

Division II
Section 2200
Paving

DIVISION II
CONSTRUCTION AND MATERIAL SPECIFICATIONS
STREETS

SECTION 2200 PAVING

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Kansas City Metropolitan Chapter
of the American Public Works Association

2201 SUBGRADE PREPARATION	22-1
2201.1 Summary	22-1
2201.2 Definitions.....	22-1
2201.3 Construction.....	22-1
2201.4 Methods of Measurement.....	22-2
2201.5 Basis of Payment.....	22-2
2202 UNTREATED COMPACTED AGGREGATE.....	22-3
2202.1 Summary	22-3
2202.2 Material	22-3
2202.3 Placement.....	22-4
2202.4 Methods of Measurement.....	22-5
2202.5 Basis of Payment.....	22-5
2203 DRAINABLE BASE COURSE.....	22-6
2203.1 Summary	22-7
2203.2 Materials.....	22-7
2203.3 Crushed Aggregate Base Course.....	22-7
2203.4 Portland Cement Concrete Drainable Base.....	22-9
2203.5 Plant Mix Bituminous Drainable Base Course	22-12
2203.6 Underdrains	22-16
2203.7 Permeability Test Procedure	22-20
2203.8 Methods of Measurement.....	22-25
2203.9 Basis of Payment.....	22-26

TABLE OF CONTENTS

2204 PRIME AND TACK COAT	22-27
2204.1 Summary	22-27
2204.2 Liquid Asphalt Material	22-27
2204.3 Sand Cover	22-28
2204.4 Approval of Materials	22-28
2204.5 Pressure Distributor	22-28
2204.6 Preparation of Existing Surface	22-28
2204.7 Application of Asphalt Material	22-28
2204.8 Application of Sand Cover	22-29
2204.9 Methods of Measurement	22-30
2204.10 Basis of Payment	22-30
2205 ASPHALTIC CONCRETE SURFACE AND BASE	22-31
2205.1 Summary	22-32
2205.2 Materials	22-32
2205.3 Mixing and Proportioning	22-33
2205.4 Asphalt Mixing Plant	22-44
2205.5 Transportation of Mix	22-44
2205.6 Scales and Weighing of Vehicles	22-44
2205.7 Requirements for Asphalt Paving Equipment	22-46
2205.8 Construction Requirements	22-48
2205.9 Method of Measurement	22-56
2205.10 Basis of Payment	22-56
2206 ASPHALT CRACK SEALING, CHIP SEALING, SLURRY SEALING, AND MICROSURFACING	22-57
2206.1 Summary	22-58
2206.2 Crack Sealing	22-58
2206.3 Improved Street Chip Seal	22-63
2206.4 Unimproved Street Chip Seal	22-66
2206.5 Improved Street Slurry Seal	22-69
2206.6 Improved Street Micro-Surfacing	22-74
2206.7 Method of Measurement	22-79
2206.8 Basis of Payment	22-80
2207 COLD MILLING	22-81
2207.1 Summary	22-81
2207.2 Equipment	22-81
2207.3 Construction Details	22-81
2207.4 Method of measurement	22-82
2207.5 Basis of payment	22-82
2208 PORTLAND CEMENT CONCRETE PAVEMENT	22-83
2208.1 Summary	22-84
2208.2 Materials	22-84
2208.3 Construction Details	22-85

TABLE OF CONTENTS

2208.4	Joints	22-87
2208.5	Placing, Finishing, Curing, and Protection	22-89
2208.6	Backfill.....	22-94
2208.7	Joint Sealing and Cleanup.....	22-94
2208.8	Integral Curb	22-94
2208.9	Pavement Smoothness and Surface Defects:	22-95
2208.10	Repairing Defects.....	22-96
2208.11	Methods of Measurement.....	22-97
2208.12	Basis of Payment.....	22-97
2209	CURBING.....	22-98
2209.1	Summary	22-98
2209.2	Materials.....	22-98
2209.3	Joints	22-98
2209.4	Joints	22-99
2209.5	Concrete Work	22-100
2209.6	Backfill.....	22-101
2209.7	Joint Sealing and Clean-Up.....	22-101
2209.8	Surface Tolerances	22-101
2209.9	Method of Measurement	22-101
2209.10	Basis of Payment.....	22-101
2210	MEASUREMENTS AND PAYMENTS	22-102
2210.1	Summary	22-102
2210.2	General	22-102
2210.3	Measurement.....	22-102
2210.4	Items not listed in the Proposal	22-102
2210.5	Measurement and Payment Summary Table.....	22-103
2211	- SMOOTHNESS.....	22-104
2211.1	Summary	22-104
2211.2	Local Streets & Residential Collectors	22-104
2211.3	Arterials and Urban Collectors.....	22-104

SECTION 2201 SUBGRADE PREPARATION

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

D 698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

2201.1 Summary: This section includes subgrade preparation at locations which have been previously graded in accordance with the requirements of Section 2100 entitled "Grading and Site Preparation".

2201.2 Definitions:

- A. **Subgrade:** Subgrade is defined as a well graded and compacted layer on which base and subsequent courses are placed.
- B. **Subgrade Preparation:** Subgrade preparation is the repeated operation of fine-grading and compacting the subgrade until the specified lines, grades, and cross-section, as indicated on the plans are obtained and the materials are compacted to the specified depth and density.

2201.3 Construction:

- A. **General:** The subgrade surface shall be brought to the specified lines, grades and cross-section by adding or removing material and compacting to the specified density. Tolerance allowed on all lines, grades and cross-sections shall be no more than 1/4 inch (6 mm).
- B. **Compacting the Subgrade:** The top 6 inches (15.24 cm) of subgrade for pavements shall be compacted to 95% of the standard proctor maximum density for the material used as determined by ASTM D 698 and within a tolerance of plus 3% and minus 2% of the optimum moisture content. The tolerance applies only to the top 6 inches (15.24 cm).
- C. **Protection and Maintenance of Subgrade:** The subgrade shall be protected from action of the elements or others. Any action (eg. settlement or erosion) that damages the subgrade prior to placing the pavement thereon, shall be repaired and the specific lines, grades, cross-section, tolerance, density, and moisture content range reestablished.

The Contractor shall protect all existing improvements from damage resulting from his subgrade operation. Any improvement damaged shall be repaired or replaced by the Contractor at his own expense.

- D. **Cleanup:** Subgrade cleanup shall follow the work progressively. The Contractor shall remove from the project site all rubbish, surplus or discarded material, unsuitable material, and any equipment, tools and temporary construction items used for the preparation of the subgrade.
- E. **Roll Testing:** Once the subgrade has been brought to the final plan elevation, but prior to approval of the subgrade for paving, all lanes shall be roll tested in their entire length. The subgrade will not be acceptable if rutting, pumping, or deformation of the subgrade results from the roll test. This testing will be done by the contractor, and will be in addition to the applicable moisture and density testing.

Equipment for roll testing shall be a tandem dump truck (one front and two rear axles) carrying the maximum allowable legal load.

The truck shall proceed slowly along each traffic lane, allowing the Engineer to walk alongside and observe the results. Areas failing the roll test will be reworked and retested prior to approval of the subgrade for paving.

2201.4 Methods of Measurement: Subgrade Preparation will generally not be listed in the Proposal as a separate item.

2201.5 Basis of Payment: Subgrade Preparation will generally be included in payment for other items listed in this proposal.

SECTION 2202 UNTREATED COMPACTED AGGREGATE

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

- C 88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C 131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- C 136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates
- C 142 - Test Method for Clay Lumps and Friable Particles in Aggregates

- D 4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

AASHTO

- T 99 - The Moisture-Density Relations of Soils Using a 5.5-lb. (2.5 kg) Rammer and a 12-in. (305 mm) Drop

2202.1 Summary: This section includes the construction of aggregate base course as outlined in the contract special provisions and on the plans.

2202.2 Material: The base course material shall consist of crushed stone aggregate with not more than 1.0% clay lumps and friable particles in accordance with ASTM C 142, and free from vegetable or other deleterious substances. The abrasion loss shall be no more than 35% when tested in accordance with ASTM C 131. That fraction passing the 1 inch (25.0 mm) sieve and retained on the No. 4 (4.75 mm) sieve shall have a loss not greater than 15% by weighted average at 5 cycles of ASTM C 88 (Magnesium Sulfate) Soundness Test. That fraction of the material passing the 1-inch (25.0 mm) Sieve and retained on the No. 4 (4.75 mm) Sieve shall contain less than 20% by weight of flat and elongated particles (flat being a ratio of 1 to 3 between thickness and least width and a ratio of 1 to 3 between the least width and length). The material shall consist of angular particles with no less than 90% of particle count having two or more fractured surfaces. The gradation in percentages by weight passing square mesh sieves shall be in accordance with ASTM C 136 and as follows:

U. S. Standard Square Mesh Sieve	Percent Passing
1-1/4" (31.5 mm)	100
1" (25.0 mm)	72-100
3/4" (19.0 mm)	60-90
3/8" (9.5 mm)	43-74
No. 4 (4.75 mm)	28-60
No. 10 (2.00 mm)	16-40
No. 40 (425 um)	3-22
No. 200 (75 um)	0-15

In addition to the above limits, the difference between the "Percent Passing Square Mesh Sieve" of successive sieve sizes shall not exceed 25 percent.

That fraction of the material passing the No. 40 (425 um) sieve shall have a plasticity index not to exceed 8 when tested in accordance with ASTM D 4318.

2202.3 Placement:

- A. **Subgrade:** Prior to placement of base course material the previously prepared subgrade surface shall be cleared of all foreign substances and restored in shape, tolerance and density as specified in Section 2201 entitled "Subgrade Preparation".
- B. **Material Placement:** The material shall be uniformly spread in successive layers to such depth that when compacted, the base will have the minimum thickness specified. The contractor may construct the base in any number of layers that he chooses except that in no case shall any individual layer have a compacted thickness of more than 4 inches (10.16 cm). Each layer shall be compacted as hereinafter specified before any succeeding layer is placed.

After spreading a layer of material, water in an amount sufficient to insure the desired compaction shall be added and uniformly mixed with the aggregate in a manner to prevent segregation. Excess moisture resulting in runoff shall be avoided. If for any reason, the material and subgrade become too wet to permit satisfactory work, they shall be allowed to dry to a moisture content that will permit satisfactory work.

- C. The material shall meet the required specifications immediately before compaction operations are commenced. If, for any reason, segregation occurs in excess of 10% variation from the gradation required under the above paragraph "Material" or the materials become contaminated, such segregated or contaminated materials shall be removed and replaced with suitable materials at the expense of the Contractor. The limited segregation of 10% variation will be ascertained by a sieve analysis of a

minimum 100 pound (45.36 Kg) sample taken from the in-place base course. However, when crushed stone is used, segregated surface areas may be corrected by adding limestone screenings of such gradation and quantity as required to fill the surface voids and firmly bind the loose material in place. Screenings so used in correcting segregated surface areas will be paid for as a part of the aggregate base material.

- D. Shaping and compacting shall be carried on continuously until a true, even and uniform surface of proper grade and cross-section is obtained, and until the density of the complete base is at least 95% of maximum density as determined by AASHTO T 99. The proper moisture content shall be maintained by wetting the surface as required during shaping and compacting operations. Final rolling shall be accomplished by use of a self-propelled smooth-wheeled roller.

2202.4 Methods of Measurement: Untreated Compacted Aggregate Base will be measured by one of the following:

- A. Per square yard (square meter) or tenth part thereof for the specified depth.
- B. Per ton (metric ton) or tenth part thereof.

2202.5 Basis of Payment: Untreated Compacted Aggregate Base will be paid for by one of the following:

- A. Contract unit bid price.
- B. Contract lump sum bid price.

SECTION 2203 DRAINABLE BASE COURSE

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

- C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field
- C 33 - Standard Specification for Concrete Aggregates
- C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C 88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C 117 - Test Method for Materials Finer than 75- um (No. 200) Sieve in Mineral Aggregates by Washing
- C 131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- C 136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates
- C 150 - Standard Specification for Portland Cement
- D 75 - Practice for Sampling Aggregates
- D 695 - Test Method for Compressive Properties of Rigid Plastics
D 946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
- D 1621 - Test Method for Compressive Properties Of Rigid Cellular Plastics
- D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- D 3034 - Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
- D 3381 - Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
- D 3666 - Specification for Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials
- D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- D 4716 - Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
- D 4791 - Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- D 5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- F 758 - Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

AASHTO

- M 252 Corrugated Polyethylene Drainage Tubing

T 102 Spot Test of Asphaltic Materials

2203.1 Summary: This section includes the requirements for drainable base courses.

2203.2 Materials: All drainable base materials shall have a minimum coefficient of permeability of 1000 ft/day (305 m/day) as determined by the test method described in 2203.7.

2203.3 Crushed Aggregate Base Course**A. Materials:**

1. Aggregates shall consist of clean, sound, durable particles of crushed stone or crushed gravel and shall be free from coatings of clay, silt, vegetable matter, and other objectionable materials and shall contain no clay balls.
2. Fine aggregate (passing the No. 4 (4.75 mm) sieve) shall consist of fines from the operation of crushing the coarse aggregate. If necessary, additional fine aggregate may be added to produce the correct gradation. All fine aggregate shall be produced by crushing stone or gravel that meets the requirements for wear and soundness specified for the coarse aggregate.
3. The crushed aggregate portion which is retained on the No. 4 (4.75 mm) sieve shall contain not more than 15%, by weight, of flat and elongated pieces as defined in ASTM D 4791 (ratio = 5:1) and shall have at least 90% by weight of particles with at least two fractured faces and 100% with at least one fractured face. The area of each face shall be equal to at least 75% of the smallest midsectional 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.
4. The percentage of wear shall not be greater than 35% when tested in accordance with ASTM C 131.
5. The magnesium sulfate soundness loss shall not exceed 15%, after 5 cycles, when tested in accordance with ASTM C 88.

6. The fraction passing the No. 40 (0.42 mm) sieve shall have a liquid limit no greater than 25 and a plasticity index of not more than 8 when tested in accordance with ASTM D 4318. The fine aggregate shall have a minimum sand equivalent value of 35 when tested in accordance with ASTM D 2419.

B. Sampling and Testing: Aggregates for preliminary testing shall be furnished by the Contractor prior to the start of production. All tests for initial aggregate submittal necessary to determine compliance with the specification requirements shall be made by the Contractor at no expense to the Engineer.

1. Samples of aggregates shall be furnished by the Contractor at his expense at the start of production and at intervals during production. The sampling points and intervals will be designated by the Engineer. The samples will be the basis of approval of aggregates from the standpoint of the quality requirements of this Section.
2. Sampling may be observed by and shall be subject to the approval of the Engineer. Samples shall be large enough to provide ample material to the satisfaction of the Engineer. No aggregate shall be incorporated in the Work without prior approval by the Engineer.
3. In lieu of testing, the Engineer may accept certified test results performed by an approved independent testing laboratory indicating that the aggregate meets specification requirements. Certified test results shall be less than 6 months old.
4. Samples of the aggregate to check gradation may be taken by the Engineer at least once daily. Sampling shall be in accordance with ASTM D 75, and testing shall be in accordance with ASTM C 136 and C 117.

C. Gradation Requirements: The gradation (job mix) of the final mixture shall fall within the design range indicated in Table 1, when tested in accordance with ASTM C 117 and C 136.

TABLE 1. REQUIREMENTS FOR GRADATION OF AGGREGATE		
Sieve Size	Design Range Percentage by Weight Passing Sieves	Job Mix Tolerances Percent
2 in (50 mm)	100	
1-1/2 in (37.5 mm)	100	+/- 5
1 in (25.4 mm)	70-100	+/- 8
3/4 in (19 mm)	55-100	+/- 8
1/2 in (12.5 mm)	40-80	+/- 8
3/8 in (9.5 mm)	30-70	+/- 8
No. 4 (4.75 mm)	10-45	+/- 8
No. 8 (2.36 mm)	0-25	+/- 5
No. 16 (1.18 mm)	0-5	+/- 3

The job mix tolerances in Table 1 shall be applied to the job mix gradation to establish a job control grading band. The resulting job control grading band must comply with the Design Range criteria.

2203.4 Portland Cement Concrete Drainable Base

A. **Summary:** This item shall consist of an open-graded drainable base composed of mineral aggregate, Portland cement and water 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.

B. Materials:

1. Coarse Aggregate:

- a. **General:** Coarse aggregate shall be ¾ inch (19 mm) maximum size consisting of crushed gravel or crushed stone and shall meet the requirements of ASTM C 33 and quality requirements of 2203.3a.
- b. Gradation shall be ASTM C 33, Size 67.

2. **Fine Aggregate:** Fine aggregate shall consist of natural sand or manufactured sand meeting the requirements of ASTM C 33.

3. **Cement:** Portland cement shall conform to the requirements of ASTM C 150, Type I or Type II. Substitution of fly ash or other pozzolan for Portland cement shall be in conformance with Section 2208.
 4. **Water:** Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable or other substances injurious to the finished product as possible. Water known to be of potable quality may be used without testing.
 5. **Admixtures:** The use of any material to be added to the mixture shall be approved by the Engineer.
- C. The Contractor shall furnish vendor's certified test reports for the materials used in the project. The report shall be delivered to the Engineer as part of the mix design before permission to use the cement is granted.
- D. **Proportions:** The Contractor shall submit a mix design containing the quantity of each material to the the Engineer including certifications of materials used. The Contractor will be responsible for preparing the drainable base mix design at no cost to the Owner. The testing laboratory preparing the mix design shall comply with Section 2203.5F. The mix design shall include the following:
- Cement Content.
 - Water-Cement Ratio. Approximately 0.36.
 - Coarse Aggregate.
 - Fine Aggregate.
 - All Admixtures.
 - Coefficient of Permeability. Tested per Section 2203.7.
 - Compressive Strength. Proportions will be such to produce a compressive strength of 800 psi (5.52 Mpa) in 28 days as determined by test cylinders made in accordance with ASTM C 31 and tested in accordance with ASTM C 39. A strength of 500 psi (3.45 MPa) will be required prior to any traffic being allowed on the surface.

- E. **Spreading:** The base material shall be spread to the lines and grades shown on the Plans. Any material which becomes mixed with soil or other contaminants shall be removed and replaced with fresh mixture.
- F. **Compaction:** After spreading and/or trimming, the base material shall be uniformly compacted by making a minimum of 2 coverages with a steel wheeled roller meeting the requirements of Section 2205.7 B 1. The compaction process may be adjusted on the project by the Contractor with approval of the Engineer to assure uniform compaction of the drainable base material. In areas not accessible by the roller, the base material shall be compacted by mechanical hand methods. Compaction must be completed within 2 hours of the time water is introduced to the mixture.

If after spreading and compacting the base is not to the required lines and grade, the Contractor shall trim the base by means of an electronically controlled machine utilizing string line controls for grade. The Engineer reserves the right to direct the Contractor to suspend all operations if the Contractor produces excessive fines in the trimming process which are viewed by the Engineer to be detrimental to the permeability of the base. Appropriate corrections to the trimming process shall be made by the Contractor prior to beginning again.

After compaction of the drainable base, the Contractor shall protect the surface from damage and/or contamination. If the integrity of the drainable base is disturbed at any time prior to placement of the succeeding pavement course the area shall be removed and replaced with new material and compacted to conform to the original lines and grades at the Contractor's expense. Any removed material shall not be reincorporated into the drainable base or other drainage features.

- G. **Curing Of The Drainable Base Material:** The Contractor will be required to provide a curing plan to the Engineer.
- H. **Temperature Limitations:** The air temperature must be between 50°F (10°C) and 90°F (32°C) for drainable base construction. The engineer may order operations to cease in hot windy conditions if it appears the mixture is drying out prior to achieving initial set.
- I. **Construction Joints:** The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall present the same texture and smoothness as other sections of the course.

All contact surfaces of previously constructed courses shall be cleaned of all dirt or other objectionable materials, and thoroughly moistened with water prior to placing the new material.

- J. **Thickness:** The thickness of the base course shall be measured by cores taken at intervals determined by the Engineer.

2203.5 Plant Mix Bituminous Drainable Base Course

- A. **Summary:** This item shall consist of an asphalt stabilized drainable base course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with the 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, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course. A prime coat will be used on the subbase prior to placement of the first course, and no tack coat will be used between courses.

B. Materials:

1. **Aggregate:** Aggregate shall consist of crushed stone or crushed gravel and be free of organic materials.
 - a. **Coarse Aggregate:** Coarse aggregate shall comply with Section 2303.3a except wear may not exceed 50 % in accordance with ASTM C 131 and the magnesium sulfate soundness loss shall not exceed 15%, after five cycles, when tested in accordance with ASTM C 88.
 - b. Aggregate shall contain at least 70% by weight of individual pieces having two fractured faces and 85% by weight having at least one fractured face as determined by ASTM D 5821
 - c. The aggregate shall not contain more than 8%, by weight, of flat and elongated pieces, when tested in accordance with ASTM D 4791 (ratio = 5:1).
 - d. **Sampling:** ASTM D 75 shall be used in sampling the coarse aggregate.
2. **Bituminous Material:** The asphalt cement shall be in conformance with Section 2205.2A. The type and grade of asphalt used shall be specified in the mix design but shall not be lower than a PG 64-22.

- C. **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:

Coarse Aggregate
Percent of wear.
Soundness.

Bituminous Material

The certification(s) shall show the appropriate ASTM test(s) for each material, the test results, and a statement that the material meets the specification requirement.

- D. **Job Mix Formula. (JMF):** No bituminous mixture for payment shall be produced until the Engineer has approved a JMF in writing. The method of determining the proper asphalt content is to store the mix trial batches in the laboratory overnight (15-18 hrs) at 140°F (60°C). The proper asphalt content will then be selected visually. The asphalt content mix is selected from the batch from which a small amount of asphalt drains to the bottom of the pan and the mix still appears glossy. A heat resistant, clear glass dish may be used for better visibility of the drained asphalt. The asphalt content may be varied as necessary during construction to meet this requirement.

The aggregate shall be of such size that the percentage composition by weight will conform to the gradation of gradations specified in Table 2, when tested in accordance with ASTM Standards C 117 and C 136. The gradation shall be on the coarse side of the Master Band.

TABLE 2. PLANT MIX BITUMINOUS DRAINABLE BASE MASTER GRADATION	
Sieve Designation (Square Opening)	Percentage by Weight Passing Sieve
1-1/2" (37.5 mm)	100
1" (25.4 mm)	90-100
3/4" (19 mm)	75-100
1/2" (12.5 mm)	70-90
3/8" (9.5 mm)	50-70
No. 4 (4.75 mm)	20-40
No. 8 (2.36 mm)	15-25
No. 30 (637 um)	5-15
No. 200 (75 um)	0-3

Recommended Asphalt Cement Content 2.0 – 3.5%

The gradations in Table 2 represent the limits that shall determine the suitability of aggregate for use from the supply source.

The job mix tolerance shown in Table 3 shall be applied to the JMF to establish a job control-grading band. The resulting job control grading band must comply with the Master Gradation criteria..

TABLE 3. JOB MIX FORMULA TOLERANCES(Based on a Single Test)	
Material	Tolerance Plus or Minus
Aggregate passing No. 4 (4.75 mm) sieve or larger	5%
Bitumen*	0.40%
Temperature*	20 degrees F. (-7 degrees C.)

*Unless otherwise approved by the Engineer.

The aggregate gradation may be adjusted within the limits of Table 2 as directed, without adjustments in the contract unit prices.

Should a change in sources of materials be made, a new JMF shall be established before the new material is used.

Dry aggregate gradations will be made at least twice daily. The aggregate gradation shall be tested by the Contractor in accordance with ASTM C 117 and C 136.

The JMF shall be submitted in writing by the Contractor and approved by the Engineer prior to the start of paving operations. The job mix shall have been prepared no more than 12 months prior to submittal and shall include as a minimum:

- Percent passing each sieve.
- Percent of asphalt cement.
- Asphalt designation and certifications
- Mixing temperature.
- Compaction temperature.
- Temperature of mix when discharged from the mixer.
- Percent fractured faces.
- Percent elongated particles.

The Contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing.

- E. **Test Section:** Prior to full production, the Contractor shall prepare and place a section of drainable base according to the JMF. The amount of mixture should be 80 tons (72.6 metric tons) and may be placed as part of the project. 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.

Two random samples of mixture may be taken at the plant and tested for aggregate gradation and asphalt content. The test section shall be considered acceptable if the gradation and asphalt content are within the limits specified in Tables 2 and 3.

If the initial test section should prove to be unsatisfactory to the Engineer, 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 do not conform to specification requirements shall be removed at the Contractor's expense. Full production shall not begin until a satisfactory section has been constructed and accepted by the Engineer. The test sections that meet the specification requirements shall be paid for in accordance with project quantities.

The Contractor shall perform Job mix control testing at the start of plant production and in conjunction with the calibration of the plant for the JMF. It should be recognized that the aggregates produced by the plant may not satisfy the gradation requirements or produce a mix that exactly meets the JMF. In those instances, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens should be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

F. **Testing Laboratory:** The laboratory used to develop the JMF formula shall meet the requirements of ASTM D 3666.

G. **Construction Methods:**

1. **Weather Limitations:** The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than 40 degrees F (4.4 degrees C) or the wind chill factor is less than 35 degrees F (1.7 degrees C). The temperature requirements may be waived by the Engineer, however, all other requirements including compaction shall be met.
2. These materials will be placed, handled, hauled and accepted based on requirements of Section 2205.

2203.6 Underdrains:

A. **Summary:** Underdrain construction shall consist of furnishing of all labor, equipment and materials necessary for the complete installation of underdrains, including pipe, geotextiles and granular filter material in accordance with these specifications, standard drawings, the contract special provisions, and as shown on the Plans or established by the Engineer.

B. **Materials:**

1. **Aggregate:** Blanket Underdrain Aggregate and Pipe Underdrain Aggregate shall conform to requirements of Section 2203.3.a with the following gradations:

TABLE 1. BLANKET UNDERDRAIN AGGREGATE	
Sieve Size	Percent Passing By Weight
1-1/2 inch (38.1 mm)	100
1-inch (25.4 mm)	90-100
3/4-inch (19 mm)	60-90
3/8-inch (9.5 mm)	--
No. 4 (4.75 mm)	0-20
No. 8 (2.4 mm)	--
No. 16 (1.2 mm)	0-10
No. 30 (0.6 mm)	--
No. 50 (0.3 mm)	0-7
No. 100 (150 µm)	0-2

TABLE 2. PIPE UNDERDRAIN AGGREGATE	
Sieve Size	Percent Passing By Weight
1-1/2 inch (38.1 mm)	--
1-inch (25.4 mm)	--
3/4-inch (19 mm)	100
3/8-inch (9.5 mm)	85-100
No. 4 (4.75 mm)	--
No. 8 (2.4 mm)	40-60
No. 16 (1.2 mm)	--
No. 30 (0.6 mm)	5-30
No. 50 (0.3 mm)	--
No. 100 (150 µm)	0-2

2. Underdrain Pipe:

- a. Polyvinyl chloride pipe shall meet the requirements of ASTM F758/D3034.

- b. Corrugated Polyethylene Tubing. may be used only outside of traffic areas and driving surfaces. The tubing shall be the heavy duty type and shall meet the requirements of AASHTO M 252. In addition, the tubing shall have a minimum pipe stiffness of 30 psi (210 kPa) at 10% deflection.
- c. All underdrain pipes shall have a nominal minimum inside diameter of six inches (150 mm) unless shown otherwise on the Plans.
- d. Perforations shall be approximately circular and cleanly cut; shall have nominal diameters not less than 3/16-inch (5 mm) nor more than 3/8-inch (10 mm); and shall be arranged in at least two rows parallel to the axis of the pipe.
- e. Fittings shall be of the same composition and have the same physical properties as the pipe and shall not restrict flow.

3. **Geocomposite Edge Drain:**

- a. Edge drain shall consist of a plastic core completely surrounded by geotextile. The core shall provide a minimum of 10 percent open area to facilitate water entry or cross flow and shall be composed of plastic which is physically and chemically stable under a normal range of conditions.
- b. The edge drain shall have nominal dimensions of 1 to 1-1/2 inches (25 to 40 mm) in thickness and 12 inches (305 mm) in height.
- c. The edge drain shall have a minimum flow capacity of 15 gallons per minute per foot of width (1.9 liters/cm) as determined by ASTM D4716 when tested under a confining stress of 10 psi (70 kPa) or more at a gradient of 0.1 or less.
- d. The edge drain shall have a minimum compressive strength of either 7,000 psf (335 kPa) at a maximum deformation of 10 percent of the original thickness when tested in accordance with ASTM D1621, or 8,000 psf (385 kPa) at a maximum deformation of 20 percent when tested in accordance with ASTM D695.
- e. Geotextile shall have an apparent opening size (AOS) corresponding to a U.S. sieve number greater than 50 (0.3 mm) but not exceeding 100 (150 μm).

4. **Geotextile:** Geotextile for use with pipe and edge underdrains shall be a nonwoven geotextile and shall meet the requirements of Section 2605.2.C.2.

C. Construction:

1. **General:** The exact location and layout of underdrains and/or edge drains as shown on the Plans shall be subject to revision by the Engineer as determined during construction.
2. **Excavation:**
 - a. Trenches for all lateral and longitudinal underdrains shall be excavated to the dimensions, depths and elevations or as ordered by the Engineer. In case of a conflict, where the actual elevation of the strata or stratum to be intercepted is found to vary from Plan elevation, the stratigraphy shall govern in the installation of underdrains.
 - b. Trench bottoms for perforated pipe underdrain and edge drain shall be in firm material (no mucky or soupy condition existing) and constructed to permit the placing of three inches (75 mm) of aggregate underneath the pipe. If unstable material is encountered in the bottom of the trench, the trench shall be over excavated to firm material.
 - c. Minimum width of trench shall be as shown on the Standard Plan.
3. **Laying Pipe:**
 - a. All underdrain pipe shall be laid carefully to line and grade.
 - b. All pipe shall be laid on a minimum grade of one percent unless otherwise shown on the Plans.
 - c. All dead ends of pipe underdrains shall be completely closed with a cap of the same material as the pipe.
 - d. All junctions and turns shall be made with wyes, tees, and bends as supplied by the manufacturer of the pipe.
 - e. Perforations shall be laid down unless otherwise indicated on the Plans.
4. **Installing Edge Drain:**
 - a. Installation shall be in accordance with manufacturer's instructions.

- b. Each length of drain shall be joined to the adjacent length prior to installation. Splices shall keep adjoining lengths in proper alignment, shall not separate during installation, shall have the same or greater compressive strength than the geocomposite drain, and shall be sealed against infiltration of backfill material.
- c. Drain shall be placed in the center of the trench and held in place with a temporary support while blanket underdrain aggregate backfill is placed.
- d. The placement of the edge drain and the first lift of backfill shall be accomplished in a single continuous operation.

5. **Backfilling:**

- a. Backfilling the trenches of lateral and longitudinal underdrains shall not be started until approved by the Engineer.
- b. The trenches shall be backfilled to the elevations shown on the Plans, in accordance with the Standard Plan.
- c. The backfill material shall be placed in such a manner as to prevent formation of large cavities in the backfill and walls of the trench.
- d. Overbreakage due to blasting of rock in trench excavation and widening due to caving of trench walls or overbreakage at construction outcrops shall be backfilled with aggregate.

2203.7 Permeability Test Procedure:

A. **Summary:** This test method is used to determine the permeability of unbound and bound aggregate base material. Bound base material will use Portland Cement, Fly Ash or Asphaltic Cement as a cementing agent.

B. **Unbound Base and Base Bound with Fly Ash or Portland Cement:**

1. **Apparatus:**

- a. **Mold:** A cylindrical metal mold with an approximate inside diameter of 152 mm (6") and a minimum height of 152 mm (6"). The mold shall be equipped with a removable collar at least 51 mm (2") in height and a removable base plate. The base plate may be used as part of the permeability test equipment. If so, the base plate must exceed the permeability of the material being tested. A #40 screen shall be placed on

top of the base plate to prevent test material from being lost through the base plate during compaction and permeability testing.

- b. **Standpipe:** A standpipe with the same diameter as the removable collar for the mold with a minimum height of 216 mm (8.5"). The standpipe shall be equipped with an overflow outlet.
- c. **Rammer:** A mechanically operated metal rammer equipped to control the height of drop to 305 mm (12") plus or minus 2 mm (1/16") above the elevation of the sample. The rammer shall be equipped to distribute the blow uniformly over the sample surface. The rammer shall have a rigid flat faced "pie shaped" foot and a nominal weight of 25 kg (5.50 lbs.). The "pie shaped" foot shall be a sector of 152 mm (6") diameter circle and shall have an area equal to that of 51 mm (2") circular foot.
- d. **Straight edge:** A rigid steel straight edge with one edge beveled, at least 203 mm (8") in length.

2. Sample preparation:

- a. Obtain a 22.7 kg (50 lb.) to 27.2 kg (60 lb.) sample, dry if necessary.
- b. Mix a sufficient amount of aggregate and cementing agent, if required, to fill the mold 1 and 1/2 times.
- c. Add the appropriate amount of water and thoroughly mix.
- d. Place the assembled mold on the rigid base and fill approximately 1/2 full of the loose moist material. Compact the layer with 25 blows of the rammer with the blows being distributed uniformly over the surface of the layer. Place three additional approximately equal layers of material in the mold and compact each layer in a similar manner (four layers total).
- e. After the fourth layer has been compacted, remove the collar and trim excess material level with top of the mold.
- f. Cure Portland Cement and Fly Ash treated specimens by covering with plastic, to prevent drying for 3 days at room temperature.
- g. Unbound specimens do not need to be cured before testing.

C. Asphalt Bound Aggregates:

1. Apparatus:

- a. **Mold:** A cylindrical mold with an inside diameter of approximately 152 mm (6") and a minimum length of 114 mm (4.5"). The mold is open at each end and is equipped with a removable collar and a base plate about 13 mm (0.5") thick.
- b. **Specimen Mold Holder:** The specimen mold holder has a semi circular base and a flanged top to hold the specimen mold in place during the compaction process. Any equivalent hold down device that performs the same function is satisfactory.
- c. **Compaction Hammer:** The compaction hammer consists of a hammer having a flat circular tamping face 149 mm (5.88") in diameter and appropriate extension rod with handle which acts as guide for a free falling weight. The weight shall weigh 10 kg (22.5 lbs.) and have a free fall of 547 mm (18") plus or minus 2 mm (0.1"). The hammer may be operated manually or be driven with a motor.
- d. **Compaction Pedestal:** The compaction pedestal is a wood block approximately 305 mm x 305 mm x 457 mm (12" x 12" x 18"). A 305 mm x 305 mm x 25 mm (12" x 12" x 1") steel plate is securely fastened to the top of the block. The pedestal is set on and securely fastened to a solid concrete slab with the vertical axis plumb and the top level.
- e. **Heating Equipment:** Ovens or hot plates for heating aggregates, bituminous material, specimen molds, compaction hammers and other associated items required for mixing and molding. It is recommended that, when possible all heating units be thermostatically controlled to maintain the required temperature within $\pm 2.8^{\circ}\text{C}$ (5°F). Suitable shields, thick steel plates or pans of sand shall be used on the surfaces of hot plates to minimize locally overheating.
- f. **Mixing Apparatus:** Mechanical mixing is recommended. Any type of mechanical mixer may be used provided it will produce a well coated, homogeneous mixture of the required amount in the allowable time and further that the mixing paddle or whip does not fracture or pulverize aggregate fractions during the mixing process. The bowl employed with the mixer shall be such a nature that essentially all of the batch can be removed. More than one mixing bowl is recommended unless the mixer is equipped with a heating jacket to keep the bowl heated during the mixing process.

2. Determination of Mixing and Compacting Temperature:

- a. The temperature to which the asphalt cement must be heated to produce a viscosity of 85 ± 10 SFS shall be the mixing temperature.
- b. The temperature to which the asphalt cement must be heated to produce a viscosity of 130 ± 15 SFS shall be the compacting temperature.

3. Sample Preparation for Laboratory Prepared Mix:

- a. Combine the dry individual aggregates to produce desired combined aggregate with a batch weight of approximately 4050 grams (8.9 lbs.). This should be sufficient to produce a compacted specimen 95 ± 3 mm (3.75 ± 0.125 inches) thick. Adjust the weight of the batch as needed to produce a compacted specimen of 95 ± 3 mm (3.75 ± 0.125 inches) thick.
- b. Prepare a minimum of two aggregate and asphalt specimens. The first specimen shall be mixed and thrown away. This sample is to "butter" the mixing bowl and paddle and thus reduce material loss when mixing the test specimen.
- c. Heat the aggregate and asphalt within the limits of mixing temperature determined in paragraph 2203.7 C2a. Charge the mixing bowl with the heated aggregate and form a crater in the top. Add the required amount asphalt and mix the aggregate and asphalt until coated at least 2 minutes. Care should be taken to keep all of the sample in the mixing bowl during this process.

4. Compaction of Specimen:

- a. Prior to the addition of the asphalt to the batches, thoroughly clean the specimen mold assembly and the face of the compaction hammer and heat the mold assembly and hammer to a temperature between 93.3°C (200°F) and 176.7°C (350°F). Assemble the mold, base plate and collar and place a paper disc cut to size in the bottom of the mold.
- b. Place the hot batch of aggregate-asphalt mixture in the mold, spade vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior of the mold. Smooth the surface of the mix to a slightly rounded shape. The temperature of the mix prior to compaction shall be within the limits in 2203.7 C2b. Place a paper disc on top of the mix.
- c. Place the mold assembly, including the collar, on the pedestal, fasten securely with the mold holder and apply 20 blows with the compaction

hammer. Each blow must have the prescribed free fall of 457 mm (18") with the axis of the compaction hammer held perpendicular to the base of the mold assembly during the compaction process. Remove the base plate and collar, and reverse and reassemble the mold. Apply the specified number of blows to the reversed specimen. After compaction remove the mold assembly from the pedestal, remove the collar and base plate and cool the specimen in the mold until the mold can be handled comfortable with bare hands. Asphalt treated samples do not need to be cured before testing, only cool to the touch.

D. Test Procedure:

1. Assemble test equipment, base plate, mold with specimen, and standpipe.
2. Prior to conducting the test, allow a sufficient amount of water to pass through the specimen to cause all air to be expelled from the specimen. (Establish reservoir around the base with water open to atmospheric pressure.)
3. Conduct Constant-Head Permeability test and report coefficient of permeability "k" in meters (feet) per day. Repeat a minimum of two additional times until two runs agree reasonably well.
4. Constant-Head Permeability:

$$K = \frac{QL}{Aht}$$

Q = quantity of water discharged (volume)

L = length of specimen

A = cross-sectional area of specimen

h = hydraulic head (height column of water above discharge)

t = elapsed time of test

K = coefficient of permeability (length/time)

Note: For very permeable material, maintain elevation of water above the sample for 3 minutes then measure Q (flow).

2203.8 Methods of Measurement:

- A. Crushed Aggregate Drainable Base will be measured by one of the following:
1. Per square yard (square meter) or tenth part thereof for the specified depth.
 2. Per ton (metric ton) or tenth part thereof.
- B. Portland Cement Concrete Drainable Base may be included in the Proposal as a single item or as separate items (Portland Cement and Base Aggregate) and measured by one of the following:
1. Per square yard (square meter) or tenth part thereof for the specified depth.
 2. Per ton (metric ton) or tenth part thereof.
- C. Plant Mix Bituminous Drainable Base may be included in the Proposal as a single item or as separate items (Asphaltic Cement and Base Aggregate) and measured by one of the following:
1. Per square yard (square meter) or tenth part thereof for the specified depth.
 2. Per ton (metric ton) or tenth part thereof.
- D. Pipe Underdrains will be measured per lineal foot (meter) or tenth part thereof. Drainable Base Aggregate shall be subsidiary to the Pipe Underdrain.
- E. Blanket Underdrains will be measured by the actual quantities used as follows:
1. Pipe Underdrain will be measured per lineal foot (meter) or tenth part thereof.
 2. Drainable Base Aggregate will be measured by one of the following:
 - a. Per square yard (square meter) or tenth part thereof for the specified depth.
 - b. Per ton (metric ton) or tenth part thereof.

2203.9 Basis of Payment:

- A. Crushed Aggregate Drainable Base will be paid for by one of the following:
 - 1. Contract unit bid price.
 - 2. Contract lump sum bid price.
- B. Portland Cement Concrete Drainable Base will be paid for by one of the following:
 - 1. Contract unit bid price.
 - 2. Contract lump sum bid price.
- C. Plant Mix Bituminous Drainable Base will be paid for by one of the following:
 - 1. Contract unit bid price.
 - 2. Contract lump sum bid price.
- D. Pipe Underdrains will be paid for by one of the following:
 - 1. Contract unit bid price.
 - 2. Contract lump sum bid price.
- E. Blanket Underdrains will be paid for by one of the following:
 - 1. Contract unit bid price.
 - 2. Contract lump sum bid price.

SECTION 2204 PRIME AND TACK COAT

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

D 140 - Practice for Sampling Bituminous Materials

2204.1 Summary: This section includes the application of liquid asphalt to a prepared pavement (concrete, asphaltic concrete), or granular base. The type and grade of asphalt material to be used as prime or tack coat, is as specified in the Special Provisions or as indicated by the plans.

2204.2 Liquid Asphalt Material: The liquid asphalt material to be used for surface preparation shall be as listed in the following table:

Material to be Treated	Application Usage	Type of Emulsion or Grade of Cutback	Application Rate Gal/SY (L/SM)	Application Temperature °F (°C)	Cure Time at 70°F (21°C)
Existing Asphalt or Concrete Surface	Tack	RC-70	0.05-0.10 Gal/SY (0.23-0.46 L/SM)	150-225 (65 – 107)	1-6 hrs
	Tack	SS-1 SS-1h CSS-1 CSS-1h	0.05-0.15 Gal/SY (0.23–0.69 L/SM)	70 – 160 (22.5- 42)	1-3 hrs
Treated Base ;ie, lime, fly/ash, cement	Prime	MC-30 MC-70	0.1-0.3 Gal/SY (0.46-1.38 L/SM)	85-120 (29-49)	12-24 hrs
	Prime	SS-1 SS-1h CSS-1 CSS-1h	0.1-0.3 Gal/SY/in (0.46-1.38 L/SM/mm)	70-160 (20-70)	24-48 hrs
Untreated Aggregate Base w/ Fines	Prime	MC-30, MC-70	0.1-0.3 Gal/SY (0.46-1.38 L/SM)	85-120 (29-49)	12-24 hrs
W/o Fines	Prime	MC-250	0.2-0.5 Gal/SY (0.92-2.30 L/SM)	85-120 (29-49)	12-24 hrs
Untreated Aggregate Base	Prime	SS-1 SS-1h CSS-1 CSS-1h	0.1-0.3 Gal/SY/in (0.46-1.38 L/SM/mm)	70-160 (20-70)	24-48 hrs
	Prime	EAP PAE, or PEP	0.1-0.3 Gal/SY (0.46-1.38 L/SM)	70-160 (20-70)	12-24 hrs

The asphalt material shall conform to the latest ASTM specifications for "Asphalt Cements and Liquid Asphalts." Sampling shall be in accordance with ASTM D 140.

2204.3 Sand Cover: Sand Cover, if used, shall be any clean granular mineral meeting the following grading requirements. When tested with laboratory sieves 100% shall pass the No. 4 (4.75 mm) sieve and not more than 2% shall pass the No. 200 (75 um) sieve. The moisture content of the sand shall not exceed 3% by weight.

2204.4 Approval of Materials: Asphalt materials shall be approved by the Engineer prior to use in the work. The Engineer may accept a certified analysis by the material supplier laboratory when a copy of the certified analysis accompanies each shipment of asphalt to the project. The Engineer reserves the right to perform tests of the asphalt received on the job.

2204.5 Pressure Distributor: The distributor shall be so designed, equipped, maintained and operated that liquid asphalt at even heat may be applied uniformly on variable widths of surface up to 15 feet (4.5 m) at readily determined and controlled rates from 0.02 to 1.00 gallon per square yard (100 to 5000 milliliters per square meter), with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.02 gallons per square yard (100 milliliters per square meter). Distributor equipment shall include a tachometer, pressure gauges, a calibrated tank and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. The calibration of all distributors must be approved by the engineer, and the contractor shall furnish all equipment, material and assistance necessary if calibration is required.

2204.6 Preparation of Existing Surface:

- A. **For tack coats:** The existing surface shall be free of all dust, loose material, grease or other foreign material at the time the tack is applied. Any excess surface oil on the roadway or bituminous joint material will be removed by others without cost to the contractor before the tack is applied.
- B. **For prime coats:** the surface to be primed shall be shaped to the required grade and cross section, shall be free from all ruts, corrugations, segregated material or other irregularities, and shall be uniformly compacted by rolling. The surface shall be firm and slightly damp when primer is applied. Delays in priming may necessitate reprocessing or reshaping to provide a smooth compacted surface.

2204.7 Application of Asphalt Material:

- A. **For Tack Coats:** Asphalt emulsion shall be applied uniformly with a pressure distributor at the rate specified in the contract, or as revised by the engineer to be within a minimum of 0.05 and a maximum of 0.15 gallons per square yard (minimum of 230 and a maximum of 690 milliliters per square meter). Water may be added to

the asphalt emulsion and mixed therewith in such proportion that the resulting mixture will contain not more than 50% of added water, the quantity of added water to be approved by the engineer. The application of the resulting mixture shall be such that the original emulsion will be spread at the specified rate. The asphalt emulsion shall be heated at the time of application to a temperature in accordance with the limits provided in Sec 2204.2, or as specified in the contract. The tack shall be properly cured and the tacked surface shall be cleaned of all dirt and surplus sand before the next course is placed.

The tack coat shall be applied in such manner as to cause the least inconvenience to traffic and to permit one-way traffic without pickup or tracking of the asphalt emulsion.

- B. For Prime Coats:** Bituminous material shall be applied to the width of the section to be primed by means of a pressure distributor in a uniform, continuous spread. The subgrade shall be moistened before the prime is applied. The application rate shall be as specified in the contract or as approved by the engineer between 0.1 and 0.5 gallons per square yard (0.46 and 2.30 liters per square meter). The primer shall be heated at the time of application to a temperature in accordance with the limits provided in Sec 2204.2, or as specified in the contract.

Care shall be taken that the application of bituminous material at the junctions of spreads is not in excess of the specified quantity. Building paper shall be placed over the end of the previous applications and the joining application shall start on the building paper. Building paper used shall be removed and satisfactorily disposed of. Pools of primer material remaining on the surface after the application shall be removed.

When traffic is maintained, not more than one half of the width of the section shall be treated in one application and one-way traffic will be permitted on the untreated portion of the roadbed. As soon as the bituminous material has been absorbed by the surface and will not pick up, traffic shall be routed to the treated portion and the remaining width of the section will be primed.

The primer shall be properly cured, and the primed surface shall be cleaned of all dirt and surplus sand before the next course is placed.

2204.8 Application of Sand Cover: If the asphalt material is not completely cured within the maximum specified curing time, sufficient sand shall be spread over the surface with a mechanical spreader to blot up the excess asphalt. The rate of application shall be specified or approved by the Engineer. Prior to placing an asphalt paving course, all loose sand shall be swept from the primed or tacked surface.

2204.9 Methods of Measurement: Asphalt Prime and Tack Coat will be measured per gallon (liter).

2204.10 Basis of Payment: Asphalt Prime and Tack Coat will be paid for at the contract unit bid price.

SECTION 2205 ASPHALTIC CONCRETE SURFACE AND BASE

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

- C 88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C 117 - Test Method for Materials Finer than 75- um (No. 200) Sieve in Mineral Aggregates by Washing
- C 127 - Test Method for Specific Gravity and Absorption of Coarse Aggregate
- C 128 - Test Method for Specific Gravity and Absorption of Fine Aggregate
- C 131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- C 136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates
- C 142 - Test Method for Clay Lumps and Friable Particles in Aggregates
- D 75 - Practice for Sampling Aggregates
- D 140 - Practice for Sampling Bituminous Materials
- D 290 - Practice for Bituminous Mixing Plant Inspection
- D 979 - Practice for Sampling Bituminous Paving Mixtures
- D 1188 - Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
- D 2041 - Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

- D 2172 - Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures
- D 2726 - Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
- D 2950 - Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
- D 3666 - Specification for Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials
- D 4552 - Practice for Classifying Hot-Mix Recycling Agents
- D 5444 - Test Method for Mechanical Size Analysis of Extracted Aggregate
- D 6307 - Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method
- D 6373 - Specification for Performance Graded Asphalt Binder

AASHTO

- PP 26 Practice for Certifying Suppliers of Performance Graded Asphalt Binders
- T 245 Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
- T 283 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage

Asphalt Institute
 “Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types”, MS-2, Sixth Edition

National Bureau of Standards
 Handbook #44, “Specifications, Tolerance and other Technical Requirements for Commercial Weighing and Measuring Devices”

2205.1 Summary: This section includes the construction of asphalt concrete base and/or asphalt concrete surface.

2205.2 Materials: No material shall be used until it has been approved by the Engineer. All costs associated with material testing, certification and the preparation of trial mixes to determine the job mix formula shall be the responsibility of the contractor. Representative samples of all materials proposed for use under these specifications shall be submitted to the testing laboratory by the Contractor, at the Contractor's expense, for testing and the preparation of trial mixes to determine the job-mix formula. Additional tests necessary for determining conformance with the requirements specified herein will be performed under the supervision of the Engineer without cost to the Contractor, unless testing is the responsibility of the contractor in the contract.

- A. **Asphalt:** Asphalt cement used in the manufacture of asphalt paving mixtures shall conform to the Performance Graded system. The PG graded material used shall conform to the provincial grade used by the local DOT or as designated by the Engineer. In the Kansas City Metropolitan area, the provincial grade is a PG64-22.

These general usage guidelines may not address all project conditions. APWA strongly recommends that the engineer apply sound pavement design principles when designating mix type and selecting asphalt cement grade based upon individual project conditions. The Federal Highway Administration makes available LTPPBIND software that will assist with asphalt grade selection for specific projects.

The asphalt cement shall conform to ASTM D 6373. Sampling shall be in accordance with ASTM D 140.

The contractor or asphalt supplier shall submit a quality assurance plan for the asphaltic cement to the engineer that conforms to AASHTO PP 26. He shall also submit a temperature-viscosity chart showing the recommended mix and compaction temperatures for non-modified asphalts, and shall provide the specific gravity of the asphalt.

- B. **Aggregate:** The quality of aggregates used in Asphaltic Concrete shall conform to the following:

<u>Coarse Aggregate (Retained on the No. 4 Sieve)</u>	
LA Abrasion (ASTM C 131)	35% loss (maximum)
Soundness using Mag. Sulfate (ASTM C 88 5 cycles)	15% loss (maximum)
Total shale, clay, coal and lignite content ASTM C 142	1.0% by weight (max)
<u>Fine Aggregate (Passing the No. 4 Sieve)</u>	
Organic content	1% maximum
The parent material of manufactured sand must also meet the requirements for coarse aggregate shown above.	

Sampling shall be in accordance with ASTM D 75. Gradation analysis shall be in accordance with Standard Method of Test for Material Finer than No. 200 (75 μ m) Sieve in Mineral Aggregates by Washing, ASTM C 117 and Standard Method Test for Sieve Analysis of Fine and Coarse Aggregate, ASTM C 136.

2205.3 Mixing and Proportioning:

- A. **Composition of the Mix:** Asphaltic concrete mixtures shall consist of Mineral Aggregates and Asphalt Cement within the following limits for the type specified.

	ASPHALTIC CONCRETE-TYPE					
	1-01	2-01	3-01	4-01	5-01	6-01
<u>Percent by Weight of Total Mixture</u>						
Asphalt Cement	4-6	4-7	4-7	5-7.5		
<u>Aggregate-U. S. Standard</u>						
<u>Square Sieve Size</u>	<u>Total</u>	<u>Percent</u>	<u>Passing</u>	<u>by</u>	<u>Weight</u>	
1 1/2" (37.5 mm)	100	--	--	--	--	--
1" (25.0 mm)	75-100	100	--	--	100	--
3/4" (19.0 mm)	60-85	80-100	100	--	95-100	100
1/2" (12.5 mm)	--	--	85-100	100	--	86-100
3/8" (9.0 mm)	40-65	60-80	70-90	85-100	--	75-100
No. 4 (4.75 mm)	30-50	48-65	50-70	55-75	--	--
No. 8 (2.4 mm)	19-36	35-47	37-47	39-50	28 min	28 min
No. 16 (1.2 mm)	13-26	25-36	26-36	27-38	--	--
No. 30 (0.6 mm)	--	18-30	18-30	19-30	--	--
No. 50 (0.3 mm)	--	12-22	12-22	11-23	--	--
No. 100 (150 μ m)	4-12	6-14	6-15	6-16	--	--
No. 200 (75 μ m)	2-10	3-10	4-10	4-10	2-6	2-6

In addition to the above limits, the difference between the "Percent Passing Square Mesh Sieve" of successive sieve sizes shall not exceed 25 for types 1-01, 2-01, 3-01, and 4-01.

That fraction of material retained on the No. 4 (4.75-mm) Sieve shall be composed of particles with not less than 75% having two or more fractured faces for asphalt types 1-01, 2-01, 3-01, and 4-01, and not more than 20% by weight of that fraction shall be composed of flat or elongated particles as described in Section 2202.2.

For Asphalt Types 5-01 and 6-01 only, the total aggregate (coarse aggregate, fine aggregate, and the material passing the No. 200 sieve (75um) shall contain not less than 85% crushed material for intermediate course and surface course.

It shall be noted that when the gradation varies appreciably from the single point gradation used in the mix-design, the test properties of the mix will be out of specifications. This condition can occur even though the gradation meets the tolerances below.

The job-mix formula shall be within the limits specified above. The maximum permissible variation from the job-mix formula, within the specification limits, shall be as followed:

Permissible Gradation Variation from Mix Design Percent by Wt. of Total Mix

<u>U. S. Standard Sieve Size</u>	<u>Type 1-01, 5-01 & 6-01</u>	<u>Type 2-01, 3-01, & 4-01</u>
No. 4 (4.75 mm) and larger	5.0	4.0
No. 8, 16, 30 and 50 (2.4, 1.2, 0.6, 0.3 mm)	4.0	3.0
No. 200 (75 um)	2.0	1.0
Asphalt Cement	0.5 (1-01 only)	0.3

B. Asphalt Mix General Usage

	<u>Surface</u>	<u>Base</u>
Arterial	3-01, 5-01, 6-01	1-01, 5-01
Collector	3-01, 5-01, 6-01	1-01, 2-01, 5-01
Local/Access	2-01, 3-01, 5-01	1-01, 2-01, 5-01
Paved Trail	2-01, 3-01, 4-01, 5-01	1-01, 2-01, 5-01
Recreational Surface	4-01	1-01, 2-01, 5-01
Parking Lot	2-01, 3-01, 5-01	1-01, 2-01, 5-01

Generally, mix types 1-01, 2-01, 3-01 and 4-01 are composed of local materials and are appropriate for general use. Mix types 5-01 and 6-01 are engineered to have

better mix properties to increase durability and life of the pavement, and as such are best used on high-type pavements.

Mix type 2-01 is acceptable for surfacing, but is generally more open-graded than the other surface mixes, and may not provide a tightly sealed surface.

Mix type 4-01 is very susceptible to rutting and is only recommended for non-vehicular use.

C. Asphalt Hot-Mix Recycling:

1. **General:** Except as modified herein, Recycled Asphaltic Concrete (RAC) shall be equal to that produced as new material. Reclaimed Asphalt Pavement (RAP) and/or Reclaimed Aggregate Materials (RAM) shall represent no more than 30% of the composition for all surface mixtures and no more than 50% of the composition for all base mixtures except type 5-01 and 6-01 (no more than 30%). Only virgin materials shall be used in the surface course for new construction projects. Recycled or virgin materials may be used on restoration projects. Recycled Asphaltic Concrete may contain combinations of RAP, RAM, coarse aggregate, fine aggregate, mineral filler, asphalt cement, recycling agent, anti-stripping agent and approved additives to produce an acceptable mixture. Recycled Asphaltic Concretes shall be designated by prefacing the type with "RC," such as "RC-Type 1-01"
2. **Materials Evaluation:** All recycled materials shall have the following additional tests:
 - a. A sieve analysis shall be performed on RAP and/or RAM in accordance with ASTM C 117, "Standard Test Method for Material Finer than No. 200 Sieve (75 um) in Mineral Aggregates by Washing" and ASTM C 136, "Standard Method for Sieve Analysis of Fine and Coarse Aggregates" after extraction of asphalt.
 - b. Asphalt content analysis shall be performed for RAP in accordance with Method "A" of ASTM D 2172, "Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures" where the RAP content exceeds 30%. For mixtures with RAP contents less than 30%, asphalt content may be determined using ASTM D6307.
 - c. The asphalt cement used shall be determined as follows:

For RAP contents of up to 20%, the asphalt grade shall be as specified in the mix design.

For RAP contents from 20% up to 30%, the asphalt grade shall be decreased one temperature range. For example, a design PG 64-22 would be decreased to a PG 58-22 with a viscosity in the range of 800 to 1200 poises.

For RAP contents from 30% to 50%, the asphalt grade of the new asphalt shall be determined using the procedures outlined in MS-2, 6th Edition, Appendix A.

- d. All sources of material for use in RAC must be approved by the Engineer prior to use.

3. **Material Requirements:**

- a. New asphalt cements added to the aged asphalt shall meet the requirements of Section 2205.2A
- b. Recycling Agents, if used, shall meet the requirements of ASTM D 4552, "Standard Practice for Classifying HOT MIX Recycling Agents."
- c. The RAP and/or RAM stockpiled at the plant site shall be maintained in stockpiles separated into surface and base. The RAP and/or RAM shall be processed such that 100% will pass the 1-1/2 inch (38 mm) sieve and 90% will pass the 1-inch (25.4 mm) sieve.
- d. The final product shall be free of foreign matter (e.g., old planer teeth, ice, wood, soil, broken sewer castings, loop detector wire, protective membranes, rubberized joint filler materials and foil turn lane markers, trash, debris, etc.)

- 4. **Mix Design Requirements:** The necessary steps for a final mix design for recycled mixtures, shall be done in accordance with the Asphalt Institute's Manual MS-2 Sixth Edition in the appendix entitled "Mix Design Using RAP

When a change in the RAP and/or RAM percentage exceeds 15% of the original amount of RAP and/or RAM in the mix design, a new mix design must be submitted.

5. **Asphalt Plant Requirements:** All delivery tickets shall designate the type of recycled mix, (RC-Type 1-01, RC-Type 2-01, RC-Type 3-01, or RC-Type 4-01).
- D. **Mix Design Criteria:** Laboratory Test Specimen(s) of the Paving Mix, combined in proportions of the job-mix formula, shall be prepared and tested in accordance with AASHTO T 245 and the volumetric properties of the compacted paving mixtures as calculated by ASTM procedures using Chapter 4 of the Mix Design Methods for Asphalt Concrete and other Hot-Mix types (MS-2), Sixth Edition, Asphalt Institute referred hereafter as “MS-2”. The Marshall procedure and the Voids in the Mineral Aggregate (VMA) shall be as specified in Chapter 5 of the MS-2. The automatic Marshall Hammer may be used when it has been calibrated with a manual hammer.

Optionally, for mix type 5-01 and/or 6-01 a SuperGyratory Compactor (SGC) may be used to prepare the asphalt samples for design and quality control testing. The gyratory values to be used for this purpose are $N_{\text{initial}} = 6$, $N_{\text{design}} = 50$, and $N_{\text{max}} = 75$. If this option is selected, Marshall stability and flow measurements will be waived during design and production. At N_{initial} , the specific gravity of the specimen must be 90.5% or less of G_{mm} , at N_{max} the specific gravity of the specimen must be 98% or less of G_{mm} .

The material for the theoretical specific gravity ASTM D 2041 and the material for the Marshall specimens (pucks) shall be cured at 285+/-5°F (140+/-3°C) for two hours in a closed oven after the mix is produced in the laboratory. Also, the plant-produced mixture shall be tested when the mix is two hours old. The mixture shall be transported to the laboratory in an insulated container and then stored in a laboratory oven at 140 +/-3°C (285 +/-5°F) for the remainder of the curing period. This procedure shall be used when the water-absorption as determined by ASTM C 127 and ASTM C 128 of any aggregate in the mixture exceeds 1.25%. The mixture shall be compacted at 140 +/-3°C (285 +/-5°F).

Test requirements and criteria for the paving mixes under these specifications shall be as follows:

Marshall Stability: 1500 lbs. (6672 N) Min (Types 1-01, 2-01, 3-01, and 4-01),
1800 lbs (8000 N) (Types 5-01 & 6-01)

No. of compaction blows: 50 (for Types 1-01, 2-01, 3-01, and 4-01),
75 (for Types 5-01 & 6-01)

Flow: 0.08-0.16 inches (2-4 mm) max (Types 1-01 – 4-01),
.14 inches (3.5 mm) max (Types 5-01 & 6-01)

Air Voids: (Laboratory Specimen)	Percent
Base	3-5
Surface	3-5

Voids filled with asphalt;
percent (VFA) Types 5-01 & 6-01 65-75 Percent

Voids in Mineral Aggregate (VMA)

(Nominal Max Size as defined in MS-2)	Percent (min.)
1 1/2" (38 mm)	11
1" (25.4 mm)	12
3/4" (19 mm)	13
1/2" (12.5 mm)	14
3/8" (9.5 mm)	15

The VMA properties for mixes 1-01,2-01,3-01, & 4-01 shall be measured in accordance with the procedure described herein and reported on the material data forms; however, there is no minimum criteria controlling VMA associated with these material gradations.

The VMA for Mix Types 5-01 & 6-01 shall be the minimum value allowed. For these mixes, the asphalt content should be just to the left side of the low point on the VMA vs. Asphalt Percent curve, not to the “wet” or right (increasing) side of the curve.

The VMA requirements shown represent values that may be higher than those obtained in the KC Metropolitan area using locally available materials. The minimum values are values recommended by the Asphalt Institute in MS-2 6th Edition for high

quality asphaltic concretes, but may require the use of non-local aggregates. VMA values shown are for 4% air voids and should be used for the design of conventional roadway pavements. During production, the voids can be expected to vary plus or minus 1% of this design value of 4%. Under these conditions, the minimum allowable VMA values should be calculated by interpolation of the chart in MS-2, 6th Edition. For mix types 1-01, 2-01, 3-01, and 4-01, 3% air voids may be used for design, and production may be allowed to vary plus or minus 1% of the design value.

The ratio of minus 200 (75 um) material to % Effective asphalt cement (P_{eff}) based on the weight of the aggregate shall be between 0.6-1.2 for Types 5-01 and 6-01.

The blend of RAP and/or RAM and virgin aggregates or non recycled asphalts shall be checked for resistance to stripping using AASHTO T 283 to determine if an anti-stripping agent is needed for the same asphalt chosen for the project. The index of retained strength shall exceed 75% for Types 1-01 – 4-01, and 80% for types 5-01 and 6-01.

- E. **Sampling and Testing of the Mixture:** Mixes shall be sampled in accordance with ASTM D 979 and tested in accordance with AASHTO T 245. The mixtures will be tested for binder content in accordance with ASTM D 2172 or D 6307. The recovered aggregate will be sieved in accordance with ASTM D 5444.
- F. **Mixture Temperature Requirements:** The temperature of the completed mix at the plant and at the paver shall be set by the Contractor who shall consider hauling and placing conditions, asphalt specifications as set forth in section 2205.2, and weather limitations set forth in section 2205.8 (B). The temperature of Types 5-01 and 6-01 shall not exceed 315° F (157° C) at the point of discharge from the asphalt plant when using PG 64-22 asphaltic oil.

When the mix is produced in a batch-type plant, the aggregate shall be weighed accurately in the designated proportions to provide the specified batch weight. The temperature of the aggregate at the time of introduction into the mixer shall be determined by the contractor, with a tolerance of + or - 25° F (16° C). In no case, however, shall the temperature of the mixture exceed the maximum temperature recommended by the manufacturer or supplier of the asphaltic cement (generally 350° F (177° C)).

- G. **Control of Mixing Time:** The contractor shall control mixing time to produce asphaltic concrete that is uniformly and thoroughly coated with asphaltic cement.
- H. **Preparation of Asphalt Cement:** The asphalt shall be heated so that it can be distributed uniformly throughout the mix. For mixing applications, the specified

temperature generally will be such that the asphalt viscosity is within the range of 150-190 centistokes and shall not exceed 350° F (177° C). The material shall be sufficiently fluid to produce a complete coating on every particle of aggregate within the specified mixing time.

The contractor shall maintain calibrated temperature monitoring equipment at the point of discharge from the asphalt plant and at the asphalt tank, and shall supply temperature records upon request.

- I. **Preparation and Handling of Aggregate:** Coarse and fine aggregate shall be stored at the plant in such a manner that the separate sizes will not become intermixed. Cold aggregates shall be carefully fed to the plant in such proportions that surpluses and shortages in the bins will not cause breaks in the continuous operation. When loading aggregate into stockpiles, and into cars, barges, and trucks, the material shall be placed in such a manner as to prevent segregation of aggregate sizes. Stockpiles shall be built in uniform layers not exceeding 5 feet (1.52 m) in depth.
1. Samples of coarse and fine aggregate shall be submitted to the Engineer for testing upon request. The contractor shall be responsible for the preparation and handling of aggregates to insure that the cold-feed gradations fall within the mix design limits. Cold-feed gradation tests shall be taken as requested by the Engineer.
 2. **Drying:** The aggregate shall be thoroughly dried and heated to provide a paving mix temperature within a tolerance of + or – 25° F. (4° C), of that specified by the approved mix design. The moisture content of the heated and dried aggregate shall not exceed 0.5%. The quantity of material fed through the dryer shall in all cases, be held to an amount which can be thoroughly dried and heated.
- J. **Inspection and Control of Asphalt Mixing Plant:**
1. **Tests:** During production the plant shall have the following tests performed by an approved laboratory: AC content, extracted gradation, Marshall density, stability, voids, vma, vfa and max theoretical density. Laboratories shall be approved if they are:
 - a. Accredited in accordance with ASTM D3666; and/or
 - b. Approved for Superpave asphalt testing by the State Highway Department in the state where the plant is located.

- 1). The individual performing the test must carry a state certification for Superpave testing.
 - 2). The laboratory must have an annual certification by an independent testing agency of all testing equipment used for Superpave mix designs, and must also have the Marshall hammer weight and height of drop certified by that same agency.
2. **Availability of test reports:** The results of the latest current test report shall be furnished to the Engineer upon request. All test reports shall be kept at the plant, and shall be made available upon request. If the mix is found to be outside of tolerance, or outside the specification limits as specified in Section 2205.3, correction shall be made. Test reports shall be furnished on the following "Asphalt Concrete Test" form.
3. **Frequency of testing:** For mixes 1-01 through 4-01, the tests listed in paragraph 1 shall be performed every 3000 tons (2700 metric tons) of asphalt production except during initial startup, or whenever the production asphalt fails one of the following conditions at which time they will be tested every 1000 tons (900 metric tons) until four consecutive tests show compliance with the specifications:
- a. Production void content measured at the plant discharge is 1% below laboratory mix design void content, or more than 5% total void content.
 - b. Extracted gradation of the production asphalt exceeds the permissible gradation variation for the mix type being produced.
 - c. Asphalt cement exceeds the content variation for the mix type being produced.
4. **Frequency of testing:** For mixes 5-01 and 6-01, the tests listed in paragraph 1 shall be performed once per day of production, or every 1000 tons (900 metric tons), whichever is less frequent except during initial startup; or whenever the production fails one of the following conditions at which time they will be tested every 500 tons (450 metric tons), or twice per day of production, whichever is less frequent until 4 consecutive tests show compliance with the specifications:
- a. Production void content measured at the plant discharge is less than 3% or more than 5%

- b. Extracted gradation of the production asphalt exceeds the permissible gradation variation for the mix type being produced.
 - c. Production vma measured at the plant discharge is below the design minimum vma.
 - d. Production vfa measured at the plant discharge is outside the allowable range.
5. **Redesign of Asphalt mixes:** If four consecutive tests performed as described in paragraph 3 or 4 above show noncompliance with the specifications as enumerated in the subparagraphs of paragraph 3 or 4 above, production of that type of asphalt will immediately cease, and may not be resumed until a new mix design is submitted and approved, or the plant can demonstrate to the engineer an ability to meet specifications. Resumption of asphalt production after a mix redesign or failure of four consecutive tests to meet specifications will be treated as a initial startup for testing purposes.

ASPHALTIC CONCRETE TEST (Verified Mix Design)

Description:			
APWA Type:			
LAB I.D.:	LOT		
Sample Date:	Belt		Tons
Sample I.D.:	Hot Mix		Tons
Supplier:			

Sieve Size	Belt Sample	Hot-Mix Sample*	Single Point Job-Mix Formula	Job-Mix Formula Tolerances	ASTM C 136, C 117, D 5444
25mm(1")					
19mm (3/4")					
12.5mm (1/2")					
9.5mm (3/8")					
4.75mm (No. 4)					
2.36mm (No. 8)					
1.18mm (No. 16)					* Uncompacted
600 um (No 30)					Behind paver
300 um (No 50)					** total mix basis
150 um (No 100)					***total aggregate
75 um (No 200)					Basis

EXTRACTION DATA-ASTM D6307	Plant Setting**	Sample*
(method B except sec. 12)	% AC	

Aggregate Type	%***	Aggregate Type	%***

MARSHALL CHARACTERISTICS (ACCEPTANCE CRITERIA)			
Compaction Blows (average of 3 specimens) Circle one (50 Types A-D, 75 Types E-F)			
	Sample*	Specifications	
Stability, lbs (kg)		Min	AASHTO T 245
Flow, 1/100 in (mm)		Max	AASHTO T 245
% Voids		3-5	
% VMA		__ min	
% VFA			
Density, pcf (kg/cu.m)		----	ASTM D 2726
Ratio (-) 75 um (No. 200) to % Eff. Binder			
Max Theoretical Specific Gravity Gmm		----	ASTM D 2041
Bulk Spec. Gr. Of total Agg. Gsb		----	ASTM C 127 & 128
COMMENTS:			

LOT DENSITY SHALL BE TIED TO THE LOT AND DATE
Laboratories shall conform to ASTM D 3666.

2205.4 Asphalt Mixing Plant: Plants used by the Contractor for preparation of the asphalt paving mix shall conform to the following requirements:

- A. **Field Testing Laboratory:** The Contractor shall provide a laboratory building or room at the plant site, for the exclusive use of the Engineer for performing tests, keeping records, and making reports at such times as the Engineer is performing those actions.

The Contractor shall also furnish necessary laboratory sieves and a powered shaker device for sieve analysis, scales, extractor and supplementary equipment to make aggregate sieve analysis, asphaltic concrete paving mixture analysis, and paving mixture density tests.

- B. The asphalt producer shall establish a quality control plan and shall maintain records. The quality control plan required by the state highway agency is a suggested standard.

2205.5 Transportation of Mix: The mix shall be transported to the job site in vehicles with tight metal bottoms, clean of all foreign material which may affect the mix. If a release agent is used, it must comply with State and Federal environmental regulations. The dispatching of the vehicles shall be so scheduled that all materials delivered may be placed in daylight unless the Engineer approves artificial light. Delivery of the material to the paver shall be at a uniform rate and in an amount within the capacity of the paving and compacting equipment.

Haul trucks shall be provided with covers of sufficient size and weight to completely cover the truck bed to protect the load and to prevent cooling of the upper surface. Failure to have the load completely covered shall be sufficient cause for rejection of the entire load. The load shall remain covered until the truck is next in line to be unloaded. In no case shall a load remain uncovered for more than 10 minutes before starting to use the load. If for any reason there is a delay in completely using a load, the remaining part of the load shall be recovered until it can be used. It shall be the responsibility of the Contractor to inform all truck drivers of these provisions before starting work.

2205.6 Scales and Weighing of Vehicles: The vehicle's tare and gross weight shall be established by actually weighing the vehicle on a certified scale. The tare weight will be established at least twice each day. The vehicle, when establishing tare, shall be clean, bed empty, fuel tanks filled and shall have all side and back boards in place.

- A. **Measurement by weight:** Measurement will be made by weighing each truck load on scales conforming to the requirements of 2205.6 B "Vehicle Scales."

- B. **Vehicle Scales:** Vehicle scales shall be approved by the engineer and shall conform to the requirements specified herein. The specifications, tolerances, and other technical requirements for weighing and measuring devices as recommended by the National Conference on Weights and Measures and published in the National Institute of Standards and Technology Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, and supplements thereto or revisions thereof, shall apply to all vehicles scales used.
- C. **Scale acceptance shall be based on one of the following:**
1. A valid certification or seal of approval by the Division of Weights and Measures from the state.
 2. A certification of calibration from a commercial scale service company showing that the scale meets the requirements of these specifications. The contractor shall furnish the certification of calibration to the Engineer.
- D. **Scale Calibration:** Scales shall have been calibrated within the nine month period prior to any material being delivered, or at any time the Engineer has cause to question the accuracy of the scale. Scales shall meet the requirements of Accuracy Class III L as defined in Handbook 44 (above).

Verification of a vehicle scale may be required by weighing a hauling unit on another recently calibrated and certified scale.

If equipment to be weighed is of such length that all axles cannot be weighed simultaneously, a level paved surface shall be provided permitting those axles not on the scale platform to be supported by the paved surface. The approach shall be at least as wide as the platform and of sufficient length to insure the level positioning of vehicles during weight determinations. The weighing shall be performed with all brakes released. If equipment to be weighed is equipped with an air bag suspension unit on any axle, the equipment including semi-trailers or pup trailers shall be weighed on vehicle scales of sufficient size to weigh all axles of the combination simultaneously.

All cost incurred in obtaining a certification of calibration or verification shall be borne by the contractor.

2205.7 Requirements for Asphalt Paving Equipment: All asphalt paving equipment used by the Contractor shall meet the requirements of this section and shall be maintained in acceptable mechanical condition. Equipment shall be serviced and lubricated away from the paving site. Units that drip fuel, oil, grease or other fluids shall be removed from the project until such leakage is corrected.

- A. **Pavers and Laydown Machines:** Mechanical self-powered pavers shall be capable of spreading the mix within the specified tolerances, true to the line, grade and crown indicated on the plans.

Pavers shall be equipped with quick and efficient steering devices and shall be capable of traveling both forward and in reverse. They shall be equipped with hoppers and distributing screws that place the mix evenly in front of the adjustable screeds. They shall be equipped with either a vibrating screed or a tamping bar immediately preceding a static screed.

There shall be sufficient auxiliary attachments for the paving machine so that it may be operated to lay the necessary width as determined in the field by the engineer. Vibrating screed or tamp bars shall be provided for the full width of all paving operations.

The screed shall include a strike-off device which is effective on mixes at workable temperatures without tearing, shoving or gouging them, and which produces a finished surface of an even and uniform texture. The screed shall be adjustable as to the height and crown and shall be equipped with a controlled heating device for use when required. However, for irregular width paving, hydraulic extensions without tamping bars or a vibrating screed may be used only along the curb or outer edge of pavement.

1. **Automatic Screed Controls:** The paver shall be equipped with and use an approved system capable of automatically controlling the elevation and transverse slope of the paver screed unless otherwise directed by the Engineer. An erected stringline, traveling stringline or other approved device operating on the roadbed being paved or the surface of the previously placed lane shall be used to establish the grade reference. The grade reference device shall operate on either or both sides of the paver as required and shall be capable of maintaining the desired transverse slope regardless of changes in the screed elevation.

2. The traveling stringline shall be constructed in such a manner that it does not vibrate or cause the sensor to make erroneous readings during the laydown operation. The length of the beam to be used shall be approved by the Engineer and shall be between 20 feet and 40 feet (6.1 and 12.2 m).
 3. The use of the automatic screed control devices on asphalt pavers will not be required for paving small irregular areas, entrances, approaches, or side street connections.
 4. Automatic screed control devices will be required for matching the joint with all previously laid strips, except for those areas noted above.
- B. **Rollers:** Compaction equipment shall consist of vibratory steel wheel, static steel wheel and pneumatic-tired rollers unless otherwise directed by the engineer. They shall be self-propelled and equipped with such controls that starting, stopping and reversing direction can be accomplished without displacing the hot asphaltic concrete pavement.

Rollers shall be equipped with adjustable scrapers to keep the wheel surfaces clean and with efficient means of keeping them wet to prevent mixes from sticking. The roller surfaces shall have no flat areas, openings or projections that will mar the surface of the pavement.

1. **Steel-Wheeled Rollers:** Steel-Wheeled Rollers shall be vibratory two-axle tandem rollers. These rollers shall develop contact pressure of 250 to 350 pounds per inch of width (45 to 62.5 kg per cm of width) (vibratory mode) or 150 to 180 pounds per inch of width (26.8 to 32 kg per cm of width) (static). Rollers shall be in good working condition.
2. **Pneumatic-Tired Rollers:** Heavy pneumatic-tired rollers shall be self-propelled and shall consist of two axles on which are mounted an odd number of pneumatic tired wheels. The roller shall have at least nine pneumatic-tired wheels mounted in such a manner that the rear group of wheels will not follow in the tracks of the forward group, but shall be spaced to give essentially uniform coverage with each pass. Axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. Tires shall be smooth, inflated to 90 p.s.i. (620 kPa). Construction of the roller shall be such that each wheel is loaded to a minimum of 2,300 pounds (1043 kg.).

3. **Trench Rollers:** Trench rollers shall have an auxiliary wheel that operates outside the area to be compacted at such a distance from the pavement edge as to cause no damage thereto. It shall be mounted upon an axle that is adjustable in height. The auxiliary wheel shall be kept in adjustment so that the compression wheels will develop a smooth, compacted surface true to crown and grade.

The contact pressure of the compression wheels shall be from 250 to 350 pounds per inch of width (45 to 62.5 kg per cm of width).

4. In lieu of the above requirements pertaining to non-vibratory compaction equipment, consideration will be given to use other types of equipment that are capable of producing equivalent results consistent with the requirements of the specifications.
- C. **Pressure Distributor:** The pressure distributor shall meet the requirements of Section 2204.5 entitled "Pressure Distributor."
- D. **Hand Tools:** The Contractor shall provide sufficient lutes, rakes, shovels, tamping tools and other equipment as required to produce results consistent with the specifications.

2205.8 Construction Requirements:

- A. **Preparation of the Area to be Paved:** The area to be paved shall be true to line and grade, and shall have a properly prepared surface prior to the start of the paving operations. It shall be free from all loose or foreign material.

Where a base is rough or uneven, a leveling course shall be placed and properly compacted before the placing of subsequent courses.

When leveling course is not required, all depressions and other irregularities shall be patched or corrected, and the work approved by the Engineer before the paving operation begins.

The area to be paved shall be primed or tacked uniformly in accordance with the provisions of Section 2204 entitled "Prime and Tack Coat".

The surfaces of curbs, gutters, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin, complete coating of asphaltic material to provide a closely bonded, watertight joint.

- B. **Weather Limitations:** When the moisture of the aggregate in the stockpile or from the dryer interferes with the quality of mix production, or with normal plant operations, or when pools of water are observed on the surface to be paved, the mixing and placing of hot-mix asphalt will not be permitted without the permission of the Engineer.

Hot Mix asphalt paving shall not be mixed or placed when the ambient air or base temperature is below 40° F (4.4° C), or when there is frost in the subgrade or any other time when weather conditions are unsuitable for the type of material being placed without expressed approval of the Engineer.

Asphalt mix laydown temperatures and rolling times shall conform to the following table:

Minimum Laydown Temperature			
Base Temp.	1-1/2"	2"	3" and Greater
40-50° F (4.4-10° C)	300° F (149° C)	285° F (141° C)	275° F (135° C)
50-60° F (10-16° C)	295° F (146° C)	280° F (138° C)	270° F (132° C)
60-70° F (16-21° C)	285° F (141° C)	275° F (135° C)	265° F (129° C)
70-80° F (21-27° C)	280° F (138° C)	270° F (132° C)	265° F (129° C)
80-90° F (27-32° C)	270° F (132° C)	265° F (129° C)	260° F (127° C)
90°+ F (32°+ C)	265° F (129° C)	260° F (127° C)	255° F (124° C)
Rolling Time	12 minutes	15 minutes	15 minutes

Regardless of the temperature, final acceptance of the asphalt mat shall be based on density determined in accordance with section 2205.8 (E). Rolling times shown are maximum times during which target density must be achieved.

- C. **Spreading and Finishing:** The spreading and finishing of each course shall be to the thickness and width indicated on the plans or Special Provisions. The thickness of individual layers shall not exceed the following for the respective type of mixture. The suggested minimum lift thickness shall be three times the nominal maximum size of the mix. Nominal maximum is defined as the first sieve size larger than the sieve which retains at least 10% of the aggregate by weight.

Asphalt Type	Max. Compacted Lift Thickness
Type 1-01	6" (150 mm)
Type 2-01	4" (100 mm)
Type 3-01	3" (76 mm)
Type 4-01	2" (50 mm)
Type 5-01	4" (100 mm)
Type 6-01	3" (76 mm)

Spreading and finishing shall be conducted in the following manner:

1. **Mechanical Pavers:** The base and surface courses shall be spread and struck-off with a mechanical paving machine meeting the requirements of Section 2205.7A entitled "Pavers and Laydown Machines." The paving machine shall be operated so that the material does not accumulate and remain along the sides of the receiving hopper. The wings of the spreader hopper shall not be emptied (flipped) between truck loads.
 - a. Equipment which leaves tracks or indented areas which cannot be corrected in normal operation, or which produces other permanent blemishes or fails to produce a satisfactory surface, shall not be used. The screed auger shall be operated approximately $\frac{3}{4}$ full and the hopper conveyor shall not be allowed to run out of material during the paving operation.
 - b. Longitudinal joints and edges shall be constructed to true lines. Lines for the paver to follow in placing individual lanes will be established parallel to the centerline of the proposed roadway. The paver shall be positioned; and operated to follow closely the established line.
 - c. Sufficient trucks shall be used to continuously supply asphalt to the paver. Delays in the paving operation shall be kept to a minimum.
 - d. The Contractor shall make every effort to minimize the number of passes heavy equipment makes over uncompleted roadway sections.
 - e. When using pavers in echelon, the second paver shall follow the edge of the material placed by the first paver. The length of each laydown pass shall be limited, depending on weather conditions, to assure a hot joint and obtain proper compaction.
 - f. As soon as the first load of material has been spread, the texture of the unrolled surface shall be checked to determine its uniformity. Segregation of materials shall not be permitted. If segregation occurs, the spreading operation shall be immediately suspended until the cause is determined and corrected.
 - g. Transverse joints in succeeding courses shall be offset at least 2 feet (0.6 m). Longitudinal Joints shall be offset at least 6 inches (150 mm). The longitudinal joints shall be laid out so that the surface joint is under the lane markings where possible.

- h. Any irregularities in alignment left by the paver shall be corrected by trimming directly behind the machine. Distortion of the pavement during this operation shall be avoided.
 - i. Edges against which additional pavement is to be placed shall be placed on a 30° (2:1) bevel, or as specified by the engineer. Any irregularities in the surface of the pavement course shall be corrected directly behind the paver. Excess material forming high spots shall be removed by a shovel or lute. Indented areas shall be filled with hot mix and smoothed. Broadcasting of material shall not be permitted.
2. **Hand Spreading:** In small areas where the use of mechanical finishing equipment is not practical, the mix may be spread and finished by hand. The material shall be distributed uniformly to avoid segregation of the coarse and fine aggregate. Broadcasting of material shall not be permitted. During the spreading operation, all material shall be thoroughly and uniformly distributed by lutes or rakes. Material that has formed into lumps and does not break down readily shall be removed. Following placing and before rolling, the surface shall be checked with templates and straightedges and all irregularities corrected.

D. Compaction:

1. **General:** A minimum of three rollers shall be used for compacting mixes unless otherwise approved by the engineer. These rollers shall meet the requirements of Section 2205.7B entitled "Rollers." Additional rollers shall be used as necessary to provide specified pavement density.

Immediately after spreading, each course of the pavement mixture shall be compacted by rolling. The initial or "breakdown" rolling shall be accomplished with a steel-wheeled vibratory roller. The pneumatic-tired roller shall be used to knead and compact the pavement mixture following the initial rolling and preceding the final rolling. Care shall be exercised in the use of the pneumatic-tired roller to ensure that the pavement mixture is sufficiently cooled to avoid "picking up" of the mixture on the tires of the roller, and also to ensure that the pneumatic-tired rolling is completed before the mixture becomes too cool to allow satisfactory finish rolling. Final, or finish rolling, shall be done with a steel-wheeled roller. The sequence of rolling operations may be changed with the approval of the engineer. All rolling shall be longitudinal, starting near the edge of the pavement. Alternate trips of the roller shall be of slightly different lengths. The initial

rolling shall take place as closely behind the laydown machine as the temperature and condition of the mat will allow.

The motion of the roller shall be slow enough at all times to avoid displacement of the hot mixture. The initial compaction roll shall be accomplished with the roller drive wheel leading the tiller wheel. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected immediately by the use of rakes and fresh mixture when required. To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excess water will not be permitted.

The surface of the mixture after compaction shall be smooth and true to established section and grade. Any surface which is segregated, or is in any way defective, shall be removed and replaced with fresh hot mixture at the Contractor's expense, and shall be immediately compacted to conform with the surrounding area.

2. **Rolling Procedure:**

- a. **Thin Layers (Lifts):** When placing a thin lift (less than 2 in.[50 mm] compacted thickness) in single-lane width or full width, the mixture should be rolled in the following sequence:
 - 1). Transverse joint.
 - 2). Outside edge.
 - 3). Breakdown rolling, beginning on the low side.
 - 4). Intermediate rolling; same procedure as Step 3.
 - 5). Finish rolling.
- b. When paving a thin lift in echelon, or when abutting a previously placed lane or other lateral restraint, the mixture should be rolled in the following sequence:
 - 1). Transverse joint.
 - 2). Longitudinal joint.

- 3). Outside edge.
 - 4). Breakdown rolling, beginning on the low side.
 - 5). Intermediate rolling; same procedure as Step 4.
 - 6). Finish rolling.
- c. **Thick Layers (Lifts):** When placing a thick lift (2 in. [50 mm] or more compacted thickness) in single-lane width or full width, the mixture should be rolled in the following sequence:
- 1). Transverse joint.
 - 2). Breakdown rolling, beginning 12 to 15 in.(300 to 380 mm) interior to the lower unsupported edge. The return pass shall be made with the edge of the roller 3 inches (76 mm) exterior to the unsupported edge of the pavement.
 - 3). Breakdown rolling of outside edge. Repeat the process described in Step 2 above on the other longitudinal edge.
 - 4). Intermediate rolling, beginning on the low side.
 - 5). Finish rolling.
- d. When paving a thick lift in echelon, or when abutting a previously placed lane or other lateral restraint, the mixture should be rolled in the following sequence:
- 1). Transverse joint.
 - 2). Longitudinal joint.
 - 3). Breakdown rolling, beginning at the longitudinal joint.
 - 4). Intermediate rolling, beginning on the low side.
 - 5). Finish rolling.

- e. When paving in echelon, 2-3 inches (5.08-7.62 cm) of the first mat shall be left unrolled, and rolled when the joint between the lanes is rolled and after the 2nd mat is placed. Edges shall not be exposed more than fifteen minutes without being rolled. Particular attention shall be given to the construction of transverse and longitudinal joints in all courses.
 - f. In laying a surface mix adjacent to any finished area, it shall be placed sufficiently high so that, when compacted, the finished surface will be true and uniform. Where the grade is slight a level will be used to insure drainage to the desired outlet.
3. **Transverse joints:** When the transverse joint is next to an adjoining lane, the first pass shall be made with a static steel-wheeled roller moving along the longitudinal joint for a few feet. The surface will then be checked with a straightedge and corrections shall be made if necessary. The joint then shall be rolled transversely, with 6 in.(150 mm) of the drum width on the newly laid material. This operation shall be repeated with successive passes, each covering an additional 6 to 8 in.(150 to 200 mm) of the new mat, until the entire width of a drive roll is on the new mixture. During transverse rolling, wooden boards of the proper thickness should be placed at the edge of the pavement to give the roller a surface to drive on once it passes the edge of tile Mat. if boards are not used, transverse rolling must stop 6 to 8 in. (150 to 200 mm) short of the outside edge to prevent damaging it, and the edge must be compacted later during longitudinal rolling. Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. If the joint has been distorted, it shall be trimmed to a line. The joint face shall be tacked before the fresh material is placed against it.
4. **Longitudinal joints:** Longitudinal joints shall be rolled directly behind the paving operation. The edge to be joined shall be tack coated. The paver screed shall be set to overlap the first mat by 1-2 inches (25-50 mm). The elevation of the screed above the surface of the first mat should be equal to the amount of roll-down expected during compaction of the new mat. For large aggregate mixes, the coarse aggregate in the material overlapping the cold joint should be carefully removed and wasted, leaving only the finer portion of the mixture to be pressed into the compacted lane at the time the joint is rolled. For mixes with smaller coarse aggregate, such as surface courses, the overlapping material should be pushed with a lute into a hump over the joint area prior to compaction.

5. **Edges:** The edges of the pavement shall be rolled concurrently with or immediately after rolling the longitudinal joint. In rolling pavement edges, roller wheels shall extend 2-4 inches (50-100 mm) beyond the pavement edge provided the lateral displacement is not excessive.
 6. **Breakdown Rolling:** Breakdown rolling shall immediately follow the rolling of the longitudinal joint and edges. Rollers shall be operated as close to the paver as necessary to obtain adequate density without causing undue displacement. The breakdown roller shall be operated with the drive wheel nearest the laydown machine. Exceptions may be made by the Engineer when working on steep slopes or super-elevated curves.
 7. **Intermediate Rolling:** Pneumatic-tired rollers as specified in Section 2205.7B entitled "Rollers" shall be used for intermediate rolling. The intermediate rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still of a temperature that will result in maximum density from this operation. Pneumatic-tired rolling shall be continuous after the initial rolling until all of the mix placed has been compacted to the required density. Turning of pneumatic-tired rollers on the hot paving mix which causes displacement shall not be permitted.
 8. **Finish Rolling:** The finish rolling shall be accomplished while the material is still warm enough for the removal of roller marks. All roller marks shall be removed by the finish rolling operation. All rolling operations shall be conducted in close sequence.
 9. In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by trench rollers or others meeting the requirements of Section 2205.7B entitled "Rollers." The trench roller shall be operated until the lift is thoroughly compacted. Hand tamping, manual or mechanical, may be used in such areas, if such operations will give the required density.
- E. **Density and Surface Requirements:** The completed asphalt concrete paving shall have a density equal to or greater than 95% for Type 1-01 and 5-01 Asphalt Concrete Base and 96% for Types 2-01, 3-01, 4-01, 5-01 and 6-01 Asphalt Concrete Surface. Density is based on laboratory specimens prepared as specified in Section 2205.3B entitled "Mix Design Criteria" and made from plant mix conforming to the job mix formula. Density testing shall conform to ASTM D 2950 or ASTM D 2726 or D 1188.

If cores are used to determine density, one or more tests (one test equals three cores) will be taken for each tonnage lot and averaged to determine acceptance. Two cores will be taken from the lane being paved, and one core centered on the longitudinal joint with the adjoining lane. The Engineer will mark the locations of all cores.

The compacted surface shall be 0-1/4 in. (0-6 mm) above the edge of curb. All unsatisfactory work shall be repaired, replaced or corrected. The surface of the final course shall be of a uniform texture and conform to line and grade shown on the plans.

The field control density will be based on the density of plant produced mix compacted in a laboratory in accordance with Section 2205.3 (C).

2205.9 Method of Measurement: Asphaltic concrete base, asphaltic concrete surface, or asphaltic concrete base and surface may be included in the proposal as separate items, or as a single item, and may be measured by one of the following:

- A. Per square yard (square meter) or tenth part thereof for the specified depth.
- B. Per ton (metric ton) or tenth part thereof.
- C. If pavement smoothness is required in the proposal, pay adjustments will apply to the traffic lane design driving width only in accordance with Section 2211.

2205.10 Basis of Payment: Asphaltic Concrete Surface, Asphaltic Concrete Base, or Asphaltic Concrete Base and Surface whether used for paving, patching, or leveling courses will be paid for by one of the following:

- A. Contract unit bid price.
- B. Contract lump sum bid price.
- C. Testing described in Section 2205.3 paragraph I is subsidiary to the price bid for asphalt unless otherwise provided for in the contract.

**SECTION 2206 ASPHALT CRACK SEALING, ASPHALT CRACK FILLING,
CHIP SEALING, SLURRY SEALING, AND MICROSURFACING**

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

- C 88 - Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- C 117 - Test Method for Materials Finer than 75- um (No. 200) Sieve in Mineral Aggregates by Washing
- C 131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- C 136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates
- D 36 - Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
- D 140 - Practice for Sampling Bituminous Materials
- D 242 – Standard Specification for Mineral Filler For Bituminous Paving Mixtures
- D 244 – Standard Test Methods for Emulsified Asphalts
- D 946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
- D 977 - Standard Specification for Emulsified Asphalt
- D 1073 - Standard Specification for Fine Aggregate for Bituminous Paving Mixtures
- D 1190 - Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
- D 2027 – Standard Specification for Cutback Asphalt (Medium-Curing Type)
- D 2028 – Standard Specification for Cutback Asphalt (Rapid-Curing Type)
- D 2397 - Standard Specification for Cationic Emulsified Asphalt
- D 2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- D 3381 - Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
- D 3405 - Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
- D 3910 - Standard Practices for Design, Testing, and Construction of Slurry Seal
- D 5078 - Standard Specification for Crack Filler, Hot-Applied, for Asphalt Concrete and Portland Cement Concrete Pavements
- D 6372 - Standard Practice for Design, Testing, and Construction of Micro-Surfacing

ISSA

Bulletin #139 “Test Method to Classify Emulsified Asphalt/Aggregate Mixture Systems by Modified Cohesion Tester Measurement of Set and Cure Characteristics”

AASHTO

T 53	Softening Point of Bitumen (Ring-and-Ball Apparatus)
T 59	Testing Emulsified Asphalts
T 104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
T 112	Clay Lumps and Friable Particles in Aggregate
MP 1	Specification for Performance Graded Asphalt Binder
M 208	Cationic Emulsified Asphalt

Manual of Uniform Traffic Control Devices, latest Edition (MUTCD)

2206.1 Summary: This section includes minor pavement patching and crack cleaning and sealing, construction of asphalt seal-coat, microsurfacing and slurry seal, complete, in place, at the locations specified in the Special Provisions and as directed by the Engineer.

2206.2 Crack Sealing/Filling:

- A. **Crack Sealant Application:** Material used for crack sealing shall be a modified asphalt product selected to be compatible with the environment of application and found to meet the criteria of one of the following specifications, ASTM D 1190 or ASTM D3405 with a modified resilience value between 30 and 60 percent , or material meeting the requirements of ASTM D 5078. Crack Sealing shall be understood to be the process of placing an asphaltic material into and/or above working cracks to prevent the intrusion of surface water and/or incompressibles into the crack. A working crack shall be understood to correspond to cracks that sustain more than 0.1 inches (2.5 mm) movement during the course of the year.
- B. **Crack Filling Application:** Material used for crack filling shall be an viscosity-graded AC-20 asphalt product meeting the criteria of ASTM D 3381 Table 1, a penetration-graded asphalt product having a penetration number in the range of 85-100 measured in accordance with ASTM D 946, or material meeting the criteria of ASTM D-5078. Crack filling material may contain polyester or polypropylene fibers. Material satisfying the criteria of a crack sealant may also be used as a crack filling material. Crack filling shall be understood to be the process of placing an asphaltic material into non-working cracks to substantially reduce water infiltration and reinforce adjacent cracks. Crack filling materials shall not be used for sealing pavements in preparation for an overlay.

C. Equipment:

1. **Router:** This machine shall be an impact cutterhead with a minimum of 6 tungsten-carbide cutters. The router blades shall be driven with a minimum 25-hp gasoline engine.
2. **Compressor:** The compressor shall be a two-stage compressor rated as a minimum 40 CFM unit capable of delivering compressed air to the nozzle at a minimum pressure of 100 psi. The compressor shall be equipped with a filter trap to eliminate oil and moisture from the air line.
3. **Hot-Air Lance (HCA):** The hot air lance shall be capable of delivering super-heated air at an exit temperature in excess of 1500°F and at a velocity in excess of 1000 ft/sec against the side walls of the crack. The hose shall be wrapped with reflective tape to keep hoses together and to protect worker in low light situations.
4. **Melter/Applicator:**
 - a. The melting pot shall consist of double-boiler type jacket and shall be equipped with a full sweep agitator that promotes proper mixing and maintains uniform heat distribution throughout the melting pot. The melting pot shall have sufficient capacity of the heat transfer oil reservoir that heat transfer oil is able to come in contact with 100 percent of the outside area of the jacket. The melting pot shall be equipped with a drain plug to permit 100 % of the heat transfer oil to drain from the boiler. The heat transfer oil shall consist of ISO grade 68.
 - b. The heat transfer oil shall be heated with a properly sized vapor fuel LP or diesel fuel burner. The heat shall be applied directly to the bottom of the heat transfer tank. The burner shall be lit by an electric spark igniter controlled by a sensor, which detects a lack of burn or ignition and subsequently shuts down the fuel supply. The unit must be capable of starting at ambient temperature and bringing the sealant up to the required applications temperature within the period of approximately one hour while continuously agitating and recirculating the sealant. The unit shall have the capability of independently monitoring both the transfer oil and melting pot temperatures. The unit shall be capable of heating a variety of application materials within a range of temperatures between 200°F (93.3°C) and 425°F (218.3°C). The sealant should not be heated to a temperature in excess of that specified by the manufacturer.

- c. The agitator and material pump shall be actuated by hydraulic motors driven by a single, pressure-compensated hydraulic pump. Hydraulic fluid should only be pumped to the agitator or material pump motor on demand.
- d. The sealant shall be applied to the pavement through an application system consisting of a pressure feed hose and wand. The hose shall be specially manufactured to handle liquid asphalt products up to 450°F (218°F) at 350 psi (2400 kPa) working pressure. The hose shall not be less than 15 feet in length. The hand wand shall be constructed of steel of sufficient strength to withstand normal day-to-day operations. Material flow through the wand shall be controlled with a toggle switch. A squeegee shall be used to distribute the asphalt evenly and uniformly in the recommended configuration.
- e. All equipment shall be in good working order, as determined by the Engineer, on a day-to-day basis. The Engineer shall not be responsible for payment of labor or rental charges on days when the equipment is not in good working order.

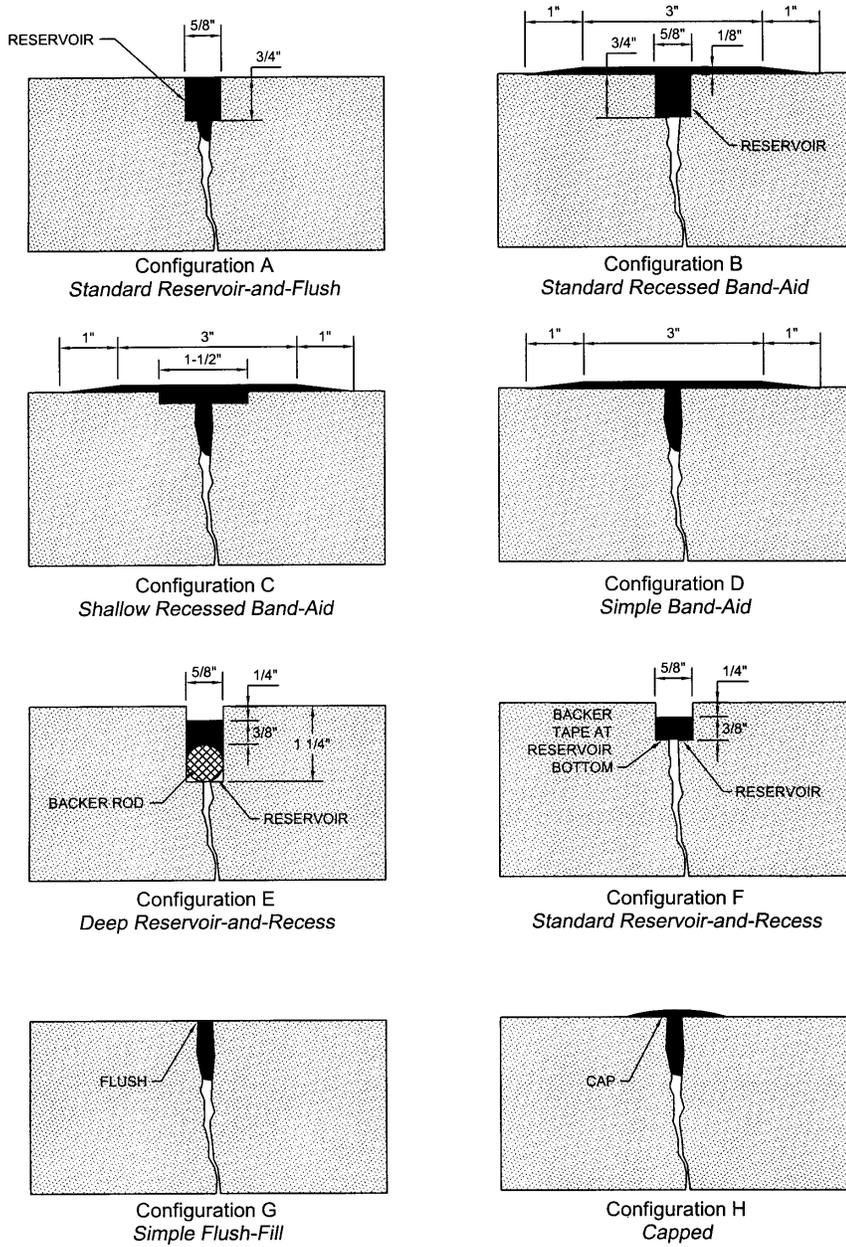
D. Preparation:

1. Crack sealing shall be limited to working, transverse cracks that are more than 1/4-inch (6mm) in width. Cracks 1/4- to 5/8-inches (6mm to 16 mm) in width requiring sealing shall be routed to 5/8-inches (16 mm) in width. Cracks 5/8- to 1-inch (16mm to 25 mm) in width requiring sealing do not require routing but shall be thoroughly cleaned and sealed. Cracks shall be sealed using either the Standard Reservoir and Flush or Standard Recessed Band-Aid configurations. Cracks greater than 1-inch (25 mm) in width shall be filled with either an emulsion slurry and sand, widened and backfilled with Hot-Mix Asphalt (HMA), or repaired in a manner approved by the Engineer. Cracks requiring filling do not require any routing but simply thorough cleaning. Cracks shall be filled using either the Simple Band-Aid, Simple Flush Fill, or Capped Configurations.
2. Cracks shall be cleaned free of all deleterious materials, including any old sealant; incompressibles; and organic material. The crack shall be free of any standing water and any moisture along the sidewalls of the crack as evidenced by a darker color than the adjacent pavement. This shall be accomplished in one of three manners: **wire-brushing** – where the crack channels are cleaned with a mechanical wire brush followed by high-pressure compressed air; hot **air blasting** – where the crack channels are cleaned,

heated, dried with hot compressed air (HCA) lance connected to a high pressure air compressor; or **high-pressure air blasting** – where the crack channels are cleaned with high-pressure compressed air. Pavement cracks to be sealed or filled shall be cleaned and dried using one of the methods described previously within 10 minutes of the application of the sealer/filler. Equipment for the two operations should be kept in a compact configuration such that not more than 50 feet separates equipment required by the two operations. Additionally, not more than 10 minutes time shall pass between the cleaning of a crack and the filling of the crack with the appropriate sealing/filling material.

E. Installation:

1. Sealer/filler materials should not be applied when the pavement surface is wet or when the pavement temperature is less than 40°F (4.5°C) without the use of hot air blasting or the approval of the Engineer.
2. Sealant/Crack filler should be applied to fill the crack from the bottom to the top in order to prevent air bubbles from forming and creating a point of weakness in the sealant. Upon application, hot sealant/filler material should not make a hissing or popping noise indicative of moisture in the crack. Noises of this kind should indicate that additional drying of the crack is necessary in order to facilitate proper bonding of the material to the sidewalls of the crack. Application of the sealant/filler material shall be made in such a way as to completely fill the crack and provide enough excess to facilitate completion of the seal/fill consistent with the configuration selected. The use of a squeegee or applicator disk to shape the application material to conform with one of the material placement configurations shown on Figure 1 is required. Care shall be taken not to place any sealant/filler material on top of any pavement markings, manholes, or drainage castings. The Contractor shall be responsible to prevent tracking of the sealant/filler material onto the adjacent pavement surfaces to the satisfaction of the Engineer.
3. The manufacturer's technical representative shall be notified by the Contractor and shall be present during the initial installation. Prior to beginning the work, the Contractor will be required to demonstrate to the satisfaction of the Engineer and the manufacturer's representative his ability to apply the material in accordance with the manufacturer's specifications. Operations and procedures which are considered by the Engineer as detrimental to the effectiveness of the material will not be permitted.



Material placement configurations for AC crack treatments

Figure 1

2206.3 Improved Street Chip Seal:

A. **Description:** This work shall consist of the application of a thin, uniform layer of emulsified asphalt to the existing pavement surface in order to universally seal cracks from the intrusion of surface water. Cover aggregate shall then be uniformly distributed upon the asphalt layer and seated in place with the use of a rubber-tired roller. Any excess aggregate material shall be removed, leaving a durable wearing surface.

B. Material Requirements:**1. Emulsified Asphalt:**

- a. The asphaltic sealant material applied to the roadway surface shall consist of a rapid-setting emulsified asphalt either an anionic RS-2 meeting the criteria of ASTM D-977 or a cationic CRS-2 meeting the criteria of ASTM D-2397. These materials may be modified with rubber products in the form of liquid latex, styrene-butidane-rubber, or styrene-butidane-styrene to enhance performance of the material as approved by the Engineer. If a polymer-modified material is used, the emulsified asphalt shall meet the additional specification criteria required by the Engineer.
- b. A sample of the emulsified asphalt may be taken from any of the distributors or delivery tankers on the job site. Failure of the emulsified asphalt to meet the material specification criteria at the time of application, shall require the Contractor, at his own expense, to correct all unsatisfactory areas. No additional areas shall be sealed until correction has been make to the satisfaction or the Engineer.

2. Cover Aggregate – Precoated Chips:

- a. **Materials:** Aggregate materials shall consist of an approximately cubic and uniformly-graded, hard, durable 100 percent crushed and washed limestone, sandstone, lightweight aggregate, basalt/porphyry, granitic material, steel slag, gravel, or chat. Chat is a by-product from the production of lead and zinc from the area located in southwestern Missouri, northeastern Oklahoma, and southeastern Kansas. Lightweight aggregate shall consist of expanded shale. The application rates reported

in these specifications is for the Bethany Falls Limestone in the Kansas City area. The specific gravity of this material is approximately 2.58

b. **Physical properties required of the aggregate materials:**

Los Angeles Abrasion (ASTM C 131)	35% loss (maximum)
Soundness using Mag. Sulfate (ASTM C88)	15% loss (maximum)
Total Shale, clay, coal, and lignite content	0.5% by weight (max)
Absorption	4.0% (max)

c. **Gradation:** Gradation of cover aggregates shall conform to the following percentages:

Sieve Size	Percent Passing
3/4" (19mm)	100
1/2" (12.5mm)	90-95
3/8" (9.5mm)	30-50
No. 4 (4.75mm)	0-5
No. 8 (2.36mm)	0

d. **Precoating of Chips:** Aggregate chips shall be uniformly heated in a dryer until surface dry. All material shall be free of moisture, dust, and lumps and shall be approved by the Engineer prior to use. The aggregate chips shall then be pre-coated with 0.9%+ 0.025% a liquid asphalt cement having a viscosity of 2000 poise, +20%. The asphaltic material and hot aggregate shall be measured separately and accurately immediately before introduction into the mixer. Mixing shall be accomplished at a temperature between 275°F (135°C) and 325°F (163°C), sufficient to produce a thoroughly and uniformly coated aggregate. The pre-coated chips shall be stockpiled at least 3 days prior to use.

3. **Weighing:** Weighing of cover aggregate shall be accomplished by the Contractor on scales that he furnishes for the purpose of weighing the cover aggregate as required in Section 2205.6 entitled "Scales and Weighing of Vehicles." All loads of cover aggregate will be weighed and evidenced by approved delivery tickets showing the net weight in pounds (kilograms) for each load. Two copies of each ticket shall accompany the load to the work site. Upon the load being incorporated in the work, the Engineer will sign both copies and one of these copies will be returned to the Contractor.

- C. **Spot Patching:** Areas where base failure of the roadway has occurred, or where the surface is broken out shall be repaired prior to the sealing operation. The failed sections will be marked by the engineer, and shall be removed by sawing a neat rectangular hole into the pavement. The failed material shall be removed without damage to the adjacent pavement. Where base failures have occurred, the pavement shall be removed to the subgrade which shall be corrected to the satisfaction of the engineer prior to patching. Unstable material shall be overexcavated and replaced with base materials meeting the requirements of Section 2202. All surfaces shall be properly primed and tacked in accordance to Section 2204.

The prepared hole shall be patched with hot-mix asphaltic patching material by placing in layers not to exceed 2 inches (5.08 cm); each layer being thoroughly compacted before the next layer is placed. After the patching material is placed and raked to a uniform surface, it shall be thoroughly compacted by rolling with a roller meeting the requirements of Section 2205.7. The edges shall be well bonded with the old surface. The completed patch shall be in the same plane as the existing pavement.

The asphaltic concrete used for patching at the different locations shall be as directed by the Engineer and shall conform to one of the mixes as set out-in Section 2205.3.

D. **Sealing:**

1. **Cleaning:** After all holes and cracks have been repaired to the satisfaction of the Engineer, and immediately before sealing the Contractor shall thoroughly clean the area to be sealed with a mechanical pickup type sweeper to insure proper adhesion of the new seal coat to the existing pavement. The street shall be dry before applying the seal coat.
2. **Sealing:** After the street has been prepared as set forth above the Contractor shall apply the emulsified asphalt by means of an approved distributor meeting the requirements of Section 2204.5. Provisions shall be made by the Contractor to properly protect the curbs and gutters from the asphaltic spray. Emulsified asphalt shall be applied at a rate between 0.28 and 0.35 gallons per square yard (1.27 and 1.58 Liters per square meter). The specific rate for each job will be determined by the Engineer in the field.

Immediately after the application of the asphalt, the Contractor shall, by means of a self-propelled mechanical spreader, apply a uniform layer of cover aggregate. This material shall be spread at the rate specified by the Engineer. This rate shall be between 18 and 25 pounds per square yard (9.7

and 13.6 kg per square meter) of pre-coated limestone chips. The application rate shall be set to prevent bleeding of the asphaltic material through the cover aggregate. If material is spread on any area in excess of the amount specified by the Engineer, the surplus shall be immediately removed and placed elsewhere as directed. No payment will be made to the Contractor for the picking up and redistribution of such excess. Hand spreading will be permitted only in those areas not accessible to the mechanical spreader.

Immediately after spreading the cover aggregate, the entire surface shall be rolled with multiple-wheel, pneumatic-type rollers meeting the requirements of Section 2205.7. Rolling shall be continued until a thoroughly compacted surface with a uniform aggregate coverage has been obtained, a minimum of 6 passes. The Engineer may require additional rollers if one roller cannot keep up with the operations. The first pass of the rollers over the cover aggregate shall not exceed 3 miles per hour (5 km per hour). The rollers shall not exceed 5 miles per hour (8 km per hour) during any rolling operation.

Forty-eight hours after spreading the cover aggregate, the entire surface shall be swept with a mechanical pickup type sweeper to remove any loose or excess cover aggregate.

During the sealing operation as described above, the Contractor shall cooperate with the Engineer in arranging a program and schedule of work so traffic may be handled or routed around or through the section being sealed. Whenever possible, the street will be closed; but when this is not possible, the sealing will be done in strips while traffic is diverted to the balance of the street. No traffic will be permitted on the sealed portion of the roadway until rolling is completed. All traffic control signage shall conform to the MUTCD handbook for traffic control in work zones.

When bleeding occurs or more material is required, additional cover aggregate shall be spread as directed. As soon as the cover material has adhered to the surface, and the emulsion is thoroughly cured all excess cover aggregate shall be removed with a mechanical pickup type sweeper. This curing period is generally 48 hours, but may be adjusted by the engineer.

2206.4 Unimproved Street Chip Seal:

- A. **Description:** This work shall consist of the application of a thin, uniform layer of liquified asphalt to the surface of the existing roadway which may either consist of an existing surface of asphaltic concrete or a gravel-surfaced road. Cover aggregate

shall then be distributed uniformly upon the liquified asphalt and seated in place with the use of a rubber-tired roller leaving a durable wearing surface..

B. Requirements for Liquified Asphalt Materials:

Asphaltic materials used for the sealing of unimproved streets shall be liquified either by the introduction of a diluent (cutback) or by emulsification. The particular grade of cutback material for use on a particular roadway shall be determined by the Engineer. Cutback asphaltic materials shall comply with the requirements of either ASTM D-2027 or ASTM D-2028. The particular grade of emulsified asphalt material for use on a particular roadway shall be determined by the Engineer. Anionic emulsified asphaltic materials shall comply with the requirements for either a rapid or medium-setting emulsion as described in ASTM D-977 while cationic emulsified asphaltic materials shall comply with the requirements for either a medium or rapid-setting emulsion as described in ASTM D-2397.

C. Requirements for Cover Aggregate Materials:

- a. Aggregate materials shall consist of an approximately cubical and uniformly-sized, hard, durable 100 percent crushed and washed limestone, sandstone, lightweight aggregate, basalt/porphyry, granitic material, steel slag, gravel, or chat. Chat is a by-product from the production of lead and zinc from the area located in southwestern Missouri, northeastern Oklahoma, and southeastern Kansas. Lightweight aggregate shall consist of expanded shale. Due to the variation in specific gravities between these materials, the application rate will need to be adjusted to reflect the change in specific gravity. The application rates reported in these specifications is for the Bethany Falls Limestone in the Kansas City area. The specific gravity of this material is approximately 2.58

b. Physical properties required of the aggregate materials:

Los Angeles Abrasion (ASTM C 131)	35% loss (maximum)
Soundness using Mag. Sulfate (ASTM C88)	15% loss (maximum)
Total Shale, clay, coal, and lignite content	0.5% by weight (max)
Absorption	4.0% (max)

Aggregate chips applied to cutback asphalt shall be shown to have a moisture content less than 1 percent immediately prior to application. Aggregate chips applied to emulsified asphalt shall be shown to have a moisture content of 3 percent or less immediately prior to application.

Gradation for aggregate chips used for Single sealing:

<u>Square Sieve Size</u>	<u>Percent Passing</u>
½" (12.5mm)	100
3/8" (9.5mm)	80-100
No. 4 (4.75 mm)	0-26
No. 10 (2.00mm)	0-2

Gradation for aggregate chips used for the first application of a Double sealing:

<u>Square Sieve Size</u>	<u>Percent Passing</u>
¾" (19mm)	100
½"(12.5mm)	90 to 100
3/8"(9.5mm)	40 to 70
No. 4 (4.75mm)	0 to 15
No. 10 (2.0mm)	0-2

Gradation for aggregate chips used for the second application of a Double sealing shall conform to the gradation for a Single sealing above.

The Contractor shall furnish scales for weighing cover aggregate as required in Section 2201.6 entitled "Scales and Weighing of Vehicles." All loads of cover aggregate will be weighed as required, and evidenced by approved delivery tickets showing the net weight in pounds (kilograms) for each load. Two copies of each ticket shall accompany the load to the work site. In order for the load to be received and incorporated into the work, both copies will be signed by the inspector and one of these copies returned to the Contractor.

D. Sealing:

Sealing shall be accomplished in the same manner as described in Section 2101.1.c.1 except as modified herein. Where a seal coat is applied to a gravel-surface roadway the surface shall be prepared in accordance with Section 2201.5. The surface shall then be primed in accordance with Section 2201.6 prior to the application of the seal coat.

The application rate of cutback asphalt shall be in the range 0.25 to 0.45 gallons per square yard (1.13 and 2.04 liters per square meter) as directed by the Engineer or demonstrated to result in a satisfactory seal in a test strip provided by the Contractor. Anti-Strip agent may be added to Cutback Asphalt at a rate not to exceed 1 percent of the residual asphalt volume as directed by the Engineer in order to improve adhesion

of the asphalt to the moist aggregates. The cutback agent shall be thoroughly mixed and blended with the cutback asphalt. The application rate of emulsified asphalt shall be in the range of 0.28 to 0.40 gallons per square yard (1.27 to 1.81 liters per square meter) as approved or directed by the Engineer. The distributor used shall meet the requirements of Section 2204.5.

Limestone materials shall be spread at the rate specified by the Engineer with the range of 16 to 24 pounds per square yard (8.70 and 13.05 kg per square meter).

Where double sealing is indicated on the plans or required by the Engineer, the area shall be treated with two seal coats. The application rate of the asphaltic material for the first application shall be approximately one-half of that used for a single seal with the remainder applied during the second seal application. The application rate of the first application of cover aggregate shall be within the range specified for a single seal. The application rate of the second application shall be approximately one-half the application rate of the first layer.

2206.5 Improved Street Slurry Seal:

- A. **Description:** This work shall consist of the application of Slurry Seal Material to an existing surface. The Slurry Seal shall consist of a mixture of emulsified asphalt, mineral aggregate and potable water, properly proportioned, mixed and spread on the surface in accordance with this specification and as directed by the Engineer.
- B. **Materials:**
1. **Emulsified Asphalt:** The emulsified asphalt shall conform to Grade SS-1h of Specification ASTM D 977, for emulsified asphalt, or Grade CSS-1h of Specification ASTM D 2397, for cationic emulsified asphalt. Quick-set emulsified asphalts QS-1h and CQS-1h may also be used. They shall conform to Specifications ASTM D 977 and ASTM D 2397 respectively, except that the test requirements for cement mixing and storage stability shall not apply. Refer to the International Slurry Surfacing Association (ISSA) Bulletin NO. 139. The emulsified asphalt shall have not less than 60% residue after distillation when tested using Specification ASTM D 244 and shall have a penetration of between 40 and 90 when tested using specification ASTM D 2397 at 77° F (25° C). Each load of emulsified asphalt delivered shall have a certificate of analysis/compliance matching the material used in the mix design.
 2. **Aggregate for Slurry Seal:** The mineral aggregate used for this work shall be natural or manufactured crushed granite, slag, or chat which is a by-

product of the milling of lead and zinc ores and shall conform to one of the following grading requirements when tested in accordance with Specification ASTM C136 and ASTM C117. All aggregate shall conform to the quality requirements of Specification ASTM D 1073.

GRADING REQUIREMENTS FOR AGGREGATE

Sieve Size	Amount Passing Sieves, Weight %		
	Type I	Type II	Tolerance
3/8 inch (9.5 mm)	100	100	
No. 4 (4.75 mm)	100	90-100	+5%
No. 8 (2.36 mm)	90-100	65-90	+5%
No. 16 (1.18 mm)	65-90	45-70	+5%
No. 30 (600 um)	40-65	30-50	+5%
No. 50 (300 um)	25-42	18-30	+4%
No. 100 (150 um)	15-30	10-21	+3%
No. 200 (75 um)	10-20	5-15	+2%*

The percent passing the No. 200 (75 um) sieve shall be determined by Specification ASTM C 117.

3. **Mineral Filler:** Mineral Fillers are of two types, chemically active and chemically inactive. Both shall conform to Specification ASTM D 242. Chemically active mineral fillers such as Portland cement, hydrated lime, and ammonium sulfate are used to improve workability, regulate the setting time, and, in some cases, to alter the aggregate gradation. Chemically inactive mineral fillers such as limestone dust, fly ash, and rock dust are used mainly to alter aggregate gradation.
4. **Water:** All water used shall be potable and shall be free of harmful salts or contaminants.
5. **Mix Design:** The Engineer shall approve all Slurry Seal Materials and methods prior to mixing and application. The contractor shall submit a completed and tested Slurry Seal mix design for the Engineer's approval. The approved test method for Emulsified Asphalt Slurry Seal shall be found in Specification ASTM D 3910. The mix design shall be made with the same materials the contractor will be using on the project. The percentage of each material must be shown on the mix design. Proportions of the mixture shall be as follows unless variations are approved by the Engineer:

	TYPE I	TYPE II
Aggregate for Slurry Seal	8.0 to 12.0 lbs per sq yd 3.63 to 5.44 kg/m ² (dry basis)	13.5 to 16.5 lbs per sq yd 7.32 to 8.95 kg/m ² (dry basis)
Emulsified Asphalt (Residual Asphalt Content)	10.0 to 16.0 % by weight of dry aggregate	7.5 to 13.5 % by weight of dry aggregate
Mineral Filler	1.5 to 3.0 % by weight of dry aggregate	1.5 to 3.0 % by weight of dry aggregate
Water	Minimum amount necessary to obtain a fluid and homogenous mixture	Minimum amount necessary to obtain a fluid and homogeneous mixture

Once the proper consistency is obtained, changes in proportioning of the various components of the mixture shall be held to a minimum.

6. **Application Rates:** The Slurry Seal mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition and shall be in accordance with the following:

Type I: 8.0 to 12.0 lbs per sq yd (3.63 to 5.44 kgs per sq meter)

Type II: 13.5 to 20 lbs per sq yd (5.44 to 9.07 kgs per sq meter)

Application rates are affected by the unit weight of the aggregate, the gradation of the aggregate and the demand of the surface to which the slurry seal is being applied.

7. **Equipment:** The slurry mixing machine shall be a continuous flow mixing unit and shall be capable of delivering accurately a predetermined proportion of aggregate, water and asphalt emulsion to the mixing chamber and to discharge the thoroughly mixed product on a continuous basis. The equipment shall be capable of prewetting the aggregate immediately prior to mixing with the emulsion. The mixing unit of the mixing chamber shall be capable of thoroughly blending all of the components together without violent mixing. The mixing machine shall be equipped with an approved fines feeder that includes an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer. The mineral filler shall be fed at the same time and location as the aggregate. The fines feeder shall be required whenever added mineral filler is a part of the aggregate

blend. The mixing machine shall be equipped with a water pressure system and fog-type spray bar, adequate for complete fogging of the surface receiving slurry treatment. Attached to the mixer machine shall be a mechanical type squeegee distributor, equipped with flexible material in contact with the surface of the pavement to prevent loss of slurry from the distributor. It shall be maintained so as to prevent loss of slurry on varying grades and crown by adjustments to insure uniform spread. There shall be a steering device and a flexible strike-off. The spreader box shall have an adjustable width. The box shall be kept clean and build up of asphalt and aggregate on the box or in the corners shall not be permitted. Use of burlap drags or other drags shall be approved by the Engineer. Hand squeegees, shovels, and other equipment shall be provided if necessary to supplement the slurry mixing machine. Power brooms, power blowers, air compressors, and hand brooms suitable for cleaning the surface and cracks of the existing surface shall be implemented to provide a clean surface.

8. **Construction Requirements:**

- a. **Surface Preparation:** Immediately prior to applying the slurry, clean the surface of all loose material, mud spots, vegetation, and other objectionable material. Any standard cleaning method used to clean pavements will be acceptable except water flushing. A pickup sweeper must be used unless otherwise approved by the Engineer. Manholes, valve boxes, drop inlets, and other service entrances shall be protected from the slurry seal by a method approved by the Engineer.
- b. **Application:** The surface shall be prewetted by fogging ahead of the slurry box unless waived by the Engineer. Water used in prewetted the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the slurry box. The slurry mixture shall be of the desired consistency upon deposit on the surface and no additional elements shall be added. Total time of mixing shall not exceed 4 minutes. A sufficient amount of slurry shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided. No lumping, balling, or unmixed aggregate shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate shall be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry shall be removed from the pavement. No excessive breaking of emulsion shall be allowed in the spreader box. No streaks, such as those caused by oversized aggregate will be left in the finished pavement.

- c. **Hand Work:** Approved squeegees shall be used to spread slurry in areas not accessible to the slurry mixer. Care should be exercised in leaving no unsightly appearance from the hand work.
- d. **Curing:** Treated areas shall be allowed to cure for four hours , or until such time as the Engineer permits their opening to traffic.
- e. **Weather Limitation:** The slurry seal shall not be applied if either the pavement or air temperature is below 60° F (18° C) and falling. The mixture shall not be applied if the relative humidity exceeds 80%.
- f. **Traffic Control:** Suitable methods shall be used to protect the slurry from all types of traffic until sufficiently cured to accept traffic. The length of time before traffic is permitted to use the surface depends on the type of emulsified asphalt, mixture characteristics, and weather conditions.
- g. **Lines:** Care shall be taken to insure straight lines along curb and shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide good appearance.
- h. **Property Owners Notification:** The Contractor shall supply and place door tags on the doors of all involved property owners. The door tag shall comply with the sample language provided by the Engineer.
- i. **Provisions for Public Convenience During Sealing Operation:** The Contractor shall provide and maintain sufficient signs, barricades, warning lights, flag persons and watch persons to protect the work and public in a manner satisfactory to the Engineer. Any areas damaged prior to acceptance by the City shall be repaired at the Contractor's expense. "No Parking" signs will be furnished by the Contractor. These signs shall comply with the standards established by the MUTCD with regard to size, color, working height and placement. When "No Parking" signs are posted on the streets with parking meters, the Contractor shall cover the parking meter heads with cloth or paper bags. The Contractor shall take all necessary precautions to protect the public (pedestrian and vehicular) from flying debris. The Contractor shall use warning signs and devices to warn motorists and pedestrians of work ahead.

2206.6 Improved Street Micro-Surfacing:

A. **Description:** This work shall consist of the application of a polymer modified asphalt emulsion, mineral aggregate, mineral filler, potable water, and other additives, properly proportioned, mixed and spread on a paved surface in accordance with this specification and as directed by the Engineer.

B. **Materials:**

1. **Emulsified Asphalt:** The emulsified asphalt shall be a quick wet polymer modified asphalt emulsion conforming to the requirements specified in Specification ASTM D 2397 or Specification AASHTO M 208 for Grade CSS-1h. The cement mixing test shall be waived for this emulsion. The polymer material shall be milled or blended into the asphalt or emulsifier solution prior to the emulsification process. The emulsified asphalt shall have not less than 62% residue after distillation when tested using specification ASTM D244. The temperature for this test shall be held below 280° F (138° C). Higher temperatures may cause the polymers to break down. In addition, the emulsified asphalt shall have a penetration of between 40 and 90 when tested using Specification ASTM D 2397 at 77° F (25° C) and shall have a minimum softening point of 135° F (57° C) when tested using Specification ASTM D 36. Each load of emulsified asphalt delivered shall have a certificate of analysis/compliance matching the material used in the mix design.
2. **Aggregate for Micro-Surfacing:** The aggregate shall be a manufactured crushed stone such as granite, or chat which is a by-product of the milling of lead and zinc ores. The aggregate shall be totally crushed with 100% of the parent aggregate being larger than the largest stone in the gradation to be used. The mineral aggregate used shall conform to one of the following grading requirements when tested in accordance with Specification ASTM C136 and ASTM C117. All aggregate shall conform to the quality requirements of Specification ASTM D 1073.

GRADING REQUIREMENTS FOR AGGREGATE

Sieve Size	Amount Passing Sieves, Weight %		
	Type II	Type III	Tolerance
3/8 inch (9.5 mm)	100	100	
No. 4 (4.75 mm)	90-100	70-90	+5%
No. 8 (2.36 mm)	65-90	45-70	+5%
No. 16 (1.18 mm)	45-70	28-50	+5%
No. 30 (600 um)	30-50	19-34	+5%
No. 50 (300 um)	18-30	12-25	+4%
No. 100 (150 um)	10-21	7-18	+3%
No. 200 (75 um)	5-15	5-15	+2%

The combined aggregate prior to the addition of any chemically active mineral filler shall have a sand equivalent of not less than 65 when tested by Specification ASTM D 2419. The aggregate shall have a weighed average loss not greater than 25% using magnesium sulfate when tested by Specification ASTM C 88. Testing of abrasion resistance shall not exceed 30% when tested by Specification ASTM C 131.

3. **Mineral Filler:** Mineral filler shall be any recognized brand of non-air-entrained Portland cement or hydrated lime. The mineral filler shall be free of lumps and accepted upon visual inspections. The type and amount of mineral filler needed shall be determined by a laboratory mix design and will be considered as part of the aggregate gradation. .
4. **Water:** All water used shall be potable and shall be free of harmful salts or contaminants.
5. **Additives:** Additives may be added to the emulsion mix or any of the component materials to provide the control of the quick-traffic properties. They must be included as part of the mix design and be compatible with the other components of the mix.
6. **Mix Design:** The Engineer shall approve all Micro-Surfacing Materials and methods prior to mixing and application. The contractor shall submit a completed and tested Micro-Surfacing mix design for the Engineer's approval. The approved test method for Micro-Surfacing shall be found in Specification ASTM D 6372. The mix design shall be made with the same materials the contractor will be using on the project. The percentage of each

material must be shown on the mix design. Proportions of the mixture shall be as follows unless variations are approved by the Engineer.

	TYPE II	TYPE III
Aggregate for Micro-Surfacing	10.0 to 20.0 lbs per sq yd 4.53 to 9.07 kg/m ² (dry basis)	15.0 to 30.0 lbs per sq yd 6.80 to 13.61 kg/m ² (dry basis)
Emulsified Asphalt (Residual Asphalt Content)	7.5 to 13.5 % by weight of dry aggregate	5.5 to 13.5 % by weight of dry aggregate
Polymer Based Modifier	Minimum of 3% solids based on asphalt weight content	Minimum of 3% solids Based on asphalt weight content
Additive	As needed	As needed
Mineral Filler	0.0 to 3.0 % by weight of dry aggregate	0.0 to 3.0 % by weight of dry aggregate
Water	Minimum amount necessary to obtain a fluid and homogenous mixture	Minimum amount necessary to obtain a fluid and homogeneous mixture

Once the proper consistency is obtained, changes in proportioning of the various components of the mixture shall be held to a minimum.

7. **Application Rates:** The Micro-Surfacing mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition and shall be in accordance with the following:

Type II: 10.0 to 20.0 lbs per sq yd (5.4 to 18.6 kgs per sq meter)

Type III: 15.0 to 30.0 lbs per sq yd (8.1 to 16.2 kgs per sq meter)

Application rates are affected by the unit weight of the aggregate, the gradation of the aggregate, and the demand of the surface to which the micro-surfacing is being applied.

8. **Equipment:**

- a. **Micro-Surfacing Mixing Equipment:** The Micro-Surfacing mixing machine shall be specifically designed and manufactured to lay micro-surfacing. The machine shall be self propelled, continuous flow mixing

unit able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler, control setting additive, and water to a revolving multi-blade double shafted mixer and discharge the mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler, control additive, and water to maintain an adequate supply to the proportioning controls. On major highway work, the machine may be required to be a self loading machine capable of loading materials while continuing to lay micro-surfacing. The self loading machine shall be equipped to allow the operator to have full control of the forward and reverse speed during application of the micro-surfacing material and be equipped with opposite side drivers stationed to assist in alignment. The self loading device, opposite side drivers stations, and forward and reverse speed controls shall be original equipment manufacturer designed.

- b. **Proportioning Devices:** Individual volume or weight controls for proportioning each material, and used in material calibration, shall be provided and properly marked.
- c. **Calibration:** Each mixing unit to be used in the performance of the work shall be calibrated prior to construction. A calibration documentation shall include an individual calibration of each material at various settings, which can be related to the machine metering devices. No machine will be allowed to work on the project until a calibration has been completed. Final calibration sheets shall be provided to the Engineer for acceptance.
- d. **Micro-Surfacing Spreading Equipment:** The machine shall include a surfacing box with twin shafted paddles or spiral augers fixed in a spreader box. A flexible front seal shall be provided to insure no loss of mixture at the road surface contact point. The rear flexible seal shall act as a final strike-off and shall be adjustable in width. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off box. The box shall have suitable means provided to side-shift the box to compensate for variations of pavement geometry. A secondary strike-off shall be provided to improve the surface texture. It shall have the same leveling adjustments as the spreader box.
- e. **Auxiliary Equipment:** Hand squeegees, shovels, traffic control equipment, and other support and safety equipment shall be provided if necessary to perform the work.

- f. **Cleaning Equipment:** Power brooms, pickup sweepers, power blowers, air compressors, and hand brooms suitable for cleaning shall be utilized to provide a clean surface.

9. **Construction Requirements:**

- a. **Surface Preparation:** Immediately prior to applying the micro-surfacing, the surface shall be cleaned of all loose material, silt spots, vegetation, and objectionable material as determined by the Engineer. Any standard cleaning method used to clean pavements will be acceptable except water flushing. Manholes, valve boxes, drop inlets, and other service entrances shall be protected from the micro-surfacing by a method approved by the Engineer.
- b. **Application:** If the pavement area to be covered is extremely oxidized and raveled or is concrete or brick, a tack coat may be required at the discretion of the Engineer. The tack coat shall conform to Section 2204 and shall be a SS or CSS grade. The tack coat shall be allowed to cure sufficiently before the application of micro-surfacing. The surface shall be prewetted by fogging ahead of the spreader box unless waived by the Engineer. Water used in prewetted the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the spreader box. The micro-surfacing mixture shall be of the desired consistency upon deposit on the surface and no additional elements shall be added. A sufficient amount of material shall be carried in all parts of the spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling, or unmixed aggregate shall be permitted. No streaks, such as those caused by oversized aggregate shall be left in the finished surface.
- c. **Hand Work:** Areas which cannot be reached with the mixing machine shall be surfaced using approved hand squeegees to provide a complete and uniform coverage. If necessary, the area to be handworked shall be lightly dampened prior to mix placement. The same type of finish as applied by the spreader box shall be required.
- d. **Curing:** Micro surfacing shall be allowed to cure for one hour, or until the Engineer permits opening the street to traffic.

- e. **Weather Limitation:** Micro-surfacing shall not be applied if either the pavement or air temperature is below 60° F (18° C) and falling. The mixture shall not be applied if the relative humidity exceeds 80%.
- f. **Traffic Control:** Suitable methods shall be used to protect the micro-surfacing from all types of traffic until sufficiently cured to accept traffic. The length of time before traffic is permitted to use the surface shall be determined by the Engineer.
- g. **Lines:** Care shall be taken to insure straight lines along curb and shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide good appearance.
- h. **Property Owners Notification:** The Contractor shall supply and place door tags on the doors of all involved property owners. The door tag shall comply with the sample language provided by the Engineer.
- i. **Provisions for Public Convenience During Surfacing Operation:** The Contractor shall provide and maintain sufficient signs, barricades, warning lights, flag persons and watch persons to protect the work and public in a manner satisfactory to the Engineer. Any areas damaged prior to acceptance by the City shall be repaired at the Contractor's expense. "No Parking" signs will be furnished by the Contractor. These signs shall comply with the standards established by the MUTCD with regard to size, color, working height and placement. When "No Parking" signs are posted on the streets with parking meters, the Contractor shall cover the parking meter heads with cloth or paper bags. The Contractor shall take all necessary precautions to protect the public (pedestrian and vehicular) from flying debris. The Contractor shall use warning signs and devices to warn motorists and pedestrians of work ahead.

2206.7 Method of Measurement:

- A. Asphaltic Crack Seal will be measured per pound (kilogram).

- B. Chip seal will be measured by one of the following:
1. Per square yard (square meter) or tenth part thereof.
 2. Actual quantities used:
 - a. Asphaltic concrete patch, per ton (metric ton) or tenth part thereof.
 - b. Bitumen (asphaltic cement or liquid asphalt) per gallon (liter).
 - c. Coated cover aggregate, per ton (metric ton) or tenth part thereof.
- C. Slurry seal will be measured per square yard (square meter) or tenth part thereof.
- D. Microsurfacing will be measured per square yard (square meter) or tenth part thereof.

2206.8 Basis of Payment:

- A. Asphaltic Crack Seal will be paid for by one of the following:
1. Contract unit bid price.
 2. Contract lump sum bid price.
- B. Chip Seal will be paid for by one of the following:
1. Contract unit bid price.
 2. Contract lump sum bid price.
- C. Slurry Seal will be paid for by one of the following:
1. Contract unit bid price.
 2. Contract lump sum bid price.
- D. Microsurfacing will be paid for by one of the following:
1. Contract unit bid price.
 2. Contract lump sum bid price.

SECTION 2207 COLD MILLING

2207.1 Summary: This section includes cold milling pavement surfaces.

2207.2 Equipment: Milling the surface of pavements shall be completed by the use of a milling machine conforming to the following:

- A. **Machine:** The cold milling machine shall be self-propelled and shall have in combination the means of milling and cutting, without softening the old surface and blading the cuttings into a single windrow, or depositing them directly into a truck.
- B. **Air Pollution:** The machine shall be equipped with a dust suppression system including water storage tanks and high pressure spray bars.
- C. **Operating Width:** It is desirable that the cutting width be greater than 6 feet (2 m). In the event the cutting width is less than 6 feet (2 m) a system of electronic grade control for consecutive passes will be required.
- D. **Cutting Drum:** The cutting drum shall be totally enclosed to prevent discharge of any loosened material on adjacent work areas.
- E. **Warning Light:** The milling machine shall be equipped with a flashing warning light visible from 360 degrees. The light shall be mounted near the rear of the machine, at least 2 feet (61 cm) above the highest part of the milling machine, and shall be used whenever the machine is being used or moved upon the City streets.

2207.3 Construction Details:

A. Methods of Operations for Milling:

1. **Operator:** The milling machine shall be operated by an experienced and capable operator.
2. **Utilities:** Street surfaces adjacent to manholes, water valves and other utility extensions, shall be completely removed to the full depth of cut specified for the street unless otherwise specified by the Engineer.
3. **Material Disposal:** The material windrowed by the machine shall be removed immediately from the surface of the pavement and properly disposed of by the Contractor.

4. **Surface Conditions:** The drum lacing patterns shall produce a smooth surface finish after milling, with groove depths not to exceed 1/4 inch (0.64 cm) and groove spacing not to exceed 1 inch (2.54 cm) unless otherwise approved by the Engineer.

B. Types of Cuts to be made by Milling:

1. **Leveling:** Sufficient passes, shall be made such that all irregularities or high spots are eliminated, and that 100% of the surface is milled.
2. **Average Depth:** Sufficient passes, or cuts, shall be made in order to remove a specified depth over the entire street section. These depths will be designated in the Special Provisions.
3. **Curb Cut:** Sufficient passes, or cuts shall be made in order to remove a specified depth at the curb for a specified width. The depth at the width furthest from the curb is 0. These dimensions will be designated in the Special Provisions.
4. **Bridge Deck Milling:** Sufficient passes, or cuts, shall be made in order to remove the material as specified on-the plans or in the Special Provisions.

- C. **Cleanup:** All loose asphalt and debris shall be removed from the street surface and curb and gutter. Any material and debris that adheres to the curb and gutter shall be removed.

2207.4 Method of measurement: Cold milling will be measured per square yard (square meter) or tenth part thereof for the specified depth.

2207.5 Basis of payment: Cold milling will be paid for by one of the following:

- A. Contract unit bid price.
- B. Contract lump sum bid price.

SECTION 2208 PORTLAND CEMENT CONCRETE PAVEMENT

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

ASTM

- A 185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
- A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- C 1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete
- C 1315 - Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

- C 1399 - Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete
- D 1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
- D 1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
- D 2628 - Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
- D 2835 - Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
- D 3405 - Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
- D 3406 - Standard Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements
- E 965 - Test Method for Measuring Surface Macrotexture Depth Using a Sand Volumetric Technique

AASHTO

- M 213 Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
- M 220 Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
- M 282 Joint Sealants, Hot-Poured, Elastomeric Type, for Portland Cement Concrete Pavements
- M 301 Joint Sealants, Hot-Poured, for Concrete and Asphalt Pavements

MCIB
Section 4-4 Concrete Pavement

2208.1 Summary: This section includes the construction of Portland Cement Concrete pavement.

2208.2 Materials:

- A. **Concrete Control and Quality:** The current editions of the "Bulletins" and Approved Sections of the "Standard Concrete Specifications" issued by the Mid-West Concrete Industry Board, Inc. (MCIB) are made a part hereof by reference. However, when the provisions of this Specification differ from the provisions of such "Bulletins" and "Sections" the provisions of this Specification shall govern.
- B. **Concrete:** Concrete shall conform to MCIB Section 4-4 entitled "Concrete Pavement." Concrete for ultra-thin whitetopping (UTW) projects shall also include fiber reinforcement conforming to Section 2208.2 C.4, and shall have a maximum nominal coarse aggregate size of 1/3 the thickness of the concrete overlay.
- C. **Reinforcement:**
1. **Bars:** Bars shall conform to ASTM A 615.
 2. **Welded Steel Wire:** Welded steel wire fabric shall conform to ASTM A 185.
 3. **Supporting Elements:** Representative samples of supporting elements shall be submitted and approved by the Engineer prior to their use in the project.
 4. **Fibers:** Where required, fibers shall be applied at the rate of 3 pounds per cubic yard (1.8 kg per cubic meter) of concrete. Fibers for concrete reinforcement shall be composed of only 100% virgin homopolymer polypropylene, fibrillated and graded. Fibers shall contain no reprocessed olefin materials, and shall be specifically manufactured to an optimum gradation for use as secondary concrete reinforcement, meeting the requirements of ASTM C 1116, Type III, 4.1.3, and ASTM C 1116 Performance Level 1, and a minimum residual strength of 30 psi (210 kPa) per ASTM C 1399, average of 4 beams sampled at the point of discharge (or when appropriate, the point of placement).
- D. **Isolation Joint Fillers:** Isolation joint fillers shall conform to ASTM D 1752.

- E. **Joint Sealing Compounds:** Joint sealing compounds shall conform to the standards for the type of sealant specified as listed in the following table:

Joint Seals and Sealants	AASHTO	ASTM
Hot-poured, Polymeric Asphalt Based	M 301	D 3405
Hot-poured, Elastomeric-Type	M 282	D 3406
Preformed Polychloroprene Elastomeric	M 220	D 2628
Lubricant for Installation of Preformed Seal	--	D 2835
Preformed Expansion Joint Filler	M 213	D 1751

- F. **Curing Membrane:** All material to be used or employed in curing Portland Cement Concrete must be approved by the Engineer prior to its use. It shall be of the liquid membrane type and shall conform to ASTM C 1315, Type II, Class A.

2208.3 Construction Details: Portland Cement Concrete pavement shall be constructed to the configuration, and to the lines and grades shown on the plans.

- A. **Grading and Subgrade Preparation:** All excavation or embankment required shall be as defined in sections 2100 and 2201 entitled "Grading," and "Subgrade Preparation." If areas of the subgrade are below the lines and grades shown on the plans, they shall be brought to the proper line and grade by one of the following:

1. Additional fill material placed in accordance with Sections 2100 and 2201.
2. Areas may be filled with Untreated Compacted Aggregate conforming to Section 2202.
3. Areas may be filled with additional thickness of Portland Cement Concrete Pavement.

- B. **Asphalt Surface Preparation for Ultra-thin Whitetopping:**

1. Mill existing asphalt surface to the depth indicated on the project drawings. When measured with a straightedge or stringline, the surface should be true to the plan drawings. The milled surface shall be no more than ½ inch (12.5 mm) below nor ¼ inch (6 mm) above the plan grade.
2. Remove all loose foreign material from the asphalt surface with compressed air, by brooming, or by other methods immediately prior to the placing of concrete. A pickup sweeper must be used unless otherwise directed by the Engineer.

3. The asphalt surface shall not be below 40° F (4° C), and shall be free of any standing water prior to the placement of concrete.
4. Water shall be used to cool the asphalt surface when the surface temperature is above 100° F (37.8° C), but shall be free of any standing water prior to the placement of the concrete.

C. Concrete Surface Preparation for Portland Cement Concrete Bonded Overlay:

1. Remove the entire surface of the existing concrete pavement (.25 in./ 5 mm nominal) by milling.
2. Clean the existing concrete pavement by shot blasting.
3. Thoroughly wet the concrete surfaces to which the overlay is to bond with clean water for not less than two hours before the placing of the concrete. Blow away all free water immediately ahead of the placing operation. Bonding surfaces should be maintained in a damp condition with no free standing water.

D. Forms: All forms shall be in good condition, clean, and free from imperfections. Each form shall not vary more than 1/4 inch (0.64 cm) in horizontal and vertical alignment for each 10 feet (3.05 m) of length.

1. **Material & Size:** Forms shall be made of metal and shall have a height equal to or greater than the prescribed edge thickness of the pavement slab.
2. **Strength:** Forms shall be of such cross-section and strength, and so secured as to resist the pressure of the concrete when struck off, vibrated, and finished, and the impact and vibration of any equipment which they may support.
3. **Installation:** Forms shall be set true to line and grade, supported through their length and, joined neatly in such a manner that the joints are free from movement in any direction.
4. **Preparation:** Forms shall be cleaned and lubricated prior to each use and shall be so designed to permit their removal without damage to the new concrete.

2208.4 Joints: Generally joints shall be formed at right angles to the true alignment of the pavement and to the depths and configuration specified by the appropriate standard or as modified by the plans and specifications.

- A. **Isolation joints:** Isolation joints shall be placed at all locations where shown on the plans and standards or as directed by the Engineer.
1. Isolation joints shall extend the entire width of the pavement and from the subgrade to one inch (25 mm) below the surface of the pavement or the material will have a suitable tear strip provided to allow for the application of the joint sealer.
 2. Under no circumstances shall any concrete be left across the isolation joint at any point.
 3. **Material:** Isolation joints shall be formed by a one piece, one inch (2.54 cm) thick preformed joint filler cut to the configuration of the correct pavement section.
 4. **Stability:** Isolation joints shall be secured in such a manner that they will not be disturbed during the placement, consolidation and finishing of the concrete.
 5. **Dowels:** If isolation joints are to be equipped with dowels they shall be of the size and type specified, and shall be firmly supported in place, by means of a dowel basket which shall remain in place. One half of each dowel shall be lightly painted or greased with a product approved by the engineer.
- B. **Contraction joints:** Contraction joints shall be placed where indicated and to the depth indicated by the plans, specifications and standards.
1. **Method:** Contraction joints shall be formed or sawed.
 2. When sawing joints, the contractor shall begin as soon as the concrete hardens sufficiently to prevent excessive raveling along the saw cut and shall finish before conditions induce uncontrolled cracks, regardless of the time or weather. The longitudinal contraction joints shall be sawed immediately after sawing transverse joints. When joint sealing backup material is specified with sawed joints, the first stage, which provides a relief cut shall be approximately 1/8 inch (3 mm) wide, and shall be to plan depth. The second stage which widens the joints to allow the insertion of joint sealing backup material to plan depth shall not be performed until the concrete is at least 48

hours old, and shall be delayed longer when the sawing causes raveling of the concrete. If second stage sawing is performed prior to the completion of the curing period, the contractor shall maintain the cure by use of curing tapes, plastic devices, or other materials approved by the engineer.

3. For portland cement concrete pavements, sawed contraction joints shall be one-third the thickness of the slab (minimum).
 4. Where not indicated on the plan drawings, joint spacing for ultra-thin whitetopping projects shall not exceed 12 times the thickness of the overlay, and shall be constructed such that the larger dimension of any panel does not exceed 125% of the smaller dimension. Joints of adjacent panels shall be aligned. Joints shall intersect pavement free edges at 90 degrees, and shall extend a minimum of 1 ft (300 mm) from the pavement edge. Saw joints shall be one-third the thickness of the slab, or two inches (50 mm), whichever is greater.
 5. For bonded portland cement concrete overlays, joints shall be located above existing joints, shall be sawed full depth plus one-half inch (12mm) for overlays up to 4 inches (100 mm) in two stages. The first stage provides a relief cut approximately 1/8 inch (3 mm) wide.
 6. **Dowels:** If contraction joints are to be equipped with dowels they shall be of the size and type specified and shall be firmly supported in place and accurately aligned parallel to the pavement line and grade with an allowable tolerance of 1/8 inch (3 mm).
- C. **Longitudinal and Construction joints:** Longitudinal joints or construction joints shall be placed as shown on the plans or where the Contractor's construction procedure may require them to be placed. Longitudinal construction joints (joints between construction lanes) shall be keyed or tied joints of the dimensions shown on the plans or standards.
- D. **Center joints:** Longitudinal center joints shall be constructed using the methods specified in Section 2208.4 B "Contraction joints."
- E. **Transverse Construction joints:** Transverse construction joints of the type shown on the plans or standards shall be placed wherever concrete placement is suspended for more than 30 minutes.

- F. **Tiebars:** Tiebars shall be of deformed steel of the dimensions specified by the plans or standards. Tiebars shall be installed at the specified spacing and firmly secured so as not to be disturbed by the construction procedure.

2208.5 Placing, Finishing, Curing, and Protection: Concrete shall be furnished in quantities required for immediate use and shall be placed in accordance with the requirements of MCIB Concrete Pavement (Section 4.4). Prior to commencing construction, the contractor shall furnish a concrete delivery plan which includes at a minimum the number of trucks which will be dedicated to the project, the location of the concrete plant, the route and distance from the plant to the job site, and the anticipated rate of concrete usage. It is essential that concrete be delivered in sufficient quantities to prevent stoppage of the paving operation.

- A. **Concrete Placement:** The concrete shall be deposited on the subgrade to the required depth and width of the construction lane in successive batches and in a continuous operation without the use of intermediate forms or bulkheads. The subgrade shall be moistened prior to the placement of concrete. The concrete shall be placed as uniformly as possible in order to minimize the amount of additional spreading necessary. While being placed, the concrete shall be vibrated and compacted with suitable tools so that the formation of voids or honeycomb pockets is prevented.

The concrete shall be well vibrated and tamped against the forms and along all joints. Care shall be taken in the distribution of the concrete to deposit a sufficient volume along the outside form lines so that the curb section can be consolidated and finished simultaneously with the slab.

No concrete shall be placed around manholes or other structures until they have been brought to the required grade, alignment, and cross slope.

Concrete shall not be allowed to extrude below the forms.

- B. **Concrete Finishing Methods:** The pavement shall be struck off and consolidated with a mechanical finishing machine. Hand-finishing methods may be used for small or irregular areas. Furnish paving and finishing equipment applicable to the type of construction as follows:
1. **Slip-form Machines:** Furnish slip-form machines capable of spreading, consolidating, screeding, and float finishing the freshly placed concrete in one pass to provide a dense and homogeneous pavement with minimal hand finishing.

2. **Self-Propelled Form-Riding Machines:** Furnish mechanical, self-propelled spreading and finishing machines capable of consolidation and finishing the concrete with minimal hand finishing. Do not use machines that displace the fixed side forms.
3. **Manual Fixed-Form Paving Machines:** Furnish spreading and finishing machines capable of consolidating and finishing the concrete with minimal hand finishing.
4. **Hand Methods:** When finishing by hand methods, concrete shall be consolidated by use of vibrating units operating in the concrete. Unless the vibrating apparatus is such that the full width of concrete is consolidated in a single passage, a definite system or pattern shall be used in the operation of the vibrator so the full width of concrete in each linear foot of lane will receive adequate and uniform consolidation. The system and methods of vibrating shall be subject to approval of the Engineer. Vibrating equipment shall, under no circumstances, be used as a tool for moving concrete laterally on the grade.

C. Concrete Finishing:

1. **Floating:** All surfaces shall be consolidated and floated after strike-off prior to final surface finish.
2. **Straightedging:** Straightedging in conformance with Section 2211 shall be used when the optional smoothness section is not used.
3. **Surface Tolerance:** After the longitudinal floating has been completed and the excess water has been removed, and while the concrete is still plastic, the slab shall be tested for trueness with a highway straightedge.
 The highway straightedge shall be held in successive positions parallel to the road center-line in contact with the surface and the whole area worked from one side of the slab to the other as necessary.
 Advancement along the pavement shall be in successive stages of not more than one half the length of the highway straightedge.
 Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished.
 Check surface longitudinally while concrete is still plastic; correct any surface deviations greater than 1/8 inch (3 mm) in 10 feet (3 m). Round edges of pavement to 1/8 inch (3 mm) radius.

4. **Edging:** Before final finishing is completed and before the concrete has taken its initial set, the edges of the slab and curb shall be finished to the radius shown on the plans or standards by the paving equipment, or with hand edging tools.
5. **Final Surface Finish:**
 - a. **Dragged Surface Treatment:** Astroturf or burlap shall be dragged longitudinally over the finished surface to produce a tight, uniform, textured surface, and the edges shall be rounded in a workmanlike manner for roadways with a design speed of 45 MPH (70 KM/H) or to be posted 45 MPH (70 KM/H) or less.

The texture achieved by the astroturf or burlap drag shall be tested by the Contractor in accordance with ASTM E 965, "Test Method for Measuring Surface Macrotexture Depth Using a Sand Volumetric Technique", to ensure the texture is adequate for skid resistance when this surface treatment is used for roadways to be posted 50 MPH (80 KM/H) or more. Test locations will be determined by the engineer. The results of ASTM E 965 shall show an average texture depth of any lot, as defined below, shall have a minimum value of 0.032 inch (0.80 mm). Any lot showing an average of less than 0.032 inch (0.80 mm) but equal to or greater than 0.024 inch (0.60 mm) will be accepted as substantial compliance but the contractor shall amend their operation to achieve the required 0.032 inch (0.80 mm) minimum depth. (It is not the intention of this tolerance to allow the contractor to continuously pave with an average texture depth of less than 0.032 inch [0.80 mm]). Any lot showing an average texture depth of less than 0.024 inch (0.60 mm) shall require diamond grinding of the pavement represented by this lot to attain the necessary texture. Any individual test showing a texture depth of less than 0.020 inch (0.50 mm) shall require diamond grinding of the pavement represented by this lot to attain the necessary texture. Limits of any failing individual test shall be determined by running additional tests at 100 foot (30 m) intervals before and after the failing test location. All testing of the surface texture shall be completed no later than the day following pavement placement.
 - b. **Groove Treatment:** Unless otherwise specified the texture surface of travel lanes of pavement shall be given a suitable transverse or longitudinal grooving, or a dragged surface treatment as described in paragraph a for roadways to be posted at 50 MPH (80KM/H) or more. If grooving is required, surface grooving shall be done with a mechanical device such as a wire broom or comb or by hand. The broom or comb

shall have a single row of spring steel tines, rectangular in cross section, 1/8 inch to 3/16 inch (3 mm to 4.8 mm) wide; spaced on 3/4 inch (19 mm) centers of sufficient length, thickness, and resilience to form grooves to a depth of a minimum of 1/8 inch (3 mm) to a maximum of approximately 3/16 (4.8 mm) inch in the plastic concrete.

This operation shall be done at such time and in such manner that the desired surface texture will be achieved while minimizing displacement of the larger aggregate particles and before the surface permanently sets. Where abutting pavement is to be placed, the grooving should extend as close to the edge as possible without damaging the edge.

If abutting pavement is not to be placed, the 6 inch (150 mm) area nearest the edge or 1 foot (300 mm) from the face of the curb is not required to be grooved.

For small or irregular areas or during equipment breakdown, grooving may be done by hand methods.

6. **Curing:** As soon as practical after the concrete is finished it shall be cured with one of the acceptable methods. Curing shall conform to the requirements of MCIB Standard Concrete Specifications except water proof paper or polyethylene sheeting shall not be acceptable as curing methods for concrete pavement. If a liquid curing membrane is used, it shall be applied in accordance to the manufacturer's directions.
 - a. **Method of Applying Curing Membrane:** A nozzle producing a uniform fan pattern will be used on all spray equipment when applying the liquid curing membrane. The curing compound should be applied immediately after final finishing, and before the loss of all free water on the surface of the concrete. Normally one smooth, even coat shall be applied at a rate of 150 to 200 square feet per gallon (3.7 to 3.8 square meters per liter), but two coats may be necessary to ensure complete coverage and effective protection. Second coats should be applied at right angles to the first.
 - b. **Curing Formed Surfaces:** If the forms are removed from finished concrete pavement within a period of 72 hours or if a slip form paving machine has been used, these surfaces shall also be cured. Curing membrane damaged by joint sawing operations shall be repaired by the Contractor as directed by the Engineer.
7. **Protection:** The Contractor shall, at his own expense, protect the concrete work against damage or defacement of any kind until it has been accepted by the Engineer.

All vehicular traffic shall be prohibited from using the new concrete pavement until it has attained strength in accordance with the following table:

Slab Thickness	Strength for Opening to Traffic psi (MPa)	
	Compressive	3 rd -Point Flexural
All UTW	2000 (13.8)	300 (2.1)
6.0" (150mm)	3600 (24.8)	540 (3.7)
7.0" (175mm)	2700 (18.6)	410 (2.8)
8.0" (200mm)	2150 (14.8)	340 (2.3)
9.0" (225mm)	2000 (13.8)	300 (2.1)
10"+ (250mm+)	2000 (13.8)	300 (2.1)

Concrete pavement that is not acceptable to the Engineer because of damage or defacement, shall be removed and replaced, or repaired to the satisfaction of the Engineer, at the expense of the Contractor.

8. **Diamond Grinding:** Grind the riding surface to reduce or eliminate the irregularities.
 - a. Use a self-propelled grinding machine with diamond blades mounted on a multi-blade arbor. Avoid using equipment that causes excessive ravels, aggregate fractures, or spalls. Provide uniform texture the full width of the lane.
 - b. Transverse grooving will not be required.
 - c. Use vacuum equipment or other continuous methods to remove grinding slurry and residue. Prevent the grinding slurry from flowing across lanes being used by traffic.
 - d. After corrections have been made to the riding surface, test the pavement for smoothness using the same technique used to determine smoothness originally. Furnish and operate the smoothness measurement equipment, and evaluate the results as specified in Section 2211.
 - e. Where smoothness is determined through the use of a profilograph, run two traces in each lane that has been corrected. Run one trace three feet (one meter) from the longitudinal joint between the lanes, and another

trace three feet (one meter) from the shoulder or curb edge of the lane. Assure that the profilograph testing and evaluation is performed by a trained and certified operator. Within two days after the corrections to the riding surface are made, furnish the Engineer with the profilogram and its evaluation.

- f. Evaluate the profilogram of the corrected riding surface in 250 ft. (76 m) sections per lane. The required profile index per trace is 15 inches per mile (0.24 meters per kilometer).
- g. Perform additional grinding as required to attain the required profile index. Correct all deviations (in excess of ½ inch [12.5 mm] in a length of 25 feet [7.6 m]) within each section regardless of the profile index value.

- 9. **Temperature Limitation:** Concrete work shall be in accordance with the requirements of MCIB Sections 10 and 11.

2208.6 Backfill: A minimum of 24 hours shall elapse before forms are removed and 5 days shall elapse or the concrete must have attained 75% of its 28 day compressive strength before pavement is backfilled unless otherwise approved by the Engineer.

Backfill shall be accomplished in accordance with Sections 2100 and 2201 entitled "Grading and Site Preparation" and "Subgrade Preparation."

The Contractor shall be responsible for the repair of any existing street pavement damaged by the construction to the satisfaction of the Engineer.

2208.7 Joint Sealing and Cleanup: All joints shall be sealed with an approved joint sealer meeting the requirements of Section 2208.2 applied in accordance with the manufacturer's directions within 7 days of the placement of the concrete and prior to the opening of the pavement to traffic.

The Contractor shall be responsible for the removal of excess dirt, rock, broken concrete, concrete splatters and overspray from the area of the construction.

2208.8 Integral Curb: Integral curbs shall be required along the edges of all street pavement as indicated on the plans, or standards, except at such locations as the Engineer may direct.

The integral curb shall be constructed during or immediately following the finishing operation unless otherwise shown on the plans. Special care shall be taken so that the curb construction does not lag behind the pavement construction and form a "Cold joint."

Steel curb forms or integral slipforming shall be required to form the backs of all curbs except where impractical because of small radii street returns or other special sections.

Curbs shall be formed to the cross section as shown on the drawings with a mule; or templates supported on the side forms and with a float not less than four feet (1.22 m) in length.

The finished surface of the curb and gutter shall be checked for no more than $\frac{1}{4}$ inch (6 mm) deviation by the use of a 10 foot (3.05 m) straightedge and corrected if necessary. Where grades are flat and while the concrete is still plastic, the drainage of the gutter should be checked with a 4 ft. (1.2 m) carpenter's level.

2208.9 Pavement Smoothness and Surface Defects:

Concrete pavement smoothness shall be in conformance with section 2211-Pavement Smoothness.

2208.10 Repairing Defects: Repair defects in conformance with the following. Do not begin corrective work until after submitting a plan and receiving the Engineer's approval for repair methods.

Defect Type	Defect Direction	Defect Location	Description	Repair Procedure	Alternate Procedure
Plastic Shrinkage Crack	Any	Anywhere	Only partially Penetrates depth	Do nothing	Fill with HMWM2
Uncontrolled Crack	Transverse	Mid-slab	Full-depth	Saw and seal Crack	LTR ³
Uncontrolled Crack	Transverse	Crosses or ends at transverse joint	Full-depth	Saw and seal the crack; Epoxy uncracked joint	
Uncontrolled Crack	Transverse	Relatively parallel and within 1.5 m of joint	Full-depth	Saw and seal the crack; Seal joint	FDR4 to replace crack and joint
Saw cut or Uncontrolled Crack	Transverse	Anywhere	Spalled	Repair spall by PDRS if crack not Removed	
Uncontrolled Crack	Longitudinal	Relatively parallel & within 1 ft. (0.3 m) of joint; May cross or end at longitudinal joint	Full-depth	Saw and seal the crack; Epoxy uncracked joint	Cross-stitch' Crack
Uncontrolled Crack	Longitudinal	Relatively parallel & in wheel path 1-4.5 ft (0.3 -1.35 m from joint)	Full-depth, Hairline or Spalled	Remove and replace slab	Cross-stitch' Crack
Uncontrolled Crack	Longitudinal	Relatively parallel and further than 4.5 ft. (1.35 m) from a long. joint or edge	Full-depth	Cross-stitch' crack; Seal longitudinal joint	
Saw cut or Uncontrolled Crack	Longitudinal	Anywhere	Spalled	Repair spall by PDRS if crack not Removed	
Uncontrolled Crack	Diagonal	Anywhere	Full-depth	FDR4	
Uncontrolled Crack	Multiple per Slab	Anywhere	Two cracks Dividing slab into 3 or more pieces	Remove and replace slab	

1 m=3.28 ft

HMWM = High molecular weight methacrylate poured over surface and sprinkled with sand for skid resistance.

LTR = load-transfer restoration; 3 dowel bars per wheel path grouted into slots sawed across the crack; Slots must be parallel to each other and the longitudinal joint.

FDR = full-depth repair; 10 ft (3 m) long by one lane wide. Extend to nearest transverse contraction joint if 10 ft (3-m) repair would leave a segment of pavement less than 10 ft (3 m) long.

PDR = partial-depth repair; Saw around spall leaving 2 in. (50 mm) between spall and 2 in. (50-mm) deep perimeter saw. Chip concrete free, then clean and apply bonding agent to patch area. Place a separating medium along any abutting joint or crack. Fill area with patching mixture.

Cross-stitching; for longitudinal cracks only, drill ¾" (18 mm) holes at 35° angle, alternating from each side of joint on 30-36 in. (750-1000 mm) spacing. Epoxy #5 epoxy coated deformed steel tiebars into hole.

2208.11 Methods of Measurement: Portland Cement Concrete Pavement will be measured per square yard (square meter) or tenth part thereof for the specified depth. If pavement smoothness is included in the Proposal, pay adjustments will apply to the traffic lane design driving width only.

2208.12 Basis of Payment: Portland Cement Concrete Pavement will be paid for by one of the following:

- A. Contract unit bid price.
- B. Contract lump sum bid price.

SECTION 2209 CURBING

Referenced Standards: The following standards are referenced directly in this section. The latest version of these standards shall be used.

MCIB
Standard Concrete Specifications

2209.1 Summary: This includes the construction or reconstruction of curbing.

2209.2 Materials: All Materials shall conform to Section 2208.2.

2209.3 Construction Details: The curbing shall be constructed or reconstructed to the configuration and to the lines and grades shown on the plans. Generally the curbing shall be placed prior to the placement of pavement or sidewalk sections, except when curb and gutter is integral with the pavement.

- A. **Removal of Existing Curbing for Reconstruction:** Existing curbing shall be totally removed to the nearest contraction or expansion joint or with the approval of the Engineer it may be sawed provided no free section is left that is less than 5 lineal feet (1.52 m) in length, and provided the entire curbing section is sawed a minimum of 2 inches (5.08 cm) below any exposed surface, or sufficiently to prevent disturbance or damage to all adjacent structures or slabs, whichever is greater.
- B. **Grading and Subgrade Preparation:** All excavation or embankment shall conform to Sections 2100 and 2201 entitled "Grading and Site Preparation" and "Subgrade Preparation" and as follows:

Compaction shall conform to Section 2201.3, paragraph B.

The top 6 inches (15 cm) of the subgrade shall be compacted to obtain a density of 95% of the maximum standard proctor density within -2 to +3% of the optimum moisture content.

If during reconstruction operations, additional fill material is needed beneath the curb, it shall be crushed limestone conforming to Section 2202.

- C. **Forms:** All forms shall be in good condition, clean, and free from imperfections. Each form shall not vary more than $\frac{1}{4}$ inch (6 mm) in horizontal and vertical alignment for each 10 feet (3.0 m) in length.

1. **General:** Face forms will be used with all curb standards except CG-2 (roll-back) as applicable.
 2. Forms shall have a height equal to or greater than the height of the curb face being formed.
 3. The forms shall be set true to line and grade and shall be supported to stay in position while depositing and consolidating the concrete. The forms shall be designed to permit their removal without damage to the concrete. The forms shall be lubricated.
- D. **Curb Machine:** A slip-form curb machine may be used in lieu of forms. The machine must be equipped with mechanical internal vibrators and be capable of placing curb to the correct cross section, line and grade within the allowable tolerances.

2209.4 Joints: The joints shall be formed at right angles to the alignment of the curbing and to the depths specified by the appropriate standard drawing or as shown on the plans.

- A. **Isolation joints:** Isolation joints shall be placed at all radius points, driveways, curb inlets, or where directed by the plans or Engineer.
1. **Material:** Isolation joints shall be formed by a one piece, 3/4 inch (19 mm) thick preformed joint filler cut to the configuration of the correct curb section, and conforming to Section 2208.2D..
 2. **Stability:** Isolation joints shall be secured in a manner so they will not be disturbed by depositing and consolidating of concrete.
 3. **Edging:** The edges of the joints shall be rounded with an edging tool of 1/4 inch (6 mm) radius.
- B. **Contraction joints:** Curbing shall have contraction joints formed at intervals of not less than 10 feet (3.05 m) or more than 15 feet (4.57 m). They shall extend through the entire curb section from the top of the curb to a depth 2 inches (5.0 cm) below pavement surface.
1. **Method:** Contraction joints shall be formed or sawed.
 - a. When sawing joints, the contractor shall begin as soon as the concrete hardens sufficiently to prevent excessive raveling along the saw cut and

shall finish before conditions induce uncontrolled cracks, regardless of the time or weather. When joint sealing backup material is specified with sawed joints, the first stage, which provides a relief cut shall be approximately 1/8 inch (3 mm) wide, and shall be to plan depth. The second stage which widens the joints to allow the insertion of joint sealing backup material to plan depth shall not be performed until the concrete is at least 48 hours old, and shall be delayed longer when the sawing causes raveling of the concrete. If second stage sawing is performed prior to the completion of the curing period, the contractor shall maintain the cure by use of curing tapes, plastic devices, or other materials approved by the engineer.

b. Saw joints shall be a minimum of 2 inches deep (5 cm).

2. **Joint Sealer:** When specified, joint sealants shall conform to Section 2208.2.

2209.5 Concrete Work: Concrete for curbing shall be placed in accordance with the requirements of Section 2208.5. Isolation and contraction joints shall be constructed as shown on the plans, standard drawings, or where directed by the Engineer.

- A. **Concrete Placement:** Concrete shall be mechanically vibrated and may extrude no more than 2 inches (50 mm) on the back side when using a curb machine.
- B. **Finishing:** After placing and initial strike-off the curb shall be tooled to the required radii. If the surface of the concrete is sufficiently wet that a ridge is formed at the inside of the radius tool, finishing will cease until the excessive moisture has evaporated.

After initial set, the face forms shall be removed and the surface finished to the required dimensions. No water, dryer, or additional mortar shall be applied to the free surface of the concrete.

The finished surface of the concrete shall be broomed perpendicular to the curb with a clean broom to provide an antiskid surface.

In all cases the finished curb shall have a true surface, free from sags, twists, or warps, and shall have a uniform color and appearance.

- C. **Curing:** As soon as practical after the concrete is finished it shall be cured with a liquid curing membrane meeting the requirements of Section 2208.2, applied according to the manufacturer's directions.

If front and/or back forms are removed from finished curbing within a period of 72 hours of placement these surfaces shall also be cured.

Wet burlap, cotton mat, waterproof paper, polyethylene sheeting or earth backfill is not an acceptable curing method for curbing.

- D. **Protection:** The Contractor shall protect the concrete work against damage or defacement of any kind until it has been accepted by the Engineer. Concrete which is damaged or defaced, shall be removed and replaced, or repaired to the satisfaction of the Engineer, at the expense of the Contractor.
- E. **Temperature Limitations:** Concrete work shall be placed in accordance with requirements of MCIB Sections 10 and 11.

2209.6 Backfill: Backfill shall conform to Section 2208.6.

The Contractor shall be responsible for the repair of any street pavement disturbed by the construction to the satisfaction of the Engineer.

2209.7 Joint Sealing and Clean-Up: Joint sealer shall be applied in accordance with the manufacturer's directions within 7 days of the placement of the concrete.

The Contractor shall be responsible for the removal of excess dirt, rock, broken concrete, concrete splatters and overspray from the area of the construction.

2209.8 Surface Tolerances: Curbing shall have a surface tolerance of 1/4 inch (6 mm) in 10 feet (3 m) when checked with a ten foot (3.05 m) straightedge.

2209.9 Method of Measurement: Curbing will be measured per lineal foot (meter) or tenth part thereof for the applicable type.

2209.10 Basis of Payment: Curbing will be paid for by one of the following:

- A. Contract unit bid price.
- B. Contract lump sum bid price.

SECTION 2210 MEASUREMENTS AND PAYMENTS

2210.1 Summary: This section includes the method of measurement and the basis of payment, for furnishing all labor, equipment, tools and materials and for the performance of all related work necessary to complete any construction covered in Section 2200.

2210.2 General: Unless specifically altered by the Contract Special Provisions, the methods of measurement and payment shall be as specified in each section herein, and as listed in the Proposal.

2210.3 Measurement: The Engineer or his representative will measure the work for payment. The method of measurement and computations used in determination of quantities of work performed will be those methods generally recognized as conforming to good engineering practice.

2210.4 Items not listed in the Proposal: There shall be no measurement or separate payment for any item of work not specifically identified and listed in the Proposal and all costs pertaining thereto shall be included in the contract unit prices for other items which are listed in the Proposal.

2210.5 Measurement and Payment Summary Table

Item Description	Ref. Section	Method of Measurement	Basis of Payment
1. Subgrade Preparation	2201	Subsidiary to other item	Subsidiary to other item
2. Untreated Compacted Aggregate Base	2202	0.1 sq. yd. (0.1 sq. m.)* 0.1 ton (0.1 metric ton)	Unit Bid Price Lump Sum Bid Price
3. Crushed Aggregate Drainable Base	2203.3	0.1 sq. yd. (0.1 sq. m.)* 0.1 ton (0.1 metric ton)	Unit Bid Price Lump Sum Bid Price
4. Portland Cement Concrete Drainable Base**	2203.4	0.1 sq. yd. (0.1 sq. m.)* 0.1 ton (0.1 metric ton)	Unit Bid Price Lump Sum Bid Price
5. Plant Mix Bituminous Drainable Base**	2203.5	0.1 sq. yd. (0.1 sq. m.)* 0.1 ton (0.1 metric ton)	Unit Bid Price Lump Sum Bid Price
6. PipeUnderdrains***	2203.6	1.0 lineal ft. (0.1 m.)	Unit Bid Price Lump Sum Bid Price
7. Blanket Underdrains****	2203.6	1.0 lineal ft. (0.1 m.) 0.1 sq. yd. (0.1 sq. m)	Unit Bid Price Lump Sum Bid Price
8. Asphalt Prime and Tack Coat	2204	gallon (liter)	Unit Bid Price
9. Asphaltic Concrete Base and Surface**	2205	0.1 sq. yd. (0.1 sq. m.)* 0.1 ton (0.1 metric ton)	Unit Bid Price Lump Sum Bid Price
10. Asphaltic Crack Seal	2206.2	pound (kilogram)	Unit Bid Price Lump Sum Bid Price
11. Improved Street Chip Seal**	2206.3	0.1 sq. yd. (0.1 sq. m.)	Unit Bid Price Lump Sum Bid Price
12. Unimproved Street Chip Seal**	2206.4	0.1 sq. yd. (0.1 sq. m.)	Unit Bid Price Lump Sum Bid Price
13. Improved Street Slurry Seal	2206.5	0.1 sq. yd. (0.1 sq. m.)	Unit Bid Price Lump Sum Bid Price
14. Improved Street Microsurfacing	2206.6	0.1 sq. yd. (0.1 sq. m.)	Unit Bid Price Lump Sum Bid Price
15. Cold Milling	2207	0.1 sq. yd. (0.1 sq. m.)*	Unit Bid Price Lump Sum Bid Price
16. Portland Cement Concrete Pavement	2208	0.1 sq. yd. (0.1 sq. m.)*	Unit Bid Price Lump Sum Bid Price
17. Curbing (Specify the applicable type)	2209	0.1 ft. (0.1 m.)	Unit Bid Price Lump Sum Bid Price

*Items measured per sq. yd. (sq. m.) shall be listed with the specified depth of material indicated.

**Items may be measured as a single item or as the separate items that comprise the materials.

***Drainable Base Aggregates used with PipeUnderdrains shall be a subsidiary item .

****Blanket Underdrains shall be measured for the actual quantities used, to include Pipe Underdrains and Drainable Base Aggregate.

SECTION 2211 – SMOOTHNESS

2211.1 Summary: This section includes methods of determining smoothness, and includes a pay adjustment table where smoothness is required in the contract as a pay item adjustment.

2211.2 Local Streets & Residential Collectors:

Finished pavements on local and minor collectors shall be checked with a 10 foot (3 meter) straightedge placed parallel to the center line at any location within a driving lane. Areas showing high spots of more than 1/4 of an inch in 10 feet (6.35 mm in 3 m), shall be marked and ground down with an approved grinding tool to an elevation where the area or spot will not show surface deviations in excess of 1/8 inch (3.2 mm) when tested with a 10 foot (3 m) straight edge. The surface corrections will be done in a manner that produces a surface texture as similar as possible to the adjacent sections. Grinding will be performed on the full width of the lane failing to meet the smoothness criteria. The cost of correcting the smoothness and associated traffic control shall be at contractor's expense.

2211.3 Arterials and Urban Collectors:

If specified, pavement smoothness on arterial and major collectors will be measured at Contractor's expense by a 25-foot (7.6-meter) California profilograph using a .2 inch (5 mm) blanking band, and will follow Table 1. If profilographs are not specified, Section 2211.2 shall apply. Run one trace three feet (one meter) from the longitudinal joint between the lanes, and another trace three feet (one meter) from the shoulder or curb edge of the lane. Assure that the profilograph testing and evaluation is performed by a trained and certified operator. Within two days after the paving, furnish the Engineer with the profilogram and its evaluation.

All pavements will be corrected at Contractor's expense to 15 inches per mile (23.7 cm per km). Pay adjustments will be based on initial average profilograph measurements. Areas excluded from profilograph testing will not be subject to pay adjustments. Pavements with horizontal curves less than 300 ft. (91.4 m) and or vertical curves or transition areas with K values less than 30 will be excluded from the profilograph specification.

Table 1 Pay Adjustment

Final Profile Index		Percent of Contract Unit Price
(inches/mile) (cm/kilometer)		
0-10	(0-15.8)	105.0
10.1-15	(15.9-23.7)	100.0
15.1-20	(23.8-31.6)	90.0
20.1-25	(31.7-39.5)	80.0

Division II
Section 2300
Incidental Construction