Standard Specification for

Reclaimed Concrete Aggregate for Unbound Soil-Aggregate Base Course

AASHTO Designation: M 319-02

1. SCOPE

1.1 This specification covers the use of reclaimed concrete aggregate as an unbound granular base course material. When properly processed, hauled, spread, and compacted on a prepared grade to appropriate density standards, reclaimed concrete aggregate used alone or blended with natural or crushed aggregate can be expected to provide adequate stability and load support for use as road or highway base courses. The approach presented in this specification is suitable for the satisfactory installation of a reclaimed concrete aggregate base course. However, local experience, practices, or materials that have been successfully applied may be used in lieu of this specification. This specification is not intended for use in base courses in locations where surfacing will not be placed over the base course.

1.2 Since reclaimed concrete aggregate is a recycled material, various state and local jurisdiction laws and regulations may be applicable. The user of this specification is cautioned to contact state and local environmental and other local regulators to determine what requirements are appropriate.

1.3 The values stated in SI units are to be regarded as the standard. The English unit equivalents shown in parentheses may be appropriate, except with regard to sieve sizes and aggregate size as determined by the use of testing sieves, in which case the standard SI designation shown is the standard, as required by M 92.

Note 1 — The engineer is cautioned to provide appropriate construction specifications to ensure compaction to an extent that further densification of the compacted pavement from traffic loadings will be insignificant. At the time of placement, the reclaimed concrete aggregate material shall contain moisture approximately equal to the optimum moisture content necessary to make certain that the design density requirements are obtained when the material is compacted. Reclaimed concrete aggregate can be expected to exhibit higher absorption than natural aggregate materials. Accordingly, the engineer should expect to experience moderately higher optimum moisture content values than would be expected with natural aggregate materials. The reclaimed concrete aggregate shall be compacted using vibratory or other proven effective rollers or tampers to achieve the required density results. Further discussion of compaction issues is presented in Appendix A.

Note 2 — The engineer should be aware of the highly alkaline nature of reclaimed concrete aggregate, the relatively high degree of solubility of these alkaline materials, and the potential increase in pH that could occur in waters percolating through a reclaimed concrete aggregate base. Depending on the sensitivity of local soils, surface waters, and groundwater to the presence of alkaline material, the engineer should set appropriate limits on the proximity of placement of reclaimed concrete aggregate relative to groundwater and surface waters. Additionally, the presence of water percolating through reclaimed concrete aggregate will induce a corrosive solution with a pH of approximately 11 to 12. Therefore, reclaimed concrete aggregate shall not be used in the vicinity of metal culverts such as aluminum culverts that are sensitive to highly alkaline environments.

Note 3 — The engineer is cautioned to prevent, or minimize when possible, the use of reclaimed concrete aggregate over a geotextile drainage layer, gravel drain fields, drain field piping, or open soil-lined stormwater retention or detention facilities. Soluble minerals rich in calcium salts and...
calcium hydroxide can be hydraulically transported from the reclaimed concrete aggregate material. When this occurs and the reclaimed concrete aggregate is located above such porous drainage systems, there is a tendency for the referenced minerals to precipitate out of solution and bind the drainage structure. The mineral deposits formed are sometimes referred to as tufa-like or portlandite deposits. Over time the permeability of the drainage system can be reduced. Further discussion of this topic and recommended drainage evaluation procedures are presented in Appendix B.

Note 4—The engineer should be aware that reclaimed concrete aggregate used as base course could, with time, gain strength and exhibit a corresponding loss of permeability in the base course layer. This is due to residual cementitious reactions in the concrete material. If the base course is intended for use as a drainage layer, then the fine portion of the reclaimed concrete aggregate should be removed or modified to reduce the potential for this occurrence.

Note 5—The engineer is cautioned that some reclaimed concrete aggregate materials will yield high soundness loss values when subjected to conventional sulfate soundness testing methods, and such testing methods may not be suitable for reclaimed concrete aggregate soundness testing. Further discussion of this topic is presented in Section 6.3 and Appendix C.

Note 6—The engineer is cautioned to ensure that reclaimed concrete source materials are not contaminated with extraneous solid waste or hazardous materials. Methods and criteria for examining and approving reclaimed concrete materials prior to use should be established by the specifying jurisdiction. This provision is further addressed in Section 7.3.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
- M 92, Wire-Cloth Sieves for Testing Purposes
- M 146, Terms Relating to Subgrade, Soil-Aggregate, and Fill Materials
- M 147, Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses
- T 2, Sampling of Aggregates
- T 11, Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 87, Dry Preparation of Disturbed Soil and Soil-Aggregate Samples for Test
- T 88, Particle Size Analysis of Soils
- T 89, Determining Liquid Limit of Soils
- T 90, Determining Plastic Limit and Plasticity Index of Soils
- T 96, Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- T 99, Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- T 103, Soundness of Aggregates by Freezing and Thawing
- T 104, Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
- T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- T 180, Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- T 193, The California Bearing Ratio
- T 292, Resilient Modulus of Subgrade Soils and Untreated Base/Subbase Materials

2.2. ASTM Standards:
- D 2940, Graded Aggregate Material for Bases or Subbases for Highways and Airports
- D 5101, Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio

2.3. Additional Standards:
3. DEFINITIONS

3.1. The definitions of base course and other soil aggregate terms are given in M 146. For use in this specification, base course shall mean the uppermost unbound granular layer of the pavement structure. The definition for reclaimed concrete aggregate as used in this specification is a manufactured aggregate material that is derived from the crushing, processing and classification of Portland cement concrete construction debris recovered from roadways, sidewalks, buildings, bridges, and other sources.

4. ORDERING INFORMATION

4.1. The purchaser or specifier shall include the following information in the purchase order or contract documents:

4.1.1. Reference to this specification, including year,
4.1.2 Grading to be furnished for the granular base,
4.1.3 Soundness testing requirements,
4.1.4 Exceptions or additions to this specification.

5. GRADING AND PROPORTIONS

5.1. Reclaimed concrete aggregate or reclaimed concrete aggregate combined with other approved natural or man-made aggregate materials shall comply with the gradation requirements of M 147, ASTM D 2940, or the requirements of the specifying jurisdiction.

5.2. If the contractor/supplier wishes to use combinations of reclaimed concrete aggregate or reclaimed concrete aggregates with other approved aggregate materials, a request shall be made to the engineer for approval. The percentage of materials shall be established as part of a pre-submitted blended aggregate combination. In cases where the contractor/supplier wishes to change the approved combination, a special request for approval shall be made to the engineer. At the engineer's discretion, revised density acceptance testing shall be required.

5.3. When the engineer permits the contractor/supplier to combine reclaimed concrete aggregate with other approved aggregates, this shall be accomplished by mechanical interlock blending or belt blending to ensure uniform mixing. The contractor/supplier may use other methods of blending if it can be demonstrated to the engineer that the alternate blending method will prevent segregation.

6. PHYSICAL PROPERTIES

6.1. Reclaimed concrete aggregate shall consist of crushed concrete material and natural aggregate particles derived from the crushing of portland cement concrete that are hard, durable fragments of stone, gravel, slag, crushed concrete, or sand.

6.2. Reclaimed concrete aggregate shall be limited in plastic soils such that the minus 0.425-mm (No. 40) sieve material when tested for liquid limit (T 89) shall not be greater than 30 and the plasticity index (T 90) shall not be greater than four, and/or at the discretion of the engineer, the sand equivalent value
(T 176) of the minus 0.425-mm (No. 40) sieve material shall be a minimum of 25 percent.

Reclaimed concrete aggregate shall have a percentage of wear by the Los Angeles abrasion test (T 96) of not more than 50 percent.

6.3. Reclaimed concrete aggregate shall have a percentage of wear by the Los Angeles abrasion test (T 96) of not more than 50 percent.

6.4. Reclaimed concrete aggregate soundness testing shall be required at the discretion of the engineer. Appendix C lists the permissible alternative soundness test methods and acceptance criteria (See Note 5.)

7. **DELETERIOUS SUBSTANCES**

7.1. Reclaimed concrete aggregate shall contain not more than five percent bituminous concrete materials by mass. (See Note 7.)

7.2. Reclaimed concrete aggregate shall contain not more than five percent brick by mass. (See Note 7.)

7.3. Reclaimed concrete aggregate material shall be free of all materials that fall under the category of solid waste or hazardous materials as defined by the state or local jurisdiction. (See Note 8.)

7.4. Reclaimed concrete aggregate shall be substantially free of wood, metal, plaster, and gypsum board, when these materials are not classified as solid waste as defined in Section 7.3. (See Notes 8 and 9.)

**Note 7**—If the engineer wishes to specify reclaimed concrete aggregate material where the percentages of bituminous concrete and/or brick exceed those shown above, an evaluation method for approving higher percentages is presented in Appendix D.

**Note 8**—The engineer may select stockpiling as an approach to assist in qualitatively identifying the presence of deleterious materials. Stockpiling can also be used as a means to qualitatively assess the uniformity of the material. When such an approach is used, the stockpile may represent all or part of the material to be used on a project, and should be constructed in a manner that will minimize segregation and permit a complete visual examination of the material.

**Note 9**—Substantially free, in the context of this specification, shall mean percentages of undesirable materials that are less than the following: wood—0.1 percent maximum; metals—0.1 percent maximum; plaster and gypsum board—0.1 percent maximum. At the engineer's discretion these respective quantities may be adjusted if, in the engineer's opinion, such adjustment will not impact the performance of the base course.

8. **METHODS OF SAMPLING AND TESTING**

8.1. Sample and test the aggregate in accordance with the following standard methods of the American Association of State Highway and Transportation Officials, except as otherwise provided in this specification.

- T 2, Sampling
- T 11, Elutriation
- T 27, Grading
- T 87, Sample Preparation
- T 88, Particle Size Analysis
- T 89, Liquid Limit
- T 90, Plastic Limit and Plasticity Index
- T 96, L.A. Abrasion
- T 104, Aggregate
- T 176, Sand Equivalent Test
APPENDIX A—DENSITY CONTROL METHODS FOR RECLAIMED CONCRETE MATERIALS

Nonmandatory Information

A1.1. The traditional method to control density is to perform a proctor test and compare in-place density values with the maximum dry density. Procedural methods have also been used and are based on the performance of standard compaction techniques performed for a designated number of passes, and are usually based on the experience of the specifying agency. In this second approach, once the required numbers of passes are made, the lift is accepted. Both of the previously referenced methods have been successfully applied to reclaimed concrete materials. If reclaimed concrete from different sources is used on a specific job site, however, or if the reclaimed concrete is blended with other natural or manufactured aggregates, density control problems may result. An alternate compaction control method to account for variations in the specific gravity of reclaimed concrete aggregate is presented below.

A1.2. This alternative field control method allows for variations in source materials and automatically adjusts for those changes to ensure maximum compaction of the reclaimed concrete material in the field. In overview, the procedure involves the use of a variable acceptance criteria for compaction based on testing on each designated lot and sublet on a project site. The compaction equipment and compaction practices shall be approved by the engineer. After placing the initial lot at approximately its optimum moisture content as determined in the laboratory, the acceptance degree of compaction is established by measuring the density of the compacted material between each pass of the compaction equipment and continuing such equipment passes until there is no longer an increase in the density. The lift density established in this manner then becomes the acceptance criteria and the lift has met that value and is accepted. All subsequent lots and sublets are placed at or near the moisture content of the first lot and tested in a similar manner. The following is a step-by-step description of this test method.

A.1.2.1. Lot and Sublet Description and Size—For purposes of control of the compaction of reclaimed concrete aggregate for base course, the base material shall be divided into lots, each of which shall represent approximately 5,000 square meters (5,980 square yards) of base course, or the amount that is placed in one day, whichever is less. When more than one shift is performed on a given day, the engineer may use each shift to define a lot. Each lot will be further subdivided into four sub-lots of approximately 1,250 square meters (1,490 square yards) each or for smaller lots into four sub-lots of approximate equal size.

A.1.2.2. After the initial sublet is laid down and moisture is added to achieve a moisture content approximately at the optimum moisture content as determined in the laboratory, a testing plan shall be defined for the measurement of in-place density in at least four different locations in each sublet. The sublet will be compacted and tested for density after each pass. After each of the four locations is tested, the lift shall be compacted with one or more additional passes. After each compaction pass in-place density testing will again be performed. This sequence shall continue until there is no significant increase or decrease in the density of the lift as the result of an additional pass. In-place density testing shall be performed using an approved testing method. For reasons of this specification, the term "compaction pass" shall mean the passing of the compaction equipment over the entire lot surface one complete time.

A.1.2.3. When the compaction described in the Section A1.2 has been achieved, the base course lot shall be considered to be compacted adequately. Such testing shall be ongoing until the project is completed.
APPENDIX B—TUFA-LIKE DEPOSITS

Nonmandatory Information

B1.1. Portland cement concrete contains among other minerals a mix of complex calcium salts and calcium hydroxide that can be highly soluble. Once in solution these minerals will remain so until the conditions of solubility change. This may occur as the result of the evaporation of water, thus resulting in the minerals having a solubility concentration above the solubility constant for that mineral, if temperature conditions change or in the presence of other compounds, such as carbon dioxide, that may react with these minerals to promote precipitation. The resulting mineral deposits are commonly referred to as tufa-like or portlandite deposits. Such deposits may affect the permeability of the geotextiles, gravel drain fields, drain field piping, or open soil-lined stormwater retention or detention facilities placed downgradient of the reclaimed concrete aggregate base. If the supplier wishes to use reclaimed concrete aggregate in the vicinity of geotextiles or fine-grained drainage layers the following evaluation and acceptance criteria are recommended.

B1.1.1. Validation of geotextile or fine-grained drainage layer permeability by field experience. The supplier may submit evidence to the engineer that the same reclaimed concrete aggregate material has performed satisfactorily with the same geotextile or fine-grained drainage layer to be used on the project for a period of at least three years with no perceptible reduction in the permeability of the geotextile.

B1.1.2. Validation of geotextile or fine-grained drainage layer clogging potential by use of comparative permeability testing. The effect of tufa-like deposition on the permeability of geotextiles or finegrained drainage layers may be determined by use of ASTM D 5101. To determine the potential for geotextile or fine-grained drainage-layer clogging using this method, a control sample (e.g., natural aggregates and geotextile or fine-grained drainage layer) and the reclaimed concrete aggregate and geotextile or fine-grained drainage layer should be tested and compared. During this test the permeability of the natural aggregate-geotextile or fine-grained drainage-layer combination and the reclaimed concrete aggregate-geotextile or fine-grained drainage-layer combination should be recorded after less than one week of flow through testing as described in the ASTM specification, and after 12 weeks of flow through testing. The degree to which reclaimed concrete aggregate might impact a geotextile or fine-grained drainage layer can be assessed by comparing the results of reclaimed concrete aggregate testing and that of a control material to determine the relative impact of using reclaimed concrete aggregate above a geotextile or fine-grained drainage layer. A reduction in permeability by 10 percent or more over the 12-week time period of the reclaimed concrete aggregate sample relative to the control sample would suggest a measurable impact.

APPENDIX C—SOUNDNESS TESTING OF RECLAIMED CONCRETE AGGREGATE

Nonmandatory Information

C1.1. Reclaimed concrete aggregate can be susceptible to sulfate attack when it is tested for soundness using sodium sulfate or magnesium sulfate solution, resulting in high loss values, particularly when sodium sulfate solution is used. Sulfate solution test methods (T 104) may be applied if local experience has found these methods to be satisfactory; however, alternative approaches are available if sulfate solution testing is found to exhibit high-loss values.

C1.2. Alternative Test Approaches include the following:

C1.2.1. The No-Test Alternative—This approach accepts the reclaimed concrete aggregate based on the other quality measures and waives the soundness requirements.
C1.2.2. *AASHTO T 103*—This approach uses a freeze-thaw procedure in water with 25 freeze-thaw cycles and a maximum allowable loss of 20 percent.

C1.2.3. *New York State DOT, Test Method NY 703-08*—This approach uses a test sample saturated in a three percent sodium chloride brine solution and a maximum allowable loss of 20 percent.

C1.2.4. *Ontario Ministry of Transportation (MOT), Test Method LS-614*—This approach uses a three percent sodium chloride brine solution with five freeze-thaw cycles and a maximum allowable loss of 20 percent.

**APPENDIX D—PROVISIONS FOR USING EXCESS BITUMINOUS CONCRETE OR BRICK**

Nonmandatory Information

D1.1. If the engineer wishes to use higher percentages of bituminous concrete or brick in the base course material, permitted in Sections 7.2 and 7.3, respectively of this specification, then one or more of the following performance acceptance criteria is recommended:

D.1.1.1. Validation by use of California Bearing Ratio (AASHTO T 193) testing—The engineer should compare California Bearing Ratio test results conducted on a control sample, consisting of reclaimed concrete aggregate material that complies with granular base specifications, to the blend of reclaimed concrete aggregate that contains the higher percentage of bituminous concrete and/or brick the supplier wishes to use on the project. If the California Bearing Ratio value for the reclaimed concrete aggregate and bituminous concrete and/or brick combination is equal to or greater than that for the control material, then the higher percentage of bituminous concrete and/or brick combination may be used.

D.1.1.2. Validation by use of Resilient Modulus (AASHTO T 292) testing—The engineer should compare the results of Resilient Modulus testing on a control sample, consisting of reclaimed concrete aggregate material that complies with the granular base specifications, to the reclaimed concrete aggregate material plus the percentage of bituminous concrete aggregate or brick material that the supplier wishes to use on the project. Three tests for each condition shall be performed and the values averaged. If the average Resilient Modulus value for the reclaimed concrete aggregate and bituminous concrete and/or brick combination is equal to or greater than the average value for the control material alone, then the higher percentage of bituminous concrete and/or brick combination may be used.

D.1.1.3. Validation by field application—The engineer shall show by constructing a test strip or introducing historical data that incorporating percentages of bituminous concrete and/or brick into reclaimed concrete aggregate that are higher than permitted in this specification does not adversely affect the performance of the granular base.