

**BASIC LAB COURSE
WORKBOOK**

CIT Program



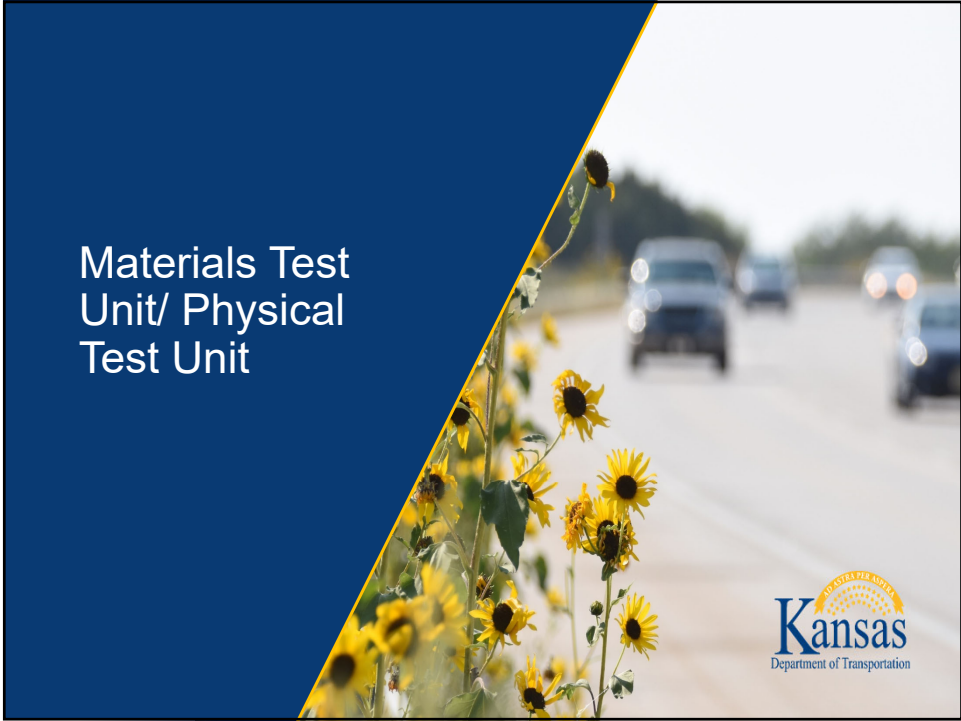
Basic Lab Course Workbook

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Updated June 2026




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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #1


- **Link to Standards:**
 - [KDOT: 2015 Standard Specifications for State Road and Bridge Construction \(ksdot.gov\)](http://ksdot.gov)
- **DIVISION 400 – Concrete**
 - **General concrete, structural concrete, general on grade, on grade for prestressed members,**
 - **Tests performed in concrete:**
 - **Freeze and thawing of concrete beams**
 - **Wetting and drying of concrete beams**



Wetting and Drying beams in water



Wetting and Drying beams in the oven



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #2

- **DIVISION 400 – Concrete cont.**
 - **Compressive strength of cylinders and pavers**



Cylinders being ground for sulfur capping



Cylinders being sulfur capped



Cylinder with Sulfur cap



Cylinder being crushed with sulfur caps



This is what the technicians see while the cylinder is being crushed



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #3

- **DIVISION 1100 – AGGREGATES**
 - **Aggregates for Concrete, Asphalt, Base, Backfill, Micro surfacing, Rock Shoulders, etc.**
 - **Tests performed in aggregates:**
 - **LA wear and micro deval**



LA Wear testing machine



Micro Deval Testing Machine



Various aggregates that are tested at the MRC.



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #4

- Tests performed in aggregates cont.:
- Gradation
- Soundness (Freeze and Thaw)
- Specific gravity 1 and 2



Aggregate Gradation sieve stack in Mary Ann gradation shaker.



Aggregate Freeze and thaw cylinders in Glycol bath freezer



Aggregate Freeze and Thaw cylinders in water bath.



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #5

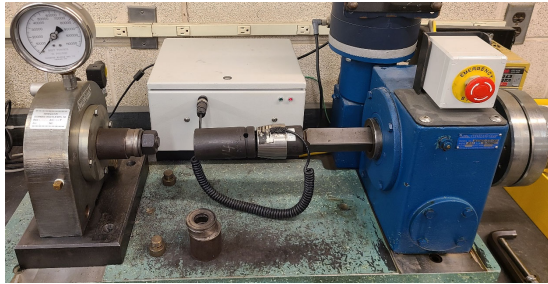
- **DIVISION 1300 - BRICK AND CONCRETE MASONRY UNITS**
- **DIVISION 1400 - CONCRETE ADMIXTURES AND CURING MATERIALS**
 - Admixtures, Liquid Membrane forming compounds,
- **DIVISION 1500 - JOINT SEALING AND JOINT FILLER MATERIAL**



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO
THE PHYSICAL TEST UNIT* MATERIALS DIVISION #6

- **DIVISION 1600 - FERROUS AND NON-FERROUS METALS**
 - **Steel Reinforcing Bars, Wire Fabric for Concrete Reinforcement, Strand for Prestressed Concrete, Structural Steel, Steel Pile, Steel Plate Shear Connectors, Anchor Bolts, Zinc coating, cast Bronze, Steel Posts, etc.**
 - **Tests performed on metals:**
 - **Tensile testing of rebar, bolts and cable**
 - **Only A325 and A490 structural bolts are tested**
 - **Rotational capacity testing of bolt assemblies**
 - **Chemical testing of bolt assemblies and rebar**



Rotational capacity testing



Tensile testing of
Rebar



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO
THE PHYSICAL TEST UNIT* MATERIALS DIVISION #7

- **DIVISION 1700 - MISCELLANEOUS MATERIALS**
 - **Manholes, Gabions, Rapid-set Concrete Patching Material, Detectable Warning Surface Panels for Curb Ramps and Medians**
- **DIVISION 1900 -CULVERT, SEWER AND UNDERDRAIN PIPE**
 - **Quality control Program for Precast concrete Products, Corrugated Metal Pipe and End Sections**
- **DIVISION 2600 - MATERIALS CERTIFICATIONS**
 - **Material Certifications**



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2015 KDOT STANDARD SPECIFICATIONS SECTIONS APPLICABLE TO THE PHYSICAL TEST UNIT* MATERIALS DIVISION #8

- **DIVISION 2000 - PORTLAND CEMENT, LIME AND FLY ASH**
 - **Cement, Fly Ash, Silica Fume, Slag**
 - Testing performed on cement:
 - Cubes for compressive strength
 - Chemical testing of cement and water
 - Time of set, permeability, air content, normal consistency, ...etc
- **DIVISION 2400 – WATER (Water for use in Concrete)**
- **DIVISION 2500 - MISCELLANEOUS METHODS OF TEST**
 - Part V



Time of set needle



Curing environmental cabinet for cement cubes



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MATERIALS AND RESEARCH (MR) CENTER TEST PROCEDURES APPLICABLE TO PTU

SECTION

- **MR-11** ROTATIONAL CAPACITY TESTING OF HIGH STRENGTH FASTNERS-FHWA SUPPLEMENTAL SPECIFICATION (RE: 1616)
- **MR-16** TESTING OF DOWEL BARS PLACED IN CONCRETE FOR RESISTANCE TO REMOVAL (PULL OUT)
- **MR-21** SOUNDNESS AND MODIFIED SOUNDNESS OF AGGREGATES BY FREEZING AND THAWING
- **MR-22** RESISTANCE OF CONCRETE TO RAPID FREEZING AND THAWING
- **MR-23** WETTING AND DRYING TEST OF SAND-GRAVEL AGGREGATE FOR CONCRETE
- **MR-24** PROCEDURES FOR TESTING LIGHTWEIGHT AGGREGATES
- **MR-26** TEST METHOD FOR COMPRESSIVE STRENGTH OF HYDRAULIC CEMENT MORTARS (USING 2 in. OR [50 mm] CUBE SPECIMENS)
- **MR-27** MODIFIED SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATE
- **MR-28** DETERMINATION OF TOTAL ACID INSOLUBLE RESIDUE
- **MR-29** WETTING AND DRYING TEST OF STEAM CURED REINFORCED CONCRETE PIPE WITH FLY ASH



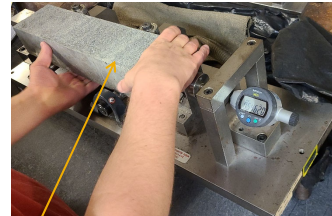
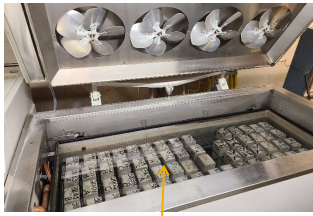
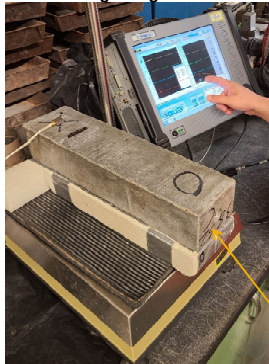
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Testing Purposes and Sample Sizes

2015 Standard Specifications w/o Special Provisions

400: concrete

Production: For monitoring the quality of OGCA aggregate that is being used in concrete pavement production. Sampled from quarry production and consists of 80# each of material between -3/4+1/2 sieves and -1/2 +3/8 inch sieves. RE: most current version of Part V for sampling frequency. Productions typically consist of aggregate from multiple beds. Nominal test time is 140 days (beam test) unless MF&T fails radically. Failure for any reason will result in a follow up sample or a quarry inspection by Geologists depending on degree of failure. Use of material failing production testing can also result in premature pavement failure. RE: Note above regarding test time.



Freeze and Thaw beams in custom beam freezer

Freeze and Thaw beams getting length checked

Freeze and thaw beam being checked for weight and RDME (internal degradation)



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Testing Purposes and Sample Sizes

2015 Standard Specifications w/o Special Provisions #2

1100: Aggregates

Official Quality: To determine what specifications an aggregate is compliant with. One per source per product per process per year for crushed stone, one per source per product at least every five years for sand/sand gravel (siliceous). Failure to complete an OFQ could result in structure/pavement degradation and/or failure. Sample sizes vary per material, refer to the most current version of Part V of the C&M Manual, READ CAREFULLY. Nominal test time is 2-3 weeks.

Ledge: To determine if limestone from an open quarry qualifies for use in on grade concrete. Sampled by Geologists.

Verifications and Information's: these tests are performed much the same as an official quality but often the materials are pulled directly off of projects to verify against the OFQ results or to ensure the product meets the requirements for the intended use. Information's are performed as a means to check different labs results or purely as an informational test to see what a product is.



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Testing Purposes and Sample Sizes

2015 Standard Specifications w/o Special Provisions #3

1600: Ferrous and Non-Ferrous Metals

Several materials/products governed by this division are structure critical and failure could result in catastrophic failure of a bridge or other structure.

Prequalification: *Steel reinforcing bars (uncoated)*-30 samples per mill of representative sizes and heats, mill tests half of each sample, KDOT tests remaining half, test for tensile and bend properties and compare to mill data and specifications, one, two, three year repetition cycle barring problems, sample bar lengths tentatively differ from Part V. *Welded wire fabric*-30 per mill of fabric (and wire if available) representative of sizes, combinations, and heats, mill tests half of each sample, KDOT tests remaining half, test for tensile and weld properties and compare to mill data and specifications, one initially then Type C certification barring problems. *Reinforcing steel splices*-3 fully assembled splices of sizes #4, 6, 8, bars tested for tensile properties, one initially then Type C certification and testing on lot by lot basis for spec. compliance.

Acceptance: High strength fasteners for structural applications-lot by lot basis for overhead structures, signing and lighting, tested for tensile and rotational capacity properties as an assembly that includes the bolt, nut, and washer(s) by lot, only to be used as tested and not intermixed in the field unless tested as a different combination, 6 each bolt, nut, washer, a lot is size as well as heat dependent, one heat can have several lots but not conversely. Anchor bolts-when certifications are not available-tested on a lot by lot basis for tensile properties. Nuts and washers typically tested for dimensions, hardness, composition, and coating thickness, due to their size. Prestressing strand for concrete beams and post tensioning for slabs-weight basis involving specific heats and lots.

Information: Can be taken on any material at any time for any credible reason.

Verification: As prescribed by the applicable subsection, such as for rebar and splices, or at any time as deemed necessary in order to ascertain that the product being purchased is essentially the same as that prequalified and/or is compliant with the applicable specifications. Steel reinforcing bar-RE: 1601, verification samples are mandatory and will normally be obtained by the Regional Materials Laboratories. Splices-prequalified sources-tested for specification compliance on a lot by lot basis from jobsite, prefabricated splices have different sampling requirements than those requiring operator prequalification.



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Testing Purposes and Sample Sizes

2015 Standard Specifications w/o Special Provisions #4

2000: Portland Cement, Lime, and Fly Ash Cementitious Materials

Prequalification: Portland and blended hydraulic cement- prequalification by testing of one gallon sample per source to determine compliance with applicable specs., also must submit required documentation which is to include an acceptable quality control program. Fly ash for use in concrete-test one gallon pql sample for specification compliance, also submit required documentation, including QC program. Fly ash for stabilization, mod., and cold recycle asphalt-test a two quart pql sample for specification compliance, also submit required documentation including quality control data. Fly ash for concrete pipe-test one gallon pql sample for specification compliance, also submit required documentation, including analytical test data, in addition (re: 1902) the fly ash, as utilized in the precast design mix it is intended for must have modified wetting and drying test requirements for precast products. Ground granulated blast furnace slag for use in concrete and mortars-test one gallon pql sample for specification compliance, also submit required documentation, including analytical test data.

Information: Can be taken on any material at any time for any credible reason.

Verification: Required for all of the above, random samples and typically at least one per year.

2400: Water

Acceptance: All water for use with cement in prestressed concrete products will be based on M&R Center sample test results, acceptance based on compliance with the applicable specifications.

KDHE Approval for Domestic Use: Water for use with cement in other applications accepted if from a city water source and approved for domestic use by KDHE, otherwise acceptance is based on M&R Center sample test results being compliant with the applicable specifications.

Note: Verification and Information samples can be taken for any material at any time if someone is concerned about the material quality.



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Questions?

Email me at zachary.katzer@ks.gov



Basic Laboratory Course

Materials Quality Management Section

aka, Quality Assurance and Quality Control

Tabitha Taylor



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Quality Assurance Responsibilities

- Part V of the Construction Manual
- District laboratory inspections
- Laboratory certification under the AASHTO Accreditation Program
- Review of Type A & B materials certifications
- Hot Mix Aggregate Specific Gravity Values List, also known as The SpG List, consist of two lists.
 - **Procedure I List**, coarse aggregate retained on the No. 4 (4.75mm sieve).
 - **Procedure II List**, fine aggregate that passes the No.4 (4.75mm sieve).

Link for KDOT 2022 Part V, [Part V](#)



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Title 23, Chapter 1, Subchapter G, Part 637, Subpart B of the Code of Federal Regulations, CFR

- Title 23 covers Highways
- Chapter 1 covers the Federal Highway Administration, FHWA, requirements that must be met by each State Department of Transportation or STD
- Subchapter G covers Engineering and Traffic Operations
- Part 637 covers Construction Inspection and Approval
- Subpart B covers Quality Assurance Procedures for Construction

Note: The Code of Federal Regulations sets the requirements for a lot of what KDOT does in terms of materials testing and personnel performing the testing and inspections.

Link for the Code of Federal Regulations, [eCFR::CFR Part 637 Subpart B--Quality Assurance Procedures for Construction](#).



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Title 23, Chapter 1, Subchapter G, Part 637, Subpart B

Some aspects of 637

- Quality Assurance
- Qualified laboratories/lab inspections
- Independent Assurance program
- Random sampling
- Qualified sampling and testing personnel/CIT² Program
- Proficiency Sample Testing



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Purpose of Title 23, Chapter 1, Subchapter G, Part 637, Subpart B – Quality Assurance Procedures for Construction

- To prescribe policies, procedures, and guidelines to assure the quality of materials and construction in all Federal-Aid Highway projects on the National Highway System.

Which in turn will ensure us that we ...

“get what we pay for!”



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Quality Assurance Program

**The Quality Assurance program is a requirement of part
637.205.(a)**

- Each STD shall develop a quality assurance program which will ensure that the materials and workmanship incorporated into each Federal-Aid Highway construction project on the National Highway System are in conformity with the requirements of the approved plans and specifications, including approved changes.
- The program must meet the criteria in 637.207 and be approved by the FHWA.



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Part 637.207 Quality Assurance Program

Each STD is to have an acceptance program that covers such things as:

- Frequency guide schedules for verification sampling and testing which give general guidance to personnel responsible for the program.
- That sampling and testing is performed by qualified laboratories and personnel.
- Quality control sampling and testing is evaluated by an Independent Assurance program, IA. The samples used for quality control and verification sampling and testing shall be random samples.
- Identification of the specific location in the construction or production operation at which the verification samples and testing is to be accomplished.



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Part 637.207 Quality Assurance program

The STD's Independent Assurance program shall cover sampling procedures, testing procedures and testing equipment and each IA program shall include such things as:

- Frequency schedules for IA evaluation
- Evaluation of test equipment by using one or more of the following; calibration checks, split samples or proficiency samples
- Evaluation of qualified sampling and testing personnel shall be evaluated by using observations and split samples or proficiency samples
- Evaluation of sampling and testing procedures
- Annual reporting of IA results to the FHWA when using a system approach, as opposed to a project basis system

Note: The system that the State of Kansas uses is the system approach. This requires us to provide an annual report to the FHWA summarizing the results of the IA program.

Link for the Independent Assurance Witness Checklists, jawitness.asp.



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District Laboratories and Lab Inspections

637.209 Laboratory and sampling and testing personnel qualifications

(a) Laboratories.

- (1) After June 29, 2000, all contractor, vendor and STD testing used in the acceptance decision shall be performed by qualified laboratories.

(b) Sampling & testing personnel.

- After June 29, 2000, all sampling and testing data to be used in the acceptance decision or the IA program shall be executed by qualified sampling & testing personnel.

Note: District labs must be “qualified labs “and the Materials and Research Center is the State central laboratory and as such must be Accredited by the AASHTO AAP.



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637.203 Definitions of Qualified Laboratory

Qualified Laboratories.

- Laboratories that are capable as defined by appropriate programs established by each STD.
- As a minimum, the qualification program shall include provisions for checking test equipment and the laboratory shall keep records of calibration checks.

Note: District Lab inspections are a part of KDOT's qualification program.



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District Laboratory Inspections

The following are performed annually:

- Witnessing of test procedures performed by the lab.
- Inspection of testing equipment and calibration reports.
- We are required to submit a report of our IA Witness Program to the FHWA annually.

Note: The selection of the presenter is random.



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District Lab Inspection Process

An excel spread sheet, otherwise known as the Grid Sheet, is sent to each District Materials Lab Specialist to select the test methods that are either performed or witnessed being performed by each technician. Once the grid sheet is returned, a formula will select each test method at random.

- During the inspection, each technician must successfully demonstrate the test methods assigned to them. The results are entered into AWP as a Witness Report.

The Quality Manual is reviewed to make sure it is kept up to date and contains all verification, calibration, and maintenance reports for all lab testing equipment.

Testing equipment will be inspected to verify its performance.

A memo is written summarizing the inspection findings.



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District Laboratory Inspections

Contractor Quality Manuals

The Contractor Quality Manual is to include all calibration & verification documents of their equipment and should be reviewed regularly. Particularly if a problem or question arises concerning test results.

Examples of contractor's quality manuals are found in Part V.

- Contractors Quality Control Plan 5.2.7.
- HMA 5.2.7.3.
- Concrete 5.2.7.5.



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Hot Mix Aggregate Specific Gravity List

- Samples are taken by District Materials and the contractor or producer.
- Split samples are run by the District Materials Laboratory, Materials & Research Center's Aggregate Laboratory, and the Contractor/Producer Materials Lab.
- Results are used to establish the specific gravity and absorption values per 5.6.5.7. The Hot Mix Aggregate Specific Gravity Values List, otherwise known as the SpG List, these lists are conceived as a bidding aid for contractors.

This list is updated monthly and published by the Bureau of Construction and Materials.

Link for The SpG List, <https://www.ksdot.org/htmxAggravValu.asp>.



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The SpG List consist of 2 sections

- Coarse aggregate, **Procedure 1**, is aggregate that is retained on the No. 4 (4.75mm sieve).
- Fine aggregate, **Procedure II**, is aggregate that passes the No. 4 (4.75mm sieve).
 - **Part V, 5.7.2.** Sand Sand-Gravel must be verified every 5 years to remain on the SpG List.
 - **Part V, 5.7.3.** Chat and Crushed-Stone must be verified every 2 years to remain on the SpG List.



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Example of the Hot Mix Aggregate Specific Gravity Values List

Hot Mix Aggregate Specific Gravity Values

This site provides aggregate specific gravity values for contractors to use to calculate the VMA for hot mix designs for projects in each letting. This procedure is being used to reduce some of the risks associated with bidding projects in the letting. Actual specific gravity values of the individual aggregates used on the projects should be determined as part of the mix design review process. Changes in geology, processing, location, and procedures, and the passing of time may cause changes in the specific gravity. KDOT will honor, as a minimum value, only those specific gravities in black print. The values in red print at the end of each list have not been verified within the required timeframes. They are for information only and the specific gravities must be verified before the aggregates are used on any KDOT projects. The specific gravity values for the aggregates shown in red may be adjusted up or down by the districts to reflect the results of their tests.

Note: If no list is shown for the current month, use the previous month's list.

Monthly Hot Mix Aggregate Specific Gravity Values

June 07	July 07	August 07	September 07	October 07	November 07	December 07
January 08	February 08	March 08	April 08	May 08	June 08	July 08
August 08	September 08	October 08	November 08	December 08	January 09	February 09
March 09	April 09	May 09	June 09	July 09	August 09	September 09
October 09	November 09	December 09	January 10	February 10	March 10	April 10
May 10	June 10	July 10	August 10	September 10	October 10	November 10
December 10	January 11	February 11	March 11	April 11	May 11	June 11
July 11	August 11	September 11	October 11	November 11	December 11	January 12
February 12	March 12	April 12	May 12	June 12	July 12	August 12
September 12	October 12	November 12	December 12	January 13	February 13	March 13
April 13	May 13	June 13	July 13	August 13	September 13	October 13
November 13	December 13	January 14	February 14	March 14	April 14	May 14
June 14	July 14	August 14	September 14	October 14	November 14	December 14
January 15	February 15	March 15	April 15	May 15	June 15	July 15
August 15	September 15	October 15	November 15	December 15	January 16	February 16
March 16	April 16	May 16	June 16	July 16	August 16	September 16
October 16	November 16	December 16	January 17	February 17	March 17	April 17
May 17	June 17	July 17	August 17	September 17	October 17	November 17
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April 20	May 20	June 20	July 20	August 20	September 20	October 20
November 20	December 20	January 21	February 21	March 21	April 21	May 21
June 21	July 21	August 21	September 21	October 21	November 21	December 21
January 22	February 22	March 22	April 22	May 22	June 22	July 22
August 22	September 22	October 22	November 22	December 22	January 23	February 23
March 23	April 23	May 23	June 23	July 23	August 23	September 23
October 23	November 23	December 23	January 24	February 24	March 24	April 24
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September 33	October 33	November 33	December 33	January 34	February 34	March 34
April 34	May 34	June 34	July 34	August 34	September 34	October 34
November 34	December 34	January 35	February 35	March 35	April 35	May 35
June 35	July 35	August 35	September 35	October 35	November 35	December 35
January 36	February 36	March 36	April 36	May 36	June 36	July 36
August 36	September 36	October 36	November 36	December 36	January 37	February 37
March 37	April 37	May 37	June 37	July 37	August 37	September 37
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December 38	January 39	February 39	March 39	April 39	May 39	June 39
July 39	August 39	September 39	October 39	November 39	December 39	January 40
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March 44	April 44	May 44	June 44	July 44	August 44	September 44
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May 45	June 45	July 45	August 45	September 45	October 45	November 45
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September 47	October 47	November 47	December 47	January 48	February 48	March 48
April 48	May 48	June 48	July 48	August 48	September 48	October 48
November 48	December 48	January 49	February 49	March 49	April 49	May 49
June 49	July 49	August 49	September 49	October 49	November 49	December 49
January 50	February 50	March 50	April 50	May 50	June 50	July 50
August 50	September 50	October 50	November 50	December 50	January 51	February 51
March 51	April 51	May 51	June 51	July 51	August 51	September 51
October 51	November 51	December 51	January 52	February 52	March 52	April 52
May 52	June 52	July 52	August 52	September 52	October 52	November 52
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July 53	August 53	September 53	October 53	November 53	December 53	January 54
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June 56	July 56	August 56	September 56	October 56	November 56	December 56
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November 62	December 62	January 63	February 63	March 63	April 63	May 63
June 63	July 63	August 63	September 63	October 63	November 63	December 63
January 64	February 64	March 64	April 64	May 64	June 64	July 64
August 64	September 64	October 64	November 64	December 64	January 65	February 65
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February 75	March 75	April 75	May 75	June 75	July 75	August 75
September 75	October 75	November 75	December 75	January 76	February 76	March 76
April 76	May 76	June 76	July 76	August 76	September 76	October 76
November 76	December 76	January 77	February 77	March 77	April 77	May 77
June 77	July 77	August 77	September 77	October 77	November 77	December 77
January 78	February 78	March 78	April 78	May 78	June 78	July 78
August 78	September 78	October 78	November 78	December 78	January 79	February 79
March 79	April 79	May 79	June 79	July 79	August 79	September 79
October 79	November 79	December 79	January 80	February 80	March 80	April 80
May 80	June 80	July 80	August 80	September 80	October 80	November 80
December 80	January 81	February 81	March 81	April 81	May 81	June 81
July 81	August 81	September 81	October 81	November 81	December 81	January 82
February 82	March 82	April 82	May 82	June 82	July 82	August 82
September 82	October 82	November 82	December 82	January 83	February 83	March 83
April 83	May 83	June 83	July 83	August 83	September 83	October 83
November 83	December 83	January 84	February 84	March 84	April 84	May 84
June 84	July 84	August 84	September 84	October 84	November 84	December 84
January 85	February 85	March 85	April 85	May 85	June 85	July 85
August 85	September 85	October 85	November 85	December 85	January 86	February 86
March 86	April 86	May 86	June 86	July 86	August 86	September 86
October 86	November 86	December 86	January 87	February 87	March 87	April 87
May 87	June 87	July 87	August 87	September 87	October 87	November 87
December 87	January 88	February 88	March 88	April 88	May 88	June 88
July 88	August 88	September 88	October 88	November 88	December 88	January 89
February 89	March 89	April 89	May 89	June 89	July 89	August 89
September 89	October 89	November 89	December 89	January 90	February 90	March 90
April 90	May 90	June 90	July 90	August 90	September 90	October 90
November 90	December 90	January 91	February 91	March 91	April 91	May 91
June 91	July 91	August 91	September 91	October 91	November 91	December 91
January 92	February 92	March 92	April 92	May 92	June 92	July 92
August 92	September 92	October 92	November 92	December 92	January 93	February 93
March 93	April 93	May 93	June 93	July 93	August 93	September 93
October 93	November 93	December 93	January 94	February 94	March 94	April 94
May 94	June 94	July 94	August 94	September 94	October 94	November 94
December 94	January 95	February 95	March 95	April 95	May 95	June 95
July 95	August 95	September 95	October 95	November 95	December 95	January 96
February 96	March 96	April 96	May 96	June 96	July 96	August 96
September 96	October 96	November 96	December 96	January 97	February 97	March 97
April 97	May 97	June 97	July 97	August 97	September 97	October 97
November 97	December 97	January 98	February 98	March 98	April 98	May 98
June 98	July 98	August 98	September 98	October 98	November 98	December 98
January 99	February 99	March 99	April 99	May 99	June 99	July 99
August 99	September 99	October 99	November 99	December 99	January 00	February 00
March 00	April 00	May 00	June 00	July 00	August 00	September 00
October 00	November 00	December 00	January 01	February 01	March 01	April 01
May 01	June 01	July 01	August 01	September 01	October 01	November 01
December 01	January 02	February 02	March 02	April 02	May 02	June 02
July 02	August 02	September 02	October 02	November 02	December 02	January 03
February 03	March 03	April 03	May 03	June 03	July 03	August 03
September 03	October 03	November 03	December 03	January 04	February 04	March 04
April 04	May 04	June 04	July 04	August 04	September 04	October 04
November 04	December 04	January 05	February 05	March 05	April 05	May 05
June 05	July 05	August 05	September 05	October 05	November 05	December 05
January 06	February 06	March 06	April 06	May 06	June 06	July 06
August 06	September 06	October 06	November 06	December 06	January 07	February 07
March 07	April 07	May 07	June 07	July 07	August 07	September 07
October 07	November 07	December 07	January 08	February 08	March 08	April 08
May 08	June 08	July 08	August 08	September 08	October 08	November 08
December 08	January 09	February 09	March 09</			

2015 KDOT Special Provision to the Standard Specification Section 2601 Materials Certifications 15-26001-R10

SP Specification Section 2601 governs the requirements for the content and distribution of certifications when dictated. In part or in whole, as the basis of acceptance for a material.

What is a certification?

- A certification, or materials certification, is a paper validation of confirmation of the authenticity of a material. It's a guarantee that the material meets a given specification. In other words, if we were to test it, we would get the same results.
- This comes from the manufacturer or qualified lab.

We , KDOT, do not write Certifications.
We create a report based on the certification(s).



17

Does a Material need a certification?

SP 2601 MATERIALS CERTIFICATIONS; TABLE 2601-1: Reference Chart for Material Related Specifications

- Tabel 2601-1: Reference Chart for Material Related Specifications. This lists what KDOT Specification governs the material, if the material is required to be on a PQL and the list number, if the material is covered under a "Blanket Cert", and what type of cert is required for that material.
 - The Basis of Acceptance located within a specification lists the requirements and the type of certification needed.



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**KDOT Special Provision to the Standard Specifications, 2015 Edition, section 2601.2a(2)
Provide the following information on all certifications regardless of the type:**

- Identification of the organization submitting the certification.
- KDOT project number and KDOT contract number.
- Name of contractor.
- Identification markings on the shipment. As a minimum, this must include the name of the manufacturer. Also include the lot or heat number referenced in the certification, the serial number if applicable, and the date of manufacture if available. This information is not required for Type "F" and "G" certifications.
- Quantity of material represented by the certification. If multiple lot/heat numbers are submitted, the quantity should be listed per lot/heat number.
- KDOT Contract line number (bid item) and item code number of the material represented by the certification.
- Statement that all material complies with the applicable specifications. List the specifications by responsible organization, number, section reference or other appropriate identification.
- Additional information as required in the specification for the material, or as added requirements for the various types of certifications in subsection 26012b.
- "Buy America" statement on domestic iron & steel products and "Buy America, Build America" (BABA) on construction materials and manufactured products as required in section 106.



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2601.2a(3) The general information outlined in 2601.2a(2) must be provided by the material supplier on a cover sheet to the manufacture's certification(s). Verify that the cover sheet & certification(s) are so well cross referenced & identified as a unit that they can be reunited if accidentally separated.

The example, below, is located at the end of SP 2015, section 2601 Materials Certifications

Date:

Submitted by:

Kansas Department of Transportation
Materials Certifications
2300 Van Buren
Topeka, Kansas

Project Number:

Contract Number:

Line Number: Item Code:

Contractor Name:

ID Markings on Shipment:

Additional Information:

This is to certify that the following items furnished by our firm for use on the reference project meet or exceed the requirements of section of the edition of the Kansas Department of Transportation Standard Specification.

Quantity	Description	Heat	Lot	Manufacturer



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Type “A” Certification

This certification is to include a copy of the results of tests conducted by the manufacturer or other qualified laboratory on samples obtained from the lot or lots of material in the shipment.

When a mill test report is submitted as the laboratory report, the quantity in the shipment does not need to be included on the report, provided that the identifying heat or lot numbers involved are roll stamped, embossed, or durably affixed to each item of material in the shipment represented by the report.

In this case, provide the necessary quantity information on a cover sheet, clearly identifying the quantity of each heat or lot in the shipment.



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Type “B” Certification

This certification is to include a current summary of the maximum to minimum range of the manufacturer’s quality control test results as determined by the manufacturer or other qualified laboratory.

These summaries must provide data on all major specification requirements and include the range of lots and manufacture dates represented by the data.

When combining multiple components into a single item, submit a detailed parts summary indicating the lot/heat number, part description and quantity for each part. Summary reports dated more than six months prior to the date of manufacture or shipment of the product will not be accepted.

The Engineer of Tests may also request copies of detailed test reports for material produced during a specified time interval for verification of the certification.



22

Type "C" and "D" Certifications

Type "C" Certification

This certification is to include a statement certifying that the material in the shipment is essentially the same as material that is prequalified.

Type "D" Certification

This certification is to include a statement certifying that the material in the shipment is essentially the same as material that is specified.



23

Type "E" Certification

This certification applies to assemblies or structures that are composed of two or more components or materials.

These components or materials have been approved previously on an individual basis for KDOT projects but lose their identity when they are incorporated into an assembly or structure.

This certification would apply to signs, overhead signs and lighting structures, etc.

The certification is to state that all the components or materials used in the fabrication of the represented assembly or structure were previously approved for KDOT use.



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Type “F” and “G” Certification

These certifications are referred to as “blanket certifications”. As permitted by Table 2601-1, submit Type “F” and “G” certifications covering material provided throughout the present calendar year. Clearly denote the covering year. Submit “F” or “G” for each manufacturer, producer, fabricator, plant, production facility, or supplier; and for each unique product, design, model, mix design, or formulation. If the previous criteria is satisfied, multiple pipe sizes of the same type can be covered by one certification, but each size must be clearly listed. Certification may cover multiple contracts and identical materials supplied under multiple line-items, provided the contracts and associated line-items are clearly listed. For multi-year contracts submit blanket certifications for each calendar year that material is supplied. Submit the certification in the covering year prior to the material's first use, not in advance of the covering year. Unanticipated changes in any of the criteria listed above during the course of a year requires submittal of an additional blanket certification.

Type “F” certifications. This certifications is to include a statement certifying that the material supplied during the covering calendar year is essentially the same as material that is prequalified.

Type “G” certifications. This certification is to comply with subsections 2601.2a. This is stated on slide 19.



25

Responsibility for preparation of certifications?

- **2601.2.a.(1).** The contractor is responsible for obtaining all certifications and arranging for their delivery to the proper destination prior to use of the material and allowing sufficient time for review as stated herein.
- **2601.2.c.** The manufacturer of the individual item is responsible for preparing certifications of Type “A”, “B”, “C”, “D”, “F” and “G” certifications.
- **2601.2.c.** The fabricator or assembler of individual items is responsible for preparing a Type “E” certifications.
- **2601.2d.** The Engineer reserves the right to sample and test any material or product that is governed by a certification. If deviations from the applicable specifications are found, the results will be reviewed by the Engineer to determine the final disposition of the material or product. Serious deviations may cause for removal from prequalification status.



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Who Gets Them?

2601.2e(1) Types “A” and “B” certifications. Submit one copy of the certification via hard mail or e-mail to:

Materials and Research Center, Materials Certifications, 2300 Van Buren, Topeka, KS, 66611

Email address: KDOT.CM.TypeABCerts@ks.gov

2601.2e(2) Types “C”, “D”, “E”, “F” and “G” certifications. Issue one copy to the Field Engineer responsible for the project construction.

Note: Epoxy Coated Materials (reinforcing, dowels, tie bars), A325 & A490 Nuts, Bolts, Washers, DTIs are handled by our Regional Materials Labs.

Email address: KDOT.CM.GreenBarCerts@ks.gov

Special Note: A325 & A490 bolts used for structural uses are to be tested by the MRC Metals Lab. *Contact Susan Barker for information regarding certifications for the materials listed in this note.



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This concludes the presentation

Thank you!!



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1

Duties of the Research Asphalt Section- Materials through the years,

Investigate the use of recyclable materials proposed to be used in Asphalt Pavement mixtures such as tire rubber, coal fly ash, broken glass, steel slag, steel staples, lignin, asphalt roofing shingles, sulfur, FRAP and high percentages of RAP



2

Duties of the Research Asphalt Section- Equipment through the years₂

Investigate the potential use of new test equipment such as Auto Rice, CoreLok, CoreDry, Bulk Specific Gravity Tester SG-4, MIST Tester, SSD Detect, Raveling and Brush Tester, Thermal Stress Restrained Specimen Tester (TSRST), Air and Water Permeability Testers, Linear Asphalt Compactor, Asphalt Beam Fatigue Tester, Pull-Off Test for HMA, Asphalt Mixture Pavement Tester (AMPT), Interlaken, DTS-30 Universal testing Machine, Smart-Jig and SmartLoader



3



**Research Lab
Unique
Equipment₃**

4

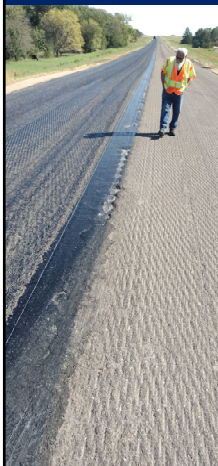
Duties of the Research Asphalt Section⁴

- Perform lab testing on HMA in use or trial mixes Examples: Cold-In-Place-Recycling (CIR), Micro-Surfacing, Asphalt Treated Base, Reflective Crack Inner-Layer (RCI), Stone Matrix, Open-Friction Graded Course, High % RAP mixes, Spray Paver, Warm Mix Asphalt, and Recycled Asphalt Shingle Mixes



5

Duties of the Research Asphalt Section⁵



- Develop Test Sections relating to new trial mixes
- Map out a **1000-foot test** section of the pavement by recording all existing distresses on the pavement prior to the new treatment
- Spring of following years observe and record the distresses of the designated test section



6

Duties of Research Asphalt Section₆

- Superpave Field (SF) CIT course
- Obtain 4000 pounds of HMA from a plant, edit/print manuals in-house, prepare test procedure samples and deliver to the university
- Instructors for the course
- Supplemental Examiner on test day



7

Duties of Research Asphalt Section₇

- Investigate premature HMA pavement failures
 - Obtain field cores from the distressed area, perform lab testing to determine problem
- Referee testing of active HMA projects
 - If the District Material Lab has a dispute with an Asphalt Contractor over Lot/Sublot test results and it cannot be solved at the district level
 - Split sample of the disputed material is given to research asphalt
 - Research Asphalt performs same tests to compare all results



8

Latest Testing in Research Asphalt

- IDEAL CRACKING TEST (CT)
 - **ASTM D-8225, Standard Test Method for Determination of Cracking Tolerance Index of Asphalt Mixture Using the Indirect Tensile Cracking Test at Intermediate Temperature**
- IDEAL RUTTING TEST (RT)
 - **ASTM D-8360, Standard Test Method for Determination of Rutting Tolerance Index of Asphalt Mixture Using the Ideal Rutting Test**
- Both methods calculate the CT or RT Index from the load-displacement curves that are used to evaluate HMA for cracking and rutting



9

Latest Testing in Research Asphalt

Ideal CT/RT₉

- Same equipment for Volumetric testing
 - SGC, Gmm, KT-15 Proc. III, Stability machine, jigs for the IDEAL CT & RT
 - Stability machine
 - Uses a **Smart-Jig**
 - **SmartLoader**
 - Pre-installed software for IDEAL CT, Stability & Flow, TSR, SCB (Semi-Circular Bend).
- **Smart-Loader**
 - 6 district labs and contractors
 - KT-XX method is being created for eventual KDOT use



10

Latest Testing in Research Asphalt IDEAL CT¹⁰

- **IDEAL-CT (Cracking Test)** Following ASTM D-8225
 - Specimens are compacted on SGC to a height of 62 ± 1 mm by 150mm diameter and $7 \pm 0.5\%$ air void content
 - Specimens preconditioned to a temperature of $25 \pm 1.0^\circ$ C
 - Environmental cabinet $2 \text{ hr} \pm 10 \text{ min}$
 - Water bath $2 \text{ hr} \pm 10 \text{ min}$
 - Lottman breaking head and cradle $19.05 \pm 0.3\text{mm}$ wide
 - Data analyzed using InstroTek SmartLoader Analysis Program



11

Latest Testing in Research Asphalt IDEAL RT¹¹

- **IDEAL – RT (Rutting Test)** Following ASTM D-8360
 - Specimens are compacted on the SGC to a height of 62 ± 1 mm by 150mm diameter and $7 \pm 0.5\%$ air void content
 - Test specimens are preconditioned to a temperature of $50 \pm 1.0^\circ$ C
 - Environmental cabinet $150 \pm 10 \text{ min}$
 - Water bath $45 \pm 5 \text{ min}$.
 - Lottman breaking head and cradle $19.05 \pm 0.3\text{mm}$ wide
 - Special cradle for the sample to rest in
 - Data analyzed using InstroTek SmartLoader Analysis Program



12

Latest Testing in Research Asphalt₁₂

• Hamburg Rut Tester or Hamburg Wheel Tester

- Evaluates the rutting and moisture-susceptibility of asphalt mixture pavement
 - Specimens compacted by a slab compactor or by Superpave Gyrotory Compactor
 - Compacted slab specimens 12.5" L X 10.25" W X 1.5 – 4" thick
 - SGC 4-150mm diameter X 62 mm thick specimens
 - $7 \pm 0.5\%$ air void content
- HDPE (high-density polyethylene) mold to secure the specimens for testing
 - Test stops after:
 - 20,000 passes and/or
 - maximum impression depth established by KDOT



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Hamburg Wheel Tracker₁₃

Before Testing



After 20,000 cycles or max depth
in 50° C water



14

KDOT RESEARCH- ASPHALT¹⁴

- AASHTO Accredited Laboratory
 - Become proficient in performing AASHTO test procedures similar to Kansas Test Methods
 - Verify test equipment used for HMA test procedures as required
 - Equipment documentation
 - Proficiency samples provided by AASHTO
- re:source
- AASHTO Lab Inspection
 - 18 months
 - On-site performance tests



15

AASHTO Methods used in Research Lab¹⁵

- AASHTO R-30 - Laboratory Conditioning of HMA
- AASHTO T-324 - Hamburg Wheel-Track Testing
- AASHTO TP-10 - Thermal Stress Restrained Specimen Test (TSRST)
- AASHTO T-312 – Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- ASTM D-8225 – Standard Test Method for Determination of Cracking Tolerance Index of Asphalt Mixtures (IDEAL-CT)
- ASTM D-8360 – Standard Test Method for Determination of Rutting Tolerance Index of HMA, using the IDEAL Rutting Test (IDEAL-RT)



16

Sampling of HMA Materials in the Field₁₆



- Sampling of HMA for IDEAL Cracking (CT) or Rutting (RT) tests if done for Research Asphalt
 - By the auger of the paving machine
 - Typically, 150 pounds
 - **Maximum** 50 pounds per bag/container
- Information needed
 - Mix design
 - date of sampling
 - Location
 - Sublot report that includes the sampled material
- Aggregate sampling
 - It is important that we obtain a representative sample from the material by following KT-1
- Sampling of HMA for QC/QA testing is done behind the paver following KT-25



17

Questions?
michael.feiden@ks.gov

18

Concrete Testing & Sampling

KDOT Concrete Research

Basic Laboratory Course
May 2023

Jennifer Distlehorst
Research Staff Engineer



1



2

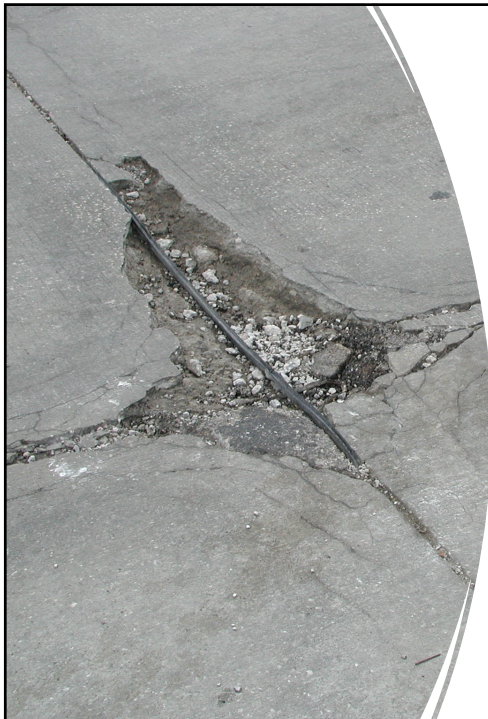
What does Concrete Research do?

Improve durability of Kansas concrete pavements by

- Evaluating new tests, materials, and construction methods
- Answering questions about concrete and testing
- Surveying pavement condition in test sections and for specific reasons, like D-Cracking
- Developing new test methods and specifications
 - Air void testing 2004
 - Permeability 2008
- Performs permeability testing for verification



3



Our goal: durable concrete

- Concrete must be strong AND durable
- Freezing water destroys pavements
- Salt rusts reinforcing steel destroying bridge decks
- Concrete Research develops and implements tests and requirements to protect concrete
- *Photo: freeze-thaw joint damage on K-68 in Franklin County*

4

Why prequalify mix designs?

- Durability must be part of the mix from the beginning
- Air voids protect pavement from freeze/thaw damage
- Lowering permeability protects structures from salt that rusts steel
- Aggregate gradation, additives and cements all affect air quality and permeability
- Reactive aggregates are kept out
- Once concrete is placed none of this can be changed or fixed



5

Keeping the water out

- PERMEABILITY is the ability of water and salt to travel through concrete
- Low permeability concrete keeps water and salt out.
- Water and salt travel through the concrete paste.
- Paste is everything except the aggregates: cement, water and air voids.
- *Photo: polished slab of concrete with dark aggregates and light paste.*



6

Permeability for Mix Design Approval

Permeability test results are required for mix design approval for

- All projects with over 250 cubic yards of concrete TOTAL, including structures and pavements AND
- All bridge deck overlay concrete
- All moderate permeability structural concrete
- *Specifications Section 401.3, General Concrete Mix Design*



7

Permeability Testing Requirements

- Test for mix design approval at the **highest water to cementitious materials ratio** that meets the permeability requirements
- Choice of three tests
 - KT-73 (Volume of Permeable Voids) at **28** days
 - KT-79 (Surface Resistivity) at **28** days
 - AASHTO T-277 (Rapid Chloride Permeability) at **56** days
- Test **three cylinders** for each mix
- Verify project concrete permeability **with same test** used for approval for each mix design



8

Permeability for Structural Concrete

Three permeability classes for structural concrete

- Low Permeability Concrete (LPC) for bridge overlays
- Moderate Permeability Concrete (MPC) for full-depth bridge decks
- Standard Permeability Concrete (SPC) for all other structural concrete not specified as LPC or MPC



9



Permeability for On-grade Concrete

- Same permeability requirements for pavement and shoulders
- Same as Standard Permeability Concrete for structures
- Not required for patching materials on pavements over ten years old

10

Three Permeability Test Methods

- **KT-73** Volume of Permeable Voids (Boil Test)
 - Standard Test Method For Density, Absorption, And Voids In Hardened Concrete
- **KT-79** Surface Resistivity Test (SRM)
 - Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration
- **AASHTO T 277** Rapid Chloride Permeability Test (RCP)
 - Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration



11

Permeability Requirements

	KT-73 Volume of Permeable Voids	KT-79 Surface Resistivity Measurement	AASHTO T-277 Rapid Chloride Permeability
Age at testing	28 days	28 days	56 days
Limit	Maximum	Minimum	Maximum
LPC	9.5%	27.0 kΩ-cm	1000 Coulombs
MPC	11.0%	13.0 kΩ-cm	2000 Coulombs
SPC and On-grade	12.5%	9.0 kΩ-cm	3000 Coulombs



12

KT-73 Boil Test Introduction

- The Boil Test measures the volume of permeable voids in concrete.
- Not all voids in concrete are permeable so they don't dry out completely and don't fill completely during boiling.
- Boiling forces air out of permeable voids and water in.
- Permeability is easily water travels through the concrete
- Low percent permeable voids = Low permeability
- Can be used accurately on cores



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KT-73 Boil Test Timeline

- Day 0: Cast cylinders
- Day 1: Demold and standard cure
- Day 26: Cut specimens and dry in oven
- Day 28: Weigh dry then boil for five hours
- Day 29: Weigh in water and at SSD



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What is Percent Permeable Voids?

How much of the volume of the concrete is permeable voids?

- Compare amount of water forced into voids by boiling to amount of total water displaced
- SSD weight – dry weight = water in permeable voids
- SSD weight - weight in water = water displaced by whole specimen
- $\frac{\text{Water in permeable voids}}{\text{Total water displaced}} \times 100 = \text{Percent Permeable Voids}$
- Record result to nearest 0.01%



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Percent Permeable Void Requirements

Parameter	Requirement
Age at testing	28 days
Limit	Maximum
Low Permeability Concrete (LPC)	9.5%
Moderate Permeability Concrete (MPC)	11.0%
Standard Permeability Concrete (SPC) and On-grade	12.5%



16



KT-79 Surface Resistivity Introduction

- Electrical current is carried through concrete by water
- **Resistance** to current is measured by Surface Resistivity in $k\Omega\text{-cm}$
- High resistance means LOW permeability
- A **minimum** resistivity is required
- SRM must be performed on 4"x 8" standard cylinders

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KT-79 Surface Resistivity Timeline

- Day 0: Cast three cylinders
- Day 1: Demold and standard cure
- If transporting cylinders to testing lab
 - Wrap in wet towels, then place in plastic bag and seal
 - Deliver cylinders within 48 hours of casting
 - Remove cylinders from bags within 30 minutes of arrival and cure
 - DO NOT ALLOW SAMPLES TO DRY OUT AT ANY TIME
- Day 28: Measure surface resistivity in $k\Omega\text{-cm}$, taking four measurements on each cylinder

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Calculating Surface Resistivity

- Average four resistivity measurements for each specimen
- Average three specimens for sample
- Adjust sample results for curing condition
 - If lime-cured, multiply sample average by 1.1
- Record result to nearest 0.1 k Ω -cm



19

Surface Resistivity Requirements

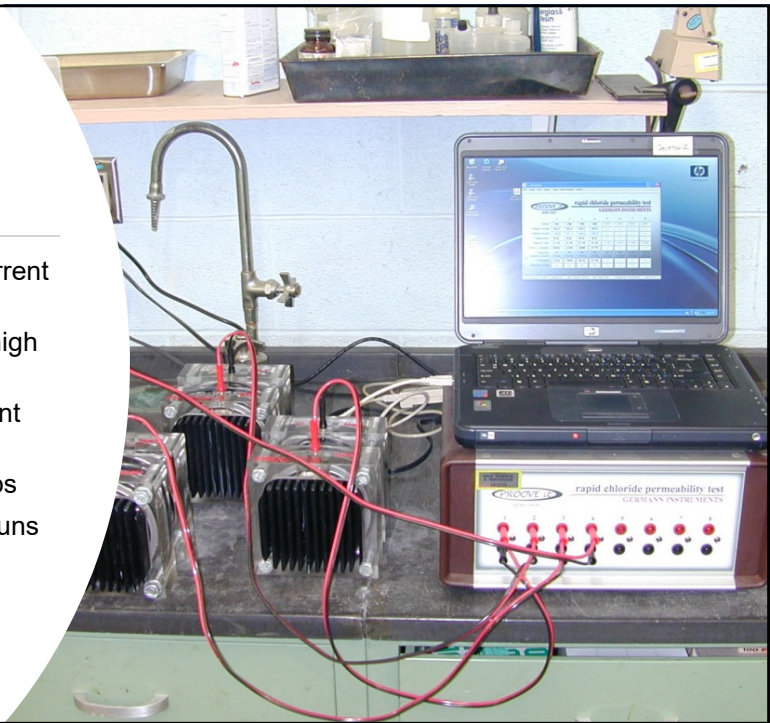
Parameter	Requirement
Age at testing	28 days
Limit	Minimum
Low Permeability Concrete (LPC)	27.0 k Ω -cm
Moderate Permeability Concrete (MPC)	13.0 k Ω -cm
Standard Permeability Concrete (SPC) and On-grade	9.0 k Ω -cm



20

AASHTO T 277 Rapid Chloride Permeability

- Measures transmission of electric current through concrete
- HIGH RCP means high current and high permeability
- RCP is specified by MAXIMUM current passed
- RCP current is measured in Coulombs
- Research is the only KDOT lab that runs RCP



21

Rapid Chloride Permeability Timeline

- Day 0: Cast three cylinders
- Day 1: Demold and standard cure
- Day 54: Cut specimens to 2", weigh in water and SSD
- Day 55: Vacuum saturate specimens and keep in water until testing
- Day 56: Run RCP Test

22

Day 55 Vacuum Saturation



- Place specimens in vacuum chamber
- Apply vacuum for three hours
- Add water to chamber without opening
- Apply vacuum for another hour



23

Day 56 Running the RCP Test

- Specimens are placed in RCP cells
- NaCl solution (salt water) is added to one cell and NaOH (sodium hydroxide) solution is added to the other
- Electrical leads connect each side of the cell to the voltage applicator
- Current must pass through the concrete to complete the circuit



24

Rapid Chloride Test Results

- Results are measured in Coulombs of current passed through the concrete
- Adjust results for size of sample with equation

$$Q_s = Q_x * \left(\frac{3.75}{x} \right)^2$$

- X = diameter of specimen in inches
- Q_x = Coulombs measured in test
- Q_s = Coulombs reported, adjusted for a 3.75 in. specimen diameter
- Record result to nearest 10 Coulombs



25

Rapid Chloride Permeability Requirements

Parameter	Requirement
Age at testing	56 days
Limit	Maximum
Low Permeability Concrete (LPC)	1000 Coulombs
Moderate Permeability Concrete (MPC)	2000 Coulombs
Standard Permeability Concrete (SPC) and On-grade	3000 Coulombs



26

Air in Concrete

- Air voids give freezing water space to expand without cracking the concrete
- Freezing water can only travel 0.01 inches before cracking starts
- Need air voids within 0.01 inches or less for protection
- **Spacing Factor** is the average distance to an air void from any point in the concrete



27

Air everywhere without too much total air?

- Distribute the air in lots of smaller air voids
- Think lots of chocolate chips in ice cream vs one big chunk: same amount of chocolate but more bites with chocolate!

Small spacing factor



Ice cream with chips all the way through!

Large spacing factor



Lots of ice cream with no chocolate in it

28

KT-71 Air-Void Analyzer (AVA) Measures Spacing Factor

- Older spacing factor methods required hardened concrete
- Air Void Analyzer: a faster test of fresh concrete
- Sample from pavement behind the paver
- Vibrating drill with cage fills syringe with mortar
- Three samples at one location



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Where to run an AVA test

- Field samples, lab testing
- The AVA is a sensitive instrument and needs a stable location away from wind and vibration
- District labs, area offices and sub-area shops are used
- The AVA is set up before testing begins

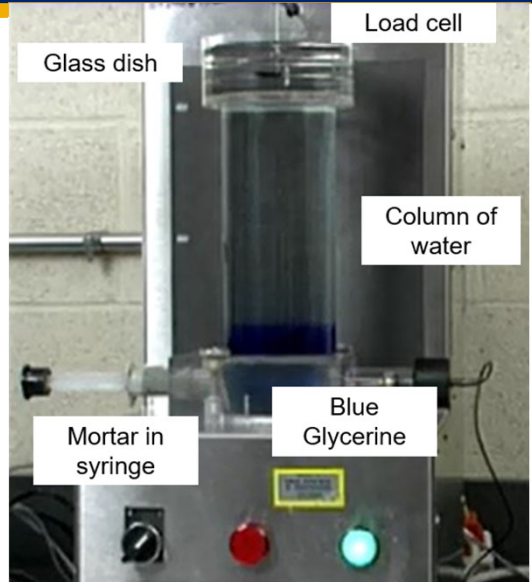


30

How the AVA test works

AVA measures bubbles released from fresh mortar

- Mortar is mixed with glycerine at the bottom of a column of water
- Bubbles rise to a glass dish at the top
- Big bubbles go faster and are first at the dish
- Speed of bubbles is known so all bubbles arriving at the same time are the same size
- The load cell measures buoyancy of the dish
- Computer calculates bubble distribution from change in weight of dish with time

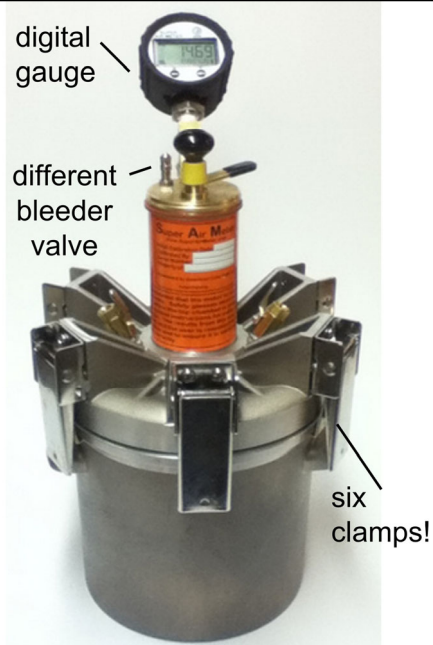


31

AVA Results and Requirements

- Test two samples and compare spacing factor results
 - Valid results agree within 0.0025 inch
 - If first two tests don't agree, run third test
- Average all results that agree within 0.0025 in
- Report spacing factor to nearest 0.0001 in
- Minimum spacing factor is 0.0100 in
- Required for **pavement** mix design prequalification and field verification

32



In Development: Super Air Meter

- KT-86 Characterization of the Air-void System Of Freshly Mixed Concrete by the Sequential Pressure Method
- Evolved from pressure meter, with
 - Digital pressure gauge
 - Different bleeder valve
 - Six clamps
- Gives total percent air and SAM number

33

Running the SAM test

- Use KT-18 procedures to fill the measurement bowl
- Secure the lid
- Add water through the petcocks
- Pump the pressure up to 14.5 psi, then 30, then 45
- Let pressure off, pump up three steps again
- The SAM records the equilibrium pressure at each step

34

SAM test results

- Different sizes of air voids respond to pressures differently
- SAM number is the difference in equilibrium pressures after the first and second 45 psi pressure steps
- Valid SAM tests give SAM numbers between 0.03 and 0.70 psi
- Larger air voids compress more, giving a higher SAM number
- Higher SAM number indicates higher spacing factor
- Report SAM number to nearest 0.01 psi



35

Summary

- Concrete Research works to improve concrete durability
- Three different tests measure permeability
 - KT-73 Volume of Permeable Voids (Boil Test)
 - KT-79 Surface Resistivity
 - AASHTO T 277 Rapid Chloride Permeability
- KT-71 Air Void Analyzer measures spacing factor of air voids in concrete
- Super Air Meter test in development also measures air system quality
- Permeability and AVA test results are required for mix design prequalification



36

Basic Laboratory Soils Section

Isaac M Ferguson



1

Sample Preparation (tips) 1.1

- We recommend a minimum of 100 lb sample for testing soils.
- We recommend a minimum 150 lb sample for testing aggregate, MSE Wall, Relative Density, or treated subgrade/base testing.



2

Sample Preparation 1.2

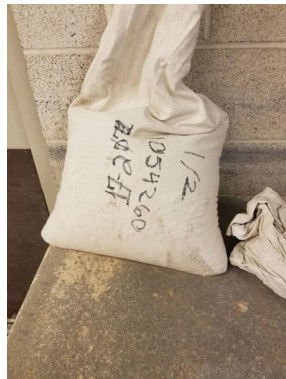
- It takes about 2 days to prepare the sample before testing starts
- This is why not having a large enough sample initially could delay test results.



3

Routine Testing 1.3

- Routine tests can be performed using disturbed sample



4

Routine Tests 1.4

- Standard Compaction KT-12
- Atterberg Limits KT-10
- Grain Size Analysis
- Specific Gravity



5

Strength Testing 1.5

- Strength testing are typically performed from an undisturbed sample collected by a Shelby Tube.



6

Strength Tests 1.6

- Unconfined Compression
- Direct Shear
- Ring Shear
- Triaxial
- Consolidation



7



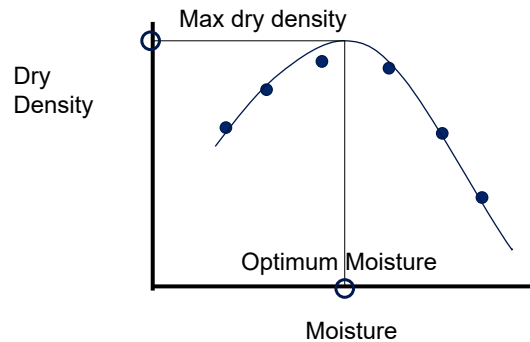
Standard Compaction



8

Standard Compaction (KT-12) 2.1

- Maximum Dry Density
- Optimum Moisture



9

Standard Compaction 2.2

- Standard Compaction uses a 5.5 lb hammer with a 12-inch drop
- Soils typically use a 4 inch mold with 25 blows to 3 lifts
- Aggregate typically uses a 6-inch mold with 56 blow to 3 lifts.
- Note: The 4-inch and 6-inch molds are both approx. 4.584-inch tall.



10

Standard Compaction (KT-12) 2.3

- Performed on fine grained material
 - 1. The material has less than 10% retained on the No. 4 sieve or
 - 2. The material has more than 10% but less than 30% retained on the No 4 sieve and the fraction passing the No. 40 sieve has a plasticity index greater than 8
- Coarse grained (Aggregate)
 - Typically this material will have sufficient fines to hold moisture.
 - If “too clean” then a Relative Density would be more suitable.



11

Relative Density



12

Relative Density (KT-69) 3.1

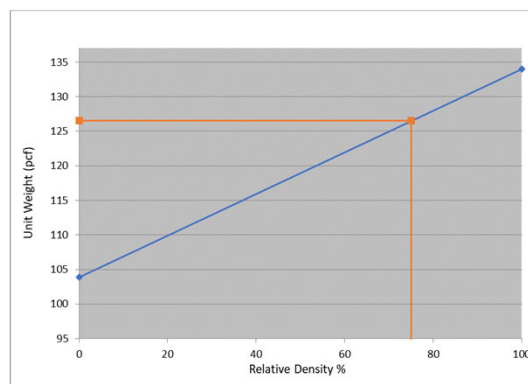
- Uses a Vibrating Table
- For testing free draining, cohesionless material containing a maximum of 15% fines and 100% passing the 3" sieve
- The minimum density is determined when the material is in its uncompacted state
- The maximum density is determined after being loaded and vibrated



13

Relative Density (KT-69) 3.2

$\rho_{\text{max}} = 134.0\text{pcf}$ $\rho_{\text{min}} = 103.9\text{pcf}$ 75% Relative Density: 126.5 pcf



14




Atterberg Limits



15

Atterberg Limits 4.1

- Liquid Limit
- Plastic Limit
- Plasticity Index



16

Atterberg Limits 4.2

- **Liquid Limit: LL**
- Plastic Limit
- Plasticity Index



17

Atterberg Limits 4.3

- **Liquid Limit:** this test determines the water content at which the soil passes from a plastic to a liquid state.



18

Atterberg Limits 4.4

- Liquid Limit: LL
- **Plastic Limit: PL**
- Plasticity Index



19

Atterberg Limits 4.5

- **Plastic Limit:** this is the lowest water content of the soil at which the soil remains plastic



20

Atterberg Limits 4.6

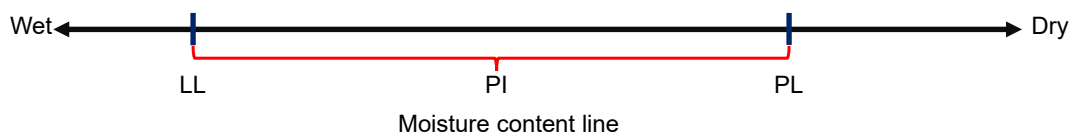
- Liquid Limit: LL
- Plastic Limit: PL
- Plasticity Index: PI



21

Atterberg Limits 4.7

- Plasticity Index of a soil is the range in water content within which the material is in a plastic state.
- $PI = LL - PL$



22

Sieve Analysis/Gradation



23

Sieve Analysis/Gradation 5.1

- Sieves are used for determining the distribution of particle sizes in soils/aggregates
- Aggregate is washed to determine material passing #200 sieve



24

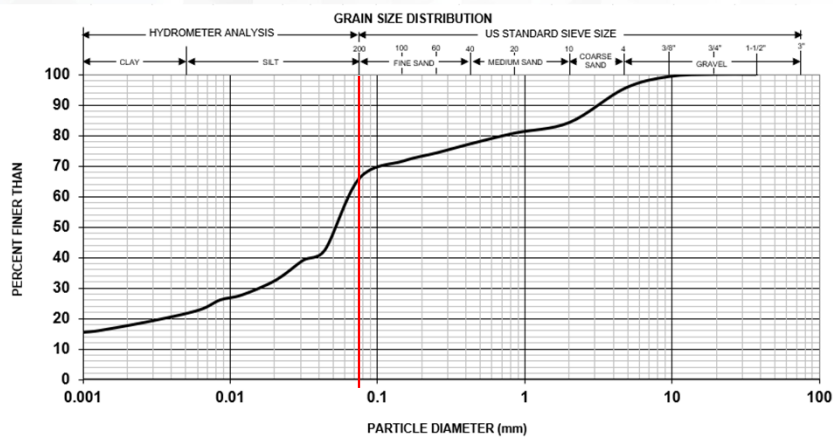
Hydrometer 5.2

- Analysis of particle size distribution of material passing a #200 Sieve
- Silts
- Clays



25

Gradation Curve 5.3



PHYSICAL PROPERTIES										
SAMPLE NUMBER	STATION	CL. DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET.	SPEC. GRAV.	CLASSIFICATIONS	
							ON 10 SEIVE (PASS NO. 10)	(PASS NO. 10)	KANSAS	USCS
1A-1	762+00	85RT	0-2.0'	37	22	15	15.8	2.65	CL	CL



26

Classification of Soils 5.4

- AASHTO-uses a classification system based on laboratory determination of particle size distribution, liquid limit, and plasticity index.

Table 1—Classification of Soils and Soil-Aggregate Mixtures

General Classification Group Classification	Granular Materials (35 Percent or Less Passing 75 µm)			Silt-Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1	A-3 ^a	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing:							
2.00 mm (No. 10)	—	—	—	—	—	—	—
0.425 mm (No. 40)	50 max	51 min	—	—	—	—	—
75 µm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40):							
Liquid limit	—	—	—	40 max	41 min	40 max	41 min
Plasticity index	6 max	Nonplastic (NP)	—	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

^a The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

^b See Table 2 for values.



27

Classification of Soils 5.5

- Unified Soil Classification System

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^a				Soil Classification		
				Group Symbol	Group Name ^b	
COARSE-GRAINED SOILS	Gravels (More than 50 % of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5 % fines ^c)	Cu ≥ 4.0 and 1 ≤ Cc ≤ 3.0 ^d	GW	Well-graded gravel ^e	
		Gravels with Fines (More than 12 % fines ^c)	Cu < 4.0 and/or (Cc < 1 or Cc > 3.0) ^d	GP	Poorly graded gravel ^e	
	Sands (50 % or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5 % fines ^f)	Cu ≥ 6.0 and 1.0 ≤ Cc ≤ 3.0 ^d	SW	Well-graded sand ^f	
		Sands with Fines (More than 12 % fines ^f)	Cu < 6.0 and/or (Cc < 1.0 or Cc > 3.0) ^d	SP	Poorly graded sand ^f	
FINE-GRAINED SOILS	Sils and Clays	inorganic	Fines classify as CL or CH	GC	Clayey gravel ^{e, f, g}	
		organic	Fines classify as ML or MH	GM	Silty gravel ^{e, f, g}	
	Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line ^h	CL	Lean clay ^{k, L, M}	
		organic	PI < 4 or plots below "A" line ^h	ML	Silt ^{k, J, M}	
	50 % or more passes the No. 200 sieve	Sils and Clays	inorganic	PI plots on or above "A" line	CH	Fat clay ^{k, L, M}
		Liquid limit 50 or more	organic	PI plots below "A" line	MH	Elastic silt ^{k, L, M}
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor	inorganic	Liquid limit - not dried < 0.75	OL	Organic clay ^{k, L, M, N} Organic silt ^{k, L, M, O}	
		organic	Liquid limit - not dried < 0.75	OH	Organic clay ^{k, L, M, P} Organic silt ^{k, L, M, Q}	
				PT	Peat	



28

Classification of Soils 5.6

- KDOT Classification System



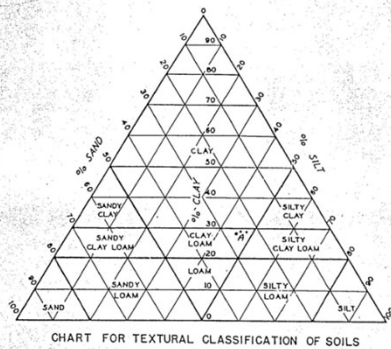
29

TABLE I
PERCENTAGE OF SOIL FRACTIONS PRESENT

CLASS NAME	SAND	SILT	CLAY
Sand	80-100	0-20	0-20
Sandy Loam	50-80	0-50	0-20
Sandy Clay Loam	50-80	0-30	20-30
Sandy Clay	50-70	0-20	30-50
Silt	0-20	80-100	0-20
Silty Loam	0-50	50-80	0-20
Silty Clay Loam	0-30	50-80	20-30
Silty Clay	0-20	50-70	30-50
Clay	0-50	0-50	30-100
Clay Loam	20-50	20-50	20-30
Loam	30-50	30-50	0-20

Classification of Soils 5.7

- KDOT Classification System

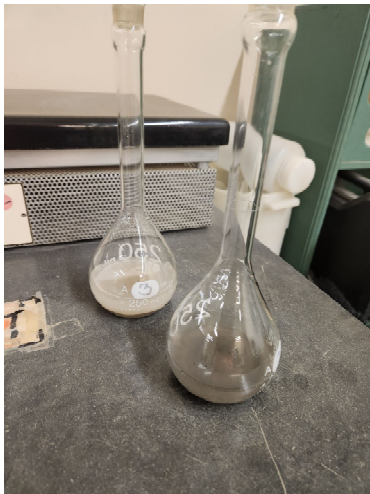


30

Specific Gravity

31

Specific Gravity 6.1



- The ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.
- Soils determines specific gravity by means of a pycnometer.

32

Soil Swell Test Checks

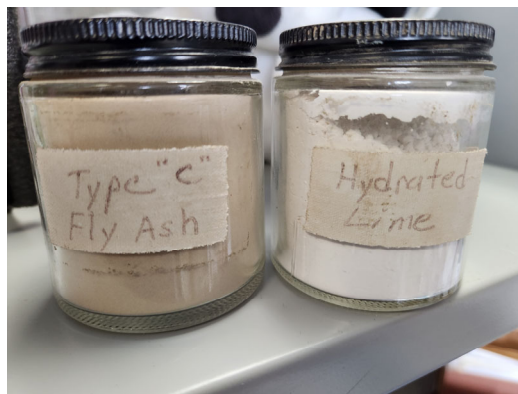
- Soils with 2% or greater swelling potential beneath pavement is not good.
- We can check swelling potential by using Oedometer or Atterberg test results



33

Soil Stabilization

- Examples are: Hydrated Lime, Type "C" Fly Ash, Portland Cement



34

Consolidometer (Oedometer)



- Predicts settlement
- Predicts swell potential



35

Strength Testing



36

Strength Tests

- Direct Shear
- Ring Shear
- Triaxial
- Unconfined Compression



37



Direct Shear

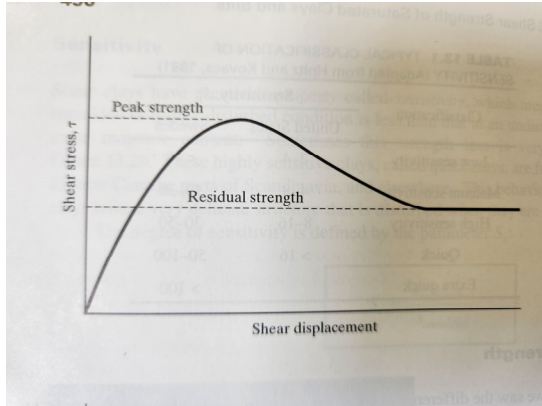
- Calculates shear strength of soil as internal angle of friction = ϕ'



38

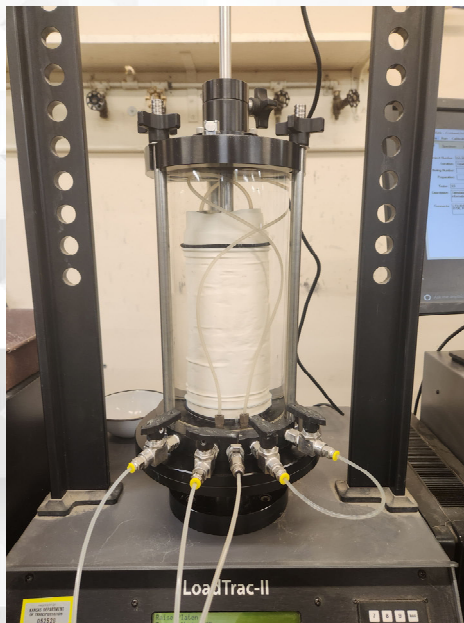
Ring Shear Test

- Used to calculate the residual strength of soils
- Information is useful for landslide/slope failure analysis.



39

Triaxial Testing




40



41

Unconfined Compression Test

- Similar to the Triaxial Test, but does not have a confining pressure.
- This test is used for analysis of cohesion = c



42

Permeability Test

- This test is used to predict the hydraulic conductivity of soil.



43

Testing Request



44

Requesting Testing

- KT-12: Standard Compaction test. (also know as Proctor)
- KT-10: Atterberg Limits
- Note: currently both of these tests can be found in AASHTOWare under the name **Routine Tests**
- **Note:** Make sure all testing is assigned to the Soils section ie if a gradation needs to be performed with KT-12 and KT-10. Make sure the lab is assigned to **SOILS**.



45

End of Presentation



46




1

Geology Research Section

Tasks Include

- **Air System Analysis of Hardened Concrete**
- **Microscopy/Petrographic/Forensic Analysis**
- **Alkali-Aggregate Reactivity (AAR)**
 - Alkali-Silica Reaction (ASR)
 - Alkali-Carbonate Reaction (ACR)
- **Aggregate Studies**
 - Resistance of aggregate to D-cracking
 - Resistance of aggregate to internal reactions
 - Resistance of aggregate to chlorides
- **Assist in any other study**



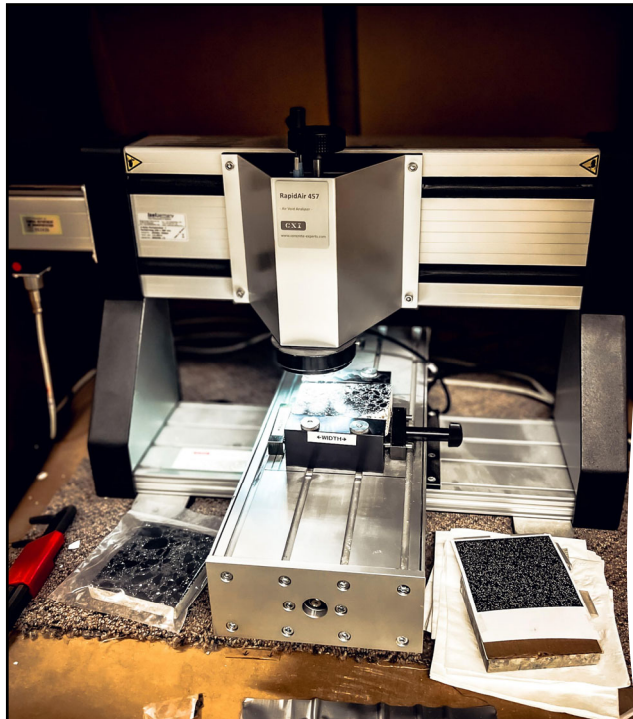
2

ASTM Standard C 457

- Standard test method for microscopical determination of parameters of the air-void system in hardened concrete
- We use the Linear Traverse Method



3



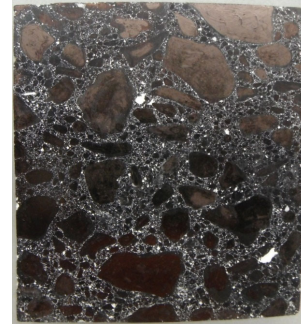
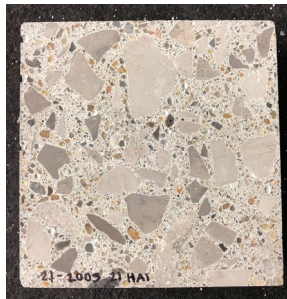
RapidAir 457 Automated System

- Analyzes air content in hardened concrete
- Cuts the analysis time from 4-6 hours per samples to under 10 minutes per sample
- Replaces the manual test performed as described in ASTM C457



4

Evaluation of the Air Void System in Hardened Concrete Samples



5

Importance of the Air Void System in Concrete

- Air in the concrete helps protect the paste from cracking during freezing weather
- Critical in environments where freeze-thaw cycles are prevalent
- Measure total air, size of air voids, and distribution of air voids



6

What Do We Want To Know From The Linear Traverse Test

- **Total Percent Air in the sample**
 - Generally accepted range of 5% to 8% in hardened samples
 - Most KDOT designs call for 6.5% +/- 1.5 %
- **Spacing Factor**---how the voids are distributed in the paste
 - Generally accepted range in hardened samples is 0.004 to 0.008 inch
- **Specific Surface Value**
 - How fine or coarse the air void system is
 - Generally accepted range 600 to 1100
 - Higher numbers mean a finer air void system (smaller air voids)
- **Amount of the type of air**
 - Entrained Air vs. Entrapped Air



7

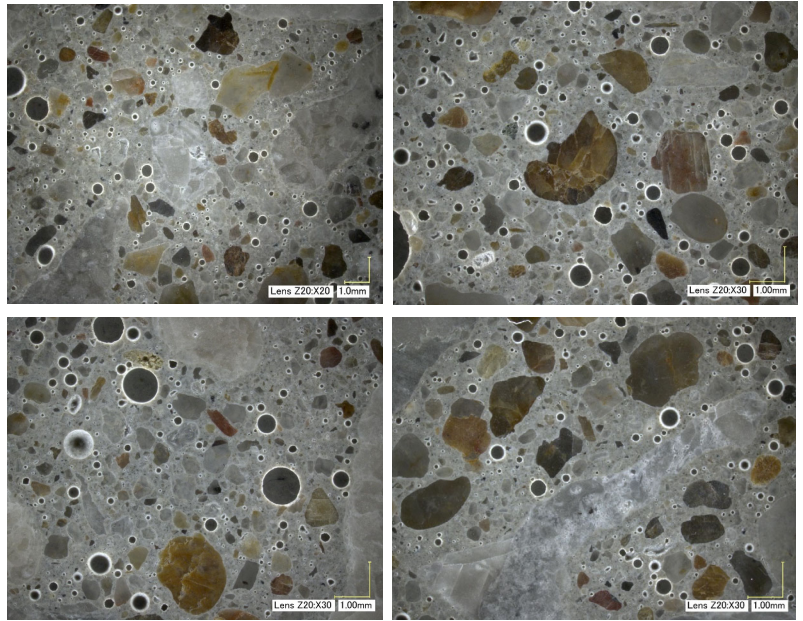
Two Types of Air Voids

- **Entrained Air**
 - Usually spherical
 - Very small in size
 - 5 to 500 micrometers (1/2 mm)
 - ASTM states 1000 micrometers (1 mm)
- **Entrapped Air**
 - Usually odd shaped
 - Usually larger in size
 - >1000 micrometers (1 mm)
 - But can be of any size



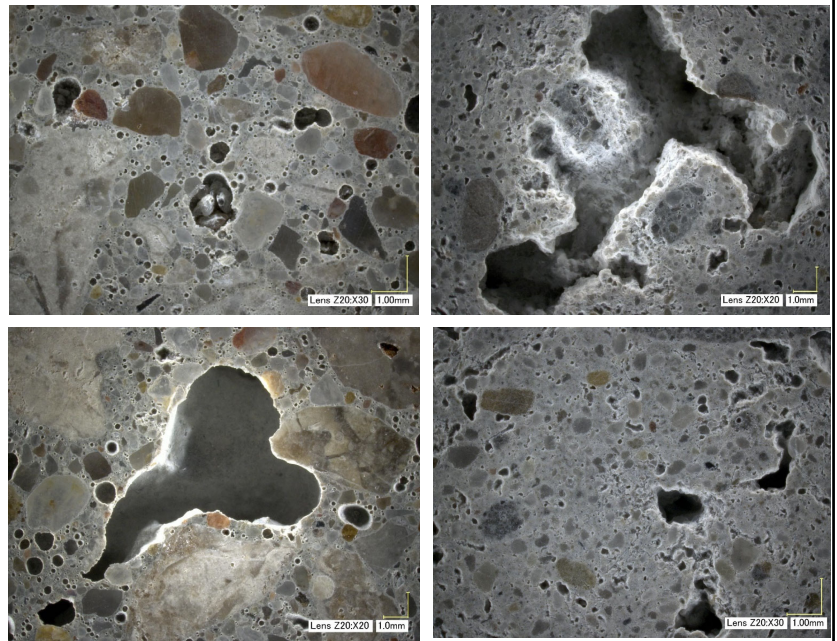
8

Entrained Air



9

Entrapped Air



10

ASTM C457 Test

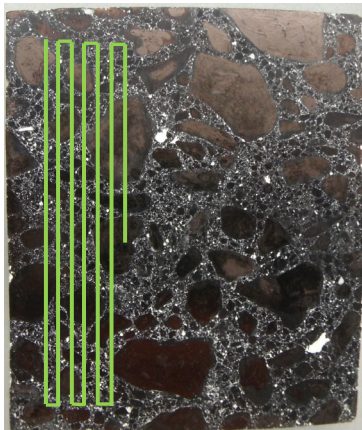
- There is a minimum length of traverse required for ASTM C457 Test
- Dependent on maximum aggregate size
- If the maximum aggregate size is:
 - 3/4-inch aggregate----90 linear inch traverse
 - 1/2-inch aggregate----80 linear inch traverse
 - 3/8-inch aggregate----75 linear inch traverse

These are listed in the ASTM C457 Standard



11

Liner Traverse Example



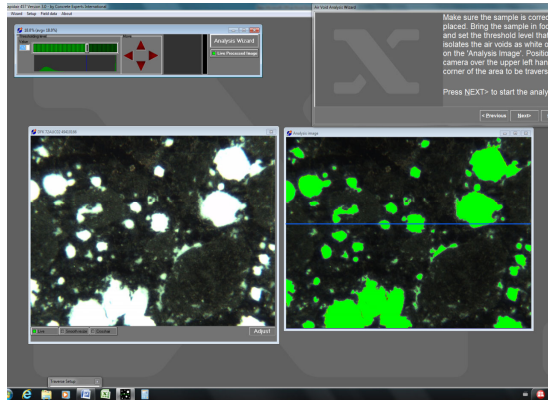
- 4 X 8-inch cylinder/core
- Sample size 4.0 X 4.25 inch
- Area Traversed approximately 3.1 X 3.1 inches (80x80mm)
- 3/4-inch maximum aggregate size (most common)
- Requires 90 linear inches of traverse
- We input the length of traverse we want completed (always a little more than required)



12

ASTM C457 Test

- Test is run at 100 x magnification
- ASTM requires at least a 50x magnification
- Only count the voids that intersect the reference line



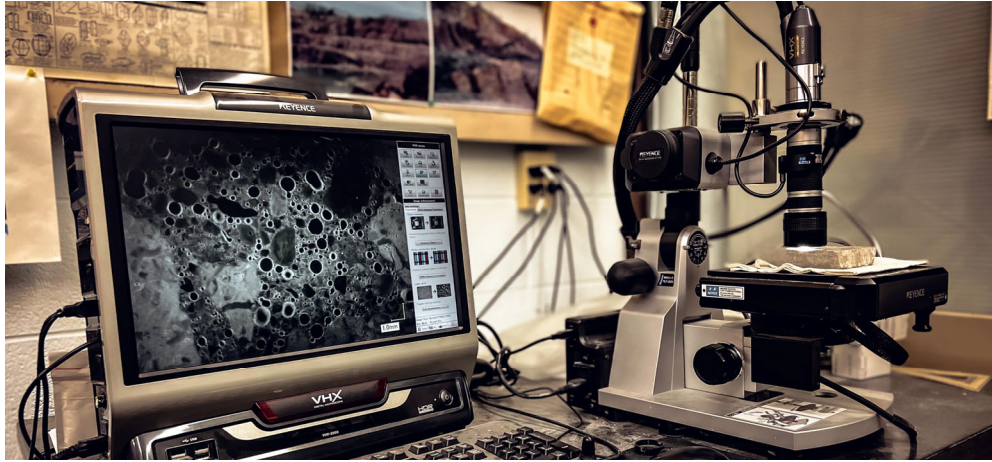
13

Linear Traverse Report

Sample ID:	17-0294 10							
Sample Size (in x in):	4.4 x 4.0	Length Traversed (in):	92.94					
Paste Content (%):	24.40	Area Traversed (in ²):	3.1 x 3.1					
Chord Length Distribution - Table								
Class No.	Chord size (µ1000 inch)	Number of Chords in Class	Number of Chords in Percent	Air Content in Class	Cumulated Air Content	Chord length frequency	Air content fraction	
1	0.00-0.04	183	6.96	0.040	0.040	0.06	0.040	
2	0.04-0.08	495	21.85	0.240	0.280	0.22	0.240	
3	0.08-0.12	248	10.06	0.260	0.530	0.13	0.260	
4	0.12-0.16	207	10.90	0.300	0.830	0.11	0.300	
5	0.16-0.20	161	6.48	0.330	1.160	0.09	0.330	
6	0.20-0.24	120	6.32	0.280	1.440	0.06	0.280	
7	0.24-0.31	165	8.83	0.450	1.890	0.05	0.450	
8	0.31-0.39	123	6.48	0.470	2.360	0.06	0.470	
9	0.39-0.47	76	4.00	0.350	2.710	0.04	0.350	
10	0.47-0.55	47	2.47	0.260	2.970	0.02	0.260	
11	0.55-0.63	41	2.16	0.260	3.230	0.02	0.260	
12	0.63-0.71	29	1.53	0.200	3.440	0.02	0.210	
13	0.71-0.79	26	1.37	0.200	3.650	0.01	0.210	
14	0.79-0.87	22	1.16	0.200	3.850	0.01	0.200	
15	0.87-0.94	9	0.47	0.090	3.930	0.00	0.090	
16	0.94-1.02	6	0.42	0.090	4.020	0.00	0.090	
17	1.02-1.10	7	0.37	0.080	4.100	0.00	0.080	
18	1.10-1.18	5	0.28	0.060	4.160	0.00	0.060	
19	1.18-1.26	13	0.68	0.160	4.340	0.01	0.160	
20	1.26-1.37	16	0.84	0.250	4.590	0.01	0.250	
21	1.37-1.47	4	0.21	0.070	4.660	0.00	0.070	
22	1.47-1.57	6	0.32	0.020	4.780	0.00	0.020	
23	1.57-1.64	25	1.02	0.170	4.940	0.01	0.170	
24	1.64-1.71	6	0.32	0.130	5.080	0.00	0.130	
25	1.71-1.87	2	0.11	0.140	5.220	0.00	0.140	
26	1.87-2.04	1	0.05	0.190	5.390	0.00	0.190	
27	2.04-2.18	3	0.16	0.250	5.640	0.00	0.250	
28	2.18-2.6	1	0.05	0.100	5.880	0.00	0.100	
Only chords from 30 to 4000 microns are included in results								
Air Content (%)	6.04							
Specific Surface (in ²)	799.6							
Spacing Factor (in)	0.0051							
Void Frequency (in ³)	12.08							
Average Chord Length (in)	0.0050							
Paste to Air Ratio:	4.04							

14

Microscopy/Petrographic/Forensic Analysis Using the Keyence Microscope



15

Air Void Clustering

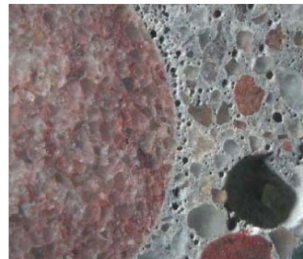


Rating 0 - No clustering present

- Clustering can be categorized as no clustering, minor, moderate or severe clustering



Rating 1 - Minor clustering



Rating 2 - Moderate clustering

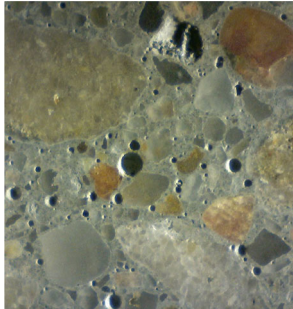


Rating 3 - Severe clustering

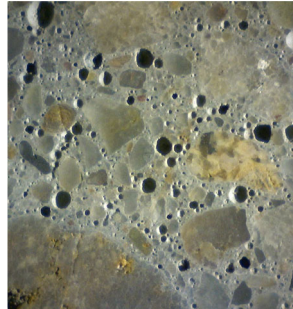
16

Percent Air Comparison

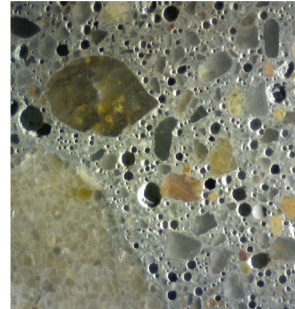
Low



Normal



High



17

Microscopy/Petrographic/Forensic Analysis

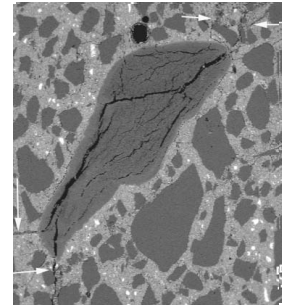
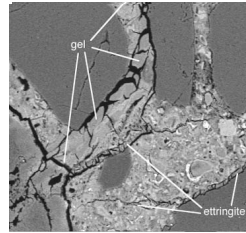
- Air void system analysis—clustering, percent air
- Alkali-Aggregate Reactions (ASR & ACR)
- D-Cracking of limestone aggregates
- Frozen concrete
- Overwatered concrete
- Soil analysis—Gypsum in the soil
- Low break strength in concrete cylinders/cores
- Mineral identification
- Many other tasks.....



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Alkali-Aggregate Reactivity

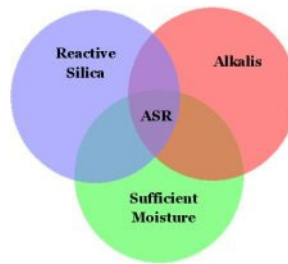
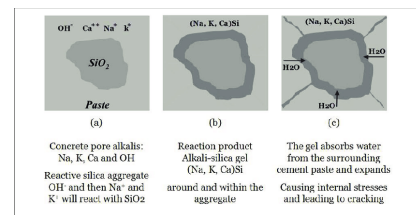
- Alkali-Aggregate Reactivity (AAR)
 - Alkali-Silica Reaction (ASR)
 - Alkali-Carbonate Reaction (ACR)



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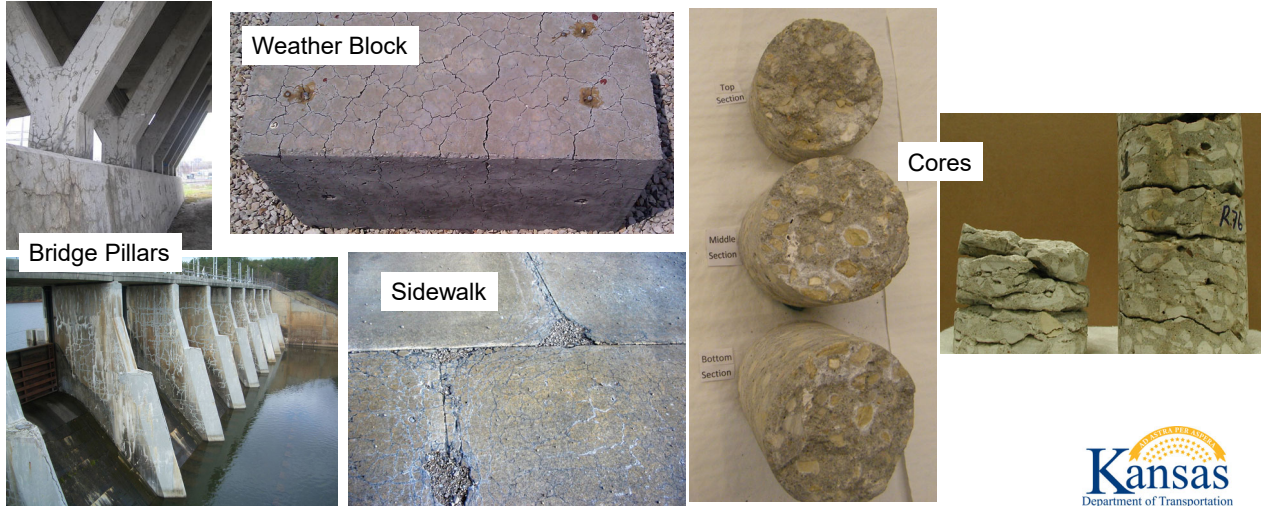
How Does ASR Occur?

- Reactive silica (from aggregates)
 - Chert, Quartz and other silica
- Alkalis' (mainly from Portland cement)
 - Sodium and Potassium
- Sufficient moisture



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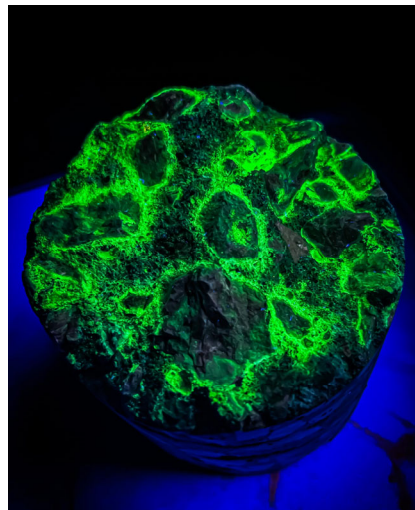
ASR in Concrete Structure



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ASR Uranyl Acetate Treatment

- Treated with uranyl acetate solution and viewed under UV light



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Alkali-Carbonate Reactivity (ACR)

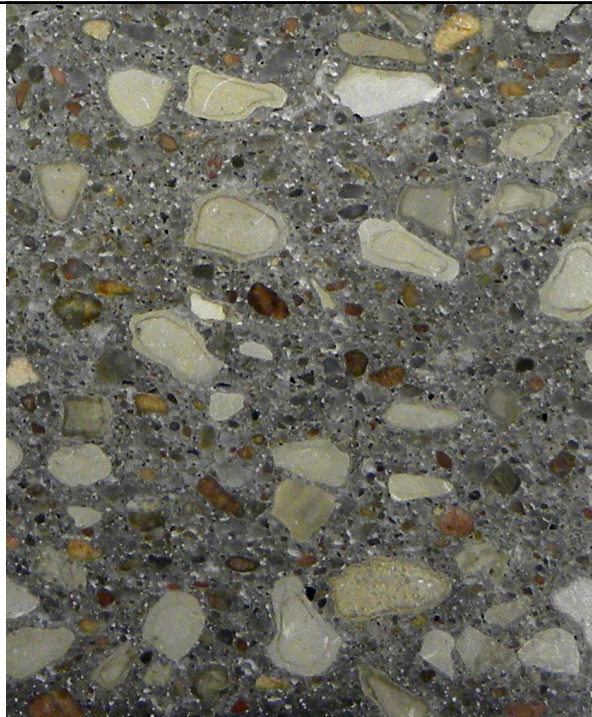
- Alkali in the cement reacts with dolomite crystals present in limestone aggregate
- Forms reaction rings within the limestone aggregate
- Makes the aggregate more porous allowing more water absorption



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Alkali-Carbonate Reactivity (ACR)

Damage pattern in concrete very similar to ASR



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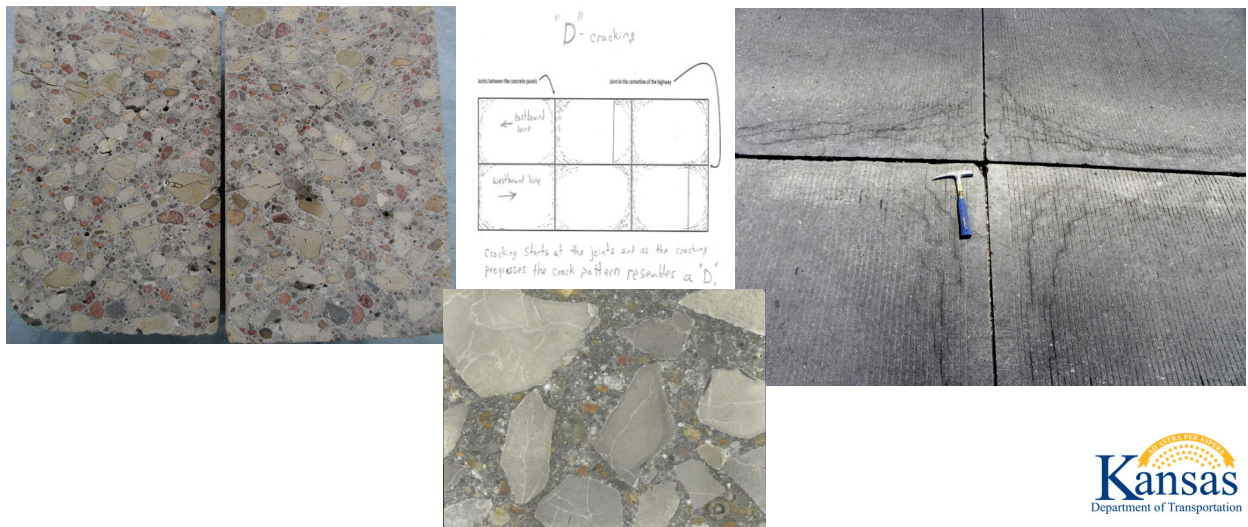
D-cracking Evaluations

- D-Cracking is an aggregate issue
- Aggregates absorb water and cracks form during freeze thaw cycles
- D-Cracking patterns differ from those that form from ASR and ACR
- Cracking begins at the joints in a pavement and progress outward



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D-Cracking Examples



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Cylinder/Core Low Break Strengths Causes

- **Air issues**
 - For every 1% increase in air there is a 5% decrease in strength
- **Paste issues**
 - Un-hydrated paste
- **Poor Paste-Aggregate Bond**
- **Handling/Making of cylinders**
- **Concrete placement issues—cores**



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Questions?



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