STATE OF OHIO
DEPARTMENT OF TRANSPORTATION
SUPPLEMENT 1117

CONCRETE USING RECYCLED COARSE AGGREGATE FOR CONCRETE
PAVEMENT AND INCIDENTAL ITEMS

April 15, 2011

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1117.01 General. Provide concrete made with Recycled Concrete Aggregate (RCA) for Items 305 Portland Cement Concrete Base; 451 Reinforced Portland Cement Concrete Pavement; 452 Non-Reinforced Portland Cement Concrete Pavement; 608 Walks, Curb Ramps and Steps; 609 Curbing, Medians and Traffic Islands; and 622 Concrete Barrier; and Supplemental Specification 888 Portland Cement Concrete Pavement using QC/QA; in lieu of 499 Class C Concrete.

In addition to this Supplement’s requirements the following sections of 499 apply:

1. 499.02, except requirements of 703.02 and 703.13 coarse aggregate as modified herein; and

2. 499.06 through 499.10

Notify the Engineer of intent to use RCA during the preconstruction meeting.

1117.02 Pavement Survey. Prior to demolition of the pavement, shoulders and other incidental items approved by the Engineer, conduct a survey of the concrete with the Engineer to
identify material related distress such as Alkali Silica Reaction (ASR) or D-Cracking. Remove any asphalt overlay prior to the survey.

For the pavement survey, initially divide the pavement into sublots of 2,000 yd$^2$. Evaluate each sublot for distress conditions. Changes in distress over the length of the project are an indication that material quality or sources have changed. Separate the materials from these areas into different lots where the material related distress changes and evaluate as defined below. Do not inter-mingle dissimilar materials into a stockpile.

A pavement exhibiting map cracking is an indication that ASR may be present. Extract three (3) 4-inch diameter cores from different sublots of the cracked pavement for evaluation. Send them to an AMRL accredited lab for petrographic analysis of detecting ASR according to ASTM C856, Annex A1. If the results indicate the presence of ASR, use a Class F fly ash, GGBF slag or combination thereof in the concrete mix design to mitigate reactions in the new concrete.

Pavements that have cracks along more than 10% the joints, either transverse or longitudinal, are considered having a D-cracking susceptible aggregate. Process the RCA to a No.8 gradation when the pavement survey indicates that D-cracking susceptible aggregates are present.

1117.03 Aggregate Requirements. Only use concrete from an ODOT project for the RCA. Process the RCA on-site or at a nearby processing facility. In order to maintain consistent quality material, do not inter-mingle concrete from different ODOT concrete sources. Do not use non-ODOT sources.

Process the pavement to remove steel, joint sealant, soil and other contaminants from the concrete. Use necessary crushing, screening, washing and beneficiation methods to remove all fines and impurities and produce coarse aggregate with consistent quality and properties. Do not use RCA as a fine aggregate or any produce a coarse aggregate material with more than 5% passing the No. 16 sieve, in the concrete.

Provide only coarse RCA meeting the following requirements:

1. Insure that the RCA meets the quality requirements of 703.02-B, except:

   a. Percent of Wear, Los Angeles test, maximum 50%
   b. Amount passing the No. 200 (75µm) sieve, maximum 1.5%
   c. Chloride Content (AASHTO T 260), maximum 0.6 lbs/yd$^3$ in new concrete
   d. Specific Gravity variability, maximum* 0.100
   e. Absorption variability, maximum* 0.8%

* Stockpile aggregates that have specific gravity and absorption values that fall outside the limits of variability separately.
2. Use only material passing 703.13. For each coarse aggregate gradation and each different source provide a sample of the RCA material to the Department for testing. Allow 10 weeks for testing.
3. Process the coarse RCA to meet the gradation requirements of the accepted mix design in 1117.04 and 1117.05.
4. Use only coarse RCA with absorption of 7.0% or less.

5. Provide coarse RCA with an asphalt content of 1.0% or less.

Stockpile material and do not use until RCA is tested and approved. ODOT will take quality assurance samples of stockpiles to verify the quality and consistency of the RCA.

**1117.04 Concrete.** The concrete using RCA will have different properties than similar concrete using 100% virgin material, therefore concrete mix proportions for item 499 Class C do not apply. Design the concrete mix to meet the following requirements:

1. Proportioning the mix so that the nominal maximum aggregate size is 1 inch and the combination of aggregates are workable, finishable and well graded and within the percent retained on each sieve as follows:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>1 ½&quot;</th>
<th>1&quot;</th>
<th>¾&quot;</th>
<th>½&quot;</th>
<th>3/8&quot;</th>
<th>#4</th>
<th>#8</th>
<th>#16</th>
<th>#30</th>
<th>#50</th>
<th>#100</th>
<th>#200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min % Retained</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>1.5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max % Retained</td>
<td>4</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>5</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

a. Design deviations of the aforementioned sieve recommendations are permissible with the following limitations:

i. No single sieve requiring a minimum of 8% retained will be below 5% retained and no more than two below sieves will be allowed.

ii. When the percent retained on each of two adjacent sieve sizes is less than 8%, the total percent retained on either of these sieves and the adjacent sieve that is not below 8% shall be at least 13%.

iii. A single sieve may retain up to 22%.

b. Use combined RCA and virgin aggregate gradations as necessary to obtain a well graded mix.

2. The minimum cementitious content required for the concrete design is 564 lbs/ yd³.

a. Use up to 20% fly ash (701.13, F or C)
b. Use up to 30% GGBF slag (701.11)

c. Use up to 50% combined pozzolan

3. The maximum water–cementitious ratio is 0.45

4. Use a water reducing admixture (705.12) to achieve an acceptable level of consistency, workability and finishability.

5. Design the concrete to obtain a Modulus of Rupture of 600 psi in 7 days (ASTM C 293 - simple beam with center-point loading) and 700 psi in 28 days (ASTM C78 – simple beam with third-point loading). Base the strength on the average of three 6"x 6" beam tests results.

6. Design the concrete to achieve a minimum compressive strength at 28 days of 5500 psi at the same time as achieving the Modulus of Rupture requirements in Item 5.

7. Provide concrete with 6 ±2% air. If the absorption of the RCA is over 5%, measure the air using the volumetric method (ASTM C173) for the initial approval and during production.

8. Design the mix to mitigate any material related distresses found during the pavement survey (1117.02).

   a. To mitigate for ASR, use 20% type F fly ash; 30% GGBF Slag; or a combination of both materials up to 50%, not exceeding the maximum content for either material.

1117.05 Mix Design Submittal. Provide documentation to the Project Engineer and Office of Materials Management for preliminary acceptance of the concrete mix design. Final acceptance is based on the results of the test placement. Include:

1. Results of the Pavement Survey (1117.02)

2. Aggregate information (1117.03)

   a. Quality test results from an AMRL accredited lab.

   b. Gradation of each aggregate and of the combination of all of the aggregates.

   c. Specific gravity and absorption of all aggregates

3. Mix design information:

   a. Analysis showing that the design meets the combined gradation of 1117.04-1
b. Design weights (SSD)

c. Theoretical yield to equal 27.0 $\text{ft}^3/\text{yd}^3$ at the design air content.

d. Maximum water-cementitious ratio

e. Sources of all material

4. Test data showing compliance to the strength requirements:

   a. Mix the concrete at the maximum water-cementitious ratio of the proposed design and 6% minimum air.

   b. Report the air, slump, temperature, unit weight and yield of concrete as tested.

      i. Report the aggregate correction factor (if applicable)

1117.06 Test Placement. At least one (1) month prior to paving, conduct a test placement with the proposed mix design to verify that the mix is workable, finishable, and meets the required strength and durability parameters as mixed and placed in the field. Use an AMRL accredited lab and ACI certified technicians to test the concrete.

1. Mix the concrete at the maximum design W/Cm ratio and within the air content requirements.

2. Place a test slab that is the full width of the paving operation to be used on the project and a length four (4) times the transverse joint spacing; the same depth as the thinnest pavement for the project.

   a. Placed on a similar base as the pavement.

   b. Finish, texture and cure the concrete in the same manner as the pavement to be placed.

   c. Saw joints as required by the plan spacing at appropriate time to prevent cracking.

3. Make at least 4 beams. Break two beams at 7 days and two beams at 28 days.

   a. Verify that the concrete will meet the design strength at field cured conditions.

4. Extract two 4 inch diameter cores from different areas of the pavement.

   a. Verify that there is no coarse aggregate segregation.

   b. Test the concrete to ensure adequate air void system.
i. Total content > 4%

ii. Specific Surface > 600 in\(^2\)/in\(^2\)

iii. Spacing Factor < 0.008 inches

iv. No air-void clustering around the coarse aggregate

5. The test slab should not exhibit:

   a. Cracking
   
   b. Honeycombing
   
   c. Edge slump
   
   d. Raveling at the joints
   
   e. Finishing difficulties

6. If the results of the test placement are not satisfactory, adjust the materials, mix, construction practices and/or control procedures as needed. Perform a new test placement to verify that the concrete can be placed according to the specifications to the Engineer’s satisfaction.

   a. If problems arise during the pavement placement, immediately take appropriate action, including work stoppage, to make appropriate adjustments to prevent the problem.

7. A maturity curve may be made according to Supplement 1098 during the test placement if desired.

**1117.07 Controls.** Develop and implement a quality control plan for aggregate production the details the production procedures, testing methods and testing frequencies that will assure consistent material and that the recycled concrete aggregate meets the requirements of this specification. Provide the following controls on the RCA and the concrete during construction:

1. Stockpile the RCA in increments of no more than 5,000 tons and test the absorption and specific gravity of the RCA prior to use. Use the information to make batch adjustments as necessary and do not use RCA with an absorption exceeding 7%.

2. Maintain moisture all coarse aggregate above SSD during concrete production by stockpile soaking.

   a. Test the moisture content of all aggregates at the beginning of each day’s production and retest at least every for 1000 yd\(^3\) of concrete thereafter.
3. Test gradation of all aggregates daily to maintain gradation within specification limits and adjust mix proportions if necessary to stay within the original gradation.

4. Establish a slump range for the mix for each method of placement, and control the mixes within the established range. Submit the slump range to the Engineer for acceptance.

5. Remove wash water from the mixer prior to batching concrete.

6. If during the work, the specific gravity changes by more than 0.02 from the original design, adjust the design weight to conform to the new specific gravity.

7. Adjust the amount of water added at the mixer based on the moisture in the aggregate and the moisture the aggregate will absorb. Do not exceed maximum established water-cementitious ratio.

8. Use an approved set-retarding admixture conforming to 705.12, type B or D when the concrete temperature exceeds 75°F (24°C).

9. Test the air content, slump, unit weight and temperature on the first 3 loads. If consistent to the Engineer's satisfaction, extend testing to every 5 loads of concrete or as directed by the Engineer.
   
   a. Maintain the air, yield and temperature within the specification requirements and slump within the established range

10. Make beams for strength specimens twice a day at the Engineer’s direction. Perform air, slump, yield and temperature tests when strength specimens are made. Insure that the pavement obtains 600 psi modulus of rupture before subjecting the pavement to traffic.

Do not allow moisture runoff from RCA stockpiles to enter streams or groundwater.