ARIZONA DEPARTMENT OF TRANSPORTATION * MATERIALS GROUP

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CHANGE LETTER

James P. Delton
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MATERIALS TESTING MANUAL	CHANGE LETTER NO. 24
SUBJECT: Title Page; Table of Contents; Cover Sheets for Series 100, Series 200, Series 300, and Series 700; Arizona Test Methods 251a, 318, 729b, 730, and 742; ASTM Test Method D 4491.	EFFECTIVE DATE: March 31, 2010

SUMMARY:

NOTE: Unless otherwise specified, changes issued under this Change Letter are effective for projects with a bid opening date on or after March 31, 2010. Retain items removed from the Materials Testing Manual under this change letter for use as necessary on projects with a bid opening date prior to March 31, 2010.

1. TITLE PAGE - The Title Page has been revised to show the latest Change Letter number and revision date. Please replace the existing Title Page with the attached.

2. TABLE OF CONTENTS - The Table of Contents has been revised to reflect the changes made in this Change Letter. Please replace the existing Table of Contents with the attached.

3. The following items are revised by this Change Letter. Please replace the respective existing items with the attached.

   Series 100 Cover Sheet, "SAMPLING" (March 31, 2010).

   Series 200 Cover Sheet, "SOILS AND AGGREGATES" (March 31, 2010).

   Series 300 Cover Sheet, "CONCRETE" (March 31, 2010).

   Series 700 Cover Sheet, "CHEMICAL AND SPECIALTY" (March 31, 2010).

Arizona Test Method 251a, "COMBINED COARSE AND FINE AGGREGATE SPECIFIC GRAVITY AND ABSORPTION".

Arizona Test Method 729b, "EXCHANGABLE SODIUM IN TOPSOIL".

4. The following items are added by this Change Letter.

   Arizona Test Method 318, "ESTIMATING THE DEVELOPMENT OF CONCRETE STRENGTH BY THE MATURITY METHOD".

   Arizona Test Method 742, "MEAN MACROTEXTURE DEPTH OF MILLED PAVEMENT".

5. The following item is deleted by this Change Letter.

   Arizona Test Method 730, "GEOTEXTILE FABRIC PERMITTIVITY MEASUREMENT BY THE FALLING HEAD METHOD".

   NOTE: Arizona Test Method 730 has been replaced by ASTM D 4491, "WATER PERMEABILITY OF GEOTEXTILES BY PERMITTIVITY".

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Attachments

MATERIALS

TESTING MANUAL

SAMPLING AND TESTING PROCEDURES

PREPARED BY:
ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION
MATERIALS GROUP

REVISED TO CHANGE LETTER NO. 24
(March 31, 2010)

March 31, 2010
(5 Pages)

MATERIALS TESTING MANUAL

TABLE OF CONTENTS

****** The above Arizona Test Methods, and also commonly used AASHTO procedures in this category, are shown on Series 200 Cover Sheet (March 31, 2010).

SERIES 300 CONCRETE**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures in this category are show on Series 300 Cover Sheet (March 31, 2010).

SERIES 400 BITUMINOUS MIXTURES**

****** The above Arizona Test Methods, and also commonly used AASHTO procedures in this category, are show on Series 400 Cover Sheet (November 14, 2008).

SERIES 500 BITUMINOUS MATERIALS**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures and specifications are shown on Series 500 Cover Sheet (July 15, 2005).

SERIES 600 CEMENT AND RELATED MATERIALS**

****** Commonly used AASHTO and ASTM procedures in this category are show on Series 600 Cover Sheet (July 15, 2005).

SERIES 700 CHEMICAL AND SPECIALTY**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures in this category are show on Series 700 Cover Sheet (March 31, 2010).

March 31, 2010
(1 Page)

SERIES 100

SAMPLING

The following methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Sampling Bituminous Materials…………………………………	ARIZ 103a
Sampling Bituminous Mixtures…………………………………..	ARIZ 104c
Sampling Soils and Aggregates………………………………..	ARIZ 105d
Sampling Hydrated Lime and Lime Products………………….	ARIZ 108
Sampling Metallic Materials………..………………………….	ARIZ 109
Sampling Miscellaneous Materials…………………………….	ARIZ 110

Note: Sampling of crumb rubber is performed in accordance with Arizona Test Method 714.

AASHTO TEST METHODS:

TITLE	DESIGNATION
Sampling and Testing Brick ……………………………………...	T 32
Sampling and Amount of Testing of Hydraulic Cement ....…...	T 127
Sampling Freshly Mixed Concrete ....….	T 141
Reducing Samples of Aggregate to Testing Size………………	T 248

NOTE: It shall be assured that the appropriate methods as given in the project requirements are being adhered to.

NOTE: Refer to Series 900, "Materials Quality Assurance Program", of the Materials Testing Manual for current guidelines on sampling of materials for acceptance, independent assurance, and correlation testing.

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(4 Pages)

SERIES 200

SOILS AND AGGREGATES

The following test methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
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Composite Grading……………………………………………	ARIZ 205c
Specific Gravity and Absorption of Coarse Aggregate……….	ARIZ 210b
Specific Gravity and Absorption of Fine Aggregate…………..	ARIZ 211d
Percentage of Fractured Coarse Aggregate Particles……….	ARIZ 212e
Determination of Cement Content Required for Cement Treated Mixtures……………………………….	ARIZ 220
Moisture-Density Relations of Cement Treated Mixtures…………………………………………………….	ARIZ 221
Rock Correction Procedure for Maximum Density Determination of Cement Treated Mixtures………………	ARIZ 222b
Field Density of Cement Treated Mixtures by Sand Cone Method or by Rubber Balloon Method…..	ARIZ 223
Maximum Dry Density and Optimum Moisture of Soils by Proctor Method A……………………………….	ARIZ 225a
Maximum Density and Optimum Moisture of Soils – Methods C and D………………………………….	ARIZ 226
Rock Correction Procedure for Maximum Dry Density and Optimum Moisture Content Determination…………	ARIZ 227c

ARIZONA TEST METHODS: (continued)

ARIZONA TEST METHODS: (continued)

AASHTO TEST METHODS:

AASHTO TEST METHODS: (continued)

TITLE	DESIGNATION
Resistance R-Value and Expansion Pressure of Compacted Soils	T 190
Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester	T 217
Determination of Strength of Soil-Lime Mixtures	T 220
Reducing Field Samples of Aggregates to Testing Size	T 248
Total Evaporable Moisture Content of Aggregate by Drying	T 255
Laboratory Determination of Moisture Content of Soils	T 265

NOTE: It shall be assured that the appropriate test methods as given in the project requirements are being adhered to.

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(2 Pages)

SERIES 300

CONCRETE

The following test methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Method of Adjusting Concrete Mixes for Variations in Moisture Content……………………………………….	ARIZ 308a
Testing Impervious Materials and Compounds for Curing Concrete……………………………………….	ARIZ 309a
Measuring Texture Depth of Portland Cement Concrete with Metal Tine Finish..…………………….	ARIZ 310a
Method of Test for Flow of Grout Mixtures (Flow Cone Method)………………………….……………..	ARIZ 311a
Compressive Strength of Cylindrical Concrete Specimens……………………………………..	ARIZ 314b
Precast Mortar Blocks Test…………………………….……	ARIZ 315
Obtaining and Testing Drilled Cores and Sawed Beams of Concrete……………………...……….	ARIZ 317a
Estimating the Development of Concrete Strength by the Maturity Method……………..……..………...	ARIZ 318

AASHTO & ASTM TEST METHODS:

TITLE	DESIGNATION AASHTO	DESIGNATION ASTM
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Flexural Strength of Concrete (Using Simple Beam with Third - Point Loading) …….....	T 97	
Slump of Hydraulic Cement Concrete	T 119	
Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete	T 121	
Air Content of Freshly Mixed Concrete by the Pressure Method	T 152	
Capping Cylindrical Concrete Specimens	T 231	
Making and Curing Concrete Test Specimens in the Laboratory	R 39	
Temperature of Freshly Mixed Hydraulic-Cement Concrete		C 1064
Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders ………………………………..........		C 1231

NOTE: It shall be assured that the appropriate test methods as given in the project requirements are being adhered to.

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(2 Pages)

SERIES 700

CHEMICAL AND SPECIALTY

The following test methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Testing of Paint, Varnish, Lacquer, and Related Material….	ARIZ 702a
Sampling and Sieving of Crumb Rubber…………………....	ARIZ 714b
Heating and Drying Materials in Microwave Oven…………	ARIZ 719c
Tensile Proof Dowel Test…………………………………….	ARIZ 725a
Reflectance, Dry Opacity, and Yellowness Index of Traffic Paint……………………………………....	ARIZ 726a
Chloride in Hardened Concrete…………………………….	ARIZ 727a
Exchangeable Sodium in Topsoil…………………………..	ARIZ 729b
Calcium Carbonate in Topsoil (Neutralization Potential of Topsoil)………………………………………………….…….	ARIZ 732
Sulfate in Soils……………………………………….………	ARIZ 733a
Determination of Portland Cement Content in Cement Treated Base Material…………………………….	ARIZ 734
Testing of Thermoplastic Pavement Marking Material………	ARIZ 735a
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Chloride in Concrete Admixtures……………………………….	ARIZ 738
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AASHTO & ASTM TEST METHODS:

TITLE	DESIGNATION AASHTO	DESIGNATION ASTM
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Sampling and Testing Brick	T 32	
Preformed Expansion Joint Filler for Concrete Construction	T 42	
Mass [Weight] of Coating on Iron or Steel Articles with Zinc or Zinc-Alloy Coatings	T 65	
Mechanical Testing of Steel Products	T 244	
Roundness of Glass Spheres		D 1155
Rubber Property - Durometer Hardness		D 2240
Water Permeability of Geotextiles by Permittivity		D 4491
Rockwell Hardness of Metallic Materials		E 18

NOTE: It shall be assured that the appropriate test methods as given in the project requirements are being adhered to.

COMBINED COARSE AND FINE AGGREGATE SPECIFIC GRAVITY AND ABSORPTION

(An Arizona Method)

1. SCOPE

(a) This procedure describes the method which is used to determine the combined coarse and fine aggregate specific gravity and absorption when the specific gravity and absorption of the fine aggregate and the coarse aggregate are known. Arizona Test Method 210 describes the procedure for determining the coarse aggregate specific gravity and absorption. Arizona Test Method 211 describes the procedure for determining the fine aggregate specific gravity and absorption.

(b) This procedure also contains provisions for calculating the combined specific gravity and combined absorption when it is desired to perform those calculations for coarse aggregate, fine aggregate, and mineral admixture.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. CALCULATIONS

(a) Combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity for coarse aggregate and fine aggregate is determined by the following:

$$\text{Combined Specific Gravity} = \frac{P_c + P_f}{\dfrac{P_c}{G_c} + \dfrac{P_f}{G_f}}$$

Where:
P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
$P_c + P_f$ = 100
G_c = Specific Gravity of Coarse Aggregate
G_f = Specific Gravity of Fine Aggregate

Example:

P_c = 41
P_f = 59
G_c = 2.597
G_f = 2.626

$$\text{Combined Specific Gravity} = \frac{41 + 59}{\frac{41}{2.597} + \frac{59}{2.626}} = 2.614$$

(b) Combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity for coarse aggregate, fine aggregate, and mineral admixture, is determined by the following:

$$\text{Combined Specific Gravity} = \frac{P_c + P_f + P_{admix}}{\frac{P_c}{G_c} + \frac{P_f}{G_f} + \frac{P_{admix}}{G_{admix}}}$$

Where:
P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
P_{admix} = Percent of Mineral Admixture, by weight of the mineral aggregate
$P_c + P_f + P_{admix}$ = 100 + % Mineral Admixture
G_c = Specific Gravity of Coarse Aggregate
G_f = Specific Gravity of Fine Aggregate
G_{admix} = Specific Gravity of Mineral Admixture

Type I or II Cement = 3.14
Type IP Cement = 3.00
Hydrated Lime = 2.20

Example:

P_c = 41
P_f = 59
P_{admix} = 1.0%
G_c = 2.597
G_f = 2.626
Type of Mineral Admixture = Hydrated Lime
Mineral Admixture Specific Gravity = 2.20

$$\text{Combined Specific Gravity} = \frac{41 + 59 + 1.0}{\frac{41}{2.597} + \frac{59}{2.626} + \frac{1.0}{2.20}} = 2.609$$

(c) Combined absorption for coarse aggregate and fine aggregate is determined by the following:

$$\text{Combined Absorption} = \frac{(P_c \times A_c) + (P_f \times A_f)}{P_c + P_f}$$

Where: P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
$P_c + P_f$ = 100
A_c = Percent water absorption of coarse aggregate
A_f = Percent water absorption of fine aggregate

NOTE: The equation shown above for combined absorption differs from that currently shown in Arizona Test Methods 210 and 211. In the future, appropriate changes in these test methods will be made to reflect the above equation, but in the interim period the calculation shall be performed as shown above.

Example:
P_c = 41
P_f = 59
A_c = 1.51
A_f = 1.43

$$\text{Combined Absorption} = \frac{(41 \times 1.51) + (59 \times 1.43)}{41 + 59} = 1.46\%$$

(d) Combined absorption for coarse aggregate, fine aggregate, and mineral admixture, is determined by the following:

$$\text{Combined Absorption} = \frac{(P_c \times A_c) + (P_f \times A_f) + (P_{admix} \times A_{admix})}{P_c + P_f + P_{admix}}$$

Where:

P_c = Percent of Coarse Aggregate

P_f = Percent of Fine Aggregate

P_{admix} = Percent of Mineral Admixture, by weight of the mineral aggregate

$P_c + P_f + P_{admix}$ = 100 + % Mineral Admixture

A_c = Percent water absorption of coarse aggregate

A_f = Percent water absorption of fine aggregate

A_{admix} = Percent water absorption of mineral admixture (assumed to be 0.0%)

Example:

P_c = 41

P_f = 59

P_{admix} = 1.0

A_c = 1.51

A_f = 1.43

A_{admix} = 0.0

$$\text{Combined Absorption} = \frac{(41 \text{ x } 1.51) + (59 \text{ x } 1.43) + (1.0 \text{ x } 0.0)}{41 + 59 + 1.0} = 1.45\%$$

3. REPORT

(a) Report combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity to the nearest 0.001, and indicate the type of specific gravity, whether Bulk (Oven Dry), Bulk (SSD), or Apparent.

(b) Report combined absorption to the nearest 0.01%.

(c) Report whether the combined specific gravity and absorption is for coarse aggregate and fine aggregate, or whether the combined specific gravity and absorption is for coarse aggregate, fine aggregate, and mineral admixture.

ARIZ 729b
March 31, 2010
(4 Pages)

EXCHANGEABLE SODIUM IN TOPSOIL

(An Arizona Method)

1. SCOPE

(a) This test method is used to compare or qualify topsoil for cultivation of plants insofar as the proportion of exchangeable sodium among the four major cations (Sodium, Potassium, Calcium, and Magnesium) is related to plant welfare. "Exchangeable" is defined by the method itself and is based on the exchange of ammonium ion from the reagent Ammonium Acetate Solution with the four major cations under the conditions given by the method. The four cations are brought into solution by the reagent and their concentrations in solution are determined by Atomic Absorption or Flame Emission Spectrophotometry.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

(a) Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(1) No. 12 sieve.

(2) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 gram.

(3) Plastic vials, 1-1/4 inches in diameter and 4 inches in length, with caps.

(4) Reciprocating shaker capable of 180 cycles per minute, with carrier for holding vials in place.

(5) Sodium-free quantitative filter paper, 11 cm diameter.

(6) Atomic Absorption or Flame Emission Spectrophotometer capable of determining Sodium, Potassium, Calcium, and Magnesium.

3. REAGENTS

(a) Ammonium Acetate Solution, 1 Normal. (Measure 57 mL reagent glacial acetic acid into a 1 liter volumetric flask and dilute to 500 mL with deionized water. Add 69 mL reagent concentrated ammonium hydroxide. Dilute to approximately 950 mL with deionized water and mix. Adjust pH to 7.0 using glacial acetic acid or ammonium hydroxide dropwise as necessary. Dilute to the mark with deionized water.)

(b) Sodium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(c) Potassium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(d) Calcium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(e) Magnesium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(f) Hydrochloric Acid Solution, 50%. (Dilute concentrated reagent grade hydrochloric acid 1:1 with deionized water.)

(g) Lanthanum Chloride Reagent Solution, 0.26%. (Weigh 1.30 grams anhydrous reagent grade lanthanum chloride into a 500 mL volumetric flask. Dilute to the mark with deionized water.)

4. PROCEDURE

(a) Weigh 2.00 grams of soil, passing a No. 12 sieve into a plastic vial.

(b) Pipette 40.0 mL Ammonium Acetate Solution into the vial, and cap it.

(c) Place vial into carrier of reciprocating shaker. Shake at 180 cycles per minute for exactly 5 minutes.

(d) Immediately filter into a clean vial. (The folded filter paper can be placed onto the rim of the vial instead of using a funnel.) Cap the vial. This is the Original Extract Solution.

(e) Prepare a diluted solution by transferring a suitable aliquot from the Original Extract Solution to a volumetric flask, adding hydrochloric acid to 1% and lanthanum chloride to 26 mg/liter. (If a 50 mL flask is used, 1.0 mL of Hydrochloric Acid Solution and 0.5 mL of Lanthanum Chloride Reagent Solution is required.) The dilution is made with deionized water. This is the Diluted Extract Solution. The dilution should be sufficient to bring the absorbances of the four elements to values below those of the Standard Solution.

(f) Prepare a solution with concentrations of 1.00 mg/liter of sodium, 2.00 mg/liter of potassium, 5.00 mg/liter of calcium, and 0.50 mg/liter of magnesium. This solution should have 1% strength hydrochloric acid and 26 mg/liter lanthanum chloride. The dilution is made with deionized water. This is the Standard Solution.

(g) Prepare a solution with 1% Hydrochloric Acid and 26 mg/liter Lanthanum Chloride in deionized water. This is the Reagent Blank Solution.

(h) Perform an Atomic Absorption or Flame Emission Spectrophotometric analysis using the Diluted Extract Solution, the Standard Solution, and the Reagent Blank Solution. (The instrumental parameters, given in the table below are recommended for the analysis.) Determine the concentration of each of the four cations in the Original Extract Solution to the nearest 0.1 mg/liter. If the concentration of any element in the Diluted Extract Solution is higher than that in the Standard Solution, a more dilute Diluted Extract Solution should be prepared as in paragraph 4(e).

ELEMENT	WAVELENGTH	FLAME
Sodium	589.2	Air-Acetylene
Potassium	766.5	Air-Acetylene
Calcium	422.7	Air-Acetylene
Magnesium	285.2	Air-Acetylene

5. CALCULATIONS

(a) Calculate the concentration of exchangeable cations in milliequivalents per 100 grams (meq /100 g) of soil using the following formulas:

$$C'_{Na} \text{ (in meq/100 g)} = (0.087) \times (C_{Na})$$

$$C'_{K} \text{ (in meq/100 g)} = (0.051) \times (C_{K})$$

$$C'_{Ca} \text{ (in meq/100 g)} = (0.100) \times (C_{Ca})$$

$$C'_{Mg} \text{ (in meq/100 g)} = (0.165) \times (C_{Mg})$$

Where: C_{Na}, C_{K}, C_{Ca}, or C_{Mg} is the concentration of each cation, in mg/liter, respectively in the Original Extract Solution.

(b) Compute the total Cation Exchange Capacity (CEC) of the soil, which is the sum of the four exchangeable cation concentrations, as follows:

$$\text{CEC (in meq/100 g)} = C'_{Na} + C'_{K} + C'_{Ca} + C'_{Mg}$$

(c) Compute the Exchangeable Sodium Percentage (ESP), which is the exchangeable sodium proportion of the total Cation Exchange Capacity, as follows:

$$\text{ESP} = \frac{C'_{Na}}{\text{CEC}} \times 100$$

(d) Compute the Exchangeable Sodium (ES) in the soil, in parts per million, using the following formula:

$$\text{ES (in ppm)} = (20) \times (C_{Na})$$

6. REPORT

(a) Report Exchangeable Sodium Percentage (ESP) to the nearest 0.1 percent.

(b) Report Exchangeable Sodium (ES) to the nearest 1.0 ppm.

ARIZ 318
March 31, 2010
(8 Pages)

ESTIMATING THE DEVELOPMENT OF CONCRETE STRENGTH BY THE MATURITY METHOD

(An Arizona Method)

1. SCOPE

(a) This test method provides a procedure for estimating the development of concrete strength by means of the maturity method.

NOTE: See ASTM C1074 and AASHTO T325 for additional information regarding this procedure.

(b) This procedure is normally used, when desired, for Class S and Class P concrete; however, if directed by the Engineer, it may be used for other classes of concrete.

(c) The concept of the maturity method is based on the combined effects of concrete age and temperature during the hydration process on the rate of strength gain for a specific mix.

(d) This method requires the establishment of a relationship curve between compressive strength and calculated maturity index for a specific concrete mixture (mix design) prior to placement of the mixture in the field.

(e) This procedure may not be used to estimate the strength of mass concrete unless the strength-maturity relationship is developed at elevated temperatures. Mass concrete is defined as concrete which has a least dimension of three feet or more.

(f) The maturity method shall not substitute for compressive strength acceptance testing (28-day test cylinder breaks).

(g) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(h) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. TERMINOLOGY

(a) Maturity - The extent of development of concrete properties that are dependent on the hydration of cementitious materials.

(b) Maturity Function - A mathematical expression that converts the temperature history of concrete to an index, which indicates its maturity.

(c) Maturity Index - An index, calculated by using a maturity function, which can be used as an indicator of strength development in concrete.

(d) Strength-Maturity Relationship - An empirical relationship between concrete strength and its maturity index, determined by comparing the strength of concrete cylinders, made from a specific concrete mix, to their maturity index at the time of strength testing.

3. SIGNIFICANCE AND USE

(a) The estimated strength of in-place concrete determined by this procedure provides guidance useful in making decisions concerning:

(1) Removal of formwork and reshoring.

(2) Post-tensioning.

(3) Opening of the roadways to traffic.

(4) Initiation of strength tests, such as coring and pullout tests, on the in-place concrete.

(b) The most critical limitations of the procedures presented are:

(1) Concrete must be cured in a condition that supports the reaction of cementitious materials.

(2) Batching or placement errors that are not detected.

(3) Curing errors other than those that affect temperature that are not detected.

(4) The actual strength of the concrete that is not measured.

(c) This method provides technical personnel with a coordinated procedure for:

(1) Developing a strength-maturity relationship for the approved concrete mix design in the laboratory.

(2) Determining the temperature history of the in-place concrete.

(3) Determining the maturity index of the in-place concrete.

(4) Using the strength-maturity relationship and the maturity index to estimate the strength of the in-place concrete.

4. MATURITY METHOD

(a) The temperature-time factor (Nurse-Saul) method shall be used to determine the maturity index.

(b) Unless otherwise directed by the Engineer, maturity digital data loggers shall be set at a datum factor of 0 °C.

5. APPARATUS

(a) A maturity meter capable of reading a maturity digital data logger that has a secure method of collecting un-interruptible and un-alterable data, subsequent to the concrete pour and initial concrete set, for a minimum of 28 days. The system shall be accurate to at least ± 1 °C.

(b) Maturity digital data loggers shall contain a real time clock and be capable of:

(1) Recording the current temperature, in real time, as well as the temperature history in real time.

(2) Recording the maximum and minimum temperatures along with an associated and corresponding time stamp of the concrete placement for this same period.

(3) Variable datum factors inputs.

(c) Documentation shall be provided by the manufacturer that certifies the accuracy of the maturity meter and digital data loggers.

6. PROCEDURE TO DEVELOP STRENGTH-MATURITY RELATIONSHIP

(a) A strength-maturity relationship curve shall be developed for a specific concrete mix prior to using this method on the project.

(b) As described in paragraphs 6(c) and 6(d) below, the strength-maturity relationship curve is developed utilizing compressive strength cylinders which have been fabricated, cured, and tested from a trial batch as described in ADOT Materials Policy and Procedure Directive No. 15. The concrete mixture shall meet the specification (design mix) requirements in order to determine the strength-maturity relationship curve. The concrete mixture shall be at or above the target air content.

(c) The compressive strength testing for the development of the strength-maturity relationship curve shall be performed as follows:

(1) This procedure requires the initial casting of at least 17 strength test cylinders. The test cylinders shall be fabricated in accordance with the requirements of AASHTO T23. A minimum of fifteen cylinders will be tested for compressive strength as described below. Two cylinders will be outfitted with maturity digital data loggers.

(2) Compressive strength tests shall be performed on three cylinders, at a minimum of five different ages encompassing the age at which the desired strength is needed. Compressive strength testing shall be performed in accordance with the requirements of Arizona Test Method 314. More cylinders may be fabricated, cured, and tested at additional ages if desired.

(3) The compressive strength of each of the three test cylinders at each age and their average compressive strength shall be determined. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three test cylinders differ by more than 10 percent from the average of the three, the results of both will be discarded and the compressive strength shall be the strength of the remaining cylinder.

(d) The following information shall be provided to the Regional Materials Engineer and the Resident Engineer prior to using this method on the project:

(1) The ADOT Project/TRACS number.

(2) Concrete Product Code and the source of each material (aggregate, cement, supplementary cementitious material, and admixtures).

(3) Date(s) and times(s) that compressive strength testing of the cylinders is performed.

(4) The air content, slump, water content, and the water/cementitious material ratio for each batch of concrete tested.

(5) The amount and type of admixtures used in the concrete mixture.

(6) The strength of each test cylinder and the average strength of the test cylinders at each test age.

(7) The maturity index for each instrumented test cylinder and the average maturity index for the instrumented test cylinders at each test age.

(8) A graph of the plotted points for the average compressive strength at each age versus the average maturity index at each age, and the best-fit curve. An example of such a graph is shown in Figure 1. To be acceptable, the plotted points shall produce a correlation coefficient (R^2) of at least 0.90.

7. PLACEMENT OF DIGITAL DATA LOGGERS IN THE FIELD

(a) Maturity digital data loggers shall be placed as follows, either prior to concrete placement (with maturity digital data loggers properly secured in their proper location) or into the fresh concrete following the placement of concrete.

(1) For Class P [Portland Cement Concrete Pavement (PCCP)], a minimum of one maturity digital data logger shall be placed for every 100 cubic yards or fraction thereof, or as directed by the Engineer. Maturity digital data loggers shall be placed at approximately mid-depth of the concrete pavement and no less than 12 inches from the edge of the concrete pavement.

(2) For structural concrete (Class S), a minimum of one maturity digital data logger shall be placed for every 50 cubic yards or fraction thereof, or as directed by the Engineer. At least two additional maturity digital data loggers shall be available to be placed as directed by the Engineer. Maturity digital data loggers shall be embedded in the concrete at locations that are considered critical in terms of exposure conditions, structural requirements, or as directed by the Engineer.

(3) If maturity digital data loggers are used for other than Class S or Class P concrete, they shall be placed as directed by the Engineer.

(b) Activate the maturity digital data loggers as soon as practicable after concrete placement, but not before the maturity digital data loggers are fully encapsulated in concrete.

8. FIELD VALIDATION OF STRENGTH-MATURITY RELATIONSHIP

(a) The maturity method does not account for variations in strength due to proportioning, mixing, placing, and moisture conditions of the field-placed concrete. Proper curing of the concrete and minimizing moisture loss is critical in achieving reliable strength-maturity relationship results.

(b) During the initial use of this method for the concrete mixture for which the strength-maturity relationship has been developed, a field validation of the strength-maturity relationship shall be performed. A minimum of three compressive strength test cylinders shall be made, cured, handled, protected, and transported in accordance with the requirements of AASHTO T23. In addition, a minimum of one test cylinder shall be fabricated in the same manner as the three compressive strength test cylinders, and at least one maturity digital data logger shall be embedded in the additional cylinder(s), as close to the center (± 1/2 inch) of the cylinder as possible. The three compressive strength cylinders shall be tested in accordance with the requirements of Arizona Test Method 314. The average compressive strength of the three test cylinders shall be determined. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three test cylinders differ by more than 10 percent from the average of the three, the results of both will be discarded and the compressive strength shall be the strength of the remaining cylinder. The Regional Materials Engineer or the Resident Engineer shall determine if more concrete cylinders are to be fabricated, cured, and tested.

(c) Compare the average strength of the field validation test cylinders to the original strength-maturity relationship curve. The average strength result of the field validation cylinders is used only for comparison to the original strength-maturity relationship curve.

(d) If the average compressive strength of the validation test cylinders is equal to or differs by less than ± 10 percent of the strength-maturity relationship which has been developed for the concrete mixture, the development of a new strength-maturity relationship curve may not be required, unless otherwise directed by the Engineer.

(e) If the average compressive strength of the validation test cylinders differs by greater than ± 10 percent of the original strength-maturity relationship, the Regional Materials Engineer and the Resident Engineer shall both be notified immediately. The development of a new strength-maturity relationship curve shall be required.

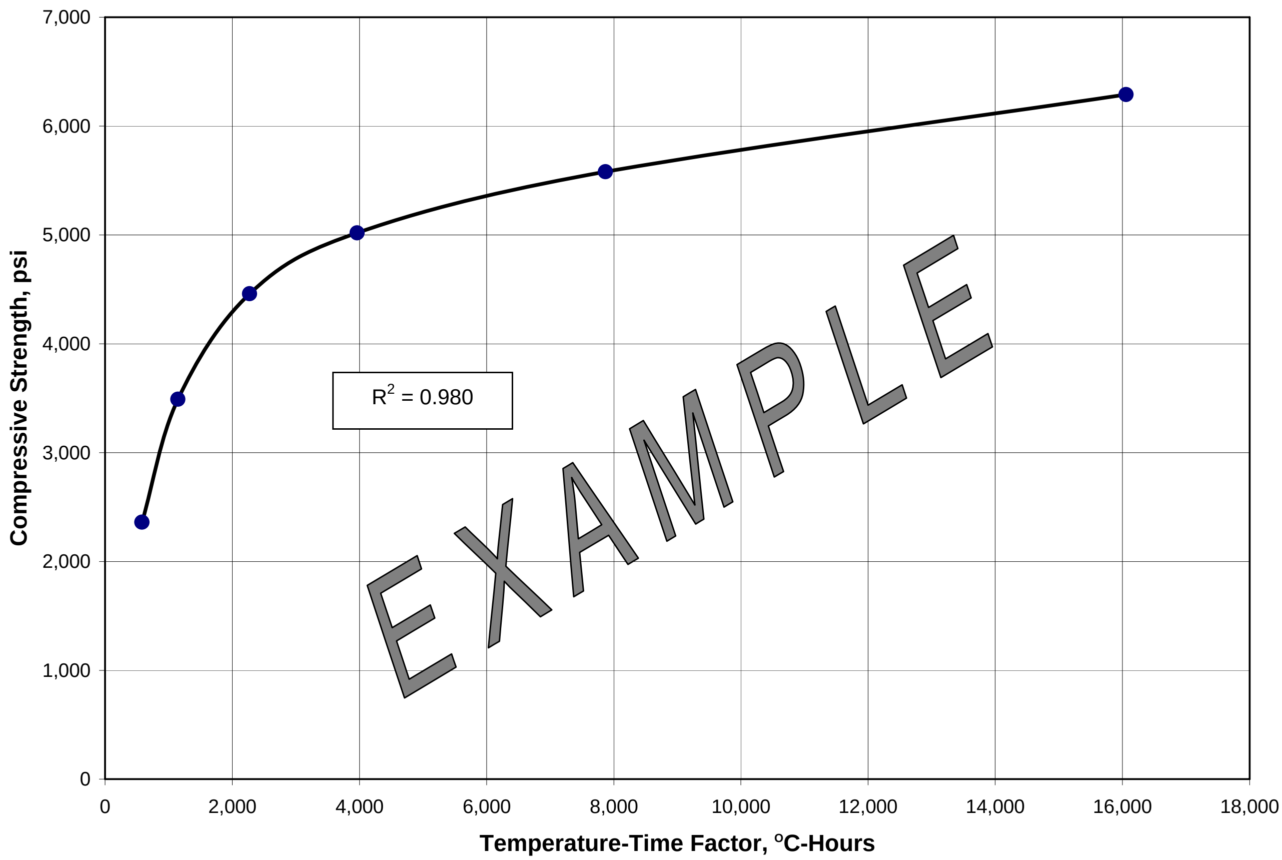
(f) During placement of the concrete mixture, field validations of the strength-maturity relationship curve shall be performed in accordance with the requirements of paragraph 8(b). The minimum frequency of field validations will be as follows:

(1) For Class P concrete: every 10 days of concrete placement, or as directed by the Engineer.

(2) For Class S concrete: every 300 cubic yards of concrete placement, or as directed by the Engineer.

(3) For other than Class P or Class S: as determined by the Engineer.

(g) Each field validation will be compared to the respective strength-maturity relationship in accordance with paragraphs 8(c) through 8(e), and the appropriate action, as specified in those paragraphs shall be taken.



Example Strength-Maturity Relationship Curve

FIGURE 1

MEAN MACROTEXTURE DEPTH OF MILLED PAVEMENT

(A Modification of Indiana Test Method 812-03T and ASTM E 965)

1. SCOPE

(a) This test method describes the procedure to determine the Mean Macrotexture Depth of a milled pavement surface.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

(a) The apparatus shall consist of the following:

(1) Filler - Type 1 glass beads conforming to the requirements of AASHTO M 247.

(2) Spreader - A flat, stiff, hard disk made from methyl methacrylate (Plexiglas) with a thickness of 0.5 ± 0.1 inch, and a diameter of 8 inches ± 1/4 inch, with a handle attached to the top of the disk.

(3) Graduated Cylinder - Class B or better, Style III, 250 mL capacity graduated cylinder conforming to the requirements of ASTM E 1272, used to measure the amount of filler required for the test.

(4) Brushes - A stiff wire brush and a soft bristle brush, used to clean the pavement.

(5) Container - Small container, with a secure and easily removable cover, used to store 200 mL of filler.

(6) Wind Screen - A shield used to protect the test area from air turbulence created from wind or traffic.

(7) Measuring device - A tape measure, or ruler at least 12 inches long, graduated in at least 1/8 inch increments. A tape measure, or ruler at least 300 millimeters long, graduated in millimeter increments may be used if desired.

3. PREPARATION OF FILLER MATERIAL

(a) For each test location, one container with 200 mL of filler is prepared as follows:

(1) Fill the graduated cylinder to the 200 mL mark and gently tap the base of the cylinder several times on a rigid surface. Add more material to fill the graduated cylinder to the 200 mL mark. Gently tap the side of the cylinder to level the material. As necessary, add additional material, tap, and level until the filler is at the 200 mL mark.

(2) Place the measured amount of filler in the container.

4. PROCEDURE

(a) Randomly select a test location.

(b) Inspect the selected test location and ensure that it is dry, uniform, and free of unique or localized features such as cracks, joints, stripping, and patching. Clean the test location using the brushes to remove any residue, debris, or loosely bonded material. Position the wind screen around the test location.

(c) Holding the container above the test location at a height not greater than 4 inches from the pavement surface, pour the measured amount of filler into a conical pile on the test area.

(d) Lightly place the spreader on top of the conical pile, being careful not to compact the filler.

(e) Using the spreader, carefully spread the material into a circular patch filling the surface voids flush with the top of the milled pavement.

(f) Measure and record the diameter of the circular patch at four locations (intervals of 45º) to the nearest 1/8 inch. Convert each reading to the nearest millimeter (1 inch = 25.4 millimeters). If desired, measurements may be taken directly in millimeters and recorded to the nearest millimeter.

Example: (For a reading of 9-3/8")

9-3/8" = 9.375"
9.375" x 25.4 = 238.125 millimeters =
238 millimeters (rounded to the nearest millimeter)

5. CALCULATIONS

(a) Calculate the average diameter of the circular patch as follows:

$$D_a = \frac{D_1 + D_2 + D_3 + D_4}{4}$$

Where:

D_a = Average diameter of the circular patch, nearest millimeter
D_1, D_2, D_3, D_4 = Individual diameters of the circular patch, nearest millimeter

(b) Using the average diameter of the circular patch, determine the Mean Macrotexture Depth by referencing Figure 1. The values for Mean Macrotexture Depth shown in Figure 1 have been determined using the equation for Mean Macrotexture Depth shown below. When necessary, use the equation to determine the Mean Macrotexture Depth for average diameters outside the range of values given in Figure 1.

Since: Volume = (Area) x (Height, or Depth)

Therefore: $$\text{Height, or Depth} = \frac{\text{Volume}}{\text{Area}}$$

so: $$\text{Mean Macrotexture Depth, mm} = \frac{V}{(\pi) \times \left(\frac{D_a}{2}\right)^2}$$

Where: V = Volume of glass beads, 200,000 mm^3 (200 mL)
D_a = Average diameter of the circular patch, mm

6. REPORT AND EXAMPLE

(a) An example of a completed Mean Macrotexture Depth test report is provided in Figure 2.

(b) A blank Mean Macrotexture Depth test report form is provided in Figure 3.

MEAN MACROTEXTURE DEPTH (Based on 200 mL of Glass Beads and Average Diameter)					
Average Diameter (mm)	Mean Macrotexture Depth (mm)	Average Diameter (mm)	Mean Macrotexture Depth (mm)	Average Diameter (mm)	Mean Macrotexture Depth (mm)
185	7.44	222	5.17	259	3.80
186	7.36	223	5.12	260	3.77
187	7.28	224	5.08	261	3.74
188	7.20	225	5.03	262	3.71
189	7.13	226	4.99	263	3.68
190	7.05	227	4.94	264	3.65
191	6.98	228	4.90	265	3.63
192	6.91	229	4.86	266	3.60
193	6.84	230	4.81	267	3.57
194	6.77	231	4.77	268	3.55
195	6.70	232	4.73	269	3.52
196	6.63	233	4.69	270	3.49
197	6.56	234	4.65	271	3.47
198	6.50	235	4.61	272	3.44
199	6.43	236	4.57	273	3.42
200	6.37	237	4.53	274	3.39
201	6.30	238	4.50	275	3.37
202	6.24	239	4.46	276	3.34
203	6.18	240	4.42	277	3.32
204	6.12	241	4.38	278	3.29
205	6.06	242	4.35	279	3.27
206	6.00	243	4.31	280	3.25
207	5.94	244	4.28	281	3.22
208	5.89	245	4.24	282	3.20
209	5.83	246	4.21	283	3.18
210	5.77	247	4.17	284	3.16
211	5.72	248	4.14	285	3.14
212	5.67	249	4.11	286	3.11
213	5.61	250	4.07	287	3.09
214	5.56	251	4.04	288	3.07
215	5.51	252	4.01	289	3.05
216	5.46	253	3.98	290	3.03
217	5.41	254	3.95	291	3.01
218	5.36	255	3.92	292	2.99
219	5.31	256	3.89	293	2.97
220	5.26	257	3.86	294	2.95
221	5.21	258	3.83	295	2.93

FIGURE 1

MEAN MACROTEXTURE DEPTH
ARIZONA TEST METHOD 742

TRACS Number: H999901C Roadway: Heraz Canyon – Lee's Bluff Contractor: Happy Days Construction

Test #	Date	Station	Offset	D_1 (mm)	D_2 (mm)	D_3 (mm)	D_4 (mm)	D_a (mm)	Mean Macrotexture Depth	Spec.	Pass (✓)	Fail (✓)
1	03-25-08	351+62	4' Rt. of CL	248	239	245	236	242	4.35	≤4.50	✓	
2	03-25-08	373+16	6' Rt. of CL	255	263	250	259	257	3.86	"	✓	
3	03-25-08	402+42	10' Rt. of CL	241	246	237	248	243	4.31	"	✓	
4	03-25-08	429+53	7' Rt. of CL	247	259	251	254	253	3.98	"	✓	
5	03-25-08	456+87	3' Rt. of CL	263	260	257	253	258	3.83	"	✓	

(03/18/08)

FIGURE 2

MEAN MACROTEXTURE DEPTH
ARIZONA TEST METHOD 742

TRACS Number: ____________ Roadway: ____________ Contractor: ____________

Test #	Date	Station	Offset	D_1 (mm)	D_2 (mm)	D_3 (mm)	D_4 (mm)	D_a (mm)	Mean Macrotexture Depth	Spec.	Pass (✓)	Fail (✓)

(03/18/08)

FIGURE 3