
Concrete Pavement Mixture Design and Analysis (MDA)

National Concrete Pavement
Technology Center



Guide Specification for Highway Concrete Pavements October 2012

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CONCRETE PAVEMENT MIXTURE DESIGN AND ANALYSIS (MDA): GUIDE SPECIFICATION FOR HIGHWAY CONCRETE PAVEMENTS

**Guide Specification
October 2012**

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TABLE OF CONTENTS

ACKNOWLEDGMENTS	ix
1.0 DESCRIPTION.....	1
1.1 General.....	1
1.2 End Product.....	1
1.3 End Product Responsibility.....	1
1.4 Pre-Paving Conference	2
2.0 SUBMITTALS	3
2.1 Pre-Construction Submittals	3
2.2 Contractor Quality Control Testing Submittals	4
2.3 Contractor Acceptance Testing Submittals.....	4
3.0 MATERIALS.....	5
3.1 Cementitious Materials	5
3.2 Aggregates	6
3.3 Water.....	10
3.4 Chemical Admixtures	10
3.5 Forms	11
3.6 Expansion Board.....	11
3.7 Embedded Steel	11
3.8 Tie Bars.....	11
3.9 Dowel Bars.....	12
3.10 Evaporation Retardants.....	12
3.11 Curing Materials	13
4.0 CONCRETE MIXTURE	14
4.1 Concrete Mixture Requirements	14
4.2 Concrete Mixture Proportions.....	15
5.0 EQUIPMENT	16
5.1 Concrete Batching Plant	16
5.2 Concrete Hauling Equipment.....	17
5.3 Transfer and Spreading Equipment	17
5.4 Paving Equipment.....	17
5.5 Texturing Equipment	18
5.6 Curing Machines.....	18
5.7 Concrete Saws.....	19
5.8 Drills	19
6.0 WEATHER MANAGEMENT	20
6.1 Hot Weather Paving.....	20
6.2 Cold Weather Paving	21
6.3 Protecting Concrete from Rain Damage.....	22

7.0	EXECUTION.....	23
7.1	Underlying Material Preparation	23
7.2	[Not Used] [Paving on Stabilized Bases].....	23
7.3	Test Section.....	23
7.4	Production Paving Adjustments to the Concrete Mixture Proportions.....	24
7.5	Tie Bar Placement.....	25
7.6	Doweled Contraction Joints.....	26
7.7	Doweled Expansion Joints.....	28
7.8	Concrete Production.....	28
7.9	Hauling.....	28
7.10	Paving	28
7.11	Texturing.....	30
7.12	Curing	31
7.13	Form Removal	32
7.14	Sawcutting.....	32
7.15	Sealing Joints	33
7.16	Opening to Construction Traffic.....	33
8.0	QUALITY ASSURANCE.....	35
8.1	Testing Personnel.....	35
8.2	Testing Laboratory Requirements.....	35
8.3	Quality Control Testing	36
8.4	Control Charts.....	39
9.0	ACCEPTANCE TESTING.....	40
9.1	Control Charts.....	40
9.2	Lot Size	40
9.3	Department Performed Acceptance Tests.....	40
9.4	Contractor Performed Acceptance Tests	41
10.0	DEFICIENT AND DEFECTIVE PAVEMENT.....	45
10.1	Deficient Pavement.....	45
10.2	Defective Pavement	46
11.0	MEASUREMENT	47
12.0	PAYMENT	48
12.1	Pay Adjustment.....	48
12.2	Composite Pay Factor.....	51
12.3	Pay Items.....	51

LIST OF FIGURES

Figure 1. Aggregate constructability chart.....	7
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LIST OF TABLES

Table 1. Recommended total air content for air-entrained concrete.....	15
Table 2. Minimum quality control testing requirements	36
Table 3. Lower specification tolerance limit for concrete strength and thickness.....	42
Table 4. Pay adjustment factor for thickness (by lot)	48
Table 5. Pay adjustment factor for strength (by lot)	49
Table 6. Pay adjustment factors and computation of final pay factor	50
Table 7. Disincentives for localized roughness	51

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1.0 DESCRIPTION

1.1 General

This work shall consist of pavement composed of hydraulic cement concrete, constructed on a prepared underlying surface, in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the plans.

This guide specification is not applicable to construction of pervious concrete pavement, two-lift concrete pavement, and roller compacted concrete.

1.2 End Product

The end product for the work is the concrete pavement constructed using materials, equipment, and processes detailed in this specification. The end product shall be accepted or shall be considered deficient or defective on the basis of the following acceptance testing:

1. Cracking. See Section 9.3.1 – Cracking
2. Joint Spalls. See Section 9.3.2 - Joint Spalls
3. Slab thickness. See Section 9.4.2 – Thickness
4. Strength. See Section 9.4.3 – Strength
5. Surface smoothness. See Section 9.4.4 – Smoothness Testing

Deficient pavement areas shall be mitigated as per Section 10.1 - Deficient Pavement. Defective pavement areas shall be mitigated as per Section 10.2 - Defective Pavement.

1.3 End Product Responsibility

The Contractor is entirely responsible for the materials and processes that produce the end products detailed in this specification. It is the Contractor's responsibility to prove by means of a test section, constructed at the start of construction, that the process for constructing the concrete pavement is valid.

The Engineer will determine if the Contractor's materials and processes produce an end product that is in conformity with the plans and specifications. Tolerances to determine conformity for measurable components of the materials, processes, and end product are provided.

When the Engineer determines that the materials furnished, work performed, or the finished product are not in conformity with the plans and specifications and result in an unacceptable product, the affected work or materials shall be removed and replaced or otherwise corrected at the Contractor's expense in accordance with Section 10.0 – Deficient and Defective Pavement.

1.4 Pre-Paving Conference

At least 7 days before and not more than 30 days before concrete placement, the Contractor and his team members shall attend a pre-paving conference with the Engineer and Department of Transportation (DOT) personnel to review project specific requirements related to the concrete paving and related project-planning activities. The following are the minimum agenda items:

1. Submittals and status of submittals
2. Critical material supply/availability issues
3. Concrete plant and aggregate stockpile management
4. Concrete paving requirements
5. Paving schedule
6. Weather management plan
7. Haul routes and traffic maintenance
8. Test section requirements
9. Contractor process testing
10. Contractor acceptance testing requirements
11. Engineer monitoring of acceptance testing
12. Who on Contractor's staff has stop work authority
13. Who on Owner's staff has stop work authority
14. Issues and disputes resolution hierarchy

2.0 SUBMITTALS

The Contractor shall provide the submittals listed in the following sections. The personnel and laboratories conducting the aggregate and concrete related testing for the project shall meet the requirements of Section 8.1 – Testing Personnel, and Section 8.2 – Testing Laboratory Requirements, respectively.

2.1 Pre-Construction Submittals

Pre-construction submittals shall be submitted to the Engineer before the pre-paving meeting. Submittals include, but are not limited to, the following:

1. Qualifications of the concrete plant inspector, when applicable.
2. Certified concrete plant checklist as per the requirements of the department or the National Ready Mix Concrete Association (NRMCA) QC3 (Plant Certification Check List) process.
3. Contractor's concrete testing laboratory certification.
4. Contractor testing personnel certification.
5. Cement mill certificates.
6. Supplementary cementing material mill certificates.
7. Aggregate certification (source and approved source certification).
8. Admixture certification.
9. Water certification.
10. Dowel bar steel certification.
11. Tie bar steel certification.
12. Dowel bar corrosion mitigation coating certification.
13. Curing material certification.
14. For each concrete mixture to be used:
 - a. Combined aggregate gradation.
 - b. Concrete mixture proportions.
 - c. Concrete flexural strength
 - d. Concrete compressive strength
 - e. Concrete splitting tensile strength, if applicable
 - f. Air content, when applicable.
 - g. Unit weight
 - h. Slump
15. Concrete uniformity test results for each concrete plant to be used.
16. Reactive aggregate mitigation plan, when applicable.
17. Weather management plan.
18. Contractor quality control/acceptance testing program.
19. Paving plan
20. List of paving equipment and manufacturers' operational requirements for the paving equipment.

For aggregates and concrete mixtures to be used on the project, the pre-construction certifications (except the aggregate mitigation plan) shall be developed using materials sampled not more than 180 days before the start of concrete placement.

For cement and supplementary cementing materials, mill certification for each truckload of the material shall be submitted to the Department within 24 hours of material delivery.

2.2 Contractor Quality Control Testing Submittals

Submittals related to process control testing include the results of the Contractor's process control testing, as per Section 8.0 – Quality Control. The Department shall be notified of the results in writing within 72 hours of completion of a day's paving. These submittals include the following process control tests:

1. Accuracy of plant batching
2. Aggregate moisture content
3. Combined aggregate gradation – Workability and Coarseness Factors
4. For site delivered concrete
 - a. Air content, when applicable
 - b. Concrete temperature
 - c. Unit weight of fresh concrete

2.3 Contractor Acceptance Testing Submittals

Submittals related to Contractor acceptance testing include the results of the Contractor performed acceptance testing for pavement thickness, concrete strength, and pavement smoothness, as per Section 9.4 – Contractor Performed Acceptance Tests. The Department shall be notified of the results in writing within 72 hours of completion of testing for a lot.

3.0 MATERIALS

The materials to be used in the construction of the concrete pavement shall meet the requirements of this paragraph. New submittals are required when the material source or type changes.

3.1 Cementitious Materials

Cementitious materials shall include hydraulic cement and supplementary cementitious materials.

3.1.1 Hydraulic Cement

Hydraulic cement shall conform to the requirements of [ASTM C 150][AASHTO M 85], Type I or II [] or [ASTM C595][AASHTO M 240], Type [] or ASTM C 1157, Type [].

ASTM C 150 and AASHTO M85 cover portland cements Type I, II, III, and V. Type I and II are the most common. Type III is a high-early-strength cement and its use shall be limited to fast-track paving applications. Type V is used in concrete exposed to severe sulfate action.

ASTM C 595 and AASHTO M 240 cover blended hydraulic cements as follows:

- **Type IS(X) - Portland blast-furnace slag cement.**
- **Type IP(X) - Portland-pozzolan cement**
- **Type IL(X) – Portland limestone cement**
- **Type IT(AX)(BY) – Ternary blended cement**

The X and Y in parenthesis denote the targeted percent of pozzolan, slag or limestone in the blended cement. A and B denote the materials used in a ternary cement.

ASTM C 1157 is a performance-based classification for hydraulic cement. These cements are defined by their performance attributes and must meet physical performance test requirements, as opposed to prescriptive restrictions on ingredients or cement chemistry as found in other cement specifications.

3.1.2 Supplementary Cementitious Materials

Supplementary cementitious materials (SCMs) may be used as part of the total cementitious content.

3.1.2.1 Fly Ash

Fly ash shall meet the requirements of [ASTM C 618][AASHTO M 295] for Class C or F. **[The supplementary optional physical requirements, except the ones pertaining to alkali-silica reactivity, contained in ASTM C 618 shall apply.] [The supplementary optional physical requirements, except the ones pertaining to alkali-silica reactivity and sulfate resistance, contained in ASTM C 618 shall apply.]**

Delete the first option if sulfate resistant concrete is not required. Delete the second option if sulfate resistant concrete is required.

3.1.2.2 Ground Granulated Blast Furnace Slag (GGBFS)

Ground granulated blast furnace slag shall meet the requirements of [ASTM C 989][AASHTO M 302], Grade 100 or Grade 120.

3.1.2.3 Other SCMs

Other SCMs, when used, shall meet the requirements of applicable ASTM or AASHTO standards.

3.2 Aggregates

Sources of aggregates shall be selected by the Contractor. There is no limit to the number of aggregate sizes that may be used or blended. **[Maximum aggregate size shall be selected by the Contractor.] [Maximum aggregate size shall be [] inch.]**

In regions with D-Cracking, the Engineer may specify a 3/4-inch maximum aggregate size. However, specifying a maximum aggregate size of 3/4 inch may reduce, but not eliminate, D-cracking distress development. The maximum aggregate size for D-cracking also needs to be coordinated with Item 8, Section 3.2.2 – Aggregate Quality, as State DOTs may specify the maximum aggregate size separately for D-cracking, e.g. by ledge. The Engineer needs to evaluate this requirement based upon experience in the region.

3.2.1 Gradation Evaluation of the Proposed Aggregates

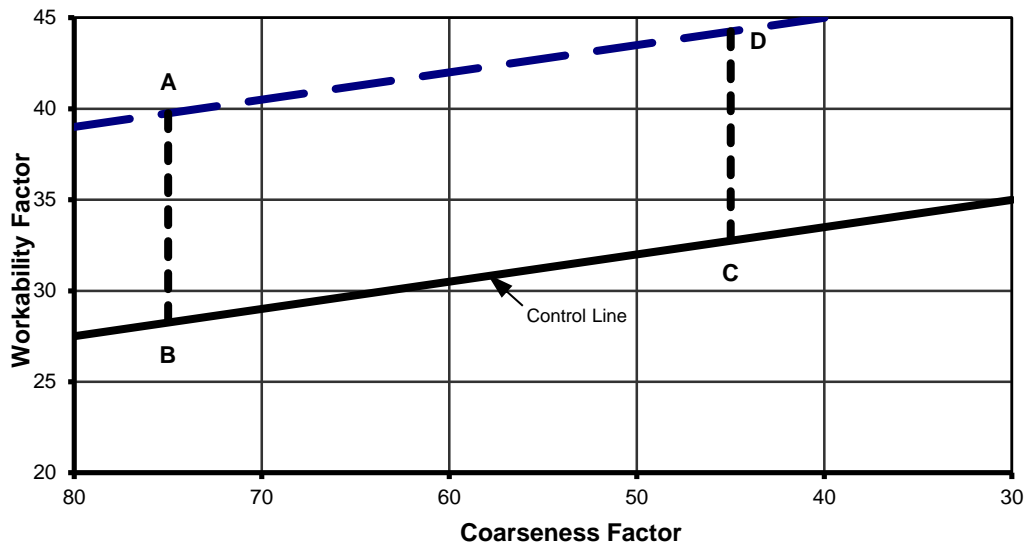
The Contractor shall combine the aggregates in the proportions proposed for the concrete mixture and evaluate on the following sieve sizes: 2½-inch, 2-inch, 1½-inch, 1-inch, ¾-inch., ½-inch, ⅜-inch, No. 4, No. 16, No. 30, No. 50, and No. 100.

The Contractor shall determine the Workability Factor (WF) and the Coarseness Factor (CF). The WF is the percentage of the combined aggregate by weight finer than the No. 8 sieve. The CF is the percent of material by weight retained on the ⅜-inch sieve divided by the percent by weight of all the aggregate retained on the No. 8 sieve and multiplying the ratio by 100.

The aggregates, as proportioned, shall be deemed to have met the requirements of a combined aggregate gradation when the following criterion is met:

- The WF and CF shall be within the parallelogram ABCD of the Aggregate Constructability Chart (Figure 1).

The combined aggregates, as proportioned, shall be rejected if the combined aggregate gradation criterion is not met.



Point A – CF = 75; WF = 40; Point B – CF = 75; WF = 28
Point C – CF = 45; WF = 32; Point D – CF = 45; WF = 44

Figure 1. Aggregate constructability chart

3.2.2 Aggregate Quality

The aggregates shall meet the following requirements. Aggregates may be from sources approved by the State DOT.

1. The portion of the combined aggregate passing the No. 4 sieve shall meet the requirements for deleterious substances contained in ASTM C 33, Table 1.
2. The portion of the combined aggregate retained on the No. 4 sieve shall meet the requirements for deleterious substances contained in ASTM C 33, Table 3, Class [] for pavements.

Class 4S shall be specified for severe weathering regions, 4M for moderate weathering regions and 1N for negligible weathering regions. Engineer will determine if there are historic aggregate problems in the region by observation of older pavements in surrounding areas and by review of material requirements in State DOT concrete pavement construction specifications. The stricter requirements of the State DOT or ASTM C 33 shall be used. The Engineer's review shall be documented in the Engineer's Basis of Design report.

1. The portion of combined aggregate retained on the No. 4 sieve shall not contain more than 20 percent by weight of flat or elongated pieces when tested in accordance with ASTM D 4791. A flat particle is defined as one having a ratio of width to thickness greater than 3 and an elongated particle is one having a ratio of length to width greater than 3.
2. For the portion of the combined aggregate retained on the No. 4 sieve, the percentage of wear shall be no more than [40] [] at 500 revolutions when tested in accordance with ASTM C 131 or ASTM C 535.

The Engineer may specify a maximum percentage wear of 50 in regions when local availability of harder aggregates is poor.

1. Use of steel-making slag as an aggregate is not permitted.
2. Use of Air-Cooled Blast Furnace Slag is **[not]** permitted.

Acceptability of Air-Cooled Blast Furnace Slag as an aggregate will be at the discretion of the Engineer. If use is allowed, it must be emphasized that it is very important to ensure that the moisture content of the ACBFS aggregate stockpiles at the concrete plant site is monitored regularly and appropriate adjustments are made in the batch water during concrete production.

- 3. [Not Used] [Aggregates that have a history of D-cracking shall not be used.] [Aggregates meeting _____ Department of Transportation Class _____ shall be used.] [Aggregate shall have a Durability Factor of 95 or more when subjected to freezing and thawing in accordance with ASTM C 666, Procedure A, using a concrete mixture prepared in accordance with ASTM C 1646. The test data shall not be more than one year old at the time of submittal.]

The Engineer will determine if D-cracking related requirements are necessary based on local experience. Typically, the State DOT will have already identified D-Cracking issues, and the Engineer will insert the State DOT provisions for appropriate approved aggregate sources. Note that the State DOT requirements for D-cracking may be more than limiting maximum aggregate size. Therefore, this item should be coordinated with Section 3.2 - Aggregates. Explicitly include the requirements for adjacent states if it is probable that aggregates from sources from these states may be imported for the project. Engineer is cautioned to carefully refer to the applicable State DOT specifications related to D-cracking to ensure that these requirements will not conflict with other coarse aggregate requirements in this specification. Do not make a blanket reference to DOT standards; carefully select and cite the appropriate Section and sections; and ensure non-applicable references in the DOT manual to other DOT requirements are stricken.

If the Contractor uses an out-of-state aggregate source and the state from where the aggregates are originating from does not have D-cracking related requirements that equal or exceed the requirements of the local State DOT, the Engineer will require ASTM C 666 testing, knowing that a lead time of about 4 months will be necessary to conduct the testing. The Durability Factor shall be greater than or equal to 95 (Method A).

- 4. [Recycled crushed concrete for aggregate shall comply with the requirements of AASHTO MP 16-10 Reclaimed Concrete Aggregate for Use as Coarse Aggregate in Hydraulic Cement Concrete] [Recycled crushed concrete for aggregate shall be from a known source. Recycled aggregates shall meet all of the requirements applicable to virgin aggregates, except for the requirements related to ASTM C 131 or ASTM C 535 tests.]

When used, recycled concrete aggregate needs to be from a known source. The Engineer will have petrographic testing conducted, especially for Alkali-Silica Reactivity (ASR) and Durability Cracking (D-Cracking) before identifying such concrete for recycled aggregate in the project documents, and do not use when these or other detrimental properties are present. Do not allow recycled crushed concrete from a commercial recycle yard.

3.2.3. Reactive Aggregate Screening

The Contractor shall determine if the aggregates are deleteriously reactive with alkalis in accordance with AASHTO Recommended Practice PP 65-10, "Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete. The results of testing shall be submitted to the Engineer.

Actions to accept or accommodate aggregates determined to be reactive shall be submitted in a mitigation plan as per Section 2.1.

3.3 Water

Water shall meet the requirements of ASTM C 1602. Water known to be potable may be used without testing.

3.4 Chemical Admixtures

Chemical admixtures may only be used when the specific admixture type and manufacturer is the same material used in the mixture proportions approved by the Engineer. Calcium chloride, admixtures containing calcium chloride [**and**] shall not be used.

The Engineer may insert the names or types of admixtures to be excluded, based on local experience and Airport requirements.

3.4.1 Air-Entraining Admixture

The air-entraining admixture shall meet the requirements of ASTM C 260.

3.4.2 Chemical Admixture

Retarding, water-reducing, accelerating and other admixtures shall meet the requirements of ASTM C 494/C 494M.

3.5 Forms

Forms shall have a depth equal to the pavement thickness at the edge. Forms shall be cleaned each time before concrete is placed.

3.6 Expansion Board

The expansion board for expansion and isolation joints shall conform to the requirements of [ASTM D 1751] [ASTM D 1752, Type II or III]. When dowels are used at expansion joints, holes shall be precut in the expansion board. Expansion board shall be fitted with a removable cap with the proper dimensions for the joint-seal reservoir shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth required for the joint.

3.7 Embedded Steel

Embedded steel shall [conform to the requirements of ASTM [A 185] [A 497] [A 184 or A 704] [A 615] [Grade 60] [meet the requirements as shown on the plans]. [Welded wire fabric shall be furnished in flat sheets only.]

The Engineer will designate the appropriate steel for the project:

Welded steel wire fabric	ASTM A 185
Welded deformed steel fabric	ASTM A 497
Bar mats	ASTM A 184 or A 704
Deformed bars	ASTM A 615

Grade 60 steel is the most commonly used. Welded wire fabric shall be furnished in flat sheets only.

3.8 Tie Bars

Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615, Grade 60 or Grade 40. Grade 60 tie bars shall not be bent or re-straightened during construction. Tie bars designated as Grade 40 in ASTM A 615 shall be used for construction requiring bent bars.

Before delivery to the construction site, tie bars shall be coated on all surfaces lengthwise with epoxy coating conforming to the requirements of ASTM A 775/A 775M, with a minimum thickness of 8 mils.

3.9 Dowel Bars

Dowel bars shall be smooth steel bars conforming to ASTM A 615, Grade 60 and shall be free of loose material, be clean, and straight. Dowel bar deviation from true shape shall not exceed 0.04 inch on the diameter of the dowel and shall not extend more than 0.04 inch from the end of the dowel.

3.9.1 Dowel Bar Corrosion Protection Coating

Before delivery to the construction site, steel dowel bars shall be coated on all surfaces lengthwise with epoxy coating conforming to the requirements of ASTM A 775/A 775M, with a minimum thickness of 8 mils.

3.9.2 Dowel Bar Bond Breaker

A wax based bond breaker meeting the requirements of AASHTO M-254 shall be used over the dowel bar coating.

3.9.3 Expansion Sleeves

The sleeves for dowel bars used in expansion joints shall be made of non-corrosive material and designed to cover 2 to 3 inches of the dowel ends. It shall have a closed end and a suitable stop to hold the end of the dowel bar at least 1 inch from the closed end of the sleeve. Sleeves shall be of such design that they shall not collapse during construction.

3.9.4 Dowel Basket Assemblies

Dowel basket assemblies shall provide rigid support to prevent dowels from becoming misaligned during paving operations.

Dowel baskets shall be designed and assembled in accordance with "Guide to Dowel Load Transfer Systems for Jointed Concrete Roadway Pavements," published by the National Concrete Consortium.

3.10 Evaporation Retardants

Monomolecular evaporation retardants shall be used in accordance with manufacturers' instructions.

3.11 Curing Materials

Curing materials shall have water-retention properties in accordance with [ASTM C 309] [the requirements established by [the _____ Department of Transportation] []].

4.0 CONCRETE MIXTURE

4.1 Concrete Mixture Requirements

The concrete mixture shall meet the following requirements:

1. Concrete shall be designed to achieve a 28-day [flexural strength of [600] [] psi]
[compressive strength of [4000] [] psi]
2. The minimum cementitious-material content shall be [470] [517] pounds per cubic yard.

Use 470 pounds in mild and moderate regions, 517 pounds in severe weathering regions.

3. The minimum water-to-cementitious-materials ratio shall be 0.38. The maximum water-to-cementitious-materials ratio shall be [0.42] [0.45] [0.50].

A maximum water-cementitious-materials ratio of 0.42 is adequate for severe weathering regions. In moderate and mild/negligible weathering regions, a maximum ratio of 0.50 is adequate. The weathering regions are defined in ASTM C 33. Local experience shall also be applied to establish the weathering category for a region.

4. The supplementary cementing material use shall be as follows:
 - a. When used with ASTM C 150 cements:
 - i. Fly ash – not to exceed 25% of total cementitious material
 - ii. GGBFS – not to exceed 50% of total cementitious material
 - iii. If both fly ash and GGBFS are used, the total supplementary cementing material shall not exceed 50% of total cementitious material
 - b. Total supplementary cementitious content shall not exceed 50% for mixtures using ASTM C 595 or ASTM C 1157 cements.
 - c. In case of reactive aggregates, the use of the supplementary cementing material shall be governed by the Contractor’s reactive aggregate mitigation plan, as per Section 2.1.
5. [The target percentage of air in the mixture shall be based upon the [severe] [moderate] [mild] exposure condition and maximum aggregate size in accordance with ASTM C 94/C 94M. Air content shall be determined by testing in accordance with ASTM C 231 or ASTM C 173/C 173M, as appropriate.]

Table 1. Recommended total air content for air-entrained concrete

TABLE 1 Recommended Total Air Content for Air-Entrained Concrete^{A,B}

Exposure Condition ^C	Total Air Content, %						
	Nominal Maximum Sizes of Aggregate, in. [mm]						
	¾ [9.5]	½ [12.5]	¼ [19.0]	1 [25.0]	1½ [37.5]	2 [50.0]	3 [75.0]
Mild	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Moderate	6.0	5.5	5.0	4.5	4.5	4.0	3.5
Severe	7.5	7.0	6.0	6.0	5.5	5.0	4.5

^A For air-entrained concrete, when specified.
^B Unless exposure conditions dictate otherwise, it is permissible to reduce air contents recommended above by up to 1 % for concretes with specified compressive strength, f_c , of 5000 psi [35 MPa] or above.
^C For description of exposure conditions, refer to Standard Practice ACI 211.1, Section 6.3.3, with attention to accompanying footnotes.

The Engineer will determine the exposure condition. The Contractor shall select the air content appropriately based on the maximum aggregate size in accordance with ASTM C 94/C 94M. The specific test method to be used to determine the air content shall be based on aggregate type.

4.2 Concrete Mixture Proportions

The Contractor shall submit the concrete mixture proportions and the combined aggregate gradations for each concrete mixture proposed for use in the work. The concrete mixture submittal shall include the maximum aggregate size and the target air content. The concrete mixtures shall be optimized to facilitate concrete placement, consolidation, and finishing.

The water-to-cementitious materials ratio of each approved concrete mixture is designated as the approved maximum water-to-cementitious materials ratio for that mixture.

Changes in the source of any of the concrete ingredients, requires submission of a new concrete mixture proportion that shall meet the specified concrete mixture requirements.

The Engineer will review the concrete mixture submittal for conformance with the specification before the concrete is delivered to the project site.

5.0 EQUIPMENT

The Contractor shall furnish all equipment and tools necessary for handling materials and performing all parts of the concrete pavement construction. At least one backup saw shall be on-site available for use if a breakdown occurs during initial sawcutting operations. An inventory of at least two saw blades shall be on-site during initial sawcutting operations.

Concrete placement shall be suspended when any equipment is leaking oil in a manner which allows the oil to contaminate the fresh concrete mixture; placement may resume after appropriate repairs are made.

5.1 Concrete Batching Plant

The concrete batching plant shall be designed and operated to produce concrete within the specified tolerances and shall conform to the requirements of the NRMCA QC3 document [**or State of _____ Department of Transportation**]. In addition, the concrete uniformity requirements given in Section 5.1.3 - Concrete Uniformity Tests, shall be met at the start of concrete placement, once every six months after the start of concrete placement, and each time the plant is mobilized for the project.

5.1.1 Plant Certification

The Contractor shall complete NRMCA QC3 checklist [or the DOT checklist/requirements] for each concrete plant to be used for the work. Each plant shall pass in all categories. Trucks for transit-mixed concrete, when used, shall also pass the NRMCA QC3 checklist [or the DOT checklist/requirements].

The NRMCA QC3 checklist [or the DOT checklist/requirements] shall be performed not more than one month from the start of production paving. In addition, the checklist inspection shall be repeated when the plant is remobilized.

Personnel performing the inspection in accordance with the NRMCA QC3 checklist [or the DOT checklist/requirements] shall provide documentation of knowledge of batch plant operations and concrete production. A Statement of Qualifications shall be maintained for all personnel involved in the inspection process and shall include the following:

- Name and present company title
- Date of preparation of the Statement of Qualifications
- Years of service with the present company
- Job titles and dates of service of prior positions held within the company
- Years of service with other companies that produce concrete, concrete contractors, testing laboratories, or other companies that provide experience with concrete technology and concrete construction

- Training related to concrete production

The Engineer will review and approve qualifications of the plant inspector.

Documentation to validate that the plant has been inspected shall be submitted to the Engineer and maintained at the batch plant.

5.1.2 Mixers

Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn more than 10 percent of their depth, when compared with the manufacturer's dimension for new blades or paddles and included with the mixer submittal.

5.1.3 Concrete Uniformity Tests

Concrete mixer uniformity tests shall be conducted on central mix plants and truck mixers before production of the project concrete. Uniformity tests shall also be conducted for all batch plants that are moved.

Criteria for mixer uniformity in accordance with ASTM C 94/C 94M shall be met.

The number of revolutions for truck-mixed and central mixed concrete shall be determined by uniformity tests in accordance with ASTM C 94/C 94M.

5.2 Concrete Hauling Equipment

All concrete hauling equipment shall be operated to deliver and discharge the required concrete mixture completely without segregation.

5.3 Transfer and Spreading Equipment

Use of transfer and spreading equipment shall be at the Contractor's option. Such equipment, when used, shall not segregate or contaminate the concrete.

5.4 Paving Equipment

The paving equipment shall be capable of placing and consolidating the concrete uniformly across the width of placement. The equipment shall shape the concrete to the specified cross

section. Rotary trowels or other equipment that can burn or polish the concrete surface shall not be used to finish the concrete surface.

Paving equipment shall be fitted with internal vibrators and be equipped with a vibrator monitoring device that indicates the frequency of each installed vibrator. The vibrator mounting shall allow adjustments to the vibrator depth and attitude. Hand held vibrators are not considered internal vibrators and shall be used only for hand placement areas.

5.4.1 Dowel Bar and Tie Bar Inserter(s)

Equipment used for inserting dowel bars in transverse contraction joints and tie bars in longitudinal contraction joints shall be capable of placing bars to specified tolerances. The contractor shall demonstrate and verify bar placement within specified tolerances during placement of the test section and once per lot of production paving.

5.5 Texturing Equipment

Longitudinal tining shall be accomplished by equipment with automated horizontal and vertical controls to ensure straight, uniform depth tined grooves. The texturing equipment shall provide uniform surface texture in plastic concrete across the full width of the paving lane. A drag shall be used prior to longitudinal tining, to impart microtexture. Final macrotexture shall conform to requirements given in Section 7.12.

5.6 Curing Machines

The machine for applying membrane-forming curing compound shall be a self-propelled frame that spans the paving lane and provides uniform curing material coverage at the specified rate on the concrete surface and any exposed edges. Self-propelled curing machines are required when the paving lane for any day is larger than [500] [] square yards.

Minimum size of paving lane to require self-propelled curing machine may be determined by the Engineer. Generally, when the area is large enough to accommodate a slipform or a side-form paver, then a self-propelled curing machine shall be used.

Hand-operated sprayers shall only be used where forms have been removed, when the paving lane for any day is equal to or less than [500] [] square yards or on odd-shaped slabs where there is insufficient clearance for self-propelled curing machine to operate.

5.7 Concrete Saws

Equipment for sawing joints and for other similar sawing of concrete shall be mounted on a wheeled-chassis, which can be easily guided to follow the required alignment. All saws shall be capable of sawing to the depth specified in a single pass.

The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions in a timely manner. The Contractor shall provide standby saws in good working order and a supply of saw blades at the site at all times during sawing operations.

5.8 Drills

Gang-mounted rigs for drilling holes for bars in construction joints shall be capable of drilling holes at proper alignment without excessive chipping and spalling. Hand-held drills shall only be used in isolated areas where there is insufficient clearance for gang-mounted drill rig.

6.0 WEATHER MANAGEMENT

[The Contractor shall submit, for the Engineer’s review, a Weather Management Plan for paving in hot weather and/or cold weather, as applicable, and for protective measures in case of imminent rainstorm. The plan shall be submitted before start of concrete paving. The Contractor shall indicate the weather station to be used for monitoring the weather. The Plan shall include the following, as a minimum.]

[The Contractor shall meet the following requirements for paving in hot weather and/or cold weather, as applicable, and for protective measures in case of imminent rainstorm. The Contractor shall indicate the weather station to be used for monitoring the weather.]

A Weather Management Plan is not required for projects less than 25,000 square yards. The Engineer should select the second paragraph for these projects.

6.1 Hot Weather Paving

Hot weather paving is defined as paving when the concrete temperature at the paver is greater than 85 degrees F or the moisture evaporation rate at the concrete surface is greater than 0.20 lb/square foot/hour or greater than 0.10 lb/square foot/hour for concrete mixtures containing SCMs, as determined using the American Concrete Institute (ACI) moisture evaporation rate chart.

[The Weather Management Plan for hot weather paving shall incorporate the applicable recommendations of ACI 305 – Hot Weather Concreting and other industry-accepted procedures to mitigate any problems resulting from hot weather concrete placement, especially plastic shrinkage cracking due to late curing and full-depth cracking due to late sawing. The use of evaporation retarders, to minimize surface moisture loss and occurrence of plastic shrinkage cracking, shall be addressed in the Weather Management Plan.]

[The Contractor shall take necessary precautions, including use of evaporation retarders, to minimize surface moisture loss and occurrence of plastic shrinkage cracking, and correct timing of sawcutting to avoid random cracking.]

A Weather Management Plan is not required for small projects. The Engineer should select the second paragraph for small projects.

Maximum allowable concrete temperature after depositing in front of the paving equipment is 95 degrees F. The Contractor shall be aware that concrete placement difficulties may be encountered when the temperature of the delivered concrete exceeds 85 degrees F.

For side-form paving, the steel forms shall be cooled or protected as necessary to keep the steel form temperature below 120 degrees F.

[Contractor’s Weather Management Plan shall include provisions for placement of concrete with temperature greater than 95 degrees F for short lengths, not exceeding 200 ft per day to expedite concrete placement activities. These provisions shall include use of mitigation methods, such as curing blankets and fog spraying for a period of 72 hours after concrete placement. Fog spraying shall not result in ponding on the concrete surface.]

The Engineer should select the above paragraph for large projects.

6.2 Cold Weather Paving

[The Weather Management Plan for cold weather paving shall incorporate the applicable recommendations of ACI 306 – Cold Weather Concreting. The Plan shall include provisions to ensure that concrete production is consistent during cold weather, that concrete with adequate workability and early-age strength is delivered to the project site, and the temperature of fresh concrete is 50 degrees F or higher at the location of placement. The Plan shall also include provisions for adequate protection of concrete to retain the heat of hydration during cold weather.]

[The Contractor shall take necessary precautions to ensure that concrete production is consistent during cold weather, that concrete with adequate workability and early-age strength is delivered to the project site, and the temperature of fresh concrete is 50 degrees F or higher at the location of placement. The Contractor shall provide for adequate protection of concrete to retain the heat of hydration during cold weather.]

A Weather Management Plan is not required for small projects. The Engineer should select the second paragraph for small projects.

Concrete shall not be placed when the temperature of the air at the site is 40 degrees F and dropping or the surfaces on which the concrete is to be placed is less than 32 degrees F.

Concrete pavement surface temperature shall be maintained at or above 32 degrees F for a period of at least 72 hours and until in-place concrete compressive strength of 1,500 psi is attained. Corners and edges are the most vulnerable to freezing and shall be adequately protected. Coverings and other means of protecting the concrete from freezing shall be available before starting placement in cold weather and used as necessary.

Concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. The sensors shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface. The sensors shall be placed within the last 50 feet placement of the day. These sensors shall be monitored to determine when the maturity equivalent of 500 psi is achieved. Protective insulation may be removed after the pavement reaches the maturity equivalent compressive strength of 1,500 psi.

Concrete is considered damaged by freezing if any of the following conditions are allowed to occur:

1. Concrete placement when the temperature of the air at the site is 40 degrees F and dropping or the surface on which the concrete is to be placed is less than 32 degrees F
2. Concrete pavement surface temperature is not maintained at or above 32 degrees F for a period of at least 72 hours and until in-place concrete compressive strength of 1,500 psi is attained

Slabs with damaged concrete are considered defective and shall be mitigated as per Section 10.2 – Defective Pavement.

6.3 Protecting Concrete from Rain Damage

[Contractor’s Weather Management Plan shall include provisions to protect the freshly placed concrete from rain damage.]

The Contractor shall not place concrete when rain conditions appear imminent. The Contractor shall maintain on-site sufficient waterproof material and means to rapidly place it over all unhardened concrete surface or concrete surface that may be damaged by rain. Concrete shall not be placed during rain that results in any standing water on the surface of the fresh concrete surface.

Rain-damaged concrete shall be cored as directed by the Engineer and depth of damage determined by petrographic examination. When the depth of damage is 1/4 inch or less of the pavement thickness, the damaged areas shall be corrected by diamond grinding. Diamond grinding requirements are detailed in Section 10.1.2 - Surface Grinding. Coring shall be at the Contractor’s expense. Diamond grinding and related activities shall be at the Contractor’s expense.

If depth of damage is greater than 1/4 inch, the slab shall be considered defective and mitigated as per Section 10.2 – Defective Pavement.

7.0 EXECUTION

7.1 Underlying Material Preparation

Before setting forms or placing concrete, the underlying material shall be accepted by the Engineer for concrete placement. The underlying material shall have been satisfactorily graded, including at any thickened edge locations. The underlying material shall be clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water.

Underlying material disturbed by construction operations shall be reworked in accordance with the appropriate specification.

For slipform paving, typical sections shall include at least 3 feet additional width for all layers beneath the concrete at the outer paving lanes to support the tracks. These quantities shall be included in the plan quantities.

7.2 [Not Used] [Paving on Stabilized Bases]

Paving on stabilized bases shall require treatment [as shown on plans] [contained in Item P-_____] [as follows:]

Paving on stabilized bases requires specific design considerations to prevent early age cracking. These considerations include use of a geotextile, a hot-mix asphalt concrete interlayer, or another treatment. The Engineer will show requirements on plans and in appropriate stabilized base item or insert language into this specification.

7.3 Test Section

[A test section may be constructed. The test section shall be the first day of paving with a minimum length representative of production paving of 100 feet and a maximum length equivalent to 10 percent of the total concrete production for the selected paving method. The test section area shall be considered as single lot, irrespective of the length of the test section. The test section width shall be [width of the production paving area], and the thickness shall be [the thickness of the production paving area].]

7.3.1 Test Section Requirements

The Contractor shall demonstrate that the concrete can be placed to the specified requirements at the test section. The Contractor shall place concrete and adjust the concrete mixture, as

necessary, within the limits specified in Section 7.4 – Production Paving Adjustments to the Concrete Mixture Proportions. The Contractor shall adjust equipment and modify procedures, as necessary, such that when the start of the test section is designated, the specified end product is attained.

During the test section placement, the Contractor shall demonstrate control of the construction process, including concrete mixing, transporting, placing, consolidation, finishing, application of curing, construction of contraction joints and headers, and the performance of the Contractor's process control and acceptance testing.

The Contractor shall designate the start of the test section after he has determined that his concrete mixture and his construction process can produce a concrete pavement that is in conformance with the plans and specifications. Concrete placed prior to the start of the test section shall be mitigated as necessary in accordance with Section 10.0 and subsequently accepted, measured, and paid for according to specification requirements.

The test section shall be deemed acceptable when it meets the process control and acceptance testing criteria with no deficient or defective pavement and when the test section achieves a percent within limits (PWL) of 90 or higher for thickness. Strength testing for the test section shall be performed at a later date in accordance with Section 9.4.3 - Strength. The process control and acceptance test results shall be provided to the Engineer in writing.

Test section determined to be not-acceptable shall be mitigated in accordance with Section 10.0 – Deficient and Defective Pavement and a new test section shall be constructed.

The concrete mixture proportions used in the accepted test section shall be designated as the approved concrete mixture for production paving.

Production paving shall not be started until the test section has been accepted by the engineer. The materials, process, and level and skill of the workforce used for the conforming test section shall be maintained throughout production paving.

When the concrete plant or plant type changes, the Contractor shall validate the new process by constructing another test section.

7.4 Production Paving Adjustments to the Concrete Mixture Proportions

Production paving concrete mixture proportions shall be adjusted to achieve uniformity in the properties of fresh concrete, to maintain concrete workability, and to provide the specified properties for the fresh and the in-place concrete. The following field adjustments to the approved concrete mixture, as established by the laboratory testing are permitted, without requiring a new submittal for the concrete mixture proportions:

1. Individual aggregate proportions may be adjusted as necessary within the limits of Section 8.3.3.2 – Combined Aggregate Gradation.
2. As necessary, cementitious materials may be increased by up to 10 percent by mass of the approved mixture proportions. Cementitious material content shall not be reduced from the approved mixture proportions.
3. As necessary, cement may be replaced with the approved SCM in an amount not to exceed 10 percent of the original SCM mass. When applicable, the Contractor's mitigation plan for reactive aggregates shall be re-evaluated.
4. As necessary, any SCM may be replaced with the approved cement. When applicable, the Contractor's mitigation plan for reactive aggregates shall be re-evaluated.
5. Quantities of admixtures may be adjusted in accordance with the manufacturer's recommendations.
6. Field adjustment for water is permitted provided that the water-cementitious materials ratio does not exceed the ratio for the approved concrete mixture and is not less than that listed in Section 4.1 – Concrete Mixture Requirements.
7. For truck mixed concrete, additional water may be added only once to adjust the workability of concrete, provided the approved water-to-cementitious-materials ratio is not exceeded. The maximum amount to be added shall be adjusted based upon the volume of concrete already discharged. The drum or blades shall be turned a minimum of 30 additional revolutions at mixing speed after water addition.
8. Water addition to the concrete by spraying in front of and behind the paving equipment is not allowed.

7.5 Tie Bar Placement

Deformed tie bars shall be installed as shown on the plans. Tie bars shall be placed parallel to the pavement surface and in the middle of the slab depth. Tie bars shall not be greased or enclosed in sleeves.

Tie bars shall not be placed within 15 inches of intersecting contraction joints. Tie bar placement shall be verified at least once per day of production paving. Placement methods shall be modified as necessary to maintain a minimum of 2 inches concrete cover over all tie bars. Tie bars found to be within 15 inches of an intersecting contraction joint shall be sawed completely through.

7.6 Doweled Contraction Joints

The dowel bars shall be of the dimensions and spacing as shown on the plans. The bars shall be installed as shown on the plans. The portion of each dowel shown on the plans to receive a bond-breaker lubricant shall be thoroughly coated to prevent the concrete from bonding to that portion of the dowel.

Verification of Dowel Bar Alignment

Use either properly secured dowel baskets or a dowel bar inserter, provided the ability to correctly locate and align the dowels at the joints is demonstrated as described below. If dowel baskets are used, clip the shipping wires prior to concrete placement to enable the use of a magnetic imaging device to determine dowel alignment.

Provide a calibrated magnetic imaging device that will document dowel bar location and alignment. Calibrate the magnetic imaging device to the type and size dowel bar used in the work. Utilize this device as a process control and make necessary adjustments to ensure the dowels are placed in the correct location.

Scan at least 25% of the joints in the initial placement or 1.0 mile of pavement, whichever is greater, at random intervals throughout the pavement each time the paving train is mobilized. Mark scanned joints on the pavement.

Scan all joints in this initial placement if the dowel bars exhibit longitudinal translation (side shift), horizontal translation, vertical translation (depth), horizontal skew, or vertical tilt, above the allowable tolerances defined below. In addition, continue scanning no less than 25% of the joints until it is established that the dowel bar inserter or secured dowel basket assemblies are consistently placing the dowel bars at the correct location (meeting the tolerances defined below). Once the engineer determines that consistency is established, the contractor may reduce the percentage of scanned joints to no less than 10%. Any time inconsistency in the placement of the dowel bars becomes evident, additional scanning may be required up to 100% of the joints.

If consistency of the proper dowel bar alignment cannot be established within a reasonable time frame, the Engineer will have the option of suspending the paving operation.

Provide an imaging device printout of the scanned joints within 72 hours of completing the day's production and a finalized report within 7 days. The report should include the station and lane of the joint scanned, as well as the horizontal location, depth, longitudinal translation (side shift), horizontal skew, and vertical tilt, of each dowel bar in the joint. If a dowel bar inserter is used, the joint score described below should also be provided in the report.

Longitudinal translation (side shift) is defined as the position of the center of the dowel bar in relation to the sawed joint. The maximum allowable longitudinal translation (side shift) is 2 inches for dowel bars 18 in. in length or longer.

Horizontal translation is defined as difference in the actual dowel bar location from its theoretical position as detailed in the standard details. The maximum allowable horizontal translation is 2 inches.

Vertical translation (depth) is the difference in the actual dowel bar location from the theoretical midpoint of the slab. The maximum allowable vertical translation is ½ inch higher than the theoretical midpoint, and 1 inch lower than the theoretical midpoint.

Dowel bar misalignment, either vertical tilt or horizontal skew, is defined as the difference in position of the dowel bar ends with respect to each other. Vertical tilt is measured in the vertical axis whereas horizontal skew is measured in the horizontal axis.

Determine a joint score for each joint scanned. The joint score is a measure of the combined effects from the dowel's horizontal skew or vertical tilt. The joint score is determined by summing the product of the weight (shown in the table below) and the number of bars in each misalignment category and adding 1. The vertical tilt and horizontal skew should be evaluated and the greater misalignment shall be utilized in determining the joint score. If two lanes are poured simultaneously, the joint score is calculated for the 24 foot section.

Misalignment Category, mm	Weight
0 <= d <= 15	0
15 < d <= 20	2
20 < d <= 25	4
25 < d <= 38	5
38 <= d	10

where d is the individual dowel bar misalignment.

A joint that has a joint score of 10 or greater per lane width incorporating 12 dowel bars will be considered locked.

When a locked joint as defined above is discovered, scan the two joints immediately adjacent to the locked joint. If either of the adjacent joints is deemed to be locked, provide a written proposal to address the dowel misalignment for each locked joint. No corrective action should be performed without written approval.

Any and all corrective action necessitated by improper joint alignment shall be at no cost to the Department.

7.7 Doweled Expansion Joints

A dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints. These caps shall be rigid enough to prevent collapse and shall be placed on the ends of the dowels as shown on the plans. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight. The expansion gap allowable shall be as shown on the plans.

The maximum permissible tolerances on dowel bar alignment shall be in accordance with Section 9.3.3 – Dowel Bar Alignment.

7.8 Concrete Production

Concrete shall be mixed and produced according to the procedures demonstrated at the test section.

7.8.1 Batch Tickets

Every load of concrete delivered to the paving site shall have a batch ticket indicating all of the information identified in the NRMCA QC3 (or the DOT) document for batch tickets. For truck-mixed concrete, the batch tickets shall also show the amount of water that can be added without exceeding the approved water-to-cementitious-materials ratio. Batch tickets for central-mixed concrete delivered in trucks that do not have the capability of adding water may be retained at the plant and provided to the Engineer upon request.

7.9 Hauling

Haul time is defined as the elapsed time from the addition of cementitious material into the mixture until the paving equipment has passed over the concrete. Haul time shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, or 105 minutes when the concrete is hauled in truck mixers or truck agitators. Concrete shall be transported to the point of discharge without segregation. Concrete that has been deposited, but whose haul time exceeded the specified limits before the paving equipment passes over the concrete, shall be removed.

During hot weather, as defined in Section 6.1 – Hot Weather Paving, the haul time shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, or 90 minutes when the concrete is hauled in truck mixers or truck agitators.

7.10 Paving

The Contractor shall place, spread, consolidate, and finish the concrete to meet the requirements of Section 9.0 – Acceptance Testing. The paving operation shall result in a dense concrete matrix that does not exhibit segregation. Hand-finishing operations behind the paver shall be kept to a minimum to correct minor surface defects.

Uniformly vibrate the concrete after it has been spread. Consolidate the full width and depth of the concrete in a single pass. The consolidated concrete shall result in a dense concrete matrix that does not exhibit segregation.

Vibrators for full width vibration of concrete paving slabs shall be the internal type with either immersed tube or multiple spuds. Attach the vibrators to the spreader or the finishing machine, or mount the vibrators on a separate carriage.

Furnish an electronic vibrator monitoring device, displaying the operating frequency of each individual vibrator on the paving equipment. Operate the electronic vibrator monitoring device in areas where the mainline, ramp, or loop pavement exceeds 600 feet in length. Record the time, station location, paver track speed, and operating frequency of each individual vibrator after every 25 feet of paving or after each 5-minute time interval has elapsed. Provide a report of the vibrator data to the Engineer daily for the first 3 days of paving and weekly thereafter. The Engineer may determine that more frequent submissions are necessary, particularly if equipment is malfunctioning.

Set the internal vibrators to approximately mid slab depth and provide a locking device to avoid contact with any joint hardware, load transfer device, tie bar, subgrade, or side form. Provide an operating position locking device so that no part of the vibrating unit can be lowered to the extent that it will come in contact with dowel bars, dowel bar assemblies, or tie bars while paving.

Set the horizontal spacing of vibrators to the manufacturer's recommendations, but in no case exceed 16 inches from center to center.

Operate vibrators in a manner not to cause a separation of the mix ingredients. A reduction in vibrator frequency may be required when the forward motion of the paver is reduced to avoid segregation of the mix. Either discontinue the use or remove from contact with the concrete, the machine mounted vibrators, whenever the forward motion of the machinery is stopped.

Should the electronic monitoring device fail to operate properly, immediately check the vibrators manually in the presence of the Engineer or his representative. If the vibrators are functioning properly, paving may continue. Repair the monitoring device within 3 production days or suspend paving.

Hand placement of concrete shall not be permitted, except under the following conditions:

1. In the event of breakdown of the paving equipment, hand placement methods may be used to consolidate and finish the concrete already deposited on the grade.
2. In areas of narrow widths or of irregular dimensions where operation of the paving equipment is not practical.

The hand placed concrete, as soon as placed, shall be consolidated, struck off, and screeded. Concrete consolidation shall be achieved using hand held or other vibrators. Hand placed concrete shall result in a dense concrete matrix that does not exhibit segregation.

7.11 Texturing

Complete final texturing as soon as possible after finishing, but before the concrete has attained its initial set. This is accomplished by applying both a drag pretexture and by tining.

7.11.1 Drag Pretexture

Drag artificial turf or burlap longitudinally along the concrete pavement surface after finishing to enhance texture. The turf or burlap shall be mounted on a work bridge or a moveable support system capable of varying the area of turf or burlap in contact with the pavement.

The turf or burlap drag shall be a single piece of artificial turf or burlap of sufficient length to span the full width of the pavement being placed. The turf or burlap shall have a means to adjust the height and/or length so as to always maintain a minimum of 4-foot longitudinal length of turf or burlap in contact with the concrete being placed. Where construction operations necessitate and with the approval of the Owner-Agency, the length and width of the turf or burlap may be varied to accommodate specific applications.

The turf used shall be an artificial grass type having a molded polyethylene pile face. The pile shall contain blades that are curled and/or fibrillated. The pile shall not contain straight, smooth monofilament blades. The pile shall include blade lengths of 0.6 to 1.3 inch. The turf shall have a minimum weight of 60 ounces per square yard. The backing shall be a strong, durable material not subject to rot, and shall be adequately bonded to withstand use as specified.

The burlap material used shall meet Class 3 or Class 4 requirements of AASHTO M 182, "Standard Specification for Burlap Cloth Made from Jute or Kenaf." The trailing end of the burlap that is in contact with the concrete surface shall be frayed by removing yarns perpendicular to the direction of paving. The frayed burlap shall be 2 to 6 inches in length and uniform across the width of the pavement being placed.

Turf or burlap dragging operations should be delayed if there is excessive bleed water. During paving, prevent the turf or burlap from getting plugged with grout or dragging larger aggregates or foreign materials by cleaning or replacing as necessary. Measures should be taken to ensure a surface of uniform appearance that is free from deep striations. Turf or burlap should be thoroughly cleaned or replaced at the end of each day's use. Damaged or worn turf or burlap should be repaired and/or replaced.

7.11.2 Tining

Texture is further enhanced through the placement of longitudinally tined grooves in the surface of a pavement while the concrete is plastic. The tining shall be done with a mechanical device such as a wire comb. The comb shall have a single row of tines that each has a nominal width of 5/64 inch to 1/8 inch. The nominal spacing of the tines shall be $3/4 \pm 1/8$ inch center-to-center. The nominal depth of tined groove in the plastic concrete shall be $1/8 \pm 1/32$ inch.

Longitudinal tining shall be accomplished by equipment with automated horizontal and vertical controls to ensure straight, uniform depth tined grooves. The texture geometry shall be the same as imparted throughout the length of the tining comb. A 2-inch to 3-inch wide strip of pavement surface shall be protected from tining for the length of and centered about longitudinal joints.

The tining operation shall be done at such time and 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 tining shall extend as close to the edge as possible without damaging the edge. If abutting pavement is not to be placed, the 6-inch area nearest the edge or 1 foot from the face of the curb shall not be tined. Hand-operated tining equipment that produces an equivalent texture may be used only on small or irregularly shaped areas. Tines should be thoroughly cleaned at the end of each day's use, and damaged or worn tines replaced.

When surface corrections for pavement smoothness are made in the hardened concrete, no additional texturing is required.

7.12 Curing

Concrete shall be continuously protected against loss of moisture for at least 72 hours after the completion of finishing operations. Curing shall be accomplished by use of curing compounds or by moist curing.

When a curing compound is used, it shall be applied using a curing machine immediately after the surface texture has been applied. Curing shall be applied at a coverage rate that is the smaller of [100 – 200] square feet per gallon or that recommended for paving applications by the manufacturer. When discontinuities exist in the applied curing material, an additional coat shall be applied to the affected areas within 30 minutes of the initial curing application. Areas where the curing compound application is allowed by hand-operated sprayers, a second coat shall be applied in a direction approximately at right angles to the direction of the first coat. If any curing machine or hand-operated sprayer fails to apply an even coating of the compound at the specified rate, it shall be replaced and the pavement area in question re-sprayed.

If any drying of the concrete surface has occurred before application of curing compound, the surface of the concrete shall be immediately fog sprayed, and the curing compound applied as soon as the free water disappears.

Curing shall not be applied to pavement surface that has standing water as a result of a rainfall or bleeding. Curing shall be applied as soon as the standing water has evaporated and the surface is still damp.

7.12.1 Curing Protection

Areas where the curing compound is damaged by subsequent construction operations within the first 72-hour curing period shall be immediately re-sprayed. Concrete surfaces to which curing compounds have been applied shall be adequately protected to prevent damage from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane. Curing compound that has been damaged by rainfall shall be re-sprayed as soon as practical at the specified coverage rate.

7.13 Form Removal

Forms shall remain in place for at least 12 hours or until the in-place concrete has attained a compressive strength of 500 psi. Concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. A sensor shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface in the last 50 feet of placement. These sensors will be monitored to determine when the maturity equivalent of 500 psi compressive strength is achieved. Forms may be removed after the pavement reaches the maturity equivalent of 500 psi compressive strength.

Forms shall be removed by procedures that do not damage the concrete. Curing compound shall be applied at the specified rate immediately to the faces exposed after form removal.

7.14 Sawcutting

Joints shall be cut as shown on the plans using equipment described in Section 5.7 – Concrete Saws. The initial sawcut shall produce a slot to the depth shown on the plans.

Sawing for transverse and longitudinal joints shall start as soon as the concrete has hardened sufficiently and before cracking of the pavement occurs. Chipping, raveling, or tearing of the concrete due to cutting, which exceeds the dimension of the sealant reservoir width, is not allowed. Sawing shall be carried on both during the day and night as required.

After sawing, the slurry and laitance shall be immediately washed from the pavement before it dries. Curing treatment shall be reapplied to areas damaged by the sawing operation and to the cleaned sawed surfaces within 15 minutes of the evaporation of any standing water from surfaces.

7.15 Sealing Joints

If plans require it, seal joints before any portion of the pavement is opened to the Contractor's forces or to general traffic. Saw or prepare joint openings to the designated dimensions.

Use a joint sealant material that meets the requirements of AASHTO M 324.

Within 3 hours after a joint has been wet sawed to the finished dimension, flush the wet sawing residue away from the sawed faces using a high pressure water blast operating with a minimum pressure of 1000 pounds per square inch (7000 kPa). Within 3 hours after the joint has been dry sawed to the finished dimension, blow the dry sawing residue from the joint. Use air compressors that provide moisture and oil free compressed air.

Immediately prior to installation of sealant, clean joints with an air blast. Do not perform sealing until visual examination verifies the joint surfaces appear dry, in addition to being clear of dust and contamination. Prepare joint sealer and install in the joint and to the proper level as recommended by the manufacturer. Heat hot poured sealers in a thermostatically controlled heating kettle. Heat the material to the temperature required for use, but not above that recommended by the manufacturer. After sealing, remove excess sealer from the pavement surface.

Place joint sealer only when the pavement and ambient air temperatures are 40°F (4°C) or above. When near this minimum, additional air blasting or drying time, or both, may be necessary to assure a satisfactory bond to the joint faces.

When surface correction is required, repair seals damaged from the corrective work. Joint preparation, cleaning, and sealing may be delayed until after corrective work, provided the pavement is not opened to traffic before corrective work is performed.

7.16 Opening to Construction Traffic

The newly constructed concrete pavement shall not be open to construction traffic, except for saw-cutting equipment, until all of the following requirements are met:

1. The curing compound is sufficiently hardened to prevent damage from vehicle traffic.
2. The joints are sealed, if required by plans, or protected from damage to the joint edge and from intrusion of foreign materials into the joint. As a minimum, backer rod or tape shall be used to protect the joints from foreign matter intrusion.
3. The minimum in-place concrete compressive strength is:
 - a. Equal to or more than 2,000 psi, or

The compressive strength of the concrete shall be determined using one of the following methods:

1. Cylinder testing - A total of three cylinders shall be prepared using concrete from the most recently placed subplot that will be subjected to construction traffic. The cylinders shall be prepared and cured at the site in accordance with ASTM C 31.
2. Another method approved by the Engineer, such as maturity testing. If maturity testing is used, in situ concrete strength shall be monitored using maturity sensors that record the temperature of the pavement at 15 minute or shorter intervals. The sensors shall be placed within 6 inches from the pavement edge and approximately 2 inches below the surface in the most recently placed subplot that will be subjected to construction traffic.

8.0 QUALITY ASSURANCE

The Contractor shall perform all activities and tests as necessary to monitor the concrete production and concrete pavement construction processes to produce a pavement that meets the specifications. The Contractor shall submit a Quality Control Plan in accordance with Section 8.3 that addresses the Contractor's overall quality processes and testing requirements for quality assurance. The Contractor shall maintain copies of the specified test and material standards at the project site.

The Contractor's Quality Control Plan shall indicate the appropriate actions that shall be taken when the concrete production and the concrete pavement construction processes are determined to be out of control.

The Contractor's Quality Control Plan shall also address the acceptance testing to be performed by the Contractor as per Section 9.4 – Contractor Performed Acceptance Testing.

The Contractor shall allow the Engineer to observe the process control testing. The Engineer shall be provided a written copy of the results within 72 hours of completion of a day's paving.

8.1 Testing Personnel

Contractor testing personnel shall be certified as follows:

1. Field testing technicians: American Concrete Institute (ACI) Concrete Field Testing Technician
2. Laboratory testing technicians (non-strength testing): ACI Concrete Laboratory Testing Technician, Grade I or II
3. Laboratory strength testing technicians: ACI Concrete Strength Testing Technician

Certification at an equivalent level by NICET, a state, or a nationally recognized organization is also acceptable.

8.2 Testing Laboratory Requirements

The Contractor's testing laboratories shall meet the requirements of ASTM C 1077 that relate to the minimum technical requirements for laboratory equipment utilized in testing concrete and concrete aggregates for use in construction or be accredited by [] [Department of Transportation] or AASHTO for concrete testing. The Contractor's curing process for strength specimens shall meet the requirements of ASTM C 31.

Add appropriate State name or highway agency designation

8.3 Quality Control Testing

During construction, the Contractor shall be responsible for sampling and testing aggregates, cementitious materials, and concrete to determine compliance with the specifications. The Contractor shall perform, as a minimum, the inspection and tests listed in Table 2.

Table 2. Minimum quality control testing requirements

Test Procedure	Frequency
AASHTO T 27 - Sieve Analysis of Fine and Coarse Aggregates	1 test per 1,000 tons of material delivered during stockpiling operations 1 test per subplot during production
AASHTO T 255 – Total Evaporable Moisture Content of Aggregate by Drying	1 test per subplot
AASHTO T 309 – Temperature of Freshly Mixed Hydraulic Cement Concrete	1 test per subplot
AASHTO T 121 – Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete	1 test per subplot
AASHTO T 152 - Air Content of Freshly Mixed Concrete	1 test per subplot sampled at point of delivery 1 test per lot sampled behind the slipform paver
AASHTO T 318 – Water Content of Freshly Mixed Concrete Using Microwave Oven Drying	1 test per subplot
Manual Probing	1 test per 100 ft of paving width placed
Tie Bar Placement	1 verification per lot
Dowel Bar Placement	1 verification per lot
Curing Compound Coverage	1 verification per lot
Vibrator Frequency	Submit vibrator monitor in accordance with Section 7.10
Sawcut Depth – Transverse Joints	1 verification per 10 transverse joints
Sawcut Depth – Longitudinal Joints	1 verification per 50 ft length of the joint
Pavement Smoothness	In accordance with acceptance criteria

Based upon the results of these inspections and tests, the Contractor shall take the action required to maintain processes under control and submit reports as required. The Contractor, regardless of any other testing performed by the Engineer, shall perform the specified process control inspection and testing.

Lot size and subplot requirements are defined in Section 9.2 – Lot Size.

8.3.1 Accuracy of Plant Batching

During production paving, the accuracy of plant batching shall be rechecked in accordance with the provisions of NRMCA QC 3 (or the DOT) document at the frequency stated in the NRMCA

QC 3 (or the DOT) document. When any requirements relating to the accuracy of batching of NRMCA QC 3 (or the DOT) document are not met, the plant operation shall be stopped and concrete production shall not be restarted until corrective measures have been implemented to bring the plant into compliance.

8.3.2 Aggregate Quality

Testing, as per Section 3.2.2 - Aggregate Quality, to determine deleterious substances and flat and elongated pieces for aggregate retained on the No. 4 sieve shall be conducted on the day of test section construction and on every seventh day of paving thereafter.

The aggregate quality tests shall be performed upon a representative sample obtained from each aggregate stockpile at the plant site. When the specified quality requirements are not met, the test(s) shall be repeated on another sample. When the specified requirements of the tests are not met for the second test(s), the affected aggregate stockpile shall be rejected and replaced with conforming aggregates.

8.3.3 Combined Aggregate Gradation

Grading for each aggregate type shall be determined at least once per day for each day of paving, in accordance with ASTM C 136 on samples representative of that day's paving. The mathematical combined aggregate gradation shall be determined using the aggregate proportions of the approved concrete mixture.

8.3.3.1 Workability Factor and Coarseness Factor

The Workability Factor (WF) and the Coarseness Factor (CF), as defined in Section 3.2.1- Gradation Evaluation of the Proposed Aggregates, of the mathematical combined aggregate gradation shall be determined. The combined aggregate gradation tolerance is plus or minus 3 points for the WF and plus or minus 5 points for the CF from the WF and CF values established for the approved concrete mixture.

8.3.3.2 Combined-Aggregate Gradation Controls

If the combined aggregate gradation is not within tolerance, the Contractor shall make adjustments in the aggregate proportions and increase the quality control testing frequency from 1 test per subplot to 2 tests per subplot until 4 successive tests are within specified tolerances. If the proportions cannot be adjusted to within the specified tolerance, the affected aggregate stockpile shall be rejected.

8.3.3.3 Aggregate Moisture Content

The moisture content of each aggregate used in the concrete mixture shall be determined twice daily during paving operations. Samples for moisture content testing shall be taken from areas of the aggregate stockpiles, which will be used for concrete production at the time when moisture content test results are completed. Concrete mixture proportions shall be adjusted for aggregate moisture content test results.

8.3.4 [Not Used] [Air Content]

Perform QC sampling and testing of the fresh concrete for air content loss at least once during each week of concrete production, or whenever QC tests have shown that the air content tested is less than 5.0%, whichever is more frequent. Sample and test a representative haul unit of concrete immediately after its discharge but before the paver. Sample and test the concrete representing the same haul unit, again, after the paver. If the difference in measured air content between the two test locations for the same concrete is greater than two percent air by volume of concrete, suspend operations and administer corrective action. Resume concrete placement only after taking the necessary corrective action to reduce the loss in air content of fresh concrete between the two test locations, as approved by the Engineer. Document the corrective action to be taken in the QC records and make the necessary changes to the QC plan, where applicable.

Air content testing is required only when there is a requirement for target percent of air in the concrete mixture in Section 4.1 – Concrete Mixture Requirements.

8.3.5 Concrete Temperature

One concrete temperature test shall be performed for each subplot of material. Concrete temperature tests shall be performed in accordance with ASTM C 1064 from material randomly sampled from trucks at the paving site. The acceptance criteria for concrete temperature specified in Section 6.0 - Weather Management Plan, shall be met. When the criterion is not met for the first test, the test shall be repeated on another sample from that load. If the second test fails, conduct testing on the next available truck. Unloading of the concrete at the paver shall be stopped unless the truckload passes the temperature requirement. Test each truck until three consecutive truckloads pass the temperature requirement. Then, the testing for temperature shall be continued on the basis of one test per subplot.

8.3.6 Hand Finishing

Hand finishing should be limited to correction of bumps/dips and closing of any surface voids.

Addition of water to the surface of the concrete pavement behind the paving equipment is not allowed. Overspray of water that occurs during re-wetting of a burlap drag is not allowed.

8.4 Control Charts

The Contractor shall maintain linear control charts or other acceptable methods for all quality control activities, which provide quantitative results.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. The Contractor shall use the control charts as part of a process control system for identifying potential problems before they occur.

9.0 ACCEPTANCE TESTING

Testing shall be performed to determine compliance with the specifications. Testing shall be performed by the Department and the Contractor, as designated in this section.

The Contractor shall make provisions to allow the Department to observe acceptance testing by the Contractor to verify the Contractor's procedures. The Department shall be notified of the results of the Contractor acceptance testing in writing within 72 hours of completion of testing for a lot.

9.1 Control Charts

The Contractor shall maintain linear control charts for the acceptance tests. Control charts shall be posted in a location satisfactory to the Department and shall be kept up to date at all times. The Contractor shall use the acceptance control charts as additional input for his process control and for identifying potential construction problems before they occur.

9.2 Lot Size

A lot shall consist of 2,000 square yards paved sequentially over one or more days.

Each lot shall be divided into 4 equal sublots of 500 square yards. Sampling locations within a subplot shall be determined in accordance with random sampling procedures described in ASTM D 3665 (as stipulated in AASHTO R-4). At the end of a project, the following rules shall apply for end lots less than 2,000 square yards:

1. The end lot less than 1,000 square yards should be made part of the previous lot, which shall be designated as the end lot. This end lot shall be sub-divided equally into five sublots.
2. The end lot equal to or greater than 1,000 square yards should be considered as a separate lot. This end lot shall be sub-divided equally into five sublots.

9.3 Department Performed Acceptance Tests

The following surface condition tests shall be conducted on a lot basis, unless otherwise noted.

9.3.1 Cracking

A slab panel exhibiting cracking within 72 hours of concrete placement that is 2 inches or less in depth and 4 ft or less in length shall be deemed deficient and mitigated as per Section 10.1 – Shallow Cracking.

A slab panel exhibiting cracking greater than 2 inches in depth and greater than 4 feet in length within the warranty period after concrete placement shall be considered defective and shall be mitigated in accordance with Section 10.2 – Defective Pavement.

9.3.2 Joint Spalls

Joint spalls wider and/or deeper than 1 inch over a length less than 15% of any one slab edge that develop within the warranty period shall be deemed deficient and shall be mitigated in accordance with Section 10.1.3 – Joint Spalls. Slabs with combined joint spalling exceeding this quantity within the warranty period shall be deemed defective and shall be mitigated in accordance with Section 10.2 – Defective Pavement.

9.3.3 Dowel Bar Alignment

Dowel bars shall be checked for position and alignment in hardened concrete. The maximum permissible tolerance on dowel bar skew (tilt) in each plane, horizontal and vertical, shall not exceed 1/4 inch per foot of dowel bar. Dowels shall be placed vertically within 1 inch of slab mid-depth, placed longitudinally within 1 inch of planned location across the joint, and spaced horizontally within 1 inch of planned location along the joint.

For construction joints, the dowel bars shall be embedded one-half the dowel length plus or minus 1 inch. For contraction joints, the dowel mid-point shall be located within 2 inches of the joint sawcut.

If the dowel alignment cannot be maintained as specified, concrete placement shall be stopped and not be restarted until corrective measures are implemented to ensure that the dowel placement conforms to the specification requirements.

Slabs with joints exhibiting misaligned dowel bars shall be considered defective and shall be mitigated in accordance with Section 10.2. – Defective Pavement.

9.4 Contractor Performed Acceptance Tests

The acceptance test for slab thickness, concrete strength, and smoothness shall be performed by the Contractor and the results shall be used to adjust the pay for the concrete pavement on a lot-by-lot basis. The Contractor shall allow the Department to observe the process control testing. The Department shall be provided a written copy of the results within 72 hours of completion of testing.

9.4.1 Percent within Limits

The acceptance tests for thickness and concrete strength shall be evaluated for acceptance on a lot basis using the method of estimating percentage of material within limits (PWL) of the

specification requirements. The PWL shall be determined in accordance with procedures specified in AASHTO R-9 and R-42. The lower specification tolerance limit (L) for concrete strength and thickness shall be as shown in Table 3.

Table 3. Lower specification tolerance limit for concrete strength and thickness

Lower Specification Tolerance Limit (L)	
Compressive Strength	[0.93] × compressive strength specified in Section 4.2 – Concrete Mixture Requirements
Thickness	Lot Plan Thickness in inches – 0.50 inches

9.4.2 Thickness

Acceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve PWL of 90 or higher.

9.4.2.1 Sampling

Slab thickness shall be determined for each subplot at randomly selected locations agreed upon with the Department. Thickness shall be determined using cores or a nondestructive test method approved by the Department. Areas with planned variable thickness, such as thickened edges, shall be excluded from sample locations.

If cores are used, the cores shall be obtained with a core drill at the rate of one thickness core per subplot. Core holes shall be filled within one day after sampling using **[a non-shrink cementitious grout]** [] approved by the Department. The thickness of the cores shall be determined by the average caliper measurement in accordance with ASTM C 174.

The average thickness of the sublots, typically four, shall be designated as the thickness of the lot.

9.4.2.2 Thickness Acceptance

The lot shall be accepted or rejected on the basis of Section 12.1 –Pay Adjustment.

9.4.3 Strength

Concrete strength shall be based on compressive strength determined using cylinders as described below. [Note: the Department may require compressive strength testing using cores and appropriately developed correlation between the flexural strength and core compressive strength. Or, the Department may require use of the splitting tensile strength to determine concrete strength. In such a case, use the appropriate test parameter instead of cylinder based

compressive strength in the applicable text.]. Acceptance of each lot of in-place pavement for concrete strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

One sample shall be taken for each subplot from the fresh concrete delivered to the job site. Samples of concrete for strength testing shall be obtained at the point of delivery to the paver, but may be transported to an on-site laboratory for specimen fabrication, curing, and storage. The concrete shall be sampled in accordance with AASHTO T-141.

9.4.3.1 Concrete Strength using Cylinders

Three concrete cylinders will be prepared from each sample of concrete representing a subplot. The concrete shall be cured and tested at the specified age in accordance with AASHTO T-23. The average strength of the three cylinders shall be designated as the compressive strength of the subplot.

The average strength of the sublots, typically four, shall be designated as the compressive strength of the lot.

9.4.3.2 Strength Acceptance

The lot shall be accepted or rejected on the basis of Section 12.1.2 – Basis for Pay Adjustment.

9.4.4 Smoothness Testing

The final pavement surfaces where the posted vehicle speed is [30 mph or greater] shall be measured using an Inertial Profiler System (IPS) and the International Roughness Index (IRI) in accordance with the procedures detailed in AASHTO R-54.

The Contractor shall furnish a properly calibrated, documented, and Department-certified IP. The IPS shall export raw profile data in an unfiltered ERD file format, and shall produce a profilogram (profile trace of the surface tested). The IPS shall conform to the Class 1 requirements of the most recent revision of ASTM E950 and must be certified by the Department.

The Contractor shall furnish an operator, trained in the operation of the particular IP and knowledgeable in the use of the most recent version of the ProVAL software. All profiler operators shall pass a proficiency test and possess a current certification issued by the Department.

9.4.4.1 Test Procedure

The IPS shall be operated at the optimum speed as defined by the manufacturer. The IPS shall be run in the direction the traffic will be moving. Profiles shall be measured in the left and right wheel paths of each lane. Pavement smoothness for each lane will be computed by obtaining the IRI for the left and right wheel paths in an individual lane and then averaging the results. The averaged results will be used to determine pay adjustments. Each lane of each lot shall be tested and evaluated separately.

The term “smoothness” will mean the composite IRI value per 0.1 mile segment on which pay adjustments are made. The term “areas of localized roughness” will mean those areas exceeding the limiting criteria for a continuous IRI calculation with a 25-ft interval, as computed using the most recent version of the FHWA’s Profile Viewing and Analysis (ProVAL) software.

Each pass shall be made continuously, regardless of length. The subsequent pass shall begin approximately 50 ft prior to, and shall include, construction headers and end-of-day work joints. Terminal headers that tie into existing concrete pavement shall be evaluated, and smoothness measurements shall begin approximately 50 ft before and end approximately 50 ft after terminal headers. Bridge approach panels and bridge surfaces are exempt from these requirements; however, paving start-up areas are not exempt.

9.4.4.2 Smoothness Determination

The IRI for the left and right wheel paths in an individual lane will be computed and then averaged when determining pay adjustments. Each lane shall be tested and evaluated separately. The Department shall determine the length in miles for each mainline traffic lane.

9.4.4.3 Areas of Localized Roughness

Areas of localized roughness will be identified using the ProVAL “Smoothness Assurance” analysis, calculating IRI with a continuous short interval of 25 ft and the 250-mm filter applied. Only the right wheel path will be used to determine areas of localized roughness. The longitudinal limits of the corrective work shall be taken from the ProVAL “Grinding” section within the “Smoothness Assurance” analysis, using the “Default Grinding Strategy” option.

9.4.4.4 Smoothness Acceptance

The pay adjustment for smoothness and localized roughness shall be determined on the basis of Section 12.1 – Basis for Pay Adjustment.

10.0 DEFICIENT AND DEFECTIVE PAVEMENT

10.1 Deficient Pavement

Deficient pavement evaluation and repair shall be at the Contractor's expense.

10.1.1 Shallow Cracking

Shallow cracks, 2 inches or less in depth and 4 ft or less in length, shall be filled with free-flowing capillary methyl methacrylate installed by an installer skilled in such repairs. The penetration of the methyl methacrylate shall be checked by coring.

10.1.2 High Spots (Localized Roughness)

Areas of localized roughness will be identified in accordance with AASHTO R-54, using the ProVAL "Smoothness Assurance" analysis and calculating IRI with a continuous short interval of 25 ft and the 250 mm filter applied. Only the right wheel path will be used to determine areas of localized roughness. The longitudinal limits of the corrective work shall be taken from the ProVAL "Grinding" section within the "Smoothness Assurance" analysis, using the "Default Grinding Strategy" option.

High spots shall be ground. Grinding equipment that causes excessive raveling, aggregate fractures, spalls, or disturbance of the transverse and/or longitudinal joints shall not be permitted. Grinding shall remove the high spot deficiencies and shall not create surface conditions that will trap surface water runoff. Corrective work required shall be performed before thickness determinations, joint sealing, and grooving operations.

Prior to commencing corrective work by grinding, the ProVAL Grinding Simulation, with an 18-foot wheelbase grinder and a maximum grinder depth of 0.3 in. [7.62 mm], must indicate a predicted improvement to the 25 ft IRI value for sections proposed to be ground. If the grinding simulation does not predict improvement for a section, that section must be corrected by a method other than grinding or the appropriate deduction in Section 12.1 will apply.

Corrective work by diamond grinding may result in thin pavements. The Department shall determine if this condition needs to be verified by coring. Additional coring for thickness verification shall be at no cost to the Department. Thin pavement sections after diamond grinding may result in thickness price deductions.

Unless otherwise approved by the Department, corrective work shall be by an approved surface diamond grinding device consisting of multiple diamond blades.

10.1.3 Joint Spalls

Slabs with joint spall deficiency shall be repaired in accordance with the department's guidelines for concrete pavement repair.

10.2 Defective Pavement

Pavement that is deemed defective shall be repaired, or removed and replaced in accordance with the department's guidelines for concrete pavement repair.

11.0 MEASUREMENT

Portland cement concrete pavement shall be measured by the number of square yards of pavement as specified in-place, completed, and accepted. Payment will be made by lot.

12.0 PAYMENT

Payment for accepted concrete pavement shall be made at the contract unit price per square yard

12.1 Pay Adjustment

12.1.1 For Thickness Deficiency

Pay adjustment by lot will be on the basis of percent within limit determination for thickness by lot, as shown in Table 4.

Table 4. Pay adjustment factor for thickness (by lot)

Thickness Percent within Limit	Pay Adjustment Factor
➤ 100%	xx
95.0 – 99.9	xx
90.0 – 94.9	xx
85.0 – 89.9	xx
80.0 – 84.9	xx
75.0 – 79.9	xx
70.0 – 74.9	xx
65.0 – 69.9	xx
60.0 – 64.9	xx
55.0 – 59.9	xx
50.0 – 54.9	xx
< 50.0	0.50 or Remove and Replace (Department's Option)

Note: Pay adjustment factors to be determined by the Department

12.1.2 For Strength Deficiency

Pay adjustment by lot will be on the basis of percent within limit determination for thickness by lot, as shown in Table 5.

Table 5. Pay adjustment factor for strength (by lot)

Strength Percent within Limit	Pay Adjustment Factor
➤ 100%	xx
95.0 – 99.9	xx
90.0 – 94.9	xx
85.0 – 89.9	xx
80.0 – 84.9	xx
75.0 – 79.9	xx
70.0 – 74.9	xx
65.0 – 69.9	xx
60.0 – 64.9	xx
55.0 – 59.9	xx
50.0 – 54.9	xx
< 50.0	0.50 or Remove and Replace (Department’s Option)

Note: Pay adjustment factors to be determined by the Department

12.1.3 For Smoothness Deficiency

[Note: The Department’s procedure may be incorporated here to determine pay adjustment for smoothness deficiency.]

As per AASHTO R-54, the pay adjustment factors from Table 6 will be used in conjunction with the histogram printout from ProVAL’s Smoothness Assurance Module based on a report of continuous IRI with a base length of 528 ft (0.10 mile), to compute a final pay factor (incentive or disincentive). The final pay factor computed to three decimals is equal to the sum of the products of the individual pay adjustment factors shown in Table 6 times ProVAL’s corresponding histogram percentages all divided by 100. In addition to the final pay factor determined from Table 6, disincentives for localized roughness may apply as described below.

Table 6. Pay adjustment factors and computation of final pay factor

IRI range, in./mi (1)	Pay Adjustment Factors (2)	Percent of Pavement within IRI Range taken from ProVAL’s Smoothness Assurance Module (SAM) (3)	Pay Factor (4)
> ##.0	0.##	## or ##.##	## or ##.##
##.1 – ##.0	0.##	## or ##.##	## or ##.##
##.1 – ##.0	0.##	## or ##.##	## or ##.##
##.1 – ##.0	0.##	## or ##.##	## or ##.##
##.1 – ##.0	1.00	## or ##.##	## or ##.##
##.1 – ##.0	1.##	## or ##.##	## or ##.##
##.1 – ##.0	1.##	## or ##.##	## or ##.##
##.1 – ##.0	1.##	## or ##.##	## or ##.##
##.1 – ##.0	1.##	## or ##.##	## or ##.##
< ##.0	1.##	## or ##.##	## or ##.##
Final Pay Factor (PF) = (Sum/100) =		#.### or 0.###	

Note: The number of steps in the table as well as the IRI Ranges and pay adjustment factors should be set by the Department

As per AASHTO R-54, the pay adjustment factors from Table 7 will be used in conjunction with the histogram printout from ProVAL’s Smoothness Assurance Module based on a report of continuous IRI with a base length of 25 ft, to compute the percent disincentive for localized roughness. The amount of the disincentive computed to three decimals is equal to 100 minus the sum of the products of the individual adjustment factors shown in Table 7 times ProVAL’s corresponding histogram percentages. The Department will either assess the disincentive per Table 7, or require that corrective action be taken. If corrective action is required, re-profile the corrected area and provide the Department the results. If the corrective action is not successful, the Department will assess the disincentive or require continued corrective action.

Table 7. Disincentives for localized roughness

IRI range, in./mi (1)	Pay Adjustment Factors (2)	Percent of Pavement within IRI Range taken from ProVAL's Smoothness Assurance Module (SAM) (3)	Pay Factor (4)
> ###.0	0.##	.# or ##.#	#.### or ##.###
###.1 – ###.0	0.##	.# or ##.#	#.### or ##.###
###.1 – ###.0	0.##	.# or ##.#	#.### or ##.###
###.1 – ###.0	0.##	.# or ##.#	#.### or ##.###
< ###.0	1.00	.# or ##.#	#.### or ##.###
Final Percent Disincentive = (100 – Sum) =		#.### or ##.###	

Note: The number of steps in the table as well as the IRI Ranges and pay factors should be set by the Department.

The average Pay Factor for smoothness by lot shall be determined using the smoothness Pay Factor for each 528 ft segment within that lot.

12.2 Composite Pay Factor

A composite Pay Factor (CPF), by lot, shall be determined as follows:

For each of thickness and strength Pay Factors equal to or greater than 50:

$$\text{CPF (by lot)} = (\text{C} * \text{Thickness Pay Factor} + \text{D} * \text{Strength Pay Factor} + \text{E} * \text{Average Smoothness Pay Factor}) / 3.0$$

where: C, D, and E are coefficients, ranging from 0.0 to 1.0, established by the Department. Coefficients C, D, and E added must equal 1.0.

For either thickness or strength Pay Factors less than 50:

CPF (by lot) = 0.5 or the Department may elect to remove and replace the affected lot's concrete.

12.3 Pay Items

Item XXX – XX Portland Cement Concrete Pavement - per square yard.