

**CITY OF COLUMBUS  
PUBLIC SERVICE DEPARTMENT  
TRANSPORTATION DIVISION  
SUPPLEMENTAL SPECIFICATION 1523  
ROLLER COMPACTED CONCRETE PAVEMENTS (RCC)  
February 17, 2009**

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## **ROLLER COMPACTED CONCRETE PAVEMENTS (RCC)**

- 1523.01 General Provisions.** This Supplement outlines the requirements for production and construction of Roller Compacted Concrete (RCC) pavement for City streets. In addition to this supplement, items 305, 306, 401, 407, 451 and 700 of the City of Columbus Construction and Material Specifications (CMSC) apply.
- 1523.02 Execution.** This supplemental specification sets forth some requirements regarding materials to be employed and the manner in which the work is to be performed. This supplemental specification also sets forth results to be obtained. The Contractor shall comply with all requirements set forth in this supplemental specification.
- 1523.03 Submittal Requirements.** The Contractor shall submit the following to the Engineer at least 45 days before start of any production of RCC pavement:
- 1523.03.01 Construction schedule for all RCC related operations.
  - 1523.03.02 Paving procedures describing direction of paving operations, paving widths, planned longitudinal and transverse cold joints and curing methods and patterns.
  - 1523.03.03 Certification for aggregate source, quality and sizing as required by the specification.
  - 1523.03.04 Certification for Portland cement and supplementary cementations materials as required by the specification.
  - 1523.03.05 Manufacturers data and specifications including capacities for equipment to be used in mixing, hauling, placing and compacting RCC.
  - 1523.03.06 Layout of plant location showing mixing plant, cement and aggregate storage and water supply.
  - 1523.03.07 Proposed RCC Mix Design. If the proposed mix design is developed by the Contractor or there is a suggested change to the mix design, it must be submitted to the Engineer for approval at least forty five days prior to RCC construction.

This mix design shall include details on aggregate gradation, cementations materials, admixtures (if used), compressive and tensile strengths and required moisture and density to be achieved.

**1523.04 Materials.** All materials to be used shall be from approved sources as documented on the “Approved Materials List” on file in the City’s testing laboratory.

Portland cement shall conform to the standard specification for Portland Cement Type I, ASTM C 150 (latest edition).

Fly Ash shall conform to ASTM C 618 Class F and section 499 of the CMSC.

Ground Granulated Blast Furnace Slag (GGBFS): GGBFS shall conform to sections 499 and 701.11 of the CMSC.

Chemical admixtures shall conform to section 499 of the CMSC.

Fine and course aggregates shall meet the requirements of section 703.02 of the CMSC for Portland Cement Concrete, item 305 and 306. The aggregates shall be well graded to conform to the following composite gradation.

<u>Sieve Size</u>	<u>Percent Passing</u>
1”	100
¾”	95 – 100
½”	70 – 90
3/8”	60 - 85
#4	40 – 70
#16	20 – 40
#100	5 – 20
#200	2 – 8

Mixing water shall be clean, potable and free from oil, acid and strong alkalis or organic.

**1523.05 Mix Design.** The Contractor/Supplier shall develop a RCC mixture proportioned in accordance with this specification and procedures discussed in ACI 325.10R-95 (Re-approved 2001) “Report on Roller-Compacted Concrete Pavements” sections 4.2, 4.3, and 4.4. Once the mix has been designed, certified test data shall be submitted in accordance with section 101.10 of the CMSC from a recognized testing laboratory that shows the proposed mix design will meet the following requirements based on test results of the cores taken from the test section.

Compressive Strength, Cores: 3500 psi @ 28 days.  
Splitting Tensile Strength, Cores: 350 psi @ 7 days.

The minimum Portland cement content shall be 350 pounds per C.Y.

Fly Ash and GGBFS may only be used between April 1 and November 1 unless otherwise authorized by the Project Engineer.

Secondary Cementations material shall not be considered as a substitute for any deficiency in the #100 sieve in section.

Strength properties shall be based on field extracted cores.

## **1523.06 Equipment.**

1523.06.01 **Mixing Plants:** Mixing plants shall be of a design that can produce a RCC pavement mixture of the proportions defined in the approved mix design and within the specified tolerances in ASTM C 94 and ASTM C 685. The mixing plant may be a Central-Mix Drum or a Stationary Continuous-Mixing Twin-Shaft Pug Mill mixer. The plant shall have a minimum manufacturer's rated capacity of 200 tons per hour.

1523.06.02 **Pavers:** RCC shall be placed with a high-density or conventional asphalt type paver subject to approval by the Engineer. The paver shall be capable of placing the RCC at a minimum of 85% of the maximum wet density in accordance with 1523.07.05. The paver shall be of suitable weight and stability to spread and finish the RCC material, without segregation to the required thickness, smoothness, cross-section and grade. Work in areas inaccessible to paving machines shall be performed according to 1523.07.06.

1523.06.03 **Vibratory Rollers:** Vibratory rollers shall be self-propelled, double drum, steel wheel vibratory rollers having a static weight of at least 10 tons. Each roller drum shall be equipped with a properly operating scraper and brush. The rollers shall transmit a dynamic impact to the surface through smooth steel drums by means of revolving weights, eccentric shafts or other equivalent methods. The roller drum shall be between 4 and 5-1/2 foot in diameter and 5-1/2 to 8 feet in width.

Finish rollers shall be self-propelled, double drum, steel wheel rollers having a static weight of between 3 and 10 tons. Each drum shall be equipped with a properly operating scraper and brush. A single drum vibrator roller with a vulcanized rubber coating may be utilized for finish rolling, at the approval of the Engineer.

1523.06.04 **Dump Trucks:** Dump Truck boxes shall be kept free of contaminants while hauling any RCC and shall have protective covers properly secured until discharge into the paver.

## 1523.07 Construction Requirements

### 1523.07.01 Preparation of Sub-grade/Sub-base:

Prepare the sub-grade according to section 204 of the CMSC. If required, construct a granular base according to section 304. Moisten the surface of the sub-grade or base without creating mud or ponding water, to minimize absorption of water from RCC mix to be deposited.

1523.07.02 **Transportation:** Transport the RCC mixture to the site in dump trucks which meet the requirements of 1523.06.04. The trucks shall dump directly into the hopper of the paver unless placement is by hand as directed by the Engineer. Hauling over the freshly placed RCC will not be permitted except in multi-lift operations to the extent required to dump the fresh RCC into the paver.

1523.07.03 **Placing RCC:** Place RCC to the thickness, grade, and lines indicated in the plans. Achieve a minimum of 85% of the maximum wet density out of the paver and 98% of the maximum wet density after final rolling. No compacted lift thickness shall be in excess of ten (10) inches or less than four (4) inches for single or multiple-lift applications unless demonstrated by the test strip. Co-ordinate RCC delivery so the mix can be spread and rolled within the specified time limit and to ensure uniform progress of the paver until the paving operation is complete. The time between mixing and compacting shall not exceed ninety (90) minutes, for all RCC placed, provided that the temperature of the RCC does not exceed 90 degrees (F).

Operate the paver in a manner that will prevent segregation and will produce a smooth continuous surface without tearing, pulling or shoving. If segregation occurs, suspend the paving operation until the cause is determined and corrected. Areas of segregated RCC shall be removed and replaced as specified in 1523.10.

Placing of the RCC mix shall be done in a pattern so that the water from previously placed RCC will not affect the fresh surface or sub-grade. Scarify all areas that require broadcasting or fanning of RCC. The surface must be scarified at least one inch deep prior to broadcasting fresh RCC over the top. Broadcasting must be completed in the allotted time within these specifications.

1523.07.04 **For multiple-lift placement,** the total pavement thickness shall be as specified on the plans. The second lift must be placed within sixty (60) minutes of the completion of the first lift. If more than sixty (60) minutes has elapsed, the interface between the first and second lifts shall be considered a cold joint and shall be prepared in accordance with

1523.08.04 Placement of the second lift must be delayed until the first lift has attained design strength as specified in 1523.05.

1523.07.05 **Compaction:** Achieve 85% of the maximum wet density, as determined in the laboratory according to ASTM D 1557, directly out of the paver and 98% of the maximum wet density after final rolling.

The contractor shall begin compaction operations within fifteen (15) minutes after spreading of the RCC mix. Any additional delay will result in the coring of the affected area at the Contractors expense to ensure that it meets the requirements of this specification.

1523.07.06 **Rolling:** The contractor shall establish a rolling pattern that will achieve the required density with a minimum number of roller passes. During vibratory compaction, the roller shall not be started, stopped, or left standing in vibratory mode. Stagger the stopping point of successive rolling passes to avoid forming depressions on the surface.

The contractor shall continually check the RCC surface while still plastic to ensure surface and grade tolerances are met. Immediately correct excessive variations in accordance with the spreading requirements. The contractor shall remove any roller marks on the surface using a steel drum roller in static mode. Each lane edge shall be constructed with a face within 15-degree of vertical.

The contractor shall spread RCC mix by hand in areas not accessible by the paver and compact to the requirements of 1523.06 and 1523.07.

1523.07.07 **Curing:** Keep the RCC surface continuously moist by water, fog spray, wet burlap, an approved membrane-forming curing compound applied at 1.5 times the rate specified by the manufacturer, or polyethylene sheeting for a period of seven (7) days or until the core strengths have meet the requirements of 1523.05.

1523.07.08 **Weather Limitation:** RCC shall not be placed on any surface containing frost or frozen material. RCC shall only be placed when the ambient temperature is a minimum of 35°F and rising, unless the procedures set forth in section 451.061 "Depositing and Curing Concrete During Cold Weather", of the CMSC, are strictly enforced. During periods of hot weather or windy conditions, special precautions shall be taken to minimize moisture loss due to evaporation. Precautions may include cooling of aggregate stockpiles by the use of a water spray, protective covers on dump trucks, temporary windbreaks to reduce wind velocity, cooling of concrete mix water, decreasing the allowable time between mixing and final compaction and keeping the surface of the newly placed

RCC pavement damp with a light spray during compaction and finishing operations.

Don't place RCC when rain is imminent. If rain occurs during placement of RCC cease all operation.

**1523.08 Joints:**

- 1523.08.01 **Fresh Vertical Joint:** A vertical joint shall be considered a fresh joint when an adjacent RCC lane is placed within 90 minutes of placing the previous lane. The contractor shall ensure that the contact face is moist and not segregated. Before rolling, the vertical joint surface should be hand-finish as necessary immediately behind the paver to produce a tight surface. When placing RCC with a fresh longitudinal joint, leave the outer 12 to 18 inches of the paving lane uncompacted during the initial rolling operation. The uncompacted edge is then used to set the height of the paver screed for paving the adjacent lane. After the adjacent lane is placed, the joint is compacted by centering the roller drum over the joint and compacting adjacent lane edges simultaneously. Roll extra passes as necessary to achieve the required density and smoothness in the joint area.
- 1523.08.02 **Cold Vertical Joint:** A cold vertical joint is made when either side of the joint is not compacted within 90 minutes of plant mixing. Saw cut the edge of previous lane back to sound RCC (minimum 6") to form a vertical face prior to placing the next pass. Trimming by grader blade is permitted, if done prior to the end of the workday. Prior to placing fresh RCC mixture against a compacted cold vertical joint, the joint shall be thoroughly cleaned of any loose or foreign material. The vertical joint face shall be wetted and a moist condition immediately prior to placement of the adjacent lane.
- 1523.08.03 **Fresh Horizontal Joint:** For multiple-lift applications, a horizontal joint is considered a fresh joint when a subsequent RCC lift is placed within sixty (60) minutes of placing the previous lift. The surface of the lower lift shall be kept clean and continually moistening the surface prior to placement of the subsequent lift.
- 1523.08.04 **Cold Horizontal Joint:** For multiple-lift applications, a horizontal joint is considered a cold joint when the placing of the subsequent RCC lift is delayed by more than sixty (60) minutes of placing the previous lift. Immediately prior to placing the second lift of RCC, a cement/sand slurry or grout shall be applied to the contact surface of the first lift. The contractor shall delay placing the second lift of RCC until the first lift attains design tensile strength as specified in 1523.05.

1523.08.05 **Contraction Joints:** Transverse and Longitudinal contraction joints shall be made as soon as possible after placement of RCC without damaging the pavement, according to City of Columbus Standard Drawing 2170 or as approved by the Engineer, except that transverse joints shall be spaced at a maximum of 30 foot intervals, or at intervals directed by the Engineer. All pavements shall have at least one center longitudinal contraction joint.

1523.09 **Quality Control and Assurance:** The contractor shall maintain equipment and qualified personnel required to determine the magnitude of the various properties of RCC governed by the specifications. These properties shall be maintained within the limits of this specification. The contractor shall notify the engineer a minimum of 24 hours prior to start of RCC paving.

Testing at the plant and the paving site is the responsibility of the Contractor or Developer and shall be performed by a private Independent Testing Laboratory approved by the City. The Contractor and Supplier shall provide safe and convenient access, acceptable to the Engineer, for the inspection and sampling of the RCC and constituent materials, at both the production plant and the paving site and shall cooperate in the inspection and sampling process at all times.

1523.09.01 **Test Strip:** The contractor shall construct a test section for every project of a thickness equal to the plan thickness and planned construction width with at least 100 tons of RCC. The same equipment proposed for use on the project shall be used for the test strip. The test strip will be used to resolve anticipated problems with equipment, mix behavior, compaction and/or strength characteristics. The test strip shall be constructed at a location chosen by the contractor at least 45 days prior to the start of paving operations. The Contractor must also demonstrate the ability to achieve a smooth, hard, uniform surface free of excessive tears, ridges, spalls and loose material. Also, achieve 85% of the maximum wet density in accordance with ASTM D 1557, directly out of the paver and 98% of the maximum wet density after final rolling. During construction of the test section, the Contractor shall establish an optimum rolling pattern and procedure for obtaining a density of not less than 98% of the maximum wet density. After completion of the test strip, cores will be extracted to verify mix compliance. This will be performed by the Contractor's Independent Testing Laboratory, at the expense of the Contractor. During the trial placement, the City's Testing Personnel shall calibrate their nuclear density gauges in accordance with ASTM C 1040, with a sample of the test section mix. Moisture readings of the gauge shall be calibrated using oven dry samples of the plant-mixed RCC. The contractor shall not commence placement of RCC until all testing has been completed and the City has verified the results are acceptable.

1523.09.02 **Pre-placement:** The Contractor's Independent Testing Laboratory will develop a moisture/density relationship of the actual job materials in accordance with ASTM D 1557. Optimum moisture content and maximum wet densities shall be established and copies of the moisture-density curves shall be provided to the City prior to any RCC placement.

1523.09.03 **During Placement:** The Contractor shall ensure quality control at the plant, by controlling materials, obtaining test samples and ensuring segregation is not occurring while loading haul trucks. The Contractor, in cooperation with the Contractor's Independent Testing Laboratory, shall ensure that compaction and grade specifications are met and time limits are adhered to.

1523.09.04 **Field Density:** The City's Testing Laboratory shall perform density testing of the RCC in accordance with ASTM C 1040, direct transmission mode, directly behind the paver. Only wet density shall be used for evaluation. At least five (5) tests shall be performed at the back of the paver and after final compaction for each 250 cubic yards placed. The required density shall be as specified in 1523.07.05 out of the back of the paver and after final rolling as specified in 1523.07.05. The Contractor shall be responsible for verifying required densities are achieved by the paver and after final rolling.

If density test results do not meet the requirements of 1523.07.05, the Contractor shall determine the source of the problem and take immediate steps to correct the problem. If the problem cannot be resolved to the satisfaction of the Engineer, placement shall be suspended.

1523.09.05 **After Placement:** The City's Testing Laboratory shall core at least nine (9) cylindrical specimens from each Pavement Area. Pavement Area is defined as four thousand (4,000) square yards or each day's placement, whichever is less. Length measurements of the cores and compressive strength testing shall be in accordance with ASTM C 42. Splitting tensile testing shall be in accordance with ASTM C 496.

Testing shall be conducted as follows:

**Compressive Strength Testing:** Six (6) of the cores obtained for thickness verification will be tested for compressive strength at 28 days.

**Splitting Tensile Strength:** Three (3) of the cores obtained for thickness verification will be tested for splitting tensile strength at seven (7) days.

All cores tested shall meet the requirements of 1523.05 and 1523.10 or the section of RCC represented by the cores shall be subject to pay adjustment or removal according to 1523.11.

## 1523.10 Pavement Thickness and Strength

The contractor shall construct the RCC pavement not more than 0.2 inch less than the specified plan thickness, as determined by measurement of cores cut as specified in 1523.09.05. If any core shows a deficiency in thickness of more than  $\frac{1}{2}$  inch from the specified plan thickness, take additional cores to determine the limits of the deficiency. Follow the procedures below:

1. Take a core five (5) feet longitudinally on both sides of the deficient core. If both the cores are less than  $\frac{1}{2}$  inch deficient in thickness the zone of deficiency has been determined.
2. If either or both cores taken in #1 above are more than  $\frac{1}{2}$  inch deficient in thickness, cut a core 50 feet longitudinally from the deficient core(s). If the 50 foot core(s) is more than  $\frac{1}{2}$  inch deficient, cut additional cores at 100 foot longitudinal intervals until a core less than  $\frac{1}{2}$  inch deficient is obtained; until the pavement ends; or until overlapping an adjacent pavement area's core in the same lane.
3. If a pavement area has cores more than  $\frac{1}{2}$  inch deficient in thickness and the pavement area's constructed width is greater than 12 feet, obtain cores transverse to the location of the more than  $\frac{1}{2}$  inch deficient cores. Obtain transverse cores at a location half the distance from the deficient core to the furthest edge of pavement. Obtain a transverse core for each core more than  $\frac{1}{2}$  inch deficient.
4. The Engineer will use the cores that measure less than  $\frac{1}{2}$  inch deficient in thickness to define the limits of the deficiency.

If any core shows a deficiency in thickness of more than 1 inch or compressive strength less than 85% of the compressive strength mix design cited above, determine the extent limits of deficiency by following steps 1 through 4 above. Remove and replace those areas greater than 1 inch deficient in thickness and/or less than 85% of the mix design compressive strength.

The Engineer will calculate average thickness and compressive strength of concrete pavement placed as follows:

1. When zones of deficient thickness greater than  $\frac{1}{2}$  inch to 1 inch are allowed to remain in place, the Engineer will calculate two average thicknesses. A Project Average Thickness (PAT) including all cores not more than  $\frac{1}{2}$  inch deficient. Cores that exceed the specified thickness by more than  $\frac{1}{2}$  inch will be considered as the specified thickness plus  $\frac{1}{2}$  inch when calculating the PAT. A second Deficient Zone Average (DZA) will

include all cores with thickness deficiency greater than ½ inch to 1 inch. The pavement represented by each of the two averages, PAT or DZA, will be calculated and paid separately.

2. Determine and apply deductions for thickness deficiency to each separately placed width of pavement.

3. For any pavement areas removed and replaced, re-core those areas replaced following this section of the specifications. Include those core values into the calculations for average pavement thickness and strength.

4. Calculate the compressive strength deficiency area by following the steps cited above for thickness items but substituting “the 0.5 inch thickness deficiency with 90% compressive strength” and the “1.0 inch thickness deficiency” with “less than 85% compressive strength.”

**Remedial Actions:** Correct deficiencies while RCC is still plastic; otherwise do repairs after seven (7) days. After seven (7) days, the RCC shall be removed by saw cutting full depth before removal. Replace the RCC utilizing a Cast-in-Place concrete meeting the requirements of section 499; Class E Concrete as directed by the Engineer. The new concrete shall be doveled into the existing RCC utilizing epoxy coated reinforcing bars according to section 451 of the CMSC.

Any RCC pavement found to be of unacceptable thickness, or deficient in any testing done in accordance with this specification, shall be subject to removal and replacement by the contractor, at no cost to the City, including removal and replacement of any intermediate and surface asphalt courses.

Grind off high surface variations to a finish acceptable to the Engineer.

Filling of low areas with fresh RCC is not permitted.

If asphalt surfacing is specified, low areas accepted by the Engineer shall be made up with additional surfacing material without extra payment. All repairs are subject to the Engineers approval.

## 1523.11 Price Adjustments

### 1523.11.1 Thickness deficiencies:

Based on the pavement average thickness payment will be made as specified in Table 1523-11.1.

<b>Deficiency in Thickness as Determined by Cores</b>	<b>Proportional Part of Contract Price to be Paid</b>
0.0 to .2 inch	100 percent
0.3 to 0.5 inch	Ratio $\left[ \frac{PAT}{PST} \right]^6$
0.6 to 1.0 inch	Ratio $\left[ \frac{DZA}{PST} \right]^6$
Greater than 1.0 inch+	Remove and replace

1523.11.2 **Compressive strength Deficiency:** Where the average strength of a pavement area, as defined in 1523.05, is less the specified strength, but greater than or equal to 90% of the specified strength, payment will be made according to Table 1523.11.2 below.

**Table 1523.11.2**

<b>Percent of Mix Design Strength*</b>	<b>Payment Deduction Factor</b>
95%- 100%	0%
90% - 95%	10%
85% - 90%	20%
Less than 85%	Remove & Replace

\* See Section 1523.05

The Engineer will determine whether deficient pavement areas from 0.6 up to 1 inch in thickness and/or 85% to 90% of the design compressive strength will be allowed to remain in place at the reduced price or must be removed and replaced.

PAT = Project Average Thickness

PST = Plan Specified Thickness

DZA = Deficient Zone Average

In the case of a pavement area having deficiencies in thickness and strength, the greater of the two deductions shall be applied to the payment for this work.

**1523.12 Opening to Traffic**

The RCC pavement may be opened to traffic or asphalt surfaced as specified on the plans a minimum of seven (7) days after placement or once the strength requirements of section 1523.05 have been met.

**1523.13 Warranty**

Pavement constructed according to this specification shall be guaranteed by the developer/contractor for a period not less than two (2) years from date of acceptance of the street by the City. The contractor shall sign the warranty agreement attached to this specification.

**1523.14 Basis of Payment**

1523.14 .1 The accepted quantities of RCC pavement will be paid for at the contract unit price per square yard (*square meter*), which price and payment shall be full compensation for furnishing and placing all materials including reinforcing steel, dowels, and joint materials. The City will pay a reduced price, according to section 1523.11, for RCC pavement found deficient in thickness and/or strength.

1523.14 .2 No additional payment over the unit contract bid price will be made for any pavement which has an average thickness in excess of that shown on the plans.

1523.14 .3 Payment for accepted quantities, complete in place, will be paid for at the contract price for item Supplemental Specification 1523.

<b>Item</b>	<b>Unit</b>	<b>Description</b>
1523	Square Yard ( <i>Square Meter</i> )	Roller Compacted Concrete