# SECTION 306

# CEMENT TREATED BASE

**Exception: If the PCCP in the contract is <u>not</u> specified as QC/QA, (Bid item Quality Control Testing (CTB) is not included as a bid item) subsections 306.2 (entire subsection), 306.4d. and 306.4g. of this SECTION are <u>not</u> applicable to the contract.**

## 306.1 DESCRIPTION

Design a cement treated base (CTB) mixture meeting the requirements of the Contract Documents. Construct 1 or more courses of the CTB on a prepared roadway as shown in the Contract Documents.

| **BID ITEMS** | **UNITS** |
|---|---|
| Cement Treated Base | Square Yard |
| Quality Control Testing (CTB) | Square Yard |

## 306.2 CONTRACTOR QUALITY CONTROL REQUIREMENTS

**a. General**. Provide qualified personnel and sufficient equipment complying with the requirements listed in Part V to conduct quality control testing that complies with Appendix B, Sampling and Testing Frequency Chart for Concrete Construction Items for Quality Control/Quality Assurance Projects.

Allow the Engineer access to the Contractor's laboratory to observe testing procedures, calculations, test documentation and plotting of test results.

Calibrate and correlate the testing equipment with prescribed procedures, and conduct tests in compliance with specified testing procedures as listed in Part V.

Maintain a Quality Manual in the field laboratory showing the calibrations performed on all test equipment and when the next calibration is due for that equipment. As a minimum, follow the calibration/verification interval established in Table 1: Concrete Materials Test Equipment in Section 5.2.7.8-Cement Treated Base: Contractor's Quality Control Plan (CTB), Part V. See also, Part V Section 5.2.7.8.1-Example of a Laboratory Quality Manual for CTB.

Provide personnel and equipment to conduct quality control testing that complies with the Contract Documents. Provide certified technicians to perform process control testing. Use equipment that complies with, and is calibrated according to the specified test methods.

**b. Quality Control Plan (QCP).** At the pre-construction conference, submit to the Engineer for approval by the DME, a QCP as outlined in Section 5.2.7-Contractor's Quality Control Plan, Part V. Follow 5.2.7.8-Cement Treated Base: Contractor's Quality Control Plan in Part V as a general guideline. Keep a printed copy of the approved QCP in the Contractor's laboratory and make available to the Engineer when requested.

The Contractor's laboratory and equipment will be inspected and approved as outlined in Part V, Section 5.2.7-Contractor's Quality Control Plan.

Include a listing of the names and phone numbers of individuals and alternates responsible for quality control administration and inspection. On the Contractor's organizational chart, show the specified lines of authority relating both to mix design and quality control operations during production. Post the organizational chart in the Contractor's test facility.

Provide a quality control organization or private testing firm having personnel certified according to the Policy and Procedures Manual for The Certified Inspection and Testing (CIT) Training Program. The testing for this type of construction will require personnel certified in ACI Concrete Field Testing Technician (CF), Aggregate Field Tester (AGF), Soils Field Tester (SOF) and Nuclear Moisture Density Gauge Tester (NUC) classifications. Only persons certified in the appropriate classifications covering the specific tests required shall perform such testing. Provide a minimum of 1 employee on the project certified in the QC/QA Concrete/Cement Treated Base Specs (QCS) classification.

Only persons certified in the appropriate classifications covering the specific tests required shall perform such testing. At the beginning of the project, provide the Engineer with the list of certified technicians and

alternates, phone numbers and tests/inspection they will be performing. As personnel changes and certifications may expire, continue to provide the Engineer with an accurate list.

Provide an organizational chart showing the specified lines of authority relating to both mix design and quality control operations during production. Identify the company official acting as liaison with KDOT, and the Certified Technician who will direct inspection and testing. Post the chart in the test facility.

Submit the mix design for the CTB. If an existing mix design is used, provide the mix design number. Include all the elements of the mix design specified in the Contract Documents.

Submit the proposed methods and procedures to control the elements identified as necessary for the quality of the CTB. These elements include, but are not limited to: producing the aggregate, managing the aggregate stockpiles, proportioning the individual materials for the mixture, mixing and transporting the mixture, placing and consolidating the mixture, and finishing and curing the mixture.

**c. Required Duties of Certified Technicians.** Be available on the project site whenever cement treated base is being produced and being placed on the project site. Perform and utilize quality control tests and other quality control practices to assure that delivered materials and proportioning meet the requirements of the mix designs, including temperature, slump, air content and strength.

Periodically inspect all equipment utilized in transporting, proportioning, mixing, placing, consolidating, finishing and curing to assure it is operating properly and that placement, consolidation, finishing and curing comply with the mix design and other contract requirements.

**d. Contractor's Testing Facilities.** Describe the testing facility and its accreditation in the QCP.

Locate the testing facility either at the plant site or at the project. Obtain approval of the testing facilities and location from the DME before the commencement of mixture production.

Provide suitable space for the required testing equipment. Also, equip the testing facility with these items for the exclusive use of the testing facility's quality control personnel and the Engineer:

- A telephone with a private line;
- A copying machine; and
- Broadband internet connection (for 1 computer). If the Engineer determines that broadband internet service is not available, provide a fax machine, at no additional cost.

**e. Documentation.** Include in the QCP procedures, charts and forms to be used to provide the required documentation.

Record and document all test results and calculations. Record all original documentation in a bound field book or other KDOT approved bound record and turn over to KDOT at the end of the project.

At all times, have complete records of all inspections and tests readily available on site for the Engineer. All records documenting the Contractor's quality control inspections and tests become the property of KDOT upon completion of the work.

Indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and the corrective action taken in the records. Examples of quality control forms and charts are available in Part V, or Contractors may design their own. Documentation procedures are subject to approval by the Engineer before the start of the work and to compliance checks during the progress of the work.

Maintain control charts on an ongoing basis. Plot data according to **SECTION 106**.

Record all test results and calculations on electronic data sheets. Record specific test results on a Daily Quality Summary Sheet to facilitate the computation of moving test averages. Base the moving averages on 4 consecutive test results. Include a description of quality control actions taken (adjustment of aggregate or additive proportions in the mix, moisture adjustments, etc.) in the Daily Quality Summary Sheet.

Provide forms on a computer-acceptable medium, where required. Document batch tickets and gradation data according to KDOT requirements.

Complete testing and charting within 1 working day after sampling.

Keep all quality control charts current. Email or fax the data to the Field Engineer and DME, weekly. Show both individual test results and moving average values. As a minimum, plot the single test values and the 4-test moving average values for gradation of combined aggregates, in-place CTB moisture and dry density, and compressive strength (requires a separate graph for PWL, but no moving average plot).

Complete the charting within 1 working day after the sampling or testing, respective to each type of test.

Make all test results and control charts available to the Engineer at the project site. The Engineer will periodically make compliance checks on the documentation during the progress of the work.

Submit (email or fax) copies of all failing test results (based on a moving average of 4 tests, if appropriate) and a summary sheet to the Field Engineer on a daily basis.

File all reports, records, charts and diaries developed during the progress of construction activities. Upon completion of the contract, all documentation becomes the property of KDOT.

**f. Testing Requirements.** In the QCP, identify test methods, procedures and equipment proposed for use. Use standard KDOT test methods and properly calibrated measuring and testing equipment as outlined in Part V. Detail any alternative sampling method, procedure or inspection equipment proposed to be used. Such alternatives are subject to review and approval by the DME.

Take all samples for tests and perform in-place tests at random locations selected according to the Contractor's QC Plan and at the rates specified in the Sampling and Testing Frequency Chart for Cement Treated Base for Quality Control/Quality Assurance Projects in Appendix B, Part V. Retain the latest 10 gradation samples for use by the Engineer.

Retain the second half of the latest 10 gradation samples for use by the Engineer.

**g. Mix Design.** Design a mixture of aggregate and portland cement or fly ash, or both. If fly ash is used in the mixture, address the set time and strength gain as a function of the ambient temperature. Design the mixture according to the following requirements:

(1) The compressive strength shall be between 650 and 1600 psi. Any test correlating to the maximum value or higher requires scoring or sawing joints in the base that fall within the failing test section (from previous to next passing test sections). Determine compressive strength at 7 days, according to Part V.

(2) Submit a single point gradation for the combined aggregates along with a plus/minus tolerance for each sieve to the Engineer. The plus/minus tolerances shall be used by the Contractor to perform quality control checks and by the Engineer to perform aggregate gradation verification testing. Perform tests on the combined materials.

(3) Submit the mix batch weights in an acceptable manner to the DME. Address the initial set times (specified in AASHTO T 154) and placement times (with regards to the set times) in the proposed mix design.

(4) Submit laboratory compressive strength test results on a minimum of 1 set of 3 plugs, produced from the proposed mix design and utilizing the actual materials proposed for use on the contract.

(5) Submit the test results 2 weeks prior to the anticipated date for using the design on the contract. The Engineer will review the design within 5 working days of receipt. The Engineer may perform any testing necessary to verify the adequacy of the Contractor's design. If the Engineer calls for verification tests, supply the Engineer with the necessary materials to enable the Engineer to test the mix properties within 5 working days of notification.

(6) Submit any proposed changes to the approved mix design to the DME for approval before implementing the proposed changes.

**h. Corrective Action.** In the QCP, identify procedures for notifying the Engineer when corrective measures must be implemented, and for halting production.

Notify the Engineer when the moving average test result trend line for any property approaches the specification limits. Cease operations when 2 consecutive moving average points fall outside the specification limits, or 2 consecutive single compressive strength tests exceed the specification limits. Ceasing operations is the Contractor's responsibility. Quality control tests for this determination include aggregate gradation, compliance with the mix design band and in-place density of CTB.

Failure to cease operations for the conditions cited above will subject all subsequent material to rejection, or acceptance at a reduced price, as determined by the Engineer.

The Engineer may examine materials represented by individual test results, which lie beyond the Contractor's normal quality control testing variation. The investigation may be based on either Contractor or KDOT test results. The information from additional testing (including testing of in-place pavement) may be used to define unacceptable work according to **SECTION 105**. The Engineer will apply appropriate price reductions or initiate corrective action.

If a dispute exists between the Engineer and Contractor about the validity of any test results other than compressive strengths or thickness determination, the KDOT District Materials Laboratory or MRC will perform referee testing. If one of the disputed KDOT test results was generated at the MRC, then an independent laboratory agreeable to both parties will be selected. The AASHTO Accreditation Program shall have approved the selected laboratory for the appropriate test procedure. If referee testing indicates that KDOT test results are correct, the Contractor is responsible for the cost of additional testing, including referee testing performed at the MRC. If the

referee testing indicates that the Contractor test results are correct, KDOT is responsible for the cost of additional testing.

**i. Non-Conforming Materials**. In the QCP, specifically address how non-conforming materials will be controlled and identified.

Establish and maintain an effective and positive system for controlling non-conforming material, including procedures for its identification, isolation and disposition. Reclaim or rework non-conforming materials according to procedures acceptable to the Engineer.

Identify all non-conforming materials and products to prevent use, shipment and intermingling with conforming materials and products. Provide holding areas, mutually agreeable to the Engineer and Contractor.

The Engineer will determine if reclaiming or reworking of non-conforming materials is allowed.

## 306.3 MATERIALS

Provide materials that comply with the applicable requirements.

| | |
|---|---|
| Concrete Admixtures & Curing Material | **DIVISION 1400** |
| Portland Cement and Fly Ash | **DIVISION 2000** |
| Water for CTB | **DIVISION 2400** |
| Aggregates for CTB | **DIVISION 1100** |

## 306.4 CONSTRUCTION REQUIREMENTS

**a. Preparation and Maintenance of the Subgrade.** Before placing any CTB material on any section, complete the ditches and drains along that section to effectively drain the highway. Use automatic grade control equipment to trim the surface of the subgrade to the line, grade and cross-section as shown in the Contract Documents. Maintain the subgrade to the as-constructed condition under other contract bid items, repairing any encountered defects to the specifications of the previous bid items. Maintain the subgrade surface to readily drain at all times. Protect the subgrade from damage when handling materials, tools and equipment. Do not store or stockpile materials on the subgrade. Do not place material or lay CTB on a frozen or muddy subgrade.

Lightly spray the subgrade with water to obtain a thoroughly moistened condition before the CTB is placed. Do not puddle water on the grade.

Do not place CTB on frozen subgrade. Do not deposit any material until the subgrade or base has been checked and approved by the Engineer.

**b. Mixing the Materials.** Do not place CTB on the project until the Engineer has reviewed and approved the submitted mix design.

Plant mix the aggregate, cementing agent and water according to the approved mix design.

Control the charge in a batch mixer, or the rate of feed to a continuous mixer (pugmill), to allow complete mixing of all the materials. Mix the materials to produce a homogeneous mixture. Do not use frozen aggregate.

Take all compressive strength samples at the plant site. Compact the samples prior to the CTB reaching its initial set.

**c. Spreading and Compacting the CTB**. The maximum compacted thickness of a single lift is 6 inches. If the thickness is greater than 6 inches, spread and compact the subgrade in multiple lifts of equal thickness with a maximum lift thickness of 6 inches. If the base is spread in multiple lifts, offset the longitudinal joints by at least 6 inches.

If multiple lifts are placed, keep the surface of each lift moist until the succeeding lift is spread. Cover the exposed lower lift with the final lift the same day the lower lift is placed.

Compact each lift of CTB to a minimum of 95% of the standard density.

Compact the CTB within 2 hours from the time the water and cementing agent is added to the aggregate, or before the mixture reaches the initial set, whichever is the shorter timeframe.

**d. Compaction Determination.** Determine dry density and moisture content according to Part V.

If the mix is stiff (can be slip-formed), determine the standard density by averaging the 3 most recent field molded densities using plant mixed base material. Compact one standard mold (using plant mixed material with the proper moisture content) for each day's operation as specified in KT-37.

If the mix is fluid (requires forming), determine the Standard Dry Density by averaging the 3 most recent consolidated unit weight test results (KT-20). It will be necessary to convert the unit weight (wet density) into a standard dry density which also requires the percent of moisture (KT-11 (4) ) to be known. Use Equation 1 to determine the standard dry density.

**Equation 1:** $$\text{Standard Dry Density} = \frac{\text{Wet Density}}{(1 + [\%\text{Moisture} / 100])}$$

Determine the density of the CTB within 1 day of the compaction operations. The Engineer may verify the Contractor's density test results by conducting density tests at random. If the comparison is not favorable, the DME will investigate to determine the cause and may suspend production until corrective action is taken.

**e. Trimming and Finishing the CTB.** Trim and recompact the CTB within 2½ hours of the time the water and cementing agent is added to the aggregate.

Trim and compact the CTB to the grades, lines and typical cross sections shown in the Contract Documents. Dress the edge slopes and joints between sections.

Use automatic grade control equipment to trim the surface of the CTB to line grade and cross section.

Keep the surface of the CTB moist during all finishing operations.

Perform the finishing and compacting operations to produce a smooth, dense surface, free of surface compaction planes, cracks, ridges or loose material.

If required, lightly scarify the surface of the CTB to loosen any imprints left by the trimming and compacting equipment. Recompact the surface of the CTB.

At the end of each day's operations, construct a straight transverse construction joint by cutting back into the completed work to form a vertical face. Place a protective covering of earth on the newly constructed CTB a distance back of the joint for turning of equipment used on the following day's work.

Upon satisfactory performance, the Engineer may approve the use of equipment that combines the placing, compacting and finishing operations.

**f. Protection and Curing.** Keep the surface of the CTB moist until the curing material is applied. Apply the curing material immediately after completing the trimming and finishing. Protect the CTB against the loss of moisture for a curing period of 7 days (unless the Contractor's mix design test results justify a different curing period). Protect the CTB against freezing during the curing period.

Apply a wax-based liquid membrane-forming compound for the curing material. The minimum application rate for wax-based liquid membrane-forming compound is 0.12 gallons per square yard. Use an enclosed spray system that minimizes wind influence and obtains the proper application rate. Keep all traffic and construction equipment off the CTB. The only exception is the equipment used to apply the curing material. Cover the surface and edges of the CTB with a complete, uniform coverage. Use a hand sprayer in inaccessible areas.

If the wax-based liquid membrane-forming compound will be in place for more than 30 days, reapply a single coat at the single application rate within 7 days of placing the pavement.

At locations where it is necessary to carry traffic across the CTB, place a layer (8 inches or greater, compacted depth) of stable earth (sand-clay) over the CTB.

The Contractor may place portland cement concrete pavement (PCCP) on the CTB after a minimum of 24 hours, provided all traffic and construction equipment is kept off the CTB.

The Contractor assumes the risk of 7-day compressive strength requirements when PCCP is placed early.

To promote cracking through the full depth of the base, score or cut the finished CTB surface to coincide with the pavement joint locations, in a parallel manner and within 1 foot:

- if the 7-day compressive strength exceeds 1600 psi. (Note: This does not apply if the CTB has developed cracks at regular intervals prior to placing the PCCP.)
- if the Contractor opts to place the PCCP over the CTB before the 7-day compressive strength is determined. The Engineer may waive this requirement when the Contractor's control charts for CTB shows a history that the 7-day compressive strength is below 1600 psi.

**g. Compressive Strength Determination.** Using random numbers, select and obtain sampled material at the plant. Make and cure compression test specimens to represent each sublot. Make and cure compression test specimens, and determine the 7-day compressive strength of the CTB according to Part V. Sulfur cap compression test specimens in accordance with AASHTO T 231. When additional test specimens are taken for early determination of the compressive strength, the specimens are for information only. Perform the 7-day compressive strength testing. Maintain records of all sampling and testing. The Engineer will witness all compressive strength tests and initial the Contractor's documentation.

A percent within limits (***PWL***) analysis shall be made on a lot-by-lot basis and shall be based on Contractor quality control test results on all quality control samples representing the lot of the completed CTB. The ***PWL*** result shall be determined as specified under Computation of Pay Factor. Compute the pay adjustment as shown in Equation 2. It shall be based on the compressive strength values within each lot and the lower specification limits (***LSL***).

KDOT will use a spreadsheet program to calculate pay adjustments for compressive strength and to compare the Contractor's QC and KDOT's verification test results. If the comparison fails, KDOT's value will be used to calculate the pay adjustment for that lot. The lot comparison is based on KDOT's verification result falling within the Contractor's mean, plus or minus 2 times the Contractor's sample standard deviation. When the Contractor's sample standard deviation is less than 260 psi, then 260 psi shall be used for the sample standard deviation during lot comparison with KDOT's value. When there are 3 or more tests in a lot and when the lot comparison between Contractor and KDOT tests pass, the Contractor's actual standard deviation will be used to calculate the compressive strength pay factor. When requested, KDOT will provide a copy of this program to the Contractor. It is the Contractor's responsibility to obtain the software required to run this program.

Values computed using equations referenced in this specification may vary slightly from the spreadsheet values due to the rounding of numbers. In such cases, the numbers computed by the spreadsheet shall take precedence.

A typical lot is defined as a normal day's placement. At the beginning of the project, estimate the quantity to be placed during a normal day and submit to the Engineer for approval. Once approved, break the quantity into 4 equal parts (each part represents a sublot). Determine a random location for sampling within each sublot. When the total quantity for the day deviates from expectations, adjust the number of sublots based on **TABLE 306-1**.

**TABLE 306-1: SUBLOT BREAKDOWN OF A NORMAL DAY'S PRODUCTION**

| Number of Sublots | % of Daily Quantity |
|---|---|
| 4 | 75-115 |
| 3 | 50-74 |
| 2 | 25-49 |
| 1 | 1-24 |

Adjust the quantity of the last sublot to accommodate any minor changes in production, and adjust the random location for sampling based on the size of the sublot. When there is only 1 test in a lot, the pay factor will be automatically calculated by the KDOT spreadsheet using a sample standard deviation of 260 psi and n of 3. When there are 2 tests in a lot, the pay factor will be calculated by the KDOT spreadsheet using a spreadsheet calculated standard deviation and n of 3. When there are 3 or 4 tests, the lot stands on its own. Regardless of the number of Contractor tests in a lot, the lot comparison between Contractor and KDOT tests will apply. When the quantity exceeds 115% of the normal daily quantity, increase the number of sublots and restrict the $4^{th}$ sublot to a maximum of 100% of the established normal daily quantity. Each sublot added may have a maximum of 25% of the normal daily quantity.

Compute the sample standard deviation as shown in Section 5.2.1-Statistics, Part V.

Calculate the Compressive Strength Quality Indices ($\boldsymbol{Q_L}$) for each lot as shown in Section 5.2.1-Statistics, Part V. Use the following definitions, and round to the nearest hundredth.

Where: $\overline{X}$ is the average measured compressive strength of all QC samples representing a lot, rounded to 1.0 psi.

***LSL*** is the lower specification limit for compressive strength, defined as 650 psi.

***S*** is the sample standard deviation of the compressive strength of all QC samples representing a lot, rounded to 0.1 psi.

Determination of the percent within limits (***PWL***) values. Use the computed ***Q*** value to determine the compressive strength percent within limits value (***PWL$_C$***) by locating the ***Q$_L$*** values in the left column of the ***PWL*** Table in Section 5.2.1-Statistics, Part V. Select the appropriate ***PWL$_C$*** by moving across the selected ***Q$_L$*** to the column representing the number of samples in the lot.

When the computed ***Q$_L$*** is a negative value ($\overline{X}$ lies below the ***LSL***), the Engineer will determine if the material in the lot may remain in place. If the material is left in place, and there were no individual plugs found to be less than 600 psi, then 50.00 is assigned as the ***PWL*** value. For results exceeding these limits and permitted to remain in place, use the calculated ***PWL*** value.

When the computed ***Q$_L$*** is greater than the largest ***Q$_L$*** value shown in the table, a value of 100.00 is assigned as the ***PWL*** value for the designated ***PWL$_C$***.

Computation of Cement Treated Base Compressive Strength Pay Adjustment. Compute the pay factor for compressive strength using Equation 2 and round to nearest thousandth (0.001). Multiply the pay factor times the square yards, times $5.00 per square yard to determine the pay adjustment.

**Equation 2:**
$$P = \frac{(PWL_C \times 0.15)}{100} - 0.135$$

Cement Treated Base Compressive Strength Pay Factor (Failing Comparison Test). When the comparison between Contractor and KDOT tests fails, use KDOT test results to calculate the compressive strength pay factor for the lot. Follow the procedures as stated above to determine the pay factor or disposition of the lot. Use the following values to determine ***Q$_L$***: $\overline{X}$ of KDOT's test result for the lot, ***S*** of 260 psi, ***LSL*** of 650 psi. When selecting the ***PWL$_C$*** value from the ***PWL*** in TABLE 2, use ***n*** of 4.

**h. Weather Limitations.** Do not place material if the CTB will be exposed to ambient air temperatures below 32ºF during the first 7 days of cure. (See **subsections 306.4b., c.** and **f.**). Remove and replace all CTB that is permitted to freeze within the first 24 hours, whether frozen on the surface or full depth. When materials are exposed to freezing ambient air temperatures after the first 24 hours but before the 7 day cure period is complete, demonstrate that the 7 day design strength has been achieved. Failure to demonstrate the 7 day design strength has been achieved shall require removal and replacement at Contractor's expense.

As directed by the Engineer and at the Contractor's expense, repair or replace cured materials exposed to ambient air temperatures below freezing or repeated freeze/thaw cycles that result in loosening or fluffing of the surface.

A lift of pavement placed prior to exposure to freezing ambient air temperatures constitutes curing of the CTB.

Do not place material on frozen subgrade. Mixing and placing may proceed when the ambient air temperature is 40ºF and rising, and discontinue when the ambient air temperatures reaches 45ºF and falling.

**306.5 MEASUREMENT AND PAYMENT**

The Engineer will measure the CTB and quality control testing of CTB by the square yard. Material placed beyond the neat lines indicated in the Contract Documents is not measured for payment unless authorized by the Engineer.

Payment for "Cement Treated Base" and "Quality Control Testing (CTB)" at the contract unit prices is full compensation for the specified work.

No adjustment of the contract unit price for "Quality Control Testing (CTB)" is made for overruns or underruns in the contract quantity.

If the PCCP in the contract is specified as QC/QA, (Quality Control Testing (CTB) is included as a bid item), compressive strength pay adjustments will apply under the bid item "Cement Treated Base Compressive Strength Pay Adjustment", and will be shown as an added item to the contract.