SECTION 502—ROLLER COMPACTED CONCRETE PAVEMENTS

502.1 DESCRIPTION—This work is the construction of roller compacted concrete (RCC) pavement as indicated, on a prepared subgrade and subbase, using a stiffer low slump concrete mix, conventional or high-density asphalt paving equipment, and various size rollers to obtain the required thickness, density, and surface texture.

502.2 MATERIAL—

(a) Cement. Section 701

(b) Pozzolans. Section 724

(c) Aggregate. Section 703, except use well-graded aggregate that conform to the following Table A:

TABLE A
Aggregate Gradation Requirements for RCC Material

	Percent Passing by Weight Based on Maximum Nominal Aggregate Size		
	Wearing Surface		Base Course
Sieve Size	Gradation A	Gradation B	Gradation C
1" (25 mm)	100	100	82 – 100
3/4" (19 mm)	100	87 – 100	72 – 91
1/2" (12.5 mm)	81 – 100	71 – 91	61 – 81
3/8" (9.5 mm)	71 – 91	60 – 85	50 – 71
No. 4 (4.75 mm)	49 – 70	42 – 63	36 – 55
No. 8 (2.36 mm)	33 – 54	30 – 49.5	23 – 42
No. 16 (1.18 mm)	24 – 40	18 – 36	15 – 32
No. 30 (0.60 mm)	12 – 28	11.5 – 27.5	8 – 22
No. 50 (0.30 mm)	7.5 – 22	5 – 19	4.5 – 17
No. 100 (0.15 mm)	3 – 16	1 – 13	1 – 12
No. 200 (0.75mm)	0 – 10	0 – 9	0 – 8

(d) Water. Section 720.1

(e) Admixtures. Section 711.3

(f) Concrete Curing Material. Section 711.1 and Section 711.2,

(g) RCC Mixture.

1. Mix Design. According to Section 704.1(c), except 704.1(c)3. and add the following: Use the same mix design and materials for the entire project. Optimize moisture content of mix according to AASHTO T 180, Method D. Any material change requires submission of a new mix design.

2. Mix Duration. Assure complete and uniform mixing. Do not exceed the manufacturer's rated volume capacity for dry concrete in the mixing chamber. Keep the sides of the mixer and mixer blade surfaces free of hardened concrete and other materials. Check mixer blades frequently for wear and replace if wear is sufficient to cause inadequate mixing.

3. Mix Ingredient Tolerances. Produce RCC according to tolerances set in Section 704.1(e). Supply daily plant records of production and quantities of materials used that day to the Representative. These records will be used as a check on plant calibration.

502.3 CONSTRUCTION—

(a) General Requirements.

1. Field Operation QC Plan. Prepare a paving operation QC Plan, as specified in Section 704.1(d)1.a, for field control and evaluation of concrete paving operations for the Representative's review. Do not start paving until after the Representative reviews the QC Plan.

2. Concrete Technician. Provide a concrete technician as specified in Section 704.1(d)2 and a concrete field testing technician as specified in Section 704.1(d)2.a.

(b) Test Section. Construct a minimum 50-foot long test section of the RCC Material. Size the test section using the plan thickness by plan width. Use the proposed equipment for the project. Use placement to verify: the plant can produce a consistent mix and resolve any mix design issues; determine if the equipment will achieve the proper placement; establish the best combination of rollers to achieve thickness and best surface conditions; review testing procedure of field density acceptance testing; establish curing procedures and determine compressive strength. Place the test section within the RCC plan location as a portion of the pay item.

(c) Weather Restrictions. If work is halted because of weather conditions, the Representative may allow the Contractor to place limited quantities of RCC mixture that are en-route to the project. Do not place RCC pavement during a hard rain that may damage the pavement surface. Placement may continue during a light rain or mist as determined by the Representative as long as the RCC pavement surface is not damaged.

1. Cold Weather. Unless otherwise approved in writing, discontinue RCC placement when the descending air temperature, away from artificial heat, falls to 40F. Do not resume paving until the air temperature, away from artificial heat, rises above 40F.

2. Hot Weather. When the air temperature in the immediate vicinity of RCC placement rises to 85F, take temperature readings of the plastic RCC mixture, at 1/2-hour intervals and at the conclusion of the mixing cycles. Discontinue RCC placement if the RCC mixture temperature exceeds 90F after mixing. When the RCC mixture temperature has risen to 90F, cool the mixing water or aggregates to maintain a plastic RCC mixture temperature within 50F to 90F during placement.

3. Environmental Conditions. Precautions to reduce surface moisture loss are needed when the evaporation rate exceeds 0.20 pounds per square foot per hour. Determine rate of evaporation using a weather station or the individual measurements of air temperature, relative humidity, concrete temperature, wind speed and the NRMCA chart in ACI 305R-10. Minimize moisture loss by one or more of the following methods: adding retarding admixtures to the mix, reducing time between mixing and final compaction, using covers on the haul trucks, using temporary windbreaks or fogging and misting the RCC pavement surface.

(d) Equipment. Have all equipment on hand and approved by the Representative before work can proceed. Comply with, but is not limited to, the following:

1. Mixing Plant. Produce an RCC pavement mixture in the proportions defined by the approved mix design and within the specified tolerances. The plant must be able to produce a uniform mixture at a rate compatible with the placement equipment.

1.a Batch Type Plant. Meet the requirements as specified in Section 704.2 and 704.3.

2.a Continuous Mix Plant. Meet the requirements of AASHTO M 241.

2. Haul Trucks. Provide a sufficient number of trucks to ensure a continuous supply of RCC mixture to the paver. Equip haul trucks with covers to protect the RCC mixture during transit from inclement weather and to reduce surface moisture loss. Use clean trucks with no buildup of hardened or foreign material.

3. Paver. Use a paver of suitable weight and stability to spread and finish the RCC mixture without segregation, to the required thickness, smoothness, surface texture, cross-section, and grade. Do not use pavers that tear, shove, or gouge the mixture or that cause tracks, indented areas, segregation, or other permanent surface blemishes.

For single lift placement less than 6 inches, use either a conventional paver or a high-density paver equipped with compaction devices capable of producing RCC pavement with a minimum compaction of 85% of the maximum wet density prior to using rollers. For single lift placement greater than or equal to 6 inches but less than 9 inches use a high-density paver equipped with compaction devices capable of producing a minimum compaction of 90% of the maximum wet density prior to using rollers.

For multiple-lift placement, use either a conventional paver or a high-density paver equipped with compaction devices capable of producing RCC pavement with a minimum compaction of 85% of the maximum wet density in each lift prior to using rollers.

For areas inaccessible to pavers, submit alternate paving equipment for approval by the Representative.

4. Compactors. Use rollers conforming to Section 108.05(c)3.

If a minimum 95% field density is not achieved with the paver, use a self-propelled smooth dual steel drum roller operating in static or vibratory mode having a minimum weight of 8 tons to achieve primary compaction before final compaction. Increased weight may be needed for thicker lifts. Use either a steel drum roller, operating in static mode; or a rubber-tired roller, or a combination of rollers for final compaction, surface finishing, and removal of equipment marks.

If a minimum 95% field density is achieved with the paver, use either a steel drum roller, operating in static mode; or a rubber-tired roller, or a combination of rollers for final compaction, surface finishing, and removal of equipment marks.

Use walk-behind vibratory rollers or vibratory plate tampers, for compacting areas inaccessible to large rollers.

5. Water Trucks. Have at least one water truck on site and available throughout the paving and curing process. Equip the water truck with a water distribution system containing fog nozzles capable of evenly applying a fine mist of water to the RCC pavement surface without damaging the final surface.

(e) Preparation of Base Course. Before placing the RCC, prepare the subgrade/subbase as required by the Plans and Specifications.

(f) Transporting RCC Mixture. Use haul trucks to transport the RCC mixture from the plant to paver. Deposit the RCC mixture directly into the hopper of the paver or into a secondary distribution system, which deposits the material into the paver hopper. Discharge the trucks clean with no buildup or hanging of RCC mixture in the corners.

(g) Placing RCC Material. Use an RCC mixture that is within the temperature range of 50F to 90F. Do not use RCC material containing frost, lumps, or crusts of hardened materials. If needed, adjust moisture content of mix for paving equipment selected for placement. Place RCC pavement in a pattern so that the curing water from the previous placements do not pose a potential surface erosion or runoff problem on the fresh RCC surface or on the subbase layer.

1. Subgrade/Subbase Condition. Provide a subgrade/subbase surface that is clean and free of foreign material, ponded water and frost or frozen material prior to RCC placement. Do not place RCC pavement on frozen base, subbase, or subgrade. At the time of RCC placement, uniformly moisten the subgrade/subbase. If the subbase becomes dry, uniformly water, without forming mud or pools of freestanding water.

2. RCC Placement. Adjust the paver and regulate the speed to prevent segregation and provide a surface course that is smooth, continuous without tears, and pulling. Limit the spread of the RCC material to a length that can be compacted and finished within the available period under the prevailing air temperature, wind, and climatic conditions. Proceed in a steady, continuous operation with minimal starts and stops. Regulate speed to assure a constant supply of RCC material in the hopper. Maintain RCC material above the auger shaft at all times during paving.

3. Lift Thickness. Minimum lift thickness is 4 inches. Construct pavements between 4 inches and less than or equal to 9 inches in single lifts. Construct pavements greater than 9 inches in multiple lifts of equal thickness, to achieve density requirements.

4. Multiple-Lift Placement. Place the second lift within 60 minutes of the completion of the first lift. If more than 60 minutes has elapsed, the interface between the first and second lift shall be considered a cold joint. Prepare

the cold joint according to Section 502.3(i)2. At the discretion of the Representative, this time limit may be increased or decreased depending on the use of retarding admixtures or the ambient weather conditions of temperature, wind, and humidity. Multiple pavers in tandem formation may be used to reduce the opportunity for cold joints to develop.

5. Adjacent Lane Placement. Place adjacent paving lanes within 60 minutes. If more than 60 minutes has elapsed between placements of adjacent lanes, the vertical joint is considered a cold joint. Prepare the cold joint according to Section 502.3(i)2. At the discretion of the Representative, this time may be increased or decreased depending on the use of retarding admixtures or the ambient weather conditions of temperature, wind, and humidity.

(h) Compaction. Allow for in-field density readings and then begin compaction of the RCC material behind the paver. Perform field density readings with the Representative present. Plan operations and supply sufficient rollers to minimize cold joints. Determine the sequence and number of passes by vibratory and non-vibratory rolling to achieve the density acceptance requirements and to achieve a surface finish without uneven roller marks. Operation of rollers in the vibratory mode while stopped or reversing-direction is not allowed. Use a steel drum roller, operating in static mode; a rubber-tired roller or a combination of rollers for final compaction, surface finishing, and removal of equipment marks.

1. Rolling RCC Material at Longitudinal and Transverse Joints. Do not operate rollers within 12 to 18 inches of the freshly placed lane edge until the adjacent lane is placed. Within the allowable time, roll together both edges of the two adjacent lanes. If the lane edge will not have an adjacent lane or if the lane edge is the outside pavement edge, the lane may be placed wider to achieve compaction for the required width with the additional RCC pavement material cutoff after density acceptance. As an alternative to saw cutting, use an edge shoe on the paver. The shoe should have an angle of 15 to 30 degrees and should compact the edge as required. When a cold joint is planned, roll the complete lane and follow cold joint procedures as specified in Section 502.3(i)2.

Provide additional rolling for longitudinal joints with a vibratory roller as necessary to produce the specified density for the full depth of the lift and provide a tight smooth transition across the joint. Remove any uneven marks left during the vibratory rolling utilizing a static or rubber-tired roller. Roll until a smooth, flat surface, free of tearing and cracking is obtained. Avoid deformation of the RCC pavement, by operating the rollers at slow enough speeds at all times. Correct any deformations of the RCC pavement resulting from reverse direction of the roller or from any other causes.

2. Density Requirements. Perform in-place field density tests according to ASTM C 1040, Test Method A-Direct Transmission, as soon as possible, and no later than 30 minutes after completion of rolling. Use only the wet density reading for this test requirement. If the testing equipment does not calculate the compaction percentage, calculate the compaction percentage using the following equation.

$$X = \frac{\rho_w}{\rho_t} \times 100$$

X = Compaction percentage %
ρ_w = Recorded density in pounds per cubic foot
ρ_t = Computed RCC unit weight in pounds per cubic foot as provided on the project CS-4220 Batcher-Mixer Slip

Determine field density test locations using PTM No. 1. Perform at least five tests directly behind the paver and at least five tests after final compaction for each 500 cubic yards of RCC material placed. Determine the compaction percentage with the testing equipment or by calculation.

Directly behind the paver, achieve a minimum compaction of 85% of the maximum wet density for thicknesses less than 6 inches, and 90% of the maximum wet density for thicknesses greater than or equal to 6 inches.

After final rolling, achieve a minimum compaction greater than 96% of the maximum wet density for all thicknesses. Record compaction percentages after final rolling for determining density acceptance in Section 502.3(m)2.

(i) Joints.

1. Fresh Joints. A fresh joint is a vertical joint between lanes or a horizontal joint between multiple-lifts where the adjacent RCC material is placed within 60 minutes of placing the previous lane or lift. The time limit may be adjusted by the Representative depending on the use of retarders in the RCC mixture or ambient weather conditions.

Construct fresh vertical joints to assure a continuous bond between new and previously placed lanes of RCC pavement.

For fresh horizontal joints, maintain a moist surface to prevent excess moisture loss. Prior to placement of the second lift, clean all loose material from the surface.

2. Cold Joints. A cold joint is any planned or unplanned longitudinal or transverse construction vertical joint or any horizontal joint between multiple lifts in the RCC pavement that does not qualify as a fresh joint.

Before placement of an adjacent RCC lane, prepare the cold vertical joint as follows: Cut the pavement vertically for the full depth in sound compacted material, at least 6 inches from the exposed edge. Use an approved saw, wheel cutter, or other method that does not tear or ravel the vertical edge. Remove the excess RCC material. Clean the joint of any loose or foreign material. Moisten the vertical face of the cold joint immediately prior to placement of the fresh adjacent lane to prevent excess loss of moisture.

Cold vertical joints that are constructed utilizing a drop extension or edging shoe are exempt from the above cutting requirement when placed up to 15 degrees from vertical.

For cold horizontal joints, maintain a moist surface to prevent excess moisture loss. Prior to placement of the second lift, clean all loose material from surface and, if required by the Plans, place cement slurry or mortar grout (made with the same materials as in the RCC mixture) on the cold horizontal joint.

3. Control Joints. Saw cut control joints, as indicated on the Plans, to 1/4 depth of the compacted RCC pavement. Saw cut pavement, behind the rolling operation as soon as possible to prevent random cracking, using early entry saws set to the manufacturer's recommendations. Saw cut without causing raveling or other damage to the pavement; begin sawing no later than 18 hours after placement. If random cracking occurs in the pavement before the saw cutting operation repair cracks as directed by the Representative at no expense to the Department.

4. Sealing Joints. If indicated, seal joints as specified in Section 501.3(n).

(j) Curing. Immediately after final rolling and in-field density testing, keep the RCC pavement surface moist until one or more of the following curing methods are used. Maintain the selected curing method(s) for a minimum of 72 hours and the RCC pavement has developed a compressive strength of at least 3,000 pounds per square inch, determine compressive strength as specified in Section 502.3(m)3.

1. Water Cure. Apply water cure using a water truck equipped with misting spray nozzles, soaking hoses, sprinkler system or other means to maintain a uniform moist condition on the RCC pavement surface. Apply moisture in a manner that does not wash out or damage the surface of the finished RCC pavement.

2. White Polyethylene Sheeting. Apply sheet material as specified in Section 711.1.

3. Curing Compound. Apply curing compound, as specified in Section 711.2, according to the manufacturer's application rate in two uniform coats. Apply the two coats either by overlapping transversely 50% or by spraying perpendicular to each other. Provide a uniform void-free application across the entire RCC pavement surface. Reapply curing compound to saw cuts and disturbed areas.

4. Cold Weather Curing. If the forecasted air temperature during concrete curing is expected to fall below 40F, place thermometers or other temperature measuring devices on the concrete surface and monitor concrete curing temperatures. Protect the RCC pavement surface and sides to maintain a temperature of not less than 40F during the cure period. If at any time during the cure period the temperature readings fall between 40F and 35F, extend the cure period by an additional day. If at any time during the curing period the temperature readings fall below 35F, the RCC pavement will be considered defective.

(k) Surface Tolerance.

1. Testing. Test the finished RCC pavement surface with a 10-foot straight edge or crown surface template at areas the Representative determines may be deficient or irregular. Hold the straightedge in contact with the surface

and in successive positions parallel to the road centerline to check the entire width of the pavement. Advance along the pavement in stages of not more than 5 feet a stage until the entire area is tested.

2. Correction. When the pavement surface varies by more than 1/4 inch, remove high points by grinding the surface to within the tolerance; use a self-propelled diamond grinder or cutting tools at no expense to the Department. The Representative will consider depressions in the pavement surface of more than 1/4 inch to be defective. Continue straightedge testing and surface corrections until the entire surface is free from observable departures from the straightedge and until the slab conforms to the required grade and cross-section.

3. Finishing. For RCC pavement with an exposed pavement surface and a speed limit of 35 miles per hour or greater, texture the pavement surface by diamond grinding as specified in Section 514.3(c).

(l) Open to Traffic. Protect the RCC pavement from vehicular traffic for the duration of the curing period. Open to traffic when the cure period is complete as specified in Section 502.3(j).

(m) Acceptance.

1. Lots and Sublots. Material will be accepted on a lot by lot basis. Lots will be established cumulatively and will be specific for each mix design. Each lot consists of five equal sublots (n=5). Test completed lots and sublots for density, compressive strength, and pavement thickness.

A normal lot size is 500 cubic yards. If breakdowns or stoppages of short periods due to such causes as weather or equipment failure occur, the lot's size is the quantity placed for that day.

2. Density. Determine density acceptance using the recorded compaction percentages after rolling in Section 502.3(h)2. The final average for each lot cannot be less than 98% of the maximum wet density and no test less than 96% of the maximum wet density. Properly placed and compacted RCC material not meeting these requirements should be cored and tested for compressive strength at 28 days according to AASHTO T 24 at no expense to the Department. Fill core holes with RCC material. If the tested area has achieved the minimum compressive strength of 3,500 pounds per square inch, the RCC material will be paid for at full price and left in place. If the lot does not meet the maximum wet density and the compressive strength requirements, the pavement is considered defective.

3. Compressive Strength. Mold and test cylinders according to ASTM C 1435 and AASHTO T 22 to determine the 3-day, 7-day, and 28-day compressive strengths for each lot of RCC material.

Test the 3-day test cylinders to determine the compressive strength for the lot. If the 3-day compressive strength test result is greater than or equal to 3,000 pounds per square inch, the field cure on the lot of RCC pavement represented by the test cylinders may be discontinued unless otherwise directed. If the 3-day test cylinders do not meet the minimum value, continue curing the lot until the 7-day test cylinders are tested for verification. Test the 7-day test cylinders for compressive strength. If the 7-day compressive strength test result is greater than or equal to 3,000 pounds per square inch, the field cure on the lot of RCC pavement represented by the test cylinders may be discontinued unless otherwise directed. If the 7-day test cylinders do not meet the minimum value, continue curing the lot until the 28-day test cylinders are tested for verification.

Test the 28-day test cylinders to verify the RCC pavement has achieved a minimum compressive strength of 3,500 pounds per square inch. RCC pavement that fails to meet the 28-day compressive strength requirement is considered defective. Any cores taken for pavement depth measurements may be used for compressive strength testing if needed.

4. Pavement Depth. Using PTM No. 1, the Representative will designate one location within a lot to be tested for depth. For each lot, drill one core according to AASHTO T 24 in the presence of the Representative. Provide a measuring apparatus conforming to PTM No. 614 for the Representative to measure the core depth according to PTM No. 614. If the measured depth is within 1/4 inch of plan depth, the RCC pavement is acceptable. If the depth is deficient by more than 1/4 inch, core two additional cores in the presence of the Representative for measurement. If the average depth of the three cores is less than a 1/4 inch deficient, the pavement depth is acceptable. If the average depth is greater than 1/4 inch, the pavement depth is defective. Fill core holes with RCC material.

(n) Defective Work. Unless otherwise directed in writing by the District Executive, remove and replace pavement lots that are: defective during curing as specified in Section 502.3(j)4, defective in surface tolerance, as specified in

Section 502.3(k)2, defective in density as specified in Section 502.3(m)2, defective in compressive strength as specified in Section 502.3(m)3, or defective in depth as specified in Section 502.3(m)4.

502.4 MEASUREMENT AND PAYMENT—

(a) Roller Compacted Concrete Pavement. Square Yard

(b) Defective Pavement Left in Place. When the District Executive directs in writing to leave defective pavement in place, the payment will be at 5% of the contract price.