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OHD L-53
METHOD OF TEST FOR
CEMENT-TREATED BASE MIX DESIGN

1. SCOPE.

1.1 This procedure determines the amount of Portland cement that needs to be added to a soil-aggregate to produce a cement-treated base. For the purposes of this procedure, the soil-aggregate is limited to materials meeting Section 701.15, “Aggregates for Econocrete Base”. Stabilization of finer materials is covered under OHD L-50.

1.2 Laboratories performing cement-treated base mix designs shall be qualified by the Materials Division.

2. DEFINITIONS. Cement-treated base (CTB) is defined as “an intimate mixture of native soils and/or manufactured aggregates with measured amounts of Portland cement and water that hardens after compaction and curing to form a strong, durable, frost resistant paving material,” (PCA, 2006).

3. APPARATUS. Apparatus to perform AASHTO T 134, “Moisture-Density Relations of Soil-Cement Mixtures, Method B” and ASTM D 1633 “Test Methods for Compressive Strength of Molded Soil-Cement Cylinders, Method A”, except for the mold. The mold used in this procedure is larger, and shall be either:

3.1 A calibrated cylindrical mold, solid or split, approximately 6 in. (150 mm) in diameter and 6 in. (150 mm) in height and having a volume of approximately 1/10 ft^3 (2.8 l). The mold shall be equipped with a removable top collar and removable base plate.

3.2 A calibrated CBR mold, conforming to AASHTO T 193, when used without the spacer disk, and either a non-perforated base plate or the perforations covered with a thin plastic sheet.

NOTE(1): 6” diameter Proctor molds are too short to produce suitable specimens for this method.

NOTE(2): It has been found that cured specimens are difficult to remove undamaged from solid wall molds. Split molds are strongly recommended.

3.3 It is desirable to have at least twelve (12) mold sets.

4. MATERIALS.

4.1 Soil-aggregate, mixing water, cement, and fly ash (if any) shall come from sources proposed for use on the project, and conform to current ODOT Specifications (Section 317, “Cement Treated Base”, and material specifications referenced therein).

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4.2 Hereafter, “cement” is intended to refer to Portland cement and/or fly ash.

4.3 Approximately 375 lbs (170 kg) of soil-aggregate, 10 gallons of water, and 30 lbs of cement are required for mix design.

4.4 Testing may be required prior to mix design to confirm compliance.

5. PROCEDURE.

5.1 The design criteria for CTB shall be that the average compressive strength of compacted and cured specimens is no less than 600 psi and no greater than 1200 psi. A target compressive strength of 700 psi is recommended.

NOTE(3): See Appendix 2 for comments regarding constructability.

NOTE(4): Durability (i.e. wet/dry and freeze/thaw durability) is not explicitly considered in this procedure. It is intended for later versions of this procedure to include the option of durability testing. It is generally believed mixes with compressive strengths greater than 600 psi are durable.

NOTE(5): Cement-treated bases with compressive strengths in this range are prone to shrinkage cracking, which may reflect through surface layers. This is currently being addressed with a bond-breaking layer between the CTB and surface layer.

5.2 The soil-aggregate material is sampled, air-dried, and processed. A representative portion is tested for gradation and Atterberg limits, and the material is classified.

5.2.1 Sampling shall be in accordance with AASHTO T 2.

5.2.2 Air-drying and processing shall be in accordance with AASHTO T 87.

5.2.3 Gradation testing shall be in accordance with AASHTO T 88, or T 11 and T 27.

5.2.4 Atterberg limit testing shall be in accordance with AASHTO T 89 and T90.

5.2.5 Classification shall be in accordance with AASHTO M 145.

5.3 Initial cement content is estimated based on the soil-aggregate classification.

NOTE(6): Aggregate for econocrete base will generally be classified as A-1-a.

NOTE: This Document has been Replaced

AASHTO Soil Group	Cement content for initial moisture-density test (% by mass)	Cement contents for compressive strength specimens (% by mass)
A-1-a	4	2, 4, 6
A-1-b	6	4, 6, 8
A-2	7	5, 7, 9
A-3	8	7, 9, 11

5.4 Determine the optimum moisture content and maximum standard density by compacting specimens prepared at the cement content shown in the second column of the above table. Follow the procedure in AASHTO T 134, Method B, except with the following modifications:

5.4.1 Material up to 1½" is used.

NOTE(7): Material this coarse is not normally used with specimens of this size. The largest material is either "scalped and replaced" or "scalped and corrected". The Kansas version of this procedure uses 1½" material, without comment. It is intended for later versions of this procedure to address this issue, possibly by the "hand-placing" method of Texas' Tex-113-E.

5.4.2 The compactive effort shall be produced by either:

5.4.2.1 For the 6 x 6 mold, 56 blows and 4 lifts.

5.4.2.2 For the CBR mold (6 x 7), 86 blows and 3 lifts.

5.4.3 Material shall not be reused.

5.4.4 Cement application method shall be consistent with project plan notes. If no method is specified, the dry method shall be used. If the slurry method is specified, the cement slurry is prepared by thoroughly mixing equal masses of cement and water.

5.4.5 As the mixture for each layer is placed in the mold, spade along the inside of the mold with a butcher knife or spatula before compaction to obtain uniform distribution of the material retained on the No. 4 (4.75-mm) sieve. Scarify the tops of the layers to remove smooth compaction planes before placing and compacting the succeeding layers.

5.5 Specimens for unconfined compression testing shall be compacted at the optimum moisture content determined above, with cement contents listed in the last column of the table above.

5.5.1 Mold specimens in accordance with ASTM D 1633 Method A, except as modified by section 5.4 of this procedure.

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5.5.2 Prepare three specimens at each cement content. Additional specimens may be molded for replicate testing, or as backup specimens.

5.5.3 Adjust the molding water content for cement content by adding or subtracting 0.25% water for each 1% difference in cement content from the initial estimate. For example, if the initial estimated cement content is 5%, for samples molded with 7% cement, add (7- 5) x 0.25 = 0.5% water.

5.5.4 After molding, weigh the specimen and mold, and calculate the as-molded oven-dried mass of the specimen.

5.5.5 Cure the specimens in the molds in the moisture room for 16 hours (overnight), or longer if required, to permit subsequent removal from the molds using the sample extruder. Return the specimens to the moisture room, but protect from dripping, spraying, or pooled water for the remainder of the 7-day moist curing period. Alternatively, the specimens may be wrapped in plastic, covered with wet cloths, and placed in an ice chest in a controlled temperature room (heated and air-conditioned).

5.6 Cured specimens are tested for unconfined compressive strength. Determine the 7-day unconfined compressive strength in accordance with ASTM D 1633, Method A.

NOTE(8): ASTM D 1633 requires that cured specimens be immersed in water for 4 hours before testing. This step shall be omitted.

5.6.1 Before compression testing, blot the specimen surface dry, and weigh to determine the wet final mass. Minimize moisture changes until testing is completed.

5.6.2 After testing, use the entire specimen to determine the moisture content.

5.6.3 Record the oven-dried final mass of the specimen and calculate the moisture content.

5.6.4 The unconfined compressive strength is the load at failure divided by the cross-sectional area of the specimen.

NOTE(9): For the purposes of this method, strength determined for specimens of a height/diameter ratio (uncapped) of 1.0 is considered to be standard, and is not corrected.

5.6.5 Calculate the average strength for each cement content.

NOTE: This Document has been Replaced

6. DESIGN CEMENT CONTENT.

6.1 The design cement content is defined as the minimum cement content required to achieve the target unconfined compressive strength.

6.2 The minimum cement content shall not be less than the amount required to achieve 700 psi (or a value prescribed by the Pavement Engineer). This value may be interpolated between test results.

6.3 If a specimen breaks or crumbles prior to compression testing, it shall be considered to have failed, and the minimum cement content shall be the next highest molded cement content.

6.4 The design cement content shall be the maximum of “A” and “B” above, except:

6.4.1 The design strength shall be no more than 1200 psi, and

6.4.2 The cement content shall be no more than 15%.

6.5 Determine the optimum moisture content and maximum standard density at the design cement content, as in section 5.4. This is not necessary if the design cement content is the same as the cement content used in the initial optimum moisture and density determination.

7. REPORT.

7.1 The report shall include the identification of the project number.

7.2 The report shall include identification of the aggregate material and cementitious materials. Include the Department’s Producer/supplier code and naming convention shown in the Department’s website.

7.3 The report shall include; gradation, the optimum moisture content, maximum density, design cement content and average unconfined compressive strength at design values. Include a single-point gradation for the combined aggregates with a plus/minus tolerance for each sieve.

7.4 The report shall reference the procedures used, and satisfy the reporting requirements of the referenced procedures.

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8. REFERENCES:

Portland Cement Association (PCA). “Soil-Cement Laboratory Handbook”, 1992.

Portland Cement Association (PCA). “Minimizing Cracking in Cement-Treated Materials for Improved Performance”, R&D Bulletin RD123, 2002.

Portland Cement Association (PCA). “Guide to Cement-Treated Base (CTB)”, 2006.

Texas Transportation Institute (TTI). “Selecting Optimum Cement Contents for Stabilizing Aggregate Base Materials”, FHWA/TX-05/7-4920-2, 2001.

Personal conversation with Dr. Naji Khoury, University of Oklahoma, 31 January 2008.

Roper, M. B. “Evaluation of Laboratory Durability Tests for Stabilized Aggregate Base Materials”, Masters Thesis, BYU, 2007.

APPENDIX 1: DURABILITY AND MIX DESIGN EVALUATION

Within the framework of the current Mix Design Practice, there have been assumptions made concerning in-place properties of the CTB. As this material begins to be utilized in projects, there is opportunity to evaluate properties of CTB incorporated into the work. Properties of interest include: durability, cracking, in-place strength or modulus, and other issues that may become apparent. As testing and evaluation of samples or completed work can be conducted, the knowledge should be utilized for the development of revisions' to practice and for design guide inputs.

Project time constraints may limit review of mix design for approvals to a basic evaluation of the mix design report. Approvals at a minimum shall consider the following factors:

- Utilization of approved materials (aggregates, cementitious materials)
- Approved Laboratory status
- Use of proper equipment and procedures
- Complete reporting of required properties in section 8.

If the review identifies concerns or potential problems, or as time permits, the Department may request samples for further evaluation. Samples of materials from the project site may also be obtained for durability testing and evaluation of the mix design procedure. In-place, compacted properties may also be evaluated.

APPENDIX 2: CONSTRUCTABILITY

Construction methods are beyond the scope of this procedure. Some mixes may satisfy all of the requirements of this procedure, yet present problems in construction (inadequate density or strength). These problems may be due to both the mix or to the placement method chosen by the contractor or both.

In general, CTB tends to be fairly dry, and have a low slump. Methods used to place Portland cement concrete may not be appropriate, particularly when using coarse soil-aggregate gradations.

Revision Date	Revision Description
3/19/2009	Section 5.6.4: Removed correction factors for specified CTB mold sizes.
	Added Note 9 explaining the change. Improves agreement with ASTM D 1633.
	Section 8.3: Added requirement for single point gradation submittal.
	Editorial and format changes.
	Added notes 1 and 2.
	Section 5.5.5, Changed curing time from 12 hrs to 16 hrs (overnight).
	Section 6.2, added interpolation between test results.
7/24/2009	Added Note(3) to reference Appendix 2, renumbered following notes.
	Added to 5.6.1: “Minimize moisture changes…”
	Added Note(8) to omit immersion of specimens, renumbered following notes.
	Added Appendix 2 to address constructability/gradation issues.