PAVEMENTS

Guide Specification for Construction of Roller-Compacted Concrete Pavements

JUNE 2004

1. General Provisions

1.1 Description. Roller-Compacted Concrete (RCC) shall consist of aggregate, portland cement, possibly other supplementary cementing materials (fly ash, slag and silica fume) and water. RCC shall be proportioned, mixed, placed, compacted and cured in accordance with these specifications; and conform to the lines, grades, thickness, and typical cross sections shown in the Plans or otherwise established by the Engineer.

1.2 Caveat. This specification is intended to serve as a guide to format and content for normal RCC pavement construction. Most projects have features or requirements that should be incorporated in the project documents.

2. Referenced Documents

2.1 American Society for Testing and Materials (ASTM):

C 31 Practice for Making and Curing Concrete Test Specimens in the Field

C 33 Specification for Concrete Aggregates

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens

C 42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C 78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

C 150 Specification for Portland Cement

C 171 Specification for Sheet Materials for Curing Concrete

C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C 494 Specification for Chemical Admixtures for Concrete

C 496 Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

C 595 Specification for Blended Hydraulic Cements

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete

C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

C 1040 Test Methods for Density of Unhardened and Hardened Concrete In Place by Nuclear Methods

C 1157 Performance Specification for Hydraulic Cement

C 1176 Practice for Making Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Table

C 1240 Specification for Use of Silica Fume as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar and Grout

C 1435 Practice for Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer

D 977 Specification for Emulsified Asphalt

D 1557 Test Methods for laboratory Compaction Characteristics of Soil Using Modified Effort

3. Submittals

3.1 Submittal Requirements. The Contractor shall submit the following to the Engineer at least 30 days before start of any production of RCC pavement:

3.1.1 Construction schedule for all RCC related operations.

3.1.2 Paving procedures describing direction of paving operations, paving widths, planned longitudinal and transverse cold joints, and curing methods and patterns.

3.1.3 Certification for aggregate source, quality and sizing as required by the specification.

3.1.4 Certification for portland cement and supplementary cementitious materials as required by the specification.

3.1.5 Manufacturers data and specifications including capacities for equipment to be used in mixing, hauling, placing and compacting RCC.

3.1.6 Layout of plant location showing mixing plant, cement and aggregate storage, and water supply.

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3.1.7 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 four weeks prior to RCC construction. This mix design shall include details on aggregate gradation, cementitious materials, admixtures (if used), compressive and/or flexural strengths, and required moisture and density to be achieved.

4. Materials

4.1 General. All materials to be used for RCC pavement construction shall be approved by the Engineer based on laboratory tests or certifications of representative materials which will be used in the actual construction.

4.2 Portland Cement. Cement shall comply with the latest specifications for portland cement (ASTM C 150 and ASTM C 1157), or blended hydraulic cements (ASTM C 595 and ASTM C 1157)

4.3 Aggregates. Unless otherwise approved in writing by the Engineer, the quality of aggregates shall conform to ASTM C 33. The plasticity index of the aggregate shall not exceed five. Aggregates may be obtained from a single source or borrow pit, or may be a blend of coarse and fine aggregate. The aggregate shall be well-graded without gradation gaps and conform to the following gradation:

Sieve Size	Percent passing by weight
1" (25 mm)	100
3/4" (19 mm)	90-100
1/2" (12.5 mm)	70-90
3/8" (9.5 mm)	60-85
No. 4 (4.75 mm)	40-60
No. 16 (1.18 mm)	20-40
No. 100 (150 µm)	6-18
No. 200 (75 µm)	2-8

4.4 Mineral Admixtures. Mineral admixtures shall conform to the requirements of ASTM C 618 (flyash), ASTM C 989 (slag) and ASTM C 1240 (silica fume). Unless specifically directed by the Engineer, total mineral admixture content including the content in blended cements shall not exceed the weight of portland cement in the RCC mix.

4.5 Chemical Admixtures. Chemical admixtures including water-reducing and retarding admixtures shall conform to ASTM C 494 and must be approved by the Engineer prior to use.

4.6 Water. Water shall be clean, clear and free of acids, salts, alkalis or organic materials that may be injurious to the quality of the concrete. Non-potable water may be considered as a source for part or all of the water, providing the mix design indicates proof that the use of such water will not have any deleterious effect on the strength and durability properties of the RCC.

4.7 Curing Compound. Concrete curing compounds shall conform to ASTM C 309 or ASTM D 977.

5. Equipment

5.1 General. All necessary equipment shall be on hand and approved by the Engineer before work will be permitted. Roller-compacted concrete shall be constructed with any combination of equipment that will produce a completed pavement meeting the requirements for mixing, transporting, placing, compacting, finishing, and curing as provided in this specification.

5.2 Mixing Plant.

5.2.1 Location of Plant. The mixing plant shall be located within a 30 minute haul time from the RCC placement. With prior testing and Engineer's approval, a set retarding admixture may be used to extend the haul time.

5.2.2 Plant Capacity. The plant shall be capable of producing an RCC mixture in the proportions defined by the final approved mix design and within the specified tolerances. The capacity of the plant shall be sufficient to produce a uniform mixture at a rate compatible with the placement equipment. The volume of RCC material in the mixing chamber shall not be more than the rated capacity for dry concrete mixtures.[1] Multiple plants shall be supplied if a single plant can not provide an uninterrupted supply of RCC to the paver(s) during peak paving operations.

5.2.3 Pugmill Plant. A pugmill plant shall be a central plant with a twin shaft pugmill mixer, capable of batch or continuous mixing, equipped with synchronized metering devices and feeders to maintain the correct proportions of aggregate, cement, mineral admixture and water. Other pugmill plant requirements are as follows:

5.2.3.1 Aggregate Storage. If previously blended aggregate is furnished, storage may be in a stockpile from which it is fed directly to a conveyor feeding the mixer. If aggregate is furnished in two or more size groups, aggregate separation must be provided at the stockpiles.

5.2.3.2 Aggregate bins shall have a feed rate controlled by a variable speed belt, or an operable gate calibrated to accurately deliver any specified quantity of material. If two or more aggregate size stockpile sources are used, the feed rate from each bin shall be readily adjustable to change aggregate proportions, when required. Feed rate controls must maintain the established proportions of aggregate from each stockpile bin when the combined aggregate delivery is increased or decreased.

5.2.3.3 Plant Scales. Plant scales for any weigh box or hopper shall be either of beam or springless-dial type, and be sensitive to 0.5 per-

1. Because of the very dry consistency of RCC, the batch volume of mixed material especially for drum mixers may need to be less than the manufacture's rated capacity of the mixer for conventional concrete.

cent of the maximum load required. Beam-type scales shall have a separate beam for each aggregate size, with a single telltale actuated for each beam, and a tare beam for balancing hopper. Belt scales shall be of an approved design. Standard test weights accurate to plus or minus 0.1 percent shall be provided for checking plant scales.

5.2.3.4 Cement and Mineral Admixture Material Storage. Separate and independent storage silos shall be used for portland cement and mineral admixture. Each silo must be clearly identified to avoid confusion during silo loadings. If the Contractor chooses to preblend the cementitious material he must employ blending equipment acceptable to the Engineer and demonstrate, with a testing plan, the ability to successfully produce a uniform blended material meeting the mix design requirements. Testing of the preblended cementitious material shall be done on a daily basis to assure both uniformity and proper quantities.

5.2.3.5 Cement and Mineral Admixture Feed Unit. Satisfactory means of dispensing portland cement and mineral admixture, volumetrically or by weight, shall be provided to assure a uniform and accurate quantity of cementitious material enters the mixer.

5.2.3.6 Water Control Unit. Required amount of water for the approved mix shall be measured by weight or volume. The unit shall be equipped with an accurate metering device. The water flow shall be controlled by a meter, valve or other approved regulating device to maintain uniform moisture content in the mixture.

5.2.3.7 Surge Hopper. For continuous operating pugmills, a surge hopper attached to the end of the final discharge belt shall be provided to temporarily hold the RCC discharge to allow the plant to operate continuously.

5.2.4 Rotary Central-Mix Drum Plant. A rotary drum batch mixer shall be capable of producing a homogeneous mixture, uniform in color and having all coarse aggregate coated with cementitious paste. The mixer shall be equipped with batching equipment to meet the following requirements:

5.2.4.1 The amounts of cement, mineral admixture and aggregate entering into each batch of RCC shall be measured by direct weighing equipment. Weighing equipment shall be readily adjustable to compensate for the moisture content of the aggregate or for changing the proportionate batch weights, and shall include a visible dial or equally suitable device which will accurately register the scale load from zero to full capacity. The cement and mineral admixture may be weighed separately or cumulatively in the same hopper on the same scale, provided the cement is weighed first.

5.2.4.2 Bulk cement and mineral admixture weigh hoppers shall be equipped with vibrators to operate automatically and continuously while weighing hoppers are being dumped. The weigh hopper shall have sufficient capacity to hold not less than 10 percent in excess of the cementitious material required for one batch.

5.2.4.3 The amount of water entering each batch of RCC shall be measured by weight or volume. The equipment shall be capable of measuring the water to within a tolerance of plus or minus one percent and shall be equipped with an accurate gauge or dial measuring device. During batching, water shall be admitted to the mixer only through the water measuring device and then only at time of charging.

5.2.4.4 Drum mixers shall be equipped with an accurate clock or timing device, capable of being locked, for visibly indicating the time of mixing after all the materials, including the water, are in the mixer.

5.2.5 Alternative Mixing Equipment. Other types of batching and mixing equipment and configurations including dry batch plants and concrete truck mixers may be used with the approval of the Engineer. The Contractor must demonstrate that the mixing equipment has the ability to produce a consistent, well-blended, non-segregated RCC mix satisfying the minimum capacity requirements of Section 5.2.2 and within the tolerance limits as specified in Section 6.3.2.

5.3 Paver.

5.3.1 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 RCC to a minimum of 85% of the maximum wet density in accordance with ASTM D 1557 or equivalent test method. The paver shall be of suitable weight and stability to spread and finish the RCC material, without segregation, to the required thickness, smoothness, surface texture, cross-section and grade.

5.3.2 Alternative Paving Equipment. Any alternative paving equipment such as graders and dozers must be approved by the Engineer prior to use. The equipment shall be capable of producing a finished product that results in a smooth, continuous surface without segregation, excessive tearing, or rock pockets.

5.4 Compactors.

5.4.1 Self-propelled steel drum vibratory rollers having a minimum static weight of 10 tons (9.07 metric tons) shall be used for primary compaction. For final compaction either a steel drum roller, operated in a static mode, or a pneumatic-tire roller shall be utilized.

5.4.2 Walk-behind vibratory rollers or plate tampers shall be used for compacting areas inaccessible to the large rollers.

5.5 Haul Trucks. Trucks for hauling the RCC material from the plant to the paver shall have covers available to protect the material from rain or excessive evaporation. The number of trucks shall be sufficient to ensure adequate and continuous supply of RCC material to the paver.

5.6 Water Trucks. At least one water truck, or other similar equipment, shall be on-site and available for use throughout the paving and curing process. Such equipment shall be capable of evenly applying a fine spray of water to the surface of the RCC without damaging the final surface.

5.7 Inspection of Equipment. Before start-up, the Contractor's equipment shall be carefully inspected. Should any of the equipment fail to operate properly, no work shall proceed until the deficiencies are corrected.

5.8 Access for Inspection and Calibration. The Engineer shall have access at all times to any plant, equipment or machinery to be used on this project in order to check calibration, scales, controls or operating adjustments.

6. Construction Requirements

6.1 Preparation of Subgrade/Subbase.[2] Before RCC processing begins, the area to be paved shall be graded and shaped to the lines and grades as shown in the Plans or as directed by the Engineer. During this process any unsuitable soil or material shall be removed and replaced with acceptable material. The subgrade shall be uniformly compacted to a minimum of 95% of the maximum dry density in accordance with ASTM D 1557. The Contractor shall check for any soft or yielding subgrade areas by proof rolling with a loaded dump truck or pneumatic-tire roller over the entire area to be paved. All soft or yielding subgrade areas shall be corrected and made stable before RCC construction begins. If a subbase is shown on the Plans, it shall be uniformly compacted to a minimum of 95% of the maximum dry density in accordance with ASTM D 1557.

6.2 Test Section (Optional).

6.2.1 At least 30 days before the start of paving operations, the Contractor shall construct a test section using the trial mix design. This test pavement will allow the Engineer to evaluate the strength of the RCC material, methods of construction, curing process and surface conditions of the completed test pavement. The test section shall be at least 50 feet (15 meters) long and a minimum of two paver widths wide. It shall be located in a non-critical area or as indicated on the Plans. The test pavement will be constructed over an extended period to demonstrate the construction of cold joints in both a longitudinal and transverse direction, as well as fresh joint construction.

6.2.2 The equipment, materials and techniques used to construct the test section shall be that which will be used to construct the main RCC pavement.

6.2.3 During construction of the test section the Contractor will establish an optimum rolling pattern and procedure for obtaining a density of not less than 98% of the maximum wet density in accordance with ASTM D 1557 or equivalent test method. In addition, the Contractor must also demonstrate the ability to achieve a smooth, hard, uniform surface free of excessive tears, ridges, spalls and loose material.

6.2.4 Strength Testing (Optional Tests).

6.2.4.1 Field Cast Specimens. Specimens shall be prepared in accordance with ASTM D 1557, ASTM C 1435, or ASTM C 1176. Cure and transport specimens to the laboratory in accordance with ASTM C 31. Specimens shall be tested for splitting tensile strength (ASTM C 496) and compressive strength (ASTM C 39) at 7, 14, and 28 days of age.

2. Preparation of the subgrade/subbase is frequently the responsibility of excavation/grading contractor.

6.2.4.2 Cores and Beams. The test section shall be cured at least 5 days prior to extracting cores and beams for testing. The cores and beams shall be obtained in accordance with ASTM C 42. The cores will be tested for splitting tensile strength (ASTM C 496) and compressive strength (ASTM C 39) at 7, 14 and 28 days of age. In addition, 6x6x21 in. (150x150x525 mm) beams will be sawn from the test section and flexural strength at 7, 14 and 28 days will be determined in accordance with ASTM C 78. All coring, cutting and testing of the test section shall be paid for by the Owner.

6.3 Mixing Process.

6.3.1 General. Except for minor variations in moisture content, the same mixture proportions shall be used for the entire project, unless otherwise stated in the project documents. The water content shall be varied by the Contractor, as necessary, to provide a consistency that is most conducive to effective placement and compaction. If during mixing there is a change in the type or source of cementitious materials, or aggregates, the mixing must be suspended, and a new mix design shall be developed.

6.3.2 Mixture Ingredient Tolerances. The mixing plant must receive the quantities of individual ingredients to within the following tolerances:

Material	Variation in % by Weight
Cementitious materials	+/- 2.0
Water	+/- 3.0
Aggregates	+/- 4.0

6.3.3 Mixing time will be that which will assure complete and uniform mixing of all ingredients. For drum mixers and dry batch facilities, the time of mixing shall be determined from uniformity test results.

6.3.4 All material must be discharged before recharging. The mixing chamber and mixer blade surfaces must be kept free of hardened RCC or other buildups. Mixer blades shall be checked routinely for wear and replaced if wear is sufficient to cause inadequate mixing.

6.3.5 Plant Calibration. Prior to commencement of RCC production, the Contractor shall carry out a complete and comprehensive calibration of the plant in accordance with the manufacturer's recommended practice. All scales, containers and other items necessary to complete the calibration shall be provided by the Contractor. After completion of the initial calibration, the plant shall be recalibrated as directed by the Engineer.

6.3.6 Daily Reports. The Contractor shall supply daily plant records of production and quantities of materials used that day to the Engineer.

6.4 Transportation. The transportation of the RCC pavement material from the plant to the areas to be paved shall be in dump trucks fitted and equipped, when necessary, with retractable protective covers for protection from rain or excessive evaporation. The trucks shall be dumped clean with no buildup or hanging of RCC material. For paver placed RCC, the dump trucks shall deposit the RCC material

directly into the hopper of the paver or into a secondary material distribution system which deposits the material into the paver hopper. Dump truck delivery must be scheduled so that RCC material is spread and compacted within the specified time limits.

6.5 Placing.

6.5.1 Condition of the Subgrade/Subbase. Prior to RCC placement, the surface of the subgrade/subbase shall be clean and free of foreign material, ponded water and frost prior to the placement of the RCC pavement mixture. The subgrade/subbase must be uniformly moist at the time of RCC placement. If sprinkling of water is required to remoisten certain areas, the method of sprinkling shall not be such that it forms mud or pools of free-standing water. Prior to placement of RCC, the subgrade/subbase shall be checked for proper density and soft or yielding areas and these areas shall be corrected as specified in Section 6.1.

6.5.2 Paver Requirements. RCC shall be placed with an approved paver as specified in Section 5.3 and shall meet the following requirements:

6.5.2.1 The quantity of RCC material in the paver shall not be allowed to approach empty between loads. The material shall be maintained above the auger shaft at all times during paving.

6.5.2.2 The paver shall operate in a manner that will prevent segregation and produce a smooth continuous surface without tearing, pulling or shoving. The spread of the RCC shall be limited to a length that can be compacted and finished within the appropriate time limit under the prevailing air temperature, wind, and climatic conditions.

6.5.2.3 The paver shall proceed in a steady, continuous operation with minimal starts and stops. Paver speed during placement operations shall not exceed the speed necessary to ensure that minimum density requirements as specified in Section 5.3.1 are met and surface distress is minimized.

6.5.2.4 The surface of the RCC pavement once it leaves the paver shall be smooth, uniform and continuous without excessive tears, ridges or aggregate segregation.

6.5.3 Lift Thickness. Lift thickness of compacted RCC pavement shall be as indicated on the Plans. If RCC pavements are to be constructed in a thickness greater than 10 inches (250 mm), the use of two lifts shall be utilized. No lift shall be less than 4 inches (100 mm).

6.5.4 Adjacent Lane Placement. Adjacent paving lanes shall be placed within 60 minutes. If more than 60 minutes elapses between placement of adjacent lanes, the vertical joint must be considered a cold joint and shall be prepared in accordance with Section 6.8.2. At the Engineer's discretion, this time may be increased or decreased depending on the use of set retarding admixtures or the ambient weather conditions of temperature, wind, and humidity.

6.5.5 Multiple Lift Placement. For multiple lift placement, the total pavement thickness shall be as shown on the Plans, and the Contractor shall submit his method of placement and lift thickness as part of a paving plan subject to approval by the Engineer. In multiple lift construction, the second lift must be placed within 60 minutes of the completion of the first lift. If more than 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 Section 6.8.3.1. At the discretion of the Engineer, this time may be increased or decreased depending on the use of set retarding admixtures or the ambient weather conditions of temperature, wind and humidity.

6.5.6 Hand Spreading. Broadcasting or fanning the RCC material across areas being compacted will not be permitted. Such additions of material may only be done immediately behind the paver and before any compaction has taken place. Any segregated coarse aggregate shall be removed from the surface before rolling.

6.5.7 Segregation. If segregation occurs in the RCC during paving operations the spreading shall cease until the cause is determined and corrected.

6.5.8 RCC placement shall be done in a pattern so that the curing water from the previous placements will not pose a runoff problem on the fresh RCC surface or on the subbase layer.

6.5.9 Paving Inaccessible Areas. Areas inaccessible to either paver or roller may be placed by hand and compacted with equipment specified in Section 5.4.2. Compaction of these areas must satisfy minimum density requirements as specified in Section 6.7.7. An alternate and preferred method for paving inaccessible areas is to use cast-in-place, air-entrained concrete with a minimum compressive strength of 4000 psi (27 MPa) or as specified by the Engineer. In areas that may be subjected to high load transfer, the Engineer may require the cast-in-place concrete to be doweled into the RCC.

6.5.10 Placement of RCC with graders, dozers or other alternative paving equipment as specified in Section 5.3.2 shall meet the requirements of paver placed RCC where applicable.

6.6 Weather Conditions.

6.6.1 Cold Weather Precautions. RCC material shall not be placed on any surface containing frost or frozen material or when the air temperature is below 40°F (4°C), except when the air temperature is at least 35°F (2°C) and rising. When the air temperature is expected to fall below 40°F (4°C), the Contractor must present to the Engineer a detailed proposal for protecting the RCC pavement. This proposal must be accepted by the Engineer before paving operations may be resumed. A sufficient supply of protective material such as insulating blankets, plastic sheeting, straw, burlap or other suitable material shall be provided by the Contractor at his expense. The methods and materials used shall be such that a minimum temperature of 40°F (4°C) at the pavement surface will be maintained for a minimum of five days. Approval of the Contractor‘s proposal for frost protection shall not relieve the Contractor of the responsibility for the quality and strength of the RCC placed during cold weather. Any RCC that freezes shall be removed and replaced at the Contractors expense.

6.6.2 Hot Weather Precautions. During periods of hot weather or windy conditions, special precautions shall be taken to minimize moisture loss due to evaporation. Under conditions of excessive surface evaporation due to a combination of air temperature, relative humidity, concrete temperature and wind conditions, the Contractor must present to the Engineer a detailed proposal for minimizing moisture loss and protecting the RCC. Precautions may include cooling of aggregate stockpiles by use of a water spray, protective covers on dump trucks, temporary wind breaks to reduce wind effect, cooling of concrete mix water, and decreasing the allowable time between mixing and final compaction.

6.6.3 Rain Limitations. No placement of RCC pavement shall be done while it is raining hard enough to be detrimental to the finished product. Placement may continue during light rain or mists provided the surface of the RCC pavement is not washed-out or damaged due to tracking or pickup by dump trucks or rollers. Dump truck covers must be used during these periods. The Engineer will be the sole judge as to when placement must be stopped due to rain.

6.7 Compaction.

6.7.1 Compaction shall begin immediately behind the placement process and shall be completed within 60 minutes of the start of plant mixing. The time may be increased or decreased at the discretion of the Engineer depending on use of set retarding admixtures or ambient weather conditions of temperature, wind and humidity.

6.7.2 Rolling. The Contractor shall determine the sequence and number of passes by vibratory and non-vibratory rolling to obtain the minimum specified density and surface finish. Rollers shall only be operated in the vibratory mode while moving. Pneumatic-tire rollers may be used during final compaction to knead and seal the surface.

6.7.3 Rolling Longitudinal and Transverse Joints. The roller shall not operate within 12 in. (300 mm) of the edge of a freshly placed lane until the adjacent lane is placed. Then both edges of the two lanes shall be rolled together within the allowable time. If a cold joint is planned, the complete lane shall be rolled and cold joint procedures, as specified in Section 6.8.2 shall be followed.

6.7.4 Longitudinal joints shall be given additional rolling as necessary to produce the specified density for the full depth of the lift and a tight smooth transition occurs across the joint. Any uneven marks left during the vibrating rolling shall be smoothed out by non-vibrating or rubber tire rolling. The surface shall be rolled until a relatively smooth, flat surface, reasonably free of tearing and cracking is obtained.

6.7.5 Speed of the rollers shall be slow enough at all times to avoid displacement of the RCC pavement. Displacement of the surface resulting from reversing or turning action of the roller shall be corrected immediately.

6.7.6 Areas inaccessible to large rollers shall be treated as specified in Section 6.5.9.

6.7.7 Density Requirements. In-place field density tests shall be performed in accordance with ASTM C 1040, direct transmission, as soon as possible, but no later than 30 minutes after completion of rolling. Only wet density shall be used for evaluation. The required density shall be not less than 98% of the maximum wet density obtained by ASTM D 1557 or equivalent test method based on a moving average of five consecutive tests with no test below 96%.

6.8 Joints.

6.8.1 Fresh Vertical Joints. A vertical joint shall be considered a fresh joint when an adjacent RCC lane is placed within 60 minutes of placing the previous lane, with the time adjusted depending on use of retarders or ambient conditions. Fresh joints do not require special treatment.

6.8.2 Cold Vertical Joints. Any planned or unplanned construction joints that do not qualify as fresh joints shall be considered cold joints and shall be treated as follows:

6.8.2.1 Longitudinal and Transverse Cold Joints. Formed joints that do not meet the minimum density requirements of Section 6.7.7 and all unformed joints shall be cut vertically for the full depth. The vertical cut shall be at least 6 in (150 mm) from the exposed edge. Cold joints cut within two hours of placement may be cut with an approved wheel cutter, motor grader or other approved method provided that no significant edge raveling occurs. Cold joints cut after two hours of placement shall be saw cut 1/4 to 1/3 depth of the RCC pavement with the rest removed by hand or mechanical equipment. Any modification or substitution of the saw cutting procedure must be demonstrated to and accepted by the Engineer. All excess material from the joint cutting shall be removed.

6.8.2.2 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 in a moist condition immediately prior to placement of the adjacent lane.

6.8.3 Fresh Horizontal Joints. For multi-layer construction a horizontal joint shall be considered a fresh joint when a subsequent RCC lift is placed within 60 minutes of placement of the previous lift. This time may be adjusted at the discretion of the Engineer depending on use of retarders or ambient weather conditions. Fresh joints do not require special treatment other than cleaning the surface of all loose material and moistening the surface prior to placement of the subsequent lift.

6.8.3.1 Horizontal Cold Lift Joints. For horizontal cold joints the surface of the lift shall be kept continuously moist and cleaned of all loose material prior to placement of the subsequent lift. The Engineer may require other action such as use of a cement slurry or mortar grout between lifts. If supplementary bonding materials are used, they shall be applied immediately prior to placement of the subsequent lift.

6.8.3.2 RCC Pavement Joints at Structures. The joints between RCC pavement and concrete structures shall be treated as cold vertical joints.

6.8.4 Control Joints (Optional). Control joints may be constructed in the RCC pavement to induce cracking at pre-selected locations. Joint locations shall be shown on the Plans or as directed by the Engineer. Early entry saws should be utilized as soon as possible behind the rolling operation and set to manufacturer's recommendations. Conventionally cut control joints shall be saw cut to 1/4 depth of the compacted RCC pavement. Joints shall be saw cut as soon as those operations will not result in significant raveling or other damage to the RCC pavement.

6.9 Finishing.

6.9.1 Surface Smoothness. The finished surface of the RCC pavement, when tested with a 10 foot (3 meter) straight edge or crown surface template, shall not vary from the straight edge or template by more than 3/8 inch (10 mm) at any one point. When the surface smoothness is outside the specified surface tolerance the Contractor shall grind the surface to within the tolerance by use of self-propelled diamond grinders. Milling of the final surface is not acceptable, unless it is for the removal of the pavement.

6.9.2 Thickness. The thickness of the RCC pavement shall not deviate from that shown on the plans or as directed by the Engineer by more than minus 1/2 inch (12.5 mm). Pavement of insufficient thickness shall be removed and replaced the full depth. No skin patches shall be accepted.

6.9.3 When surface irregularities are outside the tolerances cited above, the contractor shall grind the surface to meet the tolerance at no additional cost to the Owner.

6.10 Curing. Immediately after final rolling and compaction testing, the surface of the RCC pavement shall be kept continuously moist for 7 days or until an approved curing method is applied.

6.10.1 Water Cure. Water cure shall be applied by water trucks equipped with misting spray nozzles, soaking hoses, sprinkler system or other means that will assure a uniform moist condition to the RCC. Application of this moisture must be done in a manner that will not wash out or damage the surface of the finished RCC pavement.

6.10.2 Curing Compound. The specified membrane curing compound shall be applied in two separate applications at right angles to one another, with the first coat being allowed to become tacky before the second is applied. This application must ensure a uniform void-free membrane across the entire RCC pavement. If the application rate is found to be excessive or insufficient, the Contractor, with approval of the Engineer, can decrease or increase the application rate to a level which achieves a void-free surface without ponding.

6.10.3 Sheet Materials. Curing paper, plastic and other sheet materials for curing RCC shall conform to ASTM C 171. The coverings shall be held securely in place and weighted to maintain a close contact with the RCC surface throughout the entire curing period. The edges of adjoining sheets shall be overlapped and held in place with sand bags, planking, pressure adhesive tape, or other Engineer-approved method.

6.11 Traffic. The Contractor shall protect the RCC from vehicular traffic during the curing period. Completed portions of the RCC pavement may be opened to traffic after seven days or as approved by the Engineer.

6.12 Maintenance. The Contractor shall maintain the RCC pavement in good condition until all work is completed and accepted. Such maintenance shall be performed by the Contractor at his own expense.

7. Measurement and Payment

7.1 Measurement. The work described in this document will be measured (1) in square yards (square meters) of completed and accepted RCC pavement as determined by the specified lines, grades and cross sections shown on the Plans and (2) in cubic yards (cubic meters) or tons (metric tons) of mixed and hauled RCC material.

7.2 Payment.

7.2.1 The work described in this document will be paid for at the contract unit price per square yard (square meter) of completed and accepted RCC pavement. The price shall include placement, compaction, curing, inspection and testing assistance and all other incidental operations. Also payment shall be made at the contract unit price per cubic yard (cubic meter) or ton (metric tons) of mixed and hauled RCC material. The price shall include mixing, hauling and all material costs. Such payment shall constitute full reimbursement for all work necessary to complete the RCC pavement.

7.2.2 Test Section. If a test section is constructed, it will be paid for on a lump sum basis. Such payment shall constitute full reimbursement for all materials, labor, equipment, mobilization, demobilization, and all other incidentals necessary to construct the Test Section in accordance with Section 6.2.

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