Illinois Department of Transportation
2300 South Dirksen Parkway / Springfield, Illinois / 62764

June 4, 2014

CIRCULAR LETTER 2014-07

ROLLER COMPACTED CONCRETE EXPERIMENTAL FEATURE

COUNTY ENGINEERS/SUPERINTENDENT OF HIGHWAYS
MUNICIPAL ENGINEERS/DIRECTORS OF PUBLIC WORKS/MAYORS
CONSULTING ENGINEERS

The central Bureau of Materials and Physical Research (BMPR) has issued a new special provision for the construction of roller compacted concrete (RCC). This special provision states the requirements for constructing pavement, shoulder, or base course widening using RCC on a prepared subgrade. Use of this special provision on a project must be a part of the Department's Experimental Features Program, which is outlined in Section 11-3.06 of the Bureau of Local Roads and Streets Manual.

The general objective of this experimental feature is to evaluate the constructability and performance of RCC. A Local Public Agency electing to construct RCC shall follow the attached Experimental Feature Work Plan and construct the RCC according to the attached IDOT special provision for RCC. The time to complete the project evaluation between construction and final reporting shall be a minimum of three years, with the final research report due to the Department no later than five years after the date of construction.

Please contact the BLRS Local Policy unit at DOT.LocalPolicy@illinois.gov with any questions.

Sincerely,

James K. Klein

James K. Klein, P.E., S.E.
Acting Engineer of Local Roads and Streets

PW/tw

Attachments

EXPERIMENTAL FEATURE WORK PLAN
ROLLER COMPACTED CONCRETE

OBJECTIVE

The general objective of this experimental feature is to evaluate the constructability and performance of roller compacted concrete (RCC). This objective includes evaluating the RCC mixture design, production method, construction method, jointing technique, and performance of both bare and overlaid pavement sections as outlined below.

SUPPORTING RESEARCH

The first commonly accepted uses of roller compacted concrete were in the 1970's and 1980's for log sorting yards and military facilities in the United States and Canada. This application for RCC provided a stable platform for large machinery and heavy equipment to operate. The US Army Corp of Engineers also started using RCC for the construction of low- to mid-level flood control dams in the United States during the same timeframe. This application for RCC provided for a bulk mass of material to hold back the hydrostatic pressures at these flood control dams. It was not until the 1990's and early 2000's that RCC gained popularity as an application for paving large industrial sites, intermodal facilities, and even general pavements. Today, RCC has been used for pavement applications across the southeastern United States including applications in Alabama, Georgia, Tennessee, and even as far north as Missouri, Indiana and Ohio. Additional information may be found in the following resources:

1) "Guide For Roller-Compacted Concrete Pavements," August 2010, National Concrete Pavement Technology Center. Harrington, Dale, et al.
2) Roller Compacted Concrete Pavements, http://www.rccpavement.info/
3) Portland Cement Association, http://www.cement.org/pavements/pv_rcc.asp

PLAN OF STUDY AND EVALUATION

This study will be conducted by observing and documenting the construction of a RCC pavement application. The pre-construction site conditions shall be evaluated and documented for the project while highlighting any areas of concern. The study will also document the selected mixture designs and source materials for mixture production. The mixture itself will be evaluated with regard to ease of production, consistency, segregation tendencies, and ease of placement. The mixture production method and placement method shall also be documented. This shall include the type of transport equipment, placement equipment, compaction equipment, curing equipment, and jointing equipment. The jointing pattern and method of curing will also be documented for each project.

A brief construction report shall be written to document the pre-construction and construction operations for the RCC placement. This report shall include, but is not limited to, the following items:

- Project owner
- Project location
- Date of construction
- General contractor
- RCC mixture producer (if different than the general contractor)
- Description of the pre-construction site conditions
- The RCC mixture design(s) including the material sources
- The RCC mixture production method
- The type of transport equipment used
- The make and model of the placement equipment
- The make and model of all the compaction equipment
- The curing method and materials used
- The transverse jointing pattern (including any variations from the standard 15-foot spacing) and equipment used to cut the joints
- A final report of the pavement surface test as required by the special provision and the quantity of pavement that was subject to corrective action
- A final report of all the density and compressive strength test results that were documented during construction
- A summary of the general construction operations including documentation of items that were successful and items that were not along with suggestions for improvement

INSPECTION AND REPORTING

Each project which is constructed shall be evaluated during the construction process as outlined above in the Plan of Study and Evaluation. In addition, each project shall also have a series of follow up inspections to document the performance of the completed pavement. Pavement distress surveys should ideally be performed twice the first year after construction (preferably in the spring and fall) and annually after that to document such things as cracking, surface distress, and any areas of possible failure. Areas of normal and exceptional pavement performance should also be documented. These surveys may be completed on short 500-foot random sections throughout the project, so long as the same segments are evaluated consistently throughout the length of the evaluation.

The biannual pavement distress surveys are the responsibility of the project owner. Included with that will be an annual report to IDOT highlighting the results of the surveys. The project owner will also be responsible to generate a final research report accumulating the results of construction reporting and annual performance reporting.

The project owner should consider taking a series of core samples from the RCC placement for testing of freeze / thaw durability (Illinois Test Procedure ITP 161). These may be taken during construction at the same location as the compressive strength samples or taken at a later date, but within the limits of the

evaluation period, at the location of the compressive strength samples. Freeze / thaw test results should also be included with the final research report.

The project owner should also consider taking core samples at a selected number of transverse contraction joints after the RCC has been in service for a few years. These core samples should be evaluated by a visual survey of the aggregate interlock or joint deterioration. Results of this inspection may also be included with the final research report.

METHOD OF CONSTRUCTION

The roller compacted concrete shall be constructed according to the attached IDOT special provision for Roller Compacted Concrete.

ESTIMATED COST

Construction history indicates that the unit cost of RCC is often lower than conventional concrete. The amount of cost savings is dependent upon the size and complexity of the project. There are some limited savings in the concrete mixture itself due to reduced cement content; however, the bulk of the cost savings come as a result of the construction process. There can be significant savings in the amount of labor required to construct RCC versus conventional concrete. There are no forming or steel placement requirements, placement and finishing is done by machine versus human labor, and there can be a reduction in the amount of saw cutting required for jointing. Finally, there are user cost savings as well due to the ability to open an RCC pavement to traffic in a shorter time period than traditional concrete pavement.

The contract unit price for CONSTRUCTING RCC TEST SECTION, ROLLER COMPACTED CONCRETE PAVEMENT, ROLLER COMPACTED CONCRETE BASE COURSE, ROLLER COMPACTED CONCRETE BASE COURSE WIDENING, or ROLLER COMPACTED CONCRETE SHOULDER shall also be included with either the construction documentation or the final research report.

ESTIMATED TIME TO COMPLETE EVALUATION

The time to complete the evaluation between construction and final reporting for each project shall be a minimum of three years. The final research report for each project shall be submitted to the Department no later than five years after the date of construction.

PRINCIPAL INVESTIGATOR

The principal investigator for this experimental feature shall be the following.

_____(Project Owner – IDOT District or Local Public Agency)
_____(Contact Name)
_____(Address)
_____(Address)
_____(Phone)
_____(E-mail)

_____(BMPR Investigator) /Engineer of Technical and Product Studies
Illinois Department of Transportation
Bureau of Materials and Physical Research
126 E Ash Street
Springfield, IL 62704
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ATTACHMENTS

The Roller Compacted Concrete special provision for use on these experimental feature projects is attached.

ROLLER COMPACTED CONCRETE (BMPR)
Effective: January 17, 2014

Description. This work shall consist of constructing roller compacted concrete (RCC) on a prepared subgrade.

Materials. Materials shall be according to Article 1020.02, except the following items will not apply: Articles 1020.02(h) and 1020.02(i).

Equipment. Equipment shall be according to Articles 406.03 and 1020.03 (Note 1), except the following will not apply: Articles 406.03(f) and 406.03(g).

Note 1. Truck mixers and truck agitators shall not be allowed for the production of RCC. Non-agitator trucks shall be equipped with a canvas cover or other suitable material meeting the approval of the Engineer.

Alternate mixing equipment including portable horizontal shaft, pugmill, and horizontal spiral blade tilt (ribbon) mixers may be used with the approval of the Engineer. The Contractor shall demonstrate that the alternate mixing equipment has the ability to produce a consistent, well-blended, non-segregated, homogenous RCC mixture in the proportions defined in the approved mix design.

Mix Design. The same mixture proportions shall be used for the entire project, unless otherwise stated in the project documents. If during the project there is a change in the type or source of the cement, finely divided minerals, or aggregates, the mixing shall be suspended and a new mix design shall be developed.

The RCC mix design shall be according to Section 1020 and shall have the same requirements as Class PV concrete as described therein, except as modified below.

Item	Criteria
Cement Factor, cwt/cu yd (kg/cu m)	5.35 (320) (Note 1)
Water/Cement Ratio, lb/lb (kg/kg)	0.25 – 0.40
Slump, in. (mm)	Not Applicable
Air Content, %	Not Applicable
Coarse Aggregate Gradations	CA11
Intermediate Aggregate Gradations	CA13, CA14, CA16
Fine Aggregate Gradations	FA01, FA02, FA20
Mix Design Compressive Strength, psi (kPa), minimum	3,500 (24,000) at 7 days; 4,500 (31,000) at 28 days

Notes: (1) The minimum portland cement content in the mixture shall be 400 lbs/cu yd (237 kg/cu m). A cement factor reduction for using a water-reducing admixture or a high range water-reducing admixture will not be allowed, and Articles 1020.05(c)(5)b. and 1020.05(c)(5)c. will not apply.

Gradation. The combined coarse, intermediate, and fine aggregates shall be well-graded and conform to the following combined gradation.

Sieve Size (Metric)	Percent Passing
1 in. (25 mm)	100
3/4 in. (19 mm)	95±5
1/2 in. (12.5 mm)	82±10
3/8 in. (9.5 mm)	74±12
No. 4 (4.75 mm)	54±12
No. 8 (2.36 mm)	40±12
No. 16 (1.18 mm)	30±10
No. 30 (600 μm)	22±8
No. 50 (300 μm)	15±8
No. 100 (150 μm)	9±8
No. 200 (75 μm)	4±4

Density. Perform a modified Proctor test to establish the target maximum wet density and optimum moisture content as specified. The modified Proctor test shall be performed according to Illinois Modified AASHTO T 180, Method D, except the sample preparation and procedure shall include Sections 6.3, 7.1, 7.2, and 7.4 of Illinois Modified AASHTO T 134.

Construction Requirements.

(a) Test Section. At least 7 days prior to construction, the Contractor shall construct a test section using the project mix design and equipment. The test section shall be a minimum 100 feet (30 m) long.

During test section construction, the Contractor shall:

(1) Establish an optimum rolling pattern to achieve the required density and provide a smooth, hard, uniform surface free of excessive tears, ridges and aggregate segregation. The required density shall not be less than 98% of the target maximum wet density established for the mix design.

(2) Conduct compressive strength testing according to Illinois Modified AASHTO T 22 on cores extracted according to ASTM C 42. The strength shall not be less than 3,500 psi (24,000 kPa) at 7 days. Construction may proceed without strength test results with the approval of the Engineer based on satisfying (1) and providing documentation of successful production of the same mix design.

The Test Section may be waived by the Engineer with documentation of successful production of the same mix design and placement with the same equipment.

(b) Preparation of Subgrade. The subgrade shall be prepared according to Section 301, or Section 302 when specified, except Articles 301.05 and 301.06 will not apply.

(c) Mixing Roller Compacted Concrete. The mixing of RCC shall be according to Article 1020.11(a)(1), except the minimum mixing time shall be 90 seconds for a stationary mixer regardless of capacity, and for tilt drum type stationary mixers the volume of RCC mixed per batch shall not exceed 60 percent of the rated capacity of the mixer for conventional concrete. Horizontal shaft and horizontal spiral blade tilt (ribbon) mixers shall follow manufacturer's recommendation for batch size and mixing time. Article 1020.11(c) will not apply.

(d) Transportation. Article 1020.11(a)(7) shall apply, except the time elapsing from when water is added to the mix until it is deposited in place at the work shall not exceed 45 minutes. Trucks shall be dumped in the order in which they were loaded.

(e) Lift Thickness. The minimum and maximum compacted lift thickness for constructing RCC shall be 4 in. (100 mm) and 8 in. (200 mm) respectively. Additional lifts shall be placed within 60 minutes of completing the previous lift. If a subsequent lift cannot be placed within 60 minutes due to factors outside the Contractor's control, such as inclement weather or equipment breakdown, the previous lift shall be made clean, free of laitance, and moist, but not wet, at the time of placement of the subsequent lift.

(f) Spreading and Finishing. Article 406.06(e) shall apply. Replace references to HMA with RCC.

(g) Temperature Control for Placement. The Contractor shall schedule placing and finishing of the RCC during hours in which the ambient air temperature is forecast to be lower than 85 °F (30 °C). For cold weather placement, RCC may be placed when the air temperature is above 40 °F (4 °C) and rising, and placement shall stop when the falling temperature reaches 45 °F (7 °C) or below, unless otherwise approved by the Engineer. The temperature of the RCC immediately before placement shall be a minimum of 50 °F (10 °C) and a maximum of 85 °F (30 °C). Aggregates and water shall be heated or cooled uniformly and as necessary to produce RCC within the specified temperature limits. No frozen aggregates shall be used in the RCC. The RCC temperature shall be determined according to Illinois Modified ASTM C 1064/C 1064M.

(h) Compaction. Rolling shall begin immediately after placement and be completed within 30 minutes. In-place density field tests shall be performed according to Illinois Modified AASHTO T 310, direct transmission mode, as soon as possible, but no later than 15 minutes after completion of rolling. A test shall be defined as the average of three readings spaced equally across the lane, a minimum 12 in. (300 mm) from edge of placement. The required density shall not be less than 98% of the maximum wet density obtained by Illinois Modified AASHTO T 180, Method D.

(i) Surface Test. The compacted RCC will be tested for trueness with a 16-ft (5-m) straightedge, furnished by the Contractor at no additional cost to the Department. Testing shall be in the wheel paths parallel to the pavement centerline and transversely across the pavement perpendicular to the centerline every 500 lane feet (150 m). Variations in the pavement that exceed 3/8 in. (10 mm) for uncapped RCC and 1/2 in. (13 mm) for capped RCC shall be corrected at the discretion of the Engineer. Corrective action shall be as defined herein under "Remedial Action".

(j) Thickness. The tolerance in thickness shall be according to Article 407.10, except corrective action shall be as defined herein under "Remedial Action".

(k) Fresh Joints. A vertical joint shall be considered a fresh joint when an adjacent RCC lane is placed within 60 minutes of the previous lane. The contact face between fresh joints shall be moist, but not wet, and shall not be segregated. If the subsequent placement cannot be placed within 60 minutes, the vertical joint shall be prepared as specified herein under "Cold Joints".

(l) Cold Joints. Planned or unplanned construction joints in the RCC shall be cut vertically for the full-depth. The vertical cut shall be at least six inches from the exposed edge.

(m) Curing and Protection. The surface of the RCC shall be protected according to the following based on final surface treatment.

(1) Uncapped, finished RCC. Within 15 minutes after final rolling, the surface of the RCC pavement shall be protected according to Article 1020.13(a)(4) with an approved Type III curing compound. The application rate shall be not less than 1 gal/125 sq ft (0.33 L/sq m) to achieve a void-free surface without ponding. No de-icing agents shall be applied to bare RCC for at least 60 days.

(2) Capped with overlay or surface treatment. The surface of the RCC shall be protected according to Article 1020.13(a)(4) with an approved Type II curing compound applied within 15 minutes after final rolling, or shall be protected according to Article 406.05(b)(1) no earlier than 30 minutes after final rolling.

(n) Contraction Joints. Transverse and longitudinal contraction joints shall be made as soon as possible without damaging the pavement according to Article 420.05, except that no steel reinforcement across the joints shall be used. Transverse joints shall be spaced at a maximum 15 ft (4.6 m) or as specified on the plans.

(o) Protection and Opening to Traffic. The Contractor shall protect all sections of newly compacted RCC from traffic until completion of contraction joint sawing. When RCC is constructed after November 1 and will be opened to traffic prior to construction of an overlay or surface treatment, a protective coat shall be applied to the surface and appurtenances according to Article 420.18, except the RCC may be opened to traffic prior to application as specified herein.

(p) Remedial Action. The Contractor shall repair defective areas as identified by the Engineer at no additional cost to the Department. All repairs are subject to the Engineer’s approval.

Quality Control. The Contractor shall establish and implement a Quality Control Plan according to the Check Sheet for "Quality Control/Quality Assurance of Concrete Mixtures," except as required in Schedules A, B, and C as follows.

(a) Comparing Test Results. Differences between the Engineer's and the Contractor's split sample test results will considered reasonable if within the following limits:

Test Parameter	Acceptable Limits of Precision
Compressive Strength	900 psi (6200 kPa)
Density	1.0 %
Aggregate Gradation	
% Passing	
3/4 in. (19 mm)	3 %
1/2 in. (12.5 mm)	5 %
3/8 in. (9.5 mm)	3 %
No. 4 (4.75 mm)	5 %
No. 8 (2.36 mm)	5 %
No. 16 (1.18 mm)	3 %
No. 30 (600 μm)	2 %
No. 50 (300 μm)	2 %
No. 100 (150 μm)	2 %
No. 200 (75 μm)	2 %

(b) Test Results and Specification Limits. Action shall be taken according to the Check Sheet for "Quality Control/Quality Assurance of Concrete Mixtures" Article 1020.16(d)(3) when either the Engineer's and the Contractor's test results are not within specification limits for strength and aggregate gradation as specified herein. Corrective action for density shall be according to Article 1030.05(d)(7), except replace references to HMA with RCC.

SCHEDULE A

CONTRACTOR PLANT SAMPLING AND TESTING			
Item	Test	Frequency	IL Modified AASHTO, IL Modified ASTM, or Illinois Test Procedure [1/]
Aggregates (Stored at Plant in Stockpiles or Bins)	Gradation [2/]	At start of production (including test section); 2500 cu yd (1900 cu m) for each gradation number [3/], and as needed to control production	ITP 2, ITP 11, ITP 27, and ITP 248
Roller Compacted Concrete Mixture	Moisture	At start of production for that day (including test section); 1 per 150 cu yd (115 cu m); and as needed to control production	T 318
Roller Compacted Concrete Mixture	Moisture-Density Relationship	Minimum 1 prior to test section, and minimum 1 prior to production following any change of material or compaction equipment	T 180 (Method D) [4/]

1/ Refer to the Department's "Manual of Test Procedures for Materials".

2/ All gradation tests shall be washed. Testing shall be completed no later than 24 hours after the aggregate has been sampled.

3/ One per week (Sunday through Saturday) minimum, unless the stockpile has not received additional aggregate material since the previous test. The sample shall be taken and testing completed prior to RCC placement.

4/ The modified Proctor test shall be performed according to Illinois Modified AASHTO T 180, Method D, except the sample preparation and procedure shall include Sections 6.3, 7.1, 7.2, and 7.4 of Illinois Modified AASHTO T 134.

SCHEDULE B

CONTRACTOR FIELD SAMPLING AND TESTING			
Item	Test	Frequency [1/]	IL Modified AASHTO, IL Modified ASTM, or Illinois Test Procedure [1/]
Pavement, Shoulder, Base Course, Base Course Widening	Density	First three truck loads delivered (including test section), and first three truck loads delivered following any change of material or compaction equipment; 1 every 500 lane feet (150 m)	T 310 (Direct Transmission)
	Compressive Strength [2/]	1 every 500 lane feet (150 m)	C 42, T 22

1/ Random test site and sample locations shall be determined according to the Department's "Determination of Random Density Test Site Locations," except the frequency shall be as specified herein and the total distance to be paved shall be subdivided into units representing 500-ft (150-m) frequency.

2/ Strength tests shall be according to Article 1020.09, except compressive strength specimens shall be cored from the RCC according to ASTM C 42 and flexural strength shall not be evaluated. The tests of record for strength shall be at 7 and 28 days. Strength shall be defined as the average of three 4-in. (100-mm) diameter cores taken at a single station, corrected for length to diameter. The strength shall not be less than 3,500 psi (24,000 kPa) at 7 days and 4,500 psi (31,000 kPa) at 28 days.

SCHEDULE C

ENGINEER QUALITY ASSURANCE INDEPENDENT SAMPLE TESTING		
Location	Measured Property	Frequency [1/]
Plant	Gradation of aggregates stored in stockpiles or bins, and Moisture	As determined by the Engineer.
Jobsite	Density and Compressive Strength	As determined by the Engineer.

ENGINEER QUALITY ASSURANCE SPLIT SAMPLE TESTING [2/]		
Location	Measured Property	Frequency [1/]
Plant	Gradation of aggregates stored in stockpiles or bins	As determined by the Engineer.
	Moisture	As determined by the Engineer.
Jobsite	Density	At the beginning of the project, the first test performed by the Contractor. Thereafter, a minimum of 20% of total tests required of the Contractor will be performed per plant, which will include a minimum of one test per mix design.
	Compressive Strength	At the beginning of the project, the first test performed by the Contractor. Thereafter, a minimum of 20% of total tests required of the Contractor will be performed per plant, which will include a minimum of one test per mix design.

1/ The Engineer will perform the testing throughout the period of quality control testing by the Contractor.

2/ The Engineer will witness and take immediate possession of or otherwise secure the Department's split sample obtained by the Contractor.

Acceptance by the Engineer. Final acceptance will be based on the Standard Specifications and the following:

(a) The Contractor's compliance with all contract documents for quality control.

(b) Validation of Contractor quality control test results using split samples. Any quality control or quality assurance test determined to be flawed may be declared invalid only when reviewed and approved by the Engineer. The Engineer will declare a test result invalid only if it is proven that improper sampling or testing occurred. The test result is to be recorded and the reason for declaring the test invalid will be provided by the Engineer.

(c) Comparison of the Engineer's quality assurance test results with specification limits using samples independently obtained by the Engineer.

The Engineer may suspend mixture production, reject materials, or take other appropriate action if the Contractor does not control the quality of RCC. The decision will be determined according to (a), (b), or (c).

Documentation. Documentation shall be according to the Check Sheet for "Quality Control/Quality Assurance of Concrete Mixtures," except the applicable Department forms will be form BMPR MI504, form BMPR MI654, form BMPR MI655, and form BMPR MI303N.

Method of Measurement. Article 420.19(b) shall apply.

Basis of Payment. This work will be paid for at the contract unit price per square yard (square meter) for ROLLER COMPACTED CONCRETE PAVEMENT, ROLLER COMPACTED CONCRETE BASE COURSE, ROLLER COMPACTED CONCRETE BASE COURSE WIDENING, or ROLLER COMPACTED CONCRETE SHOULDER of the thickness specified.

The test section will be evaluated for payment at the contract unit price per each for CONSTRUCTING RCC TEST SECTION, according to the following.

(a) If the RCC placed in the test section is determined to be acceptable by the Engineer, the test section will be paid at the contract unit price.

(b) If the RCC placed in the test section is determined to be unacceptable to remain in place by the Engineer, the test section will not be paid for and shall be removed at the Contractor's expense. An additional test section will be paid for in full, if determined to be acceptable by the Engineer.

(c) If the RCC placed in the test section is determined to be acceptable to remain in place by the Engineer and the Engineer deems a new start-up is required for any reason, the initial test section will be paid for at the contract unit prices. Any additional test sections will be paid for at one-half the unit price of each test section.

(d) If the Contractor requests and is granted approval for a mix design other than the initial approved RCC mix design, the Engineer may require the Contractor to construct a test section for the new mix design at no additional cost to the Department.