

Innovative Concepts for Concrete Pavements

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AASHTO PP-84-17

Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures

AASHTO Designation: PP 84-17;
Tech Section: 3c, Hardened Concrete
Release: Group 1 (April 2017)

INTRODUCTION

Specifications for concrete pavement mixtures have traditionally been prescriptive, with State Highway Agencies (SHA) specifying means and methods for both constituent materials and specific requirements for proportioning. This places the majority of the performance risk on the SHA and limits innovation. Recent trends of blending cementitious materials, reducing paste content, using modern additives and admixtures, and other innovations in the industry open the opportunity to move towards specifying the performance characteristics of concrete mixtures and allowing industry to design mixtures that address specific performance requirements. New methods to evaluate concrete performance have been developed, and others are being formulated, that can result in improved performance and economics. Shifting the responsibility for performance to the contractor provides an opportunity for innovation.

SCOPE

- 1.1. This specification covers the tests methods and values for a concrete pavement mixture that considers, and includes, alternative performance characteristics for acceptance.
- 1.2. In Section 6 of this specification, SHA traditions of using prescriptive methods are respected while also offering the option to use performance measures instead.
- 1.3. This specification is intended to provide SHAs flexibility in their approach to the use of performance characteristics and includes a range of choices that can be selected to best fit the needs of the agency.
- 1.4. Performance values included are for an average concrete pavement life in the range of 30 years.
- 1.5. The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.
- 1.6. The inclusion of performance measures increases the importance of Quality Control (QC), as the acceptance criteria are predicated on a well-designed and executed QC program that includes process, production, and construction control.



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Table 3—Specification Worksheet

Section	Property	Specified Test	Specified Value	Mixture Qualification	Acceptance	Selection Details	Special Notes
6.3 Concrete Strength							
6.3.1	Flexural Strength	F 37	4.1 MPa	300 psi	Yes	Choose either as	—
6.3.2	Compressive Strength	F 22	24 MPa	3500 psi	Yes	Both	—
6.4 Reducing Unwanted Slab Warping and Cracking Due to Shrinkage (if cracking is a concern)							
6.4.1.1	Volume of Void	—	2%	—	Yes	No	Choose only one
6.4.1.2	Unseasoned Volume Change	AASHTO C137	450 µm	At 28 days	Yes	No	Comp. condition
6.4.1.3	Unseasoned Volume Change	AASHTO C137	100, 400, 400 µm	At 91 days	Yes	No	—
6.4.2.1	Seasoned Shrinkage	T 104	Crack free	At 180 days	Yes	No	—
6.4.2.2	Seasoned Shrinkage	TP 553C	≤ 0.06%/ft	At 7 days	Yes	No	Dead end test is currently under consideration as an AASHTO Provisions Test Method
6.4.2.3	Probability of Cracking	Appendix C1	As specified	—	Yes	No	—
6.4.2.4	Quality Control Check	—	—	—	No	Yes	Variation controlled with mixture proportion observation or P factor and process variation
6.5 Durability of Hydrated Cement Paste for Freeze-Thaw Durability							
6.5.1.1	Water to Cement Ratio	—	0.43	—	Yes	A	—
6.5.1.2	Fine-Air Content	T 151, T 199, TP 118	5 to 8	No	Yes	Yes	Choose only one
6.5.1.3	Fine-Air Content (SAM)	T 151, T 199, TP 118	10% max. @ 2	No. psi	Yes	Yes	—
6.5.1.4	Time of Critical Saturation	Bucket Test Specification	30	30	Yes	No	** Variations controlled with mixture proportion observation or P factor and process variation
6.5.1.5	Deicing Salt Damage	—	0%	65M	Yes	Yes	Choose only one
6.5.1.6	Deicing Salt Damage	M 216	—	Typical treatment	Yes	Yes	See section on suspension chloride used in specified section
6.5.1.7	Calcium Hydroxide Limit	Test used in AASHTO	0.15 g Ca(OH) ₂ /g paste	—	Yes	No	See section on suspension chloride used
6.6 Transport Properties							
6.6.1	Water to Cementitious Ratio	—	0.43 or 0.38	—	Yes	Choose only one	The required maximum ratio to construction ratio is selected based on freeze-thaw conditions
6.6.2	Porosity Factor	Table 1	250 or 1000	—	Yes	Yes	Based on freeze-thaw conditions, other ratios could be selected
6.6.3	Ion Permeation, P Factor	Appendix C1	15 mm or 10 yr	Yes, P	Through p.	—	Decreased using guidance provided in Appendix C1
6.7 Aggregate Stability							
6.7.1	D-Cracking	T 101, ASTM C1404	—	—	Yes	No	—
6.7.2	Atkins Aggregate Reaction	R 30	—	—	Yes	No	—
6.8 Workability							
6.8.1	Box Test	Appendix C2	-0.23 mm - 10% surface void	—	No	—	—
6.8.2	Modified V-Notch Test	Appendix C3	15-30 mm/min	—	No	—	—

Strength

Shrinkage

Freeze Thaw Durability

Permeability

Aggregate Properties

Workability

Long Life Concrete Pavement (LLCP)

LLCP Specification: Pub. 408, Section 530 approved by FHWA January 7, 2016.

PTM 529 Optimized Aggregate: Established December 2015.

Components of LLCP

- > Aggregate Absorption 3% for Gravel, 2% all other (3.5 for Type A, 3.5 Type B)
- > Cement factor 517 to 611 lbs./CY
- > W/CM = 0.37 to 0.42
- > Mix Design to meet Maximum Permeability (2000 Coulombs 56 days) & Shrinkage (500 macrostrains 28 days)
- > Air content of 7%, ±1.5% in plastic state.

- > Dowel Bars: Stainless Steel, bars, sleeves, filled, pipes capped. Zinc alloy sleeves. Glass Fiber Reinforced Polymer coated steel bars.

- > Use of PAMS curing (Poly-Alpha Methyl-styrene)
- > Incentives for: w/c Ratio.

> Use Guidelines to be developed in conjunction with spec.

- Interstates
- Interstate Look-a-likes
- Projects over certain ADT
- Projects greater than 20,000 SY.



Super Air Meter (SAM)



The Super Air Meter (SAM) is a testing device that measures both the air void size and air volume of plastic (fresh) concrete in about 10 minutes.

The device can make almost real-time measurements of the size of the air bubbles as the concrete is being produced so that real-time changes can be made to control the size of the air bubbles.

Controlling the size of air bubbles is useful to ensure that concrete that is freeze thaw durable is being produced.

The device can also provide critical insights into how different additives or construction processes impact the size of the bubbles in the concrete mixture.

This can help reduce rejected concrete and ensure that freeze thaw durable concrete is being used.



Permeability (Transport Properties)



Current – AASHTO T 277

Evaluating – AASHTO T 358 Surface Resistivity

W / C Ratio below 0.45 for areas with deicer application

Future – Saturated Formation Factor.

Table 1—Saturated *F* Factor, RCPT and Resistivity

Chloride Ion Penetrability	Greatest Saturated Formation Factor ^a	Lowest Saturated Formation Factor ^a	Minimum Charge Passed @ 6 hours ^b Coulombs	Maximum Charge Passed @ 6 hours ^b Coulombs	Greatest Resistivity ^c KΩ-cm	Lowest Resistivity ^c KΩ-cm
High	500	—	4000	—	5	—
Moderate	1000	500	2000	4000	10	5
Low	2000	1000	1000	2000	20	10
Very Low	20000	2000	100	1000	200	20
Negligible	—	20000	0	100	—	200

Optimized Aggregate Concrete Mixtures

Commonwealth of Pennsylvania
Department of Transportation

PA Test Method No. 329
July 2016
4 Pages

LABORATORY TESTING SECTION

Method of Test for
DETERMINING THE OPTIMIZED AGGREGATE GRADATION FOR INTERMEDIATE CONCRETE PAVEMENT MIX DESIGNS

1. SCOPE

1.1 This method describes a procedure for analyzing combined aggregate gradations for use in optimized concrete pavement mix designs.

2. OUTLINE OF METHOD

2.1 The development of an optimized concrete mix gradation results calculation of the combined gradation of aggregates to be included in a concrete pavement mix and identification of the percent of cementitious material retained on all required sieves on the percent retained chart to determine the desired characteristics of the combined aggregate structure. The basic of trial mix design components is one cubic yard.

3. APPARATUS

3.1 The apparatus used for sampling aggregates and performing sieve analysis will be as provided in PFM 44F and PFM 45G.

4. PROCEDURE

4.1 Sieve Analysis

4.1.1 Submit a sieve analysis report for the proposed aggregate showing the cumulative combined percent passing, the cumulative combined percent retained, and the combined percent retained as shown in Table 1. Example Sieve Analysis includes all standard sieve sizes in the sieve analysis report beginning with the maximum nominal aggregate size of the proposed aggregate and proceeding in descending particle size to include the No. 200 sieve.

4.1.2 Perform sieve analysis in accordance with PFM 41B for each aggregate to be used in the mix. Complete the Sieve Analysis Report for the blended aggregate by calculating the cumulative combined percent passing, the cumulative combined percent retained, and the combined percent retained. Use the sieve analysis percent passing results of each aggregate gradation, the percentage of each aggregate for the concrete mix, and the following equation for the calculation.

4.1.3 Determine the percent of each aggregate used in the mix design combined aggregate gradation.

- Reduced water demand
- Reduction of cementitious materials, if allowed
- Reduces paste content thus reduced shrinkage potential
- Strength Increase
- Longer service life



Combined grading is used to obtain the greatest aggregate density with the materials at hand

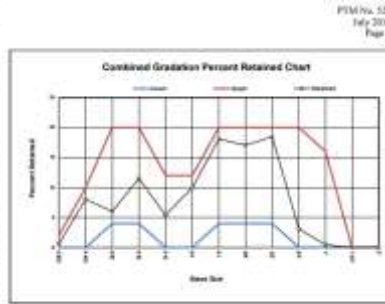
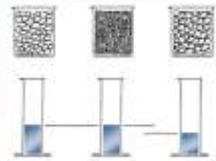


Figure 1 - 1 Combined Percent Retained Chart



Workability (Box Test)

Not an acceptance test (Producer discretion)

<p>Step 1</p> <p>Assemble the components. Hand trowel surface into level and the concrete level at 240 mm (19.3 in.)</p>	<p>Step 2</p> <p>From top surface of concrete, release straight downward the 4'.</p>
<p>Step 3</p> <p>Slow, steady weight removal for 7 s, then remove volume.</p>	<p>Step 4</p> <p>After removing the 4-lb weight and forms, inspect the sides for surface voids and edge chipping.</p>

<p>4</p> <p>Over 50 percent overall surface voids</p>	<p>3</p> <p>30-49 percent overall surface voids</p>
<p>2</p> <p>10-29 percent overall surface voids</p>	<p>1</p> <p>Less than 10 percent overall surface voids</p>

Pictures courtesy of the Oklahoma Transportation Center



Maturity Meter

Maturity Meter (ASTM C1074)

Widely used to monitor strength gain in concrete structures (buildings, bridges), paving applications include early opening to traffic, timing of joint sawing.

Publication 408 Sections that reference PTM 640 (maturity) for measuring strength to open a pavement for traffic are listed below.

These are all new/recently revised specifications.

- 501 (reinforced/plain concrete pavement)
- 530 (long-life concrete pavement)
- 540 (bonded concrete over asphalt)
- 548 (unbonded concrete over concrete)

Sections that do not reference PTM 640

- 516 (full-depth patching)
- 523 (ultra-thin concrete overlay)
- 525 (partial-depth repair)
- 545 (bonded concrete over concrete)



Non-destructive Testing (NDT) for Concrete Thickness – PTM 605 Magnetic Imaging Tomography (MIT)



PTM 605 (Effective January 2016)

- > An electromagnetic pulse induction device that creates a variant magnetic field
- > Steel targets 11.8 inches in diameter (24 gauge) are nailed to the base
- > Three readings at each target



Real-Time Smoothness



- ✓ Two commercially accepted manufacturers (2016):
 - Ames Real-Time Profiler (Laser),
 - Gomaco Smoothness Indicator (Ultrasonic sensors).
- ✓ Both systems use height, slope and distance data continuously fed to software during concrete placement.
- ✓ Having real-time information allows contractor to:
 - Immediately make process adjustments,
 - Make corrections during finishing.



Thank You

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