



Oregon

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January 1, 2026

To: All Holders of the Manual of Field Test Procedures

From:  Justin G. Moderie, P.E., G.E.

State Construction and Materials Engineer

Subject: 2026 Revision of the Manual of Field Test Procedures

Enclosed is the 2026 revision to the Manual of Field Test Procedures. The revision package also includes a document providing a general list of the associated changes based on the layout of the Manual of Field Test Procedures. The revisions are based on comments from the Quality Assurance Steering Committee, Construction Training Coordinator, Quality Control Compliance Specialists and industry material testing technicians.

The change package affects contracts advertised after this change date; any contract advertised prior to this change package falls under the appropriate MFTP change for that advertisement date. AASHTO test procedures are to be followed according to the latest MFTP change or the appropriate AASHTO test version to date. ODOT and WAQTC test procedures are in effect for the date the contract is advertised and may be modified to the new update change package through a Contract Change Order established by the Project Manager.

Note: The MFTP publication release date has changed to January 1. This replaces the previous December annual publication date. This 2026 edition covers updates for 2026.

The following pages identify the appropriate add and remove sequence necessary to update the 2024-2025 version of the MFTP. If an earlier version is being updated, then the appropriate update package will need to be applied before utilizing the enclosed documents.

To place these pages in your book, start with the package of white pages and do the following:

*****FIRST*****

INTRODUCTION TAB

REMOVE

ADD

COMMENTS

Introduction (24) Pg. 1~4

Introduction (25) Pg. 1~5

See Change Sheet for Details

SECTION 1 TAB (Test Procedures)

REMOVE

ADD

COMMENTS

INDEX (24) Pg. 1 & 2

INDEX (25) Pg. 1 & 2

Updated for 2025 Procedures

ODOT TAB (Test Procedures)

REMOVE

ADD

COMMENTS

None

None

None

AASHTO TAB (Test Procedures)

(Note: FOP Replacement is based on the procedure date, upper Rt. corner of document. Official AASHTO designated procedures publish date is identified on the procedure cover page).

REMOVE

ADD

COMMENTS

AASHTO T 19 (24) Pg. 19-1~19-9

AASHTO T 19 (25) Pg. 19-1~19-8

See Change Sheet for Details

AASHTO T 22 (22) Pg. 22-1~22-13

AASHTO T 22 (25) Pg. 22-1~22-13

“ “ “ “ “

AASHTO T27/11 (24) Pg. 12-1~12-40

AASHTO T 27/11 (25) Pg. 12-1~12-40

“ “ “ “ “

AASHTO T 30 (24) Pg. 20-1~20-11

AASHTO T 30 (25) Pg. 20-1~20-11

“ “ “ “ “

AASHTO T 84 (22) Pg. 84-1~84-10

AASHTO T 84 (25) Pg. 84-1~84-10

“ “ “ “ “

AASHTO T 85 (22) Pg. 16-1~16-6

AASHTO T 85 (25) Pg. 16-1~16-6

“ “ “ “ “

AASHTO T 99/180 (22) Pg. 8-1~8-16

AASHTO T 99/180 (25) Pg. 8-1~8-16

“ “ “ “ “

AASHTO T 166 (24) Pg. 18-1~18-8

AASHTO T 166 (25) Pg. 18-1~18-8

“ “ “ “ “

AASHTO T 196 (23) Pg.196-1~196-11

AASHTO T 196 (25) Pg.196-1~196-11

“ “ “ “ “

AASHTO T 209 (23) Pg. 17-1~17-10

AASHTO T 209 (25) Pg. 17-1~17-10

“ “ “ “ “

AASHTO T 231 (17) Pg. 231-1~231-9

AASHTO T 231 (25) Pg. 231-1~231-9

“ “ “ “ “

AASHTO T 255/265 (24) Pg. 12-1~12-8

AASHTO T 255/265 (25) Pg. 12-1~12-8

“ “ “ “ “

AASHTO T 272 (24) Pg. 15-1~15-8

AASHTO T 272 (25) Pg. 15-1~15-10

“ “ “ “ “

AASHTO T 308 (24) Pg. 16-1~16~14

AASHTO T 308 (25) Pg. 16-1~16-14

“ “ “ “ “

AASHTO R 47 (23) Pg. 14-1~14-5

AASHTO R 47 (25) Pg. 14-1~14-6

“ “ “ “ “

AASHTO R 76 (24) Pg. 10-1~10-8

AASHTO R 76 (25) Pg. 10-1~10-8

“ “ “ “ “

AASHTO R 90 (22) Pg. 9-1~9-6

AASHTO R 90 (25) Pg. 9-1~9-6

“ “ “ “ “

WAQTC TAB (Test Procedures)

REMOVE

ADD

COMMENTS

WAQTC TM 2 (21) Pg. 9-1~9-4

WAQTC TM 2 (25) Pg. 9-1~9-4

“ “ “ “ “

SECTION 2 TAB (QA Program)

REMOVE

ADD

COMMENTS

Cover Sheet & Table of Contents (24)
QA Program (24) Pg. 1-27

Cover Sheet & Table of Contents (25)
QA Program (25) Pg. 1-27

See Change Sheet for Details

“ “ “ “ “

SECTION IA TAB

REMOVE

ADD

COMMENTS

QA Program (24) Pg. 28-56

QA Program (25) Pg. 28-56

See Change Sheet for Details

SECTION 3 TAB (Report Forms & Examples)

REMOVE

ADD

COMMENTS

734-2327_IC (10-2020) & Example
734-3573 (11-2024) & Example

734-2327_IC (12-2025) & Example
734-3573 (12-2025) & Example

“ “ “ “ “
“ “ “ “ “

SECTION 4(D) TAB (Acceptance Guide)

REMOVE

ADD

COMMENTS

None

None

N/A

SECTION 5 “Green” TAB (Acceptance Guide)

REMOVE

ADD

COMMENTS

None

None

N/A

*****SECOND*****

Take the yellow packet and place or remove the yellow sheets in front of the appropriate test method.

AASHTO TAB

REMOVE

ADD

COMMENTS

Yellow Sheet T 310 (23)
Yellow Sheet T 355 (23)
Yellow Sheet R 100 (23)

Yellow Sheet T 310 (25)
Yellow Sheet T 355 (25)
Yellow Sheet R 100 (25)

See Change Sheet for Details
“ “ “ “ “
“ “ “ “ “

WAQTC TAB

REMOVE

ADD

COMMENTS

None

None

None

The yellow sheet letters provide additional information for the test procedure or define which method in a test procedure to use for ODOT projects.

FORMS

The forms to use on ODOT construction projects are available in Microsoft Excel format. These forms can be copied from the forms included herein or accessed and downloaded from our website at: <http://www.oregon.gov/ODOT/Construction/Pages/Forms.aspx>

We in the ODOT Construction Section welcome your questions, comments, or suggestions concerning this Manual. We will consider your input for future modifications to the Manual.

MFTP 2026 Update

Summary of Changes

Introduction – added to the list of Acronyms and Definitions

- “Abuse” - Knowingly deviating from approved procedures or when the technician should have known they were deviating from approved procedures.
- “Negligence” - Unintentional deviations from approved procedures that may or may not cause erroneous results.
- “Smartly” - quickly and usually done with force.
- “SQAC” - Senior Quality Assurance Coordinator.
- “SrQAE” - Senior Quality Assurance Engineer.

Section 1 – Test Procedures Index

This section was updated according to the test procedure date changes.

ODOT – Test Procedures

No Changes

AASHTO – Test Procedures

All the FOPs (WAQTC) for AASHTO test procedures have a revision date located in the upper right-hand corner and a publishing date at the lower right-hand corner of the document. The publishing date will change each year, but the test procedure date only changes with major content related modifications, not editorial corrections.

Other AASHTO test procedures in this section are from the AASHTO organization and won't have a WAQTC FOP reference and can be identified by the cover sheet with associated AASHTO official title.

T 19 (Bulk Density (“Unit Weight”) and Voids in Aggregate) - The cover sheet has been updated to reflect the new 2025 version of the procedure. There were minor changes to the procedure.

The following bullets identify additions, deletions, or modifications to the procedure:

- Section 1.3, last sentence was modified and the word Environmental was added
- Section 7.1, Third Sentence was modified from 1 h to one hour
- Section 8.7, The Following have been modified.
 - Calculate the Volume has been changed to “as described in Section 13.3.”

Minor formatting and editorial items were also addressed.

T 22 (Compressive Strength of Cylindrical Concrete Specimens) – The Cover sheet has updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Section 1.3, last sentence was modified and the word Environmental was added
- Section 1.5, first sentence the word “are” was changed to “is”

- Referenced Documents R39 and R100 has Changed the Verbiage from “Making” to “Casting”.
- Referenced Documents R100 added the word “strength”
- Section 6.2 Second Sentence changed from “3 Percent” to “Three Percent”
- Several Items Updated in Section 11, Precision and Bias.

Minor formatting and editorial items were also addressed.

T 27/11 (Sieve Analysis of Fine and Coarse Aggregates) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Verbiage changed to “Do not overload Sieves”
- Add note ‘See AASHTO T 11 Annex A for Mechanical Washer Comparison if there is potential aggregate degradation.

Minor formatting and editorial items were also addressed.

T 30 (Mechanical Analysis of Extracted Aggregate) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Add ‘If necessary, dry the sample to constant mass according to the FOP for AASHTO T 255.’
- Add new Note 1: If more than 24 hr. has passed after completion of the FOP for AASHTO T 308, the sample may have absorbed moisture.’
- Add ‘This is not more than 0.1 percent therefore the results can be used for acceptance purposes.’ to Example Mass Verification.
- Annex B – Added Multiple items regarding Sieve overload Determination.

Other Minor formatting and editorial items were also addressed.

T 84 (Specific Gravity and Absorption of Fine Aggregate) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Section 10.1 Updated the Gravity Calculation, Added the +/- 3-degree statement.
- Section 11.1 Changed from 23/23°C (73.4/73.4°F) to 23°C ± 1.7°C (73.4°F ± 3°F)

Other Minor formatting and editorial items were also addressed.

T 85 (Specific Gravity and Absorption of Coarse Aggregate) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Remove ‘The aggregate is considered “dry” when it has been maintained at a temperature of 110 ±5°C (230 ±9°F) for sufficient time to remove all uncombined water,’ from the absorption definition

Other Minor formatting and editorial items were also addressed.

T 99/180 (Moisture-Density Relations of Soils) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- In Procedure Step 2b, add stand for at least 12 hrs.’
- Calculation example, to the nearest 0.005 lb.
- Balance description changed to ‘readable’

Other Minor formatting and editorial items were also addressed.

T 166 (Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Under Apparatus - Add New note about water bath circulator to Water Bath ‘Note 1: The water bath may be equipped with a circulator and heater or chiller to maintain constant temperatures throughout the bath. If a circulator is used, turn it off before any masses are recorded.’

Other Minor formatting and editorial items were also addressed.

T 196 (Air Content of Freshly Mixed Concrete by the Volumetric Method) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Added additional Section in Section 3, pushing all sections 1 greater in numbering.
- Replaced Significance and use with Terminology in Section 3, see ASTM C125 for definitions
- Section 6.4 Added statement “ A quick check can be made by adding one or more calibrated cups of water to the assembled apparatus and observing the increase in the height of the water of the water column after filling to a given level.
- Section 8.1 Changed Verbiage to “Preparation and Filling of Measuring Bowl and Consolidation of Concrete” from “Rodding and Tapping”.
- Section 9.1 Note 5 Changed to “1.25 L of alcohol used” from “1.2 L of alcohol used”.

Minor formatting and editorial items were also addressed.

T 209 (Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures) - Under Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Revise thermometer requirements ‘An immersion thermometer readable to at least 0.5°C (1°F) and with a temperature range of at least 20 to 45°C (68 to 113°F).
- Add New note about water bath circulator to Water Bath ‘Note 1: The water bath may be equipped with a circulator and heater or chiller to maintain constant temperatures throughout the bath. If a circulator is used, turn it off before any masses are recorded.’
- Added warming statement ‘do not exceed Job Mix Formula (JMF) compaction temperature’ in parentheses.

- Move and revise last sentence of Step 11 ‘Complete steps 12B through 16B within 10 ±1 minute.’ to Procedure – Pycnometer or Volumetric Flask.

Minor formatting and editorial items were also addressed.

T 231 (Capping Cylindrical Concrete Specimens) - Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Section 1.2 Added text stating that notes and footnotes (excluding those in tables and figures) shall not be considered part of the standard.
- Section 6.2.4 Verbiage Changed from “about 130°C” to “Between 130°C to 145°C” (265°F to 290°F).”

Minor formatting and editorial items were also addressed.

T 255/265 (Total Evaporable Moisture Content of Aggregate by Drying and Laboratory Determination of Moisture Content of Soils) – Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Balance description changed to ‘readable’
- Separated Table 3 into two tables, one for aggregate and one for soils

Minor formatting and editorial items were also addressed.

T 272 (One-Point Method for Determining Maximum Dry Density and Optimum Moisture) - Under the Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Add shaded areas on the graph for the that show the area that the one-point must fall within
- Revise Step 1 in the Maximum Dry Density and Optimum Moisture Content Determination Using an Individual Moisture – Density Curve section
- Change title of the ‘Reference Curve’ to ‘Individual Reference Curve’

Minor formatting and editorial items were also addressed.

T 308 (Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method) - Under the Scope, updated the AASHTO reference year to 2024. The following bullets identify additions, deletions, or modifications to the procedure:

- In Annex, Reworked calculating the asphalt binder content correction factor, and added example of Correction Factor calculation.

Minor formatting and editorial items were also addressed.

T 310 (IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH))

- **Yellow Sheet** – Procedure Section 7 – Added, “...Placed in its final position with an open hand”.

T 355 (IN-PLACE DENSITY OF ASPHALT MIXTURES BY NUCLEAR METHODS)

- **Yellow Sheet** – Under Method A, Procedure Section 3 – Added, “...Placed in its final position with an open hand”.

R 47 (Reducing Samples of Asphalt Mixtures to Testing Size) – Under Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Add ‘Mechanical Splitter Type A (Quartermaster): having four equal-width chutes that discharge the material into four appropriately sized sample containers, designed with a receiving hopper to hold the asphalt mixture field sample until a handle releases the material to fall through a divider and distribute it into four equal portions without restriction or the loss of material.’
- Add ‘Type A (Quartermaster) Method
- Add reduction statement ‘If the reduced sample mass does not fall within the test sample size limits, continue reducing to achieve the correct sample mass. Do not adjust sample mass by adding or removing material after reduction.’
- Remove redundant sample size statement.
- Add ‘Type A (Quartermaster)’ procedure
- Add new Step 1 ‘Place the splitter on a level surface’ to Mechanical Splitter Type B (Riffle) Method
- Add ‘of the sheeting’ in Step 4 of the Incremental Method remove ‘either’

Minor formatting and editorial items were also addressed.

R 76 (Reducing Samples of Aggregate to Testing Size) - Under Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Add new Step 1 ‘Place the splitter on a level surface’ to Step 1 procedure Mechanical Splitter.
- Reformat Method B Quartering: Combine Procedure Method B Quartering Surface Steps and Tarp Steps. Match new Method B Sectoring format.

Minor formatting and editorial items were also addressed.

R 90 (Sampling of Aggregate Products) – Under Scope, updated the AASHTO reference year to 2025. The following bullets identify additions, deletions, or modifications to the procedure:

- Method B (From the Belt Discharge): Rephrased Step one moving the second sentence into the title area as general and rephrased sub steps for once in each direction, without overfilling and maintaining constant speed during process. Renumbered from 4 to 3 steps.

Minor formatting and editorial items were also addressed.

R 100 (METHOD OF MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD)

- Yellow Sheet - Under procedure, Initial Curing, Use Method 1, cure in a cooler with water that completely covers the entire mold and lid, maintained within the required temperature range. See test procedure for temperature requirements.
- Yellow Sheet - Under Procedure, Transporting Specimens, Changed temporary final cure from 12 days to 21 days.
- Yellow Sheet – Under Procedure, Temporary Final Cure, Curing may be accomplished in a moist room or water tank conforming to AASHTO M201.

WAQTC Test Procedures

TM 2 (Sampling Freshly Mixed Concrete) - The following bullets identify additions, deletions, or modifications to the procedure:

- Add 'Sampling from continuous mixers (volumetric batching or mobile mixers)
- Obtain two or more increments after all the mixture proportioning adjustments have been made and at least $\frac{1}{4}$ m³ ($\frac{1}{4}$ yd³) has been discharged. Obtain increments at regularly spaced intervals during the discharge of the middle of the batch. Obtain increments by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a receptacle
- After obtaining the composite sample, wait at least two min. but not more than five min. before beginning tests.
- Note 2: The waiting period before beginning testing is necessary because the mix water is input seconds before discharge from the continuous mixer.'

Minor formatting and editorial items were also addressed.

Section 2 QA Program

Section I, Overview – No Changes

Section II, Roles and Responsibilities – No Changes

Section III, Lab Certification Program – No Changes.

Section IV, Technician Certification Program – The word “shall” was added, notifying both parties involved when the CAC is reviewing Abuse or Negligence. Giving both parties the opportunity to meet with the CAC.

Section V, Quality Assurance Laboratory Proficiency Sample Program – No Changes.

Section VI, Product Specific QC/QA Testing Plan – No Changes

Table 1 IA parameters – *No Changes*

Appendix A, ODOT Approved Aggregate Product Program – *No Changes*

Appendix B, Contractor Quality Control Plan – *No Changes*

Appendix C, Troubleshooting Guide – *No Changes*

Section 3 Report Forms and Examples

Forms Index and Introduction – No changes.

Forms Description of Worksheet and Calculation Explanations – No changes

The following forms have been modified:

- **734-2327_IC (ACP Incinerator Oven Calibration Worksheet)** – The RAP calculation was removed from the form.
- **734-3573WS (Concrete Yield and W/C Ratio Worksheet)** – The pot calibration carried out to four decimal places to match the AASHTO test procedure

Section 4A Product Compliance – No Changes

Section 4(B) Small Quantity Guidelines – No Changes

Section 4(C) Laboratory Samples – No Changes

Field Tested Materials Guide - Section 4D

How to Use the Field-Tested Materials Acceptance Guide – No Changes

Types of Tests – No Changes

Acceptance Guide – The following bullets identify additions, deletions, or modifications to the Specification sections of the guide – No changes

Section 5 Type D & E Acceptance Guide – The same changes in section 4D will be made to this section, if applicable.

Adam Rose
Senior Quality Assurance Specialist
ODOT Construction, Quality Assurance

INSERT TAB

Introduction

Oregon Department of Transportation

Manual of Field Test Procedures

INTRODUCTION

PURPOSE

This manual is designed to be used by Contractor and Agency technicians for the sampling and testing of construction materials, and to determine their conformance to ODOT specifications. Included herein are the Test Procedures, the Quality Assurance Program, report forms and examples, and the Field-Tested Materials Acceptance Guide, to be used by field personnel for guidance, reference and instruction.

FORMAT

This Manual is divided into four main sub-sections:

- (1) Test Procedures
- (2) Quality Assurance Program
- (3) Report Forms and Examples
- (4) Field Tested Materials Acceptance Guide

The process control and acceptance test procedures in this manual are to be used for testing construction materials on ODOT projects. English and Metric unit designations are not direct conversions, use the appropriate designation identified by the Project contract documents.

Test results and supporting data shall conform to the following rounding convention, based on the significant digit requirement of the contract specifications or test procedure reporting criteria.

- The final significant digit will not be changed when the succeeding digit is less than 5.
- The final significant digit will be increased by one when the succeeding digit is 5 or greater.

All field test procedures in this manual have ODOT, AASHTO or WAQTC references. Some field test procedures have been written as Field Operating Procedures, e.g. "FOP for AASHTO T-". FOPs conform to the approved AASHTO or other test methods but may eliminate some of the verbiage and/or combine several test methods to help reduce testing time. If there is a conflict between the FOP and the AASHTO test procedure due to errors or omissions, the AASHTO test procedure will hold precedence over the FOP. The yellow sheet addendums included with the FOP's are utilized to identify preferred methods or modifications observed by the Oregon Department of Transportation.

HOW TO USE THIS MANUAL

This *Manual of Field Test Procedures* is used in conjunction with the contract plans, specifications, and the Construction Manual. It defines the requirements of ODOT's Quality Assurance Program.

The sampling and testing requirements and test procedures for most work items can be found in this Manual. Testing requirements for other materials will be specified in the contract plans and specifications.

Section 1 - Test Procedures: This section includes procedures for all regular field test procedures required by the ODOT specifications.

Section 2 - Quality Assurance Program: This section includes ODOT's Quality Assurance Program Manual, which includes the Technician Certification and Laboratory Certification programs. It also includes information on Independent Assurance parameters, random sampling, sampling programs at commercial aggregate sources, and verifying Contractor Quality Control test results.

Section 3 - Report Forms and Examples: This section includes copies of ODOT forms that are used to submit samples to ODOT's Central Materials Laboratory (ODOT-CML), and forms that can be used for field test results. It also includes completed examples of the forms and instructions for obtaining electronic versions of the forms.

Section 4:

Subsection A – Source Review/Product Compliance Testing Requirements: This subsection describes the testing requirements and frequencies for raw and processed aggregate material. Specific test requirements are included in the Field-Tested Materials Acceptance Guide (FTMAG) in subsection 4(D).

Subsection B - Small Quantity Schedule: This subsection describes the criteria under which small amounts of materials can be accepted, without testing, upon satisfaction of the stated criteria.

Subsection C – Material Sampling Requirements: This subsection provides the requirements for sample sizes, types of containers, labeling, and other necessary information for samples that will be sent to the ODOT-CML or other laboratories for testing.

Subsection D - Field Tested Materials Acceptance Guide: This subsection lists the required tests that are to be performed for construction materials. It also outlines the frequencies at which the tests shall be performed, and the certified technician who shall perform them. The Definition of Visual field acceptance at the Project Managers level is also defined in this section.

ACRONYMS AND DEFINITIONS

Following are common acronyms and definitions found in this manual. Other acronyms and definitions may be found in Section 00110 of the Standard Specifications.

AASHTO - The American Association of State Highway and Transportation Officials

Abuse – Knowingly deviating from approved procedures or when the technician should have known they were deviating from approved procedures.

ACP - Asphalt Concrete Pavement, refers to either hot mix or warm mix asphalt concrete

ASTM - The American Society for Testing and Materials

ODOT-CML - The ODOT Central Materials Laboratory located at 800 Airport Road SE in Salem

Certified Laboratory - A Quality Control or Quality Assurance laboratory that possesses a valid certification, as described in Section 2 (Quality Assurance Program), issued by the ODOT-CML indicating that the laboratory had proper, calibrated equipment at the time of the inspection.

Certified Technician - A technician who is certified to perform a specific material test(s) and who possesses a valid certification, as described in Section 2 (Quality Assurance Program), issued by the ODOT-CML. The certification indicates their knowledge of, and ability to perform, the required test procedures, and to correctly prepare the test reports.

CGC - Commercial Grade Concrete (MSC – Minor Structure Concrete)

CAC - Certification Advisory Committee See Section 2 (Quality Assurance Program)

Density of Water - (62.4 lbs/ft³ (1000) kg/m³). Use the test procedure temperature correction table for AASHTO test method T 121.

Dispute Resolution Laboratory – Used for Third Party Testing, See Section 2 Quality Assurance Program for more details.

EAC - Emulsified Asphalt Concrete

FHWA - The Federal Highway Administration

FOP - Field Operating Procedure. FOPs conform to approved test methods but may eliminate some of the verbiage and/or combine several test methods to reduce testing time.

FTMAG – Field Tested Materials Acceptance Guide. See Section 4D

HMAC - Hot Mixed Asphalt Concrete or HMA (Hot Mixed Asphalt)

IA - Independent Assurance. See Section 2 (Quality Assurance Program)

JMF - Job Mix Formula

MDT – Maximum Density Test (Use 62.4 lbs/ft³ (1000) kg/m³ for unit conversion)

MSE – Mechanically Stabilized Earth

MFTP - Manual of Field Test Procedures (this manual)

MAMD - Moving Average Maximum Density

ODOT - The Oregon Department of Transportation

Negligence – Unintentional deviations from approved procedures that may or may not cause erroneous results

PCC - Portland Cement Concrete

PM - Project Manager (Agency/Owner's Contract Administrator)

QA - Quality Assurance - generally refers to the Quality Assurance Program (See Section 2).

QAC - Quality Assurance Coordinator. See Section 2 (Quality Assurance Program).

QAE - Quality Assurance Engineer

QAT - Quality Assurance Technician. See Section 2 (Quality Assurance Program).

QC - Quality Control

QCCS - Quality Control Compliance Specialist (Agency or Contract Administrator performing the role of the QCCS). See Section 2 (Quality Assurance Program).

QPL - Qualified Products List

RAM – Recycled Asphalt Material

Random Sample – A sample of construction material taken at a random time or location. The sampling shall be performed according to a random number scheme. See Section 2 (Quality Assurance Program) for further discussion.

Random Number – A randomly selected number used to calculate a sampling time or location. See Section 2 (Quality Assurance Program) for discussion on selection and usage.

RAP - Reclaimed Asphalt Concrete Pavement

RAS – Recycled Asphalt Shingles

Smartly – Quickly and usually done with force

Source – Pit, quarry, material supplier or facility. *Term also referenced in AASHTOWare.*

Specifications- Special Provisions, Plans & Drawings, Supplemental Specifications and Standard Specifications.

SrQAC – Senior Quality Assurance Coordinator

SQAE – Senior Quality Assurance Engineer

WAQTC - Western Alliance for Quality Transportation Construction

INSERT TAB

SECTION 1
Test Procedures

INDEX OF FIELD TEST PROCEDURES

PROCEDURE DATE	TITLE OF PROCEDURE	ODOT TM*	AASHTO T / R*	WAQTC TM*
2009	Embankment and Base Using Deflection Requirements	158		
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* (TM) – Test Method.

** (T) – Test Method is a definitive procedure (such as identification, measurement or evaluation of properties) that produces a test result.

** (R) – Recommended Practices are a definitive set of instructions for performing specific operations (such as sampling, collection, or inspection) that do not produce a test result.

INSERT TAB

AASHTO

Bulk Density (“Unit Weight”) and Voids in Aggregate

AASHTO Designation: T 19/T 19-25

ASTM Designation: C29/C 29M-23

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Compressive Strength of Cylindrical Concrete Specimens

AASHTO Designation: T 22-25

ASTM Designation: C39/C 39M-24

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**SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µM (NO. 200) SIEVE IN AGGREGATE BY
WASHING
FOP FOR AASHTO T 11**

Scope

A sieve analysis, or ‘gradation,’ measures distribution of aggregate particle sizes within a given sample.

Accurate determination of the amount of material smaller than 75 µm (No. 200) cannot be made using just AASHTO T 27. If quantifying this material is required, use AASHTO T 11 in conjunction with AASHTO T 27.

This FOP covers sieve analysis in accordance with AASHTO T 27-24 and materials finer than 75 µm (No. 200) in accordance with AASHTO T 11-25 performed in conjunction with AASHTO T 27. The procedure includes three methods: A, B, and C.

Apparatus

- Balance or scale: Capacity sufficient for the masses shown in Table 1, readable to 0.1 g, and meeting the requirements of AASHTO M 231
- Sieves: Meeting the requirements of ASTM E11
- Mechanical sieve shaker: Meeting the requirements of AASHTO T 27

Note 1: Sieves with a large sieving area, greater than 304.8 mm (12 in.) diameter may not be practical for all sizes of samples. A large sieving area could result in loss of a portion of the sample if used for a smaller sample of coarse or fine aggregate, affecting final test results.

- Suitable drying equipment (refer to FOP for AASHTO T 255)
- Container: A pan or vessel of sufficient size to contain the sample covered with water and permit vigorous agitation without loss of material or water
- Optional
 - Utensil: device for agitating the sample during the washing procedure.
 - Mechanical washing device
 - Mallet: With a rubber or rawhide head having a mass of 0.57 ± 0.23 kg (1.25 ± 0.5 lb)
 - Wetting Agent: A dispersing agent that will promote separation of the fine materials without degrading the aggregate. Any detergent used shall not leave a residue on the sample during the washing procedure.

Sample Sieving

- In all procedures, the sample is shaken in nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the sample, or a portion of the sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A, *Time Evaluation*.
- Do not overload sieves, refer to Annex B, *Overload Determination*. The sample may be sieved in increments and the mass retained for each sieve added together from each sample increment to avoid overloading sieves.

Sample Preparation

Obtain samples according to the FOP for AASHTO R 90 and reduce to sample size, shown in Table 1, according to the FOP for AASHTO R 76.

TABLE 1
Sample Sizes for Aggregate Gradation Test

Nominal Maximum Size* mm (in.)	Minimum Dry Mass g (lb)
125 (5)	300,000 (660)
100 (4)	150,000 (330)
90 (3 1/2)	100,000 (220)
75 (3)	60,000 (130)
63 (2 1/2)	35,000 (77)
50 (2)	20,000 (44)
37.5 (1 1/2)	15,000 (33)
25.0 (1)	10,000 (22)
19.0 (3/4)	5000 (11)
12.5 (1/2)	2000 (4)
9.5 (3/8)	1000 (2)
6.3 (1/4)	1000 (2)
4.75 (No. 4)	500 (1)

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps between specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Sample sizes in Table 1 are standard for aggregate sieve analysis, due to equipment restraints samples may need to be divided into several “subsamples.” For example, a gradation that requires 100 kg (220 lbs.) of material would not fit into a large tray shaker all at once.

Some agencies permit reduced sample sizes if it is proven that doing so is not detrimental to the test results. Some agencies require larger sample sizes. Check agency guidelines for required or permitted sample sizes.

Selection of Procedure

Agencies may specify which method to perform. If a method is not specified, perform Method A.

Overview

Method A

- Determine original dry mass of the sample
- Wash over a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve washed sample
- Calculate and report percent retained and passing each sieve

Method B

- Determine original dry mass of the sample
- Wash over a 75 μ m (No. 200) sieve
- Determine dry mass of washed sample
- Sieve sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Sieve reduced portion
- Calculate and report percent retained and passing each sieve

Method C

- Determine original dry mass of the sample
- Sieve sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Wash reduced portion over a 75 μ m (No. 200) sieve

- Determine dry mass of washed reduced portion
- Sieve washed reduced portion
- Calculate and report percent retained and passing each sieve

Procedure Method A

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
2. Determine and record the original dry mass of the sample to the nearest 0.1 g. Designate this mass as *M*.

When the specification does not require the amount of material finer than 75 μm (No. 200) be determined by washing, skip to Step 11.

3. Nest a sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
4. Place the sample in a container and cover with water.

Note 2: When required by the agency, add a detergent, dispersing solution, or other wetting agent to the water to assure a thorough separation of the material finer than the 75 μm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

5. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. To aid in the agitation process, a utensil may be used. To avoid degradation of the sample when using a mechanical washing device do not exceed 10 minutes.

Note 3: See AASHTO T 11 *Annex A for Mechanical Washer Comparison* if there is potential aggregate degradation.

6. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.
7. Add water to cover material remaining in the container and repeat Step 5. Continue until the wash water is reasonably clear. Rinse utensil, if used, into the washed sample.
8. Remove the upper sieve and return material retained to the washed sample.
9. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
10. Return all material retained on the 75 μm (No. 200) sieve to the container by rinsing into the washed sample.

Note 4: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

11. Dry the washed sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
12. Determine and record the dry mass of the sample.

13. Select sieves required by the specification and those necessary to avoid overloading as described in Annex B. With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200).
14. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 5: Excessive shaking (more than 10 minutes) may result in degradation of the sample.
15. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 6: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

Note 7: In the case of coarse / fine aggregate mixtures, distribute the minus 4.75 mm (No. 4) among two or more sets of sieves to prevent overloading of individual sieves.
16. Perform the *Check Sum* calculation – Verify the *total mass after sieving* compared to the *dry mass before sieving* is not more than 0.3 percent. The *dry mass before sieving* is the dry mass after wash or the original dry mass (*M*) if performing the sieve analysis without washing. Do not use test results for acceptance if the *Check Sum* result is more than 0.3 percent.
17. Calculate the total percentages passing, and the individual or cumulative percentages retained to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the original dry mass (*M*) of the sample.
18. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Method A Calculations

Check Sum

$$\text{Check Sum} = \frac{\text{dry mass before sieving} - \text{total mass after sieving}}{\text{dry mass before sieving}} \times 100$$

Percent Retained

$$IPR = \frac{IMR}{M} \times 100 \quad \text{or} \quad CPR = \frac{CMR}{M} \times 100$$

Where:

IPR	=	Individual Percent Retained
CPR	=	Cumulative Percent Retained
M	=	Original dry mass of the sample
IMR	=	Individual Mass Retained
CMR	=	Cumulative Mass Retained

Percent Passing (PP)

$$PP = PPP - IPR \quad \text{or} \quad PP = 100 - CPR$$

Where:

PP	=	Percent Passing
PPP	=	Previous Percent Passing

Method A Example Individual Mass Retained

Original dry mass of the sample (<i>M</i>):	5168.7 g
Dry mass of the sample after washing:	4911.3 g
Total mass after sieving equals	
Sum of Individual Masses Retained (IMR), including minus 75 μm (No. 200) in the pan:	4905.9 g
Amount of 75μm (No. 200) minus washed out (5168.7 g – 4911.3 g):	257.4 g

Check Sum

$$Check\ Sum = \frac{4911.3\ g - 4905.9\ g}{4911.3\ g} \times 100 = 0.1\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve:

$$IPR = \frac{619.2 \text{ g}}{5168.7 \text{ g}} \times 100 = 12.0\%$$

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

$$PP = 86.0\% - 12.0\% = 74.0\%$$

Reported Percent Passing = 74%

**Method A Individual
Gradation on All Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR by dividing IMR by <i>M</i> and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from previous PP	Percent Passing (PP)	Reported Percent Passing*
19.0 (3/4)	0		0		100.0	100
12.5 (1/2)	724.7	$\frac{724.7}{5168.7} \times 100 =$	14.0	$100.0 - 14.0 =$	86.0	86
9.5 (3/8)	619.2	$\frac{619.2}{5168.7} \times 100 =$	12.0	$86.0 - 12.0 =$	74.0	74
4.75 (No. 4)	1189.8	$\frac{1189.8}{5168.7} \times 100 =$	23.0	$74.0 - 23.0 =$	51.0	51
2.36 (No. 8)	877.6	$\frac{877.6}{5168.7} \times 100 =$	17.0	$51.0 - 17.0 =$	34.0	34
1.18 (No. 16)	574.8	$\frac{574.8}{5168.7} \times 100 =$	11.1	$34.0 - 11.1 =$	22.9	23
0.600 (No. 30)	329.8	$\frac{329.8}{5168.7} \times 100 =$	6.4	$22.9 - 6.4 =$	16.5	17
0.300 (No. 50)	228.5	$\frac{228.5}{5168.7} \times 100 =$	4.4	$16.5 - 4.4 =$	12.1	12
0.150 (No. 100)	205.7	$\frac{205.7}{5168.7} \times 100 =$	4.0	$12.1 - 4.0 =$	8.1	8
0.075 (No. 200)	135.4	$\frac{135.7}{5168.7} \times 100 =$	2.6	$8.1 - 2.6 =$	5.5	5.5
minus 0.075 (No. 200) in the pan	20.4					
Total mass after sieving = sum of sieves + mass in the pan = 4905.9 g						
Original dry mass of the sample (<i>M</i>): 5168.7g						

* Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

Method A Example Cumulative Mass Retained

Original dry mass of the sample (<i>M</i>):	5168.7 g
Dry mass of the sample after washing:	4911.3 g
Total mass after sieving equals Final Cumulative Mass Retained (FCMR) (includes minus 75 µm (No. 200) from the pan):	4905.9 g
Amount of 75µm (No. 200) minus washed out (5168.7 g – 4911.3 g):	257.4 g

Check Sum

$$\text{Check Sum} = \frac{4911.3 \text{ g} - 4905.9 \text{ g}}{4911.3 \text{ g}} \times 100 = 0.1\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve:

$$\text{CPR} = \frac{1343.9 \text{ g}}{5168.7 \text{ g}} \times 100 = 26.0\%$$

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

$$\text{PP} = 100.0\% - 26.0\% = 74.0\%$$

Reported Percent Passing = 74%

**Method A Cumulative
Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
19.0 (3/4)	0		0.0		100.0	100
12.5 (1/2)	724.7	$\frac{724.7}{5168.7} \times 100 =$	14.0	$100.0 - 14.0 =$	86.0	86
9.5 (3/8)	1343.9	$\frac{1343.9}{5168.7} \times 100 =$	26.0	$100.0 - 26.0 =$	74.0	74
4.75 (No. 4)	2533.7	$\frac{2533.7}{5168.7} \times 100 =$	49.0	$100.0 - 49.0 =$	51.0	51
2.36 (No. 8)	3411.3	$\frac{3411.3}{5168.7} \times 100 =$	66.0	$100.0 - 66.0 =$	34.0	34
1.18 (No. 16)	3986.1	$\frac{3986.1}{5168.7} \times 100 =$	77.1	$100.0 - 77.1 =$	22.9	23
0.600 (No. 30)	4315.9	$\frac{4315.9}{5168.7} \times 100 =$	83.5	$100.0 - 83.5 =$	16.5	17
0.300 (No. 50)	4544.4	$\frac{4544.4}{5168.7} \times 100 =$	87.9	$100.0 - 87.9 =$	12.1	12
0.150 (No. 100)	4750.1	$\frac{4750.1}{5168.7} \times 100 =$	91.9	$100.0 - 91.9 =$	8.1	8
0.075 (No. 200)	4885.5	$\frac{4885.5}{5168.7} \times 100 =$	94.5	$100.0 - 94.5 =$	5.5	5.5
FCMR	4905.9					
Total mass after sieving: 4905.9 g						
Original dry mass of the sample (M): 5168.7 g						

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Procedure Method B

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
2. Determine and record the original dry mass of the sample to the nearest 0.1 g. Designate this mass as *M*.

When the specification does not require the amount of material finer than 75 μm (No. 200) be determined by washing, skip to Step 11.

3. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
4. Place the sample in a container and cover with water.

Note 2: If required by the agency, add a detergent, dispersing solution, or other wetting agent to the water to assure a thorough separation of the material finer than the 75 μm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

5. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. To aid in the agitation process, a utensil may be used. To avoid degradation of the sample when using a mechanical washing device do not exceed 10 minutes.

Note 3: See AASHTO T 11 *Annex A for Mechanical Washer Comparison* if there is potential aggregate degradation.

6. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.
7. Add water to cover material remaining in the container and repeat Step 5. Continue until the wash water is reasonably clear. Rinse utensil, if used, into the washed sample.
8. Remove the upper sieve and return material retained to the washed sample.
9. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
10. Return all material retained on the 75 μm (No. 200) sieve to the container by rinsing into the washed sample.

Note 4: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

11. Dry the washed sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
12. Determine and record the dry mass after wash.
13. Select sieves required by the specification and those necessary to avoid overloading as described in Annex B. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4).
14. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place the sieves in the mechanical shaker and shake for the

minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 5: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

15. Determine and record the individual or cumulative mass retained for each sieve. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained.

Note 6: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 μm (No. 30) and larger sieves, and soft hair bristle for smaller sieves.

16. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as M_1 .

17. Perform the *Coarse Check Sum* calculation – Verify the *total mass after coarse sieving* compared to the *dry mass before sieving* to not more than 0.3 percent. The *dry mass before sieving* is the dry mass after wash or the original dry mass (M) if performing the sieve analysis without washing. Do not use test results for acceptance if the *Check Sum* result is more than 0.3 percent.

18. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76 to produce a sample with a minimum mass of 500 g. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as M_2 .

19. Select sieves required by the specification and those necessary to avoid overloading as described in Annex B. With a pan on bottom, nest the sieves increasing in size starting with the 75 μm (No. 200) up to, but not including the 4.75 mm (No. 4) sieve.

20. Place the sample portion on the top sieve and place the sieves in the mechanical shaker. Shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

21. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained. (See Note 6.)

22. Perform the *Fine Check Sum* calculation – Verify the *total mass after sieving* compared to the *dry mass before sieving* (M_2) is not more than 0.3 percent. Do not use test results for acceptance if the *Check Sum* result is more than 0.3 percent.

23. Calculate to the nearest 0.1 percent, the Individual Mass Retained (IMR) or Cumulative Mass Retained (CMR) of the size increment of the reduced sample and the original sample.

24. Calculate the total percent passing.

25. Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

Method B Calculations**Check Sum**

$$\text{Coarse Check Sum} = \frac{\text{dry mass before sieving} - \text{total mass after coarse sieving}}{\text{dry mass before sieving}} \times 100$$

$$\text{Fine Check Sum} = \frac{M_2 - \text{total mass after fine sieving}}{M_2} \times 100$$

Percent Retained for 4.75 mm (No. 4) and larger

$$IPR = \frac{IMR}{M} \times 100 \quad \text{or} \quad CPR = \frac{CMR}{M} \times 100$$

Where:

IPR	=	Individual Percent Retained
CPR	=	Cumulative Percent Retained
M	=	Original dry mass of the sample
IMR	=	Individual Mass Retained
CMR	=	Cumulative Mass Retained

Percent Passing (PP) for 4.75 mm (No. 4) and larger

$$PP = PPP - IPR \quad \text{or} \quad PP = 100 - CPR$$

Where:

PP	=	Percent Passing
PPP	=	Previous Percent Passing

Minus 4.75mm (No. 4) adjustment factor (R)

The mass of material retained for each sieve is multiplied by the adjustment factor, the total mass of the minus 4.75 mm (No. 4) from the pan, M_1 , divided by the mass of the reduced split of minus 4.75 mm (No. 4), M_2 . For consistency, this adjustment factor is carried to three decimal places.

$$R = \frac{M_1}{M_2}$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M_1 = total mass of minus 4.75 mm (No. 4) before reducing
- M_2 = mass of the reduced split of minus 4.75 mm (No. 4)

Total Individual Mass Retained (TIMR):

$$TIMR = R \times B$$

where:

- TIMR = Total Individual Mass Retained
- R = minus 4.75 mm (No. 4) adjustment factor
- B = individual mass of the size increment in the reduced portion sieved

Total Cumulative Mass Retained (TCMR)

$$TCMR = (R \times B) + D$$

where:

- TCMR = Total Cumulative Mass Retained
- R = minus 4.75 mm (No. 4) adjustment factor
- B = cumulative mass of the size increment in the reduced portion sieved
- D = cumulative mass of plus 4.75mm (No. 4) portion of sample

Method B Example Individual Mass Retained

Dry mass of total sample, before washing:	3214.0 g
Dry mass of sample after washing:	3085.1 g
Total mass after sieving	
Sum of Individual Masses Retained (IMR) plus the minus 4.75 mm (No. 4) from the pan:	3085.0 g
Amount of 75 µm (No. 200) minus washed out (3214.0 g – 3085.1 g):	128.9 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3085.1 \text{ g} - 3085.0 \text{ g}}{3085.1 \text{ g}} \times 100 = 0.0\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve

$$IPR = \frac{481.4 \text{ g}}{3214.0 \text{ g}} \times 100 = 15.0\%$$

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve:

$$PP = 95.0\% - 15.0\% = 80.0\%$$

Reported Percent Passing = 80%

**Method B Individual
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR by dividing IMR by M and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from previous PP	Percent Passing (PP)
16.0 (5/8)	0		0		100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0
9.5 (3/8)	481.4	$\frac{481.4}{3214.0} \times 100 =$	15.0	$95.0 - 15.0 =$	80.0
4.75 (No. 4)	475.8	$\frac{475.8}{3214.0} \times 100 =$	14.8	$80.0 - 14.8 =$	65.2
Minus 4.75 (No. 4) in the pan	1966.7 (M_1)				
Total mass after sieving: sum of sieves + mass in the pan = 3085.0 g					
Original dry mass of the sample (M): 3214.0 g					

Fine Sample

The minus 4.75 mm (No. 4) from the pan, M_1 (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **512.8 g**. This is M_2 .

The reduced mass was sieved.

Total mass after sieving equals

Sum of Individual Masses Retained (IMR) including minus 75 μ m (No. 200) in the pan	511.8 g
--	---------

Fine Check Sum

$$\text{Fine Check Sum} = \frac{512.8 \text{ g} - 511.8 \text{ g}}{512.8 \text{ g}} \times 100 = 0.2\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Adjustment Factor (*R*) for Total Individual Mass Retained (TIMR) on minus 4.75 (No. 4) sieves

The mass of material retained for each sieve is multiplied by the adjustment factor (*R*) carried to three decimal places.

$$R = \frac{M_1}{M_2} = \frac{1,966.7 \text{ g}}{512.8 \text{ g}} = 3.835$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M₁ = total mass of minus 4.75 mm (No. 4) from the pan
- M₂ = mass of the reduced split of minus 4.75 mm (No. 4)

Each “individual mass retained” on the fine sieves must be multiplied by *R* to obtain the *Total Individual Mass Retained (TIMR)*.

Total Individual Mass Retained (TIMR) for 2.00 mm (No. 10) sieve

$$\text{TIMR} = 3.835 \times 207.1 \text{ g} = 794.2 \text{ g}$$

Individual Percent Retained (IPR) for 2.00 mm (No. 10) sieve:

$$\text{IPR} = \frac{794.2 \text{ g}}{3214.0 \text{ g}} \times 100 = 24.7\%$$

Percent Passing (PP) 2 mm (No. 10) sieve:

$$PP = 65.2\% - 24.7\% = 40.5\%$$

Reported Percent Passing = 41%

**Method B Individual
Gradation on Fine Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine TIMR by multiplying IMR by $R \left(\frac{M_1}{M_2} \right)$	Total Individual Mass Retained (TIMR)
2.00 (No. 10)	207.1	$207.1 \times 3.835 =$	794.2
0.425 (No. 40)	187.9	$187.9 \times 3.835 =$	720.6
0.210 (No. 80)	59.9	$59.9 \times 3.835 =$	229.7
0.075 (No. 200)	49.1	$49.1 \times 3.835 =$	188.3
minus 0.075 (No. 200) in the pan	7.8		
Total mass after sieving: sum of fine sieves + the mass in the pan = 511.8 g			

**Method B Individual
Final Gradation on All Sieves**

Sieve Size mm (in.)	Total Individual Mass Retained g (TIMR)	Determine IPR by dividing TIMR by M and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from previous PP	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0		100	100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0	95
9.5 (3/8)	481.4	$\frac{481.4}{3214.0} \times 100 =$	15.0	$95.0 - 15.0 =$	80.0	80
4.75 (No. 4)	475.8	$\frac{475.8}{3214.0} \times 100 =$	14.8	$80.0 - 14.8 =$	65.2	65
2.00 (No. 10)	794.2	$\frac{794.2}{3214.0} \times 100 =$	24.7	$65.2 - 24.7 =$	40.5	41
0.425 (No. 40)	720.6	$\frac{720.6}{3214.0} \times 100 =$	22.4	$40.5 - 22.4 =$	18.1	18
0.210 (No. 80)	229.7	$\frac{229.7}{3214.0} \times 100 =$	7.1	$18.1 - 7.1 =$	11.0	11
0.075 (No. 200)	188.3	$\frac{188.3}{3214.0} \times 100 =$	5.9	$11.0 - 5.9 =$	5.1	5.1
minus 0.075 (No. 200) in the pan	29.9					
Original dry mass of the sample (M): 3214.0 g						

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Method B Example Cumulative Mass Retained

Original dry mass of the sample (<i>M</i>):	3214.0 g
Dry mass of sample after washing:	3085.1 g
Total mass after sieving equals	
Cumulative Mass Retained (CMR) on the 4.75 (No. 4)	
plus the minus 4.75 mm (No. 4) in the pan:	3085.0 g
Amount of 75 μm (No. 200) minus washed out (3214.0 g – 3085.1 g):	128.9 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3085.1 \text{ g} - 3085.0 \text{ g}}{3085.1 \text{ g}} \times 100 = 0.0\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve

$$\text{CPR} = \frac{642.5 \text{ g}}{3214.0 \text{ g}} \times 100 = 20.0\%$$

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve

$$\text{PP} = 100.0\% - 20.0\% = 80.0\%$$

Reported Percent Passing = 80%

**Method B Cumulative
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)
16.0 (5/8)	0		0		100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0
9.5 (3/8)	642.5	$\frac{642.5}{3214.0} \times 100 =$	20.0	$100.0 - 20.0 =$	80.0
4.75 (No. 4)	1118.3 (D)	$\frac{1118.3}{3214.0} \times 100 =$	34.8	$100.0 - 34.8 =$	65.2
Minus 4.75 (No. 4) in the pan	1966.7 (M _I)				
CMR: 1118.3 + 1966.7 = 3085.0					
Original dry mass of the sample (M): 3214.0 g					

Fine Sample

The mass of minus 4.75 mm (No. 4) material in the pan, M_I (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **512.8 g**. This is M_2 .

The reduced mass was sieved.

Total mass after fine sieving equals

Final Cumulative Mass Retained (FCMR) (includes minus
75 μ m (No. 200) from the pan): 511.8 g

Fine Check Sum

$$\text{Fine Check Sum} = \frac{512.8 \text{ g} - 511.8 \text{ g}}{512.8 \text{ g}} \times 100 = 0.2\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

The cumulative mass of material retained for each sieve is multiplied by the adjustment factor (R) carried to three decimal places to obtain the *Adjusted Cumulative Mass Retained (ACMR)* and added to the cumulative mass retained on the 4.75 mm (No. 4) sieve, D , to obtain the *Total Cumulative Mass Retained (TCMR)*.

Adjustment factor (R) for Adjusted Cumulative Mass Retained (ACMR) in minus 4.75 (No. 4) sieves.

$$R = \frac{M_1}{M_2} = \frac{1,966.7 \text{ g}}{512.8 \text{ g}} = 3.835$$

where:

- R = minus 4.75 mm (No. 4) adjustment factor
- M_1 = total mass of minus 4.75 mm (No. 4) from the pan
- M_2 = mass of the reduced split of minus 4.75 mm (No. 4)

Adjusted Cumulative Mass Retained (ACMR) for the 2.00 mm (No. 10) sieve

$$ACMR = 3.835 \times 207.1 \text{ g} = 794.2 \text{ g}$$

Total Cumulative Mass Retained (TCMR) for the 2.00 mm (No. 10) sieve

$$TCMR = 794.2 \text{ g} + 1118.3 \text{ g} = 1912.5 \text{ g}$$

Cumulative Percent Retained (CPR) for 2.00 mm (No. 10) sieve:

$$CPR = \frac{1912.5 \text{ g}}{3214.0 \text{ g}} \times 100 = 59.5\%$$

Percent Passing (PP) 2.00 mm (No. 10) sieve:

$$PP = 100.0\% - 59.5\% = 40.5\%$$

Reported Percent Passing = 41%

**Method B Cumulative
Gradation on Fine Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine TCMR by multiplying CMR by $R \left(\frac{M_1}{M_2} \right)$ and adding D	Total Cumulative Mass Retained (TCMR)
2.00 (No. 10)	207.1	$207.1 \times 3.835 + 1118.3 =$	1912.5
0.425 (No. 40)	395.0	$395.0 \times 3.835 + 1118.3 =$	2633.1
0.210 (No. 80)	454.9	$454.9 \times 3.835 + 1118.3 =$	2862.8
0.075 (No. 200)	504.0	$504.0 \times 3.835 + 1118.3 =$	3051.1
FCMR	511.8		
Total: sum of masses on fine sieves + minus 75 μm (No. 200) in the pan = 511.8			

**Method B Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Total Cumulative Mass Retained g (TCMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0		100.0	100
12.5 (1/2)	161.1	$\frac{161.1}{3214.0} \times 100 =$	5.0	$100.0 - 5.0 =$	95.0	95
9.5 (3/8)	642.5	$\frac{642.5}{3214.0} \times 100 =$	20.0	$100.0 - 20.0 =$	80.0	80
4.75 (No. 4)	1118.3 (D)	$\frac{1118.3}{3214.0} \times 100 =$	34.8	$100.0 - 34.8 =$	65.2	65
2.00 (No. 10)	1912.5	$\frac{1912.5}{3214.0} \times 100 =$	59.5	$100.0 - 59.5 =$	40.5	41
0.425 (No. 40)	2633.1	$\frac{2633.1}{3214.0} \times 100 =$	81.9	$100.0 - 81.9 =$	18.1	18
0.210 (No. 80)	2862.8	$\frac{2862.8}{3214.0} \times 100 =$	89.1	$100.0 - 89.1 =$	10.9	11
0.075 (No. 200)	3051.1	$\frac{3051.1}{3214.0} \times 100 =$	94.9	$100.0 - 94.9 =$	5.1	5.1
FCMR	3081.1					
Original dry mass of the sample (M): 3214.0 g						

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Procedure Method C

1. Dry the sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
2. Determine and record the original dry mass of the sample to the nearest 0.1 g. Designate this mass as M .
3. Break up any aggregations or lumps of clay, silt, or adhering fines to pass the 4.75 mm (No. 4) sieve.
4. Select sieves required by the specification and those necessary to avoid overloading as described in Annex B. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4) sieve.
5. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 2: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

6. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 3: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening sieving over a full opening. Use coarse wire brushes to clean the 600 μm (No. 30) and larger sieves, and soft bristle brush for smaller sieves.

7. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as M_1 .
8. Perform the *Coarse Check Sum* calculation –Verify the *total mass after coarse sieving* compared to the *original dry mass* (M) is not more than 0.3 percent.
9. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76, to produce a sample with a minimum mass of 500 g.
10. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as M_3 .
11. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 μm (No. 200) sieve.
12. Place the sample in a container and cover with water.

Note 4: If required by the agency, add a detergent, dispersing solution, or other wetting agent to the water to assure a thorough separation of the material finer than the 75 μm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

13. Agitate vigorously to ensure complete separation of the material finer than 75 μm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. To aid in the agitation process, a utensil may be used. To avoid degradation of the sample when using a mechanical washing device do not exceed 10 minutes.

Note 5: See AASHTO T 11 *Annex A for Mechanical Washer Comparison* if there is potential aggregate degradation.

14. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μm (No. 200) sieve.
15. Add water to cover material remaining in the container and repeat Step 12. Repeat until the wash water is reasonably clear. Rinse utensil, if used, into the washed sample.
16. Remove the upper sieve and return material retained to the washed sample.
17. Rinse the material retained on the 75 μm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.
18. Return all material retained on the 75 μm (No. 200) sieve to the container by flushing into the washed sample.

Note 6: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 μm (No. 200) sieve to prevent loss of fines.

19. Dry the washed sample portion to constant mass according to the FOP for AASHTO T 255. Cool to room temperature.
20. Determine and record the dry mass, designate this mass as *dry mass before sieving*.
21. Select sieves required by the specification and those necessary to avoid overloading as described in Annex B. With a pan on bottom, nest the sieves increasing in size starting with the 75 μm (No. 200) sieve up to, but not including the 4.75 mm (No. 4) sieve.
22. Place the sample portion on the top sieve. Place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 7: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

23. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained. See Note 3.
24. Perform the *Fine Check Sum* calculation – Verify the *total mass after fine sieving* compared to the *dry mass before sieving* is not more than 0.3 percent. Do not use test results for acceptance if the *Check Sum* is more than 0.3 percent.
25. Calculate the Cumulative Percent Retained (CPR) and Percent Passing (PP) for the 4.75 mm (No. 4) and larger.
26. Calculate the Cumulative Percent Retained (CPR_{#4}) and the Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) split and Percent Passing (PP) for the minus 4.75 mm (No. 4).
27. Report total percent passing to 1 percent except report the 75 μm (No. 200) sieve to 0.1 percent.

Method C Calculations

Check Sum

$$\text{Coarse check sum} = \frac{M - \text{total mass after coarse sieving}}{M} \times 100$$

$$\text{Fine check sum} = \frac{\text{dry mass before sieving} - \text{total mass after fine sieving}}{\text{dry mass before sieving}} \times 100$$

where:

M = Original dry mass of the sample

Cumulative Percent Retained (CPR) for 4.75 mm (No. 4) sieve and larger

$$CPR = \frac{CMR}{M} \times 100$$

where:

CPR = Cumulative Percent Retained of the size increment for the total sample

CMR = Cumulative Mass Retained of the size increment for the total sample

M = Total dry sample mass before washing

Percent Passing (PP) 4.75 mm (No. 4) sieve and larger

$$PP = 100 - CPR$$

where:

PP = Percent Passing of the size increment for the total sample

CPR = Cumulative Percent Retained of the size increment for the total sample

Or calculate PP for sieves larger than 4.75 mm (No. 4) sieve without calculating CPR

$$\frac{M - CMR}{M} \times 100$$

Cumulative Percent Retained (CPR_{#4}) for minus 4.75 mm (No. 4) split

$$CPR_{\#4} = \frac{CMR_{\#4}}{M_3} \times 100$$

where:

- CPR_{#4} = Cumulative Percent Retained for the sieve sizes of M₃
 CMR_{#4} = Cumulative Mass Retained for the sieve sizes of M₃
 M₃ = Total mass of the minus 4.75 mm (No. 4) split before washing

Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) split

$$PP_{\#4} = 100 - CPR_{\#4}$$

where:

- PP_{#4} = Percent Passing for the sieve sizes of M₃
 CPR_{#4} = Cumulative Percent Retained for the sieve sizes of M₃

Percent Passing (PP) for sieves smaller than 4.75 mm (No. 4) sieve

$$PP = \frac{(PP_{\#4} \times \#4 PP)}{100}$$

where:

- PP = Total Percent Passing
 PP_{#4} = Percent Passing for the sieve sizes of M₃
 #4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve

Or calculate PP for sieves smaller than 4.75 mm (No. 4) sieve without calculating CPR-#4 and PP-#4

$$PP = \frac{\#4 PP}{M_3} \times (M_3 - CMR_{\#4})$$

where:

- PP = Total Percent Passing
 #4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve
 M₃ = Total mass of the minus 4.75 mm (No. 4) split before washing
 CMR-#4 = Cumulative Mass Retained for the sieve sizes of M₃

Method C Example

Original dry mass of the sample (M): 3304.5 g

Total mass after sieving equals

Cumulative Mass Retained (CMR) on the 4.75 (No. 4) plus the
 minus 4.75 mm (No. 4) from the pan: 3300.1 g

Coarse Check Sum

$$\text{Coarse Check Sum} = \frac{3304.5 \text{ g} - 3300.1 \text{ g}}{3304.5 \text{ g}} \times 100 = 0.1\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR) for the 9.5 mm (3/8 in.) sieve:

$$CPR = \frac{604.1 \text{ g}}{3304.5 \text{ g}} \times 100 = 18.3\%$$

Percent Passing (PP) for the 9.5 mm (3/8 in.) sieve:

$$PP = 100.0\% - 18.3\% = 81.7\%$$

Reported Percent Passing = 82%

Example for Alternate Percent Passing (PP) formula for the 9.5 mm (3/8 in.) sieve:

$$PP = \frac{3304.5 - 604.1}{3304.5} \times 100 = 81.7\%$$

Reported Percent Passing = 82%

**Method C Cumulative
Gradation on Coarse Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0		0.0		100.0	100
12.5 (1/2)	125.9	$\frac{125.9}{3304.5} \times 100 =$	3.8	$100.0 - 3.8 =$	96.2	96
9.5 (3/8)	604.1	$\frac{604.1}{3304.5} \times 100 =$	18.3	$100.0 - 18.3 =$	81.7	82
4.75 (No. 4)	1295.6	$\frac{1295.6}{3304.5} \times 100 =$	39.2	$100.0 - 39.2 =$	60.8 (#4 PP)	61
Mass in pan	2004.5					
CMR: 1295.6 + 2004.5 = 3300.1						
Original dry mass of the sample (M): 3304.5						

Fine Sample

The pan (2008.9 g) was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **527.6 g**. This is M_3 .

Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M_3): 527.6 g

Dry mass of minus 4.75mm (No. 4) reduced portion after wash: 495.3 g

Total mass after fine sieving equals

Final Cumulative Mass Retained (FCMR)
(includes minus 75 μm (No. 200) from the pan): 495.1 g

Fine Check Sum

$$\text{Fine Check Sum} = \frac{495.3 \text{ g} - 495.1 \text{ g}}{495.3 \text{ g}} \times 100 = 0.0\%$$

The result is not more than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR_{#4}) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

$$CPR_{\#4} = \frac{194.3 \text{ g}}{527.6 \text{ g}} \times 100 = 36.8\%$$

Percent Passing (PP_{#4}) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

$$PP_{\#4} = 100.0\% - 36.8\% = 63.2\%$$

**Method C Cumulative
Gradation on Fine Sieves**

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Sieve Size mm (in.)	Cumulative Mass Retained g (CMR-#4)	Determine CPR-#4 by dividing CMR by M ₃ and multiplying by 100	Cumulative Percent Retained-#4 (CPR-#4)	Determine PP-#4 by subtracting CPR-#4 from 100.0	Percent Passing-#4 (PP-#4)
2.0 (No. 10)	194.3	$\frac{194.3}{527.6} \times 100 =$	36.8	$100.0 - 36.8 =$	63.2
0.425 (No. 40)	365.6	$\frac{365.6}{527.6} \times 100 =$	69.3	$100.0 - 69.3 =$	30.7
0.210 (No. 80)	430.8	$\frac{430.8}{527.6} \times 100 =$	81.7	$100.0 - 81.7 =$	18.3
0.075 (No. 200)	484.4	$\frac{484.4}{527.6} \times 100 =$	91.8	$100.0 - 91.8 =$	8.2
FCMR	495.1				
Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M ₃): 527.6 g					
Dry mass after washing: 495.3 g					

Percent Passing (PP) for the 2.0 mm (No. 10) sieve for the entire sample:

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#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

$$PP = \frac{63.2\% \times 60.8\%}{100} = 38.4\%$$

Reported Percent Passing = 38%

**Method C Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Cumulative Percent Retained (CPR)	Percent Passing (PP -#4)	Determine PP by multiplying PP-#4 by #4 PP and dividing by 100	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0	0.0			100.0	100
12.5 (1/2)	125.9	3.8			96.2	96
9.5 (3/8)	604.1	18.3			81.7	82
4.75 (No. 4)	1295.6	39.2			60.8 (#4 PP)	61
2.0 (No. 10)	194.3	36.8	63.2	$\frac{63.2 \times 60.8}{100} =$	38.4	38
0.425 (No. 40)	365.6	69.3	30.7	$\frac{30.7 \times 60.8}{100} =$	18.7	19
0.210 (No. 80)	430.8	81.7	18.3	$\frac{18.3 \times 60.8}{100} =$	11.1	11
0.075 (No. 200)	484.4	91.8	8.2	$\frac{8.2 \times 60.8}{100} =$	5.0	5.0
FCMR	495.1					

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Example for Alternate Percent Passing (PP) for the 4.75 mm (No. 4) sieve for the entire sample:

#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

$$PP = \frac{60.8\%}{527.6} \times (527.6 - 194.3) = 38.4\%$$

Reported Percent Passing = 38%

Alternate Method C Cumulative Gradation on Coarse Sieves

Sieve Size mm (in.)	Cumulative Mass Retained, g (CMR)	Determine PP by subtracting CMR from M, and dividing the result by M then multiplying by 100	Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)	0.0		100.0	100
12.5 (1/2)	125.9	$\frac{3304.5 - 125.9}{3304.5} \times 100 =$	96.2	96
9.5 (3/8)	604.1	$\frac{3304.5 - 604.1}{3304.5} \times 100 =$	81.7	82
4.75 (No. 4)	1295.6	$\frac{3304.5 - 1295.6}{3304.5} \times 100 =$	60.8 (#4 PP)	61
Mass in Pan	2004.5			
Cumulative sieved mass: 1295.6 + 2004.5 = 3300.1				
Original dry mass of the sample (M): 3304.5				

**Alternate Method C Cumulative
Gradation on Fine Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR _{#4})	Determine PP _{#4} by subtracting CMR _{#4} from M ₃ , dividing result by M ₃ and multiplying by 100	Percent Passing _{#4} (PP _{#4})
2.0 (No. 10)	194.3	$\frac{527.6 - 194.3}{527.6} \times 100 =$	63.2
0.425 (No. 40)	365.6	$\frac{527.6 - 365.6}{527.6} \times 100 =$	30.7
0.210 (No. 80)	430.8	$\frac{527.6 - 430.8}{527.6} \times 100 =$	18.3
0.075 (No. 200)	484.4	$\frac{527.6 - 484.4}{527.6} \times 100 =$	8.2
FCMR	495.1		
Dry mass of minus 4.75mm (No. 4) reduced portion before wash (M ₃): 527.6 g			
Dry mass after washing: 495.3 g			

**Alternate Method C Cumulative
Final Gradation on All Sieves**

Sieve Size mm (in.)	Percent Passing _{#4} (PP _{#4})	Determine PP by multiplying PP _{#4} by #4 PP and dividing by 100	Determined Percent Passing (PP)	Reported Percent Passing*
16.0 (5/8)			100.0	100
12.5 (1/2)			96.2	96
9.5 (3/8)			81.7	82
4.75 (No. 4)			60.8 (#4 PP)	61
2.0 (No. 10)	63.2	$\frac{63.2 \times 60.8}{100} =$	38.4	38
0.425 (No. 40)	30.7	$\frac{30.7 \times 60.8}{100} =$	18.7	19
0.210 (No. 80)	18.3	$\frac{18.3 \times 60.8}{100} =$	11.1	11
0.075 (No. 200)	8.2	$\frac{8.2 \times 60.8}{100} =$	5.0	5.0

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

FINENESS MODULUS

Fineness Modulus (FM) is used in determining the degree of uniformity of the aggregate gradation in PCC mix designs. It is an empirical number relating to the fineness of the aggregate. The higher the FM the coarser the aggregate. Values of 2.40 to 3.00 are common for fine aggregate in PCC.

The sum of the cumulative percentages retained on specified sieves in the following table divided by 100 gives the FM.

Sample Calculation

	Example A				Example B		
	Percent				Percent		
		Retained				Retained	
Sieve Size mm (in)	Passing		On Spec'd Sieves*		Passing		On Spec'd Sieves*
75*(3)	100	0	0		100	0	0
37.5*(11/2)	100	0	0		100	0	0
19*(3/4)	15	85	85		100	0	0
9.5*(3/8)	0	100	100		100	0	0
4.75*(No.4)	0	100	100		100	0	0
2.36*(No.8)	0	100	100		87	13	13
1.18*(No.16)	0	100	100		69	31	31
0.60*(No.30)	0	100	100		44	56	56
0.30*(No.50)	0	100	100		18	82	82
0.15*(100)	0	100	100		4	96	96
			$\Sigma = 785$				$\Sigma = 278$
			FM = 7.85				FM = 2.78

In decreasing size order, each * sieve is one-half the size of the preceding * sieve.

Report

- On forms approved by the agency
- Sample ID
- Individual mass retained for each sieve
- Individual percent retained for each sieve
or
- Cumulative mass retained for each sieve
- Cumulative percent retained for each sieve
- FM to the nearest 0.01
- Report percent passing to the nearest 1 percent except for the 75 μm (No. 200) sieve, report to the nearest 0.1 percent.

ANNEX A**Time Evaluation**

(Mandatory information)

The sieving time for each mechanical sieve shaker shall be checked at least annually to determine the time required for complete separation of the sample by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve and hold in a slightly inclined position in one hand.
3. Hand shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

Note A1: A mallet may be used instead of the heel of the hand if comparable force is used.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand shaking adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

ANNEX B**Overload Determination**

(Mandatory information)

The amount of material retained on a sieve may be regulated by:

- adding a sieve with larger openings immediately above the given sieve
- sieving the sample in multiple increments
- sieving the sample over a nest of sieves with a larger sieve-frame dimension.

TABLE B1

Maximum Allowable Mass of Material Retained on a Sieve, g
Nominal Sieve Size, mm (in.)
Exact size is smaller (see AASHTO T 27)

Sieve Size	203 dia	305 dia	305 by 305	350 by 350	372 by 580
mm (in.)	(8)	(12)	(12 × 12)	(14 × 14)	(16 × 24)
Sieving Area m ²					
	0.0285	0.0670	0.0929	0.1225	0.2158
90 (3 1/2)	*	15,100	20,900	27,600	48,500
75 (3)	*	12,600	17,400	23,000	40,500
63 (2 1/2)	*	10,600	14,600	19,300	34,000
50 (2)	3600	8400	11,600	15,300	27,000
37.5 (1 1/2)	2700	6300	8700	11,500	20,200
25.0 (1)	1800	4200	5800	7700	13,500
19.0 (3/4)	1400	3200	4400	5800	10,200
16.0 (5/8)	1100	2700	3700	4900	8600
12.5 (1/2)	890	2100	2900	3800	6700
9.5 (3/8)	670	1600	2200	2900	5100
6.3 (1/4)	440	1100	1500	1900	3400
4.75 (No. 4)	330	800	1100	1500	2600
-4.75 (-No. 4)	200	470	650	860	1510

For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m² (4 g/in²) of sieving surface.

For sieves with openings 4.75 mm (No. 4) and larger, the mass, in grams shall not exceed the product of 2.5 × (sieve opening in mm) × (effective sieving area). See Table B1.

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30

Scope

This procedure covers mechanical analysis of aggregate recovered from asphalt mix samples in accordance with AASHTO T 30-25. This FOP uses the aggregate recovered from the ignition furnace used in AASHTO T 308. AASHTO T 30 was developed for analysis of extracted aggregate and thus includes references to extracted bitumen and filter element, which do not apply in this FOP.

Sieve analyses determine the gradation or distribution of aggregate particles within a given sample to determine compliance with design and production standards.

Apparatus

- Balance or scale: Capacity sufficient for the sample mass, readable to 0.1 g and conforming to AASHTO M 231.
- Sieves, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical sieve shaker, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical Washing Apparatus (optional).
- Suitable drying equipment, meeting the requirements of the FOP for AASHTO T 255.
- Containers: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.
- Wetting Agent: Any dispersing agent, such as dishwashing detergent, that will promote separation of the fine materials.
- Utensil: device for agitating the sample during the washing procedure.

Sample Sieving

- In this procedure, it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the test sample, or a portion of the test sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*.

Mass Verification

The aggregate sample mass, $M_{(T30)}$, determined in this method, shall agree with the mass of the aggregate remaining after ignition, M_f from the FOP for AASHTO T 308, within 0.1 percent. If the variation exceeds 0.1 percent, the results cannot be used for acceptance.

Procedure

If necessary, dry the sample to constant mass according to the FOP for AASHTO T 255.

Note 1: If more than 24 hr. has passed after completion of the FOP for AASHTO T 308, the sample may have absorbed moisture.

1. Determine and record the mass of the sample that was removed from the basket in the FOP for AASHTO T 308 to 0.1 g. Designate this mass as $M_{(T30)}$.
2. Verify the mass of the sample is within 0.1 percent by subtracting $M_{(T30)}$ from $M_{R(T308)}$ dividing by $M_{R(T308)}$ and multiplying by 100 (see *Mass Verification Calculation* and example).

If the variation exceeds 0.1 percent, the sieve analysis results cannot be used for acceptance.

3. Nest a sieve, such as a 2.0 mm (No. 10) or 1.18 mm (No. 16), above the 75 μ m (No. 200) sieve.
4. Place the test sample in a container and cover with water. Add a wetting agent to the water to assure a thorough separation of the material finer than the 75 μ m (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
5. Agitate vigorously to ensure complete separation of the material finer than 75 μ m (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Use a utensil to aid in the agitation process. To avoid degradation of the sample when using a mechanical washing device do not exceed 10 min.

Note 2: When mechanical washing equipment is used, the introduction of water, agitating, and decanting may be a continuous operation. Use care not to overflow or overload the 75 μ m (No. 200) sieve.

6. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 μ m (No. 200) sieve.
7. Add water to cover material remaining in the container, agitate, and repeat Step 6. Continue until the wash water is reasonably clear. Rinse utensil into the washed sample.
8. Remove the upper sieve, return material retained to the washed sample.
9. Rinse the material retained on the 75 μ m (No. 200) sieve until water passing through the sieve is reasonably clear and wetting agent is removed.
10. Return all material retained on the 75 μ m (No. 200) sieve to the washed sample by rinsing into the washed sample.
11. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the “dry mass after washing.”
12. Select sieves required by the specification and those necessary to avoid overloading. (See Annex B.) With a pan on bottom, nest the sieves increasing in size starting with the 75 μ m (No. 200).
13. Place the test sample, or a portion of the test sample, on the top sieve.

14. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

15. Determine and record the individual or cumulative mass retained for each sieve including the pan. Ensure that all material trapped in full openings of the sieves are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

16. Perform the *Check Sum* calculation – Verify the *total mass after sieving* of material compared to the *dry mass after washing* is not more than 0.2 percent. Do not use test results for acceptance if the *Check Sum* result is more than 0.2 percent.

17. Calculate the total percentages passing, and the individual or cumulative percentages retained, to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample.

18. Apply the Aggregate Correction Factor (ACF) to the calculated percent passing, as required in the FOP for AASHTO T 308 “Correction Factor,” to obtain the reported percent passing.

19. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Calculations

Mass verification

$$\text{Mass verification} = \frac{M_{f(T308)} - M_{(T30)}}{M_{f(T308)}} \times 100$$

Where:

$M_{f(T308)}$ = Mass of aggregate remaining in the basket assembly after ignition from the FOP for AASHTO T 308

$M_{(T30)}$ = Mass of aggregate sample obtained from the FOP for AASHTO T 308

Check Sum

$$\text{check sum} = \frac{\text{dry mass after washing} - \text{total mass after sieving}}{\text{dry mass after washing}} \times 100$$

Percent Retained**Individual**

$$\text{IPR} = \frac{\text{IMR}}{M_{T30}} \times 100$$

Cumulative

$$\text{CPR} = \frac{\text{CMR}}{M_{T30}} \times 100$$

Where:

IPR	=	Individual Percent Retained
CPR	=	Cumulative Percent Retained
M_{T30}	=	Total dry sample mass before washing
IMR	=	Individual Mass Retained
CMR	=	Cumulative Mass Retained

Percent Passing**Individual**

$$PP = PCP - IPR$$

Cumulative

$$PP = 100 - CPR$$

Where:

PP	=	Calculated Percent Passing
PCP	=	Previous Calculated Percent Passing

Reported Percent Passing

$$RPP = PP + ACF$$

Where:

RPP = Reported Percent Passing

ACF = Aggregate Correction Factor (if applicable)

Example**Mass verification**

$$\text{Mass verification} = \frac{2422.5 \text{ g} - 2422.3 \text{ g}}{2422.5 \text{ g}} \times 100 = 0.0\%$$

Given:

$$M_{R(T308)} = 2422.5 \text{ g}$$

$$M_{(T30)} = 2422.3 \text{ g}$$

This is not more than 0.1 percent therefore the results can be used for acceptance purposes.

Dry mass of total sample, before washing (M_{T30}): 2422.3 g

Dry mass of sample, after washing out the 75 μm (No. 200) minus: 2296.2 g

Amount of 75 μm (No. 200) minus washed out ($2422.3 \text{ g} - 2296.2 \text{ g}$): 126.1 g

Check sum

$$\text{check sum} = \frac{2296.2 \text{ g} - 2295.3 \text{ g}}{2296.2 \text{ g}} \times 100 = 0.0\%$$

This is not more than 0.2 percent therefore the results can be used for acceptance purposes.

Percent Retained for the 75 µm (No. 200) sieve

$$IPR = \frac{63.5 \text{ g}}{2422.3 \text{ g}} \times 100 = 2.6\%$$

or

$$CPR = \frac{2289.6 \text{ g}}{2422.3 \text{ g}} \times 100 = 94.5\%$$

Percent Passing using IPR and PCP for the 75 µm (No. 200) sieve

$$PP = 8.1\% - 2.6\% = 5.5\%$$

Percent Passing using CPR for the 75 µm (No. 200) sieve

$$PP = 100.0\% - 94.5\% = 5.5\%$$

Reported Percent Passing

$$RPP = 5.5\% + (-0.6\%) = 4.9\%$$

**Individual
Gradation on All Sieves**

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR by dividing IMR by <i>M</i> and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from Previous PP	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	$100.0 - 14.3 =$	85.7		86
9.5 (3/8)	207.8	$\frac{207.8}{2422.3} \times 100 =$	8.6	$85.7 - 8.6 =$	77.1		77
4.75 (No. 4)	625.4	$\frac{625.4}{2422.3} \times 100 =$	25.8	$77.1 - 25.8 =$	51.3		51
2.36 (No. 8)	416.2	$\frac{416.2}{2422.3} \times 100 =$	17.2	$51.3 - 17.2 =$	34.1		34
1.18 (No. 16)	274.2	$\frac{274.2}{2422.3} \times 100 =$	11.3	$34.1 - 11.3 =$	22.8		23
0.600 (No. 30)	152.1	$\frac{152.1}{2422.3} \times 100 =$	6.3	$22.8 - 6.3 =$	16.5		17
0.300 (No. 50)	107.1	$\frac{107.1}{2422.3} \times 100 =$	4.4	$16.5 - 4.4 =$	12.1		12
0.150 (No. 100)	96.4	$\frac{96.4}{2422.3} \times 100 =$	4.0	$12.1 - 4.0 =$	8.1		8
0.075 (No. 200)	63.5	$\frac{63.5}{2422.3} \times 100 =$	2.6	$8.1 - 2.6 =$	5.5	-0.6 $(5.5 - 0.6 =)$	4.9
minus 75 µm (No. 200) in the pan	5.7						
Total mass after sieving = sum of sieves + mass in the pan = 2295.3 g							
Dry mass of total sample, before washing (M_{T30}): 2422.3g							

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Cumulative
Gradation on All Sieves**

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0.0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	$100.0 - 14.3 =$	85.7		86
9.5 (3/8)	554.7	$\frac{554.7}{2422.3} \times 100 =$	22.9	$100.0 - 22.9 =$	77.1		77
4.75 (No. 4)	1180.1	$\frac{1180.1}{2422.3} \times 100 =$	48.7	$100.0 - 48.7 =$	51.3		51
2.36 (No. 8)	1596.3	$\frac{1596.3}{2422.3} \times 100 =$	65.9	$100.0 - 65.9 =$	34.1		34
1.18 (No. 16)	1870.5	$\frac{1870.5}{2422.3} \times 100 =$	77.2	$100.0 - 77.2 =$	22.8		23
0.600 (No. 30)	2022.6	$\frac{2022.6}{2422.3} \times 100 =$	83.5	$100.0 - 83.5 =$	16.5		17
0.300 (No. 50)	2129.7	$\frac{2129.7}{2422.3} \times 100 =$	87.9	$100.0 - 87.9 =$	12.1		12
0.150 (No. 100)	2226.1	$\frac{2226.1}{2422.3} \times 100 =$	91.9	$100.0 - 91.9 =$	8.1		8
0.075 (No. 200)	2289.6	$\frac{2289.6}{2422.3} \times 100 =$	94.5	$100.0 - 94.5 =$	5.5	-0.6 (5.5 - 0.6 =)	4.9
minus 75 µm (No. 200) in the pan	2295.3						
Total mass after sieving = 2295.3 g							
Dry mass of total sample, before washing (M _{T30}): 2422.3g							

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Report

- On forms approved by the agency
- Sample ID
- Depending on the agency, this may include:
 - Individual mass retained on each sieve
 - Individual percent retained on each sieve
 - Cumulative mass retained on each sieve
 - Cumulative percent retained on each sieve
 - Aggregate Correction Factor for each sieve from AASHTO T 308
 - Calculated percent passing each sieve to 0.1 percent
- Percent passing to the nearest 1 percent, except 75 μm (No. 200) sieve to the nearest 0.1 percent.

ANNEX A TIME EVALUATION

(Mandatory Information)

The minimum time requirement should be evaluated for each shaker at least annually by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve and hold in a slightly inclined position in one hand.
3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

ANNEX B OVERLOAD DETERMINATION

(Mandatory Information)

The amount of material retained on a sieve may be regulated by:

- adding a sieve with larger openings immediately above the given sieve
- sieving the sample in multiple increments
- sieving the sample over a nest of sieves with a larger sieve-frame dimension.

TABLE B1
Maximum Allowable Mass of Material Retained on a Sieve, g
Nominal Sieve Size, mm (in.)
Exact size is smaller (see AASHTO T 27)

Sieve Size		203 mm	254 mm	305 mm
mm (in.)		(8 in.)	(10 in.)	(12 in.)
		dia.	dia.	dia.
Sieving Area m ² (in ²)				
		0.0285	0.0457	0.0670
		(44.2)	(70.8)	(103.5)
50	(2)	3600	5700	8400
37.5	(1 1/2)	2700	4300	6300
25.0	(1)	1800	2900	4200
19.0	(3/4)	1400	2200	3200
16.0	(5/8)	1100	1800	2700
12.5	(1/2)	890	1400	2100
9.5	(3/8)	670	1100	1600
6.3	(1/4)	440	720	1100
4.75	(No. 4)	330	540	800
-4.75	(-No. 4)	200	320	470

For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m² (4 g/in²) of sieving surface.

For sieves with openings 4.75 mm (No. 4) and larger, the mass, in grams shall not exceed the product of 2.5 × (sieve opening in mm) × (effective sieving area). See Table B1.

Specific Gravity and Absorption of Fine Aggregate

AASHTO Designation: T 84-25

ASTM Designation: C 128-22

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SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE FOP FOR AASHTO T 85

Scope

This procedure covers the determination of specific gravity and absorption of coarse aggregate in accordance with AASHTO T 85-25. Specific gravity may be expressed as bulk specific gravity (G_{sb}), bulk specific gravity, saturated surface dry (G_{sb} SSD), or apparent specific gravity (G_{sa}). G_{sb} and absorption are based on aggregate after soaking in water. This procedure is not intended to be used with lightweight aggregates.

Terminology

Absorption – the increase in the mass of aggregate due to water being absorbed into the pores of the material but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass.

Saturated Surface Dry (SSD) – condition of an aggregate particle when the permeable voids are filled with water, but no water is present on exposed surfaces.

Specific Gravity – the ratio of the mass, in air, of a volume of a material to the mass of the same volume of gas-free distilled water at a stated temperature.

Apparent Specific Gravity (G_{sa})– the ratio of the mass, in air, of a volume of the impermeable portion of aggregate to the mass of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity (G_{sb})– the ratio of the mass, in air, of a volume of aggregate (including the permeable and impermeable voids in the particles but not including the voids between particles) to the mass of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity (SSD) (G_{sb} SSD) – the ratio of the mass, in air, of a volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for 15 to 19 hours (but not including the voids between particles), to the mass of an equal volume of gas-free distilled water at a stated temperature.

Apparatus

- Balance or scale: with a capacity of 5 kg, sensitive to 0.1 g. Meeting the requirements of AASHTO M 231.
- Sample container: a wire basket of 3.35 mm (No. 6) or smaller mesh, with a capacity of 4 to 7 L (1 to 2 gal) to contain aggregate with a nominal maximum size of 37.5 mm (1 1/2 in.) or smaller; or a larger basket for larger aggregates, or both.
- Water tank: watertight and large enough to completely immerse aggregate and basket, equipped with an overflow valve to keep water level constant.
- Suspension apparatus: wire used to suspend apparatus shall be of the smallest practical diameter.

- Sieves: 4.75 mm (No. 4) or other sizes as needed, meeting the requirements of FOP for AASHTO T 27/T 11.
- Large absorbent cloth

Sample Preparation

1. Obtain the sample in accordance with the FOP for AASHTO R 90 (see Note 1).
2. Mix the sample thoroughly and reduce it to the approximate sample size required by Table 1 in accordance with the FOP for AASHTO R 76.
3. Reject all material passing the appropriate sieve by dry sieving.
4. Thoroughly wash the sample to remove dust or other coatings from the surface.
5. Dry the sample to constant mass according to the FOP for AASHTO T 255/T 265 at a temperature of 110 ±5°C (230 ±9°F) and cool in air at room temperature for 1 to 3 hours.

Note 1: Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant mass may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 15-to-19-hour soaking may also be eliminated.

6. Re-screen the sample over the appropriate sieve. Reject all material passing that sieve.
7. The sample shall meet or exceed the minimum mass given in Table 1.

Note 2: If this procedure is used only to determine the G_{sb} of oversized material for the FOP for AASHTO T 99 / T 180, the material can be rejected over the appropriate sieve. For T 99 / T 180 Methods A and B, use the 4.75 mm (No. 4) sieve; T 99 / T 180 Methods C and D use the 19 mm (3/4 in).

Table 1

Nominal Maximum Size* mm (in.)	Minimum Mass of Sample, g (lb)
12.5 (1/2) or less	2000 (4.4)
19.0 (3/4)	3000 (6.6)
25.0 (1)	4000 (8.8)
37.5 (1 1/2)	5000 (11)
50 (2)	8000 (18)
63 (2 1/2)	12,000 (26)
75 (3)	18,000 (40)

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Procedure

1. Immerse the sample in water at room temperature for a period of 15 to 19 hours.

Note 3: When testing coarse aggregate of large nominal maximum size requiring large samples, it may be more convenient to perform the test on two or more subsamples, and then combine the values obtained.

2. Place the empty basket into the water bath and attach to the balance. Inspect the immersion tank to ensure the water level is at the overflow outlet height and basket is fully submerged. Tare the balance with the empty basket attached in the water bath.
3. Remove the sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. If the sample dries past the SSD condition, immerse in water for 30 min, and then resume the process of surface-drying.

Note 4: A moving stream of air may be used to assist in the drying operation but take care to avoid evaporation of water from aggregate pores.

4. Determine the SSD mass of the sample, and record this and all subsequent masses to the nearest 0.1 g or 0.1 percent of the sample mass, whichever is greater. Designate this mass as “B.”
5. Immediately place the SSD sample in the sample container and weigh it in water maintained at $23.0 \pm 1.7^{\circ}\text{C}$ ($73.4 \pm 3^{\circ}\text{F}$). Shake the container to release entrapped air before recording the weight. Re-inspect the immersion tank to ensure the water level is at the overflow outlet height and basket is fully submerged. Designate this submerged weight as “C.”

Note 5: The container should be immersed to a depth sufficient to cover it and the sample during mass determination. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

6. Remove the sample from the basket. Ensure all material has been removed. Place in a container of known mass.
7. Dry the sample to constant mass according to the FOP for AASHTO T 255 / T 265 at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) and cool in air at room temperature for 1 to 3 hours.
8. Determine and record the dry mass. Designate this mass as “A.”

Calculations

Perform calculations and determine values using the appropriate formula below.

Bulk specific gravity (G_{sb})

$$G_{sb} = \frac{A}{B - C}$$

Bulk specific gravity, SSD (G_{sb} SSD)

$$G_{sb}SSD = \frac{B}{B - C}$$

Apparent specific gravity (G_{sa})

$$G_{sa} = \frac{A}{A - C}$$

Absorption

$$\text{Absorption} = \frac{B - A}{A} \times 100$$

Where:

- A = oven dry mass, g
- B = SSD mass, g
- C = weight in water, g

Sample Calculations

Sample	A	B	C	B - C	A - C	B - A
1	2030.9	2044.9	1304.3	740.6	726.6	14.0
2	1820.0	1832.5	1168.1	664.4	651.9	12.5
3	2035.2	2049.4	1303.9	745.5	731.3	14.2

Sample	G _{sb}	G _{sb} SSD	G _{sa}	Absorption
1	2.742	2.761	2.795	0.7
2	2.739	2.758	2.792	0.7
3	2.730	2.749	2.783	0.7

These calculations demonstrate the relationship between G_{sb}, G_{sb} SSD, and G_{sa}. G_{sb} is always lowest since the volume includes voids permeable to water. G_{sb} SSD is always intermediate. G_{sa} is always highest since the volume does not include voids permeable to water. When running this test, check to make sure the values calculated make sense in relation to one another.

Report

- On forms approved by the agency
- Sample ID
- Specific gravity values to the nearest 0.001
- Absorption to the nearest 0.1 percent

**MOISTURE-DENSITY RELATIONS OF SOILS:
USING A 2.5 KG (5.5 LB) RAMMER AND A 305 MM (12 IN.) DROP
FOP FOR AASHTO T 99
USING A 4.54 KG (10 LB) RAMMER AND A 457 MM (18 IN.) DROP
FOP FOR AASHTO T 180**

Scope

This procedure covers the determination of the moisture-density relations of soils and soil-aggregate mixtures in accordance with two similar test methods:

- AASHTO T 99-25: Methods A, B, C, and D
- AASHTO T 180-25: Methods A, B, C, and D

This test method applies to soil mixtures having 40 percent or less retained on the 4.75 mm (No. 4) sieve for methods A or B, or 30 percent or less retained on the 19 mm ($\frac{3}{4}$ in.) sieve with methods C or D. The retained material is defined as oversize (coarse) material. If no minimum percentage is specified, 5 percent will be used. Samples that contain oversize (coarse) material that meet percent retained criteria should be corrected by using *Annex A, Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles*. Samples of soil or soil-aggregate mixture are prepared at several moisture contents and compacted into molds of specified size, using manual or mechanical rammers that deliver a specified quantity of compactive energy. The moist masses of the compacted samples are multiplied by the appropriate factor to determine wet density values. Moisture contents of the compacted samples are determined and used to obtain the dry density values of the same samples. Maximum dry density and optimum moisture content for the soil or soil-aggregate mixture is determined by plotting the relationship between dry density and moisture content.

Apparatus

- Mold – Cylindrical mold made of metal with the dimensions shown in Table 1 or Table 2. If permitted by the agency, the mold may be of the “split” type, consisting of two half-round sections, which can be securely locked in place to form a cylinder. Determine the mold volume according to *Annex B, Standardization of the Mold*.
- Mold assembly – Mold, base plate, and a detachable collar.
- Rammer – Manually or mechanically operated rammers as detailed in Table 1 or Table 2. A manually operated rammer shall be equipped with a guide sleeve to control the path and height of drop. The guide sleeve shall have at least four vent holes no smaller than 9.5 mm ($\frac{3}{8}$ in.) in diameter, spaced approximately 90 degrees apart and approximately 19 mm ($\frac{3}{4}$ in.) from each end. A mechanically operated rammer will uniformly distribute blows over the sample and will be calibrated with several soil types, and be adjusted, if necessary, to give the same moisture-density results as with the manually operated rammer. For additional information concerning calibration, see AASHTO T 99 and T 180.
- Sample extruder – A jack, lever frame, or other device for extruding compacted specimens from the mold quickly and with little disturbance.

- Balance(s) or scale(s) of the capacity and sensitivity required for the procedure used by the agency.
 - A balance or scale with a capacity of 11.5 kg (25 lb) and a sensitivity of 1 g for obtaining the sample, meeting the requirements of AASHTO M 231, Class G 5.
 - A balance or scale with a capacity of 2 kg and a sensitivity of 0.1 g is used for moisture content determinations done under both procedures, meeting the requirements of AASHTO M 231, Class G 2.
- Drying oven – Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying moisture content samples in accordance with the FOP for AASHTO T 255/T 265.
- Straightedge – A steel straightedge at least 250 mm (10 in.) long, with one beveled edge and at least one surface plane within 0.1 percent of its length, used for final trimming.
- Sieve(s) – 4.75 mm (No. 4) and/or 19.0 mm (3/4 in.), meeting the requirements of FOP for AASHTO T 27/T 11.
- Mixing tools – Miscellaneous tools such as a mixing pan, spoon, trowel, spatula, etc., or a suitable mechanical device, for mixing the sample with water.
- Containers with close-fitting lids to prevent gain or loss of moisture in the sample.

**Table 1
Comparison of Apparatus, Sample, and Procedure – Metric**

	T 99	T 180
Mold Volume, m ³	Methods A, C: 0.000943 ±0.000014	Methods A, C: 0.000943 ±0.000014
	Methods B, D: 0.002124 ±0.000025	Methods B, D: 0.002124 ±0.000025
Mold Diameter, mm	Methods A, C: 101.60 ±0.40	Methods A, C: 101.60 ±0.4
	Methods B, D: 152.40 ±0.70	Methods B, D: 152.40 ±0.70
Mold Height, mm	116.40 ±0.50	116.40 ±0.50
Detachable Collar Height, mm	50.80 ±0.64	50.80 ±0.64
Rammer Diameter, mm	50.80 ±0.25	50.80 ±0.25
Rammer Mass, kg	2.495 ±0.009	4.536 ±0.009
Rammer Drop, mm	305 ±2	457 ±2
Layers	3	5
Blows per Layer	Methods A, C: 25	Methods A, C: 25
	Methods B, D: 56	Methods B, D: 56
Material Size, mm	Methods A, B: 4.75 minus	Methods A, B: 4.75 minus
	Methods C, D: 19.0 minus	Methods C, D: 19.0 minus
Test Sample Size, kg	Method A: 3 Method C: 5 (1)	Method B: 7 Method D: 11(1)
Energy, kN-m/m ³	592	2,693

(1) This may not be a large enough sample depending on your nominal maximum size for moisture content samples.

**Table 2
Comparison of Apparatus, Sample, and Procedure – English**

	T 99	T 180
Mold Volume, ft ³	Methods A, C: 0.0333 ±0.0005	Methods A, C: 0.0333 ±0.0005
	Methods B, D: 0.07500 ±0.0009	Methods B, D: 0.07500 ±0.0009
Mold Diameter, in.	Methods A, C: 4.000 ±0.016	Methods A, C: 4.000 ±0.016
	Methods B, D: 6.000 ±0.026	Methods B, D: 6.000 ±0.026
Mold Height, in.	4.584 ±0.018	4.584 ±0.018
Detachable Collar Height, in.	2.000 ±0.025	2.000 ±0.025
Rammer Diameter, in.	2.000 ±0.025	2.000 ±0.025
Rammer Mass, lb	5.5 ±0.02	10 ±0.02
Rammer Drop, in.	12 ±0.06	18 ±0.06
Layers	3	5
Blows per Layer	Methods A, C: 25	Methods A, C: 25
	Methods B, D: 56	Methods B, D: 56
Material Size, in.	Methods A, B: No. 4 minus	Methods A, B: No.4 minus
	Methods C, D: 3/4 minus	Methods C, D: 3/4 minus
Test Sample Size, lb	Method A: 7 Method C: 12 ₍₁₎	Method B: 16 Method D: 25 ₍₁₎
Energy, lb-ft/ft ³	12,375	56,250

(1) This may not be a large enough sample depending on your nominal maximum size for moisture content samples.

Sample

If the sample is damp, dry it until it becomes friable under a trowel. Drying may be in air or by use of a drying apparatus maintained at a temperature not exceeding 60°C (140°F). Thoroughly break up aggregations in a manner that avoids reducing the natural size of individual particles.

Obtain a representative test sample of the mass required by the agency by passing the material through the sieve required by the agency. See Table 1 or Table 2 for test sample mass and material size requirements.

In instances where the material is prone to degradation, i.e., granular material, a compaction sample with differing moisture contents should be prepared for each point.

If the sample is plastic (clay types), it should stand for a minimum of 12 hours after the addition of water to allow the moisture to be absorbed. In this case, several samples at different moisture contents should be prepared, put in sealed containers, and tested the next day.

Note 1: Both T 99 and T 180 have four methods (A, B, C, D) that require different masses and employ different sieves.

Procedure

During compaction, rest the mold firmly on a dense, uniform, rigid, and stable foundation, or base. This base shall remain stationary during the compaction process.

1. Determine the mass of the clean, dry mold. Include the base plate but exclude the extension collar. Record the mass to the nearest 1 g (0.005 lb).
2. Thoroughly mix the selected representative sample with sufficient water to dampen it to approximately 4 to 8 percentage points below optimum moisture content. For many materials, this condition can be identified by forming a cast by hand.
 - a. Prepare individual samples of plastic or degradable material, increasing moisture contents 1 to 2 percent for each point.
 - b. Allow samples of plastic soil to stand for at least 12 hrs.
3. Form a specimen by compacting the prepared soil in the mold assembly in approximately equal layers. For each layer:
 - a. Spread the loose material uniformly in the mold.

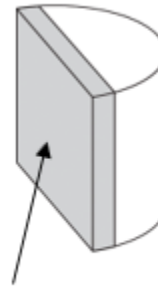
Note 2: It is recommended to cover the remaining material with a non-absorbent sheet or damp cloth to minimize loss of moisture.

- b. Lightly tamp the loose material with the manual rammer or other similar device, this establishes a firm surface.
- c. Compact each layer with uniformly distributed blows from the rammer. See Table 1 for mold size, number of layers, number of blows, and rammer specification for the various test methods. Use the method specified by the agency.
- d. Trim down material that has not been compacted and remains adjacent to the walls of the mold and extends above the compacted surface.

4. Remove the extension collar. Avoid shearing off the sample below the top of the mold. The material compacted in the mold should not be over 6 mm ($\frac{1}{4}$ in.) above the top of the mold once the collar has been removed.
5. Trim the compacted soil even with the top of the mold with the beveled side of the straightedge.
6. Clean soil from exterior of the mold and base plate.
7. Determine and record the mass of the mold, base plate, and wet soil to the nearest 1 g (0.005 lb).
8. Determine and record the wet mass (M_w) of the sample by subtracting the mass in Step 1 from the mass in Step 7.
9. Calculate the wet density (ρ_w), in kg/m^3 (lb/ft^3), by dividing the wet mass by the measured volume (V_m).
10. Extrude the material from the mold. For soils and soil-aggregate mixtures, slice vertically through the center and remove one of the cut faces for a representative moisture content sample. For granular materials, a vertical face will not exist. Take a representative sample ensuring that all layers are represented. This sample must meet the sample size requirements of the test method used to determine moisture content.



Extruded material



**Representative moisture
content sample**

- Note 3:** When developing a curve for free-draining soils such as uniform sands and gravels, where seepage occurs at the bottom of the mold and base plate, taking a representative moisture content from the mixing bowl may be preferred in order to determine the amount of moisture available for compaction.
11. Determine and record the moisture content (w) of the sample in accordance with the FOP for AASHTO T 255 / T 265.
 12. If the material is degradable or plastic, return to Step 3 using a prepared individual sample. If not, continue with Steps 13 through 15.
 13. Thoroughly break up the remaining portion of the molded specimen until it will again pass through the sieve, as judged by eye, and add to the remaining portion of the sample being tested.
 14. Add sufficient water to increase the moisture content of the remaining soil by 1 to 2 percentage points and repeat steps 3 through 11.

15. Continue determinations until there is either a decrease or no change in the wet mass. There will be a minimum of three points on the dry side of the curve and two points on the wet side. For non-cohesive, drainable soils, one point on the wet side is sufficient.

Calculations

Wet Density

$$\rho_w = \frac{M_w}{V_m}$$

Where:

- ρ_w = wet density, kg/m³ (lb/ft³)
- M_w = wet mass
- V_m = volume of the mold, Annex B

Dry Density

$$\rho_d = \left(\frac{\rho_w}{w + 100} \right) \times 100 \quad \text{or} \quad \rho_d = \frac{\rho_w}{\left(\frac{w}{100} \right) + 1}$$

Where:

- ρ_d = dry density, kg/m³ (lb/ft³)
- w = moisture content, as a percentage

Example for 4-inch mold, Methods A or C

- Wet mass, M_w = 1.928 kg (4.250 lb)
- Moisture content, w = 11.3%
- Measured volume of the mold, V_m = 0.000946 m³ (0.0334 ft³)

Wet Density

$$\rho_w = \frac{1.928 \text{ kg}}{0.000946 \text{ m}^3} = 2038 \text{ kg/m}^3 \quad \rho_w = \frac{4.250 \text{ lb}}{0.0334 \text{ ft}^3} = 127.2 \text{ lb/ft}^3$$

Where:

- ρ_w = Wet density, kg/m³ (lb/ft³)

Dry Density

$$\rho_d = \left(\frac{2038 \text{ kg/m}^3}{11.3 + 100} \right) \times 100 = 1831 \text{ kg/m}^3 \quad \rho_d = \left(\frac{127.2 \text{ lb/ft}^3}{11.3 + 100} \right) \times 100 = 114.3 \text{ lb/ft}^3$$

Or

$$\rho_d = \left(\frac{2038 \text{ kg/m}^3}{\frac{11.3}{100} + 1} \right) = 1831 \text{ kg/m}^3 \quad \rho_d = \left(\frac{127.2 \text{ lb/ft}^3}{\frac{11.3}{100} + 1} \right) = 114.3 \text{ lb/ft}^3$$

$$\rho_d = \text{Dry density, kg/m}^3 \text{ (lb/ft}^3\text{)}$$

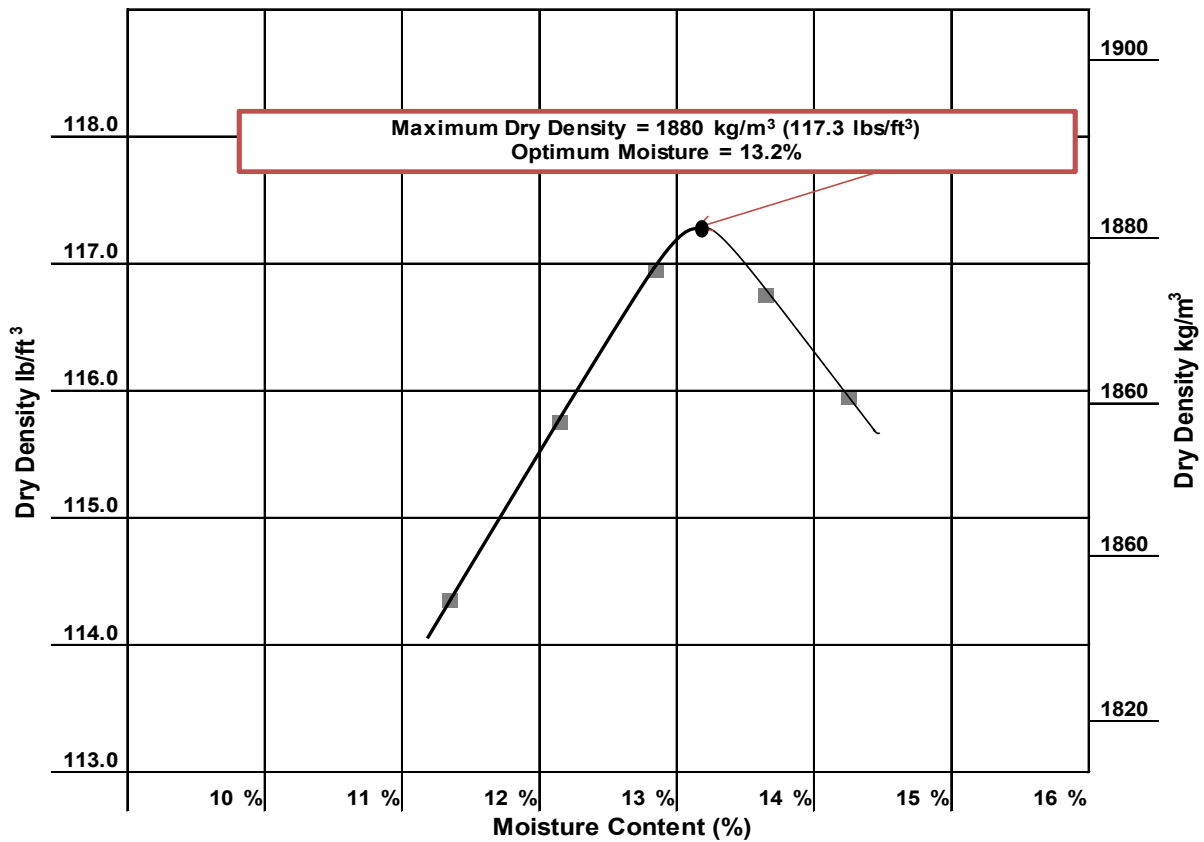
Moisture-Density Curve Development

When dry density is plotted on the vertical axis versus moisture content on the horizontal axis and the points are connected with a smooth line, a moisture-density curve is developed. The coordinates of the peak of the curve are the maximum dry density, or just “maximum density,” and the “optimum moisture content” of the soil.

Example

Given the following dry density and corresponding moisture content values develop a moisture-density relations curve and determine maximum dry density and optimum moisture content.

Dry Density		Moisture Content, %
kg/m ³	lb/ft ³	
1831	114.3	11.3
1853	115.7	12.1
1873	116.9	12.8
1869	116.7	13.6
1857	115.9	14.2



In this case, the curve has its peak at:

Maximum dry density = 1880 kg/m³ (117.3 lb/ft³)
 Optimum moisture content = 13.2%

Note that both values are approximate since they are based on sketching the curve to fit the points.

Report

- Results on forms approved by the agency
- Sample ID
- Maximum dry density to the nearest 1 kg/m³ (0.1 lb/ft³)
- Optimum moisture content to the nearest 0.1 percent

ANNEX A**CORRECTION OF MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE FOR OVERSIZED PARTICLES**

(Mandatory Information)

This section corrects the maximum dry density and moisture content of the material retained on the 4.75 mm (No. 4) sieve, Methods A and B; or the material retained on the 19 mm (¾ in.) sieve, Methods C and D. The maximum dry density, corrected for oversized particles and total moisture content, are compared with the field-dry density and field moisture content.

This correction can be applied to the sample on which the maximum dry density is performed. A correction may not be practical for soils with only a small percentage of oversize material. The agency shall specify a minimum percentage below which the method is not needed. If not specified, this method applies when more than 5 percent by weight of oversize particles is present.

Bulk specific gravity (G_{sb}) of the oversized particles is required to determine the corrected maximum dry density. Use the bulk specific gravity as determined using the FOP for AASHTO T 85 in the calculations. For construction activities, an agency established value or specific gravity of 2.600 may be used.

This correction can also be applied to the sample obtained from the field while performing in-place density.

Procedure

1. Use the sample from this procedure or a sample obtained according to the FOP for AASHTO T 310.
2. Sieve the sample on the 4.75 mm (No. 4) sieve for Methods A and B or the 19 mm (¾ in.) sieve, Methods C and D.
3. Determine the dry mass of the oversized and fine fractions (M_{DC} and M_{DF}) by one of the following:
 - a. Dry the fractions, fine and oversized, in air or by use of a drying apparatus that is maintained at a temperature not exceeding 60°C (140°F).
 - b. Calculate the dry masses using the moisture samples.

To determine the dry mass of the fractions using moisture samples.

1. Determine the moist mass of both fractions, fine (M_{Mf}) and oversized (M_{Mc}):
2. Obtain moisture samples from the fine and oversized material.
3. Determine the moisture content of the fine particles (MC_f) and oversized particles (MC_c) of the material by FOP for AASHTO T 255/T 265 or agency approved method.
4. Calculate the dry mass of the oversize and fine particles.

$$M_D = \frac{M_m}{1 + MC}$$

Where:

M_D = mass of dry material (fine or oversize particles)

M_m = mass of moist material (fine or oversize particles)

MC = moisture content of respective fine or oversized, expressed as a decimal

- Calculate the percentage of the fine (P_f) and oversized (P_c) particles by dry weight of the total sample as follows: See Note 2.

$$P_f = \frac{100 \times M_{DF}}{M_{DF} + M_{DC}} \quad \frac{100 \times 15.4 \text{ lb}}{15.4 \text{ lbs} + 5.7 \text{ lb}} = 73\% \quad \frac{100 \times 6.985 \text{ kg}}{6.985 \text{ kg} + 2.585 \text{ kg}} = 73\%$$

And

$$P_c = \frac{100 \times M_{DC}}{M_{DF} + M_{DC}} \quad \frac{100 \times 5.7 \text{ lb}}{15.4 \text{ lbs} + 5.7 \text{ lb}} = 27\% \quad \frac{100 \times 2.585 \text{ kg}}{6.985 \text{ kg} + 2.585 \text{ kg}} = 27\%$$

Or for P_c :

$$P_c = 100 - P_f$$

Where:

P_f = percent of fine particles, of sieve used, by weight

P_c = percent of oversize particles, of sieve used, by weight

M_{DF} = mass of dry fine particles

M_{DC} = mass of dry oversize particles

Optimum Moisture Correction Equation

1. Calculate the corrected moisture content as follows:

$$MC_T = \frac{(MC_F \times P_f) + (MC_C \times P_c)}{100} = \frac{(13.2\% \times 73.0\%) + (2.1\% \times 27.0\%)}{100} = 10.2\%$$

MC_T = corrected moisture content of combined fines and oversized particles, expressed as a % moisture

MC_F = moisture content of fine particles, as a % moisture

MC_C = moisture content of oversized particles, as a % moisture

Note 1: Moisture content of oversize material can be assumed to be two (2) percent for most construction applications.

Note 2: In some field applications agencies will allow the percentages of oversize and fine materials to be determined with the materials in the wet state.

Density Correction Equation

2. Calculate the corrected dry density (ρ_d) of the total sample (combined fine and oversized particles) as follows:

$$\rho_d = \frac{100\%}{\left[\left(\frac{P_f}{\rho_f}\right) + \left(\frac{P_c}{k}\right)\right]}$$

Where:

ρ_d = corrected total dry density (combined fine and oversized particles)
kg/m³ (lb/ft³)

ρ_f = dry density of the fine particles kg/m³ (lb/ft³), determined in the lab

P_c = percent of dry oversize particles, of sieve used, by weight.

P_f = percent of dry fine particles, of sieve used, by weight.

k = Metric: 1,000 * Bulk Specific Gravity (G_{sb}) (oven dry basis)
of coarse particles (kg/m³).

k = English: 62.4 * Bulk Specific Gravity (G_{sb}) (oven dry basis)
of coarse particles (lb/ft³)

Note 3: If the specific gravity is known, then this value will be used in the calculation. For most construction activities the specific gravity for aggregate may be assumed to be 2.600.

Calculation

Example

- Metric:

Maximum laboratory dry density (ρ_f):	1880 kg/m ³
Percent coarse particles (P_c):	27%
Percent fine particles (P_f):	73%
Mass per volume coarse particles (k):	(2.697) (1000) = 2697 kg/m ³

$$\rho_d = \frac{100\%}{\left[\left(\frac{P_f}{\rho_f}\right) + \left(\frac{P_c}{k}\right)\right]}$$

$$\rho_d = \frac{100\%}{\left[\left(\frac{73\%}{1880 \text{ kg/m}^3}\right) + \left(\frac{27\%}{2697 \text{ kg/m}^3}\right)\right]}$$

$$\rho_d = \frac{100\%}{[0.03883 \text{ kg/m}^3 + 0.01001 \text{ kg/m}^3]}$$

$$\rho_d = 2047.5 \text{ kg/m}^3 \text{ report } 2048 \text{ kg/m}^3$$

English:

Maximum laboratory dry density (ρ_f): 117.3 lb/ft³

Percent coarse particles (P_c): 27%

Percent fine particles (P_f): 73%

Mass per volume of coarse particles (k): (2.697) (62.4) = 168.3 lb/ft³

$$\rho_d = \frac{100\%}{\left[\left(\frac{P_f}{\rho_f}\right) + \left(\frac{P_c}{k}\right)\right]}$$

$$\rho_d = \frac{100\%}{\left[\left(\frac{73\%}{117.3 \text{ lb/ft}^3}\right) + \left(\frac{27\%}{168.3 \text{ lb/ft}^3}\right)\right]}$$

$$\rho_d = \frac{100\%}{[0.6223 \text{ lb/ft}^3 + 0.1604 \text{ lb/ft}^3]}$$

$$\rho_d = \frac{100\%}{0.7827 \text{ lb/ft}^3}$$

$$\rho_d = 127.76 \text{ lb/ft}^3 \quad \text{Report } 127.8 \text{ lb/ft}^3$$

Report

- On forms approved by the agency
- Sample ID
- Corrected maximum dry density to the nearest 1 kg/m³ (0.1 lb/ft³)
- Corrected optimum moisture to the nearest 0.1 percent

ANNEX B

STANDARDIZATION OF THE MOLD

(Mandatory Information)

Standardization is a critical step to ensure accurate test results when using this apparatus. Failure to perform the standardization procedure as described herein will produce inaccurate or unreliable test results.

Apparatus

- Mold and base plate
- Balance or scale – Accurate to within 45 g (0.1 lb) or 0.3 percent of the test load, whichever is greater, at any point within the range of use.
- Cover plate – A piece of plate glass, at least 6 mm (1/4 in.) thick and at least 25 mm (1 in.) larger than the diameter of the mold.
- Thermometers – Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C (1°F)

Procedure

1. Create a watertight seal between the mold and base plate.
2. Determine and record the mass of the dry sealed mold, base plate, and cover plate.
3. Fill the mold with water at a temperature between 16°C and 29°C (60°F and 85°F) and cover with the cover plate in such a way as to eliminate bubbles and excess water.
4. Wipe the outside of the mold, base plate, and cover plate dry, being careful not to lose any water from the mold.
5. Determine and record the mass of the filled mold, base plate, cover plate, and water.
6. Determine and record the mass of the water in the mold by subtracting the mass in Step 2 from the mass in Step 5.
7. Measure the temperature of the water and determine its density from Table B1, interpolating, as necessary.
8. Calculate the volume of the mold, V_m , by dividing the mass of the water in the mold by the density of the water at the measured temperature.

Calculations

$$V_m = \frac{M}{\rho_{water}}$$

Where:

V_m = volume of the mold

M = mass of water in the mold

ρ_{water} = density of water at the measured temperature

Example

Mass of water in mold = 0.94367 kg (2.0800 lb)

ρ_{water} at 23°C (73.4°F) = 997.54 kg/m³ (62.274 lb/ft³)

$$V_m = \frac{0.94367 \text{ kg}}{997.54 \text{ kg/m}^3} = 0.000946 \text{ m}^3 \quad V_m = \frac{2.0800 \text{ lb}}{62.274 \text{ lb/ft}^3} = 0.0334 \text{ ft}^3$$

**Table B1
Unit Mass of Water
15°C to 30°C**

°C	(°F)	kg/m ³	(lb/ft ³)	°C	(°F)	kg/m ³	(lb/ft ³)
15	(59.0)	999.10	(62.372)	23	(73.4)	997.54	(62.274)
15.6	(60.0)	999.01	(62.366)	23.9	(75.0)	997.32	(62.261)
16	(60.8)	998.94	(62.361)	24	(75.2)	997.29	(62.259)
17	(62.6)	998.77	(62.350)	25	(77.0)	997.03	(62.243)
18	(64.4)	998.60	(62.340)	26	(78.8)	996.77	(62.227)
18.3	(65.0)	998.54	(62.336)	26.7	(80.0)	996.59	(62.216)
19	(66.2)	998.40	(62.328)	27	(80.6)	996.50	(62.209)
20	(68.0)	998.20	(62.315)	28	(82.4)	996.23	(62.192)
21	(69.8)	997.99	(62.302)	29	(84.2)	995.95	(62.175)
21.1	(70.0)	997.97	(62.301)	29.4	(85.0)	995.83	(62.166)
22	(71.6)	997.77	(62.288)	30	(86.0)	995.65	(62.156)

Report

- Mold ID
- Date Standardized
- Temperature of the water
- Volume, V_m , of the mold to the nearest 0.000001 m^3 (0.0001 ft^3)

BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-25. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

Overview

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid Teset

Test Specimens

Test specimens may be either laboratory-molded or sampled from asphalt mixture pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one- and one-half times the maximum size.

Terminology

Constant mass: The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus – Method A (Suspension)

- Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Potable water: Water that is suitable for drinking.
- Water bath: For immersing the specimen in water while suspended under the balance or scale and equipped with an overflow outlet for maintaining a constant water level. Use potable water to fill the water bath. The water in the bath does not need to maintain a potable condition but must always remain clear.

Note 1: The water bath may be equipped with a circulator and heater or chiller to maintain constant temperatures throughout the bath. If a circulator is used, turn it off before any masses are recorded.

- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 15 to 45°C (59 to 113°F) and, graduated in 0.1°C (0.2°F) subdivisions.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method A (Suspension)

Recently molded laboratory specimens that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method
 - i. Initially dry overnight at $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$).
 - ii. Determine and record the mass of the specimen. Designate this mass as M_p .
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen. Designate this mass as M_n .
 - v. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , dividing by the previous mass determination M_p , and multiplying by 100.
 - vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved; specimen is defined as dry.
 - b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Fill the water bath to the overflow level with water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) and allow the water to stabilize.
4. Zero or tare the balance with the suspension apparatus attached, ensuring that the suspension apparatus is completely submerged and not touching the sides or the bottom of the water bath.

Note 2: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ± 1 minutes.
6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as C.
7. Remove the specimen from the water and quickly surface dry with a damp cloth towel within 5 sec.
8. Zero or tare the balance.
9. Immediately determine and record the mass of the saturated surface-dry (SSD) specimen to nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not exceed 15 sec. performing Steps 7 through 9.

Calculations – Method A (Suspension)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B - C}$$

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B - C} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$), g

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} \times 100 = 0.45\%$$

Given:

A	=	4833.6 g
B	=	4842.4 g
C	=	2881.3 g

Apparatus – Method B (Volumeter)

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Potable water: Water that is suitable for drinking.
- Water bath: For immersing the specimen in water, capable of maintaining a uniform temperature at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$). Use potable water to fill the water bath. The water in the bath does not need to maintain a potable condition but must remain clear at all times.
- Thermometer: Range of 15 to 45°C (59 to 113°F) and graduated in 0.1°C (0.2°F) subdivisions.
- Distilled water: Clear, distilled water for filling the volumeter.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for specimen and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of $52 \pm 3^\circ\text{C}$ ($126 \pm 5^\circ\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a specimen for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method B (Volumeter)

Method B is not acceptable for use with specimens that have more than 6 percent air voids. Recently molded laboratory specimens that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method:
 - i. Initially dry overnight at $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$).
 - ii. Determine and record the mass of the specimen. Designate this mass as M_p .
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen. Designate this mass as M_n .
 - v. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , dividing by the previous mass determination, M_p , and multiplying by 100.
 - vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved; specimen is defined as dry.

Note 3: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.
 - b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Immerse the specimen in the temperature-controlled water bath at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) for at least 10 minutes.
4. At the end of the ten-minute period, fill the volumeter with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) making sure some water escapes through the capillary bore of the tapered lid.
5. Wipe the volumeter dry. Determine the mass of the volumeter and water to the nearest 0.1 g. Designate this mass as D.
6. Remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 sec.
7. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
8. Place the specimen in the volumeter and let stand 60 sec.
9. Bring the temperature of the water to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
10. Wipe the volumeter dry.

11. Determine and record the mass of the volumeter, water, and specimen to the nearest 0.1 g. Designate this mass as E.

Calculations – Method B (Volumeter)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B + D - E}$$

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B + D - E} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$), g

E = Mass of volumeter filled with specimen and water, g

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} \times 100 = 0.45\%$$

Given:

A	=	4833.6 g
B	=	4842.4 g
D	=	2924.4 g
E	=	5806.0 g

Apparatus – Method C (Rapid Test)

- Oven: Capable of maintaining a temperature of $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$) for drying the specimens to a constant mass.

See Methods A or B.

Note 4: This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, A, as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$).
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm ($\frac{1}{4}$ in.).
6. Determine and record the mass of the specimen. Designate this mass as M_p .
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen. Designate this mass as M_n .
9. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , dividing by the previous mass determination, M_p , and multiplying by 100.

10. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved; specimen is defined as dry.
12. Cool in air to $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as A.

Calculations – Method C (Rapid Test)

Complete the calculations as outlined in Methods A or B, as appropriate.

Report

- On forms approved by the agency
- Sample ID
- G_{mb} to the nearest 0.001
- Absorption to the nearest 0.01 percent
- Method performed.

Air Content of Freshly Mixed Concrete by the Volumetric Method

AASHTO Designation: T 196-25

ASTM Designation: C 173M-24

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THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm}) AND DENSITY OF ASPHALT MIXTURES FOP FOR AASHTO T 209

Scope

This procedure covers the determination of the maximum specific gravity (G_{mm}) of uncompacted asphalt mixtures in accordance with AASHTO T 209-25. Two methods using different containers – bowl and pycnometer / volumetric flask– are covered.

Specimens prepared in the laboratory shall be cured according to agency standards.

Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g, meeting AASHTO M 231, Class G2
- Container: A glass, metal, or plastic bowl, pycnometer or volumetric flask between 2000 and 10,000 mL as required by the minimum sample size requirements in Table 1 sample and capable of withstanding full vacuum applied
- Pycnometer / volumetric flask cover: A glass plate or a metal or plastic cover with a vented opening
- Vacuum lid: A transparent lid with a suitable vacuum connection, with a vacuum opening to be covered with a fine wire mesh
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 3.4 kPa (25 mm Hg)
- Vacuum measurement device: Residual pressure manometer or vacuum gauge, capable of measuring residual pressure down to 3.4 kPa (25 mmHg) or less and readable to at least 0.2 kPa (2 mmHg)
- Suspension apparatus: Suitable apparatus and holder to permit determining the mass of the sample while suspended below the balance. The wire suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length for Bowl Method.
- Water bath: A constant-temperature water bath (optional for Pycnometer or Volumetric Flask Method)

Note 1: The water bath may be equipped with a circulator and heater or chiller to maintain constant temperatures throughout the bath. If a circulator is used, turn it off before any masses are recorded.

- Thermometer: An immersion thermometer readable to at least 0.5°C (1°F) and with a temperature range of at least 20 to 45°C (68 to 113°F).
- Bleeder valve to adjust vacuum
- Automatic vacuum control unit (optional)

- Timer
- Towel

Standardization

Use a container that has been standardized according to the Annex. Record the standardized container mass for use in subsequent calculations.

The container shall be standardized periodically in conformance with procedures established by the agency.

Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO R 97 and reduce according to the FOP for AASHTO R 47.
2. Test sample size shall conform to the requirements of Table 1. Samples larger than the capacity of the container may be tested in two or more increments. Results will be combined by calculating the weighted average ($G_{mm (avg)}$). If the increments have a specific gravity difference greater than 0.013, the test must be re-run.
3. Plant-produced samples may be short-term conditioned according to AASHTO R 30 as specified by the agency.

Note 2: Short-term conditioning at the specified temperature is especially important when absorptive aggregates are used. This short-term conditioning will ensure the computation of realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix. Plant-produced asphalt mixtures should be evaluated to make sure short-term conditioning has taken place during production and delivery.

**Table 1
Test Sample Size for G_{mm}**

Nominal Maximum* Aggregate Size mm (in.)	Minimum Mass g
37.5 or greater (1½)	4000
19 to 25 (¾ to 1)	2500
12.5 or smaller (½)	1500

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained.

Procedure – General

Two procedures – bowl and pycnometer / volumetric flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.3 mm (¼ in.). If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven (do not exceed Job Mix Formula (JMF) compaction temperature) until it is pliable enough for separation.

2. Cool the sample to room temperature.
3. Determine and record the mass of the dry container to the nearest 0.1 g.
4. Place the sample in the container.
5. Determine and record the mass of the dry container and sample to the nearest 0.1 g.
6. Determine and record the mass of the sample by subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as “A.”
7. Add sufficient water at approximately 25° C (77° F) to cover the sample by about 25 mm (1 in.).

Note 3: The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the container and attach the vacuum line. To ensure a proper seal between the container and the lid, wet the O-ring or use a petroleum gel.
9. Remove entrapped air by subjecting the sample to a partial vacuum of 4.0 ± 0.6 kPa (30 ± 5 mmHg) residual pressure for 15 ± 1 minutes.
10. Agitate the container and sample, either continuously by mechanical device or manually by vigorous shaking at 2-minute intervals. This agitation facilitates the removal of air.
11. Release the vacuum. Increase the pressure to atmospheric pressure in 10 to 15 seconds if the vacuum release is not automated. Turn off the vacuum pump and remove the lid.

Procedure – Bowl

- 12A. Fill the water bath to overflow level with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$) and allow the water to stabilize.
- 13A. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
- 14A. Suspend and immerse the bowl and sample in water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$) for 10 ± 1 minute.
- 15A. Determine and record the submerged weight of the bowl and sample to the nearest 0.1 g. Designate as “C.”

Procedure – Pycnometer or Volumetric Flask

Complete steps 12B through 16B within 10 ± 1 min.

- 12B. Immediately fill the pycnometer / volumetric flask with water without reintroducing air.
- 13B. Stabilize the temperature of the pycnometer / volumetric flask and sample so that the final temperature is within $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$).
- 14B. Finish filling the pycnometer / volumetric flask with water that is $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$), place the cover or a glass plate on the pycnometer / volumetric flask, and eliminate all air.

Note 4: When using a metal pycnometer and cover, place the cover on the pycnometer and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling the pycnometer to avoid reintroducing air into the water.

- 15B. Towel dry the outside of the pycnometer / volumetric flask and cover.
- 16B. Determine and record the mass of the pycnometer / volumetric flask, cover, de-aired water, and sample to the nearest 0.1 g. within 10 ±1 minute of completion of Step 11. Designate this mass as “E.”

Procedure – Mixtures Containing Uncoated Porous Aggregate

If the pores of the aggregates are not thoroughly sealed by an asphalt binder film, they may become saturated with water during the vacuuming procedure, resulting in an error in G_{mm} and theoretical maximum density. To determine if this has occurred, complete the general procedure and then:

1. Carefully drain water from sample through a towel held over the top of the container to prevent loss of material.
2. Spread sample in a flat shallow pan and place before an electric fan to remove surface moisture.
3. Determine the mass of the sample when the surface moisture appears to be gone.
4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.
5. Record the mass as the saturated surface dry mass to the nearest 0.1 g. Designate this mass as “ A_{SSD} .”
6. Calculate, as indicated below, G_{mm} using “A” and “ A_{SSD} ,” and compare the two values.

Calculation

Calculate the G_{mm} to three decimal places as follows:

Bowl Procedure

$$G_{mm} = \frac{A}{A + B - C} \quad \text{or} \quad G_{mm} = \frac{A}{A_{SSD} + B - C}$$

(for mixes containing uncoated aggregate materials)

Where:

- A = mass of dry sample in air, g
- A_{SSD} = mass of saturated surface dry sample in air, g
- B = standardized submerged weight of the bowl, g (see Annex)
- C = submerged weight of sample and bowl, g

Example:

$$G_{mm} = \frac{1432.7 \text{ g}}{1432.7 \text{ g} + 286.3 \text{ g} - 1134.9 \text{ g}} = 2.453 \quad \text{or}$$

$$G_{mm} = \frac{1432.7 \text{ g}}{1434.2 \text{ g} + 286.3 \text{ g} - 1134.9 \text{ g}} = 2.447$$

Given:

$$A = 1432.7 \text{ g}$$

$$A_{SSD} = 1434.2 \text{ g}$$

$$B = 286.3 \text{ g}$$

$$C = 1134.9 \text{ g}$$

Pycnometer / Volumetric Flask Procedure

$$G_{mm} = \frac{A}{A + D - E} \quad \text{or} \quad G_{mm} = \frac{A}{A_{SSD} + D - E}$$

(for mixtures containing uncoated materials)

Where:

A = mass of dry sample in air, g

A_{SSD} = mass of saturated surface-dry sample in air, g

D = standardized mass of pycnometer / volumetric flask filled with water at 25°C (77°F), g, (See Annex)

E = mass of pycnometer / volumetric flask filled with water and the test sample at test temperature, g

Example (two increments of a large sample):

$$G_{mm_1} = \frac{2200.3 \text{ g}}{2200.3 \text{ g} + 7502.5 \text{ g} - 8812.0 \text{ g}} = 2.470$$

$$G_{mm_2} = \frac{1960.2 \text{ g}}{1960.2 \text{ g} + 7525.5 \text{ g} - 8690.8 \text{ g}} = 2.466$$

Given:

Increment 1	Increment 2
A ₁ = 2200.3 g	A ₂ = 1960.2 g
D ₁ = 7502.5 g	D ₂ = 7525.5 g
E ₁ = 8812.0 g	E ₂ = 8690.8 g

$$\text{Variation} = 2.470 - 2.466 = 0.004, \text{ which is } < 0.013$$

Allowable variation is: 0.013. The values may be used.

Weighted average

For large samples tested a portion at a time, calculate the $G_{mm(avg)}$ by multiplying the dry mass of each increment by its G_{mm} , add the results together (Σ) and divide by the sum (Σ) of the dry masses.

$$G_{mm(avg)} = \frac{\Sigma(A_x \times G_{mm_x})}{\Sigma A_x}$$

or

$$G_{mm(avg)} = \frac{(A_1 \times G_{mm_1}) + (A_2 \times G_{mm_2})}{A_1 + A_2} \text{ etc.}$$

Where:

- A_x = mass of dry sample increment in air, g
- G_{mmx} = theoretical maximum specific gravity of the increment

Example:

$$G_{mm(avg)} = \frac{(2200.3 \text{ g} \times 2.470) + (1960.2 \text{ g} \times 2.466)}{2200.3 \text{ g} + 1960.2 \text{ g}} = \frac{10,268.6}{4160.5 \text{ g}} = 2.468$$

Theoretical Maximum Density

To calculate the theoretical maximum density at 25°C (77°F) use one of the following formulas. The density of water at 25°C (77°F) is 997.1 kg/ m³ in Metric units or 62.245 lb/ft³ in English units.

$$\text{Theoretical maximum density kg/m}^3 = G_{mm} \times 997.1 \text{ kg/ m}^3$$

$$2.468 \times 997.1 \text{ kg/ m}^3 = 2461 \text{ kg/ m}^3$$

or

$$\text{Theoretical maximum density lb/ft}^3 = G_{mm} \times 62.245 \text{ lb/ft}^3$$

$$2.468 \times 62.245 \text{ lb/ft}^3 = 153.6 \text{ lb/ft}^3$$

Report

- On forms approved by the agency
- Sample ID
- G_{mm} to the nearest 0.001
- Theoretical maximum density to the nearest 1 kg/m³ (0.1 lb/ft³)

ANNEX – STANDARDIZATION OF BOWL AND PYCNOMETER OR VOLUMETRIC FLASK

(Mandatory Information)

Bowl – Standardization

1. Fill the water bath to overflow level with $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ± 1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.
5. Refill the water bath to overflow level.
6. Perform Steps 2 through 5 two more times for a total of three determinations.
7. If the range of the three determinations is less than or equal to 0.3 g., average the determinations. Designate as “B.”
8. If the range of the three determinations is greater than 0.3 g., take corrective action and perform the standardization procedure again.

Bowl – Check

1. Fill the water bath to overflow level $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ± 1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.
5. If this determination is within 0.3 g of the standardized value, use the standardized value for “B.”
6. If it is not within 0.3 g, take corrective action and perform the standardization procedure again.
7. For labs that check the bowl standardization frequently (such as daily), calculate the moving average and range of the last three mass determinations. Designate the average of the last three masses as “B.”
8. If the moving range exceeds 0.3 g at any time, take corrective action and perform the standardization procedure again.

Pycnometer or Volumetric Flask – Standardization

1. Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).
2. Place the metal or plastic cover, or a glass plate on the pycnometer / volumetric flask and eliminate all air. (See Note 4.)
3. Stabilize the pycnometer / volumetric flask at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$) for 10 ± 1 min.
4. Towel dry the outside of the pycnometer / volumetric flask and cover.
5. Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate to the nearest 0.1 g.
6. Perform Steps 2 through 5 two more times for a total of three determinations.
7. If the range of the three determinations is less than or equal to 0.3 g, average the three determinations. Designate as “D.”
8. If the range of the determinations is greater than 0.3 g., take corrective action and perform the “Pycnometer or Volumetric Flask – Standardization” again.

Pycnometer or Volumetric Flask – Check

1. Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).
2. Place the metal or plastic cover or a glass plate on the pycnometer / volumetric flask and eliminate all air. (See Note 4.)
3. Stabilize the pycnometer / volumetric flask at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$) for 10 ± 1 min.
4. Towel dry the outside of the pycnometer / volumetric flask and cover.
5. Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate.
6. If this determination is within 0.3 g of the standardized value, use the standardized value for “D.”
7. If it is not within 0.3 g, perform the standardization procedure again.

Capping Cylindrical Concrete Specimens

AASHTO Designation: T 231-25

ASTM Designation: C617/C617M-23

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**TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
FOP FOR AASHTO T 255
LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS
FOP FOR AASHTO T 265**

Scope

This procedure covers the determination of moisture content of aggregate and soil in accordance with AASHTO T 255-25 and AASHTO T 265-22. It may also be used for other construction materials.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

Constant mass – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: capacity sufficient for the principal sample mass, readable to 0.1 percent of sample mass or 0.1 g, and meeting the requirements of AASHTO M 231
- Containers: clean, dry, and capable of being sealed
- Suitable drying container
 - For soils: container requires close-fitting lid
 - For aggregate: container lid is optional
- Microwave safe container with ventilated lid (for drying aggregate only)
- Heat source, thermostatically controlled, capable of maintaining $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).
 - Forced draft oven (preferred)
 - Ventilated oven
 - Convection oven
- Heat source, uncontrolled, for use when allowed by the agency, which will not alter the material being dried, and when close control of the temperature is not required:
 - Infrared heater/heat lamp, hot plate, fry pan, or any other device/method allowed by the agency .
 - Microwave oven (900 watts minimum)
- Utensils such as spoons
- Hot pads or gloves

Sample Preparation

Obtain a representative sample according to the FOP for AASHTO R 90 in its existing condition. If necessary, reduce the sample to moisture content sample size according to the FOP for AASHTO R 76.

For aggregate, the moisture content sample size is based on Table 1 or other information that may be specified by the agency.

TABLE 1
Sample Sizes for Moisture Content of Aggregate

Nominal Maximum Size* mm (in.)	Minimum Sample Mass g (lb)
150 (6)	50,000 (110)
100 (4)	25,000 (55)
90 (3 1/2)	16,000 (35)
75 (3)	13,000 (29)
63 (2 1/2)	10,000 (22)
50 (2)	8000 (18)
37.5 (1 1/2)	6000 (13)
25.0 (1)	4000 (9)
19.0 (3/4)	3000 (7)
12.5 (1/2)	2000 (4)
9.5 (3/8)	1500 (3.3)
4.75 (No. 4)	500 (1.1)

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum.

For soils the moisture content sample size is based on Table 2 or other information that may be specified by the agency.

TABLE 2
Sample Sizes for Moisture Content of Soil

Maximum Particle Size mm (in.)	Minimum Sample Mass g
50 (2)	1000
25.0 (1)	500
12.5 (1/2)	300
4.75 (No. 4)	100
0.425 (No. 40)	10

Immediately seal or cover moisture content samples to prevent any change in moisture content or follow the steps in “Procedure.”

Procedure

Determine and record the sample masses as follows:

- For aggregate, determine and record all masses to the nearest 0.1 percent of the sample mass or to the nearest 0.1 g.
- For soil, determine and record all masses to the nearest 0.1 g.

When determining the mass of hot samples or containers or both, place and tare a buffer between the sample container and the balance. This will eliminate damage to or interference with the operation of the balance or scale.

1. Determine and record the mass of the container .
 - a. For aggregate: the lid is optional unless drying with a microwave then a ventilated lid is required.
 - b. For soils: the container includes the mass of the close-fitting lid.
2. Place the wet sample in the container.
3. Determine and record the total mass of the wet sample and container with lid, when used.
 - a. For oven(s), hot plates, infrared heaters, etc.: Spread the sample in the container.
 - b. For microwave oven: Heap sample in the container; cover with ventilated lid.
4. Subtract the container mass determined in Step 1 from the mass of the container and sample determined in Step 3 and record the wet mass of the sample (M_w).
5. Remove the lid, if used, and place the sample in one of the following drying apparatuses:
 - a. For aggregate –
 - i. Controlled heat source (oven): at 110 ±5°C (230 ±9°F).
 - ii. Uncontrolled heat source (Hot plate, infrared heater, or other heat source as allowed by the agency): Stir frequently to avoid localized overheating.

b. For soil – controlled heat source (oven): at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).

Note 1: Soils containing gypsum or significant amounts of organic material require special drying. For reliable moisture contents dry these soils at 60°C (140°F). For more information see AASHTO T 265, Note 2.

6. Dry until sample appears moisture free.
7. Determine mass of sample and container and lid, when used.
8. Subtract the container mass determined in Step 1 from the mass of the container and sample determined in Step 7 and record the mass of the sample.
9. Return sample and container to the heat source for the additional time interval.
 - a. Drying intervals for aggregate –
 - i. Controlled heat source (oven): 30 minutes
 - ii. Uncontrolled heat source (Hot plate, infrared heater, or other heat source as allowed by the agency): 10 minutes
 - iii. Uncontrolled heat source (Microwave oven): 2 minutes

Caution: Some minerals in the sample may cause the aggregate to overheat, crack, and explode; altering the aggregate gradation.

Table 3
Methods of Drying

Aggregate		
Heat Source	Specific Instructions	Drying intervals to achieve constant mass (minutes)
Controlled:		
Forced draft (preferred), ventilated, or convection oven	$110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$)	30
Uncontrolled:		
Hot plate, infrared heater, or any other device/method allowed by the agency	Stir frequently	10
Microwave	Heap sample and cover with ventilated lid	2

- b. Drying interval for soil – controlled heat source (oven): 1 hour

Table 4
Method of Drying

Soil		
Heat Source	Specific Instructions	Drying interval to achieve constant mass
Controlled: Forced draft (preferred), ventilated, or convection oven	$110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$)	1 hour

10. Determine mass of sample and container with lid, if used.
11. Subtract the container mass determined in Step 1 from the mass of the container and sample determined in Step 10 and record the mass of the sample.
12. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
13. Continue drying, performing steps 9 through 12, until there is less than a 0.10 percent change after additional drying time.
14. Constant mass has been achieved; sample is defined as dry.
15. Allow the sample and container with lid, when used, to cool. Determine and record the total mass.
16. Subtract the mass of the container determined in Step 1 from the mass of the container and sample determined in Step 15 and record the dry mass of the sample (M_D).
17. Determine and record percent moisture (w) by subtracting the final dry mass determination (M_D) from the initial wet mass determination (M_w), dividing by the final dry mass determination (M_D), and multiplying by 100.

Calculation

Constant Mass

Calculate constant mass using the following formula:

$$\% \text{ Change} = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement

M_n = new mass measurement

Example:

Mass of container:	1232.1 g
Mass of container and sample after first drying cycle:	2637.2 g
Mass, M_p , of possibly dry sample:	$2637.2 \text{ g} - 1232.1 \text{ g} = 1405.1 \text{ g}$
Mass of container and sample after second drying cycle:	2634.1 g
Mass, M_n , of sample:	$2634.1 \text{ g} - 1232.1 \text{ g} = 1402.0 \text{ g}$

$$\% \text{ Change} = \frac{1405.1 \text{ g} - 1402.0 \text{ g}}{1405.1 \text{ g}} \times 100 = 0.22\%$$

0.22 percent is not less than 0.10 percent, so continue drying.

Mass of container and sample after third drying cycle: 2633.0 g

Mass, M_n , of sample: $2633.0 \text{ g} - 1232.1 \text{ g} = 1400.9 \text{ g}$

$$\% \text{ Change} = \frac{1402.0 \text{ g} - 1400.9 \text{ g}}{1402.0 \text{ g}} \times 100 = 0.08\%$$

0.08 percent is less than 0.10 percent, so constant mass has been reached.

Moisture Content Aggregate and Soils:

Calculate the moisture content, as a percent, using the following formula:

$$w = \frac{M_W - M_D}{M_D} \times 100$$

where:

w = moisture content, percent

M_w = wet mass

M_D = dry mass

Example:

Mass of container: 1232.1 g

Mass of container and wet sample: 2764.7 g

Mass, M_w, of wet sample: 2764.7 g - 1232.1 g = 1532.6 g

Mass of container and dry sample (COOLED): 2633.5 g

Mass, M_D, of dry sample: 2633.5 g - 1232.1 g = 1401.4 g

$$w = \frac{1532.6 \text{ g} - 1401.4 \text{ g}}{1401.4 \text{ g}} \times 100 = \frac{131.2 \text{ g}}{1401.4 \text{ g}} \times 100 = 9.36\% \text{ report } 9.4\%$$

Report

- On forms approved by the agency
- Sample ID
- M_w, wet mass
- M_D, dry mass
- w, moisture content to the nearest 0.1 percent

EMBANKMENT AND BASE
IN-PLACE DENSITY

WAQTC

FOP AASHTO T 255 / T 265 (25)

ONE-POINT METHOD FOR DETERMINING MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE FOP FOR AASHTO T 272

Scope

This procedure provides for a rapid determination of the maximum dry density and optimum moisture content of a soil sample, using a one-point determination in accordance with AASHTO T 272-18. This procedure is related to the FOPs for AASHTO T 99/T 180 and R 75.

One-point determinations are made by compacting the soil in a mold of a given size with a specified rammer dropped from a specified height and then compared to an individual moisture-density curve (FOP for AASHTO T 99 or T 180) or soil density-relations group (FOP for AASHTO R 75). Four alternate methods – A, B, C, and D – are used and correspond to the methods described in the FOP for AASHTO T 99/T 180. The method used in AASHTO T 272 must match the method used for the reference curve or to develop the soil density-relations. For example, when moisture-density relationships as determined by T 99 – Method C are used to form the soil density-relations group or an individual moisture density curve, then T 99 – Method C must be used for the one-point determination.

Apparatus

See the FOP for AASHTO T 99/T 180 for full apparatus requirements.

**Table 1
Field Selection of Apparatus – English**

	Method used to compact Individual Curve or Group of Curves							
	T 99				T 180			
Method	A	B	C	D	A	B	C	D
Material Size (Passing Sieve)	No. 4	¾ in.	No. 4	¾ in.	No. 4	¾ in.	No. 4	¾ in.
Nominal Mold Diameter	4 in.	6 in.	4 in.	6 in.	4 in.	6 in.	4 in.	6 in.
Nominal Rammer Mass	5.5 lb.				10 lb.			
Rammer Drop	12 in.				18 in.			
Layers	3				5			
Blows per Layer	25	56	25	56	25	56	25	56

Sample

Sample size determined according to the FOP for AASHTO T 310. In cases where the existing individual curve or soil density-relations group cannot be used a completely new curve will need to be developed and the sample size will be determined by the FOP for AASHTO T 99/T 180.

1. If the sample is damp, dry it until it becomes friable under a trowel. Drying may be in air or by use of a drying apparatus maintained at a temperature not exceeding 60°C (140°F).
2. Thoroughly break up aggregations in a manner that avoids reducing the natural size of individual particles.
3. Pass the material through the appropriate sieve.

Procedure

Use the method matching the individual curve or soil density-relations group. Refer to Table 1 of the FOP for AASHTO T 99 / T 180 for corresponding mold size, number of layers, number of blows, sieve size, and rammer specification for the various test methods.

1. Determine the mass of the clean, dry mold. Include the base plate but exclude the extension collar. Record the mass to the nearest 1 g (0.005 lb).
2. Thoroughly mix the sample with sufficient water to adjust moisture content to 80 to 100 percent of the anticipated optimum moisture.
3. Form a specimen by compacting the prepared soil in the mold (with collar attached) in approximately equal layers. For each layer:
 - a. Spread the loose material uniformly in the mold.

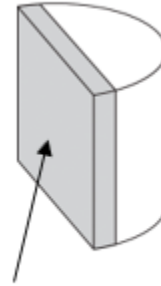
Note 1: It is recommended to cover the remaining material with a non-absorbent sheet or damp cloth to minimize loss of moisture.

- b. Lightly tamp the loose material with the manual rammer or other similar device, this establishes a firm surface.
 - c. Compact each layer with uniformly distributed blows from the rammer.
 - d. Trim down material that has not been compacted and remains adjacent to the walls of the mold and extends above the compacted surface.
4. Remove the extension collar. Avoid shearing off the sample below the top of the mold. The material compacted in the mold should not be over 6 mm (¼ in.) above the top of the mold once the collar has been removed.
 5. Trim the compacted soil even with the top of the mold with the beveled side of the straightedge.
 6. Clean soil from exterior of the mold and base plate.
 7. Determine the mass of the mold and wet soil to the nearest 1 g (0.005 lb).
 8. Determine the wet mass of the sample by subtracting the mass in Step 1 from the mass in Step 7.
 9. Calculate the wet density (ρ_w) as indicated below under “Calculations.”

10. Extrude the material from the mold. For soils and soil-aggregate mixtures, slice vertically through the center and remove one of the cut faces for a representative moisture content sample. For granular materials, a vertical face will not exist. Take a representative sample ensuring that all layers are represented. This sample must meet the sample size requirements of the test method used to determine moisture content.



Extruded material



**Representative moisture
content sample**

11. Determine the moisture content (w) of the sample in accordance with the FOP for AASHTO T 255 / T 265.

Calculations

Wet Density

$$\rho_w = \frac{M_w}{V_m}$$

Where:

ρ_w = wet density, kg/m^3 (lb/ft^3)

M_w = wet mass

V_m = volume of the mold, (FOP for AASHTO T 99/T 180)

Dry Density

$$\rho_d = \left(\frac{\rho_w}{w + 100} \right) \times 100 \quad \text{or} \quad \rho_d = \frac{\rho_w}{\left(\frac{w}{100} \right) + 1}$$

Where:

ρ_d = dry density, kg/m^3 (lb/ft^3)

w = moisture content, as a percentage

Example for 4-inch mold, Methods A or C

$$\begin{aligned} \text{Wet mass, } M_w &= 2.0055 \text{ kg (4.42 lb)} \\ \text{Moisture content, } w &= 13.5\% \\ \text{Measured volume of the mold, } V_m &= 0.0009469 \text{ m}^3 \text{ (0.0334 ft}^3\text{)} \end{aligned}$$

Wet Density

$$\rho_w = \frac{2.0055 \text{ kg}}{0.0009469 \text{ m}^3} = 2118 \text{ kg/m}^3 \quad \rho_w = \frac{4.42 \text{ lb}}{0.0334 \text{ ft}^3} = 132.2 \text{ lb/ft}^3$$

Where:

$$\rho_w = \text{Wet density, kg/m}^3 \text{ (lb/ft}^3\text{)}$$

Dry Density

$$\rho_d = \left(\frac{2118 \text{ kg/m}^3}{13.5 + 100} \right) \times 100 = 1866 \text{ kg/m}^3 \quad \rho_d = \left(\frac{132.2 \text{ lb/ft}^3}{13.5 + 100} \right) \times 100 = 116.5 \text{ lb/ft}^3$$

or

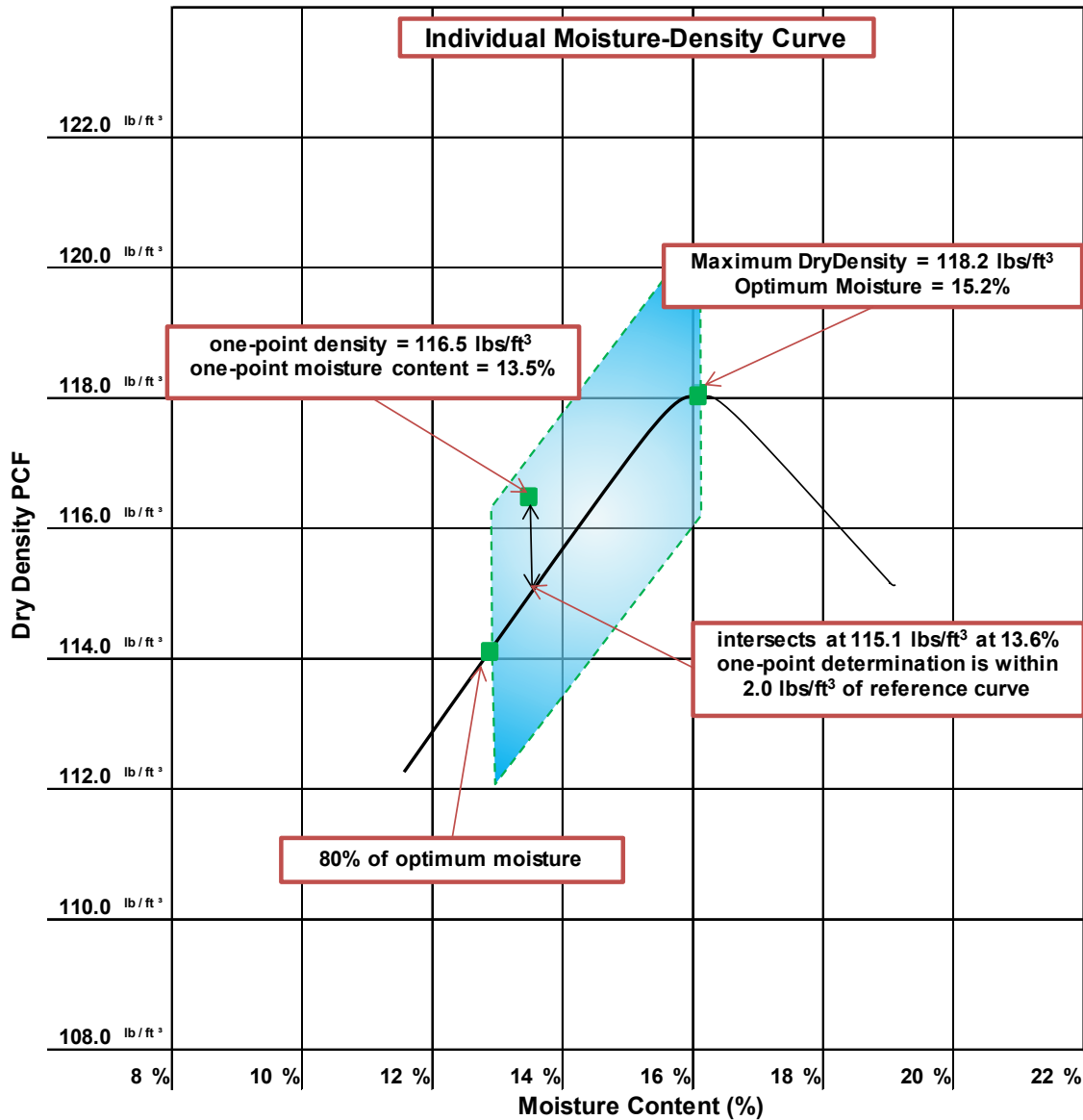
$$\rho_d = \left(\frac{2118 \text{ kg/m}^3}{\frac{13.5}{100} + 1} \right) = 1866 \text{ kg/m}^3 \quad \rho_d = \left(\frac{132.2 \text{ lb/ft}^3}{\frac{13.5}{100} + 1} \right) = 116.5 \text{ lb/ft}^3$$

$$\rho_d = \text{Dry density, kg/m}^3 \text{ (lb/ft}^3\text{)}$$

Maximum Dry Density and Optimum Moisture Content Determination Using an Individual Moisture – Density Curve

1. The moisture content must be within 80 to 100 percent of optimum moisture range of the reference curve.
 - a. If the moisture content of the one-point does not fall within the range, adjust the moisture content.
 - b. Compact another one-point specimen using the moisture adjusted sample.
2. Plot the one-point, dry density on the vertical axis and moisture content on the horizontal axis, on the reference curve graph.
3. If the one-point falls on the reference curve or within ± 2.0 lbs/ft³, use the maximum dry density and optimum moisture content determined by the curve.
4. Use the FOP for AASHTO T 99/T 180 Annex A to determine corrected maximum dry density and optimum moisture content if oversize particles have been removed.
5. Perform a full moisture-density relationship if the one-point does not fall on or within ± 2.0 lbs/ft³ of the reference curve at 80 to 100 percent optimum moisture.

Example



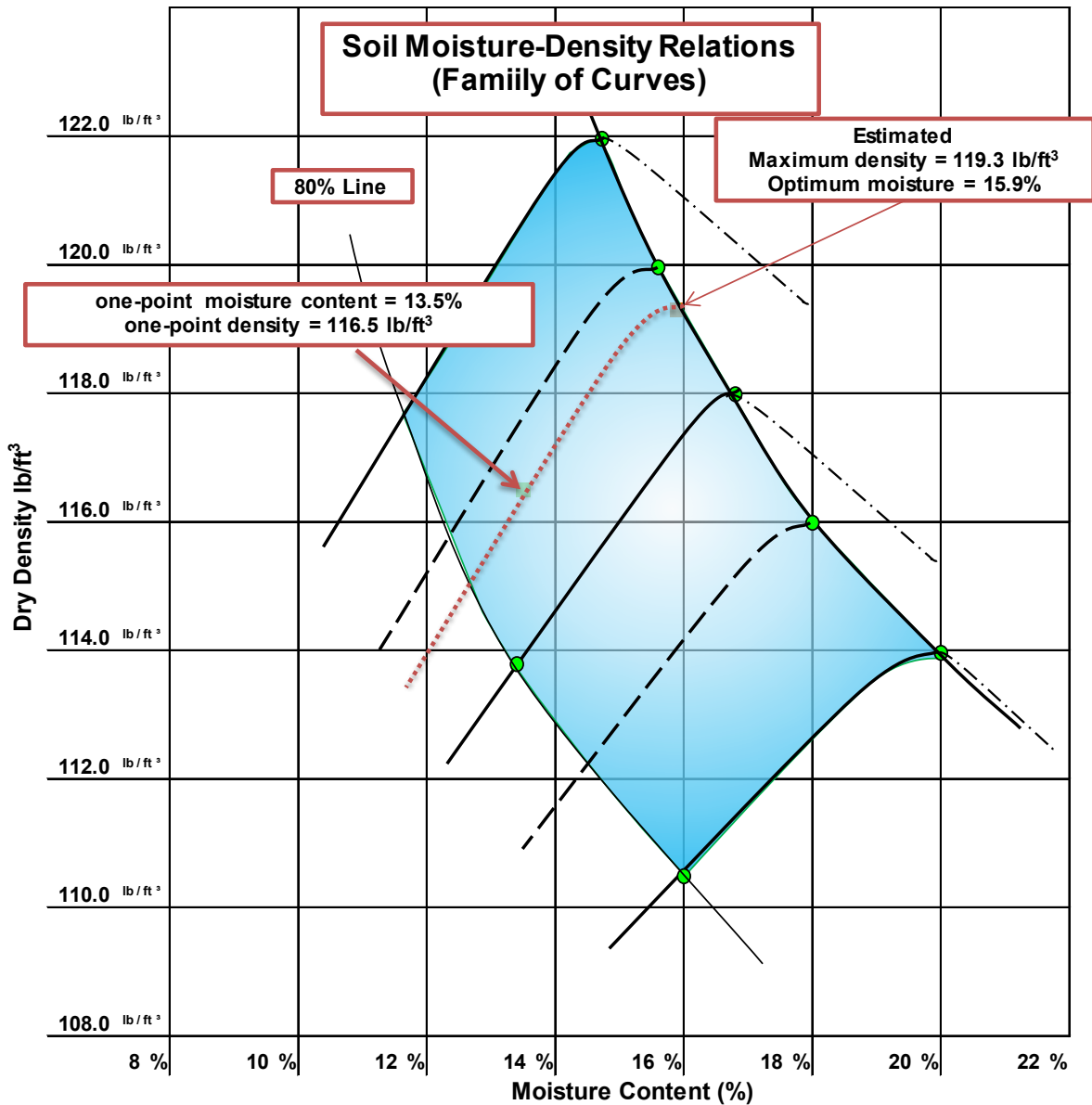
The results of a one-point determination were 116.5 lb/ft³ at 13.5 percent moisture. The point was plotted on the reference curve graph. The one-point determination is within 2.0 lb/ft³ of the point on the curve that corresponds with the moisture content.

Maximum Dry Density and Optimum Moisture Content Determination Using Soil Moisture-Density Relations

1. Plot the one-point, dry density on the vertical axis and moisture content on the horizontal axis, on the reference soil density-relations graph.
2. If the moisture-density one-point falls on one of the curves in the soil density-relations, use the maximum dry density and optimum moisture content defined by that curve.
3. If the moisture-density one-point falls within the soil density-relations but not on an existing curve, draw a new curve through the plotted single point, parallel and in character with the nearest existing curve in the soil density-relations. Use the maximum dry density and optimum moisture content as defined by the new curve.
 - a. The one-point must fall either between or on the highest or lowest curves. If it does not, then a full curve must be developed.
 - b. If the one-point plotted within or on the soil density-relations group does not fall in the 80 to 100 percent of optimum moisture content, compact another specimen, using the same material, at an adjusted moisture content that will place the one point within this range.
4. Use the FOP for AASHTO T 99/T 180 Annex A to determine corrected maximum dry density and optimum moisture content if oversize particles have been removed.
5. If the new curve through a one-point is not well defined or is in any way questionable, perform a full moisture-density relationship to correctly define the new curve and verify the applicability of the soil density-relations.

Note 2: New curves drawn through plotted single point determinations shall not become a permanent part of the soil density-relations until verified by a full moisture-density procedure following the FOP for AASHTO T 99/T 180.

Example



The results of a one-point determination were 116.5 lb/ft³ at 13.5 percent moisture. The point was plotted on the reference curve graph. The point was plotted on the appropriate group between two previously developed curves near and intermediate curve.

The “dotted” curve through the moisture-density one-point was sketched between the existing curves. A maximum dry density of 119.3 lb/ft³ and a corresponding optimum moisture content of 15.9 percent were estimated.

Report

- On forms approved by the agency
- Sample ID
- Maximum dry density to the nearest 1 kg/m^3 (0.1 lb/ft^3)
- Corrected maximum dry density (if applicable)
- Optimum moisture content to the nearest 0.1 percent
- Corrected optimum moisture content (if applicable)
- Reference curve or Soil Moisture-Density Relations used

DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD FOP FOR AASHTO T 308

Scope

This procedure covers the determination of asphalt binder content of asphalt mixtures by ignition of the binder in accordance with AASHTO T 308-25.

Overview

The sample is heated in a furnace at 538°C (1000°F) or less; samples may be heated by convection or direct infrared irradiation (IR). The aggregate remaining after burning can be used for sieve analysis using the FOP for AASHTO T 30.

Some agencies allow the use of recycled asphalt mixtures. When using recycled asphalt mixtures, check with the agency for specific correction procedures.

Asphalt binder in the asphalt mixture is ignited in a furnace. Asphalt binder content is calculated as the percentage difference between the initial mass of the asphalt mixture and the mass of the residual aggregate, with the asphalt binder correction factor, and moisture content subtracted. The asphalt binder content is expressed as a percent of moisture-free mix mass.

Two methods, A and B, are presented.

Apparatus

Note 1: The apparatus must be calibrated for the specific mix design. See “Correction Factors” at the end of this FOP.

The apparatus for Methods A and B is the same except that the furnace for Method A requires an internal balance.

- **Ignition Furnace:** A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining the temperature between at least 530 and 545°C (986 and 1013°F) and have a temperature control accurate within $\pm 5^{\circ}\text{C}$ ($\pm 9^{\circ}\text{F}$).

For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. Perform lift test according to manufacturer’s instructions weekly during use, if applicable. The furnace shall be

designed to permit the operator to change the ending mass loss percentage from both 0.01 percent to 0.02 percent.

For both Method A and Method B, the furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- **Sample Basket Assembly:** consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.
- Thermometer, or other temperature measuring device, with a temperature range of 10 - 260°C (50-500°F).
- Oven capable of maintaining 110 ±5°C (230 ±9°F).
- Balance or scale: Capacity sufficient for the sample mass and conforming to the requirements of M 231, Class G2.
- **Safety equipment:** Safety glasses or face shield, high temperature gloves, long sleeved jacket, a heat resistant surface capable of withstanding 650°C (1202°F), a protective cage capable of surrounding the sample baskets during the cooling period, and a particle mask for use during removal of the sample from the basket assembly.
- **Miscellaneous equipment:** A container larger than the sample basket(s) for transferring sample after ignition, large flat pan, spatulas, bowls, and wire brushes.

Sample Preparation

1. Obtain samples of asphalt mixture in accordance with the FOP for AASHTO R 97.
2. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 110 ±5°C (230 ±9°F) until workable.
3. Reduce asphalt mixture samples in accordance with the FOP for AASHTO R 47.
4. Test sample size shall conform to the mass requirement shown in Table 1.

Note 2: When the mass of the test specimen exceeds the capacity of the equipment used or for large samples of fine mixes, the test specimen may be divided into suitable increments, tested, and the results appropriately combined through a weighted average for calculation of the asphalt binder content.

Table 1

Nominal Maximum Aggregate Size* mm (in.)	Minimum Mass Specimen g	Maximum Mass Specimen g
37.5 (1 ½)	4000	4500
25.0 (1)	3000	3500
19.0 (¾)	2000	2500
12.5 (½)	1500	2000
9.5 (¾)	1200	1700
4.75 (No. 4)	1200	1700

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

General

1. For the convection-type furnace, preheat the ignition furnace to $538 \pm 5^\circ\text{C}$ ($1000 \pm 9^\circ\text{F}$) or to the temperature determined in the Correction Factors Annex of this method. Manually record the furnace temperature (set point) before the initiation of the test if the furnace does not record automatically. For the direct IR irradiation-type furnace, use the same burn profile as used during the correction factor determination.

Procedure – Method A (Internal Balance)

1. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.
2. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.
3. Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.
4. Determine and record the total mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.
5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the correction factor or input into the furnace controller for the specific asphalt mixture.
7. Input the initial mass of the sample (M_i) into the ignition furnace controller. Verify that the correct mass has been entered.

8. Verify the furnace scale is reading zero, if not, reset to zero.

CAUTION: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

9. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded in Step 5 within ± 5 g.

Note 3: Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall.

Note 4: Furnace temperature will drop below the set point when the door is opened but will recover when the door is closed, and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

10. Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower.

Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

11. Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01 percent for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

Note 5: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

12. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes).

13. Determine and record the mass of the sample and sample basket assembly after ignition to the nearest 0.1 g.

14. Calculate the mass of the sample by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f .

15. Use the asphalt binder content percentage from the printed ticket. Subtract the moisture content and the correction factor if not entered into the furnace controller from the printed ticket asphalt binder content and report the difference as the corrected asphalt binder content.

Asphalt binder content percentage can also be calculated using the formula from “Method B” Step 16.

Calculation**Corrected asphalt binder content:**

$$P_b = BC - MC - C_f^*$$

*If correction factor is not entered into the furnace controller

where:

- P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture
- BC = asphalt binder content shown on printed ticket
- MC = moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, $MC=0$)
- C_f = correction factor as a percent by mass of the asphalt mixture sample

Procedure – Method B (External Balance)

1. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.
2. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.
3. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the sample basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.
4. Determine and record the mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.
5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the correction factor for the specific asphalt mixture.
7. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Burn the asphalt mixture sample in the furnace for 45 minutes or the length of time determined in the “Correction Factors” section.
8. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample and allow it to cool to room temperature (approximately 30 min).

9. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
10. Calculate the sample mass by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g.
11. Place the sample basket assembly back into the furnace.
12. Burn the sample for at least 15 minutes after the furnace reaches the set temperature.
13. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 min.).
14. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
15. Calculate the mass of the sample by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g.
16. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
17. If the percent change exceeds 0.01 percent of the previous sample mass, repeat Steps 11 through 16 until the percent change does not exceed 0.01 percent.
Note 6: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.
18. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
19. Calculate the final sample mass by subtracting the mass of the sample basket assembly and sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f .
20. Calculate the asphalt binder content of the sample.

Calculations

Constant Mass

Calculate %change:

$$\% \text{ Change} = \frac{M_p - M_n}{M_p} \times 100$$

where:

M_p = sample mass after ignition

M_n = sample mass after 15 min. additional ignition

Example

Initial mass of sample and basket	= 5292.7 g
Mass of basket assembly	= 2931.5 g
M_i	= 2361.2 g
Sample mass and basket after first ignition	= 5154.4 g
Sample mass after first ignition	= 2222.9 g
Sample mass and basket after additional 15 min ignition	= 5154.2 g

Constant mass

Sample mass after additional 15 min ignition = 2222.7 g

$$\% \text{ change} = \frac{2222.9 \text{ g} - 2222.7 \text{ g}}{2222.9 \text{ g}} \times 100 = 0.009\%$$

%change is not greater than 0.01 percent, so M_f = 2222.7 g

Percent asphalt binder (P_b)

Calculate the asphalt binder content of the sample as follows:

$$P_b = \frac{M_i - M_f}{M_i} \times 100 - MC - C_f$$

where:

- P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture sample
- M_f = the final sample mass after ignition, g
- M_i = the initial mass of the asphalt mixture sample before ignition, g
- MC = moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, MC = 0).
- C_f = correction factor as a percent by mass of the asphalt mixture sample

Example

Correction factor	= 0.42%
Moisture content	= 0.04%
Initial mass of sample and basket	= 5292.7 g
Mass of basket assembly	= 2931.5 g
M _i	= 2361.2 g
M _f	= 2222.7 g

$$P_b = \frac{2361.2 \text{ g} - 2222.7 \text{ g}}{2361.2 \text{ g}} \times 100 - 0.04\% - 0.42\% = 5.41\%$$

P_b = 5.41%

Gradation

1. Empty contents of the basket(s) into a container, being careful to capture all material. Use a small wire brush to ensure all residual fines are removed from the baskets.

Note 7: Particle masks are a recommended safety precaution.

2. Perform the gradation analysis in accordance with the FOP for AASHTO T 30.

Report

- On forms approved by the agency
- Sample ID
- Method of test (A or B)
- Corrected asphalt binder content, P_b , to the nearest 0.01 percent or per agency standard
- Correction factor, C_f , to the nearest 0.01 percent
- Temperature compensation factor (Method A only)
- Total percent loss
- Sample mass
- Moisture content to the nearest 0.01%
- Test temperature

Attach the original printed ticket with all intermediate values (continuous tape) to the report for furnaces with internal balances.

ANNEX – CORRECTION FACTORS

ASPHALT BINDER AND AGGREGATE

(Mandatory Information)

Asphalt binder content results may be affected by the type of aggregate in the mixture and by the ignition furnace. Asphalt binder and aggregate correction factors must, therefore, be established by testing a set of correction specimens for each Job Mix Formula (JMF) mix design. Each ignition furnace will have its own unique correction factor determined in the location where testing will be performed.

This procedure must be performed before any acceptance testing is completed, and repeated each time there is a change in the mix ingredients or design. Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor.

All correction samples will be prepared by a central / regional laboratory unless otherwise directed.

Asphalt binder correction factor: A correction factor must be established by testing a set of correction specimens for each Job Mix Formula (JMF). Certain aggregate types may result in unusually high correction factors (> 1.00 percent). Such mixes should be corrected and tested at a lower temperature as described below.

Aggregate correction factor: Due to potential aggregate breakdown during the ignition process, a correction factor will need to be determined for the following conditions:

- a. Aggregates that have a proven history of excessive breakdown
- b. Aggregate from an unknown source.

This correction factor will be used to adjust the acceptance gradation test results obtained according to the FOP for AASHTO T 30.

Procedure

1. Obtain samples of aggregate in accordance with the FOP for AASHTO R 90.
2. Obtain samples of asphalt binder in accordance with the FOP for AASHTO R 66.
Note 8: Include other additives that may be required by the JMF.
3. Prepare an initial, or “butter,” mix at the design asphalt binder content. Mix and discard the butter mix before mixing any of the correction specimens to ensure accurate asphalt content.
4. Prepare two correction specimens at the JMF design asphalt binder content. Aggregate used for correction specimens shall be sampled from material designated for use on the project. An agency approved method will be used to combine aggregate. An additional “blank” specimen shall be batched and tested for aggregate gradation in accordance with the FOP for AASHTO T 30. The gradation from the “blank” shall fall within the agency specified mix design tolerances.
5. Place the freshly mixed specimens directly into the sample basket assembly. If mixed specimens are allowed to cool before placement in the sample basket assembly, the

specimens must be dried to constant mass according to the FOP for AASHTO T 329. Do not preheat the sample basket assembly.

6. Test the specimens in accordance with Method A or Method B of the procedure.
7. Once both correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed ignition furnace tickets, if available.
8. Calculate the difference between asphalt binder contents of the two specimens:
 - a. If the difference between the asphalt binder contents of the two specimens does not exceed 0.15 percent, use these two results to determine the correction factor.
 - b. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat with two more specimens and, from the four results, discard the high and low results. Determine the correction factor from the two remaining results.
9. Subtract the actual (batched) asphalt binder content (b) from the measured asphalt binder content (m) for each of the two specimens to 0.01 percent. The asphalt binder correction factor, C_f , is the average of the differences expressed as a percent by mass of asphalt mixture.
10. If the asphalt binder correction factor exceeds 1.00 percent, the test temperature must be lowered to $482 \pm 5^\circ\text{C}$ ($900 \pm 9^\circ\text{F}$) and new samples must be burned. If the correction factor is the same or higher at the lower temperature, it is permissible to use the higher temperature. The temperature for determining the asphalt binder content of asphalt mixture samples by this procedure shall be the same temperature determined for the correction samples.
11. For the direct IR irradiation-type burn furnaces, the **default** burn profile should be used for most materials. The operator may select burn-profile Option 1 or Option 2 to optimize the burn cycle. The burn profile for testing asphalt mixture samples shall be the same burn profile selected for correction samples.

Option 1 is designed for aggregate that requires a large asphalt binder correction factor (greater than 1.00 percent) – typically very soft aggregate (such as dolomite).

Option 2 is designed for samples that may not burn completely using the **default** burn profile.
12. Perform a gradation analysis on the residual aggregate in accordance with the FOP for AASHTO T 30, if required. The results will be utilized in developing an “Aggregate Correction Factor” and should be calculated and reported to 0.1 percent.
13. From the gradation results subtract the percent passing for each sieve, for each sample, from the percent passing each sieve of the “Blank” specimen gradation results from Step 4.
14. Determine the average difference of the two values. If the difference for any single sieve exceeds the allowable difference of that sieve as listed in Table 2, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by the FOP for AASHTO T 30. If the 75 μm (No. 200) is the only sieve outside the limits in Table 2, apply the aggregate correction factor to only the 75 μm (No. 200) sieve.

Table 2
Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to 2.36 mm (No.8)	± 5.0%
Sizes larger than to 75 µm (No.200) and smaller than 2.36 mm (No.8)	± 3.0%
Sizes 75 µm (No.200) and smaller	± 0.5%

Calculations

$$C_f = \frac{(m_1 - b_1) + (m_2 - b_2)}{2}$$

where:

C_f = correction factor

m₁ = measured asphalt binder content of sample one

m₂ = measured asphalt binder content of sample two

b₁ = actual asphalt binder content of sample one

b₂ = actual asphalt binder content of sample two

Example

Asphalt binder correction factor:

Actual (batched) binder content sample 1 (b₁) = 5.50%

Actual (batched) binder content sample 2 (b₂) = 5.50%

Measure binder content 1 (m₁) = 5.55%

Measured binder content 2 (m₁) = 5.56%

$$C_f = \frac{(5.55\% - 5.50\%) + (5.56\% - 5.50\%)}{2} = \frac{0.11\%}{2} = 0.06\%$$

Aggregate correction factor(s):

Sieve Size mm (in.)	Correction Factor Blank Sample % Passing	Correction Factor Sample #1 % Passing	Correction Factor Sample #2 % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0 (3/4)	100	100	100	0/0	0.0	
12.5 (1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	
9.5 (3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	
4.75 (No. 4)	51.5	53.6	55.9	-2.1/-4.4	-3.3	
2.36 (No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	
01.18 (No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	
75 μm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	- 0.6

In this example, all gradation test results performed on the residual aggregate (FOP for AASHTO T 30) would have an aggregate correction factor applied to the percent passing the 75 μm (No. 200) sieve. The correction factor must be applied because the average difference on the 75 μm (No. 200) sieve is outside the tolerance from Table 2.

In the following example, aggregate correction factors would be applied to each sieve because the average difference on the 4.75 mm (No. 4) is outside the tolerance from Table 2.

Sieve Size mm (in.)	Correction Factor Blank Sample % Passing	Correction Factor Sample #1 % Passing	Correction Factor Sample #2 % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0 (3/4)	100	100	100	0/0	0.0	0.0
12.5 (1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	-0.6
9.5 (3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	-0.3
4.75 (No. 4)	51.5	55.6	57.9	-4.1/-6.4	-5.3	-5.3
2.36 (No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	-2.0
01.18 (No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	-1.2
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	-2.3
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	+0.1
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	0.0
75 μm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	-0.6

REDUCING SAMPLES OF ASPHALT MIXTURES TO TESTING SIZE FOP FOR AASHTO R 47

Scope

This procedure covers sample reduction of asphalt mixtures to testing size in accordance with AASHTO R 47-23. The reduced portion is to be representative of the original sample.

Apparatus

- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Metal spatulas, trowels, metal straightedges, drywall taping knives, or a combination thereof; for removing asphalt mixture samples from the quartering device, cleaning surfaces used for splitting, etc.
- Square-tipped, flat-bottom scoop, shovel, or trowel for mixing asphalt mixture before quartering.
- Miscellaneous equipment including hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans.
- Sheeting: Non-stick heavy paper or other material as approved by the agency.
- Agency-approved release agent, free of solvent or petroleum-based material that could affect asphalt binder.
- Mechanical Splitter Type A (Quartermaster): having four equal-width chutes that discharge the material into four appropriately sized sample containers, designed with a receiving hopper to hold the asphalt mixture field sample until a handle releases the material to fall through a divider and distribute it into four equal portions without restriction or the loss of material.
- Mechanical Splitter Type B (Riffle): having a minimum of eight equal-width chutes discharging alternately to each side with a minimum chute width of at least 50 percent larger than the largest particle size. A hopper or straight-edged pan with a width equal to or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the asphalt mixture through the chutes without segregation or loss of material. Sample receptacles of sufficient width and capacity to receive the reduced portions of asphalt mixture from the splitter without loss of material.
- Quartering Template: formed in the shape of a 90-degree cross with equal sides that exceed the diameter of the flattened cone of material sufficient to allow complete separation of the quartered sample. The height of the sides must be sufficient to extend above the thickness of the flattened cone of the sample to be quartered. Manufactured of metal that will withstand heat and use without deforming.

- Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit asphalt mixture samples to be mixed without contamination or loss of material.

Sampling

Obtain samples according to the FOP for AASHTO R 97.

Sample Preparation

The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

Selection of Procedure (Method)

Refer to agency requirements when determining the appropriate method(s) of sample reduction. In general, the selection of a particular method to reduce a sample depends on the initial size of the sample vs. the size of the sample needed for the specific test to be performed. It is recommended that, for large amounts of material, the initial reduction be performed using a mechanical splitter. This decreases the time needed for reduction and minimizes temperature loss. Further reduction of the remaining asphalt mixture may be performed by a combination of the following methods, as approved by the agency.

The methods for reduction are:

- Mechanical Splitter
 - Type A (Quartermaster) Method
 - Type B (Riffle) Method
- Quartering and Sectoring Methods
 - Quartering
 - Sectoring
- Incremental Method

Procedure

When heating of the equipment is desired, heat to a temperature not to exceed the maximum mixing temperature of the job mix formula (JMF).

If the reduced sample mass does not fall within the test sample size limits, continue reducing to achieve the correct sample mass. Do not adjust sample mass by adding or removing material after reduction.

Mechanical Splitter Type A (Quartermaster) Method

1. Place the splitter on a level surface.
2. Clean the splitter and apply a light coating of approved release agent to the surfaces that will contact asphalt mixture.
3. Close and secure hopper gates.

4. Position the four sample receptacles under the splitter chutes to collect all the material.
5. Remove the sample from the agency-approved container(s) and place it in the mechanical splitter hopper. Avoid segregation, loss of asphalt mixture, or addition of foreign material.
6. Release the handle, allowing the asphalt mixture to drop through the divider chutes and discharge into the four receptacles.
7. Remove asphalt mixture retained on the surface of the splitter and place into the appropriate receptacle.
8. Close and secure the hopper gates.
9. Combine the material contained in the receptacles from opposite corners.
10. Reduce the remaining asphalt mixture until an appropriate sample size is obtained by this method or a combination of the following methods as approved by the agency.
11. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Mechanical Splitter Type B (Riffle) Method

1. Place the splitter on a level surface.
2. Clean the splitter and apply a light coating of agency-approved release agent to the surfaces that will come in contact with asphalt mixture (hopper or straight-edged pan, chutes, receptacles).
3. Place two empty receptacles under the splitter.
4. Carefully empty the asphalt mixture from the agency-approved container(s) into the hopper or straight-edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.
5. Discharge the asphalt mixture at a uniform rate, allowing it to flow freely through the chutes.
6. Any asphalt mixture that is retained on the surface of the splitter shall be removed and placed into the appropriate receptacle.
7. Reduce the remaining asphalt mixture as needed by this method or a combination of the following methods as approved by the agency.
8. Using one of the two receptacles containing asphalt mixture, repeat the reduction process until the asphalt mixture contained in one of the two receptacles is the appropriate size for the required test.
9. After each split, remember to clean the splitter hopper and chute surfaces if needed.
10. Retain and properly identify the remaining unused asphalt mixture sample for further testing if required by the agency.

Quartering and Sectoring Methods

1. If needed, apply a light coating of agency-approved release agent to quartering template.
2. Place the sample from the agency approved container(s) into a conical pile on a hard, “non-stick,” clean, level surface where there will be neither a loss of material nor the accidental addition of foreign material. The surface can be made non-stick by the application of an agency-approved release agent, or sheeting.
3. Mix the material thoroughly by turning the entire sample over a minimum of four times with a flat-bottom scoop; or by alternately lifting each corner of the sheeting and pulling it over the sample diagonally toward the opposite corner, causing the material to be rolled. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one or lifting both opposite corners.
4. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness. Make a visual observation to ensure that the material is homogeneous.
5. Divide the flattened cone into four equal quarters using the quartering template or straightedges assuring complete separation.
6. Reduce to appropriate sample mass by quartering or sectoring.

Quartering

- a. Remove diagonally opposite quarters, including all the fine material, and place in a container to be retained.
- b. Remove the quartering template, if used.
- c. Combine the remaining quarters.
- d. If further reduction is necessary, repeat Quartering Method Steps 3 through 6.
- e. Repeat until appropriate sample mass is obtained. The final sample must consist of the two remaining diagonally opposite quarters.
- f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Sectoring

- a. Using a straightedge, obtain a sector by slicing through a quarter of the asphalt mixture from the center point to the outer edge of the quarter.
- b. Pull or drag the sector from the quarter with two straight edges or hold one edge of the straightedge in contact with quartering device.
- c. Remove an approximately equal sector from the diagonally opposite quarter and combine.
- d. If necessary, repeat until the appropriate sample mass has been obtained.
- e. Continue sectoring with the unused portion of the asphalt mixture until samples have been obtained for all required tests.

- f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Incremental Method

1. Cover a hard, clean, level surface with sheeting. This surface shall be large enough that there will be neither a loss of material nor the accidental addition of foreign material.
 2. Place the sample from the agency approved container(s) into a conical pile on that surface.
 3. Mix the material thoroughly by turning the entire sample over a minimum of four times:
 - a. Use a flat-bottom scoop; or
 - b. Alternately lift each corner of the sheeting and pull it over the sample diagonally toward the opposite corner, causing the material to be rolled.
 4. Create a conical pile by depositing each scoop or shovelful of the last turning on top of the preceding one or lifting both opposite corners of the sheeting.
 5. Grasp the sheeting and roll the conical pile into a cylinder (loaf), then flatten the top. Make a visual observation to determine that the material is homogenous.
 6. Remove one quarter of the length of the loaf and place in a container to be saved by either:
 - a. Pull sheeting over edge of counter and drop material into container.
 - b. Use a straightedge at least as wide as the full loaf to slice off material and place into container.
 7. Obtain an appropriate sample mass for the test to be performed; by either:
 - a. Pull sheeting over edge of counter and drop cross sections of the material into container until proper sample mass has been obtained.
 - b. Use a straightedge at least as wide as the full loaf to slice off cross sections of the material until proper sample mass has been obtained and place into container.
- Note 1:* When reducing the sample to test size it is advisable to take several small increments, determining the mass each time until the proper minimum size is achieved.
8. Repeat Step 7 until all the samples for testing have been obtained or until the final quarter of the original loaf is reached.
 9. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE FOP FOR AASHTO R 76

Scope

This procedure covers the reduction of samples to the appropriate size for testing in accordance with AASHTO R 76-23. Techniques are used that minimize variations in characteristics between test samples and field samples. Method A (Mechanical Splitter) and Method B (Quartering) are covered.

This FOP applies to fine aggregate (FA), coarse aggregate (CA), and combinations of the two (FA / CA) and may also be used on soils.

Terminology

Saturated Surface-Dry (SSD) – condition of an aggregate particle when the permeable voids are filled with water, but no water is present on exposed surfaces.

Note 1: As a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered wetter than saturated surface-dry.

Apparatus

Method A – Mechanical Splitter

Splitter must allow the sample to flow smoothly without restriction or loss of material.

Splitter chutes:

- Even number of equal width chutes
- Discharge alternately to each side
- Minimum of 8 chutes total for CA and FA / CA, 12 chutes total for FA
- Width:
 - Minimum 50 percent larger than largest particle
 - Maximum chute width of 19 mm (3/4 in.) for fine aggregate passing the 9.5 mm (3/8 in.) sieve
- Feed Control:
 - Hopper or straightedge pan with a width equal to or slightly less than the overall width of the assembly of chutes
 - Capable of feeding the splitter at a controlled rate
- Splitter receptacles / pans:
 - Capable of holding two halves of the sample following splitting

Method B – Quartering and Sectoring

- Straightedge scoop, shovel, or trowel
- Broom or brush
- Stick or pipe
- Tarp: A tear resistant rectangular tarp, appropriate for the amount and size of the material being reduced.
- Quartering Template: Formed in the shape of a 90-degree cross with equal length sides that exceed the diameter of the flattened pile of material sufficient to allow complete separation of the quartered sample. The height of the sides must be sufficient to extend above the thickness of the flattened pile of the sample to be quartered.

Method Selection

Selecting the method of sample reduction depends on

- The type of material: fine aggregate (FA), coarse aggregate (CA), and combinations of the two (FA / CA)
- The moisture content: drier than saturated surface-dry (SSD), SSD, or wetter than SSD.

Note 2: To use Method A on samples of FA and CA/FA that are at SSD or wetter, the entire sample may be dried – using temperatures that do not exceed those specified for any of the tests contemplated – and then reduced.

Select from the following methods based on the material type and moisture condition.

Method A Mechanical

- CA
- FA/CA drier than SSD
- FA drier than SSD

Method B Quartering

- CA
- FA/CA
- FA at SSD or wetter

Method B Sectoring

- FA at SSD or wetter

Table 1

	Drier than SSD	SSD or Wetter
Fine Aggregate (FA)	Method A Mechanical	Method B Quartering Method B Sectoring
Mixture of FA/CA	Method A Mechanical Method B Quartering	Method B Quartering
Coarse Aggregate (CA)	Method A Mechanical Method B Quartering	Method A Mechanical Method B Quartering

Procedure

Method A – Mechanical Splitter

1. Place the splitter on a level surface.
2. Place two clean empty receptacles under the splitter.
3. Empty the sample into the hopper or pan without loss of material.
4. Uniformly distribute the material in the hopper or pan from edge to edge so that approximately equal amounts flow through each chute.
5. Discharge the material at a uniform rate, allowing it to flow freely through the chutes.
6. Remove any material retained on the surface of the splitter and place into the appropriate receptacle.
7. Using one of the two receptacles containing material, repeat Steps 1 through 6 until the material in one of the two receptacles is the appropriate sample size for the required test.
8. Retain and properly identify the remaining unused sample for further testing if required.

Mechanical Splitter Check

- Determine the mass of each reduced portion. If the percent difference of the two masses is greater than 5 percent, corrective action must be taken.

Calculation

$$\frac{\text{Smaller Mass}}{\text{Larger Mass}} = \text{Ratio} \quad (1 - \text{ratio}) \times 100 = \% \text{ Difference}$$

Splitter check: 5127 g total sample mass

Splitter pan #1: 2583 g

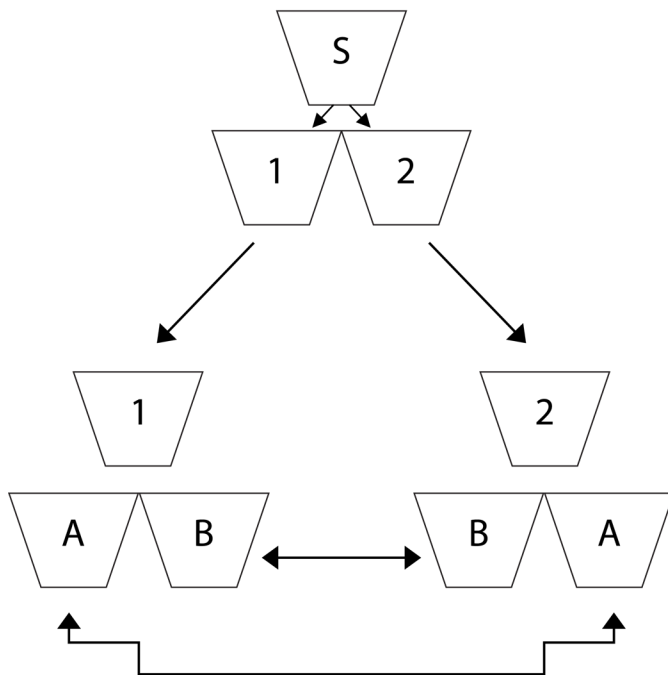
Splitter pan #2: 2544 g

$$\frac{2544 \text{ g}}{2583 \text{ g}} = 0.985 \quad (1 - 0.985) \times 100 = 1.5\%$$

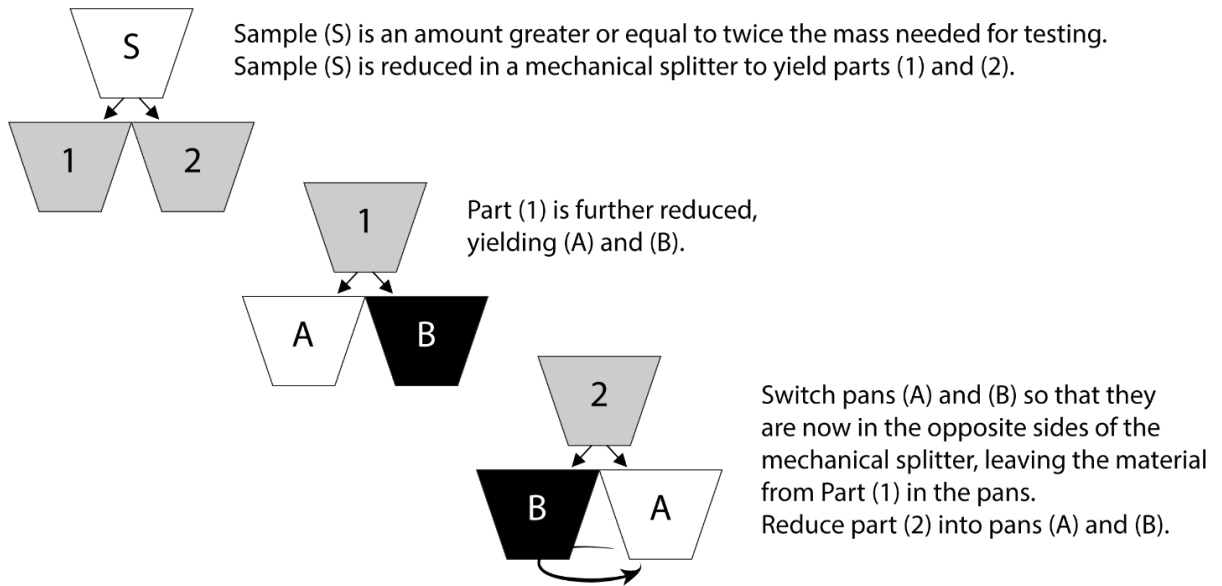
Alternative to Mechanical Splitter Check

- In lieu of determining the mass of each reduced portion, use the method illustrated in Figure 1 or 2 during reduction.

Figure 1



- Sample (S) is an amount greater than or equal to twice the mass needed for testing. Sample (S) is reduced in a mechanical splitter to yield parts (1) and (2).
- Part (1) is further reduced yielding (A) and (B) while part (2) is reduced to yield (B) and (A).
- Final testing sample is produced by combining alternate pans, i.e. A/A or B/B only.

Figure 2

Method B Quartering and Sectoring

Method B Quartering

1. Place the sample on a hard, clean, level surface or tarp where there will be neither loss of material nor the accidental addition of foreign material.
2. Mix the material thoroughly a minimum of four times by one of the following:
 - a. Turning the entire sample over with a shovel or scoop.
 - b. Pulling each corner of the tarp horizontally over the sample toward the opposite corner.
3. After the final turn, form a conical pile.
4. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel. The diameter should be four to eight times the thickness.
5. Divide the flattened pile into four approximately equal quarters:
 - a. Using a shovel or trowel
 - b. Inserting a stick or pipe beneath the tarp and under the center of the pile, then lift both ends of the stick, dividing the sample into two roughly equal parts. Remove the stick leaving a fold of the tarp between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four roughly equal quarters.

6. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean.
7. Successively mix and quarter the remaining material until the sample is reduced to the desired size.
8. The final test sample consists of two diagonally opposite quarters.

Method B Sectoring

1. Place the sample on a hard, clean, level surface or tarp where there will be neither loss of material nor the accidental addition of foreign material.
2. Mix the material thoroughly a minimum of four times by one of the following:
 - a. Turning the entire sample over with a shovel or scoop.
 - b. Pulling each corner of the tarp horizontally over the sample toward the opposite corner.
3. After the final turn, form a conical pile.
4. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel or scoop. The diameter should be four to eight times the thickness.
5. Divide the flattened pile into four approximately equal quarters using a quartering template, straightedge, shovel, or trowel, assuring complete separation.
6. Using a straightedge, obtain a sector by slicing through a quarter of the material from the center point to the outer edge of the quarter.
7. Pull or drag the sector from the quarter with two straight edges or hold one edge of the straightedge in contact with quartering device.
8. Remove an equal sector from the diagonally opposite quarter and combine to create the appropriate sample mass.
9. Continue obtaining sectors from diagonally opposite quarters until the required sample size has been obtained for all required tests.

SAMPLING AGGREGATE PRODUCTS FOP FOR AASHTO R 90

Scope

This procedure covers sampling of coarse, fine, or a combination of coarse and fine aggregates (CA and FA) in accordance with AASHTO R 90-18. Sampling from conveyor belts, transport units, roadways, and stockpiles is covered.

Apparatus

- Shovels or scoops, or both
- Brooms, brushes, and scraping tools
- Sampling tubes of acceptable dimensions
- Mechanical sampling systems: normally a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation
- Belt template
- Sampling containers

Procedure – General

Sampling is as important as testing. Use every precaution to obtain samples that are representative of the material. Determine the time or location for sampling in a random manner.

1. Wherever samples are taken, obtain multiple increments of approximately equal size.
2. Mix the increments thoroughly to form a field sample that meets or exceeds the minimum mass recommended in Table 1.

TABLE 1
Recommended Sample Sizes

Nominal Maximum Size*		Minimum Mass	
mm (in.)		g (lb)	
90	(3 1/2)	175,000	(385)
75	(3)	150,000	(330)
63	(2 1/2)	125,000	(275)
50	(2)	100,000	(220)
37.5	(1 1/2)	75,000	(165)
25.0	(1)	50,000	(110)
19.0	(3/4)	25,000	(55)
12.5	(1/2)	15,000	(35)
9.5	(3/8)	10,000	(25)
4.75	(No. 4)	10,000	(25)
2.36	(No. 8)	10,000	(25)

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size. Maximum size is one size larger than nominal maximum size.

Note 1: Sample size is based upon the test(s) required. As a general rule, the field sample size should be such that, when split twice will provide a testing sample of proper size. For example, the sample size may be four times that shown in Table 1 of the FOP for AASHTO T 27/T 11, if that mass is more appropriate.

Procedure – Specific Situations

Conveyor Belts

Avoid sampling at the beginning or end of the aggregate run due to the potential for segregation. Be careful when sampling in the rain. Make sure to capture fines that may stick to the belt or that the rain tends to wash away.

Method A (From the Belt)

1. Stop the belt.
2. Set the sampling template in place on the belt, avoiding intrusion by adjacent material.
3. Remove the material from inside the template, including all fines.
4. Obtain at least three approximately equal increments.
5. Combine the increments and mix thoroughly to form a single sample.

Method B (From the Belt Discharge)

The sampling device may be manually, semi-automatic or automatically powered.

1. Pass sampling device through the full stream of the material as it runs off the end of the conveyor belt.
 - Once in each direction
 - Without overfilling
 - Maintaining a constant speed during the sampling process
2. When emptying the sampling device into the container, include all fines.
3. Combine the increments and mix thoroughly to form a single sample.

Transport Units

1. Visually divide the unit into four quadrants.
2. Identify one sampling location in each quadrant.
3. Dig down and remove approximately 0.3 m (1 ft.) of material to avoid surface segregation. Obtain each increment from below this level.
4. Combine the increments and mix thoroughly to form a single sample.

Roadways**Method A (Berm or Windrow)**

1. Obtain sample before spreading.
2. Take the increments from at least three random locations along the fully formed windrow or berm. Do not take the increments from the beginning or the end of the windrow or berm.
3. Obtain full cross-section samples of approximately equal size at each location. Take care to exclude the underlying material.
4. Combine the increments and mix thoroughly to form a single sample.

Note 2: Obtaining samples from berms or windrows may yield extra-large samples and may not be the preferred sampling location.

Method B (In-Place)

1. Obtain sample after spreading and before compaction.
2. Take the increments from at least three random locations.
3. Obtain full-depth increments of approximately equal size from each location. Take care to exclude the underlying material.
4. Combine the increments and mix thoroughly to form a single sample.

Stockpiles

Method A – Loader Sampling

1. Direct the loader operator to enter the stockpile with the bucket at least 150 mm (6 in.) above ground level without contaminating the stockpile.
2. Discard the first bucketful.
3. Have the loader re-enter the stockpile and obtain a full loader bucket of the material, tilt the bucket back and up.
4. Form a small sampling pile at the base of the stockpile by gently rolling the material out of the bucket with the bucket just high enough to permit free flow of the material. (Repeat as necessary.)
5. Create a flat surface by having the loader back drag the small pile.
6. Visually divide the flat surface into four quadrants.
7. Collect an increment from each quadrant by fully inserting the shovel into the flat pile as vertically as possible, take care to exclude the underlying material, roll back the shovel and lift the material slowly out of the pile to avoid material rolling off the shovel.
8. Combine the increments and mix thoroughly to form a single sample.

Method B – Stockpile Face Sampling

1. Create horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile with a shovel or loader.
2. Prevent continued sloughing by shoving a flat board against the vertical face. Sloughed material will be discarded to create the horizontal surface.
3. Obtain sample from the horizontal surface as close to the intersection as possible of the horizontal and vertical faces.
4. Obtain at least one increment of equal size from each of the top, middle, and bottom thirds of the pile.
5. Combine the increments and mix thoroughly to form a single sample.

Method C – Alternate Tube Method (Fine Aggregate)

1. Remove the outer layer that may have become segregated.
2. Using a sampling tube, obtain one increment of equal size from a minimum of five random locations on the pile.
3. Combine the increments to and mix thoroughly form a single sample.

Identification and Shipping

- Identify samples according to agency standards.
- Include sample report (below).
- Ship samples in containers that will prevent loss, contamination, or damage of material.

Report

- On forms approved by the agency
- Date
- Time
- Sample ID
- Sampling method
- Location
- Quantity represented
- Material type
- Supplier

INSERT TAB

WAQTC

SAMPLING FRESHLY MIXED CONCRETE WAQTC TM 2

Scope

This practice covers procedures for obtaining representative samples of fresh concrete delivered to the project site. The practice includes sampling from stationary, paving, and truck mixers; from agitating and non-agitating equipment used to transport central mixed concrete; and from continuous mixing equipment as described in AASHTO M 241, *Concrete Made by Volumetric Batching and Continuous Mixing*.

This practice also covers the removal of large aggregate particles by wet sieving.

Sampling concrete may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus

- Receptacle: wheelbarrow, bucket or other suitable container that does not alter the properties of the material being sampled
- Sample cover (plastic, canvas, or burlap)
- Shovel
- Cleaning equipment, including scrub brush, rubber gloves, water
- Apparatus for wet sieving, including: a sieve(s), meeting the requirements of FOP for AASHTO T 27/T 11, minimum of 2 ft² (0.19 m²) of sieving area, conveniently arranged and supported so that the sieve can be shaken rapidly by hand.

Procedure

1. Use every precaution to obtain samples representative of the true nature and condition of the concrete being placed, being careful not to obtain samples from the first or last portions of the batch. The size of the sample will be 1.5 times the volume of concrete required for the specified testing, but not less than 0.03 m³ (1 ft³).
2. Dampen the surface of the receptacle just before sampling, empty any excess water.

Note 1: Sampling should normally be performed as the concrete is delivered from the mixer to the conveying vehicle used to transport the concrete to the forms; however, specifications may require other points of sampling, such as at the discharge of a concrete pump.

3. Use one of the following methods to obtain the sample:

- **Sampling from stationary mixers**

Obtain the sample after a minimum of $1/2 \text{ m}^3$ ($1/2 \text{ yd}^3$) of concrete has been discharged. Perform sampling by passing a receptacle completely through the discharge stream, or by completely diverting the discharge into a receptacle. To prevent segregation, do not restrict the flow of concrete from the mixer, container, or transportation unit. These requirements apply to both tilting and non-tilting mixers.

- **Sampling from paving mixers**

Obtain the sample after the contents of the paving mixer have been discharged. Obtain increments from at least five different locations in the pile and combine into one test sample. Avoid contamination with subgrade material or prolonged contact with absorptive subgrade. To preclude contamination or absorption by the subgrade, the concrete may be sampled by placing a shallow container on the subgrade and discharging the concrete across the container.

- **Sampling from revolving drum truck mixers or agitators**

Obtain the sample after a minimum of $1/2 \text{ m}^3$ ($1/2 \text{ yd}^3$) of concrete has been discharged. Obtain sample after all of the water has been added to the mixer. Do not obtain sample from the very first or last portions of the batch discharge. Perform sampling by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a receptacle. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

- **Sampling from open-top truck mixers, agitators, non-agitating equipment, or other types of open-top containers**

Obtain the sample by whichever of the procedures described above is most applicable under the given conditions.

- **Sampling from pump or conveyor placement systems**

Obtain sample after a minimum of $1/2 \text{ m}^3$ ($1/2 \text{ yd}^3$) of concrete has been discharged. Obtain sample after all of the pump slurry has been eliminated. Perform sampling by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a receptacle. Do not lower the pump arm from the placement position to ground level for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge.

- **Sampling from continuous mixers (volumetric batching or mobile mixers)**

Obtain two or more increments after all the mixture proportioning adjustments have been made and at least $1/4 \text{ m}^3$ ($1/4 \text{ yd}^3$) has been discharged. Obtain increments at regularly spaced intervals during the discharge of the middle of the batch. Obtain increments by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a receptacle.

After obtaining the composite sample, wait at least two minutes but not more than five minutes before beginning tests.

Note 2: The waiting period before beginning testing is necessary because the mix water is input seconds before discharge from the continuous mixer.

4. Transport sample to the testing location.
5. Combine sample or increments and remix with a shovel the minimum amount necessary to ensure uniformity. Protect the sample from direct sunlight, wind, rain, and sources of contamination.
6. Complete test for temperature and start tests for slump and air content within 5 minutes of obtaining the sample. Start molding specimens for strength tests within 15 minutes of obtaining the sample. Complete the test methods as expeditiously as possible.

Wet Sieving

When required due to oversize aggregate, the concrete sample shall be wet sieved, after transporting but prior to remixing, for slump testing, air content testing or molding test specimens, by the following:

1. Place the sieve designated by the test procedure over the dampened receptacle.
2. Pass the concrete over the designated sieve. Do not overload the sieve (one particle thick).
3. Shake or vibrate the sieve until no more material passes the sieve. A horizontal back and forth motion is preferred.
4. Discard oversize material including all adherent mortar.
5. Repeat until sample of sufficient size is obtained. Mortar adhering to the wet-sieving equipment shall be included with the sample.
6. Using a shovel, remix the sample the minimum amount necessary to ensure uniformity.

Note 3: Wet sieving is not allowed for samples being used for density determinations according to the FOP for AASHTO T 121.

Report

- On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented

INSERT TAB

SECTION 2
Quality Assurance
Program



QUALITY ASSURANCE PROGRAM

(Revised December 2025)

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**OREGON DEPARTMENT OF TRANSPORTATION
QUALITY ASSURANCE PROGRAM**

I. OVERVIEW

The Oregon Department of Transportation (ODOT) has implemented a Quality Assurance (QA) Program approach that complies with the FHWA Guidelines for a QA program for construction projects on the National Highway System. This program defines the responsibilities of the Contractor and ODOT in order to satisfy the needs of the program. This program is currently used for all construction projects administered by ODOT or its consultants.

ODOT recognizes that there are other benefits of developing and implementing quality assurance specifications into its construction program. These benefits include:

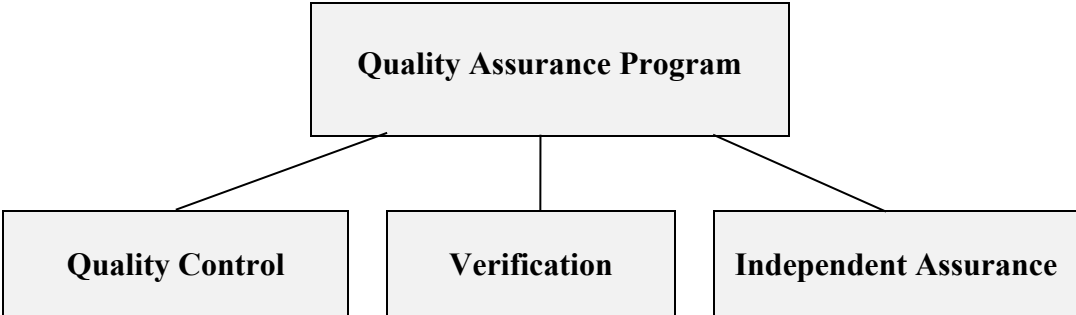
- To improve the overall quality of highway and bridge construction; and
- To place responsibility on the contractor for quality control in contracted work.

The success of the Agency’s Quality Assurance Program is dependent on three primary features. The first is the Laboratory Certification Program, which is discussed in Section III of this document. The second is the Technician Certification Program, which is discussed in Section IV and the final feature is the specific product QC/QA testing plan detailed in Section VI of this document.

Quality Assurance (QA)

Quality assurance is defined as: *All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.*

ODOT has developed its QA Program, which includes three separate and distinct sub-programs as illustrated below:



Quality Control (QC)

Quality control is defined as: *All Contractor/vendor operational techniques and activities that are performed or conducted to fulfill the contract requirements.*

The Contractor is responsible for providing quality control sampling and testing, furnishing material of the quality specified, and furnishing QL levels during aggregate production, when required. The Contractor's quality control technician must perform or observe the sampling operations. Testing operations shall be performed by technicians certified to run the respective tests. The certified technician, who performs the sampling and testing procedures, must sign the testing documentation. The signature may be a "wet signature, handwritten" or a digital signature encrypted with a digital certificate from a trust service provider (TSP).

Contractor quality control tests will be used for acceptance only if verified by tests performed by an independent group (region QA).

Small quantities of some materials may be accepted when requested by the Contractor and approved by the Project Manager (see Section 4(B) of MFTP).

ODOT will perform testing for all source/compliance tests and those non-field tested items associated with construction products (e.g. asphalts, emulsions, tack, etc.).

Verification

Verification is defined as: *Sampling and testing performed to validate the quality of the product.*

Verification samples are taken randomly (minimum ten-percent frequency of subplot quantity identified in Section 4(D) of the MFTP) and tested by an independent group (region QA) to verify that products meet required specification(s). All aggregate samples will be obtained from the stockpile. Material transported to the source of incorporation (e.g., concrete plant, ACP facility, pug mill etc.), may be subject to further testing. Quality control samples shall not be used for verification.

Independent Assurance (IA)

Independent assurance is defined as: *Activities that are an unbiased and independent evaluation of all the sampling and testing procedures used in the acceptance program.*

ODOT's Independent Assurance (IA) Program uses a combination approach requiring laboratory certification, technician certification, proficiency samples, and where possible, split samples of verification or QC tests. The Construction Section certifies quality control and quality assurance testing laboratories and technicians. Contractor's test results of split IA samples are compared to region QA test results for compliance using ODOT IA Parameters. The PM performs random inspections of QC laboratories and technicians for compliance.

The quality of region QA test results are constantly monitored through the Quality Assurance Laboratory Proficiency Sample Program which is outlined in Section V.

Quality assurance testing (both verification and independent assurance) will be performed by a quality assurance laboratory designated by the Agency in compliance with 23 CFR 637.

Quality Assurance Program Components

Third-Party Resolution

Third-party resolution is used when the Agency's quality assurance test results conflict with ongoing quality control test results according to section VI (Product Specific QC/QA Testing Plan) and when the conflict cannot be resolved. Third-party resolution can be requested by either the Contractor or the Project Manager.

Third-party resolution testing shall be performed by a third-party resolution laboratory. The ODOT Construction Section's Central Materials Laboratory (ODOT-CML) performs third-party resolutions. This is normally done by testing quality control production backup samples but may include other resolution techniques or procedures as determined by the Agency's technical expert for the corresponding specification section.

The test result(s) of the third-party resolution laboratory performing third-party resolution materials testing for any or all disputed test results will be considered the actual test results and will therefore be used for acceptance of the material.

Certification Advisory Committee (CAC)

The certification programs (both Technician and Laboratory Certifications) for ODOT's Quality Assurance Program will be overseen by a Certification Advisory Committee (CAC). The purpose of this committee is to review and provide general oversight to the certification programs. The committee will be responsible for establishing policy as related to the certification programs and will also be responsible for reviewing allegations concerning abuse by technicians. The CAC will perform other duties as required to successfully implement and continue the certification programs. A meeting of the CAC may be called at any time by the Chair of the Certification Advisory Committee or by written request of at least two members of the CAC. A majority of the members of the CAC shall be present for transaction of official business.

Membership

Membership of the Certification Advisory Committee will include the following:

ODOT Construction and Materials Engineer (Chair)
ODOT Pavements Services Engineer
ODOT State Quality Assurance Engineer
ODOT Structural Services Engineer
ODOT Laboratory Services Manager
APAO Executive Director or Representative

OCAPA Executive Director or Representative
AGC Heavy Highway Representative
Industry “At Large” Representative (appointed by CAC)

Random Samples

The Quality Assurance Program is based on theoretical conditions and the application of statistical acceptance procedures. Sampling shall be by simple random, stratified random or systematic means as specified.

To obtain a representative sample, a reliable system of random sampling shall be employed. Some work, like process control, lends itself quite well to the use of the Random Units Table and the Random Sample Location forms that ODOT has developed. ODOT TM 400, Determining Random Sampling and Testing Locations, is available to assist with random number determinations and test site locations. Random sampling is the preferred method to assure that the samples are representative and to eliminate sampling bias. In other work, like verification or independent assurance, it may be difficult to apply random numbers to sample selection. In this case, it is imperative that the samples are taken at locations or times, which do not have an identifiable pattern and are completely random, without bias.

ODOT Approved Aggregate Product Program (OAAPP)

The ODOT Quality Assurance Program allows some freedom for aggregate sources to establish their own quality control plan that is tailored to the operation of the specific source. The supplier is required to submit a written quality control plan to the appropriate region Senior Quality Assurance Coordinator (SQAC) for approval. All testing for the approved quality control plan is required to be performed by a certified technician in an ODOT certified laboratory. Specific details on the ODOT Approved Aggregate Product Program may be found in Appendix A.

II. ROLES AND RESPONSIBILITIES

Contractor

The Contractor's responsibilities are to:

- Furnish a written quality control plan (See Appendix B for minimum requirements);
- Furnish and incorporate materials/products which are of the quality specified;
- Provide ODOT certified technicians and laboratories;
- Perform quality control of all materials/products used on ODOT construction projects;
- Sample and test materials using appropriate devices and procedures;
- Furnish QLs when required;
- Provide extra testing or retesting according to section 00165.
- Sample and provide splits to ODOT upon request, witnessed by an Agency representative;
- Perform required tests on Contractor's split of IA samples;
- Properly document, sign and deliver test results as required, on ODOT forms according to Section 3 criteria; and
- Retain splits of all QC samples until the Project Manager (PM) determines that the split samples may be discarded.
- Retain all split portions of IA samples until notified in writing by the PM to discard.

Project Manager (PM)

The Project Manager has the authority and responsibility to enforce the provisions of the contract. The PM's Quality Control Compliance Specialist (QCCS) supports the project QA activities and is experienced and certified in all areas of field testing and documentation. The QCCS is required to maintain certification in CAgT, CEBT, CAT 1, CDT and QCT. Certification in CAT II, CCT and CMDT is recommended.

The Project Manager is responsible to ensure that:

- The project meets the requirements specified in the plans and specifications.
- All required tests are performed, documented, and submitted. The PM is also responsible for informing the SQAC of project schedules, current quantities, and anticipated sampling requirements, so verification testing can be accomplished.
- The Contractor's QC program meets required standards. This is accomplished by performing inspections of the Contractor's personnel, testing procedures and testing equipment.
- The Contractor and region quality assurance laboratory is notified in writing within 5 working days of an IA/Verification sample's completion, regarding which backup samples may be discarded or that an investigation is in progress. Upon the completion of an investigation inform the Contractor, in writing, as to which backup samples may be discarded.

Written notification will identify the lot/sublots represented by the IA/verification sample, include the IA test results and, if required, the resolution of an IA investigation.

Region Quality Assurance Team

The region quality assurance team consists of a Senior Quality Assurance Coordinator (SQAC), Quality Assurance Coordinator (QAC) and quality assurance technicians (QATs). They are resources for the PMs, inspectors, technicians, other agencies and contractors. They are also experienced in construction and design and certified in testing of construction materials.

Specific duties include, but are not limited to, the following:

- Maintain uniformity in construction and testing activities;
- Witness quality control technician sampling for IA and verification testing;
- Perform all required IA and verification testing;
- Properly document on ODOT forms according to Section 3 criteria;
- Calibrate or verify calibration of all nuclear moisture density gauges for ODOT, industry, and other agencies;
- Administer the region's radiation safety program;
- Troubleshoot construction problems related to materials;
- Recommend changes to mix designs;
- Assist in the technician certification program;
- Oversee region testing facilities;
- Inspect Contractor facilities and/or technicians; and
- Assist in QC laboratory certification.
- Retain IA/verification splits until notified by the PM.
- Administer the ODOT Approved Aggregate Product Program

Construction Section

The Construction Section's duties include:

- Support of the QA Program by coordinating training and certification for technicians and by certifying all testing labs associated with ODOT construction projects;
- Administer the proficiency sample program;
- Provide third-party resolution, according to the QA Program.
- Utilize the QA Steering Committee to establish and ensure statewide consistency in the QA Program.

III. LABORATORY CERTIFICATION PROGRAM

OVERVIEW

The Construction Section (CS) developed the Laboratory Certification Program to support the Oregon Department of Transportation's Quality Assurance Program for construction materials. The Laboratory Certification Program recognizes three categories of laboratories: quality control, quality assurance, and third-party resolution. To help ensure that laboratories provide consistent and accurate test results, laboratories that produce test results under the ODOT QA Program shall be certified according to this Laboratory Certification Program, as part of the Independent Assurance Program.

This laboratory certification process is designed to provide not only a "snapshot" of the quality of a laboratory, but also an evaluation of the laboratory's performance in maintaining quality and consistency. The ODOT Construction Section's Central Materials Laboratory (ODOT-CML), or its authorized representative, will examine the laboratory's conditions and testing equipment for accuracy and conformance to test procedure apparatus standards. If the laboratory's equipment is properly calibrated per the standards and the laboratory meets the specified conditions of the Laboratory Certification Program, ODOT will certify the laboratory.

Laboratory certifications are valid for one year, unless decertified by the Certification Advisory Committee or found to be deficient per the "Follow-Up On-site Inspection" criteria. If a laboratory's certification expires and the laboratory has a continued need to test materials for ODOT construction projects, the laboratory shall apply for and obtain recertification, prior to performing continued testing under the QA Program. An outline of the on-site inspection process and laboratory certification criteria is found under "On-Site Laboratory Inspection" below.

PROGRAM DESCRIPTION

Quality Control (QC) Laboratories

Quality control of construction materials is the responsibility of the Contractor. Laboratories performing quality control testing may be the Contractor's own, the material supplier's or an independent testing laboratory.

The ODOT-CML will certify all quality control laboratories for those test procedures and methods necessary to perform quality control tests of construction materials for ODOT construction projects. The QC laboratory is required to schedule laboratory inspection with the ODOT-CML to ensure certification prior to the performance of any tests under the ODOT QA Program.

Quality Assurance Laboratories

Quality assurance is the responsibility of ODOT. During the production of materials for ODOT contracts, quality assurance laboratories perform independent assurance (IA) tests in coordination with quality control laboratories and verification tests which may, or may not, be done in coordination with IA testing. These tests provide ODOT with an independent analysis of the quality control test results to help ensure that the results of quality control tests are valid.

Quality assurance laboratories will usually be ODOT region QA laboratories but may also be the ODOT Central Materials Laboratory or an ODOT contracted independent testing laboratory.

The ODOT-CML requires the certification of all quality assurance laboratories for those test methods necessary to perform quality assurance IA and verification testing. Region quality assurance laboratories are required to participate in the Quality Assurance Laboratory Proficiency Sample Program (see Section V). The ODOT-CML and/or ODOT contracted independent testing laboratories performing IA or verification testing will participate in the proficiency program, or other acceptable laboratory certification program (e.g. AMRL certification).

Third-Party Resolution Laboratories

When quality control and quality assurance test results conflict and the conflict cannot be resolved; a neutral third-party resolution laboratory will test the material in question. The test results of the third-party resolution laboratory will decide the dispute.

The ODOT-CML will perform all third-party resolutions unless a potential for conflict of interest exists. Any laboratory which has performed independent assurance, verification or quality control testing on the material under dispute is considered to have a conflict of interest and shall not perform third-party resolution testing. In this event, the third-party resolution duties will be performed by a certified laboratory meeting the requirements of CFR 0637.209 (a-4), accredited in the testing to be performed by the AASHTO Accreditation Program or a comparable laboratory accreditation program approved by FHWA.

ON-SITE LABORATORY INSPECTION CRITERIA FOR QUALITY CONTROL AND QUALITY ASSURANCE LABORATORIES

A laboratory needing information and/or an application package for ODOT laboratory certification may contact the ODOT Central Materials Laboratory at the following address:

Oregon Department of Transportation
Construction Section, Materials Laboratory
Attn: Lab Certification Coordinator
800 Airport Road SE
Salem, OR 97301-4798
Telephone: (503) 986-3087

Laboratories requesting ODOT certification shall make arrangements to receive an on-site inspection. Forms will be included in the application package to facilitate the laboratory's response to this requirement. These forms are available electronically at the following URL address:

<https://www.oregon.gov/ODOT/Construction/Pages/Lab-Services.aspx>

On-Site Inspection

The lab certification inspector will visit each laboratory whose application for certification has been accepted. The laboratory inspector will evaluate the laboratory using criteria A through G listed below. It is the responsibility of the requesting laboratory to have their lab clean, organized and in complete operating order at the time of inspection. All equipment must be readily available and accessible. The ODOT laboratory certification team does not search for stowed equipment. In addition, an authorized representative must be present at the time of inspection to answer questions and to identify and present equipment. Failure to meet these criteria may result in a canceled inspection.

- A. The laboratory (fixed or mobile) shall maintain proper environmental controls. This criterion is used to evaluate the laboratory's physical ability to provide an appropriate environment in which to test materials. General requirements include adequate power, water, lighting, floor space, temperature control, et cetera; and the capability of maintaining the proper environmental conditions that are specified in the test methods for which the laboratory is seeking certification.
- B. The laboratory shall maintain facilities for proper storage, identification, handling, retaining, and conditioning of test specimens and samples. This criterion is used to evaluate a laboratory's physical ability, internal policies and procedures to store samples and keep them organized. The laboratory shall maintain separate areas on its premises to store samples and splits of samples in an organized manner so that samples are not lost or discarded and may be found at a future date. In addition, the laboratory shall have facilities for the conditioning of samples as required by any test method for which the laboratory seeks certification.
- C. The laboratory shall use accredited calibration service providers. Calibration certificates held by laboratories shall meet the requirements of ISO/IEC 17025 and shall include appropriate statements of uncertainty. The laboratory shall maintain necessary calibration equipment and reference standards. A laboratory shall have on hand calibration and verification equipment necessary to ensure the accuracy of its equipment. Such equipment might include calibration weights for scales or balances, manometers for the verification of vacuum pumps, thermometers, etc.
- D. The laboratory shall maintain equipment conforming to specification requirements necessary for the testing performed. This criterion is used to ensure that the laboratory's testing equipment conforms to the specifications listed in the test methods for which the laboratory is seeking certification.
- E. The laboratory shall demonstrate adequate care when recording and processing data and test results. This criterion is used to evaluate the laboratory's ability to produce accurate test reports. The laboratory shall have procedures in place that facilitate the timely and accurate recording and submittal of data and the ultimate accuracy of its test reports.

- F. The laboratory shall include the laboratory's name and address and the name(s) of the technician(s) performing the test(s) on their test reports. This criterion is used to ensure that the above information appears on the laboratory's test reports that are submitted to ODOT. In addition to the above, the technician(s) certification number shall be entered on all ODOT test reports.
- G. The laboratory shall have on-site, at the time of inspection and during production operations, a copy of the current MFTP and all equipment, except items listed as mobile equipment, necessary to perform the test methods for which they have requested certification. The ODOT laboratory certification inspection team has a color-coded tagging system, which identifies lab equipment that has met the certification criterion. The unique colored tag is valid for a 1-year period and starts from the date of the final report. Not all testing equipment is tagged; reference the appropriate test procedure to identify required equipment.

Mobile equipment for additional test procedures may be added at a later date provided the following conditions are met:

- The laboratory shall demonstrate adequate workspace and electrical system to operate required equipment.
- If equipment is new, provide copies of invoices that include the make, model and serial number of the equipment.
- If the equipment is rented or borrowed, it must come from another ODOT certified laboratory and provide the make, model and serial number as well as the number and color of the ODOT inspection tag.

Mobile Equipment

1. Ignition Oven
2. Gyrotory Compactor
3. Field concrete equipment

Preliminary Report

The ODOT lab certification inspector will prepare a preliminary report of findings and present it to the laboratory manager at the conclusion of the on-site inspection. The preliminary inspection report will list all discrepancies for each test method in which the laboratory has requested certification. The inspector will discuss each discrepancy found in the preliminary report with the laboratory manager in sufficient detail so that the laboratory manager understands the scope of the problem(s) and what corrective action is required to obtain certification for the test method(s) in question. When the inspector and the laboratory manager have covered all the deficiencies, both parties will sign the preliminary report. These signatures indicate that both parties have read the report and understand its contents.

Within one business day, the ODOT lab certification inspector will deliver a copy of the report to the laboratory manager, or owner.

Laboratories are expected to correct all deficiencies within thirty days, so that a certification may be issued. If a laboratory needs more than thirty days to correct deficiencies, the laboratory shall notify the ODOT laboratory certification inspector, in writing, explaining why additional time is needed. The laboratory will not be certified until all deficiencies are corrected.

If no response to the preliminary report is received by the ODOT lab certification inspector within the thirty days allowed, the laboratory will immediately be decertified until the deficiencies are corrected, or a written response has been received.

Final Report

Once all of the deficiencies have been corrected, the ODOT lab certification inspector will prepare a final report of findings and send it to the laboratory.

Certificate of Laboratory Certification

The ODOT Central Materials Laboratory will prepare a certificate of laboratory certification for a laboratory when the laboratory has met the requirements listed in “On-Site Laboratory Inspection Criteria” and has corrected all deficiencies noted by the inspector. The certificate will be sent to the laboratory with the final report. The certificate will include the type of certification, laboratory name, test methods the laboratory has been certified to perform, color of the inspection tag and the Construction Section Manager’s signature. Laboratory certifications are valid for one year from the date of the inspection. This certificate is proof of a laboratory’s ODOT certification for the listed test methods and may be presented as such to any ODOT project manager.

Follow-Up On-Site Inspections

At any time during a laboratory’s term of certification, if the Project Manager or QA personnel suspect that any of the certified laboratory’s equipment, conditions outlined under Requirement G or the laboratory building itself are outside of specification, the Project Manager or QA personnel may request an additional on-site inspection. The Project Manager or QA personnel will contact the lab certification inspector and schedule the Follow-Up On-Site Inspection.

If the Follow-Up On-Site Inspection reveals that the laboratory is deficient in one or more areas, the laboratory inspector will immediately decertify the laboratory for those test methods affected by the deficient equipment or facilities. The laboratory inspector will recertify the laboratory following correction of all deficiencies. A laboratory shall not perform material tests using test methods for which it has been decertified.

Laboratory Decertification

A quality control or quality assurance laboratory may have its entire certification or its certification for specific test methods revoked by ODOT, if it is found to not conform to the specifications and standards of its ODOT certification. A laboratory that has had its certification revoked for a specific test method(s) shall not test materials that require the use of such revoked test method certification(s).

A laboratory that has had its entire certification revoked shall promptly cease testing materials for ODOT construction projects. A laboratory that has had its certification partially or entirely revoked may seek reinstatement by demonstrating conformance to the ODOT laboratory inspection requirements.

Any laboratory/company intentionally misrepresenting the status of their certification or falsifying test results will be subject to disciplinary action up to a one-year suspension of their certification. Any allegation regarding the practices of a certified laboratory will be made in writing to the Certification Advisory Committee (CAC). The CAC will investigate the complaint and take appropriate disciplinary action. In all cases, the parties involved in the complaint will be provided an opportunity to appear before the CAC.

IV. TECHNICIAN CERTIFICATION PROGRAM

INTRODUCTION / BACKGROUND

The Oregon Department of Transportation's Quality Assurance Program requires all personnel and laboratories performing testing on ODOT projects to be certified. The level of certification is dependent on the specific type of testing to be performed. The Certification Advisory Committee (CAC), described in Section I of the QA Program, will provide approval and general oversight for the certification programs. Specific direction and administration of the individual certifications will be provided by ODOT unless other groups are specifically referenced in the description of the individual certifications.

The Oregon Department of Transportation is a member of the Western Alliance for Quality Transportation Construction (WAQTC), which consists of the Western and Central Federal Lands Highway Divisions and 9 western states that are committed to the quality of our transportation systems. WAQTC has developed a technician training program, which is comprised of instructional and student modules used to assist in the training process of material field-tested procedures. ODOT has adopted the training packages for all certifications except for ODOT specific certifications and those controlled by entities other than WAQTC, such as QCT, CCT, CMDT and CAT II.

The purpose of the Technician Certification Program is to ensure technicians performing testing have a minimum level of knowledge in the area of certification.

Technician Certifications

Following is a summary of the approved technician certifications and the associated certification durations:

Certification Discipline	Initial Certification	Renewal of Certification
CSTT	5 years	5 years
CCT	3 years	5 years
CMDT	3 years	*3 years
CAT-II	3 years	5 years
CAGT	3 years	5 years
CEBT	3 years	5 years
CDT	3 years	5 years
CAT I	3 years	5 years
ACI Grade 1	5 years	5 years
QCT	Concurrent with ACI Grade 1	Concurrent with ACI Grade 1

*To be eligible for CMDT recertification by taking only the recertification exam, the technician must have:

- Submitted a minimum of one dense ACP mix design meeting the requirements of the Contractor Mix Design Guidelines and ODOT TM 330, for each year of certification and
- Participated in the CMDT Proficiency program for each year following the initial certification year.

Certified Aggregate Technician (CAgT):

A CAgT performs a variety of tests on soils and aggregates, including sieve analysis, fracture, sand equivalency and other tests. A CAgT also performs other duties as required by current specifications for soils and aggregate materials.

Certified Embankment and Base Technician (CEBT):

The CEBT performs testing of soils and aggregates for establishing the relative maximum density and optimum moisture for use in compaction testing of subgrade soils and aggregate bases. A CEBT also determines the specific gravities of aggregate.

Certified Density Technician (CDT):

A CDT performs in-place density testing of soils, aggregates, and asphalt mixtures using the nuclear density gauge. In addition to certification, a CDT must follow state and federal training regulations, and state and federal regulations concerning radioactive materials as administered by their company's Radiation Safety Officer (RSO). For soil, soil aggregate mixtures, and aggregates, a CDT determines: percentages of coarse and fine material, performs one- point testing and related calculations.

Certified Asphalt Technician I (CAT I):

A CAT I performs sampling and testing for ACP and EAC mixtures, including AC content, maximum specific gravity, sieve analysis, void measurements and other tests and duties as required by current specifications.

Certified Asphalt Technician II (CAT II):

A CAT II is responsible for managing the volumetric properties of asphalt mixes by controlling plant operations, for troubleshooting ACP sampling and testing processes, and for making appropriate adjustments to ACP production and lay down procedures. **Certification at the CAT II level is contingent on having successfully attained CAT I certification at least once.**

Certified Mix Design Technician (CMDT):

A CMDT is responsible for preparing ACP, PAC and EAC mix designs, including all material testing and data analysis necessary to properly complete a design. A CMDT prepares designs for both dense and open graded mixtures.

Quality Control Technician (QCT):

A QCT performs testing of fresh Portland cement concrete including sampling, concrete temperature, slump, unit weight, air content, and fabrication of specimens for strength testing and performs other duties including calculating cement content and water-cement ratio as required by specifications. QCT certification is obtained through the ACI Concrete Field-Testing Technician - Grade 1 certification program, with the Oregon written Supplemental test, conducted by the Oregon Concrete and Aggregate Producers Association (OCAPA). QCT is only valid while the ACI Concrete Field-Testing Technician – Grade Level 1 is valid.

Concrete Control Technician (CCT):

A CCT is responsible for preparing concrete mix designs, proportioning concrete mixtures to meet job requirements and for adjusting the mix design, as necessary, to provide a concrete mixture of the quality required by specifications. A CCT certification is obtained through a training program conducted by OCAPA.

Concrete Strength Testing Technician (CSTT):

A CSTT is responsible for testing the compressive or flexural strength of hardened concrete cylinders or beams. The duties of a CSTT include proper capping of specimens (bonded and un-bonded), correct operation of breaking device and visual evaluation of broken specimens. Also, the CSTT is responsible to ensure the proper handling, mold removal, logging and curing of field fabricated samples, upon arrival at the laboratory. A CSTT certification may be obtained through a program conducted by Oregon Chapter of the American Concrete Institute.

Who Must Be Certified?

For all projects for which the Quality Assurance Program applies, all personnel responsible for performing sampling and testing must be certified. All personnel performing the Quality Control Compliance Specialist duties of reviewing test reports whether working for ODOT, a contractor, a consultant or for local agencies, must be certified.

Certification Requirements

To obtain any of the above certifications, the technician will be required to pass a written and/or a practical test demonstrating a knowledge and understanding of how to perform the specific tests and the specifications that apply to the material being tested. All tests shall be administered and evaluated only by evaluators approved by the Certification Advisory Committee Chair or their designated representative.

To apply for the certification, the applicant will register either for one of the approved training classes, where the exam will be administered as part of the class or submit an application to challenge the exam. The challenge applications will be submitted through the approved training program to facilitate scheduling. Appropriate fees will be charged for the challenge exams to cover scheduling, overhead and facility use. Applicants will be scheduled for examination through a cooperative effort between ODOT and the appropriate training program service provider.

All certifications shall be contingent upon the technicians signing a rights and responsibilities agreement. This agreement outlines the technician's rights and responsibilities along with the possible consequences of the abuse and/or neglect of these responsibilities. The technician will submit a signed agreement at the time they take the certification examination. The agency has the authority to require signing of modified Rights and Responsibilities agreements approved by the Certification Advisory Committee.

Examination Process

The Asphalt Paving Association of Oregon (APAO) and Oregon Concrete Aggregate Producers Association (OCAPA) currently perform the instructional phase, while ODOT maintains the certification and administration of the written and practical exam processes. The certification system is made up of three phases. Phase one - WAQTC written exam, phase two - ODOT written exam and phase three - combined ODOT and WAQTC performance exam.

During the exam process, only hand calculators are allowed, the use of computers is not permitted during any exam phase.

Challenge Process

A person may challenge the exam process if they feel that they have the knowledge and skills to be able to pass without attending formal training. If the person does not currently possess a certification for that specific discipline and fails any of the following mentioned examination events, then that person must attend the formal training for that certification. If the person currently possesses a certification for that specific discipline and fails any of the following mentioned examination events, then that person may challenge the failed examination event for that certification a second time. If the person fails the challenged event a second time, then the person must attend formal training for that specific discipline.

WAQTC Written Examination

- a. Closed Book
- b. Consists of multiple modules, depending on the needed certification.
- c. Each module consists of 5 questions with multiple choice, true or false and required calculations.
- d. Written exam timelines vary depending on the needed certification. 1 to 1 ½ hours is given to complete the exam.

ODOT Written Examination:

- a. Open Book
- b. Consists of multiple choice, true or false, and essay questions related to test procedures as well as specifications and completion of various ODOT forms.
- c. Written exam timelines vary depending on the needed certification. 3 to 3 ½ hours is given to complete the exam.
- d. For CMTD certification, the written exam covers dense ACP and EAC & PAC open graded mix design, as well as aggregate treatment applications (i.e., lime and latex) for mix design. 4 hours is given to complete the exam.

Note: 4 ½ hours will be allowed for the combined WAQTC and ODOT written exams.

ODOT /WAQTC Combined Performance Examination

- a. Each participant will demonstrate proficiency in the designated test methods with prepared samples and will demonstrate the ability to apply specifications and ODOT specific requirements to the needed test and identify the quality of the material being tested.
- b. The exam is open book, but the technician may not use the performance exam checklist.
- c. The performance examination for ODOT is performed in conjunction with the WAQTC performance exam. 4 ½ hours is given to complete the performance exam process with 4 hours actual lab time and ½ hour given to complete calculations. The performance exam answers are graded based on completion of the required tests, accuracy of computations, application of the correct specifications and the results of computations meeting the parameters set forth in the Independent Assurance Parameters section of the Quality Assurance Program.
- d. During the performance exam the examinee may be asked to explain various steps of a procedure to reduce the full test time.
- e. The performance exam checklist consists of yes and no blocks. To complete the checklist successfully, all of the yes blocks must be filled out.

In the event, a participant fails the first attempt; a second attempt is given, if time permits and after the exam proctor explains the correct procedure. Anyone failing a test method on the performance exam may repeat that trial during the day of the performance exam, depending on the timelines and the type of test. Repeat trials will be allowed in not more than 50% of the total test methods in that performance exam. If the participant fails on the second attempt the performance exam will stop and the participant will have to re-take the exam at the scheduling convenience of the Agency.

Passing Score – Written

- a. Initial exam (first attempt) WAQTC: An overall score of 70% with a minimum of 60% on anyone-test method.
- b. Re-exam (second attempt) WAQTC: An initial exam overall score below 70% will require a re-exam on all test methods. An initial exam score above 70% overall, but below 60% on one or more test methods, will require a re-exam on only those test methods. In the case of one test method comprising the re-exam, the examinee must receive a score of 70%. In the case of more than one test method comprising the re-exam, the examinee must receive an overall score of 70% with a minimum of 60% on anyone-test method.
- c. Initial exam (first attempt and second attempt) ODOT: An overall score of 70% is required to successfully complete the exam requirement.
- d. Initial exam (first attempt) ODOT exam of:
 - QCT supplemental an overall score of 80% is required to successfully complete the exam requirement.
 - For the CCT and CMDT certification exams, an overall score of 75% is required to successfully complete the exam requirement.
 - Re-exam (second attempt) for the ODOT QCT, CMDT and CCT exam the participant must meet the same criteria as the initial exam first attempt.

Passing Score – Performance

- a. All performance checklists must have 100% yes blanks checked, and each test method must be performed within the designated time limit. Each examinee is allowed two attempts to complete procedures if time allows.
- b. First attempt: Performing all the required tests, application of correct specifications and meeting the Independent Assurance Parameters is required to receive a pass rating. The grading is based on pass/fail of all associated tests performed under the desired certification.
- c. Second attempt: The same criteria as the Initial exam must be met.
- d. For CMDT, an acceptable Level 2, 3 or 4 ACP design must be submitted along with verification materials, as described in Section 6 of the most recent edition of the “Contractor Mix Design Guidelines for Asphalt Concrete”. A six-month period will be allowed for the mix design submittal from the date of the written exam.

Re-examination Policy – Written/Performance

Failure of any exam phase on a second attempt shall require attendance of the course for that qualification and passing the exam element failed on the second attempt if certification is still desired. In addition, on the date the certification exam was first taken a technician will have 120 days to complete the exam requirements for the desired certification. If the exam requirements are not met within the 120-day period and certification is still desired the technician will be required to perform the entire exam process again.

Applicants with Disabilities or Special Needs

Applicants with a disability or those having special needs should notify the Certification Advisory Committee Chair, or their designee, at the time application is made. This will allow time to plan for implementing necessary accommodations prior to the administration of the training and/or testing.

Disclaimer

Certification of an individual by the ODOT Technician Certification Program indicates only that the individual has demonstrated a certain level of competence on a written and/or practical examination in a selected field of activity. ODOT may require this certification of individuals performing activities specified in work contracts or other activities. ODOT and the Certification Advisory Committee make no claims regarding the abilities or competence of certified individuals. Each individual or organization utilizing certified individuals must make its own independent judgment of the competence of certified individuals. ODOT specifically disclaims any responsibility for the actions, or the failure to act, of individuals who have been certified through the ODOT Technician Certification Program.

To obtain certification may involve hazardous materials, operations and equipment. This program does not purport to address all safety or regulation concerns associated with the use of the procedures used. It is the responsibility of the users to use and establish appropriate safety and health practices and determine the applicability of regulatory limitations.

Documentation of Certification

Upon the successful completion of the examination(s), the participant's name, home address and/or company affiliation is registered in the official registry of certified technicians for the appropriate certification. ODOT Construction Section maintains the official registry. It is accessible on the internet at the following address:

<http://highway.odot.state.or.us/cf/techcertdynamic/>

It is anticipated that many technicians will hold multiple certifications. An official letter(s), indicating certification(s) held, will be provided after successful completion of the certification process.

Recertification

To remain current, a certified technician must obtain recertification before the expiration date of the certification. Recertification may only be obtained by passing the written and/or practical test required for that certification. A certified technician must apply for the individual certification for which they want to remain certified. The certified technician is responsible for scheduling his/her own written and/or practical comprehensive examination.

It should be noted that should a technician fail to successfully complete a certification renewal in a specialty area, the technician will be considered disqualified in that area only until the requirements for certification renewal have been successfully met, subject to the limitations set forth in this document.

Note: A certification extension may be provided upon written request to the SQAE. The request should contain the reason for the extension, desired certification and proof of future class attendance or challenge process through a registration of the training provider.

The length and conditions of any extension will vary and are at the discretion of ODOT.

Revocation or Suspension of Certification

The Certification Advisory Committee Chair, for just cause, may revoke technician Certifications at any time. Proposed revocations are sent to the individual in writing along with the individual's right to appeal the proposed revocation. A proposed revocation is effective upon receipt by the technician and will be affirmed, modified, or vacated following any appeal.

The reasons that certified technicians will be subject to revocation or suspension of their certifications are *negligence* or *abuse* of their responsibilities. The Certification Advisory Committee (CAC) may disqualify certified technicians for other reasons of just cause, which may or may not be specifically defined herein following the due process procedures outlined herein.

Negligence is unintentional deviations from approved procedures that may or may not cause erroneous results. The following penalties are guidelines for findings of *negligence*: The first finding of *negligence* will result in a letter of reprimand being sent to both the employee and the employer. Depending on the nature of the incident, the CAC could impose up to a 30-day suspension. The second significant incident during the certification period will result in the State Quality Assurance Engineer (SQAE) discussing the issue with the individual and their employer to establish a corrective action plan. Depending on the nature of the incident, the CAC could impose up to a 180-day suspension. The SQAE will also notify the entire ODOT Quality Assurance staff of the issue. A third instance of neglect may result in permanent revocation of the certification.

Abuse is knowingly deviating from approved procedures or when the technician should have known they were deviating from approved procedures. There are two levels of severity for *abuse*.

For level 1 *abuse*: The first finding may result in up to a 180-day suspension all of the certifications of the individual. A second instance (within the certification period) would result in a minimum of 180-day suspension of all certifications.

For level 2 *abuse*: the first finding will result in a 1-year suspension of all certifications of that individual. A second finding will result in permanent revocation of all certifications.

AASHTOWare Project™: *Sharing or unauthorized use of an individual's login credentials for electronic test data entry will be considered abuse and subject to a 60-day suspension of all Material Testing Certifications. The chair of the CAC will investigate if additional action is warranted during the 60-day suspension period.*

Revocations or suspensions for *abuse* or *negligence* in one certification area are considered revocations or suspensions in *all certifications* held by the technician.

Allegations of *negligence* or *abuse* are made to the State Quality Assurance Engineer (SQAE) in writing. The allegations will contain the name, address and signature of the individual(s) making the allegation. The SQAE will investigate all allegations. The SQAE will decide if the incident is significant to warrant review by the Certification Advisory Committee (CAC). If the incident is given to the CAC for review, then the accused and the individual(s) making the allegation shall be given the opportunity to appear before the CAC to present any appropriate information. Within a 60-day period, all involved parties will receive a report of the findings in writing. Any warranted penalties will be imposed in accordance with guidance contained herein and according to the guidelines outlined under the Technician Compliant Process. Decisions regarding allegations of *negligence* or *abuse* may be appealed in writing to the CAC Chair. The CAC Chair will independently consider such written appeals but may rely on the advice and counsel of the CAC.

In all cases, the CAC will conduct the investigation into the allegations and make a recommendation to the ODOT State Construction & Materials Engineer as to appropriate sanctions against the technician. All final decisions regarding suspension of certifications will be up to the ODOT Construction & Materials Engineer.

Since ODOT is a member of the Western Alliance for Quality Transportation Construction, the certifications are honored by other member states. The Certification Advisory Committee will notify the other members of the WAQTC, or other participants in the Transportation Technician Qualification Program (TTQP), of anyone having a certification revoked or suspended.

TECHNICIAN COMPLAINT PROCESS

The Oregon Department of Transportation’s Technician Certification Program is intended to assure qualified personnel are performing all materials testing for ODOT construction projects. In addition to certified technicians, the department needs a means to address concerns that are raised regarding those technicians not following approved procedures. The Technician Complaint Process will provide guidance on how to deal with these concerns.

It should be understood that the intent of the process is to resolve differences of opinion on appropriate procedures at the lowest possible level. Technicians are encouraged to work together to resolve any differences they might have. Only when those issues cannot be resolved at the project level should they be raised to the level of filing an official complaint. It should be understood that in no way is the formal complaint process intended to remove any authority the Project Manager may have under an existing contract.

Any individual may file a complaint regarding testing procedures or practices. The first step when filing a complaint is to decide whether the issue is a case of “neglect” or “abuse”. “Neglect” is unintentional deviations from approved procedures. “Abuse” is knowingly deviating from approved procedures or when the technician should have known they were deviating from approved procedures. The appropriate process for dealing with the issue is followed after a decision is made on the type of offence. The following pages outline the process for dealing with both neglect and abuse:

Complaint Process for Neglect

Again, neglect is much less severe than abuse and individuals are encouraged to resolve their differences at the project level so the project can continue forward in a positive fashion. The complaint process for neglect is intended primarily to allow a means of tracking the types of problems being encountered and to look out for technicians who seem to have repeated instances of neglect.

Step 1: When an individual discovers a significant problem with a technician’s procedures or testing process, that individual will personally point out the concern to the technician. The two individuals will work together to try to resolve the issue. They may need to refer to the Manual of Field Test Procedures or other contract documents to verify proper procedures.

If the two can agree on corrective action, the issue can be resolved at their level. If not, the region SQAC should be contacted for clarification. If discrepancies on correct procedures still exist, the issue will be brought to the ODOT State Quality Assurance Engineer (SQAE) for resolution.

Step 2: Once the problem is resolved, the individual who discovered the problem will send a short memo to the SQAE describing the issue and the resolution.

Depending on the severity of the issue, the SQAE may send a letter of reprimand to the technician and their employer, and the CAC could impose up to a 30-day suspension.

Step 3: If a second significant incident is reported within the certification period for a specific technician, the SQAE will discuss the issues with the technician and their employer and establish a corrective action plan to help the technician avoid further complaints. Depending on the nature of the incident, the CAC could impose up to a 180-day suspension. In addition, the CAC could require the technician to attend additional training and retake the particular certification exam before reinstatement as a certified technician. The SQAE will also send out notice to all ODOT quality assurance staff of the issue. This notification is intended to help put ODOT staff on notice of problems being encountered.

Step 4: If a third instance of neglect is reported within the certification period, the specific technician and his/her employer must meet with representatives from the Certification Advisory Committee (CAC) to discuss the issues.

The technician will be responsible for providing a plan of how they will correct their deficiencies and assure no further instances will occur. The CAC may gather further information to substantiate the claims. The CAC will review the information and could impose up to permanent revocation of the certification in question.

It should be noted that because of the potential for repeated offences of neglect, the CAC could at any point in the process decide that the successive instances no longer qualify as neglect, but because of the repeated nature of an offense, may become an instance of abuse. If this occurs, the issue would be dealt with through the complaint process for abuse.

Complaint Process for Abuse

Because abuse is defined as intentional, the process for dealing with instances of abuse will be more formal and penalties more severe than for instances of neglect.

Step 1: If abuse is suspected, the issue shall be raised immediately to the ODOT State Quality Assurance Engineer (SQAE). The SQAE will investigate the issue and make a preliminary determination on whether it is abuse or neglect. If the issue is determined to be abuse, move to step 2 below. If it is determined to be a case of neglect, move to step 1 of the process for dealing with neglect.

Step 2: The SQAE will gather information regarding the incident from both the technician involved as well as the individual filing the complaint. The SQAE will review the information and determine whether the incident is significant to warrant review by the Certification Advisory Committee (CAC). This review will be completed within 60 days of receipt of the complaint. If the incident is determined to be “significant” the issue will be put on the agenda for the next CAC meeting.

Both the technician and the individual filing the complaint shall be invited to attend the meeting to present any appropriate information. Insignificant issues will be handled directly by the SQAE and a summary of the incident will be submitted to the CAC for their review.

Step 3: The CAC will determine the merits of the complaint and the severity level of the abuse. Abuse will be identified as one of two different levels of severity.

Level 1 being identified as the least severe form of abuse. This level is identified as knowingly deviating from approved procedures or when the technician should have known they were deviating from approved procedures. The key component for Level 1 Abuse is there is no misrepresentation the quality of material being incorporated in the project. This level of abuse could result in up to a 180-day suspension of all certifications held by the technician. The exact duration of the suspension will be set by the CAC depending on the circumstances encountered. A second instance (within the certification period) of Level 1 abuse would result in a minimum 180-day suspension of all certifications.

Level 2 abuse is much more severe. The distinguishing component of Level 2 abuse is misrepresentation of the quality of material being tested. This level of abuse will be dealt with by a 1-year suspension of all certifications for the technician. A second instance of level 2 abuse will result in permanent revocation of all certifications.

Record Retention

Investigations, supporting exhibits, letters of expectation, CAC recommendations and other investigative correspondence will be kept on file according to the following guidelines:

- Negligence – records will be kept for a 5-year period starting on the date of the investigation.
- Abuse – records will be kept permanently.

At any time retained records may be used to support further allegations of negligence or abuse.

V. QUALITY ASSURANCE LABORATORY PROFICIENCY SAMPLE PROGRAM

OREGON DEPARTMENT OF TRANSPORTATION CONSTRUCTION SECTION

Proficiency sample testing is an additional factor used to evaluate the performance of a quality assurance (QA) laboratory and the quality assurance (QA) laboratory technicians. It provides information not otherwise available from the On-Site Laboratory Inspection (see Section III) and a means of continued monitoring of testing personnel and testing equipment. The ODOT Construction Section requires QA laboratories and QA laboratory technicians to participate in this QA Proficiency Sample Program. Participation includes testing all applicable samples, which are to be distributed and completed within the specified time frame. The resulting data is analyzed by the ODOT State Quality Assurance Engineer.

Proficiency samples are distributed by the Construction Section at annual intervals as outlined in the Proficiency Sample Testing Plan in Table 1 of this section. The Construction Section will distribute a minimum of one set of samples from each material test method listed in Table 1 for each of the QA laboratory technicians. The ODOT Central Materials Laboratory (ODOT-CML) and the QA laboratory technicians will perform the required testing listed in Table 1 on each set of samples. The distribution of proficiency samples is not intended to coincide with the on-site laboratory inspection. Proficiency Sample test results will be submitted to the State Quality Assurance Engineer within thirty days of receipt of the sample. The State QAE will tabulate all of the testing results from the ODOT-CML and the QA laboratory technicians and statistically evaluate if any of the technician results are more than two standard deviations beyond the grand mean for each test method.

When a QA laboratory technician's results are beyond two standard deviations of the grand means, the Senior Quality Assurance Coordinator (SQAC) will investigate the reason for the discrepancies and report the findings and actions taken to the State Quality Assurance Engineer (SQAE) within thirty days of issuance of a final report. The SQAE will determine whether the findings warrant further action to address the testing deviations and identify steps that need to be taken to ensure that the technician is correctly performing the test. The SQAE will be responsible for monitoring the technician testing results until there is confidence that the technician is following approved procedures.

When an ODOT-CML technician's results are beyond two standard deviations of the grand means, the ODOT Laboratory Services Manager shall investigate the reason for the discrepancies and report the findings and actions taken to the State Quality Assurance Engineer (SQAE) within thirty days of issuance of a final report. The SQAE will address the testing deviations, identify steps to be taken and be responsible for monitoring results in the same manner as for a QA laboratory technician.

If a QA laboratory technician or ODOT-CML technician exceeds the two standard deviation limit on the next year’s proficiency samples for the same material test method and is not able to provide the SQAE with a satisfactory explanation for exceeding the limits; the technician will immediately perform a backup proficiency sample witnessed by the SQAE or designated representative. The SQAE will review the process that was followed from the previous year’s investigation findings and make a determination if the technician is not following approved procedures. If the SQAE finds that the technician is not following approved procedures, the SQAE will immediately suspend the technician from performing any QA project work or third-party resolution work involving the test method that has been identified. The SQAE will identify what steps are necessary to allow the technician to resume testing for the failing test method.

TABLE 1 – PROFICIENCY SAMPLE TESTING PLAN

January Distribution

TEST METHOD
SOIL & Aggregate Sample
Bulk Specific Gravity – AASHTO T 85
Coarse Particle Correction – AASHTO T 99
Max. Density – AASHTO T 99 Aggregate Base
Max. Density – AASHTO T 99 Soil
Sieve Analysis – AASHTO T 27/11
Sand Equivalent – AASHTO T 176
Fracture – AASHTO T 335
Wood Particles – ODOT TM 225
Elongated Pieces – ODOT TM 229
ACP Mixture Sample
Bulk Specific Gravity – AASHTO T 166, Method A
Max. Specific Gravity – AASHTO T 209
AC Content by Incinerator – AASHTO T 308
Mechanical Analysis of Extracted Aggregate- AASHTO T 30
Fabrication of Gyratory Specimen – ODOT TM 326
Incinerator Calibration Samples – ODOT TM 323

A laboratory may obtain additional information on the Construction Section’s Quality Assurance Laboratory Proficiency Sample Program by contacting the Construction Section at the following address:

Oregon Department of Transportation
 Construction Section, Materials Laboratory
 Attn: State Quality Assurance Engineer
 800 Airport Road S.E.
 Salem, OR 97301
 Telephone (503) 986-3061

VI. PRODUCT SPECIFIC QC/QA TESTING PLAN

The Quality Assurance Program consists of three distinct sub-programs. The Quality Control Program, the Verification Program and the Independent Assurance Program. This section provides specific details on how these programs work together to assure specification materials are incorporated into ODOT projects. It also provides details on specific requirements of each of the programs for each of the materials, which are utilized on ODOT projects.

In general, the Contractor's quality control tests are obtained at the highest frequency. Agency verification tests are usually run on a minimum frequency of 10% of subplot quantities identified in section 4(D) of the MFTP. While the Independent Assurance program takes steps to assure the quality of both the QC and the verification test results.

ODOT will accept materials based on the contractors QC test results only if verified by the Agency verification testing. Verification of QC test results will require all of the following conditions to be met:

1. The Department's testing results show that the material meets the specified quality.
2. The split samples meet Independent Assurance Parameters.
3. The Department's verification test results compare reasonably to the ongoing quality control data.

If any of the above conditions are not met, an investigation will be conducted by the Project Manager to determine whether to reject the material or if the material is suitable for the intended purpose according to section 00150.25 and what price adjustment may be applied. See Investigation Criteria for details and requirements.

Step 2 in the above conditions compares the Contractor's test results on the split IA sample to the Agency results. The Independent Assurance Parameters to be used for the comparison are listed in Table 1 of this section.

The following pages detail the Investigation Criteria, quality control, verification and independent assurance requirements for each of the specific materials used on ODOT projects.

Investigation Criteria

The intent of the investigation is to determine reasonable cause for the discrepancy and provide supporting documentation of materials failing to meet the conditions outlined for verification, independent assurance, and prior quality control testing. An investigation is required for all materials failing to meet these conditions because of the potential impact on the quality of the material produced or incorporated into the project.

Several resources are available to assist with the troubleshooting process and data collection. Appendix C (Troubleshooting Guide) provides some guidance through the evaluation phase based on material discipline and the associated tests. The guide is an evaluation tool and is not necessarily a complete listing of all potential areas to be investigated and the assistance of the region Sr. QAC, State QAE, Sr. QAE or other technical resources is encouraged.

The investigation and the resolution of the discrepancy shall be documented on form (734-4040) and at a minimum will contain the following information:

- Clearly explain the issue under investigation. Provide the bid item number, material description, test procedure or process in question, associated quality assurance testing references and date or timelines of the testing issue.
- Describe the steps taken to resolve the discrepancy and the associated information or test results gathered to support the findings.
- Provide a conclusion based on the findings.
- Describe recommendations or actions to be taken.
- Provide written notification to the region Sr. QAC and quality control entity upon completion of the investigation. Ensure a copy of the investigation is maintained in the project files.

INSERT TAB

**SECTION IA
Parameters**

TABLE 1
Independent Assurance Parameters
Maximum Allowable Differences

Gradation Sieve Sizes with Assigned Tolerances T 27, T 27/11 & T 30	
Larger than No. 8	5%
No. 8	4%
No.10	4%
Larger than No. 200 and smaller than No. 10	2%
No. 200 with targets 10.0% or less	1.0%
No. 200 with targets greater than 10.0%	1.5%
Asphalt Content – T 308	0.40%
Fracture - T 335	5%
Wood Particles - TM 225	0.05%
Elongated Pieces – TM 229	
5:1 Ratio	2.0%
3:1 Ratio	4.0%
Sand Equivalent – T 176	8 points
Soil Curves – T 99/180 (ρ_f)	
<i>Maximum Density</i>	3.0 lbs. per ft ³
<i>Moisture</i>	3.0%
Aggregate Base – T 99/180 (ρ_f)	
<i>Maximum Density</i>	3.0 lbs. per ft ³
<i>Moisture</i>	2.0%
<i>Plant Mixed Moisture Content</i>	1%
Maximum Specific Gravity – Rice - T 209	
<i>Standard G_{mm}</i>	0.020
<i>Dryback G_{SSD} (If required)</i>	0.020
Bulk Specific Gravity of Lab fabricated specimens - T 166	0.032
Maximum Specific Gravity (G_{sb}) - T 85	0.032
Air Content of Concrete - T 152	0.5%
Slump of Concrete - T 119	1"
Temperature of Concrete - T 309	3°F
Unit Weight of Concrete - T 121	3.0 lbs. per ft ³

AGGREGATE PRODUCTION

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Required	Required	Required

Quality Control

The ODOT Central Materials Laboratory (ODOT-CML) will retain quality control of source/product compliance as stated in Section 4(A). The Contractor's QC technician shall sample the aggregates, place the sample in a proper container and label as specified in Section 4(C), complete the *ODOT Sample Data Sheet* (Form 734-4000), and deliver to the PM.

The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor's QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM by the middle of the following work shift.

Pre-produced aggregates shall be tested at the frequency applicable for the material and use as determined by the appropriate specifications(s) and Section 4(D) of the MFTP (i.e., a 20,000-ton stockpile of aggregate base will require 10 QC tests and 1 QA test).

The Contractor is responsible for furnishing quality levels during aggregate production when specified. The Contractor's QC technician shall reject material that does not meet the specified quality and notify the PM of the disposition and quantities of those materials. All required tests, except for gradation, are considered pass/fail. *Gradation is subject to statistical analysis as described in specifications Section 00165.*

Backup samples for aggregates shall be a minimum of 1/2 the minimum mass shown in Table 1 of AASHTO R 90 for the appropriate nominal maximum size aggregate.

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)). A split of the sample taken by QC will be given to QA for testing.

If verification testing fails to meet the specifications, other than gradation, QA will immediately notify the PM. The PM will evaluate the results and resolve the discrepancy.

If verification test results indicate that a material is out of specification for gradation, QA will notify the PM, who will determine if the stockpile QL meets the specifications. The PM will determine if the stockpile is acceptable.

Independent Assurance

All parties that test materials shall employ ODOT certified technicians and use ODOT certified laboratories.

The Contractor's QC technician shall test the Contractor's split of IA samples and provide the results to the PM the next workday. The PM will verify that the Contractor's test results, and QA's test results are within IA parameters.

If the Contractor's test results and QA's test results for IA samples are not within IA parameters, the PM will evaluate the results and resolve the discrepancy. See Investigation Criteria.

EARTHWORK

(Section 00330)

ESTABLISHING MAXIMUM DENSITIES

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Required	Not Required	Required

Quality Control

The Contractor's QC technician is responsible for establishing maximum densities and optimum moisture content for each unique soil type and soil/aggregate mixture incorporated into the project. *Backup samples shall be a minimum mass of (45 lbs.) and retained until notified by the PM to discard.*

Verification

None Required

Independent Assurance

All parties involved in the testing process shall employ ODOT certified technicians and use ODOT certified laboratories.

QA will test the Contractor's split of the soil sample and provide the results to the PM within a 48-hr. period, based on the time the sample was split. The PM will verify that the Contractor's test results, and QA's test results are within IA parameters.

If the Contractor's test results and QA's test results are not within IA parameters, the PM will perform an investigation (see Investigation Criteria) evaluate the results and resolve the discrepancy.

COMPACTION

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Required	Required	Required

Quality Control

The Contractor's QC technician shall establish a random sampling and testing program.

The Contractor’s QC technician shall be on the project during performance of earthwork operations, as needed, to ensure that materials/products are in conformance with the specifications. The QC technician’s duties include, but are not limited to visual observation, sampling and testing. The Contractor shall rework all areas showing visual deflection. Sampling and testing procedures shall be performed at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM by the end of the work shift for T-99 Method A applications and within a 24-hr. period for T-99 Method D applications, based on the time the test information was collected in the field.

The Contractor's QC technician shall use the "one-point" method to establish the correct soil curve for each density test performed. If the soil does not match an established soil moisture-density relations or a single curve, the Contractor shall establish a new curve for the soil, within a 48-hr. period, based on the time the sample was acquired. If use of the new maximum density curve results in a failing test, the Contractor shall take corrective action and retest until compaction is determined to meet the specifications, **prior to construction of a new lift.** *Backup samples shall be all uncontaminated portions of materials removed from beneath the gauge to perform the “one point”.*

If the equipment or material changes, the QC technician shall verify by testing that the specified densities are attained.

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)).

If the soil tested, according to the “one-point” method, does not match the established curves, the Contractor shall establish a new curve from the soil at the test location and provide the test results within a 48-hr. period, based on the time the sample was acquired. Do not add new lifts until compaction is proven to meet the specified densities. QA shall notify the Contractor and PM of the test results by the end of the work shift for T-99 Method A applications and within a 24-hr. period for T-99 Method D applications, based on the time the test information was collected in the field.

If the density test fails, the Contractor shall identify the limits of failing compaction, take corrective action, and notify the PM. The PM will schedule a new verification test. Do not add new lifts until the verification tests demonstrate that specified densities exist.

Independent Assurance

All parties involved in the testing process shall employ ODOT certified technicians, use ODOT certified labs, and use nuclear density gauge(s) meeting the requirements of ODOT TM 304.

CONCRETE

(Sections 00440, 00512, 00540, 00559, 00660, 00754, 00755, 00756, 00758 and 00921)

AGGREGATE PRODUCTION

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Required	Required	Required
See Aggregate Production details, page 29.	See Aggregate Production details, page 29.	See Aggregate Production details, page 29.
Not required for commercial grade concrete	Not required for commercial grade concrete	Not required for commercial grade concrete

MIXTURE

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Required	Required	Required
	Not required for commercial grade concrete	

Quality Control

The Contractor's QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results, of the plastic properties of the concrete, to the PM by the end of the work shift. Concrete Strength test results shall be delivered to the PM within 24 hours of the specified break date.

The Contractor's quality control (QC) plan shall identify the method used for standard curing, the type of capping system used in the strength testing of concrete cylinders and the size of cylinders to be cast.

Verification

QA performs verification tests for strength, taken randomly, according to the Manual of Field Test Procedures Materials Acceptance Guide (Section 4(D)). Cylinders cast shall be of the same size identified in the QC plan. Strength testing shall use the same capping methods identified in the QC plan. Cylinders cast for strength verification will be delivered to the ODOT-CML for further testing.

If verification strength testing fails to meet the specifications. The PM will evaluate the results and resolve the discrepancy.

Independent Assurance

All parties involved in the testing process shall employ ODOT certified technicians and use ODOT certified laboratories.

The PM will perform random inspections to ensure that the Contractor's quality control plan is followed.

The Contractor's QC technician shall test the same load and portion of load from which the verification samples are taken. The sample may be taken by QC or independent samples may be taken by both QC and QA. When independent samples are taken, acquire portions as close as possible to each other. Concrete with Nominal Aggregate size of 1 ½" will often require individual samples taken by QC and QA, due to sample size(s) and wet sieving requirements.

This testing will be for plastic properties and QA strength testing. The QC technician shall immediately report the results of the plastic properties testing to QA. QA will verify that the contractor's plastic properties test results and QA's plastic properties test results are within IA parameters.

If the Contractor's plastic properties test results and QA's plastic properties test results for the verification sample are not within IA parameters, QA will evaluate the results, resolve the discrepancy and notify the PM of the resolution. If either parties' plastic properties test results are out of specification, then QC will follow the requirements of specification sections 00540.16 and 02001.50(b).

The QA test results, of the plastic properties of the concrete, or the investigation of IA issues will be given to the PM by the end of the work shift, if an agency representative is available.

On a single truck placement when verification/IA is performed by the region quality assurance lab, the Contractor's test results may be used for normal quality control testing.

AGGREGATE BASE, SUBBASE, AND SHOULDERS

(Section 00641)

AGGREGATE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required
See Aggregate Production details, page 29.	See Aggregate Production details, page 29.	See Aggregate Production details, page 29.

ESTABLISHING MAXIMUM DENSITIES

Quality Control	Verification	Independent Assurance
Required	Not Required	Required

Quality Control

The Contractor's QC technician is responsible for establishing maximum densities and optimum moisture content for each unique aggregate mixture type incorporated into the project. *Backup samples shall be a minimum mass of (45 lbs.).*

Verification

None Required

Independent Assurance

All parties involved in the testing process shall employ ODOT certified technicians and use ODOT certified laboratories. QA will test the Contractor's split of the aggregate sample and provide the results to the PM the next day. The PM will verify that the Contractor's test results, and QA's test results are within IA parameters.

If the Contractor's test results and the QA's test results are not within IA parameters, the PM will perform an investigation (see Investigation Criteria), evaluate the results, and resolve the discrepancy.

AGGREGATE MIXTURE (PLANT MIX)

Quality Control Required	Verification Required	Independent Assurance Required
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Quality Control

The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor's QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM by middle of the following work shift. *Backup samples shall be a minimum mass shown in Table 1 of T 255 / T 265 and kept in an airtight container.*

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)).

If the moisture content exceeds the limits according to specification, the Contractor shall take corrective action and notify the PM. The PM will schedule a new verification test.

Independent Assurance

All parties that test materials shall employ ODOT certified technicians and use ODOT certified laboratories.

If the Contractors test results and QA's test results for IA samples are not within IA parameters, the PM will perform an investigation (see Investigation Criteria), evaluate the results, and resolve the discrepancy.

COMPACTION

Quality Control	Verification	Independent Assurance
Required	Required	Required

Quality Control

The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM on the same day the testing is performed.

The Contractor's QC technician shall also perform the following:

- Use the test procedures applicable for determination of the maximum density for this material indicated in Section 4(D) of the MFTP.
- Establish a rolling pattern to provide the specified compaction.
- Stop placement if the specified densities are not met.

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)).

If the density test fails, the Contractor shall identify the limits of failing compaction, take corrective action, and notify the PM. The PM will schedule a new verification test. Do not add new lifts until the verification test demonstrates that the specified density has been achieved.

Independent Assurance

All parties involved in the testing process shall employ ODOT certified technicians, use ODOT certified laboratories, and use nuclear density gauge(s) meeting the requirements of ODOT TM 304.

EMULSIFIED ASPHALT PRODUCTS/MATERIALS

(Sections 00710, 00711, 00712, 00715 and 00730)

AGGREGATE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required
See Aggregate Production details, page 29.	See Aggregate Production details, page 29.	See Aggregate Production details, page 29.

EMULSIFIED ASPHALT CEMENT

Quality Control	Verification	Independent Assurance
Required	Not Required	Not Required

Quality Control

Sample all required materials as specified in Sections 4(C) and 4(D). Complete *ODOT Sample Data Sheet* (Form 734-4000), place in the proper containers and label as specified in Section 4(C) and deliver to the PM by the middle of the following work shift.

EMULSIFIED ASPHALT CONCRETE PAVEMENT (EAC)

(Section 00735)

AGGREGATE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required
See Aggregate Production details, page 29.	See Aggregate Production details, page 29.	See Aggregate Production details, page 29.

MIXTURE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required

Quality Control

The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor's QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM by the middle of the following work shift. *Backup samples for aggregates shall be a minimum of 1/2 the minimum mass shown in Table 1 of AASHTO R 90 for the appropriate nominal maximum size aggregate.*

The Contractor's QC technician is responsible for monitoring plant operation to ensure that specification materials are delivered to the project. Monitoring activities may include, but are not limited to, the following:

- Calibrate the asphalt plant
- Maintain an inventory of materials, including generated waste
- Control segregation in silo(s) and truck loading operations
- Reject any mixture that is visually defective. Inform the PM of the quantity and disposition of the rejected material
- Sample all required materials as specified in Sections 4(C) and 4(D) (e.g., liquid asphalt, emulsion, cement, tack, etc.), place in the proper container and label as specified in Section 4(C), complete the *ODOT Sample Data Sheet* (Form 734-4000) and deliver to the PM by the middle of the following work shift.

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)). A split of the sample taken by QC will be given to QA for testing.

If verification testing fails to meet specifications, QA will immediately notify the PM. The PM will evaluate the results and resolve the discrepancy.

Independent Assurance

All parties that test materials shall employ ODOT-certified technicians and use ODOT-certified laboratories.

The PM will perform random inspections to ensure that the Contractor's quality control plan is followed.

The Contractor's QC technician shall test the Contractor's split of IA samples and provide the results to the PM the next day. The PM will verify that the Contractor's test results, and QA's test results are within IA parameters.

If the Contractor's test results and QA's test results for IA samples are not within IA parameters, the PM will perform an investigation (see Investigation Criteria), evaluate the results, and resolve the discrepancy.

COMPACTION

<i>Quality Control</i>	<i>Verification</i>	<i>Independent Assurance</i>
Not Required See specifications – 00735.46	Not Required	Not Required

POROUS ASPHALT CONCRETE & ASPHALT CONCRETE PAVEMENT (STATISTICAL ACCEPTANCE)

(Sections 00743 and 00745)

AGGREGATE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required
See Aggregate Production details, page 29.	See Aggregate Production details, page 29.	See Aggregate Production details, page 29.

MIXTURE PRODUCTION

Quality Control	Verification	Independent Assurance
Required	Required	Required

Quality Control

The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor's QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM by the middle of the following work shift.

Backup samples shall be a minimum mass of (20 lbs.) or for porous asphalt concrete (PAC), accepted under the cold feed method, a backup sample of ½ the minimum mass shown in Table 1 of AASHTO R 90 for the appropriate nominal maximum size aggregate can be used. If grade sampling is identified in the contract Special Provisions, QC will obtain an ACP sample and provide an ACP backup sample to the on-site agency representative. Label backup samples with the following information:

- Material
- Use of Material (i.e., “Level 3 ACP”)
- ODOT Mix Design Number
- Contract Number
- Date of sampling
- Bid Item, Lot and Sublot
- Location where sample was obtained.

The Contractor's QC technician is responsible for monitoring plant operation to ensure that specification materials are delivered to the project. Monitoring activities may include, but are not limited to the following:

- Calibrate the asphalt plant
- Maintain an inventory of materials, including generated waste
- Control segregation in silo(s) and truck loading operations
- Monitor mix temperature
- Reject any mixture that is visually defective (e.g., graybacks, overheated, contamination, slumping loads etc.) Inform the PM of the disposition and quantity of rejected material
- Sample all required materials as specified in Sections 4(C) and 4(D) (e.g., liquid asphalt, emulsion, cement, tack, etc.), place in the proper container and label as specified in Section 4(C), complete *ODOT Sample Data Sheet* (Form 734-4000), and deliver to the PM by the middle of the following work shift.

Verification

QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)). A split of the sample taken by QC will be given to QA for testing.

If verification testing fails to meet the specifications, QA will immediately inform the PM. The PM will evaluate the results and resolve the discrepancy.

Independent Assurance

All parties that test materials shall employ ODOT certified technicians and use ODOT certified laboratories.

The PM will perform random inspections to ensure that the Contractor's quality control plan is followed.

The Contractor's QC technician shall test the Contractor's split of IA samples and provide the results to the PM the next day. The PM will verify that the Contractor's test results, and QA's test results are within IA parameters.

If the Contractor's test results and QA's test results for IA samples are not within IA parameters, the PM will perform an investigation (see Investigation Criteria), evaluate the results, and resolve the discrepancy.

COMPACTION

Quality Control	Verification	Independent Assurance
Required	Required	Required

Quality Control

Dense Graded: The Contractor's QC technician shall establish a random sampling and testing program and submit it to the PM prior to the start of production.

The Contractor’s QC technician shall perform quality control sampling and testing required to ensure a quality product at the frequencies indicated in Section 4(D) of the MFTP. The Contractor shall deliver the test results to the PM on the same day the test is completed.

The Contractor's QC technician shall also perform the following:
(Activities listed below are not exhaustive and are considered minimums.)

- Establish a rolling pattern according to (TM-306) to provide the specified compaction;
- Notify PM and CAT-II if rolling pattern is not being maintained;
- Notify the PM and CAT-II if the specified densities are not achieved;
- Monitor the mix temperature during laydown and compaction to keep the mix within the Specifications;
- Coordinate with the plant technician when changing lots;
- Notify the region Sr. QAC and PM when performing Core Correlations;
- Notify the CAT-II of Control Strip Results;
- Notify PM, CAT-I and CAT-II if any density results exceed 95%.

Porous Asphalt Concrete: Compaction to a specified density is not required. See 00743.49 in the specifications.

Verification

Dense Graded: QA performs verification tests, taken randomly, according to the Manual of Field Test Procedures Acceptance Guide (Section 4(D)).

QA selects random numbers for the test locations within the Contractor's subplot size. If verification testing fails to meet the specifications, QA will immediately notify the PM.

Failing verification requires retesting an additional verification within the next 2 shifts to confirm density specification and to isolate the original failure.

The PM will initiate an investigation. If the investigation determines there is non-specification material, the PM will evaluate the test results using the Failing ACP Compaction Guidelines (located on the following page) and perform the resolution process as needed.

Porous Asphalt Concrete: None Required

Independent Assurance

Dense Graded: All parties involved in the testing process shall employ ODOT certified technicians, use ODOT certified labs and use nuclear density gauge(s) meeting the requirements of ODOT TM 304.

The region Sr. QAC may elect to perform a gauge check as outlined in Appendix C and ODOT TM 304.

Porous Asphalt Concrete: None Required

Failing ACP Compaction Guidelines

1. QC Density Results Fail
 - a. PM will investigate and evaluate the material to determine if the material is suitable for the intended use per Section 00150.25.
 - b. PM consults the Pavements Services and Quality Assurance Unit for recommendations on:
 - Methods of investigating, evaluating, and isolating non-specification material.
 - Application of appropriate corrective action and/or price adjustment for non-specification material.
 - c. If the material is suitable for intended use the PM will apply the test results to acceptance procedures in accordance with Section 00165. The Contractor should take corrective action.
2. QA Density Results Failing
 - a. PM determines the quantity of material represented by this verification. The PM should consider all material back to the last passing verification.
 - b. PM consults Pavement Services and QA for recommendations on:
 - Methods of investigating, evaluating, and isolating non-specification material
 - Application of appropriate corrective action and/or price adjustment for non-specification material

When cores are used, laboratory testing will be conducted by the ODOT Central Materials Laboratory. Third-party resolution can be initiated by the PM or Contractor.

The PM can apply a price adjustment based on values entered into StatSpec or can use Form 734-3946 for a small number of sublots. The PM also has the ability per section 165.50(c) to isolate material that is shown to be non-specification. Core density results or isolated non-specification material will be evaluated as a separate lot per section 165.40 or 165.50(c).

APPENDIX A

ODOT APPROVED AGGREGATE PRODUCT PROGRAM

A supplier may submit in writing a request for aggregate product(s) approval through the region SQAC. The State QAE and the region SQAC will review the request and, if it is a benefit to the Department, a product(s) may be put on the ODOT Approved Aggregate Product Program (OAAPP). The request shall include the following information for review:

- Production history or prior use on an ODOT project
- Location and Source Identification
- Intended use of supplied material(s)
- Quality Control Plan

The State QAE will notify the region SQAC of final approval of the Quality Control Plan. The region SQAC will notify the supplier of the approved products. The products covered by the approved Quality Control Plan are classified as ODOT Approved Aggregate Products.

The supplier shall retain backup samples, for the previous 10 sublots, until the test results are verified by the region QA group or as required by the region SQAC.

The supplier shall obtain, under the supervision of the region SQAC, at the minimum required frequency as shown in Section 4A of the MFTP, samples for Product Compliance and then the region SQAC shall submit them for testing at the ODOT Central Materials Laboratory.

The supplier shall send requests to waive tests, as allowed by the FTMAG, to the region SQAC. The region SQAC will consult with the SQAE for any waivers to be granted. The region SQAC will notify the supplier of any waivers granted. Waivers will apply to all projects which are supplied from that source.

When a waiver requires periodic testing by the supplier, the test results shall be sent to the region SQAC.

The supplier shall maintain files of all QC tests for each stockpile. It shall enter the test results into the ODOT StatSpec program to calculate the Quality Level for each stockpile. The QL for gradation shall meet the requirements of Section 00165 of the Oregon Standard Specifications for Construction. Other required test results shall be shown in columns to the right in the program. The region SQAC may, with approval of the State QAE, accept alternate means of statistical analysis for the supplier's product. The supplier shall deliver weekly or at an interval determined by the region SQAC, copies of the ongoing subplot test results, along with the ongoing QL (quality levels).

The supplier shall keep the region SQAC informed about production schedules so that verification testing can be scheduled. The region QA group will obtain verification samples on a random basis and the split of this verification sample shall be ran by the supplier's QC technician to test for independent assurance. The test results shall be available within 24 hours of the time of sampling. If the test results indicate that the produced material meets quality requirements and the results are within IA parameters, the region SQAC may allow all backup QC samples prior to the verification sample to be discarded.

The region SQAC will randomly audit the QC files to verify that the quality levels reflect actual test results. The region SQAC will retain QL information for each stockpile along with verification and IA test results. When requested by the Project Manager, the region SQAC will send a memo to the PM verifying and identifying what materials were produced under the OAAPP and meet the required specifications.

If verification test results, for tests other than gradation, do not meet the quality requirements, no material from the stockpile in question will be accepted until the problem has been resolved. The region SQAC will notify each PM, for the projects being supplied from that source, that the material in question shall not be used until the problem has been satisfactorily resolved. The resolution may involve rejection of the stockpile if the investigation confirms non-specification material. If the material test results do not meet IA Parameters, the region SQAC will work with the supplier to resolve the problem.

The region SQAC will provide data to other regions that are using material considered ODOT Approved Aggregate Products.

The region SQAC may discontinue a supplier's approved aggregate product status for those product(s) affected based upon, but not limited to:

- The supplier not following their quality control plan,
- IA and/or verification issues,
- Product(s) failing to meet a product compliance testing requirement,
- The determination that an approved aggregate product(s) is no longer a benefit to the Agency under the program.

The approved aggregate product status may be returned upon approval of the State QAE and region SQAC.

APPENDIX B

CONTRACTOR QUALITY CONTROL PLAN

This plan is intended to provide a description of the personnel involved in the testing activities and identify the system or process for material quality control. The quality control plan must contain at a minimum the following information.

- Include: Project name, Contract number and date of anticipated use and author of submitted plan.
- Provide office telephone, cellular phone & fax numbers for contractor's superintendent & quality control manager.
- Describe personnel & methods to deliver accurate, legible & complete test results to designated agency representative, within required time limits.
- Designate who will provide required QL analysis.
- Describe location and methods for backup sample storage.
- Provide random numbers and include examples of your method for applying, to provide representative samples.
- Provide technician and lab certifications for all equipment, laboratories, & technicians used to perform testing on and offsite for the project.
- Provide current scale license and certification for all weighting devices used on the project. Identify the location of the scales and type of scale (e.g. platform, silo, etc).
- For every material that has tolerances or limits for tests listed in the Manual of Field Test Procedures, provide:
 - Bid item & Specification section number(s) for product to be used.
 - Source and supplier of material
 - Proposed production rate, methods & source of testing
 - Anticipated earliest date of use
- For each material supplier & subcontractor, provide:
 - Company name, address, & physical location.
 - Quality Control contact name and telephone #.
 - Location, type, & quantity of materials to be used.

APPENDIX C

TROUBLESHOOTING GUIDE

The following information is a guide to assist in the evaluation of discrepancies that commonly occur between independent assurance test results and verification test results. This information is only a guide and is not necessarily a comprehensive list of all potential areas to be investigated. A best practice is to consult the region SQAC for help early in the troubleshooting process.

General

1. Check if the technician signing the report is the person performing the tests.
2. Check that the technician performing the testing is certified.
3. Check that the lab and equipment used are ODOT certified.
4. Check that the proper procedures and methods were performed.
5. Check all mathematics.
6. Check Balances for accuracies and functionality.
7. Check constant mass calculations if available, comparing moistures can also indicate incomplete drying of sample.
8. Contact region SQAC, their involvement can significantly reduce time spent troubleshooting and getting to resolution.

AGGREGATE TESTING

Gradation (AASHTO T 27 & T 27/11)

1. Check sample size meets minimum requirements.
2. Inspect sieves for deformed wires or torn fabric.
3. Compare both test results for sample initial wet weights, initial dry weights, after wash dry weights, individual sieve weights and any tare weights if used. May point to a transposed or incorrectly recorded weight. May point to a splitting error.
4. Check sieve loss calculations.
5. Are their screens overloaded?
6. Check to see if the hand sieving procedure shows equipment operating correctly.
7. Check wash loss. May point to error in initial dry weight.
8. Have QC run QA split and observe. This action might indicate equipment, procedural discrepancies and /or splitting issues.
9. Compare results to ongoing StatSpec mean values.

Woodwaste Test (ODOT TM 225)

1. Is the drying method burning up wood?
2. Check equipment used for the procedure for correct size and state of repair.

Fracture Test (AASHTO T 335)

1. Did both parties test the same? (Splitting the sample or not splitting the sample.)
2. If samples not split, do F+Q+N match closely to the retained mass(s) for gradation?
3. Do both parties have approximately the same amounts of F, Q, and N? If not may indicate a difference in interpretation of fractured particles.
4. Have QC run QA split and observe. This action might reveal procedural discrepancies and if results do not vary from originals, may indicate difference introduced during splitting.

Flat & Elongated Test (ODOT TM 229)

1. Did both parties test the same? (Based on individual screens during gradation analysis and summed up or material recombined and split out with one evaluation.)
2. Does MS closely match the retained masses for gradation (+ No. 4 material)
3. Proper caliper ratio used by both parties?
4. Have QC run QA split and observe. May indicate differences introduced during splitting.
5. Check caliper for tight fit between points when closed and smooth operation of armature.

Sand Equivalent Test (AASHTO T 176)

1. Compare sand reading, if significant differences present this is an indication a under sized tin or insufficient compacting effort when filling the tin.
2. Did both parties test at the same moisture content?
3. Are the methods of shaking suspending all fines?
4. Check lab temperatures and SE stock solution's age and the SE working solution's age and temperature. When in doubt observe technician prepare new batch of working solution.
5. Have QC run QA split of sample and observe procedures.
 - a. Look for vibration in surface where SE's tubes are set.
 - b. Were all the fines put into suspension?
 - c. Check shaking device for proper throw distance and proper number of strokes.
 - d. Check irrigation wand to insure good fluid flow from both openings.
 - e. Digital timer being used.
 - f. Weighted foot assembly in good condition and properly lowered.
 - g. Graduated marks properly read
6. Observe parties cleaning the +4.75mm (No. 4) material insuring fine particles are removed.
7. If results do not vary from originals, may point to a splitting issue.

SOIL/AGGREGATE RELATIVE MAXIMUM DENSITY AND OPTIMUM MOISTURE (AASHTO T 99, Methods A & D and ODOT TM 223)

1. Was the sample initially oven-dried (not allowed)? Separate samples at each point or re-compact? Samples tested immediately or "marinated" moistures overnight?
2. Check plotting of data. Correct scale used. Dry densities plotted vs. dry basis moistures.
3. Check tare weights on molds/base plates. Collar removed?
4. Check mold volumes according to T 19; is there a significant difference from the standard volume?

5. Check surface on which samples were compacted. Is it unyielding surface?
6. Check constant mass on individual samples if available.
7. If available, check planning sheets for correct moisture addition calculations.
8. When held up to a light (or placed on a light table) do the two curve shapes match closely? Same shape, but one curve plots higher and to the left, indicates different compaction energy consistently applied to samples.
9. Was the passing No.4 or 3/4" material brushed off the retained # 4 or 3/4" material?
10. Have QC run a point at optimum moisture from their curve on the passing # 4 or 3/4". Observe them perform the sample preparation and compaction procedure. Correct moisture computed and material properly mixed? Correct layers and layer heights? Hammer dropped from the correct height? Correct number of blows? Correct trimming and cleaning of mold? Moisture samples obtained correctly tested?

Coarse Aggregate Bulk Specific Gravity Test (AASHTO T 85)

1. Check thermometers.
2. How do values compare with pit history?
3. Were samples oven dried prior to soaking?
4. Do both parties have approximately the same G_{sa} ? This indicates the difference is probably in interpretation of the SSD point. If these results are very different this points to weight in water error, so was empty basket weighed in water or "zeroed" in water?
5. Screen over a nested 1/4" and # 4 sieve. Significant material passing the # 4 indicates an error in screening of material.
6. Have QC run QA sample and observe the sample preparation procedure.

COMPACTION OF SOILS & PROCESSED AGGREGATE (AASHTO T 310 with T 99, T 255/265 (or T 217) & T 85 and T 272 & R 75 (Soils) or ODOT TM 223 (Aggregate Base))

There are no IA parameters for compaction. If verification for compaction fails see the specification specific section for how the QC is to resolve the failing area.

1. Is the correct curve being used? Is the correct density information being used?
2. Coarse particles fit the rules for AASHTO T 99, Method A or Method D? Fits curve used?
3. Observe testing in the field and look for the following: Random representative location selected. Correct site preparation, drilling of the test hole, placement and seating of the gauge, data recorded.
4. For soils. Observe proper fabrication of the one point and look for the following: Proper screening of material, in-place moisture measured prior to addition of additional moisture if needed, proper compaction of sample in correct mold, stable surface for compaction of one point?
5. Check speedy moisture tester, balances and has density gauge been calibrated and calibration been verified by the region QA lab.

ACP TESTING

The following should be considered in addition to the items listed in the Aggregate section.

Ignition Oven – AC Content Test (AASHTO T 308)

1. Was the correct calibration factor used?
2. Were calibration samples batched properly and calculations performed correctly?
3. Was companion moisture used or sample dried prior to testing?
4. Sample has a clean burn? Sample achieved constant mass?
5. Check basket weights. Check sample size.
6. Check gradation results. The coarse half of a split may have lower asphalt content than the fine half.
7. Is the Oven set at the correct temperature?
8. Does the manufacture scale drift test meet parameters?
9. Was the thermometer removed prior to initial and final weighing?
10. Were the initial and final weights taken at the same temperatures?
11. Was the mix moisture removed from the initial mass reading?

Rice Gravity Testing (AASHTO T 209)

1. Check tare weights of pycnometers and lids.
2. Check sample sizes.
3. Check pycnometers calibration numbers.
4. Check equipment. Proper vacuum pressure? Calibrated thermometer?
5. Is the “dry back” procedure appropriate for this material?
6. Check gradation results. The coarse half of a split will have a higher Rice Gravity than the fine half.

Bulk Gravity Testing (AASHTO T 166)

1. Check sample heights.
2. Check measured volumes compared to heights. Tallest specimen should have largest volume.
3. Check equipment. Suspension apparatus hanging free? Calibrated thermometers? Tank overflow? Damp towel for SSD?
4. Check compaction equipment. Proper gyrations, pressure, angle of gyration, compaction temp?
5. Observe testing. Swap samples and observe performing procedure. Watch immersion and SSD procedures. Is basket and wire assembly free floating?
6. If results do not vary from originals, may point to a splitting or compaction error.
7. If results vary from originals, may point to a technician or equipment error.

ACP DENSITY TESTING (AASHTO T 355)

There is no opportunity to rework ACP; therefore, it is imperative to troubleshoot density testing issues immediately.

QC Best Practice

Once the gauge has been initially ODOT calibrated, identify a location that can act as a reference, this site should be an area of flat concrete. Set the gauge on the flat concrete surface and scribe a line around the case. Take a four-minute test on the site and document the result. It is a good idea to paint the density on the concrete so that others may use it too. Test the gauge at this site prior to going to the project to assure that the gauge is still reading consistently. Performing standard counts on project site before starting daily work is required and running another set at mid shift helps to maintain consistent readings.

Project Manager

1. Has the Contractor's gauge calibrated or verified by the region QA group? Ask to see Cert.
2. Correct MAMD used? Core Correlation factor applied if needed (ODOT TM 327)?
3. Check the following correct; site preparation, placement and seating of the gauge, footprint marked, data recorded, rotation gauge.
4. Does the first subplot MDT match the JMF MDT within reasonable parameters? Specification is 50 kg/m^3 (3.0 lb/ft^3) this is really a large variation - check the asphalt content of the mixture.
5. If compaction is low, are there sufficient rollers of proper weight (according to specifications), to achieve compaction? Does compaction correlate with voids i.e. high voids low compaction?
6. Is the mix tender? Seek help from SQAC or ODOT Pavements.
7. Is rolling compacting the whole panel, not just the center? Consistent with the control strip?
8. Is the lay down temperature correct according to the JMF or has temperature changed during production? Has there been a substantial change in lift thickness?
9. Is weather a factor (colder, wetter, or windy)?
10. Is the existing surface being paved on in question (i.e. paving over open-graded ACP, PCC surfaces or extremely distressed existing pavement)?
11. Does coring need to be performed to validate in-place compaction? Call the pavements unit for guidance.

If any problems are found that cannot be resolved, the inspector or QCCS should contact the region QA group immediately.

QA

QA is to verify compaction using separate, randomly selected sites. There is no direct comparison, independent assurance parameter for nuclear density testing.

1. Periodically during the construction, perform counts on the region calibration blocks in the backscatter position.
2. On the project, choose one or two sites at random and perform the normal tests on these sites with both the QC and QA gauges. The average for each gauge when compared to the other should be within 2 lb/ft³.
3. If the difference between the two gauges is greater than 2 lb/ft³, the Contractor's QC technician should rerun the tests while the QAT observes.
4. If the two gauges are not in agreement, re-standardize both gauges and re-shoot the location two shots in the same direction. If the gauges still do not compare take both gauges back to the calibration blocks and check their calibration and follow TM 304.
5. If either gauge is out of calibration, recalibrate prior to project testing.
6. If the gauges are in calibration. Core correlation should be performed to remove gauge differences.
7. The Project Manager and region SQAC should work together to resolve QC sublots brought into question by verification results.

PLASTIC CONCRETE TESTING

General for All Concrete Tests

1. Was the test started within prescribed time limits of obtaining the sample?
2. Were the QA and QC samples taken from the same portion of the load?
3. Was the sample adequately recombined if taken from two parts of the load?
4. Was the concrete covered if ambient conditions were adverse?
5. Was all equipment used within specification/tolerance, clean and damp prior to test?
6. Was excess water removed from the sampling container prior to obtaining the sample?

Slump (AASHTO T 119)

1. Once the test was started was it completed in the allotted 2 ½ minutes and immediately measured?
2. Does Equipment meet specification?
3. Tamping rod w/hemispherical tip
4. Flat, rigid, non-absorbent base, level and on a surface free of vibration or disturbance (not a warped water damaged piece of plywood)
5. Cone that is free of dents, rust damage and concrete build up on the inside
6. Correct number of layers and quantity/volume in each layer?
7. Was each layer rodded 25 times extending into the preceding layer?
8. On the top layer, was a head of material kept above the top of the cone at all times?
9. Was the excess concrete cleaned away from the base of the cone prior to lifting?
10. Was the cone pulled too fast/slow?
11. Was the cone pulled straight with no twisting or lateral movement?
12. Was the measurement reading taken from the displaced original center?

Note: If mix has retained 1 ½ inch or larger aggregate, it must be removed by the wet sieve method prior to performing the test.

Air Content (AASHTO T 152)

1. Was the test started within 5 minutes of obtaining the sample?
2. Has the air meter gauge been calibrated within the last three months?

NOTE: The air meter calibration can be checked in the field.

3. Was the bowl filled in approximately equal 1/3 layers?
4. Was each layer rodded 25 times extending into the preceding layer?
5. Were the sides of the bowl tapped 10 to 15 times with a mallet after each layer had been rodded?
6. Was the cover seal moistened and seated properly on the bowl?
7. Was water injected into the petcocks and meter rocked until no air bubbles appeared?

8. Was air pumped into the initial air chamber until it passed the initial pressure setting (as determined in the calibration process) and allowed to cool? Was any air noted seeping out of open petcocks at this time?
9. Was initial gauge adjusted to initial air pressure before opening main air valve?
10. Were the sides of the bowl tapped “smartly” during release of main air valve?
11. During release of main air valve was there any air leaking out the sides due to an incomplete seal?

Temperature (AASHTO T 309)

1. Has the measuring device been calibrated or verified for accuracy within the last year?
2. Was there adequate concrete cover around the measuring device sensor (at least 3”)?
3. Was the concrete pressed around the measuring device at the surface?
4. Was the temperature recorded after a minimum of 2 minutes and the measuring device allowed to stabilize?

Unit Weight (AASHTO T 121)

Since the unit weight test is usually performed in conjunction with the air content test, see steps 3, 4 and 5 under the air content portion of this guide.

1. Check math
2. Was the dry mass of the measure accurately recorded?
3. Has the measure’s volume been accurately calibrated?
4. Was a strike off plate used to create a smooth surface free of voids and level with the rim?
5. Is the scale accurate? Cross check QA and QC scales to field verify accurate measurement.

INSERT TAB

SECTION 3
Report Forms & Examples

ACP INCINERATOR OVEN CALIBRATION WORKSHEET

PROJECT NAME (SECTION)		ODOT Forms		CONTRACT NUMBER	
CONTRACTOR OR SUPPLIER		PROJECT MANAGER		CONTRACTOR MIX DESIGN #	
Best Paving Company		Adam Rose		B5045	
INCINERATOR MAKE		BURN METHOD (A or B)		ANTISTRIP PRODUCT	
NCAT		A		Latex @ 0.0375	
SERIAL NUMBER		ASPHALT SUPPLIER		DOSAGE or RATE	
4425		Albina		0.0375	
		Sample #		Incinerator Sample #	
		1		4	
		Hot Agg Wt.		BASKET TARE	
		1387.0		3025.8	
		Binder Content		MIX MASS & BASKET	
		5.5		A 4602.8	
		Calc Add Bind.		AGG MASS & BASKET	
		80.7		B 4505.1	
		Actual Add		COOL AGG & BASKET	
		80.7		4506.8	
		Percent Binder		TEMP A	
		5.50		290.0	
				TEMP B	
				315.0	
				Mf (B-T)	
				1479.3	
				Mf (B-T)	
				300.0	
				Mf (B-T)	
				1479.4	
				Mf (B-T)	
				300.0	
				Mf (B-T)	
				1479.4	
				Mf (B-T)	
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CONCRETE YIELD AND W/C RATIO WORKSHEET

PROJECT NAME (SECTION)					CONTRACT NUMBER	
CONTRACTOR			PROJECT MANAGER		BID ITEM NUMBER	
CONCRETE SUPPLIER			SUBMITTED BY		QUANTITY REPRESENTED yd ³	
CONCRETE FOR USE IN (LOCATION OR PLACEMENT)			BRIDGE NUMBER		SPECIFIED STRENGTH PSI @ _____ DAYS	
DATA SHEET NUMBER	SET NUMBER	DATE	INVOICE NUMBER	BATCH SIZE	TRUCK NO & DRIVER	

CONCRETE BATCH TICKET AND FIELD TEST DATA

CEMENTITIOUS MATERIAL	AGGREGATES	AGG % FREE MOISTURE
CEMENT _____ lb	#1 _____ lb	_____ %
SLAG _____ lb	#2 _____ lb	_____ %
FLYASH _____ lb	#3 _____ lb	_____ %
SILICA FUME _____ lb	FINE AGG (SAND) #4 _____ lb	_____ %
TOTAL CEMENT _____ lb	TOTAL AGG _____ lb	
ADMIXTURES	1 _____ OZ	
	2 _____ OZ	
ADD WATER	3 _____ OZ	
BATCHED _____ lb	4 _____ OZ	
JOBSITE _____ lb	TOTAL ADMIXTURES _____ OZ	
TOTAL WATER _____ lb	TOTAL ADMIXTURES _____ lb	
TOTAL BATCH MASS _____ lb		

CONVERSIONS

WATER

Gal x 8.34 = lb

Admixtures

oz / 16 = lb

PLASTIC PROPERTIES

TIME CYLINDERS CAST _____	AMBIENT _____ °F	SLUMP _____ in
	CONCRETE _____ °F	AIR _____ %

DENSITY

CONCRETE + POT _____ lb	
- POT MASS _____ lb	
CONCRETE MASS= _____ lb	÷ POT CALIBRATION _____ = _____ lb/ft ³
YIELD TOTAL BATCH MASS _____ = _____	
lb/ft ³ x 27 _____ = _____	_____ = _____ lb/ft ³
CEMENT CONTENT CEMENT, FLYASH & SILICA _____ = _____	
YIELD _____ = _____	_____ = _____ lb/ft ³

WATER CEMENT RATIO

A. AGGREGATE FREE WATER (FREE MOISTURE FACTOR = % FREE MOISTURE DIVIDED BY 100. EG. : 5.5% = 0.055)

BATCH MASS - $\left(\frac{\text{BATCH MASS}}{(1 + \text{FREE MOISTURE FACTOR})} \right) = \text{AGG. FREE WATER}$ W/C RATIO = $\frac{\text{TOTAL FREE WATER (A+B+C)}}{\text{TOTAL CEMENT \& FLYASH}}$

#1 _____ - (_____ / 1+ _____) = _____ lb
#2 _____ - (_____ / 1+ _____) = _____ lb
#3 _____ - (_____ / 1+ _____) = _____ lb
FINE AGG (SAND) #4 _____ - (_____ / 1+ _____) = _____ lb

A. AGGREGATE FREE WATER TOTAL = _____ lb

B. WATER ADDED AT PLANT&JOBSITE = _____ lb

C. ADMIXTURES ADDED = _____ lb

_____ lb = _____ = **W/C RATIO**

<input type="checkbox"/> QUALITY CONTROL	<input type="checkbox"/> VERIFICATION
CERTIFIED TECHNICIAN (PLEASE PRINT) AND CARD NUMBER	COMPANY NAME
SIGNATURE	
DATE	

CONCRETE YIELD AND W/C RATIO WORKSHEET

PROJECT NAME (SECTION) Forms Example					CONTRACT NUMBER 12345		
CONTRACTOR ODOT Forms			PROJECT MANAGER Sean Parker		BID ITEM NUMBER 123		
CONCRETE SUPPLIER The Best Ready Mix			SUBMITTED BY Scott Aker		QUANTITY REPRESENTED 150 yd³		
CONCRETE FOR USE IN (LOCATION OR PLACEMENT) Deck				BRIDGE NUMBER 1234a		SPECIFIED STRENGTH 5000 PSI @ 28 DAYS	
DATA SHEET NUMBER F-43048-001	SET NUMBER 1	DATE 10/10/12	INVOICE NUMBER 123456	BATCH SIZE 9.00yd3	TRUCK NO & DRIVER #21 T. Driver		

CONCRETE BATCH TICKET AND FIELD TEST DATA

CEMENTITIOUS MATERIAL		AGGREGATES		AGG % FREE MOISTURE
CEMENT	4735 lb	3/4" Round #1	17600 lb	0.30 %
SLAG	165 lb	#2	lb	%
FLYASH	2000 lb	#3	lb	%
SILICA FUME	288 lb	FINE AGG (SAND) #4	10080 lb	7.90 %
TOTAL CEMENT	7188 lb	TOTAL AGG	27680 lb	
ADMIXTURES		Rheobuild	1 580 oz	
		997	2 512 oz	
ADD WATER		AE-90	3 64 oz	
BATCHED	1186 lb		4 oz	
JOBSITE	lb	TOTAL ADMIXTURES	1156 oz	
TOTAL WATER	1186 lb	TOTAL ADMIXTURES	72 lb	
TOTAL BATCH MASS			36126 lb	

CONVERSIONS

WATER

Gal x 8.34 = lb

Admixtures

oz / 16 = lb

PLASTIC PROPERTIES

TIME CYLINDERS CAST 11:30 AM AMBIENT 40.5 °F SLUMP 6 1/2 in
 CONCRETE 60.5 °F AIR 4.9 %

DENSITY

CONCRETE + POT	43.90 lb		
- POT MASS	7.68 lb		
CONCRETE MASS=	36.22 lb	+ POT CALIBRATION	0.2499 = 144.9 lb/ft³
YIELD	TOTAL BATCH MASS = 36126		
	lb/ft³ x 27 = 3912.30		9.23 lb/ft³
CEMENT CONTENT	CEMENT, FLYASH & SILICA = 7188		
	YIELD = 9.23		779 lb/ft³

WATER CEMENT RATIO

A. AGGREGATE FREE WATER

(FREE MOISTURE FACTOR = % FREE MOISTURE DIVIDED BY 100. EG.: 5.5% = 0.055)

BATCH MASS -	$\left(\frac{\text{BATCH MASS}}{(1 + \text{FREE MOISTURE FACTOR})} \right) = \text{AGG. FREE WATER}$		W/C RATIO=	$\frac{\text{TOTAL FREE WATER (A+B+C)}}{\text{TOTAL CEMENT & FLYASH}}$	
3/4" Round #1	17600	- (17600 / 1+ 0.0030) =	53	lb	
#2		- (/ 1+) =		lb	
#3		- (/ 1+) =		lb	
FINE AGG (SAND) #4	10080	- (10080 / 1+ 0.0790) =	738	lb	
		A. AGGREGATE FREE WATER TOTAL =	791	lb	
<u>2049</u> lb	=	0.29 = W/C RATIO	B. WATER ADDED AT PLANT&JOBSITE =	<u>1186</u>	lb
<u>7188</u> lb			C. ADMIXTURES ADDED =	<u>72</u>	lb

<input type="checkbox"/> QUALITY CONTROL	<input type="checkbox"/> VERIFICATION	
CERTIFIED TECHNICIAN (PLEASE PRINT) AND CARD NUMBER	COMPANY NAME	SIGNATURE DATE

INSERT TAB

Yellow Sheets



Oregon

Tina Kotek, Governor

Department of Transportation

Construction Section

800 Airport Road SE

Salem, Oregon 97301

Phone: 503-986-3000

Fax: 503-986-3096

December 5, 2025

To: All Holders of the Manual of Field Test Procedures

Section: **Test Procedure AASHTO T 310**

The Oregon Department of Transportation has specified method(s) for this Test Procedure. Please observe the following for our projects:

- **ODOT TM-158 shall be satisfied prior to performing AASHTO T 310.**
- **Document results of ODOT TM 158.**
- **Under Calibration add; Comply with ODOT TM 304.**
- **Under Procedure, use Method A.**
- **The backscatter/air-gap ratio method is not allowed on ODOT contracts.**

Earthwork:

- **Under Procedure, step 5, if the drive pin encounters material that prevents hole fabrication, then another test site within the random area shall be selected. If the new location still prevents hole fabrication, then the CDT should contact the field inspector, if available, for verification. Document in the remarks on form 734-1793S that the area was too rocky to test and if available, the inspector's name. Also, note if a field inspector wasn't available to witness the hole fabrication.**
- **Under Procedure , step 7, add sentence. Placed in its final position with an open hand.**
- **Under Procedure, Steps 11, 12, and 13 are required**
- **Under Procedure, Step 12, moisture content other method allowed is AASHTO T 217**

Crushed Processed Aggregate:

- **AASHTO T 272 is not required**
- **Under Procedure, Steps 11, 12 & 13 are not required.**



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December 5, 2025

To: All Holders of the Manual of Field Test Procedures

Section: **Test Procedure AASHTO T 355**

The Oregon Department of Transportation has specified method(s) for this Test Procedure. Please observe the following for our projects:

- **Under Calibration: ODOT requires calibration verified according to TM 304.**
- **Under Procedure, Step 2, a filler material is defined as material passing the No. 8 or finer sieve and from the aggregate source used to produce the Job Mix Formula.**
- **Under Procedure, use Method A for density determinations. Method B is not allowed.**
- **Under Procedure, Method A, step 3, add the following sentence. Placed in its final position with an open hand.**
- **Delete Appendix – Correlation with Cores**
- **For Core Correlation use ODOT TM-327 and utilize form 734-2327 for reporting.**

Density testing of ACP shall conform to the following:

- **Select 5 longitudinal test locations in a stratified random pattern in accordance with ODOT TM 400.**



Oregon

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December 5th, 2025

To: All Holders of the Manual of Field Test Procedures

Section: **Test Procedure AASHTO R 100**

The Oregon Department of Transportation has specified method(s) for this Test Procedure. Please observe the following for our projects:

- **Under Procedure - Initial Curing, Use Method 1, cure in a cooler with water that completely covers the entire mold and lid, maintained within the required temperature range. See test procedure for temperature requirements.**
- **Under Procedure - Transporting Specimens, Delete Bullet 4 and replace with the following:**
 - **For concrete cylinders that are not able to be placed in final cure at the site where the compression testing will be performed, within 48 hours, a “temporary final cure” environment will be provided and maintained. Cylinders placed into this “temporary final cure” environment will then be transported to the final cure location within 21 days of casting. Temporary final cure is defined as;**
 - **Temporary final cure –Curing may be accomplished in a moist room or water tank conforming to AASHTO M201.**
- **Under Procedure – Casting Cylinders, Rodding step 3, the use of a mallet meeting the requirements under apparatus may be used for single-use plastic molds conforming to AASHTO M-205.**