

Cement Stabilized Aggregate Base

SCDOT Designation: SC-M-308 (10/15)

1. SCOPE

- 1.1. Cement Stabilized Aggregate Base (CSAB) consists of aggregate, Portland cement, and water. CSAB is proportioned, mixed, placed, compacted, and cured in accordance with these specifications. CSAB will conform to the lines, grades, thickness, and typical cross section shown in the Plans or otherwise established by the RCE. CSAB will ordinarily be covered with one or more lifts of asphalt as shown on the Plans. This Specification addresses requirements for materials, equipment, and construction of CSAB.

2. REFERENCED DOCUMENTS

- 2.1. SCDOT Standard Specifications Divisions 200, 300, 400, and 700
- 2.2. **SC-T-140**, Moisture-Density Relations of Soils or Soil-Aggregate Mixtures Using a 10 lb. Rammer and 18 in. Drop
- 2.3. **SC-T-33**, Field Determination of Density and Moisture Content of Nonstandard Materials by Use of the Nuclear Density Gauge
- 2.4. **ASTM C 31**, Making and Curing Concrete Test Specimens in the Field
- 2.5. **ASTM C 1435**, Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer
- 2.6. **SCDOT-T-142**, Making, Curing and Testing of Cement Stabilized Aggregate Base Compression Specimens in the Laboratory
- 2.7. **SCDOT-T-100**, Random Method of Sampling Highway Construction Materials

3. SUBMITTALS

Proposed CSAB Mix Design: At least 30 days prior to the beginning of placing CSAB in the roadway, submit a proposed mix design to the State Pavement Design Engineer at the Office of Materials and Research for review. Ensure that the mix design was conducted in an R18 AASHTO-accredited laboratory and include aggregate gradation, cementitious materials, compressive strengths (see section 5.1) and moisture-density curve. Make no production until an approved mix design has been obtained. Additionally, submit a copy of the Contractor's Quality Control Plan outlined in these specifications to the State Pavement Design Engineer and RCE at the same time for review.

4. MATERIALS

4.1. Use materials that meet the requirements of Divisions 300, 400, and 700 of the Standard Specifications as follows:

4.1.1. *Portland Cement*

4.1.1.1 Use Type I Portland cement meeting the requirements as specified in Subsection 701.2.1, except that the allowable maximum alkali content ($\text{Na}_2\text{O}+0.658\text{K}_2\text{O}$) is increased to 1.0%.

4.1.2. *Water*

4.1.2.1 Use water meeting the requirements as specified in Subsection 701.2.11.

4.1.3. *Aggregate*

4.1.3.1 Use aggregate meeting the requirements of Macadam Base Course or Marine Limestone Base Course as specified in Subsection 305.2 with one exception. Ensure that the gradation for each material meets the following requirements.

Macadam Base Course Gradation	
Sieve Designation	Percentage by Weight Passing
2-inch	100
1½-inch	95 – 100
1-inch	70 – 100
½-inch	50 – 90
No. 4	45 – 65
No. 30	11 – 38
No. 200	0 – 12
Liquid Limit	25 max.
Plasticity Index	6 max.

Marine Limestone Base Course Gradation	
Sieve Designation	Percentage by Weight Passing
2-inch	100
1½-inch	95 – 100
1-inch	70 – 100
½-inch	50 – 85
No. 4	45 – 65
No. 30	17 – 38
No. 200	0 – 20
Liquid Limit	25 max.
Plasticity Index	6 max.

4.1.4. *Asphalt Material*

4.1.4.1 Use RS-2, CRS-2, or EA-P Special for the asphalt curing coat and meet the requirements specified for asphalt materials in Subsection 407.

5. Design Strength

- 5.1. Use a mix design that demonstrates a compressive strength of 600 psi when specimens are prepared and tested according to SC-T-142. In addition to compressive strength testing, perform durability testing of mixtures using aggregates with absorption values greater than 3%. The State Pavement Design Engineer will provide guidance for acceptable durability testing procedures.

6. EQUIPMENT

- 6.1. *General:* Ensure that the equipment necessary for the proper construction of the work is on site, in acceptable working condition, and approved by the RCE as to both type and condition before the start of work under this section. Provide sufficient equipment to enable prosecution of the work in accordance with the project schedule and completion of the work in the specified time.
- 6.2. *Compactors:* Have sufficient vibratory rollers, smooth wheel tandem rollers, three-wheel rollers, pneumatic tired rollers, or other means of obtaining compaction that is satisfactory to the RCE. Ensure that the rate of operation is sufficient to uniformly compact the specified width and depth of the base course being processed within a period of 2 hours.
- 6.3. *Paver:* Place CSAB with a high-density asphalt-type paver subject to approval by the RCE. Use only pavers equipped with compacting devices capable of producing a minimum of 90 percent of the maximum density in accordance with SC-T-140 prior to any additional compaction. Ensure that the paver is of suitable weight and stability to spread and finish the CSAB material, without segregation, to the required thickness, smoothness, surface texture, cross-section, and grade.
- 6.4. *Haul Trucks:* Use trucks for hauling the CSAB material from the plant to the paver with covers available to protect the material from inclement weather. Ensure that the trucks used have clean, tight, and smooth beds. To ensure adequate and continuous supply of CSAB material to the paver, have a sufficient number of trucks in operation. If the number of trucks is inadequate to prevent frequent starts and stops of the paver, cease production until additional trucks are obtained.
- 6.5. *Water Trucks:* Keep at least one water truck, or similar equipment, on-site and available for use throughout the paving and curing process. Equip such trucks with a spreader pipe containing fog spray nozzles capable of evenly applying a fine spray of water to the surface of the CSAB without damaging the final surface.
- 6.6. *Inspection of Equipment:* Before start-up, the contractor's equipment will be carefully inspected. Should any of the equipment fail to operate properly, cease work until the deficiencies are corrected.
- 6.7. *Access for Inspection and Calibration:* Provide the RCE or RCE's Representative access at all times for any plant, equipment, or machinery to be used in order to check calibration, scales, controls, or operating adjustments.

7. CONSTRUCTION REQUIREMENTS

7.1. *Weather Limitations*

- 7.1.1. Apply cement only when the temperature is above 40°F in the shade and rising. Perform no work on frozen or excessively wet subgrade.

7.2. *Preparation of Subgrade*

- 7.2.1. Construct the subgrade for the cement stabilized aggregate base course in accordance with the requirements specified in Section 208. Complete the subgrade at least 500 feet ahead of the placement of base course materials where feasible. When included in the work, construct shoulders in accordance with the requirements of Section 209 and accurately trim to the alignment and grade of the base course to form a trench or channeled section as prescribed on the Plans.

7.3. *Trial Batch & Test Strip*

- 7.3.1 *Trial Batch* - If the mix design appears satisfactory to the SCDOT, prepare and test a trial batch mixture at the Contractor's facilities to verify that the design criteria for strength are met prior to production. Perform batch mixture preparation and testing in the presence of representatives of the SCDOT Office of Materials and Research. Sample the CSAB mixture using SC-T-100 and prepare at least one set of test specimens in accordance with ASTM C 1435 under the direct observation of the RCE or RCE's representative at this time. A set of specimens consists of three cylinders. Cure and transport the specimens to the Contractor's (or mix producer's) Office of Materials and Research-approved laboratory in accordance with ASTM C 31. Test two cylinders for compressive strength in accordance with SC-T-142 under the direct observation of the RCE or RCE's representative. If the measured compressive strength between two cylinders varies by more than 10 percent of the stronger cylinder, test the third cylinder and average the results of the three cylinders. Otherwise, average the measured compressive strengths of the two cylinders to determine the compressive strength. Submit these results to the RCE for verification of the CSAB Mix Design Strength. Make no additional production until the results have been reviewed by the RCE.

- 7.3.2 *Test Strip* – During the production of the trial batch, complete a 1000 foot long by 12 foot wide or equivalent area test strip in the presence of representatives of the Office of Materials and Research in accordance with these specifications. Allow access for additional testing of this test strip 7 days after placement by the SCDOT Office of Materials and Research.

7.4. *Contractor Quality Control Requirements*

- 7.4.1 *Contractor Quality Control Plan* – Prepare a Quality Control Plan detailing the type and frequency of inspection, sampling and testing deemed necessary to measure and control the various properties of materials and construction governed by the specifications. As a minimum, detail sampling location and techniques, and test frequency to be utilized in the sampling and testing

plan. The Department may utilize quality control sampling and testing performed by the contractor as acceptance. Submit a Quality Control Plan for acceptance to the RCE in writing a minimum of 30 days before work begins.

7.4.1.1 *Elements of the Plan* – Include all elements that affect the quality of the CTB including but not limited to the following:

- Mix Design
- Stockpile Management
- Plant Calibration
- Proportioning, including added water
- Mixing and transportation, including time from batching to completion of delivery
- Placement
- Compaction
- Compressive Strength
- Finishing and Curing

7.4.1.1.1 *Quality Control Compressive Strength Test Specimens* – Monitor the compressive strength of the CSAB Mixture using the minimum requirements outlined below. For each day's production, up to 1500 cubic yards of mix produced, prepare a set of test specimens in accordance with ASTM C 1435 under the direct observation of the RCE or RCE's representative. Sample the material in accordance with SC-T-100. A set of specimens consists of three cylinders. Make an additional three sets for each additional 1500 cubic yards or fraction thereof. Cure and transport the specimens to the Contractor's (or mix producer's) Office of Materials and Research-approved laboratory in accordance with ASTM C 31. Test two cylinders for compressive strength in accordance with SC-T-142 under the direct observation of the RCE or RCE's representative. If the measured compressive strength between two cylinders varies by more than 10 percent of the stronger cylinder, test the third cylinder and average the results of the three cylinders. Otherwise, average the measured compressive strengths of the two cylinders to determine the compressive strength. Retain the test results and plot the 5 day moving average values for inspection by the RCE.

7.4.1.1.2 Notify the RCE when the moving average test result trend line for the compressive strength approaches 500 psi. Cease operations when 2 consecutive single compressive strength tests fall below the 500 psi limits, or one compressive strength test falls under 450 psi. Additional verification samples performed by SCDOT may be used by the RCE to define unacceptable work to initiate corrective action.

7.5. *Mixing and Placing Materials* – Use the quantity of Portland cement added to the aggregate, which is typically between 2.5% and 5.0% by weight of the surface dry aggregate, at the rate established by the CSAB mix design within the tolerance specified herein. Unless otherwise provided, the base course shall be mixed and placed by the stationary plant method and is the default mixing and placing method covered by this specification. The road mix method may be used when so specified in the special provisions or identified as an alternate bid item.

7.5.1. *Stationary Plant Method* – Mix the aggregate, Portland cement, and water in a pugmill, either of the batch or continuous-flow type. Use a plant equipped with feeding and metering devices that add aggregate, cement, and water into the mixer in the specified quantities. In all plants, the

acceptable variation of the weight or rate of feed of the cement is within 5.0% of the amount designated in the approved CSAB Mix Design. Continue mixing until a uniform homogeneous mixture is obtained. The RCE may require an increase in the mixing time when necessary to secure a proper blend of the materials.

- 7.5.1.1 *Transportation* - Haul the mixture to the roadway in trucks with protective covers. Place the mixture on a moist subgrade in a uniform layer using an approved paver. Construct layers of such contour and thickness that the completed base course conforms to the required grade and cross-section. Dumping of the mixture in piles or windrows is not permitted.
- 7.5.1.2 *Subgrade Condition* - Prior to CSAB placement, ensure that the surface of the subbase is clean and free of foreign material, ponded water, and frost prior to placement of the CSAB pavement mixture. Ensure that the subbase is uniformly moist at the time of CSAB placement. If sprinkling of water is required to remoisten certain areas, use a method of sprinkling that does not form mud or pools of freestanding water. Correct soft or yielding subbase areas prior to placement of CSAB.
- 7.5.1.3 *Paver Requirements* - Place CSAB with an approved paver as specified in Subsection 6.3 and also meet the following requirements:
 - 7.5.1.3.1 *Filling the Paver* - Do not allow the quantity of CSAB in the paver to approach empty between loads. Maintain the material above the auger at all times during paving.
 - 7.5.1.3.2 *Stopping the Paver* - Have the paver proceed in a steady, continuous operation with minimal starts and stops, except to begin a new lane. The maximum paver speed during laydown is 10 feet per minute. Higher paver speeds may be allowed at the discretion of the RCE if the higher speeds may be obtained without distress to the final product.
- 7.5.1.4 *Inaccessible Areas* - Pave areas inaccessible to either roller or paver using alternative equipment and procedures approved by the RCE. Regardless of paving methods, ensure that the final product meets all other requirements for compaction, thickness, and surface condition.
- 7.5.1.5 *Segregation* - If segregation occurs in the CSAB during paving operations, cease placement until the cause is determined and corrected to the satisfaction of the RCE. If the segregation is judged by the RCE to be detrimental to the final product, remove and replace the segregated area at no additional cost to the Department.
- 7.5.2 *Road Mixed Method* – Use any combination of machines or equipment that produces the required results meeting the approval of the RCE. Use a cement spreader which has an adjustable rate of flow and the capability of spreading the required amount of cement in one pass. Use a self-propelled rotary mixer capable of uniformly mixing to a depth of at least 10".
 - 7.5.2.1 *Aggregate Placement* – Place the required quantity of aggregate on the prepared subgrade in a uniform layer. Spread aggregate on the subgrade in advance of the mixing operations only to the extent that processing can be completed in one week.
 - 7.5.2.2 *Cement Application* – Apply the required quantity of cement in a uniform spread on the aggregate. The acceptable variation of the weight or rate of feed of the cement is within 5.0% of

the amount designated in the approved CSAB Mix Design. Immediately blend the aggregate until the cement is uniformly distributed throughout the aggregate. Maintain the moisture content at or below the optimum moisture at the time of application of the cement. Do not apply cement on excessively windy days and apply only so that work can be completed within the construction limitations given in section 7.8.

7.5.2.3 *Mixing* – Immediately after the aggregate and cement have been thoroughly blended, apply water as needed and incorporate into the mixture. Control the application of the water so that there is no excessive concentration on or near the surface of the mixture. After the necessary water has been applied, continue mixing until a uniform mixture is obtained. Maintain the moisture content at the time of final mixing and compaction within the range given in subsection 7.6.4. Make sure that the moisture content in the mix does not exceed the quantity that causes that base course to become unstable during compaction or finishing operations.

7.5.2.4 *Segregation* - If segregation occurs in the CSAB during mixing or finishing operations, cease placement until the cause is determined and corrected to the satisfaction of the RCE. If the segregation is judged by the RCE to be detrimental to the final product, remove and replace the segregated area at no additional cost to the Department.

7.6. *Compaction*

7.6.1. *Time to Compaction* - Begin compaction immediately with the placement process and no later than 60 minutes from the start of the moist mixing at the plant. The time may be increased or decreased at the discretion of the RCE depending on ambient conditions of temperature and humidity. Delays in rolling are not permitted unless approved by the RCE. Plan operations and supply sufficient equipment to ensure that these criteria are met.

7.6.2. *Inaccessible Areas* - Thoroughly compact areas inaccessible to large rollers with walk-behind rollers or hand tampers.

7.6.3. *Density Requirements* - Field density tests will be performed in accordance with SC-T-33 as soon as possible, but no later than 30 minutes after the completion of the rolling. The required density is a minimum of 98 percent of the maximum laboratory density obtained according to SC-T-140. The in-place density and moisture content is determined with a nuclear moisture-density gauge.

7.6.4. *Moisture Content* - Ensure that the moisture content of the CSAB is within 0 to + 2.0% of the specified optimum moisture content during compaction operations.

7.7. *Construction Joints*

7.7.1. At the end of each day's construction, form a straight transverse construction joint by cutting back into the completed work to form a true vertical face, free of loose or shattered materials. Construct the base course for large, wide areas in a series of parallel lanes of convenient length and width meeting the approval of the RCE. Form straight longitudinal joints at the edge of each day's construction by cutting back into the completed work to form a true vertical face, free of loose or shattered materials.

7.8. *Construction Limitations*

- 7.8.1. Limit the area over which the cement aggregate mixture is spread in order that all operations specified can be continuous and all work completed within daylight hours, unless adequate artificial light is provided. Complete all work within 3 hours after the application of water to the aggregate and cement mixture, unless the RCE approves a longer period.
- 7.8.2. If operations are interrupted for a continuous period of greater than 2 hours after the cement has been mixed with the aggregate, reconstruct the entire affected section in accordance with these specifications. When the uncompacted mixture of aggregate and cement is wetted so that the moisture content exceeds that specified, manipulate and aerate the mixture to reduce the moisture to the specified content if the base course is completed within the time limits of these specifications.

7.9. *Reconstruction*

- 7.9.1. If the construction of the base course is proceeding with the approval of the RCE and the uncompacted aggregate and cement mixture is wetted by rain so that the moisture content exceeds the allowable, the Department will pay for additional cement used in reconstructing the section but will not pay for the reconstruction work. If the reconstruction of any section is necessary because of negligence or omission by the Contractor, unsatisfactory equipment performance, or the section does not comply with the allowable variation in thickness, reconstruct the section without additional compensation.

7.10. *Surface Smoothness*

- 7.10.1. Ensure that the finished surface of the base varies neither more than $\frac{3}{8}$ inch from a straight edge 10 feet long when applied parallel to the centerline of the road, nor more than $\frac{1}{2}$ inch from the typical cross-section shown on the Plans.
- 7.10.2. Do not disturb the finished surface of the base course after the final finishing and compaction. Do not remove random high spots after the base course has hardened. Where low areas or depressions in the finished surface of the base occur, level and true the surface using the same material that the base course is to receive as the next component of the pavement structure, but in a separate operation. If the material specified as the next component in the pavement structure is considered unsatisfactory by the RCE, the RCE will specify what material to use. Provide necessary materials and perform such corrective work without any additional compensation.

7.11. *Tolerance in Base Course Thickness.*

- 7.11.1. The thickness of the completed modified base will be measured at random intervals not to exceed 250 feet in length for two-lane roads. The depth measurement will be made by coring at least 4 inch holes through the base course at 7 days when construction staging allows. Otherwise, depth measurement will be made by test holes on the day of production. The random sampling intervals will be taken in accordance with SC-T-100. Additional nonrandom sampling may be taken as

directed by the RCE or RCE representative. Where the base course is less than the specified thickness by more than ½ inch, remove and replace such areas as directed by the RCE.

- 7.11.2. Where the measured thickness is more than ½ inch greater than the specified thickness, it is considered as the specified thickness plus ½ inch. The average job thickness is the average of the depth measurements determined as specified above. If this average job thickness is less than the specified thickness by more than ¼ inch, an adjusted unit price is used for calculating payment. This adjusted contract unit price bears the same ratio to the contract unit price bid as the average job thickness bears to the specified thickness.

$$\text{Pay Factor} = \frac{\text{Average Job Thickness}}{\text{Specified Job Thickness}}$$

- 7.11.3. When the Contract includes more than one road, each road is considered separately.
- 7.11.4. No additional payment over the contract unit price is made for any base course where the average job thickness, determined as provided, exceeds the specified thickness.

7.12. *Curing Coat*

- 7.12.1. After the base course has hardened, but not later than 12 hours after the completion of finishing operations, apply an asphalt curing coat of 0.20 to 0.25 gallons per square yard of asphalt as specified in Section 406. Keep the finished base course continuously moist until the curing coat is applied. At the time the asphalt material is applied, ensure that the base course surface is dense, free of all loose and extraneous material, and contains sufficient moisture to prevent penetration of the asphalt material.
- 7.12.2. Depending upon temperature and weather conditions, the RCE may allow deferral of the application of the curing coat on base course that is placed and completed during the latter portion of a day until the early part of the following day.

7.13. *Opening to Traffic*

- 7.13.1. When staging of construction allows for extended closure to traffic, furnish such personnel and barricades along with other devices necessary to prevent construction equipment or other traffic, regardless of the type vehicle or its reason for being on the project, from using the finished base course. Use the subgrade shoulders or completed pavement for transporting materials, workers and equipment throughout the length of the project. Cross the finished base course at locations designated by the RCE only after a 7-day curing period has elapsed. Cover such designated crossings with at least 8 inches of earth as protection for the completed base course. When the paving operation is commenced, the completed section of the base course may be opened to light construction equipment for a distance not to exceed 1000 feet in advance of the paving work after the 7-day curing period has elapsed. If staging of construction requires prompt opening to traffic, the RCE may consult the State Pavement Design Engineer for recommendations. In these instances, place at least one lift of asphalt on the base course within 3 days. Repair any damage to the base caused by early traffic before overlay. If the asphalt material for the curing coat is not sufficiently dry to prevent pickup when the base course is opened to traffic as outlined above, apply a granular cover before opening.

7.14. *Maintenance*

- 7.14.1. Within the limits of the Contract, maintain the cement stabilized aggregate base course in good condition until all work is complete and accepted. Maintenance includes the immediate repairs of any defects and damage that develops. If repair or patching is necessary, extend it to the full depth of the base course and construct in a manner that ensures the restoration to a uniform and durable base course.