New Mexico Technician Training and Certification Program (TTCP)

Soil Manual

Sponsored by:
New Mexico Department of Transportation
&
Associated Contractors of New Mexico

January 2019
To: TTCP Certified Personnel and Industry

From: Matthew Janssen
TTCP Administrator – NMDOT

Date: December 4, 2018

Subject: Summary of Program Changes to TTCP Manuals – January 2019

The following provides a summary of significant program changes to the TTCP Manuals as recommended by the TTCP Technical Committee and approved by the TTCP Board of Directors. Minor word, punctuation corrections or changes may not be reflected in this summary. Updating of AASHTO year-of-review in the title with no changes to the procedure will also not be reflected in this summary. If a test procedure is not listed, no significant changes were made by AASHTO or the Committee. Significant changes for 2019 are noted in yellow in TTCP manuals.

**AGGREGATE**

AASHTO R-58-11 (2015), Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
- Modification 2 – *Minimum Sample size when the largest particle size is 9.5 (3/8) shall be 1000g*

**SOIL**

AASHTO T-180-17, Moisture-Density Relations of Soils using a 10-lb Rammer and 18-in Drop
- Method A and all procedures for Method A have been added

*NMDOT Estimated “R – Value” Method*
- Test Method was completely removed from Manual

**HMA/WMA**

AASHTO T-209-16, Theoretical Maximum Specific Gravity and Density of HMA Paving Mixtures
- Statement added to place lid on vessel and completely dry for calibration and during the test.

AASHTO T-168-16
- Reference was added for R-67 Sampling Roadway Cores after Compaction.
  • All three will now be certifications with a written and hands on test. This will increase the certification to a three (3) day class.

CONCRETE
AASHTO T-121-17, Density, Yield and Air Content of Concrete
  • Calculations will be done to the Tenth (0.1)

NUCLEAR DENSOMETER
AASHTO T-310, In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods
  • Statement was removed that indicated Do not look at exposed source for extended period of time

Should you have any comments or questions, please feel free to contact me at (505) 344-2072, ext. 18, or by e-mail at matthew.janssen@stste.nm.us
INTRODUCTION

The New Mexico Department of Transportation (NMDOT) and Associated Contractors of New Mexico (ACNM) Technician Training and Certification Program (TTCP) is an organization dedicated to improving the quality and continuity of highway materials sampling and testing. One means of accomplishing this is by ensuring that individuals have demonstrated abilities to engage in quality control or quality assurance activities in transportation construction work that is under the jurisdiction of NMDOT and those individuals have successfully completed the Technician Training and Certification Program. This program is prescribed to meet, in part, the requirements of 23 Code of Federal Regulations 637, Subpart B – Quality Assurance Procedures for Construction as mandated by the Federal Highway Administration (FHWA), effective June 29, 2000.

TTCP OBJECTIVES

The objectives of the program are:

- To certify highly skilled, knowledgeable materials sampling and testing technicians and field technicians.
- To promote uniformity and consistency in sampling and testing throughout the state.
- To create a harmonious working atmosphere between public agencies and private industry employees based upon trust, open communication, and equality of Certification.

WESTERN ALLIANCE FOR QUALITY TRANSPORTATION CONSTRUCTION (WAQTC) - RECIPROCITY

The New Mexico TTCP joined the Western Alliance for Quality Transportation Construction (WAQTC) in 2001. WAQTC is comprised of the western states of Alaska, Texas, Colorado, Hawaii, Idaho, Montana, New Mexico, Oregon, Utah and Washington, and the Western & Central Federal Lands Highway Division (WFLHD and CFLHD) of the FHWA. A technician that holds current WAQTC certifications from one of the Alliance states must provide those credentials to the TTCP Administrator prior to working on any New Mexico Department of Transportation project. A WAQTC technician working on a New Mexico Department of Transportation project without current TTCP endorsement is not considered certified in New Mexico. The WAQTC certifications will be assessed, and any test elements required, as part of the New Mexico TTCP, will need to be completed. Once the New Mexico TTCP test elements are achieved, New Mexico TTCP certificates will be issued. The technician’s WAQTC identification number will be placed on the TTCP certificates to maintain continuity within the WAQTC program. The technician will retain all WAQTC certifications.

The reciprocity review process will be performed by the TTCP Administrator on a case-by-case basis and the New Mexico TTCP will expedite the WAQTC certification upgrade, in a timely manner. Any review and certification upgrade testing – both written and hands-on examination – will be performed at the New Mexico TTCP training facility in Albuquerque. All costs associated with the certification upgrade will be prorated on a “per test element, per module” basis.

Currently, the New Mexico TTCP does not recognize and will not offer reciprocity for Nuclear Densometer (gauge) Certification. All technicians performing nuclear densometer gauge operation as part of New Mexico Department of Transportation projects shall be properly certified through the New Mexico TTCP. However, New Mexico TTCP will continue to recognize and accept Radiological Safety Training certificates from approved sources. A Radiological Safety Training certificate is a prerequisite to attend the New Mexico TTCP Nuclear Densometer Certification class.
TTCP BOARD OF DIRECTORS (Board):

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ACNM REPRESENTATIVE:

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ACNM – Executive Director
6135 Edith Blvd., NE
Albuquerque, NM 87107
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ADMINISTRATOR FUNCTIONS:
The Administrator will be responsible for the day-to-day operation and function of the training and certification laboratory, including but not limited to the following:

1. Schedule candidates for certification and training classes.
2. Provide instruction for certification and training classes.
4. Provide proctoring for candidate certification.
5. Maintain equipment inventory and certifications.
6. Secure materials necessary to perform required test for candidate certification and training.
7. Issue and maintain accurate records reflecting the accomplishments of the candidates for certification and training.
8. Make recommendations to the TTCP Board that will ensure that objectives of the certification and training program are being met.
9. Provide field inspection of project laboratories and evaluate the performance of certified laboratory technicians.
TTCP COMMITTEE MEMBERS:

NMDOT District Laboratory Supervisors:

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<tr>
<th>District</th>
<th>Location</th>
<th>Name</th>
<th>Phone</th>
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<tbody>
<tr>
<td>District 1</td>
<td>Deming</td>
<td>Valente Alvarado</td>
<td>(575) 544-6581</td>
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<tr>
<td>District 2</td>
<td>Roswell</td>
<td>Vacant</td>
<td>(575) 626-1019</td>
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<td>District 3</td>
<td>Albuquerque</td>
<td>Manuel Ramirez</td>
<td>(505) 221-7289</td>
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<td>District 4</td>
<td>Las Vegas</td>
<td>Vacant</td>
<td>(505) 617-1212</td>
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<tr>
<td>District 5</td>
<td>Santa Fe</td>
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<td>(505) 476-7150</td>
</tr>
<tr>
<td>District 6</td>
<td>Milan</td>
<td>Alfonso Lopez</td>
<td>(505) 285-3261</td>
</tr>
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Additional TTCP Committee Advisors:

- NMDOT Central Laboratory, Materials Testing Engineer  (505) 827-5191
- NMDOT Central Laboratory, Concrete Engineer (Sean Brady)  (505) 257-8673
- NMDOT Central Laboratory, Asphalt Engineer (Vacant)  (505) 490-2682
- Lea Anne Marquez, P.E. – CA^2 Engineering  (505) 718-3030
- Larry Melchior – Bohannon Huston, Inc.  (505) 823-1000
- Shawn Hammer – Fisher Sand and Gravel, Inc.  (505) 867-2600
- Rambert Waid – American Constructive Solution  (575) 313-0847
- TTCP Proctors  (505) 344-2072

Note: The TTCP Committee shall review and update this manual as necessary in order to keep it current with AASHTO and Department specifications.

TRAINING & CERTIFICATION MODULES

The following modules are currently being offered at the joint TTCP/ACNM facility located at 6135 Edith, NE, Albuquerque, NM 87107:

- Aggregate Training
- Aggregate Certification
- Soil Training
- Soil Certification
- Hot-Mix Asphalt (HMA) / Warm-Mix Asphalt (WMA) Training
- HMA/WMA Certification
- Concrete Training
- Concrete Certification
- Nuclear Densometer Training (Radiological Safety Certification)
- Nuclear Densometer Certification
- Inertial Profiler Inspector Training
- Inertial Profiler Operator Certification
- Inertial Profiler Machine Certification
- Ethics Awareness for the Transportation Industry
- HMA (Superpave) Mix Design Training
- TTCP Overview for Decision-Makers Training
- HMA Construction Inspection Training
- Daily Documentation
- Construction Management – Section 100 Training
- Drilled Shaft Inspector Certification
- Seeding Inspector Certification
EXAMINATION

As part of the Certification process, each technician will be required to pass both written and performance examinations which are designed to demonstrate both a knowledge and understanding of the test procedures. Written examination Administrators and performance examination Proctors should thoroughly explain to the participants what the examinations will entail and the examination rules prior to the beginning of the examinations. Multiple proctor stations will be required for the performance (hands-on) portion of the examination. Failure of either the written or performance portions will constitute failure of the entire Certification and will require re-examination in both examinations, at a later date, if Certification is still desired, subject to the criteria described herein.

Written Examination

The written examination will consist of multiple choices, some of which will require calculations, or True/False questions. All questions require detailed knowledge of the test method procedures and basic reading comprehension. The examination is closed book, which requires that no technical materials or notes be allowed at the workstation during the examination. Calculations may be required for some questions; therefore, a pocket calculator should be brought to the examination. Calculators may not be shared. All written examinations will be administered within a specified time frame, which will be consistent for each examination. Examination scores will remain confidential. The written examination material is not to be discussed with, or provided to, any unauthorized personnel. A participant will successfully pass the written examination by meeting the following criteria:

a. A minimum score of 70% on the entire written examination for that Certification.
b. A minimum score of 60% on each segment (test element) of the written examination.

Performance Examination

The performance examination is a closed-book demonstration of the mechanics of the individual element’s testing procedures. The participant may review the program manual or notes just prior to beginning a particular test element at a Proctor station, but once the individual element performance examination begins, no reference materials may be used. Each procedure will be completed within the time limit designated by the NMDOT for that method. The participant is required to successfully perform all steps of the designated test procedures for that particular certification area, with the exception that an examinee may be asked to explain various steps to a procedure in order to reduce the total test time. All test method time limits set by the Department will take into account the reduction of time due to accelerated steps. An individual may be required to verbally describe the procedures for sampling of a material if performance of the method is not practical or feasible.

The Proctor’s judgment of Pass/Fail will be based on the ability to correctly perform all required procedures for each of the methods based on the criteria shown on the performance examination checklist. Performance examination checklists are compiled from test elements found in the TTCP Manual. Omission of one or more of the prescribed steps will constitute failure of that test method. The inability to complete the test within the designated time limit will constitute failure of the test method. The examinee may perform one repeat trial of a failed test method after completing all elements in the first round. No failed elements will be re-tested until all first round elements are complete. This provides an overall assessment of the candidate’s technical background, ability, and knowledge. Complete re-testing of individual elements will be allowed in not more than 50% of the total test elements in that performance examination. Failure of any one of the prescribed test methods after two trials will constitute failure of the performance examination portion of the certification process. Scoring of the exam will be on a Pass/Fail basis.

The performance examination will occur in the direct presence of the Proctor. All steps of the test methods must be performed, except the Proctor may accelerate the procedure by manipulation of time required to perform certain steps. The Proctor may not respond to questions or assist in the performance of the test method. Immediately after completion of the method, the Proctor will inform the individual if he/she has passed or failed that trial. If a failure has occurred, the Proctor will denote which part of the method was performed or described incorrectly. If the mechanics of the test method were completed correctly, however, minor errors were stated or omissions to the procedure were made, a Proctor may issue a “VERBAL” re-test on the minor errors for the second round testing. If the Proctor witnesses a lack of demonstrated ability for a test element, the Proctor would have the candidate “RE-DO” all, or a portion of the selected elements of the test method on the second round of testing. The failed test elements that constitute “RE-DO’s” will be the elements that may
not exceed 50% of the first round elements. “VERBAL” failures will not be included as part of the 50%.
If a candidate has a written examination element that is less than 60%, and the candidate has successfully completed the performance examination, the candidate must re-test the failed written examination element. The candidate must achieve a score of greater than or equal to 60% on the second round re-test of the written examination element. If the candidate fails to achieve the designated passing score on the written re-test, the candidate will have failed to complete the certification process and must re-test the entire program level at a later date.

PROBATION, SUSPENSION, OR REVOCATION OF CERTIFICATION

Certifications awarded by the New Mexico Technician Training and Certification Program (TTCP), may be placed on probation, suspended, or revoked at any time by the New Mexico Department of Transportation’s (hereinafter referred to as the “Department”) State Materials Bureau Chief, as recommended by the TTCP Board of Directors, for just cause. Proposed probations, suspensions, or revocations shall be sent to the technician in writing along with the technician’s right to appeal the decision. A proposed probation, suspension, or revocation is effective immediately upon receipt by the technician of a certified letter from the Department’s State Materials Bureau Chief and shall be affirmed, modified, or vacated following any appeal. The reasons that a technician will be subject to probation, suspension, or revocation of their certification are negligence or abuse of their responsibilities.

“Negligence” is defined as unintentional deviations from approved procedures that may or may not cause erroneous results. The following penalties are guidelines after a finding of negligence:

- The first finding of negligence shall result in a letter of probation being sent to both the technician and the employer placing the technician on probation for a period of time as deemed appropriate for the infraction not to exceed one-hundred-eighty (180) days. During this period, follow-up reviews of the technician on probation will be conducted by the TTCP.
- The second finding shall result in a thirty-day (30) suspension of certification. The term “suspension” indicates that the technician will not be allowed to perform any sampling and/or testing under the suspended certificate for the period of time mentioned.
- The third incident shall result in one-hundred-eighty-day (180) suspension of technician’s certification.
- The fourth finding or incident of negligence shall result in permanent revocation of technician’s certification. The TTCP Board of Directors may deviate from these penalty guidelines if warranted.

“Abuse” is defined as intentional deviations from approved procedures or reporting of results not directly generated by an approved test procedure (i.e., “pencil whipping,” “magic pencil,” or using white out). The following penalties are guidelines for finding of abuse:

- The first finding of abuse shall result in a one (1) year suspension of the technician’s certification.
- Any subsequent finding of abuse shall result in that technician being ineligible for any future type of TTCP Certification. The TTCP Board of Directors may deviate from these penalty guidelines if warranted.

A complaint must be made against a TTCP certified technician to initiate a corrective action. The complaint shall be made in writing on company letterhead or Department’s standard “confer-memo” form. The complaint should include the following information:

- The TTCP certified technician’s name;
- The project that the infraction occurred on;
- The date the infraction was observed;
- A brief description of the problem;
- The name of the person making the complaint;
- His/her affiliation to the project; and
- A phone number that the complainant can be reached.
A complaint shall be addressed to any of the individuals listed below as investigators. The person with whom the complaint is lodged with shall immediately contact the TTCP Administrator for assignment of the case. In the event the TTCP Administrator can be contacted, the Department’s State Materials Bureau Chief shall be contacted for assignments. Two investigators will be chosen to investigate the complaint. The investigators shall be from a different district than the district that the complaint is lodged in. The investigators shall investigate the complaint as soon as practical, but no later than two (2) to three (3) working days from the time that the complaint is filed. The investigators shall be given free access to inspect the field laboratory or similar facility during operations to make their assessment of the infraction listed in the complaint. The infraction shall be considered valid and the appropriate action shall be taken if access is denied or the TTCP certified technician proves to be uncooperative to the investigators. During the inspection, the investigators shall record the deviations in writing, complete with a notation of how the procedure should be performed correctly, or how out-of-specification items should be rectified.

Once the investigation is complete, the investigators, TTCP Administrator, and the Department’s District Laboratory Supervisor of jurisdiction, shall meet within five (5) working days and determine their recommended action related to the particular complaint. Their signed written recommendation will then be sent to the Department’s State Materials Bureau Chief within two (2) working days of this meeting. The Department’s State Materials Bureau Chief shall, based on the information provided, discussions with the involved technician, and the recommendations of the TTCP Board of Directors, issue a written certified letter to the involved technician, with uncertified copies of this letter to the technician’s employer and to the TTCP Board of Directors on whether or not probation, suspension, or revocation of that technician’s certification will occur.

A disciplinary action may be appealed to the TTCP Board of Directors. Appeals shall be made in writing to the Department’s State Materials Bureau Chief in order to schedule a meeting. The revocation or suspension shall be in effect until the TTCP Board of Directors reviews the case. When making an appeal, the investigators shall attend the board meeting, if possible, to provide information on the investigation.

A complaint lodged against a TTCP certified technician shall be investigated by any two of the following investigators:

- Department’s District 1 Laboratory Supervisor, Deming, NM;
- Department’s District 2 Laboratory Supervisor, Roswell, NM;
- Department’s District 3 Laboratory Supervisor, Albuquerque, NM;
- Department’s District 4 Laboratory Supervisor, Las Vegas, NM;
- Department’s District 5 Laboratory Supervisor, Santa Fe, NM;
- Department’s District 6 Laboratory Supervisor, Milan, NM;
- Department’s Asphalt Unit Supervisor, State Materials Bureau, Santa Fe, NM;
- Department’s TTCP Administrator, Albuquerque, NM; or
- ACNM’s TTCP Representative, Albuquerque, NM.

Revocations or suspensions for abuse or negligence in one certification area shall be considered revocations or suspensions in all TTCP certifications held by that technician. For any disciplinary action that requires suspension greater than or equal to one (1) year, the non-certified technician will be required to re-certify with TTCP at the end of the suspension period.

As the result of an investigation, or routine laboratory inspection, if an equipment deficiency is determined on any Department project, the project shall not proceed until the equipment is brought into compliance.
TTCP CERTIFICATIONS

AGGREGATE:
40-hour TRAINING class. This is optional TRAINING to prepare for the Aggregate certification. There will be at least 120 hours of On-The-Job Training completed by the trainee and documented using the TTCP O.J.T. form before attempting the certification examination. The training will cover the basic procedures and modifications. It is the student’s responsibility to study the AASHTO specifications to learn specific details.

24-hour CERTIFICATION. It is possible to attend a 24-hour CERTIFICATION without attending a training class. However, all participants and employers should be aware that THIS IS NOT A TRAINING CLASS – THERE IS NO TRAINING INVOLVED. Participants will participate in a short review and will be required to pass a written examination and demonstrated abilities (performance) examination.

SOIL:
16-hour TRAINING class. This is optional TRAINING to prepare for the Soil certification. There will be at least 56 hours of On-The-Job Training completed by the trainee and documented using the TTCP O.J.T. form before attempting the certification examination. The training will cover the basic procedures and modifications. It is the student’s responsibility to study the AASHTO specifications to learn specific details.

16-hour CERTIFICATION. It is possible to attend a 16-hour CERTIFICATION without attending a training class. However, all participants and employers should be aware that THIS IS NOT A TRAINING CLASS – THERE IS NO TRAINING INVOLVED. Participants will participate in a short review and will be required to pass a written examination and demonstrated abilities (performance) examination.

HOT-MIX ASPHALT (HMA) / WARM-MIX ASPHALT (WMA):
24-hour TRAINING class. This is optional TRAINING to prepare for the HMA/WMA certification. There will be at least 160 hours of HMA/WMA related On-The-Job Training completed by the trainee and documented using the TTCP O.J.T. form before attempting the certification examination. The training will cover the basic procedures and modifications. It is the student’s responsibility to study the AASHTO specifications to learn specific details.

24-hour CERTIFICATION. It is possible to attend a 24-hour HMA/WMA CERTIFICATION without attending a training class. However, all participants and employers should be aware that THIS IS NOT A TRAINING CLASS – THERE IS NO TRAINING INVOLVED. Participants will participate in a short review and will be required to pass a written examination and demonstrated abilities (performance) examination.

Note: The TTCP Training Class hours will count toward the required O.J.T. time.
TTCP CERTIFICATION ELEMENTS

AGGREGATE:
AASHTO T-2    Sampling of Aggregates (Modified)
AASHTO T-11  Materials Finer Than 75-μm Sieve in Mineral Aggregates by Washing (Modified-Procedure A)
AASHTO T-27  Sieve Analysis of Fine and Coarse Aggregate (Modified)
AASHTO R-58  Dry Preparation of Disturbed Soil & Soil Aggregate Samples for Test
AASHTO T-89  Determining the Liquid Limit of Soils (Modified)
AASHTO T-90  Determining the Plastic Limit and Plasticity Index of Soils (Modified)
AASHTO T-74  Wet Preparation of Disturbed Soil Samples for Test (Modified)
AASHTO T-176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test (Modified)
AASHTO R-76  Reducing Field Samples of Aggregates to Testing Size (Method A)
AASHTO T-255  Total Moisture Content of Aggregate by Drying
NMDOT FE-1   Flat and Elongated Particles in Coarse Aggregate (Modified) (NAME CHANGED January 2015)
AASHTO T-335  Determining the Percentage of Fracture in Coarse Aggregate (ADDED January 2012)

SOIL:  (Prerequisite: Aggregate Certification)
AASHTO M-145 Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes (Modified)
AASHTO T-85  Specific Gravity and Absorption of Coarse Aggregate (Modified)
AASHTO T-99  Moisture-Density Relations of Soils Using a 2.5 kg Rammer and a 305-mm Drop (Modified)
AASHTO T-180  Moisture-Density Relations of Soils Using a 4.54 kg Rammer and a 457-mm Drop (Modified)
AASHTO T-224  Correction for Coarse Particle in the Soil Compaction Test (Modified) (DELETED January 2010)
AASHTO T-265  Laboratory Determination of Moisture Content of Soils (Modified)
AASHTO T-272  Family of Curves – One-Point Method (Modified)
AASHTO TP-77  Specific Gravity and Absorption of Aggregate by Volumetric Immersion (DELETED January 2015)
NMDOT R-Value NMDOT Estimated R Value Determination Method (DELETED January 2019)

HMA/WMA:  (Prerequisite: Aggregate Certification)
AASHTO T-30  Mechanical Analysis of Extracted Aggregate (Modified)
AASHTO R-66  Sampling Bituminous Materials (Modified)
AASHTO T-166  Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens (Modified-
             Method A)
AASHTO T-168  Sampling Bituminous Paving Mixtures (Modified)
AASHTO T-209  Maximum Specific Gravity of Bituminous Paving Mixtures (Modified)
AASHTO T-269  Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
AASHTO T-275  Bulk Specific Gravity Compacted Asphalt Mixtures using Paraffin-Coated Specimens (ADDED January
             2015)
AASHTO T-304  Uncompacted Void Content of Fine Aggregate (Modified- Method A) (ADDED July 2003)
AASHTO T-308  Determining the Asphalt Content of Hot Mix Asphalt (HMA) by the Ignition Method (Modified)
AASHTO T-312  Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave
             Gyroratory Compactor (Modified) (NAME CHANGED January 2015)
AASHTO T-331  Bulk Specific Gravity & Density of Compacted Asphalt Mixtures – Automatic Vacuum Sealing Method
             (ADDED January 2015)
AASHTO R-47  Reducing Samples of HMA to Testing Size (Modified)
AASHTO R-79  Vacuum Drying Compacted Asphalt Specimens (ADDED January 2015)
PRE-REQUISITES

AGGREGATE Training:
- None.

AGGREGATE Certification:
- 120 hours of documented Aggregate OJT.

SOIL Training:
- None.

SOIL Certification:
- 56 hours of documented Soil OJT.
- Successful completion of AGGREGATE Certification.

HMA/WMA Training:
- None.

HMA/WMA Certification:
- 160 hours of documented HMA/WMA OJT.
- Successful completion of AGGREGATE Certification.

The AGGREGATE Certification is a requirement for both SOIL and HMA/WMA Certifications. As a result of this requirement, if a certified New Mexico TTCP technician allows their AGGREGATE Certification to expire, all other certifications held by that technician that require a current AGGREGATE Certification (SOIL and HMA/WMA) will be suspended until a time that the AGGREGATE Certification process is successfully completed. Once the required AGGREGATE Certification is re-established, the suspended certifications will be recognized.

DIRECT SUPERVISION

The current definition of Direct Supervision states:

Direct Supervision: The required supervision of TTCP Trainee by a certified TTCP technician who is on a project with the Trainee and who is both signing off and is personally responsible for all of that Trainee’s sampling and testing procedures, results, and reports.

In addition, the definition for TTCP Trainee is as follows:

TTCP Trainee: A technician who has attended the appropriate TTCP training class and has a certificate of completion, and is receiving required “on-the-job” training under the direct supervision of a TTCP certified technician, as such is eligible to take a particular TTCP certification examination.

The TTCP Committee and Board of Directors provide additional language to clarify and solidify the understanding of Direct Supervision for the TTCP Manual.

The TTCP certified technician providing the supervision/training of the trainee must have direct contact with the trainee while performing sampling and/or testing of materials until a point is reached that the TTCP certified technician “supervisor” is confident of the trainee's ability. As the trainee gains experience and demonstrates proficiency, the “supervisor” can relax the direct contact with the trainee for the remainder of the On-The-Job-Training (OJT) period. Completion of one of the TTCP Training classes by a “trainee” would be an appropriate indicator of basic knowledge for the “supervisor” to build on.

The trainee must initial all testing documentation of tests they perform, and the TTCP certified technician “supervisor” must review and sign the testing documents to show accountability and verify accuracy.

It is not the intent of this definition to allow for perpetual trainees.
TTCP CLASS SCHEDULING

If you are a Department employee, please schedule through your District TTCP “Contact” person. Contact your District Training Liaison for more information. All non-Department employees may call the TTCP Scheduler at the ACNM facility number - (505) 344-2072, extension 10 - to request a current TTCP Class schedule or sign-up for a class.

TTCP FACILITY DRESS CODE

All personnel working/training in the TTCP classroom or field setting will wear full length pants, sleeved shirts and appropriate footwear at all times while attending programs at the facility.

TARDINESS

All personnel attending TTCP classes are expected to arrive and be prepared for the scheduled start of class. If a student plans to arrive after the start of class, they shall contact TTCP to inform of their late arrival. The student’s supervisor and/or employer shall be notified of all late arrivals. The TTCP classroom is an extension of a student’s place of employment and shall be treated as such. TTCP reserves the right to send away students that arrive after the start of a scheduled class in order to maintain the continuity of the classroom setting and to eliminate the disruption caused with late students. A student’s supervisor/district/employer will be contacted if a student is sent away.

DISCLAIMERS

Certification of an individual by the TTCP indicates only that the individual has demonstrated a certain level of competence on a written and/or performance examination in a selected field of activity. NMDOT and ACNM members may require this Certification of individuals performing activities specified in work contracts or other activities. Each individual or organizations utilizing certified individuals must make their own independent judgment of the overall competence of certified individuals. The TTCP specifically disclaims any responsibility for the actions, or the failure to act, of individuals who have been certified through TTCP.
# NEW MEXICO TTCP ON-THE-JOB TRAINING (O.J.T.) REPORT

<table>
<thead>
<tr>
<th>NAME:</th>
<th>TTCP NUMBER:</th>
</tr>
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<td>ADDRESS:</td>
<td>PHONE NUMBER:</td>
</tr>
<tr>
<td>EMPLOYER/DISTRICT:</td>
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<tr>
<td>TRAINEE:</td>
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## AGGREGATE

<table>
<thead>
<tr>
<th>40-HR Training</th>
<th>16-HR Training</th>
<th>24-HR Training</th>
<th>16-HR Training</th>
<th>16-HR Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Date:</td>
<td>Class Date:</td>
<td>Class Date:</td>
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<td>Class Date:</td>
</tr>
</tbody>
</table>

- 120 hours of O.J.T. are required to attempt Aggregate Certification.
- 40 hours from Aggregate Training class will count toward the 120-hour total.

**PREREQUISITE:**
- 120 hours of O.J.T.

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>Total Hours:</th>
<th>Week Ending:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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## SOIL

<table>
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<tr>
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<tbody>
<tr>
<td>Class Date:</td>
<td>Class Date:</td>
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</tr>
</tbody>
</table>

- 56 hours of O.J.T. are required to attempt Soil Certification.
- 16 hours from Soil Training class will count toward the 56-hour total.

**PREREQUISITE:**
- Aggregate Certification
- 56 hours of O.J.T.

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>Total Hours:</th>
<th>Week Ending:</th>
</tr>
</thead>
<tbody>
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## HMA/WMA

<table>
<thead>
<tr>
<th>16-HR Training</th>
<th>24-HR Training</th>
<th>16-HR Training</th>
<th>16-HR Training</th>
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</thead>
<tbody>
<tr>
<td>Class Date:</td>
<td>Class Date:</td>
<td>Class Date:</td>
<td>Class Date:</td>
</tr>
</tbody>
</table>

- 160 hours of O.J.T. are required to attempt HMA/WMA Certification.
- 32 hours from HMA/WMA Training class will count toward the 160-hour total.

**PREREQUISITE:**
- Aggregate Certification
- 160 hours of O.J.T.

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>Total Hours:</th>
<th>Week Ending:</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

## NUCLEAR DENSOMETER

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<thead>
<tr>
<th>16-HR Training</th>
<th>16-HR Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Date:</td>
<td>Class Date:</td>
</tr>
</tbody>
</table>

- 40 hours of O.J.T. are required to attempt Nuclear Densometer Certification.
- A Radiological Safety Training certificate is required to attempt Nuclear Densometer Cert.

**PREREQUISITE:**
- Personal TLD badge.
- 40 hours of O.J.T.

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>Total Hours:</th>
<th>Week Ending:</th>
</tr>
</thead>
<tbody>
<tr>
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## CONCRETE

<table>
<thead>
<tr>
<th>16-HR Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Date:</td>
</tr>
</tbody>
</table>

- 120 hours of O.J.T. are required to attempt Concrete Certification.
- 16 hours from Concrete Training class will count toward the 120-hour total.

**PREREQUISITE:**
- 120 hours of O.J.T.

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>Total Hours:</th>
<th>Week Ending:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

I hereby authorize and verify that the above O.J.T. Hours are true and correct.

Project Manager/Supervisor:

---

Aggregate Certification

<table>
<thead>
<tr>
<th>Date:</th>
</tr>
</thead>
</table>

Soil Certification

<table>
<thead>
<tr>
<th>Date:</th>
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HMA/WMA Certification

<table>
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<th>Date:</th>
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</table>

Nuclear Densometer Certification

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<th>Date:</th>
</tr>
</thead>
</table>

Concrete Certification

<table>
<thead>
<tr>
<th>Date:</th>
</tr>
</thead>
</table>
Laboratory Determination of Moisture of Soils
AASHTO T-265-15
(Modified)

This method covers the laboratory determination of the moisture content of soil. The ratio, expressed as a percentage, of the mass of water in a given mass of soil to the mass of the solid particles. Practical application is to determine the mass of water removed by drying the moist soil to a constant mass in a drying oven.

Modification: 1. Modify the soil sample size for moisture.
2. Weigh to the nearest 0.1-gram.
3. The drying container will not be required to have a tight fitting lid provided the moist sample is weighed immediately after being taken and providing the dried sample is weighed immediately after being removed from the oven. (Note 3)

Key Elements:

1. Inspect drying container, weigh and record. Container shall be resistant to corrosion and not subject to change of mass or disintegration on repeated heating and cooling and of sufficient size to contain the sample (3.3). One container is needed for each moisture content determination (3.3). Weigh a clean, dry container and record the empty container weight to the nearest 0.1 g. (Note 3)

2. Obtain sample. Place the moisture content sample in the container. Weigh the container and moist sample and record the weight (5.1). The minimum mass of moist soil sample shall be in compliance with the table below.

<table>
<thead>
<tr>
<th>Sieve Retaining More</th>
<th>Minimum Mass of</th>
<th>Moist Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Than 10% of Sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0 mm (No. 10)</td>
<td>500 g</td>
<td></td>
</tr>
<tr>
<td>19 mm (3/4 in)</td>
<td>1000 g</td>
<td></td>
</tr>
</tbody>
</table>

3. Dry sample to constant mass. Place the container with the moist sample in the drying oven (3.1) maintained at a temperature of 110 ± 5°C (230 ± 9°F) (Soil containing gypsum shall be dried in an oven at 60°C (140°F) or lower according to Note 2) and dry to a constant mass (5.1). Constant mass is defined as after initial drying the weight of the material decreases less than 0.1% after a minimum of 10 minutes additional drying time (Note 3).

\[
\frac{W_1 - W_2}{W_2} \times 100, \quad \frac{W_2 - W_3}{W_3} \times 100, \quad \text{etc.}
\]

4. Weigh dried sample and record to the nearest 0.1 g.

5. Perform calculations. % Moisture = (W - D) ÷ D x 100

\[ W = \text{weight of moist sample} \]
\[ D = \text{weight of dry sample} \]

6. Report results. Report results to the nearest 0.1%.
Laboratory Determination of Moisture in Soils
AASHTO T-265-15
Review Questions

1. Drying container shall be __________, and not subject to change in mass due to ______.

2. How many samples per container? __________.

3. If more than 10% of your moisture sample is retained on the 2.0 mm (#10) sieve, what is the minimum mass of your moist sample? __________.

4. If more than 10% of your moisture sample is retained on the 19 mm (3/4'') sieve, what is the minimum mass of your moist sample? __________.

5. Most samples are going to be dried at __________ but if your material has loosely bound water or a lot of organic material then dry your sample in an oven at ________ or lower.

6. All the weights in this test go to the ________ of a gram.

7. What is the formula to determine percent moisture? ________________________________.

8. Report the moisture results to the nearest ______ of a percent.
Laboratory Determination of Moisture in Soils
AASHTO T-265-15
Review Answers

1. Corrosion resistant, heating and cooling

2. One (1)

3. 500

4. 1000

5. $110 \pm 5^\circ C (230 \pm 9^\circ F), 60^\circ C (140^\circ F)$

6. 0.1

7. $\frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100$

8. 0.1.
Classification of Soil and Soil-Aggregate Mixtures
For Highway Construction Purposes
AASHTO M-145-91 (2012)

This practice describes a procedure for classifying soils into seven groups based on laboratory determination of particle-size distribution, liquid limit, and plasticity index. The group classification should be useful in determining the relative quality of the soil material for use in embankments, subgrades, and backfills. For detailed design of important structures, additional data concerning strength or performance characteristics of the soil under field conditions will usually be required.

Key Elements:

1. **Determine sieve analysis.** Determine sieve analysis using AASHTO T-11 (wash) and AASHTO T-27 (gradation) test procedures (Note 1). The 2.00 mm (No. 10) sieve, 425-μm (No. 40) sieve, and 75-μm (No. 200) sieve must be included to determine the particle size distribution as a basis for classification.

2. **Determine the liquid limit.** Determine the liquid limit of the material using AASHTO T-89 test procedures.

3. **Determine the plastic limit.** Determine the plastic limit and plasticity index of the material using AASHTO T-90 test procedures.

4. **Determine classification of material.** Using the test limits shown in Table 1 of AASHTO M-145, make the classification of the material. If a more detailed classification is desired, a further subdivision of the groups may be made using Table 2 of AASHTO M-145 (3.1). With required test data available, proceed from left to right in Table 1 or Table 2 and the correct group will be found by process of elimination (3.2). The first group from the left into which all the test data will fit is the correct classification (3.2).

5. **Report classification.** All limiting test values are shown as whole numbers. If fractional numbers appear on test reports, convert to the nearest whole number for purposes of classification (3.2).

**DESCRIPTION OF SOIL CLASSIFICATION GROUPS:**

**Soil Fractions:** According to the AASHTO system, soils are divided into two major groups as shown in Table 1 or Table 2 of AASHTO M-145. These are the granular materials with 35 percent or less passing the 75-μm (No. 200) sieve (5.1, Note 2) and the silt-clay materials with more than 35 percent passing the 75-μm (No. 200) sieve (5.2). Moreover, five soil fractions are recognized and often used in word descriptions of a material. These five fractions are defined as follows:
**Boulders and Cobbles** – material retained on the 75 mm (3 in.) sieve. They should be excluded from the portion of a sample to which the classification is applied, but the percentage of such material should be recorded (4.1.5).

**Gravel** – materials passing sieve with 75 mm (3 in.) square openings and retained on the 2.0 mm (No. 10) sieve (4.1.1).

**Coarse Sand** – materials passing the 2.0 mm (No. 10) sieve and retained on the 425-μm (No. 40) sieve (4.1.2).

**Fine Sand** – materials passing the 425-μm (No. 40) sieve and retained on the 75-μm (No. 200) sieve (4.1.3).

**Combined Silt and Clay** – material passing the 75-μm (No. 200) sieve. The word “silty” is applied to a fine material having a Plasticity Index of 10 or less, and the term “clayey” is applied to fine material having a PI of more than 10 (4.1.6).

**GRANULAR MATERIALS:**

**Group A-1:** Well-graded mixtures of stone fragments or gravel ranging from coarse to fine with a non-plastic or slightly plastic soil binder (5.1.1). However, this group also includes coarse materials without soil binder.

**Subgroup A-1-a:** Materials consisting predominantly of stone fragments or gravel, either with or without a well graded soil binder (5.1.1.1).

**Subgroup A-1-b:** Materials consisting predominantly of coarse sand either with or without a well-graded soil binder (5.1.1.2).

**Group A-3:** Material consisting of sands deficient in coarse material and soil binder. Typical is fine beach sand or fine desert blow sand, without silt or clay fines or with a very small amount of non-plastic silt. This group also includes stream deposited mixtures of poorly graded fine sand and limited amounts of coarse sand and gravel (5.1.2). These soils make suitable subgrades for all types of pavements when confined and damp. They are subject to erosion and have been known to pump and blow under rigid pavements. (Information: They can be compacted by vibratory, pneumatic-tired, and steel-wheeled rollers but not with a sheepfoot roller.)

**Group A-2:** This group includes a wide variety of “granular” materials that are borderline between the materials falling in Groups A-1 and A-3 and silt-clay materials of Groups A-4, A-5, A-6 and A-7. It includes all materials containing 35 percent or less passing the 75-μm (No. 200) sieve that cannot be classified as A-1 or A-3 (5.1.3).

**Subgroups A-2-4 and A-2-5:** Include various granular materials containing 35 percent or less passing the 75-μm (No. 200) sieve, and with that portion passing 425-μm (No. 40) sieve having the characteristics of the A-4 and A-5 groups. These groups include such materials as gravel and coarse sand with silt contents or Plasticity Indexes in excess of 18.
the limitations of Group A-1, and fine sand with non-plastic silt content in excess of the limitations of Group A-3 (5.1.3.1).

Subgroups A-2-6 and A-2-7: Include materials similar to those described under Subgroups A-2-4 and A-2-5, except that the fine portion contains plastic clay having the characteristics of the A-6 or A-7 group (5.1.3.2).

A-2 soils are given a poorer rating than A-1 soils because of inferior binder, poor grading, or a combination of the two. Depending on the character and amount of binder, A-2 soils may become soft during wet weather and loose and dusty in dry weather when used as a road surface. If, however, they are protected from these extreme changes in moisture content, they may be quite stable. The A-2-4 and A-2-5 soils are satisfactory as base materials when properly compacted and drained. A-2-6 and A-2-7 soils with low percentages of minus 75-μm (no. 200) sieve material are classified as good bases, whereas these same soils with high percentages of minus 75-μm (No. 200) sieve and PI’s of 10 or higher are questionable as a base material. Frequently, the A-2 soils are employed as a cover material for very plastic subgrades.

SILT-CLAY MATERIALS:

Group A-4: The typical material of this group is a non-plastic or moderately plastic silty soil usually having 75 percent or more passing the 75-μm (No. 200) sieve. The group includes also mixtures of fine silty soil and up to 64 percent of sand and gravel retained on the 75-μm (No. 200) sieve (5.2.1). These predominantly silty soils are quite common in occurrence. Their texture varies from sandy loams to silty and clayey loams. With the proper amount of moisture present, they may perform well as a pavement component. However, they frequently have an affinity for water and will swell and lose much of their stability unless properly compacted and drained. Moreover, they are subject to frost heave. These soils do not drain readily and may absorb water by capillary action with resulting loss in strength. The silty loams are often difficult to compact properly. Careful field control of moisture content and pneumatic tired rollers are normally required for proper compaction.

Group A-5: The typical material of this group is similar to that described under Group A-4, except that it is usually of diatomaceous or micaceous character and may be highly elastic as indicated by the high liquid limit (5.2.2). These soils do not occur as widely as the A-4 soils. They are normally elastic or resilient in both the damp and semi-dry conditions. They are subject to frost heave, erosion, and loss of stability if not properly drained. Since these soils do not drain readily and may absorb water by capillary action with resulting loss in strength. Careful control of moisture content is normally required for proper compaction.

Group A-6: The typical material of this group is plastic clay soil usually having 75 percent or more passing the 75-μm (No. 200) sieve. The group includes also mixtures of fine clayey soil and up to 64 percent of sand and gravel retained on the 75-μm (No. 200) sieve. Materials of this group usually have high volume change between wet and dry states (5.2.3). These soils are quite common in occurrence and are widely used in fills. When moisture content is properly controlled, they compact quite readily with either a sheepfoot or pneumatic tired roller. They have high dry strength but lose much of this strength upon absorbing water. The A-6 soils will
compress when wet and shrink and swell with changes in moisture content. When placed in the shoulders adjacent to the pavement, they tend to shrink away from the pavement edge upon drying and thereby provide an access route to the under side of the pavement for surface water. The A-6 soils do not drain readily and may absorb water by capillary action with resulting loss in strength.

**Group A-7:** The typical materials and problems of this group are similar to those described under Group A-6, except that they have the high liquid limits characteristic of the A-5 group and may be elastic as well as subject to high volume change (5.2.4).

**Subgroup A-7-5:** Includes those materials with moderate Plasticity Indexes in relation to Liquid Limit and which may be highly elastic as well as subject to considerable volume change (5.2.4.1).

**Subgroup A-7-6:** Includes those materials with high Plasticity Indexes in relation to Liquid Limit and which are subject to extremely high volume change (5.2.4.2).

Highly organic soils such as peat or muck are not included in this classification. Because of their many undesirable properties, their use should be avoided, if possible, in all types of construction.
### Table 1 - Classification of Soils and Soil-Aggregate Mixtures

<table>
<thead>
<tr>
<th>General Classification</th>
<th>Granular Materials (35 Percent or Less Passing 75 μm)</th>
<th>Silt-Clay Materials (More Than 35 Percent Passing 75 μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Classification</td>
<td>A-1</td>
<td>A-3</td>
</tr>
<tr>
<td>Sieve analysis, percent passing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00 mm (No. 10)</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>0.425 mm (No. 40)</td>
<td>50 max</td>
<td>51 min</td>
</tr>
<tr>
<td>75 μm (No. 200)</td>
<td>25 max</td>
<td>10 max</td>
</tr>
<tr>
<td>Characteristics of fraction passing 0.425 mm (No. 40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid limit</td>
<td>-----</td>
<td>NP</td>
</tr>
<tr>
<td>Plasticity index</td>
<td>6 max</td>
<td>NP</td>
</tr>
<tr>
<td>General rating as subgrade</td>
<td>Excellent to Good</td>
<td>Fair to Poor</td>
</tr>
</tbody>
</table>

* The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

* See Table 2 for values.

### Table 2 - Classification of Soils and Soil-Aggregate Mixtures

<table>
<thead>
<tr>
<th>General Classification</th>
<th>Granular Materials (35 Percent or Less Passing 75 μm)</th>
<th>Silt-Clay Materials (More Than 35 Percent Passing 75 μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Classification</td>
<td>A-1</td>
<td>A-3</td>
</tr>
<tr>
<td>Sieve analysis, percent passing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00 mm (No. 10)</td>
<td>50 max</td>
<td>-----</td>
</tr>
<tr>
<td>0.425 mm (No. 40)</td>
<td>30 max</td>
<td>50 max</td>
</tr>
<tr>
<td>75 μm (No. 200)</td>
<td>15 max</td>
<td>25 max</td>
</tr>
<tr>
<td>Characteristics of fraction passing 0.425 mm (No. 40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid limit</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Plasticity index</td>
<td>6 max</td>
<td>NP</td>
</tr>
<tr>
<td>Usual types of significant constituent materials</td>
<td>Stone fragments, gravel and sand</td>
<td>Fine Sand</td>
</tr>
<tr>
<td>General rating as subgrade</td>
<td>Excellent to Good</td>
<td>Fair to Poor</td>
</tr>
</tbody>
</table>

* Plasticity index of A-7-5 subgroup is equal to or less than I.L-30. Plasticity index of A-7-6 subgroup is greater than I.L-30. (See Figure 2.)
Table 2 - Classification of Soils and Soil-Aggregate Mixtures

<table>
<thead>
<tr>
<th>General Classification</th>
<th>Granular Materials (35 Percent or Less Passing 75 μm)</th>
<th>Silt-Clay Materials (More Than 35 Percent Passing 75 μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-1</td>
<td>A-2</td>
</tr>
<tr>
<td>Sieve analysis, percent passing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00 mm (No. 10)</td>
<td>50 max</td>
<td>-----</td>
</tr>
<tr>
<td>0.425 mm (No. 40)</td>
<td>30 max</td>
<td>-----</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Liquid limit</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Plasticity index</td>
<td>6 max</td>
<td>NP</td>
</tr>
<tr>
<td>General rating as subgrade</td>
<td>Excellent to Good</td>
<td>Fair to Poor</td>
</tr>
</tbody>
</table>

General rating as subgrade:
- Excellent to Good
- Fair to Poor

* Plasticity index of A-7-5 subgroup is equal to or less than LL-30. Plasticity index of A-7-6 subgroup is greater than LL-30. (See Figure 2.)
Classification of Soil and Aggregate Mixtures
For Highway Construction Purposes
AASHTO M-145-91 (2012)
Review Questions

1. How many groups can you classify soils into using this procedure (Table 2)?

2. What tests need to be performed prior to doing a soil classification?

3. Do you need to determine the Plasticity Index (PI)?

4. What is the formula to determine Plasticity Index (PI)?

5. When doing particle size distribution (gradation) you need the percent passing from the

6. Work from _________ to _________ in Table 2 to determine soils class.

7. The first group from the _________ into which all the test data will fit is the correct

8. All limiting test values shall be _________ numbers.

9. Material passing the 75 μm (#200) sieve is considered silty material if it has a PI ______ or

10. The two major groups are the granular material with _________ passing the 75 μm (#200)

Classification of Soil and Aggregate Mixtures
For Highway Construction Purposes
AASHTO M-145-91 (2012)
Review Question Answers

1. Seven (7)

2. T-11 (wash), T-27 (gradation), T-89 (Liquid Limit), and T-90 (Plastic Limit)

3. Yes

4. Liquid Limit – Plastic Limit = PI

5. 2.0 mm (#10), 425 μm (#40), and the 75 μm (#200)

6. Left to the right

7. Left

8. Whole.

9. Ten (10), more

10. 35% or less, 35%
Specific Gravity and Absorption of Coarse Aggregate  
AASHTO T-85-14  
(Modified)

Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate. Bulk specific gravity (SSD) is used if the aggregate is wet, that is if its absorption has been satisfied. Conversely, the bulk specific gravity (oven-dry) is used for computations when the aggregate is dry or assumed to be dry. This method is used in conjunction with AASHTO T-180, Annex A1, for correction of coarse particles in the soil compaction test.

**Modifications:**
1. Weigh and record all weights to the nearest 0.1 gram.
2. The initial drying to constant mass may be eliminated prior to soaking.

**Key Elements:**

1. **Inspect equipment.** Equipment shall be calibrated according to AASHTO R-18, Establishing and Implementing a Quality System for Construction Materials Testing Laboratories, and shall include balance (6.1), wire basket (6.2), water tank with overflow (6.3), suspension apparatus (6.4), sieves (6.5), and drying oven (8.5).

2. **Obtain sample.** Obtain sample by AASHTO T-2 (7.1). Reduce sample according to AASHTO R-76 (7.2). Reject all material passing the 4.75 mm (No. 4) sieve. All coarse material retained on the 4.75 mm (No. 4) shall be thoroughly washed to remove dust or other coatings from the aggregate surface (7.2). Sample test size must meet or exceed the minimum mass as per the table in 7.3.

3. **Place sample under water.** Cover the aggregate in distilled or demineralized water at room temperature for a period of 17 ± 2 hours (8.1).

4. **Obtain the saturated surface dry (SSD) weight.** Remove the test sample from the water and roll it in a large, absorbent cloth until all visible films of water are removed. Wipe the particles individually. Take care to avoid evaporation of water from aggregate pores during the operation of surface drying. If the test sample dries past the SSD condition, immerse in water for 30 minutes, then resume the process of surface-drying. Determine the mass of the test sample in the saturated surface dry condition. Record to the nearest 0.1 g (8.3).

5. **Immediately place material under water and weigh.** Immediately place the SSD test sample in the sample container at the proper water level and determine its mass in water at 23.0 ± 1.7°C (73.4 ± 3°F). Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length. Take care to remove all entrapped air before determining the weight of the sample, while sample is under the water (8.4). Record the weight of the sample to the nearest 0.1 g. (8.3)

6. **Dry to a constant mass.** Dry the test sample to constant mass at 110° ± 5°C (230 + 9°F), cool in air at room temperature 1 to 3 hours, or until the aggregate has cooled to
temperature that is comfortable to handle (8.5) and determine the weight to the nearest 0.1 g and record (8.3).

7. **Calculate the bulk specific gravity (9.1.1)** as follows:

   Bulk Specific Gravity = \( \frac{A}{B - C} \)

   Where:
   
   A = mass of oven dry test sample in air, g.
   B = mass of saturated surface dry test sample in air, g.
   C = mass of saturated test sample in water, g.

8. **Calculate percent absorption (9.3)** as follows:

   \[
   \text{Absorption} = \left( \frac{B - A}{A} \right) \times 100
   \]

   Where:
   
   A = mass of oven dry test sample in air, g.
   B = mass of saturated surface dry test sample in air, g.
   C = mass of saturated test sample in water, g.

9. **Report results.** Report specific gravity results to the nearest 0.001 and absorption to the nearest 0.1 percent (10.2).

---

**Table in 7.3:**

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<th>Nominal Maximum Size, mm (in.)</th>
<th>Minimum Mass of Test Sample, kg (lb)</th>
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<td>75 (165)</td>
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<td>150 (6)</td>
<td>125 (276)</td>
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Specific Gravity and Absorption of Coarse Aggregate
AASHTO T-85-14
Review Questions

1. Obtain all weights to a __________ of a gram.

2. The water tank shall have an __________ so that the water level will remain constant.

3. This test will be run on all the aggregate that is retained on the __________ sieve.

4. Test size shall meet the minimum mass found in the table in section _____.

5. Immerse the aggregate in __________ or __________ water for ____ hours.

6. When obtaining the SSD weight use a ______________ absorbent cloth.

7. When immersing aggregate in water, what is the water temperature? ________________

8. You need to ______________ all the entrapped air before determining the mass of your sample while immersed in water.

9. Dry your sample to a constant mass at ______________.

10. What is the formula to determine Bulk Specific Gravity?

______________________________

11. Report Bulk Specific Gravity to the nearest __________.

12. What is the formula to determine Absorption?

______________________________

13. Report Absorption to the nearest __________ of a percent.
Specific Gravity and Absorption of Coarse Aggregate
AASHTO T-85-14
Review Question Answers

1. 0.1
2. Overflow
3. 4.75 mm (#4)
4. 7.3
5. Distilled or demineralized, 17 ± 2
6. Dry
7. 23 ± 1.7°C (73.4 ± 3 °F)
8. Remove
9. 110 ± 5°C (230 ± 9°F)
10. \[
\frac{\text{Weight in Air}}{\text{Weight at SSD} - \text{Weight in Water}}
\]
11. 0.001
12. \[
\frac{\text{Weight at SSD} - \text{Weight in Air}}{\text{Weight in Air}} \times 100
\]
13. 0.1
Moisture - Density Relations of Soils
Using a 2.5 kg (5.5 lb.) Rammer and a 305 mm (12 in.) Drop
AASHTO T-99-17
(Method C - Modified)

The compaction test for soils and aggregate materials determines the dry weight per cubic foot under a given compactive effort and varying water contents over a sufficient range to indicate the maximum dry weight per cubic foot and the optimum moisture content.

*Modifications:*
1. A minimum of five (5) points shall be run.
2. A minimum moisture sample size shall be 500 grams.
3. Only a mechanical hammer will be used.
4. Only a circular face rammer shall be used
5. Weigh to the nearest 0.1 of a gram or 0.01 of a pound.

**Key Elements:**

1. **Obtain Sample.** Obtain sample by AASHTO T-2, Sampling of Aggregates.

2. **Prepare Sample.** If sample is damp, it may be dried until it becomes friable under a trowel. Drying may be accomplished either by air-drying or oven drying at a temperature 60°C (140°F) or lower. After drying, the aggregations are to be broken up in such a manner as to avoid reducing the natural size of individual particles (8.1). Sieve adequate quantities of representative pulverized soil over the 19.0 mm (3/4 in.) sieve and discard the coarse material. Various methods of pulverizing may be used as long as it does not cause degradation to the material.

3. **Inspect and Prepare Apparatus.** The apparatus shall consist of the following: cylindrical mold with detachable collar and base plate (3.1). A metal rammer with a mass of 2.495 kg ± 0.009 kg (5.5 ± 0.02 lb.), and having a flat circular face of 50.80 mm ± 0.25 mm (2.000 ± 0.01 in.) (3.2.1). A hardened steel straightedge at least 250 mm (10 in.) in length and having one beveled edge (3.6). Balance (3.4), drying oven (3.5), sieves (3.7), graduated cylinder and miscellaneous mixing tools such as mixing pans, spoon, spatula (3.8), sample extruder (3.3), containers (3.9). Only a mechanical compaction hammer will be used, and it must be calibrated by the use of a hard hammer. (3.2.2 & Note 3).

4. **Determine Empty Weight of Cylindrical Mold.** Weigh mold and base plate without detachable collar and record to the nearest 0.1 g or 0.01 of a pound.

5. **Add Predetermined Amount of Moisture to Sample.** A representative sample having a minimum mass of approximately 11 pounds shall be thoroughly mixed with sufficient water to dampen it to approximately four percentage points below optimum moisture content (8.3, 9.1). In instances where the soil material is fragile in character and will reduce significantly in grain size due to repeated compaction, and in cases where the soil is a heavy-textured clayey material into which it is difficult to incorporate water, a separate and new sample shall be used in each point of the compaction test. This method is referred to as the “5-Bag Method.” The samples of soil-water mixtures shall be placed in covered containers and allowed to stand for not less than 12 hours before making the moisture-density test (Note 8).
If the material is suitable to begin the testing process immediately (i.e., sandy material) and does not require the 12-hour curing period, five separate and approximately equal representative samples shall be weighed and placed in a bowl or plastic bag used for mixing purposes. A different percentage of moisture can be added to each sample to create the five points required for this test.

6. **Compact Specimen.** Form a specimen by compacting the prepared soil in a 101.60 mm (4 in.) mold, with collar attached, in three approximately equal layers to give a compacted depth of about 125 mm (5 in.). Prior to compaction, place the loose soil into the mold and spread into a layer of uniform thickness. Lightly tamp the soil prior to compaction until it is not in a loose or fluffy state, using either the manual compaction rammer or similar device having a face diameter of approximately 50 mm (2 in.) (9.2). Each layer shall be compacted by 25 uniformly distributed blows over the surface of the layer from the rammer dropping free from a height of 305 ± 2 mm (12.00 ± 0.06 in.) above the elevation of the soil (3.2.1). During compaction, the circular face hammer shall overlap the surface area for each blow. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation or base. This base shall remain stationary during the compaction process (9.2).

7. **Trim Top of Compacted Soil.** With the extension collar removed, carefully trim the compacted soil even with the top of the mold, using the steel straightedge. Holes developed in the surface by removal of coarse material shall be patched with smaller sized material (8.2.1).

8. **Weigh Mold and Base Plate with Compacted Soil.** Clean excess material from the outside of the mold and base and weigh the mold with soil to the nearest 0.1 g or 0.01 of a pound and record (8.2.1).

9. **Obtain Moisture Sample and Weigh.** Remove the material from the mold; it may be necessary to use a sample extruder to remove the compacted specimen. Slice the specimen vertically through the center. Take a representative sample from one of the cut faces and sample the entire length of the specimen (9.3). Place this moisture sample in a suitable container and weigh to nearest 0.1g and record. The moisture sample shall be a minimum of 500 grams.

10. **Place in oven at 110 ± 5°C and dry to constant mass.** Dry sample in accordance with AASHTO T-265. Constant mass is defined as after initial drying the weight of the material decreases by less than 0.1% after a minimum of 10 minutes additional drying.

\[
\frac{W_1 - W_2}{W_2} \times 100, \quad \frac{W_2 - W_3}{W_3} \times 100, \text{ etc.}
\]
11. **Repeat Steps 5 through 11.** If the “5-Bag Method” is not used, thoroughly break up the remaining portion of the molded specimen and repeat steps 5 through 11. Add water in sufficient amounts to increase the moisture content by approximately one to two percentage points. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot of the compacted soil (9.4). A minimum of five points shall be run to accurately determine maximum density and optimum moisture, with a minimum of three points up and two points down.

12. **Calculate the Wet Weight of Compacted Soil.** Multiply the weight of the compacted specimen, minus the weight of the mold by 30 for masses recorded in pounds. This result is recorded as the wet weight in pounds per cubic foot (lb/ft³) of the compacted soil (9.2.1).

13. **Perform Calculations.** Calculate the moisture content and the dry weight of the soils as compacted for each specimen (12.1).

\[
\text{Percent Moisture in Specimen} = \frac{A - B \times 100}{B - C}
\]

\[
\text{Dry Weight} = \frac{W_1}{\% \text{ Moisture} + 100} \times 100
\]

- \(A\) = Weight of container and wet soil.
- \(B\) = Weight of container and dry soil.
- \(C\) = Weight of container.
- \(W_1\) = Wet weight, in lbs/ft³ of compacted soil.

14. **Plot Data on Appropriate Form.** Plot calculated data on appropriate form and graph to determine maximum dry density and optimum moisture content. When the densities and corresponding moistures have been plotted, it will be found that by connecting the points with a smooth line, a curve is produced. The moisture content corresponding to the top of the curve shall be termed the “optimum moisture content” of the soil (13.2). The oven-dry density in pounds per cubic foot of the soil at optimum moisture shall be termed “maximum dry density” (13.3).

15. **Report Maximum Dry Density and Optimum Moisture.** Report the maximum dry density in pounds per cubic foot, to the nearest tenth (0.0), and the optimum moisture as a percentage, to the nearest tenth (0.0) (14).

*Note: See T-180 for examples of Annex for Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles.*
Calibration of Mechanical Compactor to Manual Compactor

Using the soil prepared in accordance with this T-99, Method C, determine the optimum moisture content and maximum dry density. Prepare one five-point curve using the mechanical compactor and another five-point curve using the manual compactor (calibrated hand hammer). Record the values of both maximum dry density and compare each value. If the difference between the two values is equal to or less than 2.0 pounds per cubic foot apart, the mechanical compactor is satisfactory for immediate use.

If the difference between the two values is greater than 2.0 pounds per cubic foot apart, then obtain two additional sets of data. Using the same soil sample, determine the average percentage difference of the maximum dry density of the three values. If the difference between the averages of the three sets is less than 2.0 pounds per cubic foot, the mechanical compactor is satisfactory for immediate use.

If the difference is still greater than 2.0 pounds per cubic foot, then adjust the rammer mass of the mechanical compactor and perform three new maximum dry density curves. If the new average absolute value of the three maximum dry density curves is still not less than 2.0 pounds per cubic foot, continue to make adjustments and repeat this procedure until it is.

For more information on rammer adjustments, refer to ASTM D2168, 5.5 – 5.7.
NEW MEXICO DEPARTMENT OF TRANSPORTATION
MATERIAL AND TESTING LABORATORY
OPTIMUM MOISTURE AND MAXIMUM DENSITY

Project: ___________________________  Date: ___________________________

AASHTO TEST #: T-99  or  T-180  TEST METHOD: C  D

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Moisture Content

33
NEW MEXICO DEPARTMENT OF TRANSPORTATION  
MATERIAL AND TESTING LABORATORY  
OPTIMUM MOISTURE AND MAXIMUM DENSITY

Project: __________________________  Date: __________________________

AASHTO TEST #: T-99 or T-180  TEST METHOD: C  D

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MAX DRY DENSITY: PCF  OPTIMUM MOISTURE: %  OPERATOR: 34

Moisture Content

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### Optimum Moisture and Maximum Density

**NEW MEXICO DEPARTMENT OF TRANSPORTATION**  
**MATERIAL AND TESTING LABORATORY**  
**OPTIMUM MOISTURE AND MAXIMUM DENSITY**

**Project:** ___________________________  
**Date:** ___________________________

**AASHTO TEST #:** T-99 or T-180  
**TEST METHOD:** C  
**D**

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**Moisture Content**

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Moisture Density Relations of Soils
Using a 2.5 kg (5.5 lb.) Rammer and a 305 mm (12 in.) Drop
AASHTO T-99
(Method C - Modified)
Review Questions

1. Only method ______ shall be used.

2. If your sample is damp, it may be dried until it becomes friable under a trowel. Drying may be accomplished either by air drying or oven drying at a temperature of ________ or lower.

3. The weight of the hammer is ________ and it must have a flat circular face of ________.

4. The strait edge shall be at least ______ long and having one ___________ edge.

5. Only a ____________ hammer shall be used and it must be calibrated to hand hammer.

6. Use a ________________ mold.

7. Determine the empty weight of the empty cylindrical mold to the nearest ________ of a gram or to the nearest ________ of a pound.

8. A representative sample having a minimum mass of ________ shall be used if a one bowl method is used.

9. To start with dampen your sample to approximately _____ percentage points below optimum moisture.

10. If your dealing with a material that has clay in it then allow you sample to cure in covered container for not less that _______ hours. If water can be incorporated easily then the cure time is not necessary.

11. Compact your material in ____ approximately equal lifts. Each lift shall be compacted by ____ blows over the surface of the material from the hammer dropping free from a height of ___________ above the elevation of the soil.

12. When trimming the soil with the strait-edge any holes developed shall be ______ with smaller sized material from the same sample.

13. After trimming the soil even with the top of the mold with the collar removed, clean excess material off and weigh the mold and base plate to the _________ of a gram or the ________ of a pound.
14. To calculate the wet density multiply the wet weight of the material by _____ for masses recorded in pounds.

15. Moisture sample shall weigh not less than _____ grams

16. Dry moisture sample to a constant mass in accordance with AASHTO ________________.

17. Add water in sufficient amounts to increase the moisture content by approximately _____ to _____ percentage points.

18. A minimum of _____ points shall be run to accurately determine maximum dry density and optimum moisture, with a minimum of _____ up and _____ down.

19. How do you calculate dry density?

__________________________________________________________________________

20. Plot the ________ and the ________ for each of the points. It will be found that connecting the points with a smooth line, a curve is produced. The ________ point of the curve is the optimum moisture and the max dry density.

21. Report the maximum dry density in lbs/ft$^3$ to the nearest ________ . Moisture shall be reported to the nearest ________.
Moisture Density Relations of Soils
Using a 2.5 kg (5.5 lb.) Rammer and a 305 mm (12 in.) Drop
AASHTO T-99
(Method C - Modified)
Review Question Answers

1. C
2. 60°C (140°F)
3. 2.495 kg ± 0.009 kg (5.5 lbs. ± 0.02 lbs.). 50.80 mm ± 0.25 mm (2.0” ± 0.01”)
4. 250 mm (10”), beveled
5. Mechanical
6. 101.6 mm (4”)
7. 0.1, 0.01
8. 5 kg (11 lbs.)
9. Four (4)
10. Twelve (12)
11. Three (3), twenty five (25), 305 mm ± 2 mm (12.0” ± 0.06”)
12. Patched
13. 0.1, 0.01
14. 30
15. 500
16. T-265
17. One (1), two (2)
18. Five (5), three (3), two (2)
19. \[
\frac{\text{Wet Density}}{\% \text{ moisture} + 100} \times 100
\]
20. Moisture, Dry density, Highest

21. Tenth; tenth
Moisture-Density Relations of Soils using a 4.54-kg (10-lb.) Rammer and a 457-mm (18-in.) Drop AASHTO T-180-18 (Method D and Method A-Modified)

The compaction test for soils and aggregate materials determines the dry weight per cubic foot under a given compactive effort and varying water contents over a sufficient range to indicate the maximum dry weight per cubic foot and the optimum moisture content.

Modification: 1. A minimum of five (5) points shall be run.
2. Method D - A minimum moisture sample size shall be 1000 grams.
3. Method A - A minimum moisture sample size shall be 500 grams.
4. Only a mechanical hammer will be used.
5. Method D - Only a sector face rammer shall be used.
6. Method A - Only a round face rammer shall be used.
7. Weigh to the nearest 0.1 of a gram or 0.01 of a pound.
8. If oversized particles exceed 10%, use Annex A1: Correction for Oversized Particles.

Key Elements: Method D

1. Obtain Sample. Obtain sample by AASHTO T-2. The sample must be large enough that when the oversized (retained on the 19.0-mm (3/4-in.) sieve) particles are removed, 11 kg (25 lbs.) or more of the sample remains (9.1).

2. Prepare Sample. If sample is wet, it may be dried until it becomes friable under a trowel. Drying may be accomplished either by air-drying or oven drying at a temperature 60°C (140°F) or lower. After drying, the aggregations are to be broken up in such a manner as to avoid reducing the natural size of individual particles (8.1). Various methods of pulverizing may be used as long as it does not cause degradation to the material. T-180, Method D, shall be used for all soils and base course material. Sieve soil over the 19.0-mm (3/4-in.) sieve.

   Note: Do not screen manufactured base course material over the 19.0-mm (3/4-in) sieve. However, if base course material is used for other applications (i.e., backfill or foundation material), follow T-180, Method D, sample preparation.

When the sample has oversized particles, use Annex A1, Correction of Maximum Dry Density and Optimum Moisture Content for Oversized Particles. (Correction may not be of practical significance for materials with only a small percentage of oversized particles. If the minimum percentage is not specified, correction shall be applied to samples with more than ten (10) percent by weight of oversized particles (A1.1.2).)
3. **Inspect and Prepare Apparatus.** The apparatus shall consist of the following: 6.000 ± 0.026 in. cylindrical mold with detachable collar and base plate (3.1). A metal rammer with a mass of 4.536 ± 0.009 kg (10.00 ± 0.02 lb.), and having a sector face with an area equal to 50.80 ± 0.25 mm (2.000 ± 0.01 in) (3.2). A hardened steel straightedge at least 250 mm (10 in.) in length and having one beveled edge (3.6). Balance (3.4), drying oven (3.5), sieves (3.7), graduated cylinder and miscellaneous mixing tools such as mixing pans, spoon, spatula (3.8), sample extruder (3.3), containers (3.9). Only a mechanical compaction hammer will be used, and must be calibrated against a hand hammer of correct weight and drop (3.2.2 & Note 3).

4. **Determine Empty Weight of Cylindrical Mold.** Weigh mold and base plate without detachable collar and record to the nearest 0.1 g or 0.01 of a pound.

5. **Add Predetermined Amount of Moisture to Sample.** A representative sample having a minimum mass of approximately 25 pounds and shall be thoroughly mixed with sufficient water to dampen it to approximately four percentage points below optimum moisture content (11.1). In instances where the soil material is fragile in character and will reduce significantly in grain size due to repeated compaction, and in cases where the soil is a heavy-textured clayey material into which it is difficult to incorporate water, a separate and new sample shall be used in each point of the compaction test. This method is referred to as the "5-Bag Method." Samples of heavy-textured clayey material shall be placed in covered containers and allowed to stand for not less than 12 hours before making the moisture-density test (Note 7). If the material is suitable to begin the testing process immediately (i.e., sandy material) and does not require the 12-hour curing period. Five separate and approximately equal representative samples shall be weighed and placed in a bowl or plastic bag used for mixing purposes. A different percentage of moisture can be added to each sample to create the five points required for this test.

6. **Compact Specimen.** Form a specimen by compacting the prepared soil in a 152.40 mm (6 in.) mold, with collar attached, in five approximately equal layers to give a compacted depth of about 125 mm (5 in.). Prior to compaction, place the loose soil into the mold and spread into a layer of uniform thickness. Lightly tamp the soil prior to compaction until it is not in a loose or fluffy state, using either the manual compaction rammer or similar device having a face diameter of approximately 50 mm (2 in.) (9.2). Each layer shall be compacted by 56 uniformly distributed blows over the surface of the layer (11.1) from the rammer dropping free from a height of 457 ± 2 mm (18.00 ± 0.06 in.) above the elevation of the soil (3.2.1). During compaction, the sector face hammer shall overlap the hammer surface area for each blow. During compaction the mold shall rest firmly on a dense, uniform, rigid and stable foundation or base. This base shall remain stationary during the compaction process (9.2).

7. **Trim Top of Compacted Soil.** With the extension collar removed, carefully trim the compacted soil even with the top of the mold, using the steel straightedge. Holes developed in the surface by removal of coarse material shall be patched with smaller sized material (9.2.1).
8. **Weigh Mold and Base Plate with Compacted Soil.** Clean excess material from the outside of the mold and base. Weigh the mold with soil to the nearest 0.1 g or 0.01 of a pound and record (9.2.1).

9. **Obtain Moisture Sample and Weigh.** Remove the material from the mold; it may be necessary to use a sample extruder to remove the compacted specimen. Slice the specimen vertically through the center. Take a representative sample from one of the cut faces; sample the entire length of the specimen (9.3). Place this moisture sample in a suitable container and weigh to the nearest 0.1g and record. The moisture sample shall weigh not less than 1000 grams.

10. **Place in oven at 110 ± 5°C (230 ± 9°F) and dry to constant mass.** Dry sample in accordance with AASHTO T-265. Constant mass is defined as after initial drying the weight of the material decreases by less than 0.1% after a minimum of 10 minutes additional drying.

\[ \frac{W_1 - W_2}{W_2} \times 100, \quad \frac{W_2 - W_3}{W_3} \times 100, \text{ etc.} \]

11. **Repeat Steps 5 through 11.** If the "5-Bag Method" is not used, thoroughly break up the remaining portion of the molded specimen and repeat steps 5 through 11. Add water in sufficient amounts to increase the moisture content by approximately one to two percentage points. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot of the compacted soil (9.4). A minimum of five points shall be run to accurately determine maximum density and optimum moisture, with three points up and two points down being obtained.

**Key Elements: Method A**

12. **Obtain Sample.** Obtain sample by AASHTO T-2. The sample must be large enough that when the oversized (retained on the 4.75-mm (No.4) sieve) particles are removed, 3 kg (7 lbs.) or more of the sample remains (4.1).

13. **Prepare Sample.** If sample is wet, it may be dried until it becomes friable under a trowel. Drying may be accomplished either by air-drying or oven drying at a temperature 60°C (140°F) or lower. After drying, the aggregations are to be broken up in such a manner as to avoid reducing the natural size of individual particles (8.1). Various methods of pulverizing may be used as long as it does not cause degradation to the material. Sieve soil over the 4.75-mm (No. 4) sieve.

New Mexico Technician Training and Certification Program
14. **Inspect and Prepare Apparatus.** The apparatus shall consist of the following: 4.000 ± 0.016 in cylindrical mold with detachable collar and base plate (3.1). A metal rammer with a mass of 4.536 ± 0.009 kg (10.00 ± 0.02 lb.), and having a round face with an area equal to 50.80 ± 0.25 mm (2.000 ± 0.01 in) (3.2). A hardened steel straightedge at least 250 mm (10 in.) in length and having one beveled edge (3.6). Balance (3.4), drying oven (3.5), sieves (3.7), graduated cylinder and miscellaneous mixing tools such as mixing pans, spoon, spatula (3.8), sample extruder (3.3), containers (3.9). Only a mechanical compaction hammer will be used, and must be calibrated against a hand hammer of correct weight and drop (3.2.2 & Note 3).

15. **Determine Empty Weight of Cylindrical Mold.** Weigh mold and base plate without detachable collar and record to the nearest 0.1 g or 0.01 of a pound.

16. **Add Predetermined Amount of Moisture to Sample.** A representative sample having a minimum mass of approximately 7 pounds and shall be thoroughly mixed with sufficient water to dampen it to approximately four percentage points below optimum moisture content (11.1). In instances where the soil material is fragile in character and will reduce significantly in grain size due to repeated compaction, and in cases where the soil is a heavy-textured clayey material into which it is difficult to incorporate water, a separate and new sample shall be used in each point of the compaction test. This method is referred to as the "5-Bag Method." Samples of heavy-textured clayey material shall be placed in covered containers and allowed to stand for not less than 12 hours before making the moisture-density test (Note 8). If the material is suitable to begin the testing process immediately (i.e., sandy material) and does not require the 12-hour curing period. Five separate and approximately equal representative samples shall be weighed and placed in a bowl or plastic bag used for mixing purposes. A different percentage of moisture can be added to each sample to create the five points required for this test.

17. **Compact Specimen.** Form a specimen by compacting the prepared soil in a 101.60 mm (4 in.) mold, with collar attached, in five approximately equal layers to give a compacted depth of about 125 mm (5 in.). Prior to compaction, place the loose soil into the mold and spread into a layer of uniform thickness. Lightly tamp the soil prior to compaction until it is not in a loose or fluffy state, using either the manual compaction rammer or similar device having a face diameter of approximately 50 mm (2 in.) (9.2). Each layer shall be compacted by 25 uniformly distributed blows over the surface of the layer (11.1) from the rammer dropping free from a height of 457 ± 2 mm (18.00 ± 0.06 in.) above the elevation of the soil (3.2.1). During compaction, the round face hammer shall overlap the hammer surface area for each blow. During compaction the mold shall rest firmly on a dense, uniform, rigid and stable foundation or base. This base shall remain stationary during the compaction process (9.2).

18. **Trim Top of Compacted Soil.** With the extension collar removed, carefully trim the compacted soil even with the top of the mold, using the steel straightedge. Holes developed in the surface by removal of coarse material shall be patched with smaller sized material (9.2.1).
19. Weigh Mold and Base Plate with Compacted Soil. Clean excess material from the outside of the mold and base. Weigh the mold with soil to the nearest 0.1 g or 0.01 of a pound and record (9.2.1).

20. Obtain Moisture Sample and Weigh. Remove the material from the mold; it may be necessary to use a sample extruder to remove the compacted specimen. Slice the specimen vertically through the center. Take a representative sample from one of the cut faces; sample the entire length of the specimen (9.3). Place this moisture sample in a suitable container and weigh to the nearest 0.1g and record. The moisture sample shall weigh not less than 500 grams.

21. Place in oven at 110 ± 5°C (230 ± 9°F) and dry to constant mass. Dry sample in accordance with AASHTO T-265. Constant mass is defined as after initial drying the weight of the material decreases by less than 0.1% after a minimum of 10 minutes additional drying.

\[
\frac{W_1 - W_2}{W_2} \times 100, \quad \frac{W_2 - W_3}{W_3} \times 100, \text{ etc.}
\]

22. Repeat Steps 5 through 11. If the “5-Bag Method” is not used, thoroughly break up the remaining portion of the molded specimen and repeat steps 5 through 11. Add water in sufficient amounts to increase the moisture content by approximately one to two percentage points. Continue this series of determinations until there is either a decrease or no change in the wet weight per cubic foot of the compacted soil (9.4). A minimum of five points shall be run to accurately determine maximum density and optimum moisture, with three points up and two points down being obtained.

23. Calculate the Wet Weight of Compacted Soil. Multiply the weight of the compacted specimen, minus the weight of the mold, by 13.33 for masses recorded in pounds (11.1). This result is recorded as the wet weight in pounds per cubic foot (lb/ft³) of the compacted soil.

24. Perform Calculations. Calculate the moisture content and the dry weight of the soils as compacted for each specimen (12.1).

\[
\% \text{ Moisture in specimen} = \frac{A - B}{B - C} \times 100
\]

\[
\text{Dry Weight} = \frac{W_i}{\% \text{ Moisture} + 100} \times 100
\]

A = Weight of container and wet soil.
B = Weight of container and dry soil.
C = Weight of container.
W_i = Wet weight, in lbs/ft³ of compacted soil.
25. **Plot Data on Appropriate Form.** Plot calculated data on appropriate form and graph to determine maximum dry density and optimum moisture content. When the densities and corresponding moistures have been plotted, it will be found that by connecting the points with a smooth line, a curve is produced. The moisture content corresponding to the peak of the curve shall be termed the "optimum moisture content" of the soil (13.2). The oven-dry density in pounds per cubic foot of the soil at optimum moisture shall be termed "maximum dry density" (13.3).

26. **Report Maximum Dry Density and Optimum Moisture.** Report the maximum dry density to the nearest 0.1 lb/ft$^3$, and the optimum moisture to the nearest 0.1 percent (14).

27. **Oversized particle correction.** Report the adjusted maximum dry density to the nearest 0.1 lb/ft$^3$; the corrected optimum moisture content to the nearest 0.1 percent; the oversized particles to the nearest 0.1 percent of the original dry mass of the sample; and $G_{sb}$ of oversized particles to the nearest 0.001 (14.1.5).

**Calibration of Mechanical Compactor to Manual Compactor**

Using the soil prepared in accordance with this T-180, Method D, determine the optimum moisture content and maximum dry density. Prepare one five-point curve using the mechanical compactor and another five-point curve using the manual compactor (calibrated hand hammer). Record the values of both maximum dry density and compare each value. If the difference between the two values is equal to or less than 2.0 pounds per cubic foot apart, the mechanical compactor is satisfactory for immediate use.

If the difference between the two values is greater than 2.0 pounds per cubic foot apart, then obtain two additional sets of data. Using the same soil sample, determine the average percentage difference of the maximum dry density of the three values. If the difference between the averages of the three sets is less than 2.0 pounds per cubic foot, the mechanical compactor is satisfactory for immediate use.

If the difference is still greater than 2.0 pounds per cubic foot, then adjust the rammer mass of the mechanical compactor and perform three new maximum dry density curves. If the new average absolute value of the three maximum dry density curves is still not less than 2.0 pounds per cubic foot, continue to make adjustments and repeat this procedure until it is.

For more information on rammer adjustments, refer to ASTM D2168, 5.5 – 5.7.
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**TEST METHOD:** C or **D**

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**MAX DRY DENSITY:** PCF  
**OPTIMUM MOISTURE:** %  
**OPERATOR:**

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NEW MEXICO DEPARTMENT OF TRANSPORTATION  
MATERIAL AND TESTING LABORATORY  
OPTIMUM MOISTURE AND MAXIMUM DENSITY  

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<th>Date:</th>
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<th>T-99</th>
<th>or</th>
<th>T-180</th>
<th>TEST METHOD:</th>
<th>C</th>
<th>D</th>
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MAX DRY DENSITY: PCF  
OPTIMUM MOISTURE: %  
OPERATOR:  

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Moisture Content  

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### Optimum Moisture and Maximum Density

**NEW MEXICO DEPARTMENT OF TRANSPORTATION**
**MATERIAL AND TESTING LABORATORY**

**OPTIMUM MOISTURE AND MAXIMUM DENSITY**

**Project:**

**AASHTO TEST #:** T-99 or T-180

**TEST METHOD:** C or D

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**MAX DRY DENSITY:** PCF

**OPTIMUM MOISTURE:** %

**OPERATOR:**

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**Diagram:**

*Graph showing moisture content vs. density.*
### NEW MEXICO DEPARTMENT OF TRANSPORTATION
MATERIAL AND TESTING LABORATORY
OPTIMUM MOISTURE AND MAXIMUM DENSITY

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**MAX DRY DENSITY:** 140.6 PCF  **OPTIMUM MOISTURE:** 7.8%  **OPERATOR:**

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### Graph

- **MAX DRY DENSITY:** 140.6
- **Optimum Moisture:** 7.8%
<table>
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Optimum Moisture: %  
Operator:
ANNEX A1:

Correction of Maximum Dry Density and Optimum Moisture Content for Oversized Particles

1. This section corrects the maximum dry density and moisture content of the material retained on the 19.0-mm (3/4-in.) sieve for Method D. The maximum dry density, adjusted for oversized particles and total moisture content, are compared with the field-dry density and field moisture content (A1.1).

2. The correction is applied to the sample material (soil type) on which the maximum dry density (proctor) is performed (A1.1.1).

3. This correction can also be applied to the sample obtained from the field while performing in-place density. Obtain sample in accordance with T-310 (A1.1.2).

4. Bulk specific gravity ($G_d$) of the oversized particles is required to determine the corrected maximum dry density. If the bulk specific gravity has been determined in accordance with T-85, this value shall be used in the calculations. For most construction activities, the specific gravity can be assumed to be 2.600 (A1.2).

5. Determine the dry mass of the oversized and fine fractions [$M_{DC}$ and $M_{DF}$] (A1.3).

6. If necessary, 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) (A1.3.1).

7. Alternatively determine the moist mass of both fractions, fine ($M_{MF}$) and oversized ($M_{MC}$). Obtain moisture samples from the fine and oversized material. Determine the moisture content of the fine particles ($MC_f$) and oversized particles ($MC_o$) of the material. The moisture contents can be determined by T-265 or T-255. If the moisture content of the oversized particles is generally known, substitute that moisture content in the calculations (A1.3.2).

8. Calculate the dry mass of the oversized and fine particles as follows:

$$M_D = M_M / (1 + MC)$$

Where:

- $M_D =$ mass of dry material (fine or oversized particles);
- $M_M =$ mass of moist material (fine or oversized particles); and
- $MC =$ moisture content of respective fine or oversized particles, expressed as a decimal.
9. Calculate the percentage of the fine particles and oversized particles by dry weight of the total sample as follows:

\[ P_f = \left[ \frac{M_{DF}}{M_{DF} + M_{DC}} \right] \times 100 \]

And

\[ P_c = \left[ \frac{M_{DC}}{M_{DF} + M_{DC}} \right] \times 100 \]

Where:

- \( P_f \) = percent of dry fine particles;
- \( M_{DF} \) = mass of dry fine particles;
- \( M_{DC} \) = mass of dry oversized particles; and
- \( P_c \) = percent of oversized particles of sieve used

10. Calculate the corrected optimum moisture content of the total sample (combined fine and oversized particles) as follows:

\[ MC_T = (MC_f \times P_f) + (MC_c \times P_c) / 100 \]

Where:

- \( MC_T \) = corrected optimum moisture content of the total sample expressed as a decimal,
- \( MC_f \) = optimum moisture content of the fine particles, expressed as a decimal,
- \( P_f \) = percent of fine particles of sieve used,
- \( MC_c \) = moisture content of the oversized particles, expressed as a decimal, and
- \( P_c \) = percent of oversized particles of sieve used

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

\[ D_d = (D_f \times k) / [(D_f \times P_c) + (k \times P_f)] \times 100 \]

Where:

- \( D_d \) = corrected maximum dry density of the total sample, lb/ft\(^3\),
- \( D_f \) = maximum dry density of the fine particles, lb/ft\(^3\),
- \( k \) = 62.4 x Bulk Specific Gravity \((G_{sb})\) (oven-dry basis) of coarse particles, lb/ft\(^3\),
- \( P_c \) = percent of oversized particles of sieve used, and
- \( P_f \) = percent of fine particles used
Example #1:
- Oversized particles > 10%, use Correction for Oversized Particles.
- Laboratory maximum dry density and optimum moisture content (proctor) of the material passing the 19.0-mm (3/4-in.) sieve for Method D
  - Maximum Dry Density ($D_d$) = 130.0 lb/ft$^3$
  - Optimum Moisture Content ($MC_f$) = 10.0%
- Bulk Specific Gravity ($G_{sb}$) = 2.600
- $k = 2.600 \times 62.4$ = 162.2 lb/ft$^3$
- Total moist sample weight ($M_M$) = 8755.0g
- Moisture content for coarse particles ($MC_c$) = 8.4%

Mass of Dry Material
- $M_{DC}$ (material retained on 19.0-mm sieve) = 3210.0g / 1.084 = 2961.3g
- $M_{DF}$ (material passing 19.0-mm sieve) = 5545.0g / 1.100 = 5040.9g

Percent of Oversized Coarse Particle and Fine Particle
- $P_c = [M_{DC} / (M_{DF} + M_{DC})] \times 100$ → $[2961.3 / (2961.3 + 5040.9)] \times 100$
  → $[2961.3 / (8002.2)] \times 100$
  → $[0.370] \times 100 = 37.0\%$ coarse particles
- $P_f = [M_{DF} / (M_{DF} + M_{DC})] \times 100$ → $[5040.9 / (2961.3 + 5040.9)] \times 100$
  → $[5040.9 / (8002.2)] \times 100$
  → $[0.630] \times 100 = 63.0\%$ fine particles

Corrected Optimum Moisture Content
- $MC_T = [(MC_f \times P_f) + (MC_c \times P_c)] / 100$ → $[(10.0 \times 63.0) + (8.4 \times 37.0)] / 100$
  → $[(630.0) + (310.8)] / 100 = 9.41\%$

Corrected Maximum Dry Density
- $D_d = (D_f \times k) / [(D_f \times P_c) + (k \times P_f)] \times 100$
  → $(130.0 \times 162.2) / [(130.0 \times 37.0) + (162.2 \times 63.0)] \times 100$
  → $(21,086.0) / [(4,810.0) + (10,218.6)] \times 100$
  → $(21,086.0) / [(15,028.6)] \times 100$
  → $D_d = 1.403 \times 100 = 140.3 \text{ lb/ft}^3$ Corrected Maximum Dry Density

Note: The Corrected Maximum Dry Density and Corrected Optimum Moisture Content values are good for the percentage of coarse particle for T-310 field density test. Document the “corrected” values and attach to field density test sheets.
Example #2:
- Oversized particles > 10%, use Correction for Oversized Particles.
- Laboratory maximum dry density and optimum moisture content (proctor) of the material passing the 19.0-mm (3/4-in.) sieve for Method D
  - Maximum Dry Density ($D_f$) = 122.5 lb/ft³
  - Optimum Moisture Content ($MC_f$) = 12.5%
- Bulk Specific Gravity ($G_{sb}$) = 2.580
- $k = 2.580 \times 62.4$ = 161.0 lb/ft³
- Total moist sample weight ($M_M$) = 9132.6g
- Moisture content for coarse particles ($MC_c$) = 9.1%

Mass of Dry Material
- $M_{DC}$ (material retained on 19.0-mm sieve) = 1836.6g / 1.091 = 1683.4g
- $M_{DF}$ (material passing 19.0-mm sieve) = 7296.0g / 1.125 = 6485.3g

Percent of Oversized Coarse Particle and Fine Particle
- $P_c = \frac{M_{DC}}{M_{DF} + M_{DC}} \times 100 \rightarrow \frac{1683.4}{(6485.3 + 1683.4)} \times 100$
  \rightarrow \frac{1683.4}{8168.7} \times 100
  \rightarrow 0.206 \times 100 = 20.6\% \text{ coarse particles}
- $P_f = \frac{M_{DF}}{M_{DF} + M_{DC}} \times 100 \rightarrow \frac{6485.3}{(6485.3 + 1683.4)} \times 100$
  \rightarrow \frac{6483.4}{8168.7} \times 100
  \rightarrow 0.794 \times 100 = 79.4\% \text{ fine particles}

Corrected Optimum Moisture Content
- $MC_T = \frac{(MC_f \times P_f) + (MC_c \times P_c)}{100} \rightarrow \frac{(12.5 \times 79.4) + (9.1 \times 20.6)}{100}$
  \rightarrow \frac{992.5 + 187.5}{100} = 11.8\%

Corrected Maximum Dry Density
- $D_d = \frac{(D_f \times k)}{[(D_f \times P_f) + (k \times P_f)]} \times 100$
  \rightarrow \frac{122.5 \times 161.0}{[(122.5 \times 20.6) + (161.0 \times 79.4)]} \times 100$
  \rightarrow \frac{19,722.5}{[(2,523.5) + (12,783.4)]} \times 100$
  \rightarrow \frac{19,722.5}{15,306.9} \times 100$

$D_d = 1.288 \times 100 = 128.8 \text{ lb/ft}^3 \text{ Corrected Maximum Dry Density}$
Example #3:

- Oversized particles > 10%, use Correction for Oversized Particles.
- Laboratory maximum dry density and optimum moisture content (proctor) of the material passing the 19.0-mm (3/4-in.) sieve for Method D
  - Maximum Dry Density ($D_d$) = 114.8 lb/ft$^3$
  - Optimum Moisture Content ($M_{oc}$) = 12.0%
- Bulk Specific Gravity ($G_{sb}$) = 2.592
- $k = 2.592 \times 62.4$ = 161.7 lb/ft$^3$
- Total moist sample weight ($M_M$) = 9833.7 g
- Moisture content for coarse particles ($M_{oc}$) = 8.5%

Mass of Dry Material

- $M_{DC}$ (material retained on 19.0-mm sieve) = 968.8 g / 1.085 = 892.9 g
- $M_{DF}$ (material passing 19.0-mm sieve) = 8864.9 g / 1.120 = 7915.1 g

Percent of Oversized Coarse Particle and Fine Particle

- $P_c = \left[ \frac{M_{DC}}{M_{DF} + M_{DC}} \right] \times 100 \rightarrow [892.9 / (892.9 + 7915.1)] \times 100$
  \rightarrow [0.1014] \times 100 = 10.1\% coarse particles

- $P_f = \left[ \frac{M_{DF}}{M_{DF} + M_{DC}} \right] \times 100 \rightarrow [7915.1 / (892.9 + 7915.1)] \times 100$
  \rightarrow [0.899] \times 100 = 89.9\% fine particles

Corrected Optimum Moisture Content

- $M_{C_T} = \left[ \frac{(M_{C_F} \times P_f) + (M_{C_C} \times P_c)}{100} \right] \rightarrow [(12.0 \times 89.9) + (8.5 \times 10.1)] / 100$
  \rightarrow [(1078.8) + (85.9)] / 100 = 11.6\%

Corrected Maximum Dry Density

- $D_d = \frac{(D_f \times P_f)}{[(D_f \times P_c) + (k \times P_f)]} \times 100$
  \rightarrow (114.8 \times 61.7) / [(114.8 \times 10.1) + (161.7 \times 89.9)] \times 100
  \rightarrow (18,563.2) / [(1,159.5) + (14,536.8)] \times 100
  \rightarrow (18,563.2) / (15,696.3) \times 100

$D_d = 1.183 \times 100 = 118.3$ lb/ft$^3$ Corrected Maximum Dry Density
Moisture Density Relations of Soils
Using a 4.536 kg (10 lb.) Rammer and a 457 mm (18 in.) Drop
AASHTO T-180
(Method D and Method A - Modified)
Review Questions

1. Only method _______ shall be used for base course.

2. If your sample is damp, it may be dried until it becomes friable under a trowel. Drying may be accomplished either by air drying or oven drying at a temperature of _______ or lower.

3. Is any replacement done in this test procedure? _________________

4. The weight of the hammer is ________________.

5. The straight edge shall be at least ______ long and having one ____________ edge.

6. Only a ______________ hammer shall be used and it must be calibrated to hand hammer.

7. Use a ______________ mold for Method D and a ______________ for Method A.

8. Determine the empty weight of the empty cylindrical mold to the nearest _____ of a gram or to the nearest _____ of a pound.

9. A representative sample having a minimum mass of ____________ shall be used if a one-bowl method is used.

10. To start with dampen your sample to approximately _______ percentage points below optimum moisture.

11. Compact your material in _______ approximately equal lifts. Each lift shall be compacted by _______ blows for Method D and _______ blow for Method A over the surface of the material from the hammer dropping free from a height of ________________ above the elevation of the soil.

12. When trimming the soil with the strait-edge any holes developed shall be ____________ with smaller sized material from the same sample.

13. After trimming the soil even with the top of the mold with the collar removed, clean excess material off and weigh the mold and base plate to the _______ of a gram or the _______ of a pound.

14. To calculate the wet density multiply the wet weight of the material by _______ for masses recorded in pounds.
15. Moisture sample shall weigh not less than ________ grams for Method D and ________ grams for Method A.

16. Dry moisture sample to a constant mass in accordance with AASHTO ________.

17. Add water in sufficient amounts to increase the moisture content by approximately ________ to ________ percentage points.

18. A minimum of ________ points shall be run to accurately determine maximum dry density and optimum moisture, with a minimum of ________ up and ________ down.

19. How do you calculate dry density? ________________________________.

20. Plot the ________ and the ________ for each of the points. It will be found that connecting the points with a smooth line, a curve is produced. The ________ point of the curve is the optimum moisture and the max dry density.

21. Report the maximum dry density in lbs/ft³ to the nearest ________. Moisture shall be reported as a ________ to the nearest ________.
Moisture Density Relations of Soils
Using a 4.536 kg (10 lb.) Rammer and a 457 mm (18 in.) Drop
AASHTO T-180
(Method D - Modified)
Review Question Answers

1. D
2. 60°C (140°F)
3. No
4. 4.536 kg ± 0.009 kg (10 lbs. ± 0.02 lbs.)
5. 250 mm (10”), beveled
6. Mechanical
7. 152.40 mm (6”) – 101.23 mm (4”)
8. 0.1, 0.01
9. 11 kg (25 lbs.)
10. Four (4)
11. Five (5), fifty six (56), twenty five (25), 457 mm ± 2 mm (18.0” ± 0.06”)
12. Patched
13. 0.1, 0.01
14. 13.33
15. 1000 - 500
16. T-265
17. One (1), two (2)
18. Five (5), three (3), two (2)
19. \[
\frac{\text{Wet Density}}{\% \text{ moisture} + 100} \times 100
\]

20. Moisture, Dry density, Highest

21. Tenth of a pound; percentage; tenth
Family of Curves – One-Point Method
AASHTO T-272-16
(Modified)

This test method is for the rapid determination of the maximum density and optimum moisture content of a soil sample utilizing a family of curves and a one-point determination. A family of curves is a group of typical soil moisture-density relationships determined using AASHTO T-180, Method A or Method D, which reveal certain similarities and trends characteristic of the soil type and sources. Soils sampled from one source will have many different moisture-density curves, but if a group of these curves are plotted together, certain relationships usually become apparent. In general, it will be found that higher unit mass soils assume steeper slopes with maximum dry density at lower optimum moisture contents, while lower unit mass soils assume flatter, gentler sloped curves with higher optimum moisture contents.

Modification: 1. To comply with 2014 NMDOT Standard Specification (silver) book, only AASHTO T-180, Method A or Method D will be used for this test.
2. Weigh to the nearest 0.1 of a gram or 0.01 of a pound.
3. Report optimum moisture content as a percentage to the nearest 0.1.

Key Elements:

1. **Develop a moisture-density family of curves.** Plot proctor data obtained from AASHTO T-180, Method A or Method D, on graph paper. A separate family shall be developed for each material type.

2. **Moisten sample.** Thoroughly mix the selected representative sample with sufficient water to dampen below optimum moisture content. Moisture content of the sample shall never exceed the optimum moisture content (10.1).

3. **Form specimen by compacting.** Using the procedure as outlined in AASHTO T-180, Method A or Method D, compact the prepared soil (10.2). **Determine mass of compacted specimen.** Following compaction, remove the extension collar, carefully trim the compacted soil even with the top of the mold and determine the mass of the mold and moist soil to the nearest 0.1 g or 0.01 of a pound. Multiply the mass of the compacted specimen and the mold, minus the mass of the mold by the appropriate factor, and record the result as the wet density in pounds per cubic foot of compacted soil (10.2.1).

4. **Obtain Moisture Sample and Weigh.** Remove the material from the mold; it may be necessary to use a sample extruder to remove the compacted specimen. Slice the specimen vertically through the center. Take a representative sample from one of the cut faces. Sample the entire length of the specimen (10.3). Place this moisture sample in a suitable container per AASTHO T-265 (moisture of soils), and weigh to nearest 0.1 g and record. The moisture sample shall comply with the table below.

<table>
<thead>
<tr>
<th>Sieve Retaining More Than 10% of Sample</th>
<th>Minimum Mass of Moist Specimen</th>
</tr>
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<tbody>
<tr>
<td>19 mm (3/4 in)</td>
<td>1000 g</td>
</tr>
</tbody>
</table>
5. **Place in oven at** 110 ± 5°C (230 ± 9°F) **and dry to constant mass.** Dry sample in accordance with AASHTO T-265 (moisture of soils). Constant mass is defined as after initial drying the weight of the material decreases by less than 0.1% after a minimum of 10 minutes additional drying.

\[
\frac{W_1 - W_2}{W_2} \times 100, \quad \frac{W_2 - W_3}{W_3} \times 100, \text{ etc.}
\]

6. **Calculate dry density and moisture content.** Calculate the moisture content and the dry weight of the soil as compacted for the specimen (13.1).

\[
\% \text{ Moisture in specimen} = \frac{A - B}{B - C} \times 100
\]

\[
\text{Dry Weight} = \frac{W_1}{\% \text{ moist.} + 100} \times 100
\]

A = Weight of container and wet soil.

B = Weight of container and dry soil.

C = Weight of container.

W₁ = Wet weight, in pounds per cubic foot of compacted soil.

7. **Plot data on family of curves.** The dry density (unit mass) of the soil shall be plotted as ordinate (parallel to the vertical axis), and the corresponding moisture content as the abscissa (parallel to the horizontal axis) to define one-point within or on the family of curves for the appropriate test method (14.1).

8. **Determine maximum dry density and optimum moisture.** If the one-point falls on one of the curves in the family of curves, the maximum dry density and optimum moisture content defined by that curve shall be used (14.2, Note 4). If the one-point falls within the family, but not on a curve, a new curve shall be drawn through the plotted one-point parallel and in character with the nearest existing curve in the family of curves. The maximum dry density and optimum moisture content as defined by the new curve shall be used (14.3). **New curves drawn through plotted one-point determinations shall not become a permanent part of the family of curves until verified by a full moisture-density relationship** (Note 5).

9. **Report.** The report shall include the following: method used (T-180, Method A or Method D), optimum moisture content to the nearest 0.1 percent and maximum density to the nearest 0.1 lb/ft³ (15.1.1, 15.1.2, and 15.1.3).
Family of Curves – One-Point Method
AASHTO T-272
(Modified)
Review Questions

1. This test is used for the rapid determination of the __________ and the __________ utilizing a family of curves and a one point determination.

2. A family of curves is a group of typical soil moisture-density relationships determined using AASHTO ________ method ________.

3. If a group of these curves are plotted together certain relationships usually become apparent. In general it will be found that ____________ unit mass soils assume steeper slopes with maximum dry densities at lower ________________ contents.

4. A separate family shall be plotted for each _____________________.

5. Moisture contents of your one point shall ______________ the optimum moisture content.

6. What do you do if your one point plots on one of the curves in the family of curves? ________________.

7. If the one point falls within the family, but not on a curve, a new curve shall be drawn through the plotted one point ________________ and in ________________ with the nearest existing curve in the family of curves.

8. New curves drawn through one points shall not remain a permanent part of the family of curves until a ____________ is run.

9. Report shall include the ________________ used the ________________ and the _________________.

New Mexico Technician Training and Certification Program
Family of Curves – One-Point Method
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Review Answers

1. Optimum moisture, maximum dry density
2. T-180, D
3. Higher, optimum moisture
4. Material type
5. Never exceed
6. Use the optimum moisture and maximum dry density as defined by that curve
7. Parallel, character
8. Full five point proctor (moisture density test)
9. Method used, new optimum moisture, new maximum dry density