

## 403 – ON GRADE CONCRETE

### SECTION 403

#### ON GRADE CONCRETE

##### 403.1 DESCRIPTION

Provide the grades of concrete specified in the Contract Documents.

This specification is specific to On Grade Concrete. See **SECTION 401** for general concrete requirements.

##### 403.2 MATERIALS

Provide materials that comply with the applicable requirements.

General Concrete.....	<b>SECTION 401</b>
Aggregate .....	<b>DIVISION 1100</b>
Admixtures and Plasticizers .....	<b>DIVISION 1400</b>
Grade 2 Calcium Chloride.....	<b>DIVISION 1700</b>
Cement, Fly Ash, Silica Fume, Slag Cement and Blended Supplemental Cementitious.....	<b>DIVISION 2000</b>
Water .....	<b>DIVISION 2400</b>

##### 403.3 CONCRETE MIX DESIGN

**a. General.** Design the concrete mixes for on grade concrete as specified in the Contract Documents.

**b. Concrete Mix Design.** Use procedures outlined in **SECTION 401**.

**c. Portland Cement and Blended Hydraulic Cement and Supplemental Cementitious Materials.**

Unless specified otherwise in the Contract Documents, select the type of portland cement, blended hydraulic cement and supplemental cementitious materials as specified in **SECTION 401**.

**d. On Grade Concrete Specific Requirements.** Use Optimized, Air-Entrained Concrete. Provide the Engineer written notification of the selection prior to the pre-construction conference.

(1) Design air-entrained concrete for pavement meeting **TABLE 403-1**.

(2) Design air-entrained concrete for shoulders meeting **TABLE 403-2**.

(3) Design air-entrained concrete for other uses with a maximum water to cementitious ratio of 0.50 and a minimum cementitious content of 480 lbs per cubic yard.

(4) For projects that are not QC/QA paving projects, verify the mix design in the field by performing compressive strength tests on cylinders made from samples taken from concrete produced at the project site before or during the first day that concrete pavement is placed on the project. If the compressive strength tests indicate noncompliance with minimum design values, add additional cement to the mix or make other appropriate mix design changes at no additional cost to KDOT.

(5) Control air content for PCCP by **subsection 403.4**.

(6) The amount of cementitious material listed in **TABLES 403-1** and **403-2** is the designated minimum for concrete pavement and shoulders respectively. It may be necessary to add additional cementitious material or otherwise adjust the mix proportions as permitted by the specifications to provide a mix design that complies with the compressive strength requirement.

(7) Maximum limit of lb. of water per lb. of cementitious material includes free water in aggregates, but excludes water of absorption of the aggregates.

(8) Provide On Grade Concrete that meets either the 28-day Volume of Permeable Voids KT-73, 28-day Surface Resistivity KT-79, **or** 56-day Rapid Chloride Permeability AASHTO T-277. Submit accelerated cure procedures for the Engineer's approval. The field verification test procedure must be the same test procedure as the mix design approval test.

(9) Permeability requirements do not apply for concrete patching material used in **SECTION 833** when existing pavement to be patched is more than 10 years old.

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TABLE 403-1: AIR-ENTRAINED CONCRETE FOR PAVEMENT						
lb. of Cementitious per yd <sup>3</sup> of Concrete, minimum	lb. of Water per lb. of Cementitious, maximum	Percent of Air by Volume	28-Day Comp Strength, psi minimum	Volume of Permeable Voids, maximum	Surface Resistivity, minimum	Rapid Chloride Permeability, maximum
517	0.45	See subsection 403.3e.	4000	12.0%	9.0 kΩ-cm	3000 Coulombs

TABLE 403-2: AIR-ENTRAINED CONCRETE FOR SHOULDERS					
lb. of Cementitious per yd <sup>3</sup> of Concrete, minimum	lb. of Water per lb. of Cementitious, maximum	Percent of Air by Volume	Volume of Permeable Voids, maximum	Surface Resistivity, minimum	Rapid Chloride Permeability, maximum
480	0.45	See subsection 403.3e.	12.0%	9.0 kΩ-cm	3000 Coulombs

(10) Concrete for shoulders using the same aggregates, gradations, and water to cementitious ratio as the mainline pavement concrete on the same project will be approved without testing for Volume of Permeable Voids, Surface Resistivity or Rapid Chloride Permeability.

**e. Design Air Content.** Provide a minimum air content that complies with these 2 criteria:

- a minimum by volume of 5.0% behind the paver, and
- a maximum air void spacing factor of 0.0100 inch behind the paver.

For a typical PCCP, design the mix at the minimum air content plus 0.5%.

The target air content is the air content that meets both criteria above.

If the air void spacing factor exceeds 0.0100 inch, use the following formula as a guide to determine the target air content:

$$\text{Minimum \% air content at 0.0100 inch} = \% \text{ air measured} + (\text{measured spacing factor} - 0.0100)/0.0010.$$

Mixes with Laboratory or Field Prequalification spacing factors greater than 0.0100 inch will not be approved.

When AVA spacing factors exceed 0.010 inches (0.25 mm) take immediate steps to reduce the spacing factor.

The Field Engineer will conduct an investigation using the following steps. If any one of the steps 1 through 9 corrects the problem, the Field Engineer will stop the investigation. The steps may be completed in combination and/or out of order. For example some may want to conduct steps 5 or 6 before some of the other steps.

1. If the failing sample came from behind the paver, the Engineer will take the following steps. Obtain an AVA sample from a unit weight bucket of concrete obtained from grade in front of the paver. Also, measure the total air content in the concrete on the grade in front of the paver. Obtain AVA and total air samples from behind the paver. Determine the loss of air and spacing factor due to the paving operation. Adjust for air loss due to paving.

2. Verify calibration of the AVA.
3. Change the location of the AVA during testing.
4. Call in the Research Unit or another AVA machine for comparison testing.
5. Check the mix design for compliance with **SECTION 401**.

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6. Check all of the gradations.
7. Check the total air content vs. target air content.
8. Check for Contractor compliance with admixture supplier's recommendations on dosage rates and order of introduction of the chemicals into the mix.
9. Check for material compatibility by using different admixtures or sources of admixtures.

Refer to the "11 Strategies to Improve the Air-Void Spacing Factor" in **APPENDIX B**.

If the problem is not corrected, the Field Engineer will take the following steps:

Obtain 2 cores from any area with an AVA spacing factor >0.0125 inches and send to Materials Research Center for hardened air evaluation.

- If the AVA spacing factor > 0.0125 inches and the average hardened air spacing factor is > 0.0080 inches, then suspend paving and submit new mix design.
- If the AVA spacing factor > 0.0125 inches and the average hardened air spacing factor < 0.0080 inches, then accept PCCP.

Take immediate steps to increase the air content whenever the air content behind the paver falls below 5.0%. Suspend paving operations when 2 consecutive air contents behind the paver fall below 4.0% and remove and replace the represented concrete.

Air Void Spacing Factor does not apply to concrete used in **SECTION 833** when existing pavement to be patched is more than 10 years old.

The maximum air content is 10%. Take immediate steps to reduce the air content whenever the air content exceeds 8%.

### **f. Slump.**

(1) Maximum design slump for slip form On Grade Concrete is 2 ½ inches. Do not designate a slump in excess of 5 inches for all other On Grade Concrete

(2) For all other On Grade Concrete placement, designate a slump that is required for satisfactory placement of the concrete application. Reject concrete with a slump that limits the workability or placement of the concrete.

(3) If the designated slump is 3 inches or less, the tolerance is ±3/4 inch, or limited by the maximum allowable slump for the individual type of construction.

(4) If the designated slump is greater than 3 inches the tolerance is ±25% of the designated slump.

## **403.4 AIR-ENTRAINED ON GRADE CONCRETE**

**a. Air Content for PCCP.** Provide an air content that complies with **subsection 401.3e**.

Using fresh concrete, the Engineer will determine the air void spacing factor using the AVA according to the manufacturer's requirements. Prequalify mixtures by either the laboratory option or the field option. Contact the Engineer to arrange testing by the AVA. Additional AVA testing will be required if the concrete plant is changed during the course of the project.

**b. Laboratory Prequalification.** Prepare a trial mix using a drum-type mixer according to AASHTO T 126 using all of the materials in the proportions, except the air entraining agent, contemplated for use in the field. Laboratory mixes require more air entraining agent than is needed in the field.

The Engineer will perform the following: Consolidate a sample in the unit weight bucket by vibration according to KT-20. Obtain 3 samples from the unit weight bucket for testing by the AVA. Valid results must have a minimum of 2 spacing factor readings within a range of 0.0025 inch. Test the third sample if the first 2 do not meet these criteria. Determine the air content of the trial mix by KT-19 (Volumetric Method) or KT-18 (Pressure Method) calibrated to yield the same result. Calculate a target percent air content at a maximum air void spacing factor of 0.01 inch using the equation in **subsection 403.3e**, when applicable.

**c. Field Prequalification.** Produce a trial batch at a minimum air temperature of 60°F using the batch plant and project materials.

The Engineer will perform the following: Test for air content by the procedure specified under laboratory prequalification. Correlate this air content to the average of at least 2 valid AVA test results. Valid AVA results have a maximum range of 0.0025 inch.

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When necessary, calculate a target percent air content at a maximum air void spacing factor of 0.0100 inch, using the equation in **subsection 403.3e**.

**d. Field Verification.** Coordinate with the Engineer so production samples may be obtained behind the paver to establish the target air content on the first paving day. Produce concrete using the same materials and proportions that were used in the prequalification mixture. Adjustments may be approved in the dosage of air entraining agent and a 5% adjustment may be approved in the water-cementitious ratio. AVA samples will be taken both in the path of a vibrator and the gap between vibrators.

Perform the test for air content at the delivery site of the concrete KT-19 (Roll-a-meter) or KT-18 (pressure meter), calibrated to yield the same result. Make adjustments in the proportions, types of material or the operation to establish a satisfactory, target air content.

**e. Control of the Air Content During Paving Operations.** Maintain an air content behind the paver as determined by KT-19 or KT-18, which meets **subsection 403.3e**. Maintain all production parameters established during field verification. The dosage of air-entraining agent may be varied to control the air content. Five percent adjustments will be permitted to the cementitious content and the water-cementitious ratio. With AVA testing, 5% adjustments will be permitted to the aggregate proportions, as well as any adjustment to the water reducer. Comply with all specifications regarding production of fresh concrete.

For all mainline paving, test the concrete at the beginning of the day's operation and approximately every 2 hours thereafter for air content. For all other slipformed pavement, test for air content at the beginning of a day's operation and approximately every 4 hours thereafter. Test hand placements for air content at least once daily.

Determine the air loss due to paving operations once in the AM and once in the PM. Determine the difference between the air content from concrete sampled before the paver, and concrete sampled behind the paver. QC/QA samples may be obtained in front of the paver and then corrected subtracting the difference determined during that ½ days production. Loss of air due to paving operations may adversely affect the spacing factor.

Failure to maintain the minimum required air content will result in suspension of operation. Take immediate steps to increase the air content above the minimum values stated in **subsection 403.3e**.

Other similar designs using higher cementitious contents (this may adversely affect permeability) and the same admixture types and dosage (with the same or lower water-cementitious ratio) may be used in limited areas such as crossovers, etc. Unauthorized changes in any aspect of production are cause for rejection of the pavement.

Random checks of the air void spacing factor of the concrete in the path and gap of the vibrators will be conducted by the Engineer to verify a maximum spacing factor of 0.0100 inch at the measured air content.

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### APPENDIX A – NON-MANDATORY INFORMATION

#### GENERAL ON GRADE CONCRETE

Design On Grade Concrete according to **TABLE 403-A1** meeting the applicable requirements for Volume of Permeable Voids, Surface Resistivity or Rapid Chloride Permeability as required in **TABLE 403-1**.

<b>TABLE 403-A1: ON GRADE CONCRETE</b>		
<b>Grade of Concrete</b>	<b>lb. of Cementitious per yd of Concrete, minimum</b>	<b>lb. of Water per lb. of Cementitious, maximum</b>
<b>Grade 4.0:</b> MA Gradation	602	0.44
<b>Grade 3.5 and 3.0:</b> MA Gradation	564	0.46
<b>Grade 2.5:</b> MA Gradation	526	0.50

Air Entrained On Grade Concrete meeting **subsection 403.3e**.

Maximum water to cementitious ratio of 0.50 and a minimum cementitious material content of 480 lbs per cubic yard. Maximum limit of lb. of water per lb. of cementitious material includes free water in aggregates, but excludes water of absorption of the aggregates.

### APPENDIX B – NON-MANDATORY INFORMATION

#### STRATEGIES TO IMPROVE THE AIR VOID SPACING FACTOR

Better air-void characteristics are obtained by a more thorough mixing of the sand and the air-entraining agent. Below are listed some strategies to help the mixing process.

1. Increase the mixing time of the plant or mixing revolutions of the truck.
2. Use a higher dosage of water reducer, up to 390 ml per 100 kg (6 oz. per 100 lbs) of cement. Use a non-retarding water reducer above 195 ml per 100 kg (3 oz. per 100 lbs) if needed.
3. Reduce the Paste Content (less water or less cement).
4. Use a higher proportion of rock.
5. Use a third, mid-sized aggregate.
6. Use coarser graded sand, or a finer sand if the current one is extremely coarse.
7. Maintain a higher air content (use more air-entraining agent).
8. Use coarser cement.
9. Change types or brands of the water reducer or the air entraining agent or both.
10. Cool the mix ingredients; i.e., use chilled water.
11. Use a different plant or modify the plant configuration. Introduce aggregates together on the belt feed (multiple weigh hoppers), use live bottoms aggregate bins, use dual drums, etc.