions/volumes for proposed mixture and trial water-cementitious materials ratio, including actual slump and air content.

9. Flexural and compressive strength summaries and plots, including all individual beam and cylinder breaks.

10. Correlation ratios for acceptance testing and contractor Quality Control testing, when applicable.

11. Historical record of test results documenting production standard deviation, when applicable.

501-3.3 – Cementitious Materials.

A. **Fly Ash.** When fly ash is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If fly ash is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

B. **Slag cement (ground granulated blast furnace (GGBF)).** Slag cement may be used. The slag cement, or slag cement plus fly ash if both are used, may constitute between 25 to 55% of the total cementitious material by weight. If the concrete is to be used for slipforming operations and the air temperature is expected to be lower than 55°F (13°C) the percent slag cement shall not exceed 30% by weight.

C. **Raw or calcined natural pozzolan.** Natural pozzolan may be used in the mix design. When pozzolan is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If pozzolan is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

D. **Ultrafine fly ash (UFFA) and ultrafine pozzolan (UFP).** UFFA and UFP may be used in the mix design with the Engineer's approval. When UFFA and UFP is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 7 and 16% by weight of the total cementitious material.

501-3.4 – Admixtures.

A. **Air-Entraining.** Air-entraining admixture are to be added in such a manner that will ensure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air in the mix shall be between 2.5% and 4.5% unless otherwise approved by the Engineer. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

B. **Water Reducing Admixture.** Water-reducing admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C494.

C. **Other admixtures.** Set controlling, and other approved admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C494.
D. Lithium nitrate. Lithium nitrate shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements in accordance with paragraph 501-2.10d.

501-3.5 – Concrete Mix Design Laboratory.

A. The contractor’s laboratory used to develop the concrete mix design shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for developing the concrete mix design must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

PART 4 – CONSTRUCTION METHODS

501-4.1 – Equipment. Equipment necessary for handling materials and performing all parts of the work shall be approved by the Engineer, but does not relieve the contractor of the responsibility for the proper operation of equipment and maintaining the equipment in good working condition. The equipment shall be at the jobsite sufficiently ahead of the start of paving operations to be examined thoroughly and approved.

A. Batch plant and equipment. The batch plant and equipment shall conform to the requirements of ASTM C94.

B. Mixers and transportation equipment:

1. General. Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer’s nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

2. Central plant mixer. Central plant mixers shall conform to the requirements of ASTM C94. The mixer shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4” (19 mm) or more. The contractor shall have a copy of the manufacturer’s design on hand showing dimensions and arrangement of blades in reference to original height and depth.

3. Truck mixers and truck agitators. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C94.

4. Nonagitator trucks. Nonagitating hauling equipment shall conform to the requirements of ASTM C94.

5. Transfer and spreading equipment. Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

C. Finishing equipment. The standard method of constructing concrete pavements shall be with an approved slip-form paving equipment designed and operated to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine so that the end result is a dense and homogeneous pavement which is achieved with a minimum of hand finishing. The
paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements. It shall weigh at least 2,200 lbs per foot (3,274 kg/m) of paving lane width and powered by an engine having at least 6.0 horsepower per foot of lane width.

1. On projects requiring less than 500 square yard (418 sq m) of cement concrete pavement or requiring individual placement areas of less than 500 square yard (418 sq m), or irregular areas at locations inaccessible to slip-form paving equipment, concrete pavement may be placed with approved placement and finishing equipment using stationary side forms. Hand screeding and float finishing may only be used on small irregular areas as allowed by the Engineer.

D. **Vibrators.** Vibrator shall be the internal type. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025-0.05" (0.06 - 0.13 cm)

1. The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of American Concrete Institute (ACI) 309, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. The contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Engineer.

2. Hand held vibrators may be used in irregular areas only, but shall meet the recommendations of ACI 309R, Guide for Consolidation of Concrete.

E. **Concrete saws.** The contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. The contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations. Early-entry saws may be used, subject to demonstration and approval of the Engineer.

F. **Side forms.** Straight side forms shall be made of steel and shall be furnished in sections not less than 10’ (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge, and a base width equal to or greater than the depth. Flexible or curved forms of proper radius shall be used for curves of 100-foot (31 m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8” (3 mm) in 10’ (3 m), and the upstanding leg shall not vary more than 1/4” (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

G. **Pavers.** The paver shall be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross-section. It shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the plans, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The paver shall be equipped with electronic or hydraulic horizontal and vertical control devices.

- **501-4.2 – Form setting.** Forms shall be set sufficiently in advance of the concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the underlying surface shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base
of the forms. Forms shall be staked into place sufficiently to maintain the form in position for the method of placement.

A. Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/8" (3 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.

B. The alignment and grade elevations of the forms shall be checked and corrections made by the contractor immediately before placing the concrete.

- **501-4.3 – Conditioning of underlying surface.** The compacted underlying surface on which the pavement will be placed shall be widened approximately 3' (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, the areas that will support the paving machine and the area to be paved shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the underlying surface shall be controlled by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. The underlying surface shall be protected so that it will be entirely free of frost when concrete is placed.

A. Stabilized subbase is required to accommodate aircraft with gross weights in excess of 100,000 pounds (45300 kg) per AC 150/5320-6.

- **501-4.4 – Conditioning of Underlying Surface, Side-Form and Fill-In Lane Construction.** The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineers. If damage occurs to a stabilized subbase, it shall be corrected full depth by the contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

A. The template shall be maintained in accurate adjustment, at all times by the contractor, and shall be checked daily.

- **501-4.5 – Handling, Measuring, and Batching Material.** The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in such a manner that prevents segregation and intermixing of deleterious materials. Aggregates from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant.
A. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.

B. Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, the contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other approved device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

501-4.6 – Mixing Concrete. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C94.

A. Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted. With transit mix additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the approved mix design is not exceeded, and approved by the Engineer.

501-4.7 – Limitations on mixing and placing. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

A. Cold weather. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40°F (4°C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F (2°C).

1. The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50°F (10°C) at the time of placement. Concrete shall not be placed on frozen material, nor shall frozen aggregates be used in the concrete.

2. When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150°F (66°C). The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

B. Hot weather. During periods of hot weather when the maximum daily air temperature exceeds 85°F (30°C), the following precautions shall be taken.

1. The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.
2. The finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. When necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf (0.98 kg/m² per hour) per hour. When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

C. **Temperature management program.** Prior to the start of paving operation for each day of paving, the contractor shall provide the Engineer with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. As a minimum the program shall address the following items:

1. Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.
2. Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 11-8, PCA, Design and Control of Concrete Mixtures.
3. Anticipated timing of initial sawing of joint.
4. Anticipated number and type of saws to be used.

- **501-4.8 – Placing Concrete.** At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3’ (1 m). The finished concrete product must be dense and homogeneous, without segregation and conforming to the standards in this specification. Backhoes and grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used. All concrete shall be consolidated without voids or segregation, including under and around all load-transfer devices, joint assembly units, and other features embedded in the pavement. Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 550 psi (3792 kPa), based on the average of four field cured specimens per 2,000 cubic yards (1,530 cubic meters) of concrete placed. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi (2757 kPa).

- The contractor shall have available materials for the protection of the concrete during inclement weather. Such protective materials shall consist of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

A. **Slip-form construction.** The concrete shall be distributed uniformly into final position by a self-propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the
full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9” (23 cm) for slipform and at the end of the dowels for the fill-in lanes. The spacing of internal units shall be uniform and shall not exceed 18” (0.5 m).

1. The term internal vibration means vibrating units located within the specified thickness of pavement section.

2. The rate of vibration of each vibrating unit shall be within 8000 to 12000 cycles per minute and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least 1’ (30 cm). The frequency of vibration or amplitude shall vary proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

3. **The concrete shall be held at a uniform consistency.** The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

4. When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

5. Not more than 15% of the total free edge of each 500’ (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4” (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8” (9 mm). (The total free edge of 500’ (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500’ (150 m) of paving lane originally constructed as a separate lane will have 1,000’ (300 m) of free edge, 500’ (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18” (0.5 m) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the contractor as directed by the Engineer.

B. **Side-form construction.** Side form sections shall be straight, free from warps, bends, indentations, or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse construction joints where straight forms of other suitable material may be used.

1. Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If such build-up is attached to the top of metal forms, the build-up shall also be metal.

2. Width of the base of all forms shall be equal to or greater than the specified pavement thickness.

3. Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the weight of subgrading and paving equipment or from the pressure of the concrete. The contractor shall provide sufficient forms so that there will be no delay in placing concrete due to lack of forms.
4. Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting, and finishing the pavement.

5. Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars where these are specified.

6. Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

7. Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. Curing compound shall be applied to the concrete immediately after the forms have been removed.

8. Side forms shall be thoroughly cleaned and oiled each time they are used and before concrete is placed against them.

9. Concrete shall be spread, screeded, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross-section with a minimum of handwork.

10. The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery.

11. Concrete for the full paving width shall be effectively consolidated by internal vibrators without causing segregation. Internal type vibrators’ rate of vibration shall be not less than 7,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than 1’ (30 cm) from the vibrating element. The contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.

12. Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

13. The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete.

C. Consolidation. Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than” (50 mm). Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15” (150 to 400 mm) on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges,
large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and adjustment of the equipment or procedures as approved by the Engineer.

1. If a lack of consolidation of the concrete is suspected by the Engineer, referee testing may be required. Referee testing of hardened concrete will be performed by the Engineer by cutting cores from the finished pavement after a minimum of 24 hours curing. Density determinations will be made by the Engineer based on the water content of the core as taken. ASTM C642 shall be used for the determination of core density in the saturated-surface dry condition. When required, referee cores will be taken at the minimum rate of one for each 500 cubic yards (382 m²) of pavement, or fraction. The contractor shall be responsible for all referee testing cost if they fail to meet the required density.

2. The average density of the cores shall be at least 97% of the original mix design density, with no cores having a density of less than 96% of the original mix design density. Failure to meet the referee tests will be considered evidence that the minimum requirements for vibration are inadequate for the job conditions. Additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete conforms to the above requirements.

501-4.9 – **Strike-off of Concrete and Placement of Reinforcement.** Following the placing of the concrete, it shall be struck off to conform to the cross-section shown on the plans and to an elevation that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off, and screeded. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it shall be removed and replaced with freshly mixed concrete at the contractor’s expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

A. Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.

501-4.10 – **Joints.** Joints shall be constructed as shown on the plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the plans. Joints shall not vary more than 1/2" (12 mm) from their designated position and shall be true to line with not more than 1/4" (6 mm) variation in 10' (3 m). The surface across the joints shall be tested with a 12' (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4" (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the plans.

A. **Construction.** Longitudinal construction joints shall be slip-formed or formed against side forms, as shown in the plans.

1. Transverse construction joints shall be installed at the end of each day’s placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the contractor shall remove the excess concrete back to the previous planned joint.
B. **Contraction.** Contraction joints shall be installed at the locations and spacing as shown on the plans. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer’s instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8” wide and to the depth shown on the plans.

C. **Isolation (expansion).** Isolation joints shall be installed as shown on the plans. The premolded filler of the thickness, as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

D. **Tie bars.** Tie bars shall consist of deformed bars installed in joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. Tie bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed.

E. **Dowel bars.** Dowel bars or other load-transfer units of an approved type shall be placed across joints as shown on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. The dowels shall be coated with a bond-breaker or other lubricant recommended by the manufacturer and approved by the Engineer.

F. Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

G. **Placing dowels and tie bars.** The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 1/8” per’ (3 mm per 0.3 m). Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of ±5/8” (16 mm). The vertical location on the face of the slab shall be within a tolerance of ±1/2” (12 mm). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar and tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel and tie bar is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar and tie bar length, but not closer than 6”to its nearest neighbor. The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed. Dowels shall be installed as specified in the following subparagraphs:
1. **Contraction joints.** Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of pins or anchors. Do not cut or crimp the dowel basket wires. At the contractor’s option, in lieu of the above, dowels and tie bars in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels and tie bars are installed within specified tolerances.

2. **Construction joints.** Install dowels and tie bars by the cast-in-place or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels and tie bars in construction joints shall be as indicated.

3. Dowels installed in isolation joints and other hardened concrete. Install dowels for isolation joints and in other hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for seven (7) days or reached a minimum flexural strength of 450 psi (3.1 MPa) before drilling commences. Holes 1/8” (3 mm) greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Modification of the equipment and operation shall be required if, in the Engineer’s opinion, the equipment and/or operation is causing excessive damage. Depth of dowel hole shall be within a tolerance of ±1/2” (12 mm) of the dimension shown on the drawings. On completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above.

H. **Sawing of Joints.** Joints shall be cut as shown on the plans. Equipment shall be as described in paragraph 501-4.1. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 1/8” (3 mm) wide and to the depth shown on the plans. The top of the slot shall be widened by sawing to provide adequate space for joint sealers as shown on the plans. Sawing shall commence, without regard to day or night, as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs and shall continue without interruption until all joints have been sawn. The joints shall be sawn at the required spacing. All slurry and debris produced in the sawing of joints shall be removed by vacuuming and washing. Curing compound or system shall be reapplied in the initial sawcut and maintained for the remaining cure period.

501-4.11 – **Finishing.** Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which
requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 1/8" (3 mm) of mortar-rich surface (defined as deficient in plus U.S. No. 4 (4.75 mm) sieve size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

A. **Machine finishing with slipform pavers.** The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled non-rotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of such slurry. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

B. **Machine finishing with fixed forms.** The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

C. **Other types of finishing equipment.** Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Engineer’s approval.

1. Bridge deck finishers shall have a minimum operating weight of 7500 pounds (3400 kg) and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

D. **Hand finishing.** Hand finishing methods will not be permitted, except under the following conditions:

1. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade and in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Use hand finishing operations only as specified below.

   a) **Equipment and screed.** In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping screed and a longitudinal float for hand finishing. The screed shall be at least 1’ (30 cm) longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall
be at least 10’ (3 m) long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

b) **Finishing and floating.** As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross-section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

E. **Straightedge testing and surface correction.** After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a contractor furnished 12-foot (3.7-m) straightedge swung from handles 3’ (1 m) longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8” (3 mm) thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements of paragraph 501-5.2.e(3). Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross-section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment. This straight-edging is not a replacement for the straightedge testing of paragraph 501-5.2.E.3, Smoothness.

- 501.4.12 – **Surface Texture.** The surface of the pavement shall be finished with either a brush or broom, burlap drag, or artificial turf finish for all newly constructed concrete pavements. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Engineer.

A. **Brush or broom finish.** If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16” (2 mm) in depth.

B. **Burlap drag finish.** If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard (555 grams per square meter). To obtain a textured surface, the transverse threads of the burlap shall be removed approximately 1’ (30 cm) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16” (2 mm) in depth.
C. **Artificial Turf Finish.** Not used

- **501-4.13 – Curing.** Immediately after finishing operations are completed and marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured for a 7-day cure period in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period.

  1. **When a two-sawcut method is used to construct the contraction joint, the curing compound shall be applied to the sawcut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed.** When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

A. **Impervious Membrane Method.** The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of one gallon (4 liters) to not more than 150 sq ft (14 sq m). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. When hand spraying is approved by the Engineer, a double application rate shall be used to ensure coverage. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface. Curing shall be applied immediately after the bleed water is gone from the surface.

B. **White Burlap-Polyethylene Sheets.** The surface of the pavement shall be entirely covered with the sheeting. The sheeting used shall be such length (or width) that it will extend at least twice the thickness of the pavement beyond the edges of the slab. The sheeting shall be placed so that the entire surface and both edges of the slab are completely covered. The sheeting shall be placed and weighted to remain in contact with the surface covered, and the covering shall be maintained fully saturated and in position for 7 days after the concrete has been placed.

C. **Water Method.** The entire area shall be covered with burlap or other water absorbing material. The material shall be of sufficient thickness to retain water for adequate curing without excessive runoff. The material shall be kept wet at all times and maintained for seven (7) days. When the forms are stripped, the vertical walls shall also be kept moist. It shall be the responsibility of the contractor to prevent ponding of the curing water on the subbase.

D. **Concrete Protection for Cold Weather.** The concrete shall be maintained at an ambient temperature of at least 50°F (10°C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. The contractor shall be responsible for the quality and strength of the concrete placed during cold weather; and any concrete damaged shall be removed and replaced at the contractor’s expense.
E. **Concrete Protection for Hot Weather.** Concrete should be continuous moisture cured for the entire curing period and shall commence as soon as the surfaces are finished and continue for at least 24 hours. However, if moisture curing is not practical beyond 24 hours, the concrete surface shall be protected from drying with application of a liquid membrane-forming curing compound while the surfaces are still damp. Other curing methods may be approved by the Engineer.

- 501-4.14 – **Removing Forms.** Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be cured as per the methods indicated in paragraph 501-4.13. Major honeycombed areas shall be considered as defective work and shall be removed and replaced in accordance with paragraph 501-5.2.F.

- 501-4.15 – **Saw-cut Grooving.** If shown on the plans, grooved surfaces shall be provided in accordance with the requirements of Item P-621

- 501-4.16 – **Sealing Joints.** The joints in the pavement shall be sealed in accordance with Item P-605.

- 501-4.17 – **Protection of Pavement.** The contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the contractor’s employees and agents until accepted by the Engineer. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the contractor’s expense.

  A. Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 7 days old, or for a longer period if directed by the Engineer.

  B. In paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for 7 days and the joints have been sealed or otherwise protected, and the concrete has attained a minimum field cured flexural strength of 550 psi (37928 kPa) and approved means are furnished to prevent damage to the slab edge.

  C. All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence.

  D. Damaged pavements shall be removed and replaced at the contractor’s expense. Slabs shall be removed to the full depth, width, and length of the slab.

- 501-4.18 – **Opening to Construction Traffic.** The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 550 lb / square inch (3.8 kPa) when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion.

- 501-4.19 – **Repair, removal, or replacement of slabs.**

  A. **General.** New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable shall be removed and replaced or repaired, as directed by the Engineer and as specified hereinafter at no cost to the Owner. Spalls along joints shall be repaired as specified. Removal of
partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The Engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4” (100 mm) diameter, shall be drilled by the contractor and shall be filled by the contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Owner. All epoxy resin used in this work shall conform to ASTM C881, Type V. Repair of cracks as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/8” (3 mm) of the pavement surface.

B. **Shrinkage cracks.** Shrinkage cracks, which do not exceed 4” (100 mm) in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved by the Engineer. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks, which exceed 4” (100 mm) in depth, shall be treated as full depth cracks in accordance with paragraphs 4.19b and 4.19c.

C. **Slabs with cracks through interior areas.** Interior area is defined as that area more than 6” (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Owner, when there are any full depth cracks, or cracks greater than 4” (100 mm) in depth, that extend into the interior area.

D. **Cracks close to and parallel to joints.** All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6” (150 mm) either side of the joint shall be treated as specified here. Any crack extending more than 6” (150 mm) from the joint shall be treated as specified above in subparagraph c.

1. **Full depth cracks present, original joint not opened.** When the original un-cracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4” (19 mm), ±1/16” (2 mm), and to a width of 5/8” (16 mm), ±1/8” (3 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

   a) If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.
2. **Full depth cracks present, original joint also cracked.** At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

E. **Removal and replacement of full slabs.** Where it is necessary to remove full slabs, unless there are dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If dowels, or tie bars are present along any edges, these edges shall be sawed full depth just beyond the end of the dowels or tie bars. These joints shall then be carefully sawed on the joint line to within 1” (25 mm) of the depth of the dowel or tie bar.

1. The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb (14 kg) or less, or other approved similar equipment.

2. Care shall be taken to prevent damage to the dowels, tie bars, or to concrete to remain in place. The joint face below dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2” (12 mm) and no gradual offset greater than 1” (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

3. No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4” (38 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

4. If underbreak over 4” (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels or tie bars, or where they have been damaged, dowels or tie bars of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All 4 edges of the new slab shall contain dowels or original tie bars.

5. **Placement of concrete shall be as specified for original construction.** Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate section of these specifications. The surfaces of all 4 joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

F. **Repairing spalls along joints.** Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least 1” (25 mm) outside the spalled area and to a depth of at least 2” (50 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2” (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m³) in size, and mortar shall be
used for the smaller ones. Any spall less than 0.1 cu. ft. (0.003 m³) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Engineer. The epoxy resin materials shall be placed in the cavity in layers not over 2” (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140°F (60°C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified. If any spall would require over 25% of the length of any single joint to be repaired, the entire slab shall be removed and replaced. Repair of spalls as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper 1/8” of the pavement surface.

G. **Diamond grinding of PCC surfaces.** Diamond grinding of the hardened concrete with an approved diamond grinding machine should not be performed until the concrete is 14 days or more old and concrete has reached full minimum strength. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12” (300 mm) of cutting head width; the actual number of blades will be determined by the contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3’ (0.9 m) wide. Equipment that causes ravel, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by diamond grinding the surface of the hardened concrete should not exceed 10% of the total area of any sublot. The depth of diamond grinding shall not exceed 1/2” (13 mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, may require removing and replacing in conformance with paragraph 501-4.19.

- **501-4.20 – Existing Concrete Pavement Removal and Repair.**

A. All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

1. **Removal of Existing Pavement Slab.** When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, the joint between the removal area and adjoining pavement to stay in place, including dowels and tie bars shall first be cut full depth with a standard diamond-type concrete saw. If dowels are present at this joint, the saw cut shall be made just beyond the end of dowels. The edge shall then be carefully sawed on the joint line to within 1” of the top of the dowel. Next, a full depth saw cut shall be made parallel to the joint at least 24” (600 mm) from the joint and at least 12” (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb (14 kg) or less, or the approved light-duty equipment which
will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. Where dowels are present, care shall be taken to produce an even, vertical joint face below the dowels. If the contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the contractor shall saw the dowels flush with the joint. The contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10G. All this shall be at no additional cost to the Owner. Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10G. The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2" (12 mm) and no gradual offset greater than 1” (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

2. **Edge Repair.** The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at no cost to the Owner.

   a) **Spall repair.** Spalls shall be repaired where indicated and where directed by the Engineer. Repair materials and procedures shall be as previously specified in subparagraph 501-4.19F.

   b) **Underbreak repair.** All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

   c) **Underlying material.** The underlying material adjacent to the edge and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in paragraph 501-4.20. The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

**PART 5 – MATERIAL ACCEPTANCE**

- 501-5.1 – **Acceptance Sampling and Testing.** All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section, with the exception of coring for thickness determination, will be performed by the Engineer at no cost to the contractor. The contractor shall bear the cost of providing curing facilities for the strength specimens, per paragraph 501-5.1B.1.c), and coring and filling operations, per paragraph 501-5.1B.2.a). Testing organizations performing these tests shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

A. Concrete shall be accepted for strength and thickness on a lot basis.

B. A lot shall consist of a day’s production not to exceed 2,000 square yards.

1. **Flexural strength.**
a) **Sampling.** Each lot shall be divided into four equal sublots. One sample shall be taken for each sublot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. The concrete shall be sampled in accordance with ASTM C172.

b) **Testing.** Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C31 and the flexural strength of each specimen shall be determined in accordance with ASTM C78. The flexural strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

1) Immediately prior to testing for flexural strength, the beam shall be weighed and measured for determination of a sample unit weight. Measurements shall be made for each dimension; height, depth, and length, at the mid-point of the specimen and reported to the nearest 1/10” (3 mm). The weight of the specimen shall be reported to the nearest 0.1 pound (45 gm). The sample unit weight shall be calculated by dividing the sample weight by the calculated volume of the sample. This information shall be reported as companion information to the measured flexural strength for each specimen.

2) The samples will be transported while in the molds. The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method.

3) Slump, air content, and temperature tests will also be conducted by the quality assurance laboratory for each set of strength test samples, per ASTM C31.

c) **Curing.** The contractor shall provide adequate facilities for the initial curing of beams. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80°F (16° to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or in heavyweight closed plastic bags, or using other suitable methods, provided the temperature and moisture loss requirements are met.

d) **Acceptance.** Acceptance of pavement for flexural strength will be determined by the Engineer in accordance with paragraph 501-5.2B.

2. **Pavement Thickness.**

a) **Sampling.** Each lot shall be divided into four equal sublots and one core shall be taken by the contractor for each sublot. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.

1) **Cores shall be neatly cut with a core drill.** The contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall be filled by the contractor with a non-shrink grout approved by the Engineer within one day after sampling.

b) **Testing.** The thickness of the cores shall be determined by the Engineer by the average caliper measurement in accordance with ASTM C174.

c) **Acceptance.** Acceptance of pavement for thickness shall be determined by the Engineer in accordance with paragraph 501-5.2C.
3. **Partial lots.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the contractor and Engineer agree in writing to allow overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

   a) Where 3 sublots have been produced, they shall constitute a lot. Where one or two sublots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sublots shall be used in the acceptance criteria calculation, that is, \( n = 5 \) or \( n = 6 \).

4. **Outliers.** All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the percentage of material within specification limits (PWL) shall be determined using the remaining test values.

   ➢ **501-5.2 – Acceptance Criteria.**

   A. **General.** Acceptance will be based on the following characteristics of the completed pavement discussed in paragraph 501-5.2E:

      a) Flexural strength
      b) Thickness
      c) Smoothness
      d) Grade
      e) Edge slump

   1. Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating PWL. Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

   2. Acceptance for flexural strength will be based on the criteria contained in accordance with paragraph 501-5.2E1. Acceptance for thickness will be based on the criteria contained in paragraph 501-5.2E2. Acceptance for smoothness will be based on the criteria contained in paragraph 501-5.2E3. Acceptance for grade will be based on the criteria contained in paragraph 501-5.2E4.

   3. The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. Such rejection may be based on only visual inspection. In the event of such rejection, the contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

   B. **Flexural Strength.** Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The contractor shall target production quality to achieve 90 PWL or higher.

   C. **Pavement Thickness.** Acceptance of each lot of in-place pavement shall be based on PWL. The contractor shall target production quality to achieve 90 PWL or higher.

   D. **Percentage of Material Within Limits (PWL).** The PWL shall be determined in accordance with procedures specified in Section 110 of the General Provisions.
1. The lower specification tolerance limit \((L)\) for flexural strength and thickness shall be:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lower Specification Tolerance Limit ((L))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength</td>
<td>(0.93 \times \text{strength specified in paragraph 501-3.1})</td>
</tr>
<tr>
<td>Thickness</td>
<td>Lot Plan Thickness in inches, - 0.50 in</td>
</tr>
</tbody>
</table>

E. Acceptance Criteria.

1. **Flexural Strength.** If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

2. **Thickness.** If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

3. **Smoothness.** As soon as the concrete has hardened sufficiently, but not later than 48 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The contractor shall furnish paving equipment and employ methods that produce a surface for each section of pavement having an average profile index meeting the requirements of paragraph 501-8.1c when evaluated with a profilograph; and the finished surface of the pavement shall not vary more than 1/4” (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the pavement, full depth removal and replacement of pavement shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified.

   a) Areas in a slab showing high spots of more than 1/4” but not exceeding 1/2” in 16’ shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 1/4” or less. Where the departure from correct cross section exceeds 1/2” the pavement shall be removed and replaced at the expense of the contractor when so directed by the Engineer.

   1) **Transverse measurements.** Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50’ (15m) or more often as determined by the Engineer.

      a) Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement > 1/4” (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19G or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.
(b) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50’ (15m) or more often if directed by the Engineer. Maximum gap on final pavement surface > 1/4” (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19G or by removing and replacing full depth of surface. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

2) **Longitudinal measurements.** Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20’ (6m); and at the one third points of paving lanes when widths of paving lanes are 20’ (6m) or greater.

(a) **Longitudinal Short Sections.** Longitudinal Short Sections are when the longitudinal lot length is less than 200’ (60m) and areas not requiring a profilograph. When approved by the Engineer, the first and last 15’ (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4” (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions, at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement surface > 1/4” (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 501-4.19G or by removing and replacing full depth of surface. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(b) **Profilograph Testing.** Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2” (5 mm) blanking band. The bump template must span 1” (25 mm) with an offset of 0.4” (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of 1” (25 mm) equals 25’ (7.5 m) and a vertical scale of 1” (25 mm) equals 1” (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.

(i) The pavement must have an average profile index meeting the requirements of paragraph 501-8.1c. Deviations on final surface in longitudinal direction shall
be corrected with diamond grinding per paragraph 501-4.19G or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15” (38 cm) per mile or less. If the initial average profile index was less than 15” (38 cm), only those areas representing greater than 0.4” (10 mm) deviation will be re-profiled for correction verification.

(c) **Final profilograph of runway.** Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of paragraph 501-8.1. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2” (5 mm) blanking band. The bump template must span 1” (25 mm) with an offset of 0.4” (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of 1” (25 mm) equals 25’ (7.5 m) and a vertical scale of 1” (25 mm) equals 1” (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed 1’ right and left of runway centerline and 15’ right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the Engineer.

(i) Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 48 hours of placement of material. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours final paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions, then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

4. **Grade.** An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. The finish grade will be determined by running levels at intervals of 50’ (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50’ (15 m)) to determine the elevation of the completed pavement. The contractor shall pay the costs of surveying the level runs, and this work shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the contractor to the Engineer.

a) **Lateral deviation.** Lateral deviation from established alignment of the pavement edge shall not exceed ±0.10’ (3 mm) in any lane.

b) **Vertical deviation.** Vertical deviation from established grade shall not exceed ±0.04’ (12 mm) at any point.
5. **Edge Slump.** When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the contractor as directed by the Engineer in accordance with paragraph 501-4.8a.

F. **Removal and Replacement of Concrete.** Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with paragraph 501-4.20.

**PART 6 – CONTRACTOR QUALITY CONTROL**

- **501-6.1 – Quality Control Program.** The contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including but not limited to:
  
  A. Mix Design
  B. Aggregate Gradation
  C. Quality of Materials
  D. Stockpile Management
  E. Proportioning
  F. Mixing and Transportation
  G. Placing and Consolidation
  H. Joints
  I. Dowel Placement and Alignment
  J. Flexural or Compressive Strength
  K. Finishing and Curing
  L. Surface Smoothness

- **501-6.2 – Quality Control Testing.** The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

  A. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

  1. **Fine Aggregate.**

     a) **Gradation.** A sieve analysis shall be made at least twice daily in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

     b) **Moisture Content.** If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements
are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

2. Coarse Aggregate.

   a) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

   b) Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

3. Slump. Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 501-5.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

4. Air Content. Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 501-5.1. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

5. Four (4) unit weight and yield tests shall be made in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.

➢ 501-6.3 – Control Charts. The contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, moisture content and air content.

   A. Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension Limits, or Specification limits, applicable to each test parameter, and the contractor’s test results. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the contractor’s projected data during production indicates a potential problem and the contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

   1. Fine and Coarse Aggregate Gradation. The contractor shall record the running average of the last 5 gradation tests for each control sieve on linear control charts. Specification limits contained in the Lower Specification Tolerance Limit (L) table above and the Control Chart Limits table below shall be superimposed on the Control Chart for job control.

   2. Slump and Air Content. The contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

           Control Chart Limits
### Control Parameter

<table>
<thead>
<tr>
<th>Individual Measurements</th>
<th>Range Suspension Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Limit</td>
<td>Suspension Limit</td>
</tr>
</tbody>
</table>

### Slip Form:

<table>
<thead>
<tr>
<th>Control Parameter</th>
<th>Individual Measurements</th>
<th>Range Suspension Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump</td>
<td>+0 to -1” (0-25 mm)</td>
<td>+0.5 to -1.5” (13-38 mm)</td>
</tr>
<tr>
<td>Air Content</td>
<td>±1.2%</td>
<td>±1.8%</td>
</tr>
</tbody>
</table>

### Side Form:

<table>
<thead>
<tr>
<th>Control Parameter</th>
<th>Individual Measurements</th>
<th>Range Suspension Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump</td>
<td>+0.5 to -1” (13-25 mm)</td>
<td>+1 to -1.5” (25-38 mm)</td>
</tr>
<tr>
<td>Air Content</td>
<td>±1.2%</td>
<td>±1.8%</td>
</tr>
</tbody>
</table>

- The individual measurement control charts shall use the mix design target values as indicators of central tendency.

- **501-6.4 – Corrective Action.** The contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The contractor Quality Control Program shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

  A. **Fine and Coarse Aggregate Gradation.** When two consecutive averages of five tests are outside of the specification limits in paragraph 501-2.1, immediate steps, including a halt to production, shall be taken to correct the grading.

  B. **Fine and Coarse Aggregate Moisture Content.** Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.

  C. **Slump.** The contractor shall halt production and make appropriate adjustments whenever:

  1. One (1) point falls outside the Suspension Limit line for individual measurements or range OR
  2. Two (2) points in a row fall outside the Action Limit line for individual measurements.

  D. **Air Content.** The contractor shall halt production and adjust the amount of air-entraining admixture whenever:

  1. One (1) point falls outside the Suspension Limit line for individual measurements or range OR
  2. Two (2) points in a row fall outside the Action Limit line for individual measurements.

    a) Whenever a point falls outside the Action Limits line, the air-entraining admixture dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

### PART 7 – METHOD OF MEASUREMENT

- **501-7.1 – Portland cement concrete pavement shall be measured by the number of square yards of pavement specified in-place, completed and accepted regardless of plain or reinforced pavement.

  A. Pre-Cast Concrete panels shall be measured by lump sum for successful manufacturing, and installation, relocation, and removal of sufficient pre-past panels to allow the progression of work. In order to be eligible for payment, contractor must employ pre-cast panels in the installation of the HES Concrete, no payment will be made unless such an approach is employed. Individual panels or
the number of movements for each panel will not be measured; the manufacturing and use of the pre-cast panels will be measured per lump sum irrelevant of the quantity produced.

PART 8 – BASIS OF PAYMENT

501-8.1 – Payment. Payment for concrete pavement and test section meeting all acceptance criteria as specified in paragraph 501-5.2 Acceptance Criteria shall be based on results of smoothness, strength and thickness tests. Payment for acceptable lots of concrete pavement shall be adjusted in accordance with paragraph 501-8.1B for flexural strength and thickness, subject to the limitation that:

A. The total project payment for concrete pavement shall not exceed 100% of the product of the contract unit price and the total number of square yards of concrete pavement used in the accepted work, except for the lump sum price bid items that include PCC pavement (See Note 1 under Table 3).

B. Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings. The price shall also include dowels, tie bars, saw cutting of the joints, joint material, curing and steel reinforcement as required.

1. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 3. A pay factor shall be calculated for both flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural strength and thickness are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either flexural strength or thickness is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100%.

<table>
<thead>
<tr>
<th>Percentage of Materials Within Specification Limits (PWL)</th>
<th>Lot Pay Factor (Percent of Contract Unit Price)</th>
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</thead>
<tbody>
<tr>
<td>96 – 100</td>
<td>106</td>
</tr>
<tr>
<td>90 – 95</td>
<td>PWL + 10</td>
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<tr>
<td>75 – 90</td>
<td>0.5 PWL + 55</td>
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<tr>
<td>55 – 74</td>
<td>1.4 PWL – 12</td>
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<tr>
<td>Below 55</td>
<td>Reject2</td>
</tr>
</tbody>
</table>

1 Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment in excess of 100% shall be subject to the total project payment limitation specified in paragraph 501-8.1.

2 The lot shall be removed and replaced. However, the engineer may decide to allow the rejected lot to remain. In that case, if the engineer and contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment limitation shall be reduced by the amount withheld for the rejected lot.

a) For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 501-8.1. Payment in excess of 100% for accepted lots of concrete pavement shall be used to offset payment for accepted lots of concrete pavement that achieve a lot pay factor less than 100%.

b) The pre-cast panels will be paid for at the contract unit price per lump sum, which price and payment shall be full compensation for all labor, materials, tools, and equipment required to manufacture, install, relocate, remove and other incidentals required for the pre-cast panels to allow the progression of work. The installation, relocation, and removal of the pre-
cast panels will occur under accelerated night-time working conditions, no additional compensation will be provided for completing the work in such a manner.

### TESTING REQUIREMENTS

<p>| ASTM C 31 | Making and Curing Concrete Test Specimens in the Field |
| ASTM C 39 | Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C 70 | Surface Moisture in Fine Aggregate |
| ASTM C 78 | Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) |
| ASTM C 88 | Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| ASTM C 117 | Test for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing |
| ASTM C 131 | Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine |
| ASTM C 136 | Sieve Analysis of Fine and Coarse Aggregates |
| ASTM C 138 | Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete |
| ASTM C 142 | Test for Clay Lumps and Friable Particles in Aggregates |
| ASTM C 143 | Test for Slump of Hydraulic Cement Concrete |
| ASTM C 172 | Sampling Freshly Mixed Concrete |
| ASTM C 173 | Test for Air Content of Freshly Mixed Concrete by the Volumetric Method |
| ASTM C 174 | Measuring Thickness of Concrete Elements Using Drilled Concrete Cores |
| ASTM C 227 | Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method) |
| ASTM C 231 | Test for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C 289 | Potential Alkali-Silica Reactivity of Aggregates (Chemical Method) |
| ASTM C 295 | Petrographic Examination of Aggregates for Concrete |
| ASTM C 114 | Chemical Analysis of Hydraulic Cement |
| ASTM C 311 | Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete |
| ASTM C 535 | Test for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C 566 | Total Evaporable Moisture Content of Aggregates by Drying |
| ASTM C 642 | Test for Density, Absorption, and Voids in Hardened Concrete |
| ASTM C 666 | Resistance of Concrete to Rapid Freezing and Thawing |
| ASTM C 1077 | Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction And Criteria for Laboratory Evaluation |</p>
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>ASTM C 1260</td>
<td>Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)</td>
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<tr>
<td>ASTM C 1602</td>
<td>Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete</td>
</tr>
<tr>
<td>ASTM D 3665</td>
<td>Random Sampling of Paving Materials</td>
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<tr>
<td>ASTM D 4791</td>
<td>Test Method for Flat or Elongated Particles in Coarse Aggregate</td>
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<tr>
<td>ASTM E 178</td>
<td>Dealing With Outlying Observations</td>
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<tr>
<td>ASTM E 1274</td>
<td>Test for Measuring Pavement Roughness Using a Profilograph</td>
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<td>AASHTO T 26</td>
<td>Quality of Water to be Used in Concrete</td>
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<tr>
<td>U.S. Army Corps of Engineers (USACE) Concrete Research Division (CRD) C662</td>
<td>Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)</td>
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**MATERIAL REQUIREMENTS**

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<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>ASTM A 184</td>
<td>Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement</td>
</tr>
<tr>
<td>ASTM A 185</td>
<td>Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement</td>
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<tr>
<td>ASTM A 497</td>
<td>Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement</td>
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<td>ASTM A 615</td>
<td>Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement</td>
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<td>ASTM A 704</td>
<td>Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement</td>
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<td>ASTM A 706</td>
<td>Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement Steel Pipe</td>
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<tr>
<td>ASTM A 714</td>
<td>Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe</td>
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<tr>
<td>ASTM A 775</td>
<td>Specification for Epoxy-Coated Steel Reinforcing Bars</td>
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<tr>
<td>ASTM A 934</td>
<td>Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars</td>
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<tr>
<td>ASTM A 996</td>
<td>Specification for Rail-Steel and Axle Steel Deformed Bars for Concrete Reinforcement</td>
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<tr>
<td>ASTM A 1064</td>
<td>Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete</td>
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<td>ASTM A 1078</td>
<td>Specification for Epoxy-Coated Steel Dowels for Concrete Pavement</td>
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<td>ASTM C 33</td>
<td>Specification for Concrete Aggregates</td>
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<td>Standard</td>
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<tr>
<td>ASTM C 94</td>
<td>Specification for Ready-Mixed Concrete</td>
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<td>ASTM C 150</td>
<td>Specification for Portland Cement</td>
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<td>ASTM C 171</td>
<td>Specification for Sheet Materials for Curing Concrete</td>
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<td>ASTM C 260</td>
<td>Specification for Air-Entraining Admixtures for Concrete</td>
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<td>ASTM C 309</td>
<td>Specification for Liquid Membrane-Forming Compounds for Curing Concrete</td>
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<td>ASTM C 494</td>
<td>Specification for Chemical Admixtures for Concrete</td>
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<tr>
<td>ASTM C 595</td>
<td>Specification for Blended Hydraulic Cements</td>
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<td>ASTM C 618</td>
<td>Specification for Coal Fly ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete</td>
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<tr>
<td>ASTM C 881</td>
<td>Specification for Epoxy-Resin Base Bonding System for Concrete</td>
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<td>ASTM C 989</td>
<td>Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars</td>
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<tr>
<td>ASTM C1157</td>
<td>Standard Performance Specification for Hydraulic Cement</td>
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<tr>
<td>ASTM D 1751</td>
<td>Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)</td>
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<td>ASTM D 1752</td>
<td>Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving And Structural Construction</td>
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<tr>
<td>ACI 211.1</td>
<td>Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete</td>
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<td>ACI 305R</td>
<td>Hot Weather Concreting</td>
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<td>ACI 306R</td>
<td>Cold Weather Concreting</td>
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<td>ACI 309</td>
<td>Guide for Consolidation of Concrete</td>
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<td>AC 150/5320-6</td>
<td>Airport Pavement Design and Evaluation</td>
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<td>PCA</td>
<td>Airport Pavement Design and Evaluation</td>
</tr>
</tbody>
</table>

END OF SECTION 32 13 13
SECTION 32 13 13.20 – SIDEWALK, CURBS, AND ASSOCIATED IMPROVEMENTS

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of the installation of new concrete sidewalks and curbs and the other associated site improvements as shown on the plans and specified herein.

1.2 REFERENCES

A. Section 03 30 00 – Structural Portland Cement Concrete
B. Section 31 23 23 – Backfill and Geotextiles
C. Drawings apply to this Section.
D. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
E. California Department of Transportation, Highway Design Manual
F. American Disabilities Act Standards for Accessible Design

1.3 SUBMITTALS

A. Prior to commencing Work in this Section and delivery of materials to the job site, the contractor shall submit the following information in accordance with Specification Sections in the contract associated with Submittals.

B. Contractor shall submit dimensioned shop drawings detailing the proposed sidewalk and curb including, plan dimensions, grades, cross slopes, joint types and locations, existing features to remain, curb cuts. Contractor shall prepare shop drawings in conformance with the plans, specifications and local regulations and standards as referenced herein.

C. Upon approval of the shop drawings, contractor will be required to obtain the appropriate permits for street construction. The cost and effort of coordinating and obtaining such permits from the authorities having jurisdiction is the sole responsibility of the contractor.

D. Provide material submittals as required per the referenced specification sections, including but not limited to:
   1. Concrete Mix Design
   2. Aggregates
   3. Cement
   4. Joint Filler
   5. Detectable Warning Material
   6. Asphalt
   7. Base Materials
PART 2 – PRODUCTS

2.1 BACKFILL MATERIAL
A. Backfill material shall meet or exceed the minimum requirements of Structural Backfill per section 31 23 03 – Backfill and Geotextiles to the depth and compactions specified on the plans.

2.2 CONCRETE MATERIALS
A. Concrete material joint filler, joint sealants, curing materials and other associated items shall meet or exceed the minimum requirements of section 03 30 00 – Structural Portland Cement Concrete. Preformed expansion joint filler must comply with ASTM D1751.

2.3 DETECTABLE WARNING SURFACE
A. A detectable warning surface must be on the California Department of Transportation Authorized Material List for detectable warning surfaces and must match yellow color no. 33538 of FED-STD-595.

PART 3 – EXECUTION

3.1 DEMOLITION
A. Demolish and remove existing site improvements to allow for the installation of proposed sidewalk, curbs, and associated improvements. Unless otherwise noted, all utilities, signs, and other surface features encountered within the work site shall remain protected in place. Contractor shall adjust all existing surface features to grade.
B. Contractor shall remove existing conflicting pavements, including a minimum of 1’ of existing roadway section to allow the installation of form work.
C. Excavation to proposed subgrade shall be per Section 31 23 00 – Excavation and Embankment. All removed materials including existing pavement section shall be removed from the site and legally disposed of off airport property.

3.2 SUBGRADE PREPARATION
A. Remove soft or spongy basement material to a depth of 6” below the subgrade elevation for curbs, gutter depressions, sidewalks and curb ramps. Backfill the subgrade with suitable Structural Fill to produce a stable foundation. Apply water to the subgrade and thoroughly compact it before placing concrete. Verify that the finished surface of the subgrade does not project into the concrete cross section at any point

3.3 PLACEMENT OF FORMS
A. Concrete shall not be placed until all the forms and reinforcements have been inspected and approved by the Engineer. Forms shall be of suitable material and shall be of the type, size, shape, quality, and strength to build the structure as shown on the plans.
B. Set forms to the required alignment, grade, and dimensions. Forms must:
   1. Be smooth on the side placed against concrete.
   2. Have a straight upper edge.
   3. Be rigid enough to withstand the pressure of fresh concrete without distortion. Use enough stakes, clamps, spreaders, and braces to ensure rigidity.
   4. Be clean of debris and old concrete.
5. Coated with form oil before placing concrete.

C. Contractor may use either benders or thin plank forms on curves, grade changes, or curb returns. Wet the subgrade and forms immediately before placing the concrete. Place the preformed joint filler at expansion joints in the correct position before placing concrete against the filler.

3.4 PLACEMENT OF CONCRETE

A. Placement of concrete shall conform to the requirements presented in Section 03 30 00, specifically 610-3.12 Placing Concrete and 610-3.13 Vibration.

3.5 JOINTING OF CONCRETE

A. Contractor shall develop a jointing plan and submit for approval of the engineer as part of the shop drawing submittals. Jointing shall meet the requirements of local jurisdictions including but not limited to the following requirements:

1. Expansion Joints - Expansion Joints shall be placed at the outer edges of the proposed sidewalk when contacting existing sidewalk or other concrete site features. Expansion joints shall be provided at no more than 60’ intervals along the length of the sidewalk. Fill expansion joints with 1/4-inch-thick preformed joint filler. Finish the concrete adjacent to expansion joints with an edger tool. Shape the preformed joint filler to match the surface contour of the concrete. Joints shall continue through the adjacent curb.

2. Contraction Joints - Construct contraction joints to create rectangular patterns from 12 to 20 square’ in the surface of sidewalks. Construct contraction joints by
   a. Scoring concrete with a grooving tool and rounding corners with an edger tool OR
   b. By saw cutting hardened concrete to a depth of at least 1”. Immediately apply curing compound to the exposed surfaces of saw cut joints and an appropriate joint sealant after curing. Align curb joints with that of the sidewalk.

3. Construction Joints – Construction joints will not be permitted. Work shall be planned and sequenced such that the contractor can install all concrete between expansion joints without allowing the material to take an initial set between pours.

B. Where shown per plan, contractor shall install the curb ramps per California Department of Transportation Standard Plan A88A or as otherwise specified on the plans and details. Jointing plan shall be coordinated with any required curb ramps. Curb ramps shall have a detectable warning surface that extends the full width and 3’ depth of the ramp. Install a prefabricated detectable warning surface under the manufacturer’s instructions.

3.6 FINISHING

A. All exposed concrete surfaces shall be true, smooth, and free from open or rough areas, depressions, or projections. All concrete horizontal plane surfaces shall be brought flush to the proper elevation with the finished top surface struck-off with a straightedge and floated. Mortar finishing shall not be permitted, nor shall dry cement or sand-cement mortar be spread over the concrete during the finishing of horizontal plane surfaces.

B. Before removing the forms, finish the surface true to grade with a straightedge float at least 10’ in length. Operate the straightedge float longitudinally over the concrete surface.
C. Broom finish the surface of sidewalks, gutter depressions, curb ramps, and driveways. Make the broom finish perpendicular to the path of travel on surfaces used by pedestrians. Contractor may apply water to the surface immediately before brooming.

D. The finished surface of the sidewalk must not vary more than 0.02' from a 10-foot straightedge except at grade changes.

E. If placing pavement around or adjacent to manholes, pipe inlets, or other miscellaneous structures in sidewalk, gutter depression, island paving, curb ramps, or driveway areas, do not finish the miscellaneous structures to final grade until the pavement is finished beyond the miscellaneous structure. All standards, street and traffic signs, parking meters, sewer trap vent frames and covers, including adjusting the length of riser therefor, oil tank filler pipe covers, and the like, that require resetting to the new sidewalk level, shall be reset by the contractor to the proper elevations as Incidental Work.

F. Leave forms in place for sidewalks, gutter depressions, island paving, curb ramps, and driveways for at least 12 hours after surface finishing.

G. Remove the forms from the face of the curb from 1 to 6 hours after placing the concrete. Do not remove the forms if the concrete is plastic enough to slump. After removing the forms, immediately use a steel trowel to attain a smooth finish on the curb faces. The smooth finish must extend
   1. To within 0.17’ of the flow line OR
   2. To the flow line of a curb with an integral gutter. After smoothing the curb’s face, apply a fine-brush finish parallel to the line of the curb.

3.7 CURING

A. Curing of concrete shall conform to the requirements presented in Section 03 30 00, specifically 610-3.18 Curing and Protection. Cure concrete using the curing compound method with pigmented curing compound; completely coat the exposed faces of the concrete with curing compound.

3.8 PATCHING EXISTING ASPHALT

A. Where constructed against existing asphalt, contractor shall patch existing asphalt section to return site to existing conditions. Asphalt patch shall match the depths and materials of the adjacent asphalt pavement to remain. Asphalt material shall be locally available roadway mix that meets the minimum requirements of Standard Specifications for Public Works Construction (SSPWC), Greenbook 203-6 Asphalt Concrete and shall be placed in accordance with SSPWC 302-5.

3.9 DEFECTIVE WORK

A. Any defective work discovered after the forms have been removed, which in the opinion of the Engineer cannot be repaired satisfactorily, shall be immediately removed and replaced at the expense of the contractor. Removal shall be between established expansion joint lines; construction joints will not be permitted unless approved by the engineer. Defective work shall include deficient dimensions, or bulged, uneven, or honeycomb on the surface of the concrete.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Not applicable
PART 5 – MEASUREMENT AND PAYMENT

A. Concrete sidewalk satisfactorily constructed as specified will be measured horizontally per square foot. The curb adjoining sidewalk and curb inlets will not be included in measurements of area of sidewalk but will be considered incidental to the sidewalk installation. Any asphalt patching, regardless of area will not be measured for payment and will be considered incidental to the sidewalk installation. The areas of poles, standards, other fixtures, and of boxed-out locations for manhole and other casings and facilities, regardless of ownership thereof, will not be deducted from the areas of concrete sidewalk for which payment will be made.

B. The accepted quantities of Concrete Sidewalk will be paid for at the contract unit price per square foot. The price and payment shall be full compensation for furnishing and placing all materials, including but not limited to obtaining permits, preparing submittals, traffic control, demolition, removals, excavation, subgrade preparation, base materials, forming placement of concrete, adjusting surface features to grades, finishing, and patching asphalt sections.

END OF SECTION 32 13 13.20
SECTION 32 17 23 – RUNWAY AND TAXIWAY MARKINGS

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section shall consist of airfield painting stripes, numbers, and markings on the surface of runways, taxiways and aprons, and surface coating and markings on other areas of airfield as shown on the Plans, as specified herein, or as directed by the Engineer.

1.2 REFERENCES

A. Section 32 01 11.53 – Airfield Pavement Marking Removal.

B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

C. FAA Advisory Circular (AC) 150/5340-1 (current version), Standards for Airport Markings.


E. FAA Advisory Circular (AC) 150/5370-10 (current version), Specification Item P-620, Runway and Taxiway Marking, and as modified herein.

F. State of California Department of Transportation (Caltrans), Standard Specifications, Section 85, Pavement Markers, and Section 95, Epoxy.

G. Testing Requirements and Material Requirements as specified in P-620 and as modified herein.

1.3 SUBMITTALS

A. Prior to commencing the Work in this Section, the contractor shall submit the following pavement painting, markers, surface coating and paint removal information:

1. Test Reports: Certified test materials for materials to be used. Certified Test Report shall include a statement that the paint and glass beads materials meet the specification requirements.

2. Manufacturer’s specifications and certifications of compliance for taxiway edge retroreflective markers.

3. Manufacturer’s specifications and certifications of compliance for taxiway centerline markers.

4. Proposed paint removal method and equipment conforming to the requirements of Section 32 01 11.53.

5. Proposed paint equipment conforming to the requirements as specified in Item P-620-3.2 and as modified herein.

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-620, and as modified herein.
B. Prior to applying the final pavement striping and markings, the contractor shall cat-track the lead-in striping, parking envelope and VSR striping for the Engineer's review and approval. Cat-track marks shall be made with chalk and/or marking tapes.

C. Retroreflectivity of painted markings with glass beads shall be measured by a portable retroreflectometer, provided and paid for by the contractor and at the contractor's expense according to ASTM E1710 and the practices in ASTM D7585 shall be followed for taking retroreflectivity readings with a portable retroreflectometer and computing measurement averages. A van-mounted retroreflectometer may also be used. The test results shall be as follows:

1. Federal Specification TT-B-1325D, Type I, gradation “A”, where used for remarking of pavement markings, should yield at least 300 mcd/m²/lux on white markings at installation and at least 175 mcd/m²/lux on yellow markings at installation.

2. Federal Specification TT-B-1325D, Type III, gradation “A” where used for higher reflective value. Initial readings should yield at least 600 mcd/m²/lux on white markings and at least 300 mcd/m²/lux on yellow markings at installation.

D. The contractor shall also perform the following measurement on paint markings with and without retroreflective media (glass beads):

1. Prior to applying the pavement striping and markings, install a minimum 2-inch wide marking tape on the pavement along the Cat-track marks and within the area to be painted. After application of paint markings, measure wet film thickness. Once dry, remove the tape and measure the dry film thickness of the paint and the number/quantities of beads per 2-inch square. The results shall be evaluated on a lot basis for acceptance of pavement painting and markings test strip by the Engineer.

2. A lot shall consist of one day's production not to exceed 1,000 square feet of paint markings for taxiways, taxilanes, service roads and apron striping. Where used on the runway a lot shall consist of one day's production not to exceed 3,000 square feet of paint markings for edge and centerline markings and not to exceed 5,000 square foot of paint markings for other markings.

3. Painted markings not meeting the specification requirements may be rejected by the Engineer and shall be removed and replaced at the contractor's expense.

4. The contractor shall repair the damaged pavement painting and markings as required, at his expense, prior to final acceptance.

E. Test Strip. After approval of product, the contractor shall produce a test strip for each temporary and permanent painted marking in the presence of the Engineer.

1. The equipment should first be calibrated to establish the proper film thickness that is uniformly applied across the entire width of the marking. Based on the speed of the equipment, each glass bead dispenser should then be calibrated for the type of bead used. (See instructions on the calibration bucket).

F. The test strip shall be in accordance with FAA Specification Item P-620 Paragraph 620-3.6 “Test Strip” and as modified herein. The test strips shall include the retroreflectivity and film thickness testing as indicated in Paragraphs 1.04 C and 1.04 D. The results of the test strips, when accepted by the Engineer, shall be used to establish the baseline measurements of the painted markings completed in the field. The field painted markings not complying with the established baseline measurement may be rejected by the Engineer and shall be removed and replaced at the contractor’s expense.
1. If the initial test strip should prove to be unacceptable, a second test strip shall then be produced. Additional test strips, as required, shall be produced and evaluated for conformance to the specifications. Painted markings shall not begin until an acceptable test strip has been produced and accepted by the Engineer.

G. Prior to requiring a test strip and commencement of contract work, the contractor's nozzles/spray tips shall be clean and material guns calibrated to produce the desired paint thickness which should be based on the following table:

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<th>Mil Ratio = X</th>
<th>115/X</th>
<th>SF/Gal</th>
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<td>15/15 = 1</td>
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<tr>
<td>30/15 = 2</td>
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<td>20/15 = 1.3</td>
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<td>68.9 (70)</td>
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<td>7.5/15 = 0.5</td>
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</tbody>
</table>

Note: For example, if the specified coverage rate is 115 Square Feet per Gallon, the Mil ratio will be 15 mils.

H. Sampling and testing is the responsibility of the contractor.

1.5 EXPERIENCE

1.6 Equipment operator shall have a minimum of 5 years of experience installing Airport pavement markings and striping during nighttime and daytime operations. It is the responsibility of the contractor to pre-qualify operators and ensure quality markings, performance, and procedures are followed in accordance with the contract specifications.

PART 2 – PRODUCTS

2.1 EQUIPMENT

A. The contractor is to meet the requirements of FAA Specification Item P-620, and as modified herein.

B. The contractor shall be required to perform a test section, location as directed by the Contract Manager, to demonstrate the operator's and equipment capability of performing the work to the satisfaction of the Contract Manager and in accordance with the contract specifications.

C. Contractor material vehicles shall have the capability of placing a minimum of 4 material guns when painting 36-inch wide markings as approved by the Engineer. The equipment shall produce an even uniform film thickness at the required coverage and shall be designed so as to apply markings of uniform cross section and clear-cut edges without running or spattering.

D. Should the Contract Manager determine that the contractor's equipment is not adequately painting markings on the pavement, Contract Manager may require contractor to correct his equipment or procedures, or both, to adequately perform the work. The Airport reserves the right to inspect the contractor's equipment and the contractor shall provide for access and assistance during the inspection.

E. The equipment shall be equipped with sufficient lighting for work at night.

F. In addition to equipment in the list elsewhere, the contractor shall have the following minimum marking equipment on site at all times while marking operations.
Minimum Marking Equipment

<table>
<thead>
<tr>
<th>Number</th>
<th>Item Name</th>
<th>Minimum Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Truck Mounted Airport Marking System</td>
<td>Capable of applying markings 36” wide in a single pass, and be capable of applying two colors simultaneously. Uniform flow of beads are automatically triggered when the paint guns are activated. Pressurized bead guns On truck paint storage tanks with a minimum capacity of 100 gallons for each color.</td>
</tr>
<tr>
<td>2.</td>
<td>Walk Behind Marking System</td>
<td>With mechanical bead dispenser</td>
</tr>
</tbody>
</table>

2.2 PAINT AND REFLECTIVE MEDIA

A. Paint and reflective media (glass beads) shall conform to FAA Specification Item P-620, and as modified herein.

2.3 RETROREFLECTIVE MARKERS

A. Section not used.

PART 3 – EXECUTION

A. The contractor shall paint and provide reflective media in accordance with FAA Specification Item P-620, and as modified herein.

B. Contractor’s material vehicle is to maintain a slow speed during the installation of all markings and striping locations as shown on the plan drawings; in order for material coverage rates, film thickness, bead embedment and distribution to be effective.

C. Glass bead embedment into the marking material is to be 50-60% of the bead’s diameter; Airport reserves the right to deduct payment if embedment criteria are not met. Glass beads are not to be hand thrown. Contractor can use a pressurized or a gravity-drop system; however, with the later contractor is to ensure bead uniformity and distribution by tilting guns or installing screens.

D. Markings 4”-36” wide are to be applied in a uniform film thickness in a single pass. A minimum of 4 material guns are to be used for a 36” wide marking.

E. Contractor is to paint at an application of 50%, thickness of 7 mils, and with no glass beads.

PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item P-620, Runway and Taxiway Marking.

PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-620 and as modified herein.
FAA ITEM P-620 RUNWAY AND TAXIWAY MARKINGS

PART 1 – DESCRIPTION

- 620-1.1 – This item shall consist of the preparation and painting of numbers, markings, and stripes on the surface of runways, taxiways, and aprons, in accordance with these specifications and at the locations shown on the plans, or as directed by the Engineer. The terms “paint” and “marking material” as well as “painting” and “application of markings” are interchangeable throughout this specification.

PART 2 – MATERIALS

- 620-2.1 – Materials Acceptance. The contractor shall furnish manufacturer’s certified test reports for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. The reports can be used for material acceptance or the Engineer may perform verification testing. The reports shall not be interpreted as a basis for payment. The contractor shall notify the Engineer upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers 55 gallons or smaller for inspection by the Engineer. Material shall not be loaded into the equipment until inspected by the Engineer.

- 620-2.2 – Marking materials. Paint shall be waterborne in accordance with the requirements of paragraph 620-2.2 (Type I, II or III). Paint shall be furnished in white [37925], red [31136] with UV inhibitors, yellow [33538], black [37038], or green [34108] in accordance with Federal Standard No. 595.

  A. Waterborne black paint should be used to outline a border at least 6” (150 mm) wide around markings on all light colored pavements.

  1. For TT-P-1952E:
     a) Type I is intended for those locations where slower tracking is not a problem.
     b) Type II is intended for locations where faster curing is desirable.
     c) Type III requires the use of cross linking resin which will produce a thicker, more durable coating

  B. Waterborne. Paint shall meet the requirements of Federal Specification TT-P-1952E, Type I, Type II, or Type III. The non-volatile portion of the vehicle for all paint types shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis. The acrylic resin used for Type III shall be 100% cross linking acrylic as evidenced by infrared peaks at wavelengths 1568, 1624, and 1672 cm⁻¹ with intensities equal to those produced by a known 100% cross linking acrylic resin.

  C. Epoxy – not used

  D. Methacrylate – not used

  E. Solvent-Base – not used

  F. Preformed Thermoplastic Airport Pavement Markings – not used

- 620-2.3 – Reflective media. Glass beads shall meet the requirements for either TT-B-1325D, Type I or Type III. Type IV glass beads are not recommended unless used in conjunction with TT-P-1952E, Type III paint in a thicker application to facilitate proper embedment. Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.
### Paint Color

<table>
<thead>
<tr>
<th>Paint Color</th>
<th>Glass Beads, Type I, Gradation A</th>
<th>Glass Beads, Type III</th>
<th>Glass Beads, Type IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>See Table 1</td>
<td>See Table 1</td>
<td>See Table 1</td>
</tr>
<tr>
<td>Yellow</td>
<td>See Table 1</td>
<td>See Table 1</td>
<td>See Table 1</td>
</tr>
<tr>
<td>Red</td>
<td>See Table 1 and Note</td>
<td>Not used</td>
<td>See Table 1 and Note</td>
</tr>
<tr>
<td>Pink</td>
<td>See Table 1 and Note</td>
<td>Not used</td>
<td>See Table 1 and Note</td>
</tr>
<tr>
<td>Black</td>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
</tr>
<tr>
<td>Green</td>
<td>Not used</td>
<td>Not used</td>
<td>Not used</td>
</tr>
</tbody>
</table>

A. Federal Specification TT-B-1325D, Type I, gradation A shall be used when remarking on a frequent basis (at least every six months), and should yield at least 300 mcd/m²/lux on white markings at installation and at least 175 mcd/m²/lux on yellow markings at installation.

B. Federal Specification TT-B-1325D, Type III, gradation A shall be used when a higher reflective value is desired. Initial readings should yield at least 600 mcd/m²/lux on white markings and at least 300 mcd/m²/lux on yellow markings at installation.

C. Preformed thermoplastic pavement markings should yield at least 225 mcd/m²/lux on white markings at installation and at least 100 mcd/m²/lux on yellow markings at installation.

D. Retroreflectivity shall be measured by a portable retroreflectometer according to ASTM E1710 and the practices in ASTM D7585 shall be followed for taking retroreflectivity readings with a portable retroreflectometer and computing measurement averages. A van-mounted retroreflectometer may also be used.

### PART 3 – CONSTRUCTION METHODS

- **620-3.1 – Weather limitations.** The painting shall be performed only when the surface is dry and when the surface temperature is at least 45°F (7°C) and rising and the pavement surface temperature is at least 5°F (2.7°C) above the dew point or meets the manufacturer’s recommendations. Markings shall not be applied when the pavement temperature is greater than 130°F (55°C). Markings shall not be applied when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns.

- **620-3.2 – Equipment.** Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

  A. The mechanical marker shall be an atomizing spray-type or airless-type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray.

- **620-3.3 – Preparation of surface.** Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by waterblasting, grinding, or by a combination of these or other methods as required to remove all contaminants without damage to the pavement surface. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer. After the cleaning operations, sweeping, blowing, or rinsing with pressurized water shall be performed to ensure the surface is clean and free of grit or other debris left from the cleaning process.
A. Paint shall not be applied to Portland cement concrete pavement until the areas to be painted are clean of curing material. Sandblasting or high-pressure water shall be used to remove curing materials.

B. At least 24 hours prior to remarking existing markings, the existing markings must be removed such that 90% of the existing markings are removed with low (3,500-10,000 psi) waterblaster. After waterblasting, the surface shall be cleaned of all residue or debris either with sweeping or blowing with compressed air or both.

C. Prior to the initial application of markings, the contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the type of marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufacturer’s surface preparation and application requirements must be submitted and approved by the Engineer prior to the initial application of markings.

620-3.4 – Layout of markings. The proposed markings shall be laid out in advance of the paint application.

A. Glass beads improve conspicuity and the friction characteristics of markings. At a minimum, the Engineer shall indicate the following locations to receive glass beads per AC 150/5340-1L, Standards for Airport Markings:

1. All holding position markings used on runways, taxiways, and holding bays and used to indicate instrument landing system/microwave landing system (ILS/MLS) or precision obstacle-free zone (POFZ) critical areas.
2. Runway threshold marking.
3. Runway threshold bar.
4. Runway aiming point marking.
5. Runway designation marking.
6. Runway touchdown zone markings.
7. Runway centerline marking.
8. All taxiway centerline markings and enhanced taxiway centerline markings.
9. Geographical position marking.
10. Surface painted signs for holding position signs, taxiway direction signs, taxiway location signs, gate destination signs, and apron entrance point signs.
11. Non-movement area boundary marking.
12. Displaced threshold markings.

B. The following locations are recommended to receive glass beads:

1. Runway side stripes.
2. Taxiway edge markings.
3. Runway demarcation bar

620-3.5 – Application. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the Engineer. The edges of the markings shall not vary from a straight line more than 1/2" (12mm) in 50’ (15 m), and marking dimensions and spacing shall be within the following tolerances:
### Dimension and Spacing

<table>
<thead>
<tr>
<th>Dimension and Spacing</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>36” (910 mm) or less</td>
<td>±1/2” (12mm)</td>
</tr>
<tr>
<td>greater than 36” to 6’ (910 mm to 1.85 m)</td>
<td>±1” (25 mm)</td>
</tr>
<tr>
<td>greater than 6’ to 60’ (1.85 m to 18.3 m)</td>
<td>±2” (50 mm)</td>
</tr>
<tr>
<td>greater than 60’ (18.3 m)</td>
<td>±3” (76 mm)</td>
</tr>
</tbody>
</table>

A. The paint shall be mixed in accordance with the manufacturer’s instructions and applied to the pavement with a marking machine at the rate shown in Table 1. The addition of thinner will not be permitted. A period of 30 days shall elapse between placement of a bituminous surface course or seal coat and application of the paint.

B. Prior to the initial application of markings, the contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufactures application and surface preparation requirements must be submitted to the Engineer prior to the initial application of markings.

- **620-3.6 – Test strip.** Prior to the full application of airfield markings, the applicator shall produce a test strip in the presence of the Engineer. The test strip shall include the application of a minimum of 5 gallons (4 liters) of paint and application of 35 lbs (15.9 kg) of Type I/50 lbs (22.7 kg) of Type III glass beads. The test strip shall be used to establish thickness/darkness standard for all markings. The test strip shall cover no more than the maximum area prescribed in Table 1 (e.g., for 5 gallons (19 liters) of waterborne paint shall cover no more than 575 square feet (53.4 m2).

<table>
<thead>
<tr>
<th>Paint Type</th>
<th>Paint Square feet per gallon, ft²/gal</th>
<th>Glass Beads, Type I, Gradation A Pounds per gallon of paint-lb/gal</th>
<th>Glass Beads, Type III Pounds per gallon of paint-lb/gal</th>
<th>Glass Beads, Type IV Pounds per gallon of paint-lb/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTP-1952E, Type I or II</td>
<td>115 SF/gal</td>
<td>7 lb per gal</td>
<td>10 lb per gal</td>
<td>8 lb per gal</td>
</tr>
<tr>
<td>TTP-1952E, Type III</td>
<td>60 to 115 SF/gal</td>
<td>*</td>
<td>5-10 lb per gal</td>
<td>5-8 lb per gal</td>
</tr>
</tbody>
</table>

### Table 1 Application Rates For Paint And Glass Beads

(See Note regarding Red and Pink Paint)

#### Application Rates for Paint and Glass Beads for Table 1

<table>
<thead>
<tr>
<th>Paint Type</th>
<th>Paint Square feet per gallon, ft²/gal (Sq m per liter, m²/l)</th>
<th>Glass Beads, Type I, Gradation A Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
<th>Glass Beads, Type III Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
<th>Glass Beads, Type IV Pounds per gallon of paint-lb/gal (Kg per liter of paint-kg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterborne Type I or II</td>
<td>115 ft²/gal max (2.8 m²/l)</td>
<td>7 lb/gal min (0.85 kg/l)</td>
<td>10 lb/gal min (1.2 kg/l)</td>
<td>--</td>
</tr>
<tr>
<td>Waterborne Type III</td>
<td>90 ft²/gal max (2.2 m²/l)</td>
<td>--</td>
<td>10 lb/gal min (1.2 kg/l)</td>
<td>--</td>
</tr>
<tr>
<td>Waterborne Type III</td>
<td>55 ft²/gal max (1.4 m²/l)</td>
<td></td>
<td></td>
<td>8 lb/gal min (1.0 kg/l)</td>
</tr>
</tbody>
</table>
Note: The glass bead application rate for Red and Pink paint shall be reduced by 2 lb/gal (0.24 kg/l) for Type I and Type IV beads. Type III beads shall not be applied to Red or Pink paint.

A. Markings may be required before paving operations are complete. Paint is to be waterborne materials for temporary markings at 50% of the specified application rates (for example, rate/0.50). No glass beads are required for temporary markings. TT-P-1952E, Type II or A-A-2886B, Type III may be used for temporary markings when reflectorized temporary markings are desired. Glass beads will not adhere well at the low application rates for temporary markings and require immediate sweeping and cleanup before aircraft are allowed to use the pavement.

B. It is recommended when using waterborne paints on previously unmarked asphalt or seal coat, that an initial paint coat at 50% of the permanent coverage rates be applied for white markings to reduce the discoloration that occurs.

C. New concrete pavements should be allowed to cure for eight to twelve weeks before removing the curing compound and installing permanent markings.

D. Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished that is properly designed for attachment to the marking machine and suitable for dispensing glass beads. Glass beads shall be applied at the rate shown in Table 1. Glass beads shall not be applied to black paint or green paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made. Different bead types shall not be mixed. Regular monitoring of glass bead embedment should be performed.

E. All emptied containers shall be returned to the paint storage area for checking by the Engineer. The containers shall not be removed from the airport or destroyed until authorized by the Engineer.

620-3.7 – Application – Preformed Thermoplastic Airport Pavement Markings.

A. Asphalt and Portland Cement. To ensure minimum single-pass application time and optimum bond in the marking/substrate interface, the materials must be applied using a variable speed self-propelled mobile heater with an effective heating width of no less than 16’ (5 m) and a free span between supporting wheels of no less than 18’ (5.5 m). The heater must emit thermal radiation to the marking material in such a manner that the difference in temperature of 2” (50 mm) wide linear segments in the direction of heater travel must be within 5% of the overall average temperature of the heated thermoplastic material as it exits the heater. The material must be able to be applied at ambient and pavement temperatures down to 35 °F (2 °C) without any preheating of the pavement to a specific temperature. The material must be able to be applied without the use of a thermometer. The pavement shall be clean, dry, and free of debris. A non-volatile organic content (non-VOC) sealer with a maximum applied viscosity of 250 centipoises must be applied to the pavement shortly before the markings are applied. The supplier must enclose application instructions with each box/package.

620-3.8 – Protection and Cleanup. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The contractor shall remove from the work area all debris, waste, loose or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Engineer. The contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.
PART 4 – METHOD OF MEASUREMENT

620-4.1 – The quantity of runway and taxiway markings shall be measured by lump sum as a single complete unit of Work, and accepted by the Contract Manager.

PART 5 – BASIS OF PAYMENT

620-5.1 – Payment shall be made at the respective contract price per lump sum for Pavement Painting and Markings runway and taxiway painting and markings and other airfield pavement paintings and markings with (reflective) and without (non-reflective) reflective media (glass beads)

A. This price shall be full compensation for furnishing all materials, including reflective and non-reflective media (glass beads), retroreflective raised pavement makers and for all labor, test strip, sampling and testing of the materials, equipment, tools, and incidentals necessary to complete the item.

TESTING REQUIREMENTS

| ASTM C371 | Standard Test Method for Wire-Cloth Sieve Analysis of Nonplastic Ceramic Powders |
| ASTM D92  | Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester          |
| ASTM D1652| Standard Test Method for Epoxy Content of Epoxy Resins                              |
| ASTM D2074| Standard Test Method for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method |
| ASTM D2240| Standard Test Method for Rubber Property - Durometer Hardness                       |
| ASTM D7585| Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments |
| ASTM G154 | Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials |

MATERIAL REQUIREMENTS

<p>| ASTM D476 | Standard Classification for Dry Pigmentary Titanium Dioxide Products |
| 40 CFR Part 60, Appendix A-7, Method 24 | Determination of volatile matter content, water content, density, volume solids, and weight solids of surface coatings |
| FED SPEC TT-B-1325D | Beads (Glass Spheres) Retro-Reflective |
| American Association of State Highway and Transportation | Standard Specification for Glass Beads Used in Pavement Markings |</p>
<table>
<thead>
<tr>
<th>Officials (AASHTO) M247</th>
<th>Paint, Traffic and Airfield Marking, Waterborne</th>
</tr>
</thead>
<tbody>
<tr>
<td>FED SPEC TT-P-1952E</td>
<td>Paint, Traffic, Solvent Based</td>
</tr>
<tr>
<td>Commercial Item</td>
<td>Colors used in Government Procurement</td>
</tr>
<tr>
<td>Description A-A-2886B:</td>
<td>AC 150/5340-1 Standards for Airport Markings</td>
</tr>
</tbody>
</table>

END OF SECTION 32 17 23
SECTION 32 23 23.33 – CONTROLLED LOW-STRENGTH MATERIAL (CLSM) (FAA ITEM P-153)

PART 1 – GENERAL

1.1 SUMMARY
A. The Work under this Section shall consist of furnishing and installing controlled low-strength material (CLSM) as shown on the Plans, as specified herein, or as directed by the Engineer.
B. Unless otherwise specified in these specifications, slurry fill shall meet the requirements of this section.

1.2 REFERENCES
A. Drawings apply to this Section.
B. San Francisco International Airport Rules and Regulations/Airport Building Regulations.
C. FAA Specification Item P-153, Controlled Low-Strength Material (CLSM), and as modified herein.

1.3 SUBMITTALS
A. Prior to commencing Work in this Section and delivery of materials to the job site, the contractor shall submit the following controlled low-strength material information.
   1. Test Results: The contractor shall submit all copies of certified test results on cement, fly ash and fine aggregates to the Engineer for review. These shall include retests for items that failed initial testing.
   2. The contractor shall submit, to the Engineer, a mix design including the proportions and source of materials, admixtures, and dry cubic yard batch weights, and Compressive Strength.

1.4 QUALITY ASSURANCE
A. The contractor shall perform Quality Control testing to meet the requirement of FAA Specification Item P-153, and as modified herein.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Portland cement, fly ash, fine aggregates, and water shall conform to FAA Specification Item P-153, and as modified herein.

PART 3 – EXECUTION

3.1 The contractor shall provide CLMS in accordance with FAA Specification Item P-153, and as modified herein.

PART 4 – INCLUDED FAA SPECIFICATIONS
A. Item P-153, Controlled Low-Strength Material (CLSM).
PART 5 – MEASUREMENT AND PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-153 and as modified herein.
**FAA ITEM P-153 CONTROLLED LOW-STRENGTH MATERIAL (CLSM)**

**PART 1 – DESCRIPTION**

- 153.1.1 – This item shall consist of furnishing, transporting, and placing a controlled low-strength material (CLSM) as flowable backfill in trenches or at other locations shown on the plans or as directed by the Engineer.

**PART 2 – MATERIALS**

- 153-2.1 – **Materials**
  
  A. **Portland Cement.** Portland cement shall conform to the requirements of ASTM C 150 - Type II. If for any reason, cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.
  
  B. **Fly ash.** Fly ash shall conform to ASTM C 618, Class C or F.
  
  C. **Fine Aggregate (Sand).** Fine aggregate shall conform to the requirements of ASTM C33 except for aggregate gradation. Any aggregate gradation which produces performance characteristics of the CLSM specified here will be accepted, except as follows:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4” (19 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No. 200 (0.075 mm)</td>
<td>0 - 12</td>
</tr>
</tbody>
</table>
  
  D. **Water.** Water used in mixing shall be potable and free of oil, salt, acid, alkali, sugar, vegetable matter, or other substances injurious to the finished product.

**PART 3 – MIX DESIGN**

- 153-3.1 – **Proportions.** Contractor shall submit, to the Engineer, a mix design including the proportions and source of aggregate, fly ash, cement, water, and approved admixtures. No CLSM mixture shall be produced for payment until the Engineer has given written approval of the proportions. The proportions shall be prepared by a laboratory and shall remain in effect for the duration of the project. Laboratory costs are incidental to this item. The proportions shall establish a single percentage or weight for aggregate, fly ash, cement, water, and any admixtures proposed.

  A. **Compressive Strength.** CLSM shall be designed to achieve a 28-day compressive strength of 100 to 200 psi (690 to 1379 kPa) when tested in accordance with ASTM D4832. There should be no significant strength gain after 28 days.

  B. **Consistency.** CLSM should be designed to achieve a consistency that will produce an approximate 8-inch (200 mm) diameter circular-type spread without segregation when tested by: (1) filling a 3-inch inside diameter by 6-inch length flow cylinder (non-absorbent pipe) (2) strike off of the flow cylinder and start of lift within five seconds of filling and (3) by steady upward pull, lift the cylinder in a time period of between two and four seconds. Adjustments of the material proportions should be made to achieve proper solid suspension and flowable characteristics, however the theoretical yield shall be maintained at one cubic yard (cubic meter) for the given batch weights.

**PART 4 – CONSTRUCTION METHODS**

- 153-4.1 – **Placement.**
A. **Placement.** CLSM may be placed by any reasonable means from a mixing unit into the space to be filled. Agitation is required during transportation and waiting time. Placement shall be performed so structures or pipes are not displaced from their final position and intrusion of CLSM into unwanted areas is avoided. The material shall be brought up uniformly to the fill line shown on the plans or as directed by the Engineer. Each placement of CLSM shall be as continuous an operation as possible. If CLSM is placed in more than one layer, the base layer shall be free of surface water and loose foreign material prior to placement of the next layer.

B. **Limitations of Placement.** CLSM shall not be placed on frozen ground. Mixing and placing may begin when the air or ground temperature is at least 35°F (2°C) and rising. At the time of placement, CLSM shall have a temperature of at least 40°F (4°C). Mixing and placement shall stop when the air temperature is 40°F (4°C) and falling or when the anticipated air or ground temperature will be 35°F (2°C) or less in the 24-hour period following proposed placement.

### 153-4.2 – Curing and Protection

A. **Curing.** The air in contact with the CLSM shall be maintained at temperatures above freezing for a minimum of 72 hours. If the CLSM is subjected to temperatures below 32°F (0°C), the material may be rejected by the Engineer if damage to the material is observed.

B. **Protection.** The CLSM shall not be subject to loads and shall remain undisturbed by construction activities for a period of 48 hours or until a compressive strength of 15 psi (105 kPa) is obtained. The contractor shall be responsible for providing evidence to the Engineer that the material has reached the desired strength. Acceptable evidence shall be based upon compressive tests made in accordance with paragraph 153-3.1A.

### 153-4.3 – Acceptance

Acceptance of CLSM delivered and placed as shown on the plans or as directed by the Engineer shall be based upon mix design approval and batch tickets provided by the contractor to confirm that the delivered material conforms to the mix design. The contractor shall verify by additional testing, each 1,000 cubic yards (765 m³) of material used. Verification shall include confirmation of material proportions and tests of compressive strength to confirm that the material meets the original mix design and the requirements of CLSM as defined in this specification. Adjustments shall be made as necessary to the proportions and materials prior to further production.

**PART 5 – METHOD OF MEASUREMENT**

### 153-5.1 – Measurement

A. Except for the following bid item, the work covered by this section shall be considered as a subsidiary obligation of the contractor covered under the other contract items and no separate measurement and payment will be made under this section.

B. If there is no quantity shown in the bidding schedule, the work covered by this section shall be considered as a subsidiary obligation of the Contractor covered under the other contract items.

C. Slurry Fill to Abandon Existing Pipes - The quantity of Slurry Fill to Abandon Existing Pipes shall be measured by cubic yards of slurry placed in existing storm drain pipes to be abandoned in place in accordance with these specifications and accepted by the Contract Manager.

**PART 6 – BASIS OF PAYMENT**

### 153-6.1 – Payment
A. Except for the following bid items, there will be no separate payment for work under this section. All work shall be considered incidental to the respective contract bid items.

1. Slurry Fill to Abandon Existing Pipes - Payment will be made at the contract unit price per cubic yards installed per plans. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, hauling and disposing of waste material off of Airport property, and incidentals necessary to complete the item.

2. All associated work, as required to place slurry, shall be considered incidental to this bid item, including but not limited to: excavation, saw cutting, grinding, shoring, dewatering, pipe evacuation, hauling and backfill, welding, installation of risers, and capping pipe ends.

**TESTING REQUIREMENTS**

| ASTM D 4832 | Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders |

**MATERIAL REQUIREMENTS**

| ASTM C 33  | Specification for Concrete Aggregates |
| ASTM C 150 | Specification for Portland Cement |
| ASTM C 618 | Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete |
| ASTM C 595 | Specification for Blended Hydraulic Cements |

END OF SECTION 32 23 23.33
SECTION 32 31 13 – CHAIN-LINK FENCE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consists of furnishing and erecting chain-link fence and gates in accordance with these specifications and the details shown on the plans and in conformity with the lines and grades shown on the plans or established by the Engineer, and as specified herein.

B. This Item shall also include AOA security fencing installed on Concrete barriers and K-Rail as shown on the plans.

1.2 REFERENCES

A. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

B. Caltrans Standard Plans and Specifications.

C. CAL/OSHA Standards.

D. Caltrans Standard Plans.

E. Section 02 22 25 – Underground Utility Locating.

F. Section 03 30 00 – Structural Portland Cement Concrete FAA Item P-610

G. Section 31 23 00 – Excavation and Embankment FAA Item P-152.

H. Section 34 73 16 – Airfield Grounding.

I. FAA Specification Item F-162, Chain-Link Fence, and as modified herein.

J. American Society for Testing and Materials (ASTM), standards and tests, as referenced in FAA Item F-162.

K. When there are any discrepancies of requirements under these references, the most stringent requirement shall prevail.

1.3 SUBMITTALS

A. The contractor shall submit the following pipe and storm drain materials:

1. Fence and gate materials

2. Gate shop drawings

3. Concrete material and reinforcement.

4. Concrete K-rail

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing in accordance with all applicable codes and regulations to meet the requirement of FAA Specification Item F-162, and as modified herein.
PART 2 – PRODUCTS

2.1 MATERIALS
A. Fence and gate materials shall conform to FAA Specification Item F-162, and as modified herein.
B. Concrete K-Rail shall be Type K, 20-ft section per Caltrans Standard Drawing T3A in latest version as contracted.

PART 3 – EXECUTION

3.1 CONSTRUCTION METHODS
A. The contractor shall furnish and install fence and gates in accordance with FAA Specification Item F-162, and as modified herein.

3.2 SURVEY
A. Verify survey references provided by Airport Surveyors.

3.3 PREPARATION
A. Identify and record lines, levels, contours, datum and water table.

3.4 LOCATING OF UNDERGROUND UTILITIES
A. The contractor shall hire an underground utilities locating service to locate and mark all the known and unknown underground utilities and pipelines before digging for posts.
B. For additional requirements refer to Section 02 22 25 – Underground Utility Locating.

3.5 EXISTING CHAIN-LINK FENCE AND GATES
A. Remove existing chain-link fence and gates as indicated and dispose of them to approved site outside Airport.

3.6 MODIFICATION OF AOA PERIMETER
A. Any change to the airfield perimeter, including but not limited removal of existing AOA fencing, installation of new fencing, and the movement of temporary fencing will require the advanced notice, and approval for the Airport Aviation Security Office. Contractor shall notify the Airport Aviation Security Office no less than 10 working days in advance of a proposed perimeter modification. Contractor may be required to attend coordination meetings and or provide detailed fence plans for approval. The cost of any coordination with the Airport Aviation Security Office shall be considered incidental to the work items.
B. When installing new fencing or modifying an existing perimeter, contractor shall receive final authorization from the Airport Aviation Security Office before the fence is considered complete and eligible for payment.

3.7 SIGNAGE AND MARKING
A. Contractor shall install SFIA provided metal traffic signage at the designated locations per plan. Signs shall be mechanically secured to the fence with galvanized supports and accessories. Supports shall sufficiently secure standard traffic signs against significant movement when exposed to aircraft jet blast and environmental factors.
PART 4 – INCLUDED FAA SPECIFICATIONS

A. Item F-162, Chain Link Fence.

PART 5 – PAYMENT

A. The work under this section shall be measured and paid for in accordance with FAA Specification Item P-162 and as modified herein.
FAA ITEM F-162 CHAIN LINK FENCE

PART 1 – DESCRIPTION

- 162-1.1 – This item shall consist of furnishing and erecting a chain-link fence in accordance with these specifications, the details shown on the plans, and in conformity with the lines and grades shown on the plans or established by the Engineer.

- 162-1.2 – This item shall also consist of furnishing and erecting AOA security chain-link fence on concrete barrier in accordance with these specifications and the details shown on the plans and in conformity with the lines and grades shown on the plans or established by the Engineer.

PART 2 – MATERIALS

- 162-2.1 – Fabric. Unless otherwise indicated on the plans, the fabric shall be woven with a 9-gauge galvanized steel wire in a 2” mesh and shall meet the requirements of ASTM A392, Class 2.

- 162-2.2 – Barbed Wire. Barbed wire shall be 2-strand 12-1/2 gauge zinc-coated wire with 4-point barbs and shall conform to the requirements of ASTM A121, Class 3, Chain Link Fence Grade.

- 162-2.3 – Posts, Rails, and Braces. Line posts, rails, and braces shall conform to the requirements of ASTM F1043 or ASTM F1083 as follows.
  A. Galvanized tubular steel pipe shall conform to the requirements of Group IA, (Schedule 40) coatings conforming to Type A, or Group IC (High Strength Pipe), External coating Type B, and internal coating Type B or D.
  B. Posts, rails, and braces furnished for use in conjunction with aluminum alloy fabric shall be aluminum alloy or composite.
  C. The dimensions of the posts, rails, and braces shall be in accordance with Tables I through VI of Fed. Spec. RR-F-191/3.

- 162-2.4 – Gates. Gate frames shall consist of galvanized steel pipe and shall conform to the specifications for the same material under paragraph 162-2.3. The fabric shall be of the same type material as used in the fence.

- 162-2.5 – Wire Ties and Tension Wires. Wire ties for use in conjunction with a given type of fabric shall be of the same material and coating weight identified with the fabric type. Tension wire shall be 7-gauge marcelled steel wire with the same coating as the fabric type and shall conform to ASTM A824.
  A. All material shall conform to Federal Specification RR-F-191/4.

- 162-2.6 – Miscellaneous Fittings and Hardware. Unless otherwise indicated on the plans, miscellaneous steel fittings and hardware for use with zinc-coated steel fabric shall be of commercial grade steel or better quality, wrought or cast as appropriate to the article, and sufficient in strength to provide a balanced design when used in conjunction with fabric posts, and wires of the quality specified herein. All steel fittings and hardware shall be protected with a zinc coating applied in conformance with ASTM A153. Barbed wire support arms shall withstand a load of 250 pounds applied vertically to the outermost end of the arm.

- 162-2.7 – Concrete. Concrete for the fence shall be of a commercial grade with a minimum 28-day compressive strength of 2,500 psi. All other Concrete work shall conform to Section 03 30 00 FAA Item P-610.
162-2.8 – **Marking.** Each roll of fabric shall carry a tag showing the kind of base metal (steel, aluminum, or aluminum alloy number), kind of coating, the gauge of the wire, the length of fencing in the roll, and the name of the manufacturer. Posts, wire, and other fittings shall be identified as to manufacturer, kind of base metal (steel, aluminum, or aluminum alloy number), and kind of coating.

**PART 3 – CONSTRUCTION METHODS**

162-3.1 – **Clearing Fence Line.** All trees, brush, stumps, logs, and other debris which would interfere with the proper construction of the fence in the required location shall be removed a minimum width of 5’ on each side of the fence centerline before starting fencing operations. The cost of removing and disposing of the material shall not constitute a pay item and shall be considered incidental to fence construction.

162-3.2 – **Installing Posts.** All posts shall be set in concrete at the required dimension and depth and at the spacing shown on the plans.

A. The concrete shall be thoroughly compacted around the posts by tamping or vibrating and shall have a smooth finish slightly higher than the ground and sloped to drain away from the posts. All posts shall be set plumb and to the required grade and alignment. No materials shall be installed on the posts, nor shall the posts be disturbed in any manner within 7 days after the individual post footing is completed.

B. Should rock be encountered at a depth less than the planned footing depth, a hole 2” (50 mm) larger than the greatest dimension of the posts shall be drilled to a depth of 12” (300 mm). After the posts are set, the remainder of the drilled hole shall be filled with grout, composed of one part Portland cement and two parts mortar sand. Any remaining space above the rock shall be filled with concrete in the manner described above.

C. In lieu of drilling, the rock may be excavated to the required footing depth. No extra compensation shall be made for rock excavation.

162-3.3 – **Installing Top Rails.** The top rail shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion.

162-3.4 – **Installing Braces.** Horizontal brace rails, with diagonal truss rods and turnbuckles, shall be installed at all terminal posts.

162-3.5 – **Installing Fabric.** The wire fabric shall be firmly attached to the posts and braced as shown on the plans. All wire shall be stretched taut and shall be installed to the required elevations. The fence shall generally follow the contour of the ground, with the bottom of the fence fabric no less than 1” (25 mm) or more than 4” (100 mm) from the ground surface. Grading shall be performed where necessary to provide a neat appearance.

A. At locations of small natural swales or drainage ditches and where it is not practical to have the fence conform to the general contour of the ground surface, longer posts may be used and multiple strands of barbed wire stretched to span the opening below the fence. The vertical clearance between strands of barbed wire shall be 6” (150 mm) or less.

162-3.6 – **Electrical Grounds.** Electrical grounds shall be constructed at all AOA fences and other fences where indicated on the plans at 500’ intervals. The ground shall be accomplished with a copper clad rod 8’ (2.4 m) long and a minimum of 5/8” (16 mm) in diameter driven vertically until the top is 6” (150 mm) below the ground surface. A No. 6 solid copper conductor shall be clamped to the rod and to the fence in such a manner that each element of the fence is grounded. Installation of ground rods shall not constitute a pay item and shall be considered incidental to fence construction. The contractor shall comply with FAA-STD-019, Lightning and Surge Protection, Grounding, Bonding and Shielding.
Requirements for Facilities and Electronic Equipment, Paragraph 4.2.3.8, Lightning Protection for Fences and Gates, when fencing is adjacent to FAA facilities.

- **162-3.7 – Cleaning up.** The contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., used during construction. All disturbed areas shall be seeded per T-901.

### PART 4 – METHOD OF MEASUREMENT

- **162-4.1** – Temporary AOA fence shall be measured for payment by lump sum as a single complete unit of Work, and accepted by the Contract Manager.

- **162-4.2** – The quantity of airfield security fence dismantled and salvaged per contract plans shall be measured by the linear foot of fence and gate removed in accordance with plans and accepted by the Contract Manager. Measurement will be made along the top of the fence from center to center of end posts.

- **162-4.3** – The quantity of airfield security fence dismantled and salvaged per contract plans shall be measured by the linear foot of fence and gate removed in accordance with plans and accepted by the Contract Manager. Measurement will be made along the top of the fence from center to center of end posts.

### PART 5 – BASIS OF PAYMENT

- **162-5.1** – Payment for installation and removal of temporary AOA fencing shall be made at the contract unit price per lump sum. This price shall be full compensation for furnishing all materials and for all preparation, excavation and backfill material under the fence as required, concrete K-rail barrier, barbed wires, top and bottom braces as required, gates, removal of the fence and gates, installing signage; and for all labor equipment, tools and incidentals necessary to complete the work.

- **162-5.2** – Payment for airfield security fence dismantled and salvaged will be made at the contract unit price per linear foot of airfield security fence and gate dismantled and salvaged per contract plan, including K-rail, fence saddles, and posts, and dispose of fence fabric, barb wire and remaining hardware off Airport property, complete and accepted by the Contract Manager. Price shall include demolition and removal of associated foundations; if applicable. The price shall be full compensation for furnishing all materials, and for all labor equipment, tools, hauling, and incidentals necessary to complete the item.

- **162-5.3** – Payment for installation and removal of Airfield Security Fence fencing shall be made at the contract unit price of linear feet. This price shall be full compensation for furnishing all materials and for all preparation, excavation and backfill material under the fence as required, concrete barrier, barbed wires, top and bottom braces as required, gates, installing signage; and for all labor equipment, tools and incidentals necessary to complete the work.

### MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A 121</td>
<td>Zinc-Coated (Galvanized) Steel Barbed Wire</td>
</tr>
<tr>
<td>ASTM A 123</td>
<td>Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products</td>
</tr>
<tr>
<td>ASTM A 153</td>
<td>Zinc Coating (Hot-Dip) on Iron and Steel Hardware</td>
</tr>
<tr>
<td>ASTM A 392</td>
<td>Zinc-Coated Steel Chain-Link Fence Fabric</td>
</tr>
<tr>
<td>ASTM A 572</td>
<td>High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Steel Quality</td>
</tr>
<tr>
<td>ASTM A491</td>
<td>Aluminum-Coated Steel Chain-Link Fence Fabric</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ASTM A 653</td>
<td>Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process</td>
</tr>
<tr>
<td>ASTM A 824</td>
<td>Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence</td>
</tr>
<tr>
<td>ASTM A 1011</td>
<td>Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability</td>
</tr>
<tr>
<td>ASTM B 117</td>
<td>Standard Practice for Operating Salt Spray (Fog) Apparatus</td>
</tr>
<tr>
<td>ASTM B 221</td>
<td>Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Profiles and Tubes</td>
</tr>
<tr>
<td>ASTM B 429</td>
<td>Aluminum-Alloy Extruded Structural Pipe and Tube</td>
</tr>
<tr>
<td>ASTM F 668</td>
<td>Polyvinyl Chloride (PVC), Polyolefin and other Organic Polymer Coated Steel Chain-Link Fence Fabric</td>
</tr>
<tr>
<td>ASTM F 1043</td>
<td>Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework</td>
</tr>
<tr>
<td>ASTM F 1083</td>
<td>Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures</td>
</tr>
<tr>
<td>ASTM F 1183</td>
<td>Aluminum Alloy Chain Link Fence Fabric</td>
</tr>
<tr>
<td>ASTM F 1345</td>
<td>Zinc 5% Aluminum-Mischmetal Alloy Coated Steel Chain-Link Fence Fabric</td>
</tr>
<tr>
<td>ASTM G 152</td>
<td>Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>ASTM G 154</td>
<td>Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>ASTM G 155</td>
<td>Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>FED SPEC RR-F-191/3</td>
<td>Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)</td>
</tr>
<tr>
<td>FED SPEC RR-F-191/4</td>
<td>Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)</td>
</tr>
<tr>
<td>FAA-STD-019</td>
<td>Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment</td>
</tr>
</tbody>
</table>

END OF SECTION 32 31 13
SECTION 32 31 15 – TEMPORARY AOA FENCE

PART 1 – GENERAL

1.1 SUMMARY

A. The Work under this Section consists of furnishing and erecting temporary AOA security fence and gates in accordance with these specifications and the details shown on the plans and in conformity with the lines and grades shown on the plans or established by the Engineer, and as specified herein.

B. This item shall also include installation AOA fence on Concrete K-Rail.

1.2 REFERENCES

A. San Francisco International Airport Rules and Regulations/Airport Building Regulations.

B. Caltrans Standard Plans and Specifications.

C. CAL/OSHA Standards.

D. Section 02 22 25 – Underground Utility Locating.

E. Section 03 30 00 – Structural Portland Cement Concrete FAA Item P-610

F. Section 31 23 00 – Excavation and Embankment FAA Item P-152.

G. Section 32 31 13 FAA Specification Item F-162, Chain-Link Fence, and as modified herein.

H. American Society for Testing and Materials (ASTM), standards and tests, as referenced in these specifications.

I. Caltrans Standard Plans, latest versions as contracted.

1.3 SUBMITTALS

A. The contractor shall submit the following materials:

1. Fence and materials

2. Gate shop drawings

3. Concrete material.

4. Concrete K-Rail

1.4 QUALITY ASSURANCE

A. The contractor shall perform Quality Control testing in accordance with all applicable codes and regulations and the San Francisco International Airport Rules and Regulations/Airport Building Regulations.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Fence and gate materials shall conform to FAA Specification Item F-162, and as modified herein.
B. Concrete K-Rail shall be Type K, 20-ft section per Caltrans Standard Drawing T3A, latest version as contracted.

PART 3 – EXECUTION

3.1 CONSTRUCTION METHODS

A. The contractor shall furnish and install temporary AOA fence in accordance with these specifications and the details shown on the plans and in conformity with the lines and grades shown on the plans or as established by the Engineer.

3.2 SURVEY

A. Verify survey references provided by Airport Surveyors.

3.3 PREPARATION

A. Identify and record lines, levels, contours, datum and water table.

3.4 LOCATING OF UNDERGROUND UTILITIES

A. The contractor shall hire an underground utilities locating service to locate and mark all the known and unknown underground utilities and pipelines before digging for posts.

B. For additional requirement refer to Section 02 22 25 – Underground Utility Locating.

3.5 REMOVAL OF CHAIN-LINK FENCE AND GATES

A. Remove chain-link fence and gates as indicated and dispose of them to approved site outside Airport.

PART 4 – INCLUDED FAA SPECIFICATIONS

4.1 Not applicable

PART 5 – MEASUREMENT AND PAYMENT

5.1 The quantities of temporary AOA fence work shall be measured for payment by lump sum as a single complete unit of Work, and as accepted by the Contract Manager.

5.2 Payment for installation and removal of temporary AOA fencing shall be made at the contract unit price per lump sum.

5.3 This price shall be full compensation for furnishing all materials and for all preparation, excavation and backfill material under the fence as required, concrete K-rail barrier, barb wires, top and bottom braces as required, gates, removal of the fence and gates; and for all labor equipment, tools and incidentals necessary to complete the work.

END OF SECTION 32 31 15
SECTION 34 73 19 – JET BLAST DEFLECTING FENCE

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the design, fabrication, and erection for a complete Vertical Jet Blast Fence (hereafter referred to as JBF), including foundations, anchorage, and utility location.

B. The contractor or JBF supplier shall furnish all labor, materials, and equipment to fabricate and erect the JBF.

C. Refer to Electrical Drawings and Specifications for required grounding, lightning protection, and lighting.

1.2 REFERENCES

A. Drawings apply to this Section.

B. Section 03 30 00 – Structural Portland Cement Concrete FAA Item P-610.

C. Section 31 23 00 – Excavation and Embankment FAA Item P-152.

D. Section 31 23 23 – Backfill and Geotextiles.

E. Section 32 11 23 – Crushed Aggregate Base Course FAA Item P-209.

F. Section 32 11 33 – Cement Treated Base Course FAA Item P-304.

G. Section 32 23 23.33 – Controlled Low Strength Material (CLSM) FAA Item P-153.

H. Section 32 31 13 – Chain-Link Fence FAA Item F-162.

I. Section 31 63 29 – Drilled Concrete Piers and Shafts.

J. Section 34 73 16 – Airfield Grounding.

K. Section 34 43 13.12 – Airport Obstruction Lights FAA L-119

L. FAA AC 150/5220-23

M. FAA AC-150/5300-13A


O. American Society for Testing and Materials (ASTM), standards and tests, as referenced on the drawings and these specifications.

1.3 SUBMITTALS

A. General: Submit each item in this article:

1. Qualification data for the JBF manufacturer specified in “Quality Control” to demonstrate their capabilities and experience. JBF manufactures shall include a structural analysis, drawings, and other pertinent information necessary to verify that the JBF is suitable for the intended purpose.
2. Shop drawings detailing erection of the JBF including plans, elevations and sections. Show any anchorage or accessory items necessary for the functionality of the system.

3. Foundation Design: JBF manufacturer shall verify that the foundation design(s) shown on the Drawings for use by the contractor to support the JBF meet the requirements for the furnished JBF. The JBF manufacturer shall provide written acceptance of the foundations to the Airport.

4. Utility Location: Prior to installation, contractor shall perform utility locating along the entire alignment of the JBF and provide results in CAD format to the Airport.

5. Structural Calculations: Structural design calculations for the JBF structures, anchors, and deflecting surfaces prepared and stamped by an engineer licensed in the state of California. Calculations shall be submitted for each major frame system.

6. Anchor Data: The Perimeter JBF shall be designed to accept the anchors shown on the Drawings.

7. Warranty at Project Closeout: Provide a written copy of the manufacturer’s warranty certifying the workmanship, materials and installation of the JBF system for a period of two (2) years. See the Erection Paragraph for JBF manufacturer supervision requirements.

1.4 QUALITY ASSURANCE

A. JBF Manufacturer Qualifications: The successful JBF manufacturer shall have completed at least two (2) JBF of the type submitting or similar design.

B. Single Source Responsibility: The JBF shall be procured from a single entity responsible for designing, manufacturing, and supplying the JBF and issuing a performance guarantee/warranty.

C. To be approved as an alternate manufacturer, the following information for the proposed JBF shall be submitted to and approved by the Airport prior to fabrication.

D. Detailed design analysis, showing loads and stresses in structural members, deflecting surfaces, and bolted joints, using the design aircraft velocity profiles and code wind force.

E. Design drawings of the proposed fence with sections showing all deflecting surfaces and structural members. The proposed alternate design may not use concrete deflecting surfaces. The proposed alternate must meet all design and material specifications of this Section.

F. Verification that the supplier is currently ISO 9001 registered.

1.5 DESIGN CRITERIA

A. Loading: The JBF shall be designed to withstand high breakaway thrust velocities from all commercial aircraft specified. This velocity shall be converted to pressure at standard day conditions and applied normally to all deflecting surfaces as follows:

1. The fence shall be designed to withstand jet blast velocities of not less than 50 mph. The fence shall be designed to allow operation with the nozzle of any engine from all current commercial jet and turbo prop aircraft at high breakaway thrust no closer than 60' from the JBF deflecting surface.

B. JBF Description

1. Blast Deflector shall be a cantilevered vertical jet blast barrier with corrugated, non-perforated type sheeting material. Corrugated surfaces shall run in the horizontal direction. Deflecting
surfaces shall be rigidly supported by structural steel members spaced at 8’ maximum centers. The JBF shall be a LYNNCO Type V14-6 or an approved equal. Porous blast screens, or deflecting surfaces with perforations or other openings shall not be used, nor shall any other deflecting surface be used which permit noxious exhaust gases to be blown through or collect behind the fence.

C. JBF Performance

1. The JBF shall reduce jet blast velocities behind the structure to a maximum of 15 mph.

D. Layout:

1. As shown on drawing sheets Blast Deflector plans and profiles.
2. Height: From finished grade to highest point on completed JBF assembly - 14’.
3. Foundation: The blast fence must be compatible with the concrete foundation shown on the Drawings and concrete barrier where it occurs.
4. Connections: All field connections shall be bolted with self-locking fasteners.
5. Grounding: Provide continuous grounding of all steel structures at intervals as specified in NFPA 780-2000. See Electrical plans and specifications for additional requirements.
6. Foreign Object Damage (FOD): Fasteners used for assembly of the JBF shall provide adequate locking properties to prevent them from working loose during continued normal operation of the facility.
7. Loading: The JBF shall be designed to withstand high breakaway thrust velocities from all aircraft specified. This velocity shall be converted to pressure at standard day conditions and applied normally to all deflecting surfaces as follows:
   a. Typical Description of Blast Deflector: The fence shall be designed to withstand jet blast velocities of not less than 50 mph. The facility shall be designed to allow operation with the tail of specified aircraft no closer than 35’ from the JBF leading edge and the nozzle of any engine no closer than 60’ from the JBF leading edge.

E. Foundation Capacity (Working Load):

1. OTM: 15 k-ft/column
2. Base Shear: 2.7 kips/column

PART 2 – PRODUCTS

2.1 APPROVED JBF MANUFACTURER

A. Blast Deflectors, Inc. 8620 Technology Way Reno, NV 89521 775.856.1928 info@blastdeflectors.com
B. Or approved equal

2.2 BLAST DEFLECTOR (TYPICAL)

A. Frames: Fabricated from ASTM A992 and ASTM A572 Gr. 50 structural steel shapes/plates which shall be cut and punched as required. All field connections shall be bolted. After fabrication, all individual structural steel parts shall be hot-dip galvanized to a minimum of 2oz/ft2 per ASTM A123.
1. **Welding:** E70XX low hydrogen filler. Submit weld procedures for all welds per AWS D.1.1.

2. **Special inspection:** not required when done in an approved fabricator’s shop except for fillet welds in excess of 5/16” where periodic inspection is required. Complete penetration welds shall be tested 100% either by ultrasonic testing or radiography. The Dye penetrant test shall be performed for all welds after galvanizing.

**B. JBF Face Sheets:** Shall be galvanized corrugated steel formed from minimum 16-gauge ASTM A924 sheet steel with ASTM A653 2 oz/ft2 (G210) hot-dip galvanized coating. They shall have a minimum section modulus of 0.1961 in3/ft. Sheets shall be attached to frames with 3/8” diameter bolts using half oval washers.

**C. Anchor Bolts:** cast-in-place anchors.

**D. Fasteners:** shall have adequate locking properties to withstand direct blast, and shall be as follows:

1. **Bolts:** ASTM A449 (or equal strength)
2. **Flat Washers:** 316 Stainless Steel
3. **Nuts:** IFI 100/107 (all metal self-locking type)
4. **All hardware shall be zinc plated.**
5. **Half oval washers shall be A36 steel hot-dip galvanized per ASTM A123 to 2 oz/ft2 after fabrication. Minimum bearing area on corrugated sheets 0.92 in2.**

**E. Galvanizing Repair Paint:** High zinc dust content paint for regalvanizing damaged areas in galvanized steel, with dry film containing not less than 94% zinc dust by weight, and complying with DOD-P-21035 or SSPC-Paint 20.

**F. Refer to Section 05 12 00 – Structural Steel for additional specifications. JBF manufacturer shall provide an attachment for a 3-strand barbed wire support arm as indicated on the plans and shall conform to the specification Item F-162.**

2.3 **FABRICATION, GENERAL**

**A.** Form fabrications from materials of size, thickness, and shapes as required. Work to dimensions indicated on approved shop drawings, using proven details of fabrication and support. Use type of materials indicted or specified for various components of each fabrication.

**B.** Form exposed work with accurate angles and surfaces and straight sharp edges.

**C.** Shear and punch metals clearly and accurately. Remove burrs.

**D.** Remove sharp or rough areas on exposed surfaces.

2.4 **SITE CONDITION**

**A.** The JBF manufacturer shall inspect the site prior to beginning work and notify the Owner of any defects, which must be corrected before installation of the JBF can be completed. Do not proceed with installation until unsatisfactory conditions have been corrected.

2.5 **SOURCE QUALITY CONTROL**
A. Testing Agency: Contractor will engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.

B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

C. Bolted Connections: Shop-bolted connections will be inspected and tested to verify that torque values meet required torque as required by the JBF manufacturer.

D. Field Bolted Connections: Field-bolted connections will be inspected and tested to verify that torque values meet required torque as required by the JBF manufacturer.

PART 3 – EXECUTION

3.1 MATERIAL STORAGE AND HANDLING

A. Store materials in approved areas. Protect all components from damage. Keep all material off the ground by using pallets, platforms, or other supports. Store all fasteners in a protected area. Do not store materials in a manner that might cause distortion, deterioration, or damage. Repair or replace damaged materials.

3.2 ERECTION

A. An authorized representative of the JBF manufacturer shall observe and supervise the JBF erection for the performance warranty to be valid.

B. Set frames accurately in locations indicated on approved shop drawings in accordance with AISC specifications.

C. Provide temporary guys and braces as required to temporarily support structures during erection.

D. Do not use thermal cutting or welding during erection.

E. Install concrete anchors in accordance with manufacturer’s written instructions. Use templates during setting of anchors to ensure accurate positions.

F. Tighten all fasteners to specified torques.

G. Touch up any damaged galvanized surfaces with galvanizing repair paint. Follow paint manufacturer’s instructions for application. Match color.

3.3 PERMITS

A. The contractor shall be responsible to obtain JBF structure approval and any required building permits. The cost of coordination and permitting shall be considered incidental to the work.

3.4 FOUNDATION

A. Concrete foundation and barrier shall be built in conformance to the dimensions and form indicated on the plans. The construction shall conform to the requirements specified in Section 03 30 00 Item P-610. The reinforcement, including anchor bolts and anchor plates, as required, shall be placed as indicated on the plans and shall be approved by the Engineer before the concrete is poured.

B. For drilled concrete piers refer to Section 31 63 29.

3.5 BARBED WIRE OVERHANG
A. Barbed wire overhang shall be installed as shown on the plans and as indicated in specification Section 32 31 13 FAA Item F-162.

3.6 SIGNAGE AND MARKING
A. Contractor shall install SFIA provided metal traffic signage on the JBF at the designated locations per plan. Signs shall be mechanically secured to the fence with galvanized supports and accessories. Supports shall sufficiently secure standard traffic signs against significant movement when exposed to aircraft jet blast and environmental factors.
B. When required per plan, contractor shall install retro-reflective markings on the vertical supports of the JBF to improve visibility for roadway traffic.

3.7 INCLUDED FAA SPECIFICATIONS
A. Not applicable

PART 4 – MEASUREMENT AND PAYMENT
A. Payment shall be made at the contract unit per lump sum for Blast Deflector as shown on plans and all Work associated therewith as a single complete unit of Work, and accepted by the Contract Manager.
B. This price shall be full compensation for design, fabrication, furnishing all materials including barbed wire overhang, grounding as required, structural concrete foundation and base, steel reinforcement, dowels, tie bars, joints, installation of signage, marking, and for all preparation, forms, excavation, backfilling, and placing of the materials as required, as shown on the plans; and for all labor, equipment, tools, and incidentals necessary to complete the structure.
C. Electrical elements including obstruction light and CCTV systems shall be measured and paid separately.

END OF SECTION 34 73 19
MASTER LIST OF MANUFACTURERS

This section provides the Master List of Manufacturers approved by SFO for Airfield Civil – Pavement Renovations, organized by section and subsection. Contractors are responsible for any extra cost incurred when evaluating products by manufacturers that are not listed are approved equals.

32 01 11.53 – AIRFIELD PAVEMENT MARKING REMOVAL

PAVEMENT SEALING
  1. Gilsonite
  2. Or approved equal.

32 12 36.13 – BITUMINOUS PAVEMENT SEALER

SEALER PRODUCT
  1. Gilsonite
  2. Or approved equal

32 12 73 – JOINT SEALING FILLER

  1. Sika Corporation
  2. Or approved equal

32 17 23 – RUNWAY AND TAXIWAY MARKING

SURFACE COATING
  1. Hawker
  2. Or approved equal

32 31 13 – CHAIN LINK FENCE

  1. Anchor Fence, Inc.
  2. Western Tube & Conduit.
  3. Master Halco, Inc.
  4. Tapecoat
  5. Scotchrap
  6. Or approved equal
Standards Adoption

The "Airfield Civil – Pavement Improvements" Version 3.0, December 2018 A&E Standards were adopted by the Standards Committee on January 7, 2019, and are effective immediately.

Confirmed:

[Signature]

Geoffrey W. Neumayr, Standards Committee Chair