KAPA Research & Specifications (R&S)
KRMCA Technical and Quality Control (TQC)
Quarterly Committee Meeting
Tuesday – October 31, 2023 - 1:30 PM

AGENDA

1. Introductions

2. Antitrust Statement

3. Review and Approval of 8/9/23 R&S/TQC Meeting Minutes

Continued Discussion/Update from Previous Meeting

4. Concrete Testing Oversight Program
    A. Progress on KDOT Staffing

5. Protocols for Addressing Low Strength Test Results

6. Resistivity Testing for Concrete
    A. Variability in test results using different testing equipment

New Items

7. Technical Guidance Document to KDOT Districts on Adding Held Back Water

8. KDOT's Stricter Use of Unit Weight for Acceptance
    A. Effect on small loads

9. Tyler Ley Data Showing Air Lost in Plastic Concrete by Pumping Returns Later

ANTITRUST POLICY STATEMENT

The Kansas Aggregate Producers and the Kansas Ready Mixed Concrete Association assigns the highest priority to full compliance with both the letter and the spirit of antitrust laws. Agreements among competitors that unreasonably limit competition are unlawful under federal and state antitrust laws, and violators are subject to criminal fines and incarceration, civil fines, and private treble-damage actions. Even the successful defense of the antitrust litigation or an investigation can be very costly and disruptive. It is thus vital that all meetings and activities of the Associations be conducted in a manner consistent with the Association's antitrust policy.

Examples of illegal competitor agreements are those that attempt to fix or stabilize prices, to allocate territories or customers, to limit production or sales, or to limit product quality and service competition. Accordingly, it is inherently risky and potentially illegal for competitors to discuss under Association auspices, or elsewhere, the subjects of prices, pricing policies, other terms and conditions of sale, individual company costs (including planned employee compensation), the commercial suitability of individual suppliers or customers, or other factors that might adversely affect competition.

It is important to bear in mind that those in attendance at Association meetings and activities may include competitors, as well a potential competitors. Any discussion of sensitive antitrust subjects with one's competitors should be avoided at all times, before, during, and after any Association meeting or other activity. This is particularly important because a future adversary may assert that such discussions were circumstantial evidence of an illegal agreement, when viewed in light of subsequent marketplace developments, even though there was, in fact, no agreement at all.

If at any time during the course of a meeting or other activity, Association staff believes that a sensitive topic under the antitrust laws is being discussed, or is about to be discussed, they will so advise and halt further discussion for the protection of all participants. Member attendees at any meeting or activity should likewise not hesitate to voice any concerns or questions that they may have in this regard.

#3

Meeting Minutes
Kansas Aggregate Producers' Association
Research & Specification Committee
Kansas Ready Mixed Concrete Association
Technical Quality Control Committee
August 9, 2023

Association Office Basement Conference Room/800 SW Jackson Street/Topeka, KS
The meeting was called to order by Jerry Younger, at 1:30 PM

1. **Introductions** – Attendees introduced themselves.

2. **Antitrust Statement/Approval of Minutes** – attendees were provided a copy of KAPA-KRMCA's joint Antitrust Policy Statement and asked to abide by it. **ON MOTION** (Kelly Briggs/Dave Suchorski) Motion to approve the minutes of the May 8, 2023 R&S/TQC Committee Minutes. Motion passed.

3. **Concrete Testing Oversight Program**
   Chris Leibrock reported that KDOT hopes to have positions hired and filled by the end of September.

4. **KDOT Protocols for Addressing Low Strength Test Results**
   Dan Wadley reported that KDOT has been able to retrieve some previous data. KDOT hopes to have something to share and look at by the next R&S/TQC meeting.
   Neil questioned how KDOT was determining what constitutes a testing error and reminded the group of ACI's standard for determining low strength.
   Jerry mentioned that the problem right now is that if a producer has a low strength test and wants to go out and core it, KDOT is reluctant to allow nor will the results of that core testing carry any weight. Industry would like to get to the point that KDOT at least accepts the test results of those core samples as meaningful data.

5. **KDOT Quarry Road Reimbursement Policy**
   Jason VanNice reported that KDOT hopes to have their new policy in place with the new reimbursement rates by the end of the year. KDOT has agreed to raise the reimbursement a ton/mile basis for items covered and hauled on county roads from the materials producers to the state highway. KDOT will use the following rates per ton/mile on the types of roads when computing reimbursement:
   Dirt or Gravel at 0.15/ton/mile
   Asphalt Seal at 0.20/ton/mile (assumes that surface is a combination of asphalt seals, cold mix asphalt or both)
   Hot Mix Asphalt at 0.25/ton/mile (includes an asphalt seal over a hot mix asphalt surface)

6. **2023 Blind Sample Testing**
   Chris Leibrock reported that KDOT has completed 6 blind samples to date and hopes to have 15 by the end of the year. KDOT should be able to report out on all 2023 blind sample testing at the KDOT Issues and Answers Session at January convention.

7. **AWP – OFQ Report**
   KDOT is making progress on developing a new report within the AWP software. One of the issues KDOT is having combining the old data with current data. KDOT will leave the current OFQ report on their system until a new report is developed.

8. **KDOT Update on Fly Ash Availability**
   With the Jeffries plant coming back online, it has alleviated most immediate concerns about the availability of fly ash. Industry still has long term concerns and thinks KDOT needs to consider other resources that could replace fly ash for achieving the desired permeability.

9. **Wetting & Drying Spec (KTMR-23)**
   Jerry reported that a KAPA-KRMCA producer has a product that is having a problem getting a passing test with KDOT. Attendees were furnished a copy of KDOT's current KTMR-23 Spec – Wetting and Drying Test of Sand and Sand-Gravel Aggregate for Concrete. Tom Starkey asked if maybe it is time for KDOT to do a spec update; approve the use of 1Ls for some of the standardized tests. Dave Suchorski reported ASTM is looking at the issue of approving the use of 1Ls for some of the standardized test.

10. **Later Strength Gain with 1L Cement**
    Attendees were provided with a copy of the Corp of Engineers spec reflecting that 1L cements may produce later strength gain. Neil Morris said that they have seen noticeable strength loss from IL and has asked if KDOT could put out some sort of technical advisory to KDOT's field personnel that it is OK for producers to use water reducers and/or plasticizers that allows them to put back the water that was withheld from the mix design. Asking if KDOT could establish some sort of dose range. KDOT would first like to see the data from producers. Neil will send KDOT some mixes for them to test and review. A meeting will be set up with KDOT and some of the producers to discuss further.

11. **Resistivity Testing for Concrete**
    Tony Menke reported that KDOT District Offices are all testing with the same equipment. Neil said they are definitely seeing differences from district to district. Jerry will follow up with Tony.

12. **Macadam Type Road Construction of Low Volume County Roads**
    Keith Browning, Executive Director of Kansas Association of Counties reported that he had attended TRB's Low Volume Roads Conference and reviewed Iowa's DOT spec regarding their counties use of Macadam crushed stone. Keith reported that he plans to let his county members know it might be a good option for counties with heavy loads. Chris Leibrock said he will try and figure out if there is a comparable KDOT test to the Iowa Macadam Quality testing methods (C Freeze) and report back to Keith.

Next quarterly meeting will be held in October.

Respectfully submitted,

Jerry Younger, P.E.
Managing Director

Attendance:

See Attached Sign in Sheet

Event: R&S / TQC Meeting

Date: Wednesday, August 9, 2023

Place: KAPA-KRMCA Basement Conference Room

Time: 1:30 PM

KANSAS AGGREGATE PRODUCERS ASSOCIATION
KANSAS READY MIXED CONCRETE ASSOCIATION (KAPA-KRMCA)

ANTITRUST STATEMENT

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Print Name	Company	EMail
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Chris Leibrock	KDOT	Christopher.leibrock@ks.gov
Daniel Zirkle	KDOT	Daniel.Zirkle@KS.gov

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Print Name	Company	EMail
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Scott Navarro	Central Plains Cement	SNAVARRO@CENTRALPLAINSCEMENT.COM

#7

Kansas
Department of Transportation

Laura Kelly, Governor

Calvin E. Reed, P.E. Secretary of Transportation

TECHNICAL ADVISORY

DATE: 26 October 2023

TO: District Engineers
District Construction & Materials Engineers

FROM: Rick Barezinsky, P.E. Assistant Bureau Chief – Materials
Bureau of Construction and Materials

Christopher Leibrock, P.E. Assistant Bureau Chief – Materials Testing
Bureau of Construction and Materials

D. L. Wadley, P.E. Chief
Bureau of Research

SUBJECT: Technical Advisory 402.06: Withheld (Mix) Water Added Back at the Job Site and Use of Viscosity Modifying Admixtures

This technical advisory relates to the addition of withheld water back into a concrete mix at the job site, specifically regarding mix designs that include viscosity modifying admixtures. This only applies to concrete delivered to the job site in a rotating transit truck mixer where mixing water was withheld at the batch plant.

Withheld (Mix) Water Added Back at the Job Site

Per KDOT Specification, Sections 401, 402, and 403 the rules for adding back withheld job water are:

1. For any mix, the maximum amount of allowed water to be withheld at the plant is 2 gallons / cubic yard. <<401.8.a.R3>>

2. Do not add (job) water if no water was withheld at the mixing plant. <<401.8.a. R3>>

3. Do not add (job) water, (withheld or otherwise), if the air content of the mix is above 8%. <<401.8.a. R3>>

4. Do not exceed the mix design water / cement ratio. (No additional job water may be added, other than mixing water previously withheld at the plant.) <<401.8.a.R3>>

5. Do not add (job) water, (withheld or otherwise), if the slump of the delivered concrete is inside of the target ranges for a given mix allowed by the Specification: <<401.8a.R3, 402.3.f., 403.3.f.>>

    a. Mixes with a target slump of 3" may have (withheld) water added (back at the job) if the mix arrives to the job at a slump less than 2.25"
    b. Mixes with a target slump of 4" may have (withheld) water added (back at the job) if the mix arrives to the job at a slump less than 3.00"
    c. Mixes with a target slump of 5" may have (withheld) water added (back at the job) if the mix arrives to the job at a slump less than 3.75"

6. To verify slump, follow KT-17 but sample immediately from the first truck each day before any placement is made. Verify slump from subsequent trucks if a change in plastic properties is observed or changes are made to the admixtures or batch water. Compare the slump verification results with the mix design requirements and report to Engineer if adjustments to the mix are needed. Once the slump has been verified, proceed to follow KT-17 sampling guidance and perform all plastic acceptance testing as normal unless a change to the mix requires re-verification. <<TA402.06>>

7. Slump is not to exceed 5" for concrete unless approved by the Engineer or as proven previously by a full load trial batch, conducted prior to the day of placement. <<401.3.g.R3>>

8. Do not add (job) water, (withheld or otherwise), at the work site if a plasticizing admixture is used in the mix that produces a slump equal to or greater than 7.5" (i.e. for use in drilled shafts). <<401.3.k.(4)R3., 401.8.a.R3>>

9. For drilled shafts the target slump prior to pumping into the shaft is 9". If the slump is less than 8", re-dose the concrete with plasticizing admixtures, but do not add any additional withheld water or mixing water at the job. <<402.3.f.(4)R1>>

10. Withheld water added to the mixing truck at the job site must be added back to the entire load with a calibrated device and witnessed by the Construction Inspector. Approved devices include buckets of known volume or saddle tank lines feeding directly to the drum that have been calibrated within the last 6 months having a gauge readout in gallons. Trucks with lines not having readout gauges will need to use calibrated buckets. Prior to the placement, the Producer is to provide the Construction Inspector with proof of calibration for all trucks used on the job if lines from saddle tanks into the drum are to be used. Record the amount of water added back to each truck on the ticket. <<401.8.a.R3>>

11. Truck drivers are not authorized to add withheld water back to a mix while in transit or off site before arriving at the job. Pump truck operators are not authorized to add withheld water or any additional job water to a mix at the site. The Contractor is not authorized to add withheld water back to a mix on the job without the approval and supervision of the Construction Inspector. <<401.8.a.R3 and TA402.06>>

12. Withheld water added to the mixing truck at the job site can only be added once. Once added, turn the drum or blades an additional 20 to 30 revolutions at mixing speed. Record these additional revolutions on the batch ticket. Test the concrete for air and slump after the mixing revolutions are completed. If the concrete is within specifications, then the mix may be placed. If not, the load is rejected. Results should be communicated immediately to the batch plant, so that adjustments to the mix can be made. <<401.8.a.R3 and TA402.06>>

13. If concrete from the addition of water at the work site produces 28-day compressive strength breaks below the minimum required strength value then, for current or future work utilizing the same mix design, mixing water shall not be withheld at the batch plant and withheld water shall not be added at the job site. <<401.9 R3>>

14. If at any time during placement of concrete it is determined that adding back withheld water or redosing with admixtures is adversely affecting the desired performance properties of the concrete mix, then the concrete will be rejected, and adding back withheld water or redosing with admixtures will not be allowed for the remainder of the placement, and all following placements on the job using that mix. <<401.8.a.R3>>

15. Any known changes to a given mix design that would affect the unit weight on the day of placement are to be communicated to the Construction Inspector before placement, so that

accurate unit weights of the mix upon delivery can be calculated before the placement proceeds. Generally, the unit weight on the day of placement should not deviate from the design unit weight by more than ± 1.5% (approx. 2.2 pcf). << TA402.01(5.) and TA402.06>>

Withheld (Mix) Water in Relation to the Use of Viscosity Modifying Admixtures

KDOT allows the use of Water Reducing Admixtures, of which, Mid-Range and High-Range Water Reducers (HRWR) may also impart some increased workability to a given mix.

KDOT Specification requirements for the use of admixtures include:

1. A Water Reducer is considered a Plasticizer only if it produces a slump greater than 7.5". <<401.3.k.(4)R3>>

2. Do not withhold and/or add water if Plasticizer is added to the concrete mixture at the batch site. <<401.8.a.R3>>

3. The water reducer dosage used in the Approved Concrete Mix Design sets the minimum permitted dose for use in the field. <<401.3.k.(5)R3>>

4. Re-dosing of water reducers and air-entrainers is permitted to control slump or air content, when approved by the Engineer, and where time, temperature, and mixing revolutions have not been exceeded. <<401.3.k.(5)R3>>

5. Re-dosing should be witnessed by the Construction Inspector, and each amount recorded on the batch ticket. <<401.3.k.(5)R3>>

6. To re-dose in the field, reverse the direction of the drum of the truck to bring the concrete to the back of the drum, to aid in the proper distribution of the dose into batch. Once added, turn the drum an additional 20 to 30 revolutions at mixing speed to ensure thorough mixing and record re-dose amount and revolutions on the ticket. <<401.3.k.(5)R3>>

7. Before a concrete mix with a slump exceeding 7.5" is used on a project, conduct a full truck trial batch of the concrete mix witnessed by the Engineer to determine the adequacy of the dosage and batching sequence of the plasticizer to obtain the desired performance properties. Determine the air content of the trial batch both before and after the addition of the plasticizing admixture. Be sure admixture is thoroughly mixed prior to testing. Monitor the slump, air content, temperature, and workability at regular intervals for the time period from when the plasticizer was added until the estimated time of placement (simulating the haul time expected on the day of placement). At the discretion of the Engineer, if all properties of the trial batch remain within the specified limits, the trial batch mix may be used in the project. **Do not add any additional water after the plasticizer is added to the concrete mix.** <<401.3.k.(4)R3 and 401.8.a.R3>>

8. The batching sequence of the mix, including when each admixture is introduced during the mixing process along with any plans to re-dose admixtures in the field, should be submitted to KDOT during the initial mix design approval process. If a plasticizer is to be used, it should be noted where and when it is to be added to the mix. <<401.3a.(7)R3>>

9. The proximity of the plant to the job should be discussed at the Pre-Pour Meeting to determine if the Producer plans to withhold water during placement. If the Producer plans to withhold water, then the fresh concrete testing plan of those initial trucks should be discussed. The discussion shall include specifically who will test the slump to determine if withheld water can be added back. The delivery speed and frequency of those early trucks should also be discussed to allow

appropriate timing for testing and any necessary adjustments. If there are any concerns about the mix and how it will arrive at the job, a trial pour is recommended. <<401.3.a.(7)R3 and TA402.06>>

If problems or concerns arise during any phase of the job, immediately make a set of 6 cylinders, and contact the Bureaus of Construction, Materials and Research for assistance.

--RB, CL, DW--

Cc: Tony Menke, P.E., Director, Project Delivery
Jason Van Nice, P.E., Chief, Construction & Materials
W. Clay Adams, P.E., Director, Field Operations
Mark Hurt, P.E., S.E., Chief, Bureau of Structures and Geotechnical Services
Kansas Contractors Association
Kansas Aggregate Producers' Association & Kansas Ready Mixed Concrete Association
ACPA, Missouri-Kansas Chapter

#7

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, 2015 EDITION

Delete SECTION 401 and replace with the following:

SECTION 401

GENERAL CONCRETE

401.1 DESCRIPTION

Provide the grades of concrete specified in the Contract Documents.
See **SECTION 402** for specific requirements for Structural Concrete.
See **SECTION 403** for specific requirements for On Grade Concrete.
See **SECTION 404** for specific requirements for Prestressed Concrete.

401.2 MATERIALS

Provide materials that comply with the applicable requirements.

Aggregate ..... **DIVISION 1100**
Admixtures and Plasticizers ..... **DIVISION 1400**
Grade 2 Calcium Chloride ..... **DIVISION 1700**
Cement, Fly Ash, Silica Fume, Slag Cement and Blended Supplemental Cementitious ..... **DIVISION 2000**
Water ..... **DIVISION 2400**

401.3 CONCRETE MIX DESIGN

a. General. Design the concrete mixes specified in the Contract Documents.

Do not place any concrete on the project until the Engineer approves the concrete mix designs. Once the Engineer approves the concrete mix design, do not make changes without the Engineer's approval.

Take full responsibility for the actual proportions of the concrete mix, even if the Engineer assists in the design of the concrete mix.

Provide aggregate gradations that comply with **DIVISION 1100** and Contract Documents.

Admixture dosage rate requirements for mix design approval and field production are provided in **subsection 401.3k**.

If desired, contact the DME for available information to help determine approximate proportions to produce concrete having the required characteristics on the project.

Submit all concrete mix designs to the Engineer for review and approval. Submit completed volumetric mix designs on KDOT Form No. 694 and all required attachments at least 60 days prior to placement of concrete on the project. The Engineer will provide an initial review of the design within 5 business days following submittal.

Include the following information:

(1) Test data from KT-73 tested at 28 days, KT-79 tested at 28 days or AASHTO T-277 tested at 56 days. Provide test results on a minimum of 1 set of 3 cylinders for each mix, tested at the highest water to cementitious material ratio that meets **subsection 401.3h**. Submit accelerated cure procedures for the Engineer's approval.

(2) Test data from ASTM C1567 for blended cements meeting **subsection 401.3j.** for all concrete utilizing all actual materials proposed for use on the project at designated percentages.

(3) Single point grading for the combined aggregates along with a plus/minus tolerance for each sieve. Use plus/minus tolerances to perform quality control checks and by the Engineer to perform aggregate grading verification testing. The tests may be performed on the combined materials or on individual aggregates, and then theoretically combined to determine compliance.

(4) Laboratory 28-day compressive strength test results on a minimum of 1 set of 3 cylinders produced from the mix design with the highest water to cementitious ratio for the project, utilizing all actual materials

proposed for use on the project at designated percentages. The average compressive strength shall exceed the strength requirements for the Grade specified in the Contract Documents as determined by **subsection 401.3b**. Perform compressive strength tests according to KT-76.

(5) Historical mix production data for the plant producing concrete for the project to substantiate the standard deviation selected for use in **subsection 401.3b.**, if applicable.

(6) Necessary materials to enable the Engineer to test the mix properties, if applicable.

(7) Batching sequence. Consider the location of the concrete plant in relation to the job site, and identify when and at what location the water reducer or plasticizer is added to the concrete mixture.

Submit complete mix design data including proportions and sources of all mix ingredients, and the results of strength and permeability tests representing the mixes proposed for use. The data may come from previous KDOT project records or a laboratory regularly inspected by Cement and Concrete Reference Laboratory (CCRL). Data from other sources will only be accepted if testing was conducted or witnessed by personnel certified in Hardened Concrete Properties (HCP) according to the Policy and Procedures Manual for The Certified Inspection and Testing (CIT) Training Program.

After initial review, the Engineer will perform any testing necessary to verify the design. This may include a 3-cubic yard test batch at the producing plant. Do not make changes to the Approved Concrete Mix Design without the Engineer's approval. Limited adjustments may be made to admixture dosages and aggregate proportions in accordance with **subsection 401.3i.** and **subsection 403.4e**. These adjustments must be recorded and submitted to the Engineer.

Mix designs will remain approved when verification testing for strength and permeability conducted within the last 12 months indicate continued compliance with the specifications and percentages of constituents including aggregate and cementitious materials and product, type and supplier of admixtures remain the same. Test results on the same mix from other sources are acceptable.

Improvements in concrete strength, workability, durability and permeability are possible if the combined aggregate grading is optimized. Procedures found in ACI 302.1 or other mix design techniques, approved by the Engineer, are acceptable in optimizing the mix design.

Delay the commencement of tests for temperature, slump, and air content and molding of field cylinders from 4 to 4½ minutes after the sample has been taken from a continuous mixer. If a batch type mixer is used, take the tests at the point of placement and begin testing immediately.

b. Required Compressive Strength for Concrete Mix Design. The required compressive strength for mix design approval shall be based on previous data from similar mix designs or according to **subsection 401.1b.(2)**.

(1) Concrete Mix Design Based on Previous Data. Provide concrete mix designs based on previous 28-day compressive strength test data from similar concrete mixtures. Similar mixtures are within 1000 psi of the specified 28-day compressive strength, and are produced with the same type and sources of cementitious materials, admixtures and aggregates.

Consider sand sources the same, provided they are not more than 25 miles apart on the same river and no tributaries enter the river between the 2 points. Consider crushed locations similar if they are mined in one continuous operation, and there is no significant change in geology. Mixes that have changes of more than 10% in proportions of cementitious materials, aggregates or water content are not considered similar.

Air entrained mixes are not considered similar to non-air entrained mixes.

Mixes tested with admixtures are not the same as mixes tested without those admixtures.

Test data should represent at least 30 separate batches of the mix. One set of data is the average of at least 2 cylinders from the batch. The data shall represent a minimum of 45 days of production within the past 12 months.

Do not include data over 1 year old. When fewer than 30 data sets are available, the standard deviation of the data must be corrected to compensate for the fewer data points.

Provide a 4000 psi concrete with a $f'cr$ greater than or equal to 5200 psi. Otherwise provide a concrete mix design that will permit no more than 5% of the 28-day compressive strength tests to fall below the specified 28-day compressive strength ($f'c$) based on equation A, and no more than 1% of the 28-day compressive strength tests to fall below the specified 28-day compressive strength ($f'c$) by more than 500 psi based on equation B.

Equation A: $f'cr = f'c + 1.62 * k * s$

Equation B: $f'cr = (f'c - 500) + 2.24 * k * s$

Where: $f'cr$ = average 28-day compressive strength required to meet the above criteria.
$f'c$ = specified 28-day compressive strength
s = standard deviation of test data
k = constant based on number of data points
n = number of data points
$k = 1.3 - n / 100$, where $15 < n < 30$
$k = 1$, where $n > 30$

Provide a concrete mix design that has an average compressive strength that is equal to the larger of Equation A or Equation B. Submit all supporting test data with the mix design.

(2) All Other Concrete Mix Designs. For concrete mixes that have fewer than 15 data points, or if no statistical data is available, use Equations A and B to calculate $f'cr$ using the following values.

s = 20% of the specified 28-day compressive strength ($f'c$)
$k = 1$

c. Portland Cement and Blended Hydraulic Cement. Unless specified otherwise in the Contract Documents, select the type of portland cement or blended hydraulic cement according to **TABLE 401-1**.

TABLE 401-1: PORTLAND CEMENT & BLENDED HYDRAULIC CEMENT

Concrete for:	**Type of Cement Allowed**
On Grade Concrete	Type IP(x) Portland-Pozzolan Cement Type IS(x) Portland- Slag Cement Type IT(Ax)(By) Ternary Blended Cement Type IL(x) Portland-Limestone Cement[1] Type II Portland Cement
All Concrete other than On Grade Concrete.	Type I Portland Cement Type IP(x) Portland-Pozzolan Cement Type IS(x) Portland- Slag Cement Type IT(Ax)(By) Ternary Blended Cement Type IL(x) Portland Limestone Cement[1] Type II Portland Cement
High Early Strength Concrete	Type III Portland Cement Type I, IP(x), IS(x), IT(Ax)(By), Type IL(x)[1] or II Cement may be used if strength and time requirements are met.

Note 1 – Type IL(x) Portland Limestone Cement will have between 5-15% limestone content produced by intergrinding, blending, or a combination of intergrinding and blending at the Cement Manufacturer's facility.

d. Blended Cement Concrete. When approved by the Engineer, the concrete mix design may include SCMs such as fly ash, slag cement, silica fume or blended SCM from an approved source as a partial replacement for portland cement or blended hydraulic cement except where controlled in **SECTIONS 402, 403** or **404**. Obtain the Engineer's approval before substituting SCMs for Type III cement. Changes in SCM or cement will require a new mix design approval.

(1) Cements meeting **SECTION 2001** are not field blended cements.

(2) Cements with SCMs added at the concrete mixing plant are field blended cements.

(3) Supplementary materials can be combined with cement to create field blended cements. Do not exceed allowable substitution rates noted in **TABLE 401-2**. Substitute 1 pound of SCM for 1 pound of cement. Limestone used in Type 1L cements is not an SCM and cannot be field blended.

(4) SCMs in prequalified cements are to be included in the total combined substitution rate.

TABLE 401-2: ALLOWABLE SUBSTITUTION RATE FOR SUPPLEMENTARY CEMENTITIOUS MATERIAL.	
Material	**Substitution Rate***
Slag Cement	40% Maximum
Fly Ash	25% Maximum
Blended SCM	25% Maximum
Silica Fume	5% Max
Total Combined	50%

* Total Substitution Rate includes material in preblended cements and blended SCMs.

(5) When used, add silica fume with other cementitious materials during batching procedures. If the silica fume cannot be added to the cementitious materials, add the loose silica fume to the bottom of the stationary drum that is wet, but has no standing water, before adding the dry materials. The Engineer may approve shreddable bags on a performance basis, only when a central batch mixing process is used. If so, add the bags to half of the mixing water and mix before adding cementitious materials, aggregate and remainder of water.

Mix silica fume modified concrete for a minimum of 100 mixing revolutions.

e. Strength. Design concrete to meet **TABLE 401-3**.

TABLE 401-3: CONCRETE STRENGTH REQUIREMENTS	
Specified 28 Day Compressive Strengths, minimum, psi *f'c*	
Grade of Concrete:	**Non Air Entrained/Air Entrained Concrete**
Grade 7.0	7,000
Grade 6.0	6,000
Grade 5.0	5,000
Grade 4.5	4,500
Grade 4.0	4,000
Grade 3.5	3,500
Grade 3.0	3,000
Grade 2.5	2,500

f. High Early Strength Concrete (HESC). Design the high early strength concrete mix to comply with strength and time requirements specified in the Contract Documents.

Unless otherwise specified, design high early strength concrete for pavement at a minimum of 1 of the Contractor's standard deviations above 2400 psi (cylinders) at 24 hours. If no statistics are available, design a HESC with a compressive strength greater or equal to 2880 psi.

Submit complete mix design data including proportions and sources of all mix ingredients, and the results of time and strength tests representing the mixes proposed for use. The strength and time data may come from previous KDOT project records or from an independent laboratory, and shall equal or exceed the strength and time requirements listed in the Contract Documents.

g. Slump. Designate a slump for each concrete mix design that is required for satisfactory placement of the concrete application not to exceed 5 inches except where controlled by maximum allowable slumps stated in **SECTIONS 402, 403** and **404**. Reject concrete with a slump that limits the workability or placement of the concrete.

h. Permeability. Supply concrete meeting the permeability requirements specified in **SECTION 402** for structural concrete and **SECTION 403** for on grade concrete. Permeability testing from KT-73 tested at 28 days, KT-79 tested at 28 days **or** AASHTO T-277 tested at 56 days is required for all bridge overlays, Moderate Permeability Concrete, and any project with over 250 cubic yards of concrete (this includes structural concrete, on

grade concrete etc.). The field verification test procedure must be the same test procedure as the mix design approval test.

There are no permeability requirements for concrete for prestressed concrete members as specified in **SECTION 404**.

i. Air Content. Determine air content by KT-18 (Pressure Method) or KT-19 (Volumetric Method). With the exception of concrete for pavement as shown in **SECTION 403**, use the middle of the specified air content range of 6.5 ± 1.5% for the design of air entrained concrete. Maximum air content is 10%. Take immediate steps to reduce the air content whenever the air content exceeds 8%.

j. Alkali Silica Reactivity. If the concrete mix design includes supplemental cementitious materials (SCMs), provide mortar expansion test results from ASTM C1567 as part of mix design approval unless meeting the minimum requirements shown in **TABLE 401-4**. Use the project's mix design concrete materials at their designated percentages. Provide a mix with a maximum expansion of 0.10% at 16 days after casting. Provide ASTM C1567 results on an annual basis.

TABLE 401-4: MINIMUM SCM CONTENT REQUIRED TO WAIVE ASTM C1567 TESTING

Type of Coarse Aggregate Sweetener (refer to TABLE 1102-2 or TABLE 1116-1)	Are the Fine and Intermediate (if used) Aggregate Sources on PQL 3.1?	Proportion Required by Percent Weight of Total Cementitious Material			
		Slag Cement	Class C Fly Ash	Class F Fly Ash	Silica Fume
Crushed Sandstone, Crushed Limestone, Crushed Dolomite, or Siliceous Aggregate on PQL 3.1	No	ASTM C1567 Testing Required		25%	Any*
Any combination of Crushed Limestone, Crushed Dolomite, Crushed Sandstone, and Siliceous Aggregate on PQL 3.1	Yes	Any*	15%	Any*	Any*

*Subject to the maximum allowable percentages in **TABLE 401-2**.

ASTM C1567 Testing can be waived for ternary (3 cementitious materials) mix designs with approval of the KDOT Bureau of Research.

k. Admixtures for Acceleration, Air-Entraining, Plasticizing, Set Retardation and Water Reduction. Verify that the admixtures used are compatible and will work as intended without detrimental effects. Use the dosages recommended by the admixture manufacturers. Incorporate and mix the admixtures into concrete mixtures according to the manufacturer's recommendations. Determine the quantity of each admixture for the concrete mix design.

(1) Accelerating Admixture. When specified in the Contract Documents, or in situations that involve contact with reinforcing steel and require early strength development to expedite opening to traffic, a non-chloride accelerator may be approved. The Engineer may approve the use of a Type C or E accelerating admixture. A Grade 2 calcium chloride accelerator may be used when patching an existing pavement more than 10 years old.

Add the calcium chloride by solution (the solution is considered part of the mixing water).

- For a minimum cure of 4 hours at 60°F or above, use 2% (by dry weight of cement) calcium chloride.
- For a minimum cure of 6 hours at 60°F or above, use 1% (by dry weight of cement) calcium chloride.

(2) Air-Entraining Admixture. When specified, use an air-entraining admixture in the concrete mixture. If another admixture is added to an air-entrained concrete mixture, determine if it is necessary to adjust the air-entraining admixture dosage to maintain the specified air content.

(3) Water-Reducers and Set-Retarders. A water-reducing admixture for improving workability may be required. If unfavorable weather or other conditions adversely affect the placing and finishing properties of the

concrete mix, the Engineer may allow the use of water-reducers and set-retarders. Verify that the admixtures will work as intended without detrimental effects. If the Engineer approves the use of water-reducers and set-retarders, their continued use depends on their performance.

(4) Plasticizer Admixture. A plasticizer is defined as an admixture that produces flowing concrete, without further addition of water, and/or retards the setting of concrete. Flowing concrete is defined as having a slump equal to or greater than 7 ½ inches while maintaining a cohesive nature.

Manufacturers of plasticizers may recommend mixing revolutions beyond the limits specified in **subsection 401.8**. If necessary, address the additional mixing revolutions in the concrete mix design. The Engineer may allow up to 60 additional revolutions when plasticizers are designated in the mix design.

Before the concrete mixture with a slump equal to or greater than 7 ½ inches is used on the project, conduct tests on at least 1 full trial batch of the concrete mix design in the presence of the Engineer to determine the adequacy of the dosage and the batching sequence of the plasticizer to obtain the desired properties. Determine the air content of the trial batch both before and after the addition of the plasticizer. Monitor the slump, air content, temperature and workability at regular intervals of the time period from when the plasticizer is added until the estimated time of completed placement. At the discretion of the Engineer, if all the properties of the trial batch remain within the specified limits, the trial batch may be used in the project.

Do not add water after plasticizer is added to the concrete mixture.

(5) Field Adjustment to Admixtures. Limited adjustments to the dosage rate of accelerators, set-retarders, water reducers, and air-entraining admixtures are permitted to compensate for environmental changes during placement without a new concrete mix design or trial batch. Test the concrete for temperature, air content, and slump whenever changes are made to the dosage rates to ensure continued compliance with the specifications. The allowable adjustments are based on the dose used in the Approved Concrete Mix Design and according to the following:

- Do not exceed the accelerator dosage used in the Approved Concrete Mix Design. The accelerator dosage may be reduced or eliminated as needed. Redosing accelerators is not permitted.
- The water reducer dosage used in the Approved Concrete Mix Design sets the minimum permitted dose for use in the field. The water reducer dose may be increased from that shown in the Approved Concrete Mix Design provided that the slump does not to exceed the maximum designated slump. Slump reduction may be obtained by withholding a portion of the mix water as specified in **subsection 401.8a**.
- Redosing of water reducers and air-entraining admixtures is permitted to control slump or air content in the field, when approved by the Engineer, time and temperature limits are not exceeded, and at least 30 mixing revolutions remain before redosing. Redose according to manufacturer's recommendations.
- Set retarders may be added as needed during production. Do not include set retarders in the Concrete submitted for Mix Design Approval. Redosing retarders is not permitted. Paperwork for submitted mix designs (Form 694) with no (zero) water reducer and/or set retarder in the original Concrete submitted for Mix Design Approval must show the manufacturer of the admixtures that may be included in the Project Concrete.

401.4 REQUIREMENTS FOR COMBINED MATERIALS

a. Measurements for Proportioning Materials.

(1) Cement. Measure cement as packed by the manufacturer. A sack of cement is considered as 0.04 cubic yards weighing 94 pounds net. Measure bulk cement by weight. In either case, the measurement must be accurate to within 0.5% throughout the range of use.

(2) Supplemental Cementitious Materials. Supplemental cementitious materials proportioning and batching equipment is subject to the same controls as required for cement. Provide positive cut off with no leakage from the cut off valve. Cementitious materials may be weighed accumulatively with the cement or separately. If weighed accumulatively, weigh the cement first.

(3) Water. Measure the mixing water by weight or by volume accurate to within 1% throughout the range of use.

(4) Aggregates. Measure the aggregates by weight, accurate to within 0.5% throughout the range of use.

(5) Admixtures. Measure liquid admixtures by weight or volume, accurate to within 3% of the quantity required. If liquid admixtures are used in small quantities in proportion to the cement as in the case of air-entraining agents, use readily adjustable mechanical dispensing equipment capable of being set to deliver the required quantity and to cut off the flow automatically when this quantity is discharged.

b. Testing of Aggregates.

(1) Production of On Grade Concrete Aggregate (OGCA). If OGCA is required, notify the Engineer in writing at least 2 weeks in advance of producing the aggregate. Include the source of the aggregate and the date production will begin. Failure to notify the Engineer, as required, may result in rejection of the aggregate for use as OGCA. Maintain separate stockpiles for OGCA at the quarry and at the batch site and identify them accordingly.

(2) Testing Aggregates at the Batch Site. Provide the Engineer with reasonable facilities at the batch site for obtaining samples of the aggregates. Provide adequate and safe laboratory facilities at the batch site allowing the Engineer to test the aggregates for compliance with the specified requirements.

KDOT will sample and test aggregates from each source to determine their compliance with specifications. Do not batch the concrete mixture until the Engineer has determined that the aggregates comply with the specifications. KDOT will conduct sampling at the batching site, and test samples according to the Sampling and Testing Frequency Chart in Part V. For QC/QA contracts, establish testing intervals within the specified minimum frequency.

After initial testing is complete, and the Engineer has determined that the aggregate process control is satisfactory, use the aggregates concurrently with sampling and testing as long as tests verify compliance with specifications. When batching, sample the aggregates as near the point of batching as feasible. Sample from the stream as the storage bins or weigh hoppers are loaded. If samples cannot be taken from the stream, take them from approved stockpiles, or use a template and sample from the conveyor belt. If test results indicate an aggregate does not comply with specifications, cease concrete production using that aggregate. Unless a tested and approved stockpile for that aggregate is available at the batch plant, do not use any additional aggregate from that source and specified grading until subsequent testing of that aggregate indicate compliance with specifications. When tests are completed and the Engineer is satisfied that process control is satisfactory, production of concrete using aggregates tested concurrently with production may resume.

c. Handling of Materials.

(1) Approved stockpiles are permitted only at the batch plant and only for small concrete placements or for maintaining concrete production. Mark the approved stockpile with an "Approved Materials" sign. Provide a suitable stockpile area at the batch plant so that aggregates are stored without detrimental segregation or contamination. At the plant, limit stockpiles of tested and approved coarse, fine and intermediate aggregate to 250 tons each, unless approved for more by the Engineer. If mixed aggregate is used, limit the approved stockpile to 500 tons, the size of each being proportional to the amount of each aggregate to be used in the mix.

Load aggregates into the mixer such that no material foreign to the concrete or material capable of changing the desired proportions is included.

(2) Segregation. Do not use segregated aggregates. Previously segregated materials may be thoroughly re-mixed and used when representative samples taken anywhere in the stockpile indicated a uniform gradation exists.

(3) Cement and Supplemental Cementitious. Protect cement and supplemental cementitious materials in storage or stockpiled on the site from any damage by climatic conditions which would change the characteristics or usability of the material.

(4) Moisture. Provide aggregate with a moisture content of ±0.5% from the average of that day. If the moisture content in the aggregate varies by more than the above tolerance, take whatever corrective measures are necessary to bring the moisture to a constant and uniform consistency before placing concrete. This may be accomplished by handling or manipulating the stockpiles to reduce the moisture content, or by adding moisture to the stockpiles in a manner producing uniform moisture content through all portions of the stockpile.

Handheld moisture-determining devices are permitted. For plants equipped with an approved accurate moisture-determining device capable of continuously determining the free moisture in the aggregates, and provisions made for batch-to-batch correction of the amount of water and the weight of aggregates added, the requirements relative to manipulating the stockpiles for moisture control will be waived. Approval and accuracy of the moisture-determining device is based on daily comparisons with KT-24 or ASTM C566 and at the discretion of the Engineer. Any procedure used will not relieve the producer of the responsibility for delivering concrete of uniform slump within the limits specified.

(5) Separation of Materials in Tested and Approved Stockpiles. Only use KDOT Approved Materials. Provide separate means for storing materials approved by KDOT. If the producer elects to use KDOT Approved Materials for non-KDOT work, during the progress of a project requiring KDOT Approved Materials, inform the Engineer and agree to pay all costs for additional material testing.

Clean all conveyors, bins and hoppers of any unapproved materials before beginning the manufacture of concrete for KDOT work.

401.5 MORTAR AND GROUT

a. General. Follow the proportioning requirements in **subsections 401.5b.** and **c.** for mortar and grout unless otherwise specified in the Contract Documents, including altering the proportions when a minimum strength is specified.

b. Mortar. Mortar is defined as a mixture of cementitious materials, FA-M aggregate and water, which may contain admixtures, and is typically used to minimize erosion between large stones or to bond masonry units.

Proportion mortar for laying stone for stone rip-rap, slope protection, stone ditch lining or pavement patching at 1 part of portland cement and 3 parts of FA-M aggregate by volume with sufficient water to make a workable and plastic mix.

Proportion mortar for laying brick, concrete blocks or stone masonry at ½ part masonry cement, ½ part portland cement and 3 parts FA-M aggregate, either commercially produced masonry sand or FA-M, by volume with sufficient water to make a workable and plastic mix.

Do not use air-entraining agents in mortar for masonry work.

The Engineer may visually accept the sand used for mortar. The Engineer may visually accept any recognized brand of portland cement or masonry cement that is free of lumps.

c. Grout. Grout is defined as a mixture of cementitious materials with or without aggregate or admixtures to which sufficient water is added to produce a pouring or pumping consistency without segregation of the constituent materials and meeting the applicable specifications.

401.6 COMMERCIAL GRADE CONCRETE

If the Contract Documents allow the use of commercial grade concrete for designated items, then use a commercial grade mixture from a ready mix plant approved by the Engineer.

The Engineer must approve the commercial grade concrete mixture. Approval of the commercial grade mixture is based on these conditions:

- All materials are those normally used for the production and sale of concrete in the vicinity of the project.
- The mixture produced is that normally used for the production and sale of concrete in the vicinity of the project.
- The mixture produced contains a minimum cementitious content of 6 sacks (564 lbs) of cementitious material per cubic yard of concrete.
- The water-cementitious ratio is as designated by the Engineer. The maximum water-cementitious ratio permitted may not exceed 0.50 pounds of water per pound of cementitious material including free water in the aggregate.
- Type I, II, III, IP, IS, 1L or IT cement may be used unless otherwise designated. Fly ash, slag cement and blended supplemental materials may be substituted for the required minimum cement content as specified in **subsection 401.3**. No additives other than air entraining agent will be allowed. The Contractor will not be required to furnish the results of strength tests when submitting mix design data to the Engineer.
- In lieu of the above, approved mix designs (including optimized) for all other grades of concrete, Grade 3.0 or above, are allowable for use as commercial grade concrete, at no additional cost to KDOT.

Exercise good engineering judgment in determining what equipment is used in proportioning, mixing, transporting, placing, consolidating and finishing the concrete.

Construct the items with the best current industry practices and techniques.

Before unloading at the site, provide a delivery ticket for each load of concrete containing the following information:

- Name and location of the plant.
- Time of batching concrete.
- Mix proportions of concrete (or a mix designation approved by the Engineer).
- Number of cubic yards of concrete batched.

Cure the various items placed, as shown in **DIVISION 700**.

The Engineer may test commercial grade concrete by molding sets of 3 cylinders. This is for informational purposes only. No slump or unit weight tests are required.

401.7 CERTIFIED CONCRETE

If KDOT inspection forces are not available on a temporary basis, the Engineer may authorize the use of concrete from approved concrete plants. Approval for this operation is based on certification of the plant and plant personnel, according to KDOT standards. KDOT's approval may be withdrawn any time that certification procedures are not followed. Contact the DME for additional information.

The Engineer will not authorize the use of certified concrete for major structures such as bridges, RCB box bridges, RCB culverts, permanent main line and ramp pavement or other structurally, critical items.

Each load of certified concrete must be accompanied by a ticket listing mix proportions, time of batching and setting on revolution counter, total mixing revolutions and must be signed by certified plant personnel.

401.8 MIXING, DELIVERY AND PLACEMENT LIMITATIONS

a. Concrete Batching, Mixing and Delivery. Batch and mix the concrete in a central mix plant, in a truck mixer or in a drum mixer at the work site. Provide plant capacity and delivery capacity sufficient to maintain continuous delivery at the rate required. The delivery rate of concrete during concreting operations must provide for the proper handling, placing and finishing of the concrete.

Seek the Engineer's approval of the concrete plant/batch site before any concrete is produced for the project. The Engineer will inspect the equipment, the method of storing and handling of materials, the production procedures and the transportation and rate of delivery of concrete from the plant to the point of use. The Engineer will grant approval of the concrete plant/batch site based on compliance with the specified requirements. The Engineer may, at any time, rescind permission to use concrete from a previously approved concrete plant/batch site upon failure to comply with the specified requirements.

Clean the mixing drum before it is charged with the concrete mixture. Charge the batch into the mixing drum such that a portion of the water is in the drum before the aggregates and cementitious material. Uniformly flow materials into the drum throughout the batching operation. All mixing water must be in the drum by the end of the first 15 seconds of the mixing cycle. Keep the throat of the drum free of accumulations restricting the flow of materials into the drum.

Do not exceed the rated capacity (cubic yards shown on the manufacturer's plate on the mixer) of the mixer when batching the concrete. The Engineer may allow an overload of up to 10% above the rated capacity for central mix plants and drum mixers at the work site, provided the concrete test data for strength, segregation and uniform consistency are satisfactory, and no concrete is spilled during the mixing cycle.

Operate the mixing drum at the speed specified by the mixer's manufacturer (shown on the manufacturer's plate on the mixer).

Mixing time is measured from the time all materials, except water, are in the drum. If it is necessary to increase the mixing time to obtain the specified percent of air in air-entrained concrete, the Engineer will determine the mixing time.

If the concrete is mixed in a central mix plant or a drum mixer at the work site, mix the batch between 1 to 5 minutes at mixing speed. Do not exceed the maximum total 60 mixing revolutions. Mixing time begins after all materials, except water, are in the drum, and ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. Mix time may be reduced for plants utilizing high performance mixing drums provided thoroughly mixed and uniform concrete is being produced with the proposed mix time. Performance of the plant must conform to Table A1.1 of ASTM C94, Standard Specification for Ready Mixed Concrete. Five of the 6 tests listed in Table A1.1 must be within the limits of the specification to indicate that uniform concrete is being produced.

If the concrete is mixed in a truck mixer, mix the batch between 70 and 100 revolutions of the drum or blades at mixing speed. After the mixing is completed, set the truck mixer drum at agitating speed. Unless the mixing unit is equipped with an accurate device indicating and controlling the number of revolutions at mixing speed, perform the mixing at the batch plant and operate the mixing unit at agitating speed while travelling from the plant to the work site. Do not exceed 300 total revolutions (mixing and agitating). An additional 60 mixing revolutions may be allowed by the Engineer when plasticizers are designated in the mix design.

If a truck mixer or truck agitator is used to transport concrete that was completely mixed in a stationary central mixer, agitate the concrete while transporting at the agitating speed specified by the manufacturer of the equipment (shown on the manufacturer's plate on the equipment). Do not exceed 200 total revolutions (additional re-mixing and agitating).

Provide a batch slip including batch weights of every constituent of the concrete and time for each batch of concrete delivered at the work site, issued at the batching plant that bears the time of charging of the mixer drum with cementitious materials and aggregates. Include quantities, type, product name and manufacturer of all admixtures on the batch ticket.

On paving projects and other high-volume work, the Engineer will evaluate the haul time, and whether tickets will be collected for every load. Thereafter, random checks of the loads will be made. Maintain all batch tickets when not collected.

When non-agitating equipment is used for transportation of concrete, place within 30 minutes of adding the cement to the water. Provide approved covers for protection against the weather when required by the Engineer.

When agitating equipment is used for transportation of the concrete, place concrete within the time and temperature conditions shown in **TABLE 401-5**.

TABLE 401-5: AMBIENT AIR TEMPERATURE AND AGITATED CONCRETE PLACEMENT TIME

T = Ambient Air Temperature at Time of Batching (°F)	**Time limit agitated concrete must be placed within, after the addition of cement to water (hours)**	**Admixtures**
$T < 75$	1 ½	All Cases
$75 \leq T < 90$	1	None
$75 \leq T < 90$	1 ½	Set Retarder
T_c = Concrete Temperature at time of placement (°F)	**Time limit agitated concrete must be placed within, after the addition of cement to water (hours)**	**Admixtures**
$90 \leq T_c$*	¾	All Cases
Other conditions contributing to quick stiffening of concrete	¾	All Cases

Do not use concrete that has developed its initial set. Regardless of the speed of delivery and placement, the Engineer will suspend the concreting operations until corrective measures are taken, if there is evidence that the concrete cannot be adequately consolidated.

Weather conditions and the use of admixtures can affect the set times for the concrete. Do not use the time limits and total revolutions as the sole criterion for rejection of concrete. Exceed the time limits and total revolutions only after demonstrating that the properties of the concrete can be improved. Evaluation of the consistency and workability should be taken into consideration. Reject concrete that cannot be adequately consolidated.

Adding water to concrete after the initial mixing is prohibited, with this exception:
If the concrete is delivered to the work site in a truck mixer, the Engineer will allow water (up to 2 gallons per cubic yard) be withheld from the mixture at the batch site, and if needed, added at the work site to adjust the slump to the specified requirements. Determine the need for additional water as soon as the load arrives at the construction site. Use a calibrated water-measuring device to add the water, and add the water to the entire load. Do not add more water than was withheld at the batch site. After the additional water is added, turn the drum or blades an additional 20 to 30 revolutions at mixing speed. The Engineer will supervise the adding of water to the load, and will allow this procedure only once per load. Conduct all testing for acceptance and produce any required cylinders after all water or admixtures have been added.

Do not add water at the work site if the slump is within the designated slump tolerance, even if water was withheld.

Do not add water at the work site if the percent air is above 8%, regardless of the slump, even if water was withheld.

Do not withhold and add water if plasticizer is added to the concrete mixture at the batch site.

If at any time during the placement of concrete it is determined that redosing with water is adversely affecting the properties of the concrete, the concrete will be rejected and the Engineer will suspend the practice.

b. Placement Limitations.

(1) Placing Concrete at Night. Do not mix, place or finish concrete without sufficient natural light, unless an adequate, artificial lighting system approved by the Engineer is provided.

(2) Placing Concrete in Cold Weather. Submit a cold weather concrete plan for approval to the Engineer prior to placing concrete in cold weather.

Unless authorized by the Engineer, discontinue mixing and concreting operations when the descending ambient air temperature reaches 40°F. Do not begin concreting operations until an ascending ambient air temperature reaches 35°F and is expected to exceed 40°F.

If the Engineer approves the cold weather concrete plan, aggregates may be heated by either steam or dry heat system before placing them in the mixer. Use an apparatus that heats the mass uniformly and is so arranged as to preclude the possible occurrence of overheated areas which might injure the materials. Do not heat aggregates directly by gas or oil flame or on sheet metal over fire. Aggregates that are heated in bins, by steam-coil or water-coil heating, or by other methods not detrimental to the aggregates may be used. The use of live steam on or through binned aggregates is prohibited. Unless otherwise authorized, maintain the temperature of the mixed concrete between 50 to 90°F at the time of placing. Do not, under any circumstances, continue concrete operations if the ambient air temperature is less than 20°F.

If the ambient air temperature is 35°F or less at the time the concrete is placed, the Engineer may require that the water and the aggregates be heated to between 70 and 150°F.

Do not place concrete on frozen subgrade or use frozen aggregates in the concrete.

Make adjustments for potential longer set time and slower strength gain for concrete with SCMs. Adjust minimum time requirements as stated in **SECTION 710** for concrete used in structures. For concrete paving, be aware of the effect that the use of SCMs (except silica fume) may have on the statistics and moving averages.

401.9 INSPECTION AND TESTING

Unless otherwise designated in the Contract Documents or by the Engineer, obtain samples of fresh concrete for the determination of slump, weight per cubic yard and percent of air from the final point of placement.

The Engineer will cast, store and test strength and permeability test specimens in sets of 3.

KDOT will conduct the sampling and test the samples according to **DIVISION 2500** and the Sampling and Testing Frequency Chart in Part V. For QC/QA contracts, establish testing intervals within the specified minimum frequency.

The Engineer will reject concrete that does not comply with specified requirements.

The Engineer will permit occasional deviations below the specified cementitious content, if it is due to the air content of the concrete exceeding the designated air content, but only up to the maximum tolerance in the air content.

Continuous operation below the specified cementitious content for any reason is prohibited.

As the work progresses, the Engineer reserves the right to require the Contractor to change the proportions if conditions warrant such changes to produce a satisfactory mix. Any such changes may be made within the limits of the specifications at no additional compensation to the Contractor.

APPENDIX A – NON-MANDATORY INFORMATION

SUGGESTED GUIDELINES FOR MEETING KDOT'S PERMEABILITY SPECIFICATIONS

General:

Water and chlorides permeate through the mortar and paste of the concrete mixes. They do not readily permeate through the larger aggregates. Permeability can be improved by decreasing the mortar and paste of the concrete mix and increasing the coarse aggregate portions.

The use of optimized mix designs, blended cements, and/or supplementary cementitious materials (SCMs) can reduce the permeability of concrete. **SECTIONS 1102 and 1116**, Aggregates for Concrete describes optimized aggregate gradations for concrete mixes. Additional testing for alkali silica reaction (ASR) is required when SCMs are used in concrete as per **SECTION 401**. The amount of SCMs required to pass the ASR testing may be different than the amount required to comply with the permeability specifications. SCMs may also lower the necessary water cement (w/c) ratio and may slow set times and strength gain.

Optimizing the coarse aggregate gradations can decrease permeability. This includes mixes with more than 60% retained on the # 8 sieve and gradations with fineness modulus above 4.75. A fineness modulus of over 5.0 can yield even better results. Use the largest practical nominal maximum size aggregate allowed.

In general, keeping the w/c ratio below 0.43 may help meet the permeability specifications, as may lower cementitious content mixes when using Type I/II cements. These two properties control the paste in the mix. Concrete mixes with less than 25% paste (as displayed on KDOT Form 694) are more likely to pass the permeability specifications. Acceptable concrete can be mixed with paste contents of 23% or lower. Water cement ratios below 0.39 often do not provide enough water for all constituents to properly react, especially when admixtures are used, and may be counterproductive. High early strength concrete mixes using Type III cement and higher cementitious contents have also been able to pass the Standard Permeability requirements because of their low w/c ratios.

In general, the use of water reducers is helpful in reducing the paste content. Material compatibilities, following the admixture suppliers' recommendations for dosage rates, and the order of introduction of the chemicals into the mix are paramount to meeting KDOT specifications. Contractors should work with their admixture suppliers to find an admixture that works well with their combination of materials.

Changes made to an approved mix design will change the permeability, especially additional water, or redosing water that was withheld from the mix at a concrete plant. It is also recommended that concrete producers verify their mixes with a minimum of 3 cubic yards after doing their laboratory mix designs.

Standard Permeability Concrete (SPC) Requirements:

Volume of Permeable Voids 12.0% max, or
Surface Resistivity 9.0 kΩ-cm min, or
RCPT 3000 Coulombs max.

The SPC requirements may be met without the use of optimized mix designs, blended cements or SCMs. With certain aggregates, 25% slag cement will be required to pass the ASR testing. With other aggregates, a minimum of 40% slag cement by weight of total cementitious materials is usually needed. Some fly ashes require a minimum of 25% of the total cementitious material to pass the ASR test. Class C fly ash will react differently than Class F fly ash.

Some people believe that lower absorption aggregates have a better chance of meeting the permeability specification, but higher absorption aggregates have been used in concrete mixes utilizing these guidelines and have met the SPC specifications. KDOT has found that the properties of the concrete are often more important than the absorption of the aggregate when meeting this specification.

Moderate Permeability Concrete (MPC) Requirements:

Volume of Permeable Voids 11.0% max, or
Surface Resistivity 13.0 kΩ-cm min, or
RCPT 2000 Coulombs max.

Concrete mixes for MPC will require aggregates with a minimum Soundness of 0.95, a maximum LA Wear of 40, and a minimum Acid Insoluble Residue of 85%. These aggregates, by nature, are harder aggregates with very low absorption. MPC may rely more heavily on optimized gradations, blended cements or SCMs in order to meet the specification. Consideration could be given to ternary blends of cementitious materials, using more than one

SCM, or combining a blended cement with an additional SCM. Combinations of 25% to 30% slag cement with as little as 10% to 25% Class C fly ash have been very effective in keeping permeabilities below the level required for MPC. Incorporation of 20% Class F Fly Ash will often satisfy the requirements of the MPC specification.

Low Permeability Concrete (LPC) Requirements:

Volume of Permeable Voids 9.5% max, or
Surface Resistivity 27.0 kΩ-cm min, or
RCPT 1000 Coulombs max.

LPC will also use harder aggregates with very low absorption. These mixes must be optimized with the MA-6 gradation. Mix designs with 5% silica fume and 95% Type I/II cement often meet the LPC requirements. These mixes have traditionally been known as silica fume concrete. Ternary mix designs are useful in meeting these requirements. Consider using 3% to 5% silica fume with 25% to 30% slag cement, or 25% to 30% slag cements with 10% to 25% Class C fly ash. Class F fly ash alone may also be effective in reducing the permeability to these levels.

Contact KDOT's Bureau of Research or the District Office for additional guidance in meeting the Permeability Specifications.