Central Mix Aggregate Certification Study Guide

About Central Mix Aggregate Plant and Proficiency course:

CCWA is offering a lower priced, FastForward grant funded VDOT Central Mix Aggregate Plant course that is subsidized by the Virginia General Assembly; it is intended for Virginia residents only. It is a grant designed to quickly give eligible individuals access to important credential training courses, and therefore, has important time constraints for completion of tests. FastForward grant guidelines specify a time requirement to complete all tests necessary for full certification.

This course is an in-person, instructor-led course. When you agree to the FastForward course price, you agree to attend all of the in-class sessions and complete the required hands-on, proctored proficiency test within 90 days of the last day of class. I**ndividuals that fail to complete ALL of the components within the specified time-frame, but still want to seek certification, must pay an additional testing fee of $200.** Sign-up for proficiency tests will be available in class and are posted at www.ccwatraining.org/vdot . All VDOT Central Mix Aggregate Plant proficiency tests must be completed by December 13, 2021.

Table of Contents

Table Location

Preface and Acknowledgments

This manual is a practical guide for VDOT technicians, inspectors and contractors. Information contained herein is generally compatible with current VDOT specifications, however, it should not be considered a source for these specifications.

The Certification Training School would like to express their appreciation to all the people in the Department and Industry who have helped with the publication of this manual. It is through their dedicated effort that the Certification Program continues to be the standard for other programs to follow.

Certification Requirements

Pass Written Examination -

- Show photo identification before taking exam
- Sign Technician Certification Application
- Open book - 41 multiple choice questions
- Passing score is 70
- **Complete by November 30, 2021**

Pass Proficiency Test -

- For questions about proficiency testing, contact Community College Workforce Alliance (CCWA) at 804-523-2290.
- Show photo identification
- Demonstrate applicable aggregate tests methods (see Appendix D)
- **Complete by December 13, 2021 after passing written exam.**

Tests results are found at the VDOT University website listed below.

VDOT Employees: https://virtualcampus.vdot.virginia.gov
All other students: https://virtualcampus.vdot.virginia.gov/external

Create a new account if you have never taken a VDOT certification course. If you do not know your login and password,DO NOT create a new account, email VDOTUniversity@vdot.virginia.gov or call (804)328-3158 for login information and any questions.

APPLICATION FOR VDOT MATERIALS TECHNICIAN CERTIFICATION

This is to affirm that ____*(print your name)*__________ (Technician's Name), hereinafter **"**Technician,**"** desires to be certified by the VDOT as a **Central Mix Aggregate Technician**. By making this Application, Technician acknowledges and agrees that Certification carries inherent rights and responsibilities. The rights include being exclusively sanctioned**,** along with others so certified by VDOT**,** to perform sampling, testing, and reporting of test results for quality acceptance, quality control and assurance programs. The responsibilities include performing and reporting tests with the accuracy and precision expected of the Technician in accordance with the required test procedures.

By signing this Application, Technician agrees to strive to maintain compliance with all rules, regulations, specifications, industry standards, procedures and policies, applicable to any work performed under the Certification. A violation of the above as determined by the VDOT Technician Certification Review Board may result in a suspension or revocation of the rights and responsibilities conferred on the Technician. Revocation or suspension of one Certification may be considered a revocation or suspension of all Certifications held by the Technician. Further, any suspension or revocation of Technician's Certification in any other jurisdiction may result in the VDOT Technician Certification Review Board taking the same or other action, against Technician's Certification in Virginia.

By signing below, Technician also affirms that he/she is aware that both State and Federal laws may govern construction projects in Virginia, including Title 18, United States Code, Section 1020, that states, in pertinent part, that anyone making falsifications on Federal-aid projects,

"Shall be fined not more than $10,000 or imprisoned not more than five years, or both."

I, _____*(Print your name)*_______________**(Print Name), affirm that I have read and fully understand the foregoing "APPLICATION FOR VDOT TECHNICIAN CERTIFICATION," and I agree to be bound by these terms.**

__________*(Sign your name)*__________________________ ____________________________________

Technician's Signature **Date**

Virginia Department of Transportation
Central Mix Aggregate Certification
Typical Agenda

Day One

Registration

Introduction

Stockpiling Video

Chapter 2 - Quality Assurance
Producer & VDOT Responsibilities

Chapter 5 – Test Results Input –
MITS/PLAID

Lunch

Chapter 3 - Testing of Aggregates

Day 2

Atterberg Limits

Chapter 3 – Optimum Moisture

Chapter 4 – Acceptance of Materials Lot
Adjustments

Lunch

Chapter 4 – Acceptance of Materials Lot
Adjustments (cont.)

Appendix B - Titration

Appendix 5- Proficiency Test
Demonstrations

The History of Central Mix Aggregate

During the early 1960s, the Virginia Department of Transportation undertook a program to upgrade aggregate materials. The Department felt this was necessary since the highway construction program was booming and there was a real problem in maintaining passing aggregate materials from the stockpile to the roadway. With an expanded building program, aggregate producers were building large stockpiles and, even though the material met specifications when produced, it often failed after being placed in the roadway. This was due to stockpile segregation and/or so much handling before use. Failing materials caused the Department and Contractor a great deal of trouble as the materials had to be tested, reblended, roadway mixed and then tested again.

As a solution, the Virginia Department of Transportation decided to require that all aggregate base and subbase materials be pugmill mixed in a central mix aggregate plant. This is a process that requires aggregate materials to be mixed and brought to a proper gradation and moisture content just prior to being placed in the roadway. These materials became known as Central Mix Aggregates (CMA).

Aggregates are, for the most part, base or subbase aggregate materials, which range in sizes from 1 ½ inch (37.5 mm) in diameter to particles as fine as dust. These sizes are controlled by screening and blending operations at the aggregate producer's crushers and/or at the central mix aggregate pugmill mixers.

The central mix aggregate plant is required to be equipped with a pugmill mixer and such other equipment as necessary for blending different size aggregates and water into a homogeneous mixture. For special requirements, such as stabilized aggregates, central mix aggregate plants are also required to be equipped with feeders to introduce cement into the mixture. With the blending of aggregates and adding of water and, sometimes, other stabilization agents, the central mix aggregate plant operation is able to produce an aggregate material to meet rigid specifications and, thus, the high strengths required by modern highways.

When the decision was made to require aggregate base materials to be central mixed, provisions were also made to test the materials at the source. This required a laboratory at the production plants and qualified technicians and inspectors to oversee the operation.

With controls in place to insure a uniform gradation and thorough mixing of aggregates and additives, it was time to look at the whole picture of production testing and not just individual loads - statistical quality control was initiated for aggregate bases, subbases and select material.

Statistical quality control was needed to insure that all material has an equal opportunity to be tested without arbitrarily selecting an individual location or time. CMA (Central Mix Aggregate) Producers are aware that under statistical quality control all of their material has an equal chance of being tested. Therefore, quarry technicians were needed to run their own samples. It was now a dual testing system.

Noting this duplication of testing, the Virginia Department of Transportation established a Quality Assurance Program consisting of an industry run sampling and testing program with the Department monitoring the process.

With the question of base and subbase quality control answered, select material and open graded coarse and fine aggregate quality control needed to be addressed. It was determined that select material, if mixed in a pugmill at the source, could be included in a Quality Assurance Program with its own criteria for acceptance and adjustment.

The Modified Acceptance Program was developed for any material other than Select Material Type I, or any type subbase or base dense graded material specified in sections 208 and 209 of the Road and Bridge Specifications. It was agreed on by the Department and Industry with a mandatory starting date of October 1, 1986. This program states that the aggregate producer is to certify on the delivery ticket and TL-102A that the aggregates have been sampled and tested and meets all specification requirements. The Department, in turn, would conduct a monitoring program to verify the acceptability of the product. Unlike the QA program, which is sampled from location on trucks or stockpiles only, the Modified Acceptance Program can be sampled from stockpiles, barges, conveyors and other points which accurately represent the material being produced and shipped.

Introduction to Central Mix Aggregate Programs

The Virginia Department of Transportation currently awards a certificate to those individuals who have successfully completed a program of study which qualifies them to be Aggregate Technicians. This program is presented by the Virginia Department of Transportation and is taught by members of industry and the Materials Division. The purpose of this program is to supply the prospective VDOT or industry technician with a good basic knowledge of aggregates, and to familiarize the individual with the specifications that relate to the production and placement of these aggregates, and to acquaint the individual with the tests that are to be run on this material. This study guide serves as a text for this program and is a good reference book for the technician at the project or plant where aggregates are used.

Mix design requirements form an essential part for all aggregate mixtures. The agency or authority responsible for construction (Department of Transportation) usually establishes the mix design range and the design requirements. Once these are established, it becomes the responsibility of the Producer and their technician to develop the mix within the framework of the design requirements.

Through many years of laboratory testing and actual road application, the Department has established design ranges for aggregate mixtures in Virginia. (See Road and Bridge Specifications, Table II - 9 for dense graded aggregate and Section 207.02 for Select Material, Section 202 for fine aggregates, and Section 203 for coarse.) In this section we will generally discuss the design ranges and types of aggregate mixtures used for highway construction.

To properly design an aggregate mixture for a specific application, consideration must be given to the desirable mix properties. Open graded aggregates used in concrete pavement and other concrete construction, in drainage applications, in surface treatment and for any other use have been designed, through gradation design ranges, abrasion and soundness requirements, to provide the needed properties for each application. The requirements for open graded aggregates are covered in Tables II-1 through II-5 of the Virginia Road & Bridge Specifications:

Road & Bridge Spec. - Secton 202.02

TABLE II-1
Fine Aggregate

Grading	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Mass)							
	3/8 inch 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 30 600 µm	No. 50 300 µm	No. 100 150 µm	No. 200 75 µm
A	Min. 100	95-100	80-100	50-85	25-60	5-30	Max. 10	
B	Min. 100	94-100					Max. 10	
C	Min. 100	94-100				Max. 25		

Road & Bridge Spec. - Section 202.03

TABLE II-2
Soundness

Use	Max. Soundness Loss %	
	Magnesium Sulfate (5 Cycles)	Freeze and Thaw (100 Cycles)
Hydraulic Cement Concrete	18	8
Asphalt concrete surfaces and surface treatments	25	15
Asphalt concrete bases	30	15

Road & Bridge Spec. - Section 203.03

Table II-3
Sizes of Open Graded Coarse Aggregates
Amounts Finer Than Each Laboratory Sieve (Square Openings) (%Mass)

Va. Size No.	100 mm 4 in.	90 mm 3 ½ in.	75 mm 3 in.	63 mm 2 ½ in	50 mm 2 in.	37.5 mm 1 ½ in.	25.0 mm 1 in.	19.0 mm ¾ in.	12.5 mm ½ in.	9.5 mm 3/8 in.	4.75 mm No. 4	2.36 mm No. 8	1.18 mm No. 16	300 µm No. 50	150 µm No. 100
1	Min. 100	95±5		43±17		Max. 15		Max 5							
2			Min. 100	95±5		43±17		Max 15	Max 5						
3				Min. 100	90–100	35–70	0–15		Max 5						
357					Min. 100		60±20		20±10		Max 5				
5						Min. 100	95±5	58±17	Max 15	Max 5					
56						Min. 100	95±5	58±17	25±10	Max 15	Max 5				
57						Min. 100	95±5		43±17		Max 7	Max 3			
68							Min. 100	95±5		48±17	Max 20	Max 8	Max 5		
7								Min. 100	95±5	57±17	Max 15	Max 5			
78								Min. 100	95±5	60±20	Max 20	Max 8	Max 5		
8									Min. 100	92±8	25±15	Max 8	Max 5		
8P									Min. 100	75±100	5–30	Max 5			
9										Min. 100	92±8	25±15	Max 10	Max 5	
10										Min. 100	92±8				20±10

Road & Bridge Spec. - Section 203.03

TABLE II-4
Soundness

Max. Soundness Loss (%)		
Use	**Magnesium Sulfate (5 cycles)**	**Freeze and Thaw (20 cycles)**
Hydraulic cement concrete	12	5
Asphalt surface courses	15	6
Asphalt and aggregate bases	20	7
Select material (Type I) and subbase	30	12

TABLE II-5
Abrasion

Max. Los Angeles Abrasion Loss (%)		
Use	**100 Rev.**	**500 Rev.**
Grade A stone	9	40
Grade B stone	12	45
Grade C stone	14	50
Slag	12	45
Gravel	12	45

Crusher Run

Road & Bridge Spec. - Section 205.03

(a) **Grading:** Grading shall conform to the following when tested in accordance with the requirements of AASHTO T27:

% by Mass of Materials Passing Sieve

Size No.	2 ½ in. 63 mm	2 in. 50 mm	1 ½ in. 37.5 mm	1 in. 25 mm	¾ in. 19.0 mm	No. 4 4.75 mm
24	Min. 100	95±5				32±18
25			Min. 100	95±5		32±18
26				Min. 100	95±5	38±22

Dense Graded Aggregates

Dense graded aggregates: base and subbase material and select material, are used in pavement construction. The following are important for aggregates used for this purpose:

1. Stability — The ability of an aggregate mixture to resist deformation from imposed loads.
2. Durability — The ability of an aggregate mixture to resist disintegration by weathering and traffic.
3. Workability — The ease with which aggregate mixtures may be placed and compacted.

The design ranges as presented in Table II - 9 of the Road and Bridge Specifications have taken into consideration the above mentioned desirable mix properties. Therefore, Table II - 9 is actually stating that a mix design or job mix within the design range for a specific application or size will possess the desirable mix properties discussed above.

Road & Bridge Spec. - Section 208

TABLE II-9
Design Range for Dense Graded Aggregates

Amounts Finer Than Each Laboratory Sieve (Square Openings[1]) (% by Weight)

Size No.	2 in.	1 in.	3/8 in.	No. 10	No. 40	No. 200
21 A	100	94-100	63-72	31-41	14-24	6-12
21 B	100	85-95	50-69	20-36	9-19	4-7
22	---	100	62-78	39-56	23-32	8-12

[1] In inches, except where indicated. numbered sieves are those of the U.S. Standard Sieve Series.

Road & Bridge Spec. - Section 207.01

TABLE II-6
Design Range: Select Material, Type I

% by Weight of Passing Material

3 in. Sieve	2 in. Sieve	No. 10 Sieve	No. 40 Sieve	No. 200 Sieve	ASTM D4791 Flat & Elongated 5:1
100	95-100	25-55	16-30	4-14	30% max.

There are many types of dense graded aggregate mixtures used in highway construction. In Virginia, however, there are three basic types that are used in the construction of a pavement: Select Material, Aggregate Subbase Material and Aggregate Base Material.

2 QUALITY ASSURANCE DENSE GRADED AGGREGATES

Producer's Responsibility - Quality Assurance Program

The Producer shall furnish and maintain a plant laboratory, meeting the requirements of Section 106.07 of the Road and Bridge Specifications.

Test and Equipment

Test procedures shall be conducted in accordance with the standards referenced in the current specifications. Testing for Gradation, Atterberg Limits and cement content (where required) will be conducted. To accommodate the testing requirements, a field or plant laboratory shall be furnished and contain the following equipment:

1 - Motorized screen shaker for fine and coarse grading analysis.

1 - Set of sieves for the motorized shaker. The screen sizes shall include the specification sizes for the type of material being produced.

1 - Balance having a capacity of at least 45 lbs. (20 kg), with a sensitivity of one ounce (28 grams) or less.

1 - Balance having a capacity of at least 2.5 lbs. (1 kg), with a sensitivity of 0.1 gram or less.

1 - Drying apparatus.

1 - Set of liquid and plastic limit devices.

Under the QA program, a certified technician must be present at all times during the mixing of the final product. Such technician shall be capable of designing, sampling, testing and adjusting the mixture.

Sample, using an approved random method, and test in accordance with the Specifications. A rate of 4 samples per 2000 ton or 4000 ton lot shall be used. The specification requires that samples be obtained from the approximate center of truckloads of material or from a mini-stockpile. A statistically acceptable method of randomization is to be used to determine the time and location of the stratified random sample to be taken. The Department shall be advised of the method to be used prior to start of production.

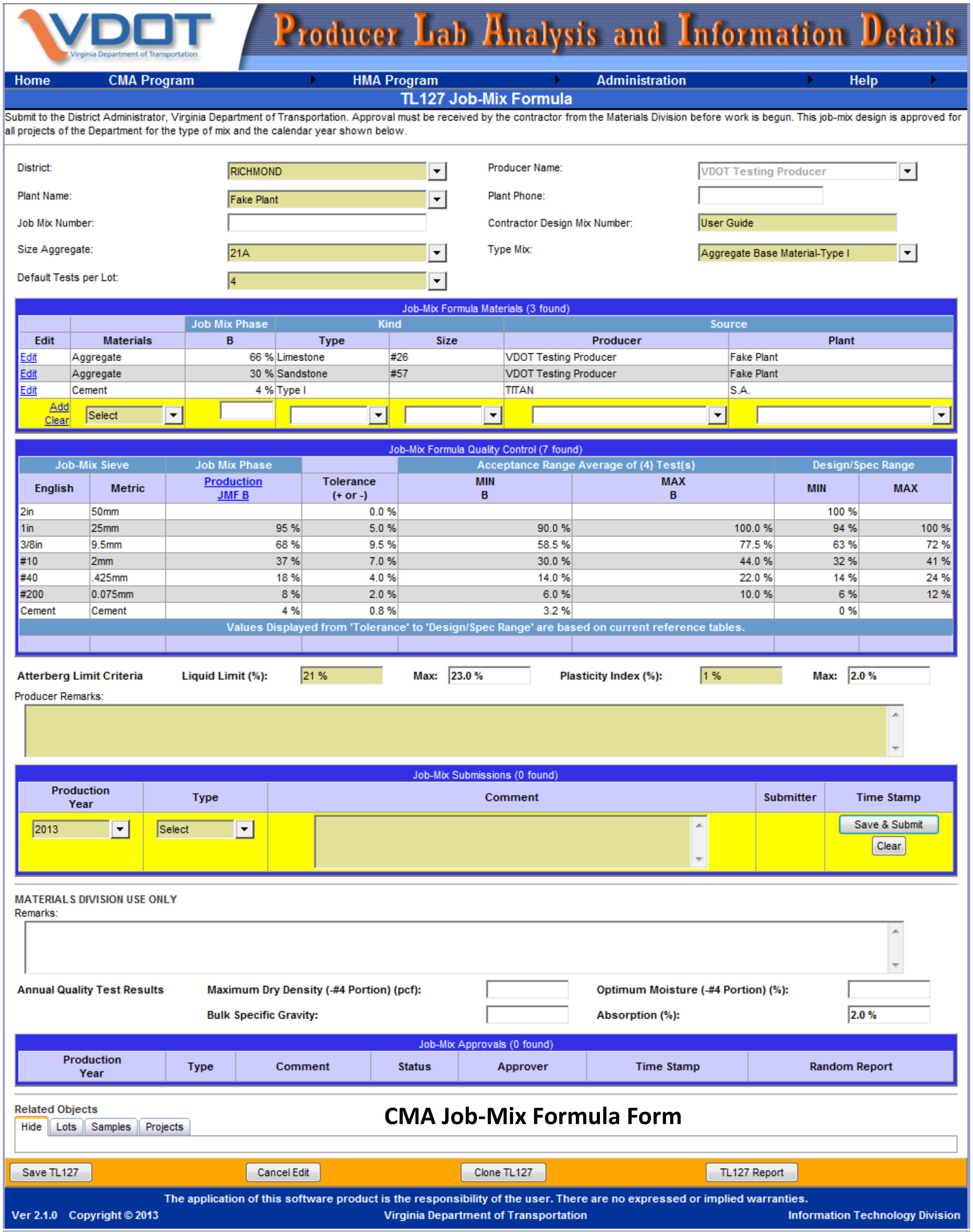
Record test results and maintain quality control charts that are kept visibly posted. Furnish the Department copies of the test results on forms furnished by the Department and maintain current control charts at the plant for review by the Department. Maintain all records and test results associated with materials production (e.g. hydraulic cement, etc.).

Notify the District Materials Engineer when production is to start or resume after a delay.

Obtain a sample at the request of the monitor and analyze half of the sample. The Department will analyze the other half. This sample shall be quartered or processed through a sample splitter in accordance with standard procedures. This sample will be used as the next production control sample. Properties to be determined include, but are not limited to, Gradation, Atterberg Limits, Cement Content and Moisture Content for subbase, aggregate base material, and select material. Form TL-52, which is available on the "Producer Lab Analysis and Information Details" (PLAID) website https://plaid.vdot.virginia.gov, shall be used by the producer to report these test results. The following information shall be provided on the TL-52 for each sample:

- District, Production Year;
- Producer Name, Plant Name;
- Size Aggregate, Mix Type, Job Mix Number;
- Lot Number, Sample Number, Sample Date, Sample Time, Sampled by, Tonnage;
- Project Number, Producer Lab location and Tested by.
- Route Number and Locality Code are (optional).

Such test results and information shall be entered and submitted by the producer within 48 hours of sampling through the PLAID website. Appropriate quality control charts shall be maintained at the plant.



VDOT Virginia Department of Transportation

Producer Lab Analysis and Information Details

Home | CMA Program | HMA Program | Administration | Help

TL127 Job-Mix Formula

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

District:	RICHMOND	Producer Name:	VDOT Testing Producer
Plant Name:	Fake Plant	Plant Phone:	
Job Mix Number:		Contractor Design Mix Number:	User Guide
Size Aggregate:	21A	Type Mix:	Aggregate Base Material-Type I
Default Tests per Lot:	4		

Job-Mix Formula Materials (3 found)

		Job Mix Phase	Kind		Source	
Edit	Materials	B	Type	Size	Producer	Plant
Edit	Aggregate	66 %	Limestone	#26	VDOT Testing Producer	Fake Plant
Edit	Aggregate	30 %	Sandstone	#57	VDOT Testing Producer	Fake Plant
Edit	Cement	4 %	Type I		TITAN	S.A.
Add Clear	Select					

Job-Mix Formula Quality Control (7 found)

Job-Mix Sieve		Job Mix Phase		Acceptance Range Average of (4) Test(s)		Design/Spec Range	
English	Metric	Production JMF B	Tolerance (+ or -)	MIN B	MAX B	MIN	MAX
2in	50mm		0.0 %			100 %	
1in	25mm	95 %	5.0 %	90.0 %	100.0 %	94 %	100 %
3/8in	9.5mm	68 %	9.5 %	58.5 %	77.5 %	63 %	72 %
#10	2mm	37 %	7.0 %	30.0 %	44.0 %	32 %	41 %
#40	.425mm	18 %	4.0 %	14.0 %	22.0 %	14 %	24 %
#200	0.075mm	8 %	2.0 %	6.0 %	10.0 %	6 %	12 %
Cement	Cement	4 %	0.8 %	3.2 %		0 %	

Values Displayed from 'Tolerance' to 'Design/Spec Range' are based on current reference tables.

Atterberg Limit Criteria Liquid Limit (%): 21 % Max: 23.0 % Plasticity Index (%): 1 % Max: 2.0 %

Producer Remarks:

Job-Mix Submissions (0 found)

Production Year	Type	Comment	Submitter	Time Stamp
2013	Select			Save & Submit Clear

MATERIALS DIVISION USE ONLY

Remarks:

Annual Quality Test Results Maximum Dry Density (-#4 Portion) (pcf): Optimum Moisture (-#4 Portion) (%):

Bulk Specific Gravity: Absorption (%): 2.0 %

Job-Mix Approvals (0 found)

Production Year	Type	Comment	Status	Approver	Time Stamp	Random Report

Related Objects

Hide | Lots | Samples | Projects

Save TL127 | Cancel Edit | Clone TL127 | TL127 Report

The application of this software product is the responsibility of the user. There are no expressed or implied warranties.

Ver 2.1.0 Copyright © 2013 Virginia Department of Transportation Information Technology Division

CMA Job-Mix Formula Form

Note: Detailed information about how to complete this form (TL 127) can be found in the PLAID user guide.

Department's Responsibility

District Materials Engineer's Staff and Independent Assurance (IA) Program

The term "Department Monitor" shall mean either a Department employee or contract personnel hired by the Department to conduct the monitor sampling.

1. Provide classroom or self-study technical instruction, examination and certification for all appropriate personnel.
2. Inspect the plant before production for compliance with specification requirements governing plant and testing equipment.
3. In the case of aggregates, furnish Proctor results (maximum dry density and optimum moisture content) to the Producer.
4. Perform unannounced periodic inspections of plants during production, including that of stockpiles, equipment, weighing operations, sampling, testing, and records kept by the Producer's technician.
5. Keep a diary of plant visits, observations and comments made to the Producer's representative.
6. Accept the product in accordance with the specifications, based upon the Producer's test results, provided such results are statistically comparable (VTM- 59) to the Department's monitor test results, and provided the material passes a visual examination for contamination and segregation at the job site. The sole purpose of the IA sample taken by the Department is to verify the accuracy of the producer's testing program. If the comparison indicates the IA test results are not in agreement with the Producer's results, an investigation will be made to determine the cause of difference. If the differences can be determined, the material will be accepted, adjusted or rejected in accordance with the specification. If the difference cannot be explained, the Department may call for the referee system to determine the final disposition of the material. In the event it is determined that the contractor's test results are not representative of the product, the Department will take such action as it deems appropriate to protect the interest of the Commonwealth.
7. Provide a referee system which may be invoked at the request of the producer or Department and which will involve use of test results obtained from samples secured from the road.

8. Independent Assurance samples are those obtained at the central mix aggregate plant by the Producer's Certified Central Mix Aggregate Technician in the presence and under the observation of the VDOT Materials Representative, and tested in the VDOT Laboratory or by AMRL- accredited consultant laboratories. These samples are tested for gradation, Atterberg Limits, water content, and cement content (if applicable). IA samples shall be obtained at a rate that both provides a statistically significant number of samples for each mix produced and allows verification of unstable mixes. At least one (1) IA sample shall be obtained and tested from each lot and as necessary to ensure statistical significance and to monitor unstable or nonconforming mixes. Unstable mixes are those that exceed variability tolerances provided in VTM-59.

Lot size shall be chosen, upon request by the Producer or District Materials Engineer and at the discretion of the District Materials Engineer, from either 2000 or 4000 ton lots. Lots shall be chosen in order to match Producer shipping rates, to reduce unnecessary testing, when past performance indicates stability, and when lot size/shipping rates are appropriate to ensure statistical significance will be obtained.

This rate of IA sampling is mandatory and it is the responsibility of the District Materials Engineer to see that it is accomplished. Should the IA effort fall behind the required frequency of sampling and/or testing, the District Administrator is to be advised immediately. Sufficient manpower is to be provided for the monitoring effort.

The Department's IA Technician will observe the manner in which sampling is performed by the producer. Not only is the when, where and how of taking the sample important but also the care taken to properly reduce the sample to testing size. The IA Technician directs when the sample shall be taken. They shall observe the producer's technician taking and splitting the sample. The IA technician takes 1/2 of the sample to a lab of their discretion for testing. The producer's technician will perform the test on the other half, which is to be considered as the next production sample for the producer.

The CMA Point Adjustment Analysis Report, E12-1710-01 (Ch. 2 page 18)) will be produced by the VDOT Materials Representative. The report should be reviewed for correctness. The report shall be put in the District Materials Engineer's project folder. In the case of non-conforming materials a copy may be sent to the prime contractor. The material notebook only requires a one line entry identifying the period of time over which the material was shipped (Fr.__________To_________), gradation or type mix, total tonnage and source. In case of non-conformance to the specifications, a copy of the test report will be furnished to the Prime Contractor by VDOT.

The success of the quality assurance program will be determined to a large extent by the effectiveness of the IA sampling and testing effort. Deficiencies revealed through this effort shall be addressed promptly and decisively. The results of the IA tests are recorded in the VDOT Material Information Tracking System (MITS). The MITS is capable of performing all of the statistical analyses required by VTM-59. Thus, this statistical test shall be made by the VDOT IA Technician immediately when the data is available, that is, after gradation results for a single lot's split sample are available from both the Producer and VDOT.

D2S Test - The D2S test is an individual test comparison between the Producer's results and VDOT's results on their respective splits of the IA sample. The D2S comparison is the individual test percent difference between two (2) results obtained on test portions of the same material. The figures for acceptable range of two (2) results, in percent, applicable for all sieve sizes, are those found in Table 2 – Estimates of Precision of AASHTO Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates, T 27-06, for multi-laboratory precision for coarse aggregate, and are listed below:

Total Percentage of Material Passing		Acceptable Range of Two Results (D2S), Percent
100	≥95	1.0
<95	≥85	3.9
<85	≥80	5.4
<80	≥60	8.0
<60	≥20	5.6
<20	≥15	4.5
<15	≥10	4.2
<10	≥5	3.4
<5	≥2	3.0
<2	0	1.3

In the event that for a given sieve, the total percentages of material passing obtained by the Producer and VDOT fall into different brackets, the acceptable range to use for the D2S test shall be that corresponding to the bracket designated by the job mix formula for the given sieve.

The benefit of performing the D2S test immediately upon the results of the IA sampling of a lot of material is that if discrepancies are found between the Producer's results and VDOT's results the reason for the discrepancies can be immediately investigated and remedied and material quality problems minimized. If the results are not in agreement, an investigation shall be made to determine the reasons for differences as given in Paragraph (d) below.

Matched Comparison Test - The IA tests performed by the MITS are made in a matched comparison report that compares the results of gradation, Atterberg Limits, and cement content tests (if applicable) of the Producer against those of VDOT on the split (matched) samples on a given job mix for a given plant using the VTM-59 methodology. The frequency of these reports shall be adjusted by the District Materials Engineer according to production schedule. The report shall use dates that include at least seven (7) IA results, if possible. Also, if there is a change in the production mix, the report shall begin with the date of the change. The report shall flag those values that are outside the statistically accepted range for samples collected from the same production operation. The report shall be reviewed by VDOT for correctness and one copy sent to the Contractor/Producer by way of a Materials Representative. If the results are not in agreement, an investigation shall be made to determine the reasons for differences as given below.

Verification Samples and Tests

Separate verification samples are not collected. The VST tests performed by the MITS are made in a non-matched comparison report that compares the results of gradation, Atterberg Limits, and cement content tests (if applicable) of the Producer against those of VDOT using the VDOT portion of the split sample and the non-split (non-matched) QC samples of the Producer on a given job mix for a given plant using the VTM-59 methodology. The frequency of these reports
shall be adjusted by the District Materials Engineer according to production schedule. The report shall use dates that include at least seven (7) IA results, if possible. Also, if there is a change in the production mix, the report shall begin with the date of the change. The report shall flag those values that are outside the statistically accepted range for samples collected from the same production operation. The report shall be reviewed by VDOT for correctness and one copy sent to the Contractor/Producer by way of a Materials Representative. When flags occur in which the data generated from VDOT's non-matched IA samples is indicating the material may not be within specification limits but the data generated from the Producer's non-matched QC samples is indicating the material is within specification limits, a thorough investigation shall be conducted. If the results are not in agreement, an investigation shall be made to determine the reasons for differences as given below.

Material Acceptance

Material is accepted in accordance with specifications, based upon the Producer's test results, provided such results are statistically comparable (per VTM-59 and as described below) to VDOT's IA and VST test results and provided the material passes a visual examination for contamination and segregation at the project site.

In the event a statistical comparative analysis of the Producer's quality control test results and VDOT's IA or VST test results indicate a statistically significant difference in the results, or either of the results indicate that the material does not conform to the gradation and Atterberg Limits requirements of the specifications, an investigation shall made to determine the reason for the differences.
Suggested checks are:

(1) Check to see if the IA test results meet the specifications for Average and Standard Deviation and the Producer's result on the mate of the IA sample to see if the two results are comparable (i.e. when flags occur from non-matched comparison test).

(2) Check to see if one of the systems is indicating a trend (consistently fine, coarse, erratic, etc.)

(3) Check sampling and testing procedure.

(4) Check testing equipment.

The results of the investigation shall be sent to the State Materials Engineer for use in preparing the annual report to FHWA, and to the Producer for their records. The sampling and testing procedures and laboratory test equipment (both the Producer's and the Materials Representative's) shall be checked as necessary. If the differences can be determined, the material shall be accepted, adjusted, or rejected in accordance with the specification. If differences still cannot be explained, then either the Producer or VDOT may call for the referee system to determine final disposition of the material. If it becomes necessary to implement the referee system, refer to Secs. 207.06 and 208.07 of the VDOT Road and Bridge Specifications to determine the sampling and testing details. If it is determined that the Producer's test results are not representative of the product, VDOT shall take such action as it deems appropriate to protect its interests.

The Project Inspector and the Quality Assurance Program

It is imperative that close communication be maintained between the Project Inspector and the District Material Engineer’s staff and/or monitor Technician.

By the end of the next working day, the bonded weighperson will send the Weighperson Daily Summary Sheet to the Project Inspector, who will check the tonnage of material shipped against the total tonnage obtained from the weigh tickets, noting any loads that were not received, totaling the tonnage of those loads not received; add the tonnage deleted to the tonnage of material that was received, compare total tonnage to that indicated by the weighperson, and sign the verification statement. The Project Inspector should notify the producer or contractor of any differences in tonnage. Record in the Material Notebook general location, date and tonnage, with a note stating ”QA”.

Also, particular note should be made by the Project Inspector of any loads that appear to have required an abnormal transit time. These loads should be noted on the Weighperson Daily Summary Sheet. Time is very critical in the case of hydraulic cement stabilized aggregates. There is a 60 minute time limit between the start of mixing and the time that compaction of the hydraulic cement treated mixture begins.

Should visual examination reveal that the material in any load is contaminated or segregated, that load will be rejected without additional sampling or testing of the lot as specified in Section 208.06 of the Road and Bridge Specifications.

The Project Inspector shall retain the Weighperson Daily Summary Sheet, attach the corresponding weigh tickets to it, and keep it in the project files until completion of the project. At the completion of the project, the Project Inspector will forward the summary sheets and attached weigh tickets to the District Office together with other project records.

Material Acceptance QA Program--Specifications

The Producer shall have a CMA Technician present at the plant during the initial set up and during subsequent production. The Technician shall perform sampling, testing, designing and adjusting mixes as needed.

Sampling and testing for the determination of gradation, liquid limit and plasticity index shall be performed by the Producer, and the Department will perform independent IA checks. The Producer shall submit such test results to the Department through the TL-52 form which is available on the PLAID website https://plaid.vdot.virginia.gov. . VDOT’s lab technician will enter test results of IA samples using the same form through the MITS website https://mits.vdot.virginia.gov. If the

Producer's test results indicate the material produced meets the appropriate requirements, the material will be accepted for use.

However, in the event a statistical comparison of the Producer's test results and the IA test results indicates a statistically significant difference, an investigation will be made to determine the reason for differences. If it is determined that the material does not conform to the requirements of the contract, appropriate price adjustments will be made.

Normally, acceptance for gradation, liquid limit, plasticity index and hydraulic cement content(when aggregate is to be stabilized) will be based upon a mean of the results of 4 tests performed on samples taken in a stratified random manner from each 2000 or 4000 ton lot. Monitor samples (also called Independent Assurance (IA) samples) shall be obtained at a rate that both provides a statistically significant number of samples for each mix produced and allows verification of unstable mixes. One (1) monitor (IA) sample shall be obtained and tested from each lot and as necessary to ensure statistical significance and to monitor unstable or nonconforming mixes. Unstable mixes are those that exceed variability tolerances provided in VTM-59.

A lot will be considered acceptable for gradation if the mean of the test results is within the deviation allowed from the job-mix formula shown in Table II-10.

A lot will be considered acceptable for Atterberg Limits if the mean of the test results is less than the maximum allowed for the liquid limit and plasticity index as shown in Table II-11.

Because the type of 75µm (minus 200) fines significantly affects the load bearing capacity of aggregate materials, there is a one point control on each individual sample run. In the event the liquid limit exceeds 30; the plasticity index exceeds 6 for Type I base material or the plasticity index exceeds 9 for Type II base material or subbase material No. 21A, 21B or 22 on any individual sample; that portion of the lot from which the sample was taken will be considered a separate part of the lot and shall be removed from the road, unless otherwise directed by the Engineer.

There is also a one point control on hydraulic cement stabilized material. If an individual test result indicates that the cement content of the material represented by the test is deficient by more than 1.6 percent from the design cement content, the portion of the material represented by the sample will be considered a separate part of the lot and shall be removed from the road.

Instances which cause a lot to be less than the normal size are: the contract requires less than a complete lot; the job-mix formula is modified within a lot; a portion of the lot is rejected on the basis of the one point controls mentioned above; or the final lot of the year produced on the annual job mix is less than a complete lot. In any of these events the mean test results of the samples taken will be compared to the requirements of Table II-10 and Table II-11 for the number of tests performed.

It is important to remember that acceptance of gradation and Atterberg Limits for Central Mixed Aggregates and Select Material, Type I is normally based on the average of 4 test results. Anything else is an exception, such as those previously mentioned. It is equally important to remember that the samples must be chosen randomly - each ton of each lot must have an equal chance of being sampled. The when and where of each sample must be chosen solely by chance, not by the sampler!

Specification requirements of Select Material, Type I, are found in Section 207 of the VDOT Road and Bridge Specification Manual; for Central Mixed Aggregate Bases and Subbases in Section 208; cement stabilized aggregates in Section 307.

Acceptance of Dense Graded Aggregates

Statistical Quality Assurance Program

In modern concepts of materials control and acceptance, a means has been adopted by the Department, by which the Producer can exercise product control while the Department can exercise product acceptance. The tool that enables this be accomplished is the Statistical method. Those who have not been exposed to statistics quite often are fearful of the term, but it should not be confusing. Statistics is simply a mathematical analysis of accumulated data. Statistical quality control is not complicated. We now accept or reject material on the average of test results in lieu of accepting or rejecting on an individual basis.

Stratified Random Sampling

An important phase of any acceptance or rejection plan is the process of “sampling”. The samples are selected using statistical systems requiring that “samples be taken in such a manner that every part of the quantity of material to be checked for compliance has an equal chance of being sampled”; that is, that the samples be taken randomly.

Another important phase of any acceptance or rejection plan is the quantity of material to be checked for compliance with specifications. In Statistical Quality Control, the term “lot” is used to denote the quantity of material to be checked for compliance with specifications, then accepted, rejected or subjected to price adjustment. 4 samples per 2000 ton or 4000 ton lot shall be used. IA samples shall be obtained at a rate that both provides a statistically significant number of samples for each mix produced and allows verification of unstable mixes. One IA sample shall be obtained and tested from each lot and as necessary to ensure statistical significance and to monitor unstable or nonconforming mixes. Unstable mixes are those that exceed variability tolerances provided in VTM-59. A statistically acceptable method of randomization is to be used to determine the time and location of the stratified random sample to be taken.

There are several acceptable methods for obtaining the 30-40 pounds of material required for testing. They are:

(1) A loaded truck dumps at a convenient location within the plant facility to create a representative mini-stockpile. With the bucket of a front-end loader strike the top of the truck dumped load creating a flat spot on top of the pile from which a representative sample is obtained

(2) When the truck containing the load that is to be sampled is in the process of being loaded, remove a randomly selected front-end loader bucket of aggregate from the post pugmill shipping stockpile. Dump it at a convenient location within the plant facility creating a mini-stockpile. Strike the top of the mini-stockpile with the bucket of the front-end loader creating a flat spot from which to obtain the representative sample.

In order for a Plant Quality Control Technician to use Statistical Quality Control, it will be necessary to know: 1. When to take a sample? 2. Where to take a sample? 3. How to take a sample? 4. How to test the sample? 5. What to do with the test results?

Job-Mix Formula - Form TL-127 (see page 2-3)

The Producer shall submit a job-mix formula for each mixture for the Engineer's approval through the PLAID website. Form TL-127, which is available on the PLAID website, shall be used by the producer to submit to the District Materials Engineer (DME) a proposed mix using column B, before production begins and there-after in time to be approved by January 1 each subsequent year. Once submitted, the TL127 shall be reviewed by the DME through the "Materials Information Tracking System" (MITS) website https://mits.virginiadot.org and approved (or rejected) upon completion of review. Each approved design will be assigned a design number by the DME and remain in effect until a new mix design is submitted.

Small changes in quantities for gradation adjustment, etc. are not considered sufficient reason for a new mix design. A separate design must be submitted for any significant changes made. Approximately one week may be required for the evaluation of a new job-mix formula.

As previously stated, statistical systems use random sampling. Therefore, Statistical Quality Control of Central-Mix Aggregates utilizes random sampling of a lot. Virginia's Statistical Quality Control Program, however, goes one step further than just random sampling.

In Virginia, the stratified random sampling method is used. Stratified random sampling is sampling from equal portions of a lot at locations which have been selected solely by chance. Any statistically acceptable method of randomization may be used to determine the time and location of the stratified random sample to be taken; However, the Department shall be advised of the method to be used prior to beginning production. The following pages of this guide will describe and discuss step by step a procedure used in one stratified random sampling.

NOTE: The following is just one of many acceptable methods available, using a Random Number Table, and is presented here for instructional and examination purposes only.

Stratified Random Sampling

Step 1 - Determine lot size (2000 ton or 4000 ton lot). Lot size shall be chosen, upon request by the Producer or District Materials Engineer and at the discretion of the District Materials Engineer, from either 2000 or 4000 ton lots. Lots shall be chosen in order to match Producer shipping rates, to reduce unnecessary testing, when past performance indicates stability, and when lot sizes/shipping rates are appropriate to ensure statistical significance will be obtained.

Step 2 - Stratify Lot. (500 tons per sample for 2000 ton lot or 1000 tons per sample for 4000 ton lot.) Four samples per lot.

EXAMPLE:

One sample shall be on or between each group of tons shown below.

2000 ton lot	4000 ton lot
1 - 500	1 - 1000
501 - 1000	1001 - 2000
1001 - 1500	2001 - 3000
1501 - 2000	3001 - 4000

Step 3 - Secure four sets of stratified numbers from a Random Number table (page 2-15). The first number of each set can represent which ton is to be sampled.

Step 4 - Record these numbers. The Plant Quality Control Technician should notify the Weighperson.

Example for 2000 ton lot

Numbers selected from Random No. Table 1			
Ton			Ton to be Sampled
0.192	1st sample	0 + (0.192 x 1000) =	192
0.432	2nd sample	500 + (0.432 x 1000) =	932
0.143	3rd sample	1000 + (0.143 x 1000) =	1143
0.214	4th sample	sample 1500 + (0.214 x 1000) =	1714

Example for 4000 ton lot

Numbers selected from Random No. Table 2			
Ton			Ton to be Sampled
0.822	1st sample	0 + (0.822 x 1000) =	822
0.826	2nd sample	1000 + (0.826 x 1000) =	1826
0.495	3rd sample	2000 + (0.495 x 1000) =	2495
0.160	4th sample	sample 3000 + (0.160 x 1000) =	3160

Random Numbers Table 1

0.192	0.051	0.299	0.450	0.442	0.479	0.008	0.204
0.432	0.070	0.123	0.024	0.017	0.083	0.111	0.010
0.143	0.172	0.277	0.179	0.187	0.178	0.455	0.234
0.214	0.153	0.488	0.404	0.946	0.129	0.476	0.028
0.353	0.408	0.486	0.234	0.151	0.375	0.176	0.388
0.038	0.100	0.033	0.180	0.244	0.256	0.187	0.493
0.021	0.116	0.003	0.463	0.051	0.129	0.388	0.340
0.405	0.362	0.043	0.067	0.378	0.314	0.088	0.203
0.277	0.356	0.278	0.091	0.485	0.344	0.265	0.399
0.403	0.132	0.090	0.434	0.058	0.031	0.381	0.369
0.493	0.463	0.452	0.273	0.251	0.338	0.245	0.074
0.020	0.398	0.336	0.366	0.293	0.077	0.446	0.190
0.101	0.104	0.168	0.163	0.151	0.401	0.348	0.136
0.452	0.021	0.355	0.227	0.259	0.129	0.146	0.401
0.395	0.338	0.378	0.474	0.310	0.361	0.484	0.185
0.425	0.279	0.437	0.221	0.110	0.430	0.141	0.352
0.354	0.189	0.166	0.044	0.488	0.143	0.268	0.204
0.499	0.447	0.406	0.454	0.288	0.353	0.201	0.056
0.449	0.194	0.049	0.389	0.392	0.333	0.329	0.130
0.383	0.350	0.430	0.002	0.340	0.464	0.022	0.260
0.456	0.477	0.298	0.279	0.484	0.242	0.129	0.409
0.249	0.425	0.334	0.464	0.226	0.085	0.032	0.004
0.271	0.309	0.247	0.290	0.301	0.465	0.267	0.067
0.042	0.288	0.415	0.034	0.136	0.350	0.208	0.183
0.218	0.166	0.106	0.370	0.262	0.448	0.302	0.262
0.295	0.293	0.249	0.056	0.297	0.280	0.387	0.116
0.366	0.294	0.273	0.404	0.482	0.049	0.055	0.356
0.442	0.096	0.009	0.093	0.290	0.333	0.082	0.098
0.339	0.275	0.148	0.271	0.087	0.093	0.426	0.474
0.126	0.216	0.273	0.484	0.362	0.476	0.286	0.470
0.131	0.084	0.442	0.411	0.022	0.449	0.211	0.065
0.016	0.103	0.341	0.410	0.237	0.240	0.293	0.182
0.412	0.156	0.495	0.386	0.365	0.082	0.404	0.463
0.117	0.191	0.046	0.456	0.426	0.287	0.008	0.347
0.351	0.444	0.085	0.443	0.144	0.117	0.022	0.458
0.084	0.470	0.062	0.171	0.049	0.472	0.256	0.315
0.418	0.487	0.238	0.077	0.143	0.401	0.404	0.348
0.035	0.042	0.222	0.133	0.132	0.405	0.101	0.228
0.205	0.468	0.048	0.088	0.217	0.073	0.039	0.009
0.360	0.184	0.330	0.011	0.439	0.014	0.152	0.083
0.231	0.277	0.479	0.154	0.107	0.115	0.361	0.450
0.039	0.417	0.472	0.127	0.267	0.103	0.379	0.298
0.260	0.077	0.192	0.383	0.249	0.421	0.078	0.388
0.447	0.061	0.327	0.020	0.266	0.422	0.425	0.271

Random Numbers Table 2

0.822	0.640	0.703	0.511	0.152	0.282	0.617	0.298	0.012	0.136
0.826	0.995	0.295	0.654	0.388	0.495	0.610	0.406	0.397	0.648
0.495	0.449	0.278	0.666	0.734	0.372	0.076	0.508	0.001	0.046
0.160	0.450	0.782	0.748	0.075	0.187	0.035	0.206	0.094	0.753
0.379	0.192	0.370	0.558	0.088	0.330	0.321	0.166	0.610	0.084
0.558	0.255	0.178	0.936	0.521	0.941	0.597	0.906	0.868	0.483
0.452	0.627	0.190	0.301	0.172	0.979	0.363	0.297	0.943	0.968
0.278	0.402	0.386	0.562	0.319	0.940	0.314	0.621	0.406	0.014
0.003	0.738	0.048	0.629	0.806	0.721	0.858	0.509	0.999	0.168
0.429	0.828	0.597	0.642	0.873	0.839	0.607	0.262	0.612	0.413
0.508	0.878	0.152	0.263	0.991	0.868	0.621	0.265	0.960	0.646
0.223	0.441	0.283	0.432	0.527	0.941	0.919	0.731	0.322	0.302
0.838	0.412	0.307	0.176	0.647	0.377	0.806	0.240	0.240	0.792
0.892	0.269	0.041	0.362	0.116	0.758	0.805	0.600	0.728	0.955
0.558	0.990	0.066	0.325	0.587	0.173	0.540	0.778	0.689	0.126
0.962	0.033	0.186	0.881	0.934	0.367	0.845	0.171	0.396	0.965
0.052	0.407	0.705	0.925	0.354	0.889	0.709	0.040	0.809	0.576
0.642	0.129	0.172	0.009	0.040	0.743	0.388	0.156	0.626	0.699
0.034	0.813	0.748	0.474	0.138	0.594	0.120	0.940	0.456	0.787
0.709	0.949	0.024	0.520	0.082	0.583	0.861	0.151	0.899	0.451
0.301	0.523	0.705	0.380	0.162	0.364	0.842	0.434	0.884	0.927
0.598	0.671	0.639	0.549	0.783	0.617	0.805	0.125	0.808	0.297
0.138	0.433	0.339	0.062	0.691	0.232	0.554	0.703	0.270	0.396
0.310	0.716	0.387	0.597	0.631	0.494	0.511	0.265	0.275	0.404
0.074	0.488	0.760	0.630	0.970	0.670	0.463	0.506	0.164	0.568
0.191	0.485	0.476	0.295	0.579	0.103	0.501	0.917	0.330	0.816
0.851	0.319	0.543	0.211	0.054	0.088	0.063	0.546	0.494	0.511
0.400	0.199	0.953	0.643	0.082	0.873	0.647	0.647	0.971	0.537
0.166	0.144	0.177	0.775	0.671	0.981	0.172	0.549	0.157	0.047
0.909	0.124	0.327	0.267	0.178	0.839	0.174	0.509	0.538	0.641
0.942	0.600	0.039	0.994	0.153	0.825	0.590	0.895	0.352	0.676
0.543	0.931	0.129	0.018	0.812	0.460	0.323	0.862	0.842	0.324
0.493	0.855	0.268	0.126	0.090	0.568	0.717	0.714	0.711	0.007
0.117	0.524	0.961	0.716	0.769	0.741	0.149	0.504	0.399	0.304
0.846	0.604	0.749	0.429	0.546	0.105	0.309	0.531	0.478	0.363
0.733	0.753	0.932	0.919	0.990	0.332	0.227	0.656	0.831	0.778
0.687	0.169	0.109	0.587	0.541	0.957	0.209	0.589	0.871	0.772
0.764	0.856	0.074	0.797	0.419	0.064	0.366	0.391	0.412	0.414
0.854	0.744	0.431	0.823	0.778	0.839	0.726	0.371	0.207	0.527
0.533	0.044	0.366	0.346	0.792	0.396	0.103	0.513	0.586	0.968
0.076	0.639	0.187	0.013	0.579	0.410	0.826	0.286	0.257	0.956
0.222	0.959	0.743	0.654	0.240	0.219	0.072	0.336	0.465	0.667
0.912	0.667	0.534	0.355	0.708	0.220	0.865	0.695	0.531	0.623
0.732	0.359	0.816	0.984	0.554	0.414	0.425	0.461	0.293	0.708
0.736	0.320	0.535	0.227	0.650	0.542	0.380	0.099	0.822	0.619
0.069	0.545	0.362	0.488	0.198	0.351	0.747	0.923	0.192	0.145

Step 5 - Take the sample. The sample shall be taken from approximately, 150 mm(6 in.) to 300 mm (12 in.) beneath the surface of the mini-stockpile. (Strike off the top 150 mm (6 in.) of material and take the sample vertically.)

*Note: **Hydraulic Cement Stabilized Central Mix Aggregate.** The sample for the cement content and water content should be taken first and as described above. The cement flow to the aggregate should be stopped or cut-off and the sample for the gradation, L.L. and P.I. taken from the next load which would not have any cement in it. This load will not be shipped to a project. The procedure form sampling should be the same as described above.

Step 6 - Test the sample. (Gradation, Atterberg Limits, Moisture Content, and Cement Content if material is stabilized. The cement content is determined by the titration test method.)

Step 7 - Submit test results through the PLAID website. (Form TL-52, Materials Division Central Mix Aggregates Test Results Form). The Test Results Form will be discussed later in this class.

E12-1710-01
Rev 8/98

Virginia Department of Transportation
Materials Division
Central Mix Aggregate
Point Adjustment Analysis Report

Report Number:

Plant ID: 1009 Cardinal Stone Company, Galax, VA
Job Mix ID: 9701 Type Material: 79 Aggregate Base Material-Type I
Lot Number: 1 Size Material: 76 Subbase/Base Material-Size 21 A

Contract/Schedule Information

Contract Number	Item	Tonnage	Price
000330	0	2000	$0.00

Sample Information

Sample Number	Ton Number	Quad	Date	Time	75 MM (3")	50 MM (2")	25 MM (1")	19 MM (3/4")	9.5 MM (3/8")	2.0 MM (#10)	0.425 MM (#40)	0.075 MM (#200)	Liquid Limit	Plasticity Index	Moisture Percentage	Cement Content
1	350		02/04/2014	10:56	0.0%	100.0%	100.0%	0.0%	71.0%	25.4%	14.6%	6.7%	16.0%	0.0%	5.3%	0.0%
2	869		02/05/2014	08:32	0.0%	100.0%	100.0%	0.0%	65.0%	28.7%	18.5%	9.1%	17.0%	0.0%	5.2%	0.0%
3	1288		02/05/2014	12:25	0.0%	100.0%	100.0%	0.0%	55.1%	26.3%	16.8%	8.1%	16.0%	0.0%	5.1%	0.0%
4	1799		08/17/2014	09:12	0.0%	100.0%	100.0%	0.0%	68.3%	29.5%	18.8%	7.2%	16.0%	0.0%	5.1%	0.0%

Analysis of Mixtures

	75 MM (3")	50 MM (2")	25 MM (1")	19 MM (3/4")	9.5 MM (3/8")	2.0 MM (#10)	0.425 MM (#40)	0.075 MM (#200)	Liquid Limit	Plasticity Index	Moisture Percentage	Cement Content
Job Mix	0.0%	100.0%	95.0%	0.0%	63.0%	32.0%	19.0%	8.0%	21.0%	1.0%	4.0%	0.0%
Upper Limit	0.0%	100.0%	100.0%	7.0%	72.5%	39.0%	23.0%	10.0%	23.0%	2.0%	6.0%	NA
Average	0.0%	100.0%	100.0%	0.0%	64.8%	27.5%	17.2%	7.8%	16.0%	0.0%	5.2%	0.0%
Lower Limit	0.0%	100.0%	90.0%	0.0%	53.5%	25.0%	15.0%	6.0%	0.0%	0.0%	2.0%	NA
Pass / Fail (Process)												

CMA Point Adjustment Analysis Report
E12-1710-01

11-sep-00

Virginia Department of Transportation
Materials Division
Central Mix Aggregate
Comparison Analysis Report

Plant ID: 1032 Tri State Lime Co., Blountville, TN
Job Mix ID: 1002 Subbase/Base Material-Size 21 B, Aggregate Base Material-Type I

		75 MM (3")	50 MM (2")	25 MM (1")	19 MM (3/4")	9.5 MM (3/8")	2.0 MM (#10)	0.425 MM (#40)	0.075 MM (#200)	Cement Content	Liquid Limit	Plasticity Index
Job Mix		0.0%	100.0%	95.0%	0.0%	64.0%	23.0%	12.0%	7.0%	0.00%	21.0%	1.0%
Lot Number	Sample Number											
Plant Data												
1	1	0.0%	100.0%	95.3%	0.0%	57.8%	18.8%	10.7%	7.0%	0.00%	10.8%	0.0%
1	2	0.0%	100.0%	93.9%	0.0%	60.3%	19.8%	11.1%	7.2%	0.00%	0.0%	0.0%
1	3	0.0%	100.0%	93.8%	0.0%	59.0%	19.8%	11.0%	7.4%	0.00%	14.2%	0.0%
1	4	0.0%	100.0%	94.1%	0.0%	59.5%	21.8%	11.0%	7.1%	0.00%	0.0%	0.0%
2	1	0.0%	100.0%	93.4%	0.0%	59.7%	21.3%	11.1%	7.1%	0.00%	11.5%	0.0%
2	2	0.0%	100.0%	91.7%	0.0%	49.9%	16.9%	8.6%	5.6%	0.00%	0.0%	0.0%
2	3	0.0%	100.0%	94.6%	0.0%	57.7%	20.0%	10.7%	6.7%	0.00%	12.9%	0.0%
2	4	0.0%	100.0%	95.4%	0.0%	64.2%	24.0%	11.5%	7.2%	0.00%	0.0%	0.0%
3	1	0.0%	100.0%	93.8%	0.0%	54.0%	19.8%	10.7%	6.9%	0.00%	12.0%	0.0%
3	2	0.0%	100.0%	96.6%	0.0%	64.9%	25.6%	11.3%	6.7%	0.00%	0.0%	0.0%
3	3	0.0%	100.0%	97.7%	0.0%	61.9%	24.9%	12.4%	7.4%	0.00%	14.2%	0.0%
3	4	0.0%	100.0%	97.0%	0.0%	61.5%	24.5%	12.5%	7.5%	0.00%	0.0%	0.0%
4	1	0.0%	100.0%	96.4%	0.0%	60.7%	23.7%	11.9%	7.0%	0.00%	16.0%	0.0%
4	2	0.0%	100.0%	99.0%	0.0%	68.1%	23.0%	11.7%	6.9%	0.00%	0.0%	0.0%
4	3	0.0%	100.0%	97.6%	0.0%	66.1%	22.3%	11.3%	6.6%	0.00%	14.9%	0.0%
4	4	0.0%	100.0%	98.2%	0.0%	65.6%	22.6%	11.5%	6.9%	0.00%	0.0%	0.0%
5	1	0.0%	100.0%	97.4%	0.0%	70.2%	25.5%	12.8%	7.5%	0.00%	12.7%	0.0%
5	2	0.0%	100.0%	97.0%	0.0%	63.2%	22.0%	11.2%	6.8%	0.00%	0.0%	0.0%
5	3	0.0%	100.0%	95.2%	0.0%	63.7%	22.1%	11.0%	6.5%	0.00%	14.9%	0.0%
5	4	0.0%	100.0%	91.5%	0.0%	63.7%	22.6%	11.3%	6.5%	0.00%	0.0%	0.0%
Plant Data												
	Count:	20	20	20	20	20	20	20	20	20	20	20
	Mean:	0.0%	100.0%	95.5%	0.0%	61.6%	22.0%	11.3%	6.9%	0.0%	6.7%	0.0%
	Standard Deviation:	0.00	0.00	2.12	0.00	4.72	2.34	0.86	0.44	0.00	6.98	0.00
Monitor												
1	1	0.0%	100.0%	96.0%	0.0%	55.8%	18.1%	10.0%	3.4%	0.00%	14.0%	0.0%
1	2	0.0%	100.0%	94.4%	0.0%	63.0%	26.0%	13.5%	8.7%	0.00%	14.0%	0.0%
1	3	0.0%	100.0%	92.2%	0.0%	48.0%	17.9%	10.0%	6.2%	0.00%	14.0%	0.0%
1	4	0.0%	100.0%	93.8%	0.0%	49.4%	16.6%	8.9%	5.8%	0.00%	14.0%	0.0%
2	2	0.0%	100.0%	92.0%	0.0%	48.4%	16.8%	8.9%	5.9%	0.00%	14.0%	0.0%
3	1	0.0%	100.0%	94.3%	0.0%	55.4%	19.5%	10.7%	7.2%	0.00%	14.0%	0.0%
3	2	0.0%	100.0%	97.4%	0.0%	64.4%	25.0%	10.4%	6.2%	0.00%	14.0%	0.0%
3	3	0.0%	100.0%	98.9%	0.0%	65.3%	26.3%	11.9%	7.1%	0.00%	14.0%	0.0%
4	1	0.0%	100.0%	97.8%	0.0%	66.8%	22.0%	10.7%	6.8%	0.00%	14.0%	0.0%
5	1	0.0%	100.0%	96.7%	0.0%	67.9%	23.4%	9.9%	6.2%	0.00%	14.0%	0.0%
5	4	0.0%	100.0%	98.3%	0.0%	66.0%	23.9%	9.2%	5.8%	0.00%	14.0%	0.0%
Monitor Data												
	Count:	11	11	11	11	11	11	11	11	11	11	11
	Mean:	0.0%	100.0%	95.6%	0.0%	59.1%	21.4%	10.4%	6.3%	0.0%	14.0%	0.0%
	Standard Deviation:	0.00	0.00	2.42	0.00	7.89	3.74	1.36	1.29	0.00	0.00	0.00
Report												
	(F):	0.00	0.00	1.31	0.00	2.79	2.56	2.48	8.56	0.00	0.00	0.00
	(F.99):	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.43 *******	3.43	3.43	3.43
	AM-AC:	0.0	0.0	0.1	0.0	2.5	0.6	0.9	0.6	0.0	7.3	0.0
	MU:	0.0	0.0	2.5	0.0	7.7	3.7	1.3	1.2	0.0	4.5 *******	0.0

CMA Comparison Analysis Report

Knowledge Check

Chapter 2 Quality Assurance/Dense-graded Aggregates Program

1. What determines the lot size for a specified material accepted under the Statistical QA Program?

   A. Production tonnage
   B. Discretion of the District Materials Engineer
   C. Size aggregate
   D. A and B

2. A normal lot is represented by how many test samples?

   A. 8
   B. 2
   C. 3
   D. 4

3. The Producer's Technician is responsible for making batch adjustments.

   A. True
   B. False

4. The job-mix formula is approved by the:

   A. Project Inspector
   B. Producer's Technician
   C. District Materials Engineer
   D. Resident Engineer

5. The Project Inspector is responsible for the submission of the job-mix formula.

   A. True
   B. False

6. One of the duties of the District Materials Engineer's CMA staff technician is to provide technical guidance to the Producer's Technician.

   A. True
   B. False

7. The inspection, sampling, and testing of the aggregates for conformance with the VDOT Specifications are the responsibilities of the:

   A. Project Inspector
   B. Weighperson
   C. Producer's Technician
   D. VDOT representative

8. Must the Producer's Technician in a plant producing Aggregate Base, Subbase and Select Material, Type I be a certified CMA Technicians?

   A. Yes
   B. No

9. When must the job-mix formula be submitted by the Producer?

10. How long does the Department have to evaluate a job mix formula change?

11. A system that allows resampling and retesting where there is doubt that the original test results are valid is the:

    A. Referee System
    B. Variability System
    C. Process Tolerance System
    D. Standard Deviation System

12. A chart that is set up to alert the Producer when to investigate his process is a Control Chart.

    A. True
    B. False

13. The job-mix formula for Aggregate Bases, Subbases, and Select Material, Type I is chosen from the:

    A. Standard Deviation
    B. Design Range
    C. Process Tolerance
    D. Acceptance Range

14. In the production of Cement Stabilized Aggregate, no one sample shall have a cement content more than 1.3 percent below that stated on the Job-Mix Formula.

    A. True
    B. False

15. Is it permissible to accept Central Mix Aggregate by visual inspection?

    A. Yes
    B. No

16. Who approves the source and quality of materials for use in Central Mix Aggregates?

17. Who is required to furnish a plant laboratory?

18. The job acceptance sample for central mix aggregate bases, subbases and select material is taken from:

    A. Conveyer belt
    B. Mini-stockpile
    C. Barge
    D. Truck

19. What is the difference in taking a sample of stabilized and non-stabilized material?

20. Does the Plant Quality Control Technician run job acceptance samples when the Producer is stockpiling?

    A. Yes
    B. No

3 SAMPLING AND TESTING AGGREGATES

Testing

As stated in the previous chapter, the Producer shall furnish and maintain a plant laboratory, meeting the requirements of Section 106.07 of the Road and Bridge Specifications.

Test and Equipment

Test procedures shall be conducted in accordance with the standards referenced in the current specifications. Testing for Gradation and Atterberg Limits will be conducted on the Department's verification samples to accommodate the testing requirements, a field or plant laboratory shall be furnished and contain the following equipment:

1 - Motorized screen shaker for fine and coarse grading analysis.

1 - Set of sieves for the motorized shaker. The screen sizes shall include the specification sizes for the type of material being produced.

1 - Balance having a capacity of at least 45 lbs. (20 kg), with a sensitivity of one ounce (28 grams) or less.

1 - Balance having a capacity of at least 2.5 lbs. (1 kg), with a sensitivity of 0.1 gram or less.

1 - Drying apparatus.

1 - Set of liquid and plastic limit devices.

Producers shipping only coarse open-graded aggregate shall not be required to obtain Atterberg Limit equipment.

Under the QA program, a certified technician must be present at all times during the mixing of the final product. Such technician shall be capable of designing, sampling, testing and adjusting the mixture.

Sieve Analysis

Aggregate gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve. Sieve numbers and sizes most often used in grading aggregates for aggregate paving mixtures are given in the table below.

Nominal Dimensions

of U. S. Standard Sieves AASHTO M 92

Sieve Designation Alternate Inches	Standard mm	Nominal Sieve Opening inches
3	75.0	3.00
2	50.0	2.00
1 ½	37.5	1.50
1	25.0	1.00
¾	19.0	0.750
3/8	9.5	0.375
No. 4	4.75	0.187
No. 10	2.00	0.0787
No. 20	0.850	0.0331
No. 40	0.425	0.0165
No. 60	0.250	0.0098
No. 80	0.180	0.0070
No. 100	0.150	0.0059
No. 200	0.075	0.0029

Sieve sizes to be checked for compliance for the various mixtures are designated in the specifications. See the Road and Bridge Specifications. Gradations are expressed on the basis of the total percent passing, which indicates the total percent of aggregate by weight that will pass a given size sieve.

Some of the descriptive terms used in referring to aggregate gradation are:

(a) Coarse aggregate – all of the material retained on the No. 10 sieve (2.00 mm).

(b) Fine aggregate or soil mortar – all of the material passing the No. 10 (2.00 mm) sieve.

Procedure for Sieve Analysis of Dense Graded Aggregates

Dry sieve analysis and washed sieve analysis are two methods of determining proportions of various particle sizes in a mineral aggregate. In Virginia, however, a combination of both methods is used in performing a sieve analysis on aggregates. Standard procedures for performing the sieve analysis are given in VTM-25. The steps are as follows:

1. Obtain a representative sample of the material from a 30 to 40 lbs. (13.6 to 18.1 kg) field sample by either a sample splitter or the quartering method. (See Paragraphs (a) and (b) below.) The sample of material should be reduced to a test sample weighing not less than 5000 grams dry weight.

   (a) Sample Splitter - A suitable riffle sampler or sample splitter for proportional splitting of the material which is capable of obtaining representative portions of the sample without loss of fines.

   (b) Quartering Method – The following method of sample - size reduction by quartering is outlined for use when a conventional sample splitter is not available.

      (1) Uniformly distribute a shovel full of the aggregate over a wide, flat area on a tight weave canvas or other smooth surface. Continue to distribute shovelfuls of material in layers until all the sample is used to make a wide, flat pile that is reasonably uniform in thickness and distribution of aggregate sizes. Do not permit coning of the aggregate.

      (2) Divide the pile cleanly into equal quarters with a square-end shovel or straight piece of sheet metal. When a canvas is used, the division may be conveniently made by inserting a thin stick (or rod) under the canvas and raising it to divide the sample equally, first into halves, then into quarters.

      (3) Remove two opposite quarters and set aside.

(4) Repeat the foregoing procedure with the remaining portion of the aggregate until a test sample of desired size is obtained.

(5) Store the portion that has been set aside for possible check testing.

2. Accurately weigh the wet sample. Record this wet weight on a moisture worksheet. This material will not only be used for the gradation test but also for the moisture test.

   Example: 5922 grams.

3. Dry aggregate sample thoroughly. The sample is dried to a constant weight by air-drying using a drying apparatus; this sample must be dried at a temperature not exceeding 230° F (110°C).

4. To complete the required tests it will also be necessary to take a small sample from the remaining material; this sample must be dried at a temperature of no more than 140° F (60° C). From this small sample the material passing the No. 40 (425 µm) sieve will be extracted to run Atterberg Limits.

5. After the sample that was taken for the gradation test and moisture test is dried to a constant weight and cooled, accurately weigh the dried sample. In weighing and handling the sample, extreme care must be taken to avoid any loss of material, as this will affect the accuracy of the results. Also, do not adjust the weight of the sample to an even figure, such as 5000 g, 5500 g, etc. Use the entire reduced and dried sample.

6. Record the weight of the dried sample. This weight is used for two purposes. First, it is recorded on the moisture worksheet and used to determine the percent of total moisture in the sample and, second, it is used as the weight of the total sample for computing the gradation of the sample obtained by either a sample splitter or quartering method.

7. Calculate the moisture content in the sample. We can determine the percent of total moisture of the sample by the following formula.

$$\% \text{ Moisture} = \frac{(\text{wt. of wet mat'l}) - (\text{wt. of dry mat'l.})}{\text{wt. of dry mat'l}} \times 100$$

wt. of wet mat'l = 5922
wt. of dry mat'l = 5640

$$\% \text{ moisture} = \frac{(5922 - 5640)}{5640} \times 100$$

$$\% \text{ moisture} = \frac{282}{5640} \times 100$$

$$\% \text{ moisture} = .05 \times 100 = 5.0$$

Note: When calculating the moisture content, round answer to the nearest 0.1 percent

8. Shake the sample in a mechanical shaker. If no clay and silt is sticking to the aggregate there is not a problem. If this is a problem, buff the entire test sample. The sample is usually by a mechanical device in which a scoopful of the aggregate is placed into a metal bowl and a rotating hard rubber mall is lowered into the material removing the dust from the stone. If the total test sample is made up of hard, fairly clean material, then the buffing of the test sample can be eliminated.

   Note: Prior to running a sieve analysis for either coarse or fine aggregates, using a mechanical shaker, the shaker should be calibrated annually as outlined in VCM-20.

9. Separate the + No. 10 (+ 2.00 mm) (coarse) portion of the test sample into individual sizes using large sieves mounted in frames. These sieves are arranged with the more coarse sieve at the top 3 inch (75 mm); each sieve below is finer; and the finest sieve, a + No. 10 (2.00 mm) is at the bottom. It will take approximately seven to ten (10) minutes of shaking to separate the material.

10. Weigh and record the weights of the + No. 10 (+ 2.00 mm) material retained on each sieve. Suppose, upon examination of the sieves, that the first sieve we found material retained on was the 1 inch (25.0 mm) sieve. The material is carefully removed, placed on the balance and the weight recorded on the 1 inch (25.0 mm) under grams retained. This material is then removed from the balance and the next sieve examined for material retained.

The material from the next sieve in this example the 3/4 inch (19.0 mm) sieve is carefully removed and placed on the balance and the weight recorded on the 3/4 inch (19.0 mm) under grams retained. This procedure is done for each successive sieve.

Example - Recorded weights of Coarse gradation (+10) material:

Mechanical Analysis of Total Sample				Mechanical Analysis of Soil Mortar			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing	Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)				37.5 mm (1 ½)			
25.0 mm (1)	**1155**			25.0 mm (1)			
19.0 mm (3/4)	**470**			19.0 mm (3/4)			
9.50 mm (3/8)	**860**			9.50 mm (3/8)			
4.75 mm (4)	**540**			4.75 mm (4)			
2.0 mm (10)	**445**			2.0 mm (10)			
.850 mm (20)				.850 mm (20)			
.425 mm (40)				.425 mm (40)			
.250 mm (60)				.250 mm (60)			
.180 mm (80)				.180 mm (80)			
.150 mm (100)				.150 mm (100)			
. 075 mm (200)				.075 mm (200)			
Total	**5640**			Total	**166.1**		

11. <u>Obtain a representative sample of the material passing the No. 10 (2.00 mm) sieve (fine material).</u> The material passing the <u>No. 10 (2.00 mm) sieve</u> is thoroughly mixed and, using a small sample splitter, is reduced until a fine gradation sample weighing between 125 - 200 grams is obtained.

12. <u>Weigh the reduced fine gradation sample.</u> Again, care must be exercised in weighing and handling the sample, as any loss of material will affect the accuracy of the results. Use the entire reduced sample.

13. <u>Record the weight of the fine gradation sample.</u> This weight is recorded and used as the total weight for computing the gradation of the soil mortar. The weight should be recorded to the nearest 0.1 gram

14. Place the fine gradation material on a No. 200 (75 µm) sieve and gently wash by passing running water through the sample. When the wash water passing through the sample is clear, the sample is considered clean. The washed material is then transferred to a drying dish and dried at 230 ± 9°F (110 ± 5°C).

15. Separate the fine gradation -10 (2.00 mm) material into individual sizes using the standard 8 in. (200 mm) diameter sieves. The sieves normally used are: No. 20 (850µm), No. 40 (425 µm), No. 60, (250 µm), No. 80 (180 µm), No. 100 (150 µm), and No. 200 (75 µm) . These sieves are arranged with the coarser sieve at the top; each sieve below is finer; and the finest sieve, a No. 200 (75 µm), is at the bottom. A pan is placed below to retain any fine material that may pass this sieve.

    The dried sample is placed on the top sieve, and the entire nest of sieves is placed in a shaker that produces a circular and tapping motion, or in other approved shaking devices. This motion assists gravity in settling the individual aggregate particles on the sieve which will properly identify the size of that particular particle.

    Note: Prior to running a sieve analysis for either coarse or fine aggregates, using a mechanical shaker, the shaker should be calibrated annually as outlined in VCM-20.

16. Weigh and record the weights of the fine gradation sample No. 200 (75 µm) retained on each sieve to the nearest 0.1 gram. Suppose upon examination of the sieves, that the first sieve we found material retained on was the No. 20 sieve (850 µm) . The material is carefully removed, placed on the balance and the weight recorded under the "mechanical analysis of soil mortar" as grams retained for the +No. 20 sieve (+ 850 µm). This material is then removed from the balance and the next sieve examined for material retained. The material from the next sieve in this example No. 40 (425 µm) sieve is carefully removed and placed on the balance and the weight recorded on + No. 40 (+425 µm) sieve under "grams retained". This procedure is done for each successive sieve. The weights should be recorded to the nearest 0.1 gram.

Example – Recorded weights of fine gradation (-10) material:

Mechanical Analysis of Total Sample				Mechanical Analysis of Soil Mortar			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing	Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)				37.5 mm (1 ½)			
25.0 mm (1)	**1155**			25.0 mm (1)			
19.0 mm (3/4)	**470**			19.0 mm (3/4)			
9.50 mm (3/8)	**860**			9.50 mm (3/8)			
4.75 mm (4)	**540**			4.75 mm (4)			
2.0 mm (10)	**445**			2.0 mm (10)			
.850 mm (20)				.850 mm (20)	**36.9**		
.425 mm (40)				.425 mm (40)	**26.6**		
.250 mm (60)				.250 mm (60)	**15.9**		
.180 mm (80)				.180 mm (80)	**7.8**		
.150 mm (100)				.150 mm (100)	**5.8**		
. 075 mm (200)				.075 mm (200)	**19.8**		
Total	**5640**			Total	**166.1**		

17. <u>Determine the percent retained on each sieve.</u> Up to this point we have made entries for the weight of the total sample, weight of each +No. 10 (2.00 mm) sieve, weight of the fine gradation sample -No. 10 (2.00 mm) material and weight of each - No. 10 (2.00 mm) sieve. In order to determine the percent retained, we must divide the grams retained on each sieve by the total dry weight of the sample (5640) for the +No. 10 (2.00 mm) sieves and the total dry weight of the sample (166.1) for the -No. 10 (2.00 mm) sieves.

Coarse Gradation Computation

$$\frac{\text{Grams Retained}}{\text{Total Weight}} \times 100 = (\%) \text{ Retained}$$

Mechanical Analysis of Total Sample			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)			
50.0 mm (2)			
37.5 mm (1 ½)			
25.0 mm (1)	**1155**	**20.5%**	
19.0 mm (3/4)	**470**	**8.3%**	
9.50 mm (3/8)	**860**	**15.2%**	
4.75 mm (4)	**540**	**9.6%**	
2.0 mm (10)	**445**	**7.9%**	
.850 mm (20)			
.425 mm (40)			
.250 mm (60)			
.180 mm (80)			
.150 mm (100)			
.075 mm (200)			
Total	**5640**		

$$\frac{\text{Grams Retained}}{\text{Total Weight}} \times 100 = (\%) \text{ Retained}$$

$$\frac{1155}{5640} \times 100 = 20.5\%$$

$$\frac{470}{5640} \times 100 = 8.3\%$$

$$\frac{860}{5640} \times 100 = 15.2\%$$

$$\frac{540}{5640} \times 100 = 9.6\%$$

$$\frac{445}{5640} \times 100 = 7.9\%$$

Fine Gradation Computation

MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)			
50.0 mm (2)			
37.5 mm (1 ½)			
25.0 mm (1)			
19.0 mm (3/4)			
9.50 mm (3/8)			
4.75 mm (4)			
2.0 mm (10)			
.850 mm (20)	**36.9**	**22.2**%	
.425 mm (40)	**26.6**	**16.0**%	
.250 mm (60)	**15.9**	**9.6**%	
.180 mm (80)	**7.8**	**4.7**%	
.150 mm (100)	**5.8**	**3.5**%	
.075 mm (200)	**19.8**	**11.9**%	
Total	**166.1**		

$$\frac{\text{Grams Retained}}{\text{Total Weight}} \times 100 = (\%) \text{ Retained}$$

$$\frac{36.9}{166.1} \times 100 = 22.2\%$$

$$\frac{26.6}{166.1} \times 100 = 16.0\%$$

$$\frac{15.9}{166.1} \times 100 = 9.6\%$$

$$\frac{7.8}{166.1} \times 100 = 4.7\%$$

$$\frac{5.8}{166.1} \times 100 = 3.5\%$$

$$\frac{19.8}{166.1} \times 100 = 11.9\%$$

18. Determine the percent passing for the +No. 10 (2.00 mm) material (coarse gradation). We must first place the figure 100.0 (%) in the "percent passing" column above the screen having the first entry of grams retained. By subtracting the percent retained from the percent passing the next larger sieve, we obtain the percent passing. This process is repeated for each sieve until the percent passing the No. 10 (2.00 mm) is obtained. All calculations should be recorded to the nearest 0.1 percent

Calculations for Percent Passing

Mechanical Analysis of Total Sample			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)			
50.0 mm (2)			
37.5 mm (1 ½)			**100.0**
25.0 mm (1)	**1155**	**20.5%**	**79.5**
19.0 mm (3/4)	**470**	**8.3%**	**71.2**
9.50 mm (3/8)	**860**	**15.2%**	**56.0**
4.75 mm (4)	**540**	**9.6%**	**46.4**
2.0 mm (10)	**445**	**7.9%**	**38.5**
.850 mm (20)			
.425 mm (40)			
.250 mm (60)			
.180 mm (80)			
.150 mm (100)			
. 075 mm (200)			
Total	**5640**		

% Passing - % Retained = % Passing

NOTE: 100% is always placed in the percent passing column one line above the screen having the first entry of grams retained.

100.0 - 20.5 = 79.5

79.5 - 8.3 = 71.2

71.2 - 15.2 = 56.0

56.0 - 9.6 = 46.4

46.4 - 7.9 = 38.5

19. Determine the percent passing for the fine gradation sample -No. 10 (2.00 mm) material). Again, we must first place the figure 100.0 (%) in the "percent passing" column above the screen having the first entry of grams retained. By subtracting the percent retained from the percent passing the next larger sieve, we obtain the percent passing. This process is repeated for each sieve until the percent passing the No. 200 (75 µm) is obtained. All calculations should be recorded to the nearest 0.1 percent.

MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)			
50.0 mm (2)			
37.5 mm (1 ½)			
25.0 mm (1)			
19.0 mm (3/4)			
9.50 mm (3/8)			
4.75 mm (4)			
2.0 mm (10)			**100.0**
.850 mm (20)	**36.9**	**22.2**%	**77.8**
.425 mm (40)	**26.6**	**16.0**%	**61.8**
.250 mm (60)	**15.9**	**9.6**%	**52.2**
.180 mm (80)	**7.8**	**4.7**%	**47.5**
.150 mm (100)	**5.8**	**3.5**%	**44.0**
.075 mm (200)	**19.8**	**11.9**%	**32.1**
Total	**166.1**		

% Passing - % Retained = % Passing

NOTE: 100% is always placed in the percent passing column one line above the screen having the first entry of grams retained.

100.0 -22.2 = 77.8

77.8 - 16.0 = 61.8

61.8 - 9.6 = 52.2

52.2 - 4.7 = 47.5

47.5 - 3.5 = 44.0

44.0 - 11.9 = 32.1

20. **<u>Determine the percent retained for the -No. 10 (2.00 mm) material of the total sample.</u>** By multiplying the percent passing the No. 10 (2.00 mm) of the total sample by the percent retained on each of the sieves of the fine gradation -No. 10 (2.00 mm) sample and then dividing by 100 , we can calculate the percent retained on each sieve of the -No. 10 (2.00 mm) material for the total sample.

% Passing (No.10) × % Retained Soil Mortar /100 = % Retained Total Sample

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAIN	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINE	PERCENT RETAINE	PERCENT PASSING
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)			**100.0%**	37.5 mm (1 ½)			
25.0 mm (1)	**1155**	**20.5%**	**79.5%**	25.0 mm (1)			
19.0 mm (3/4)	**470**	**8.3%**	**71.2%**	19.0 mm (3/4)			
9.50 mm (3/8)	**860**	**15.2%**	**56.0%**	9.50 mm (3/8)			
4.75 mm (4)	**540**	**9.6%**	**46.4%**	4.75 mm (4)			
2.0 mm (10)	**445**	**7.9%**	**38.5%**	2.0 mm (10)			**100.0%**
.850 mm (20)		**8.5%**		.850 mm (20)	**36.9**	**22.2%**	**77.8%**
.425 mm (40)		**6.2%**		.425 mm (40)	**26.6**	**16.0%**	**61.8%**
.250 mm (60)		**3.7%**		.250 mm (60)	**15.9**	**9.6%**	**52.2%**
.180 mm (80)		**1.8%**		.180 mm (80)	**7.8**	**4.7%**	**47.5%**
.150 mm (100)		**1.3%**		.150 mm (100)	**5.8**	**3.5%**	**44.0%**
. 075 mm (200)		**4.6%**		.075 mm (200)	**19.8**	**11.9%**	**32.1%**
Total	**5640**			Total	**166.1**		

% Passing (No.10) × % Retained Soil Mortar /100 = % Retained Total Sample

38.5 x 22.2 = 854.7 / 100 = 8.54 8.5%

38.5 x 16.0 = 616.0 / 100 = 6.16 6.2%

38.5 x 9.6 = 369.6 / 100 = 3.69 3.7%

38.5 x 4.7 = 180.9 /100 = 1.80 1.8%

38.5 x 3.5 = 134.8 /100 = 1.34 1.3%

38.5 x 11.9 = 458.2 / 100 = 4.58 4.6%

21. **Determine the percent passing for the -No. 10 (2.00 mm) material of the total sample.** Again, by subtracting the percent retained from the percent passing the next larger sieve, we obtain the percent passing. This process is repeated for each sieve until the percent passing the No. 200 (75 µm) is obtained. All calculations should be recorded to the nearest 0.1 percent. For a quick check of your computations, remember that the percent retained and the percent passing the -No. 200 (75µm) sieve of the total sample should agree within 0.1 percent.

MECHANICAL ANALYSIS OF TOTAL SAMPLE			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)			
50.0 mm (2)			
37.5 mm (1 ½)			**100.0%**
25.0 mm (1)	**1155**	**20.5%**	**79.5%**
19.0 mm (3/4)	**470**	**8.3%**	**71.2%**
9.50 mm (3/8)	**860**	**15.2%**	**56.0%**
4.75 mm (4)	**540**	**9.6%**	**46.4%**
2.0 mm (10)	**445**	**7.9%**	**38.5%**
.850 mm (20)		**8.5%**	**30.0%**
.425 mm (40)		**6.2%**	**23.8%**
.250 mm (60)		**3.7%**	**20.1%**
.180 mm (80)		**1.8%**	**18.3%**
.150 mm (100)		**1.3%**	**17.0%**
. 075 mm (200)		**4.6%**	**12.4%**
Total	**5640**		

% Passing - % Retained = % Passing

NOTE: 100% is always placed in the percent passing column one line above the screen having the first entry of grams retained.

38.5 - 8.5 = 30.0
30.0 - 6.2 = 23.8
23.8 - 3.7 = 20.1
20.1 - 1.8 = 18.3
18.3 - 1.3 = 17.0
17.0 - 4.6 = 12.4

COMPLETED MECHANICAL SIEVE ANALYSIS							
Mechanical Analysis of Total Sample				Mechanical Analysis of Soil Mortar			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing	Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)			**100.0%**	37.5 mm (1 ½)			
25.0 mm (1)	**1155**	**20.5**%	**79.5%**	25.0 mm (1)			
19.0 mm (3/4)	**470**	**8.3**%	**71.2%**	19.0 mm (3/4)			
9.50 mm (3/8)	**860**	**15.2**%	**56.0%**	9.50 mm (3/8)			
4.75 mm (4)	**540**	**9.6**%	**46.4%**	4.75 mm (4)			
2.0 mm (10)	**445**	**7.9**%	**38.5%**	2.0 mm (10)			**100.0%**
.850 mm (20)		**8.5**%	**30.0%**	.850 mm (20)	**36.9**	**22.2**%	**77.8%**
.425 mm (40)		**6.2**%	**23.8%**	.425 mm (40)	**26.6**	**16.0**%	**61.8%**
.250 mm (60)		**3.7**%	**20.1%**	.250 mm (60)	**15.9**	**9.6**%	**52.2%**
.180 mm (80)		**1.8**%	**18.3%**	.180 mm (80)	**7.8**	**4.7**%	**47.5%**
.150 mm (100)		**1.3**%	**17.0%**	.150 mm (100)	**5.8**	**3.5**%	**44.0%**
. 075 mm (200)		**4.6**%	**12.4%**	.075 mm (200)	**19.8**	**11.9**%	**32.1%**
Total	**5640**			Total	**166.1**		

NOTE: When reporting results, percentages should be reported to the nearest whole number, except if the percentage passing the No 200 (75 µm) sieve is less than 10 percent, it shall be reported to the nearest 0.1 percent.

Atterberg Limits

Liquid Limit

Definition: The amount of water (percent of moisture) that it takes for a soil to pass from a plastic to a liquid state.

The Atterberg Limits provide a measure of the consistency of the soil. With the gradation test completed, we now return to the small sample that has been drying at a maximum of 140°F (60°C) note*: Sample may be dried at 230 degrees F if the fine faction of aggregate sample is free of organic matter or a minimal amount which does not affect liquid and plastic results*. From this sample we must obtain the -No. 40 (-425 µm) material on which the Liquid Limit and Plastic Limit will be run. VDOT uses the procedure outlined in AASHTO T-89 Method B, except as modified by VTM-7, to perform routine liquid limit tests. AASHTO T-89 Method A except as modified by VTM-7 is used for referee testing.

The modification to the test method regards the sensitivity of the balance used. AASHTO T-89 requires that the balance conform to M 231, Class G1. A Class G1 balance has a readability of 0.01 grams. VTM- 7 states that a balance with a sensitivity of 0.10 grams may be used.

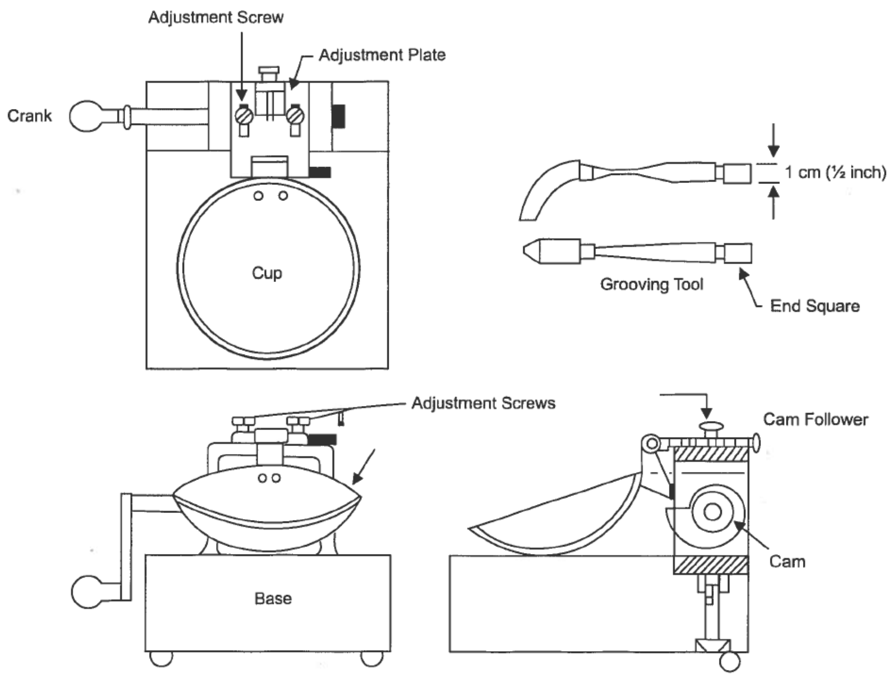
The steps for the tests procedures are outlined as follows:

l. <u>Buff and sieve the entire sample using a No. 10 (2.00 mm) sieve.</u> Buff the sample using the same procedure as outlined for the gradation sample. The material retained on the No. 10 (2.00 mm) sieve may be discarded.

2. <u>Buff and sieve a representative sample of the material passing the No. 10 (2.00 mm) sieve using a No. 40 (425 µm) sieve with a sieve pan under it.</u> Again use the same procedure for buffing as outlined for the gradation sample. The material retained on the No. 40 (425 µm) should be rebuffed and resieved until little or no material is passing the No. 40 (425 µm) sieve. The No. -40 (-425 µm) material is used for the Atterberg Limits.

3. <u>The Liquid Limit device should be inspected to determine that the device is in good working order.</u> There should be no excessive wear in the pin connecting the cup, nor a groove cut in the cup through long usage. The Liquid Limit Cup should be inspected for proper thickness. The grooving tool should be inspected to determine if there is excessive wear on the cutting edge. It is essential that the Liquid Limit cup be adjusted so that, when it is raised, the contact point of the cup is 10.0 mm ± 2 mm above the base (the back end of the grooving tool is 10.0 mm in thickness). The adjustment plate is manipulated back and forth by loosening the

screws in its tip and turning the set screw at the back. With the 10.0 mm gauge held in place, the adjustment plate is moved so that when the crank is revolved, there is a slight ringing sound when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustments are necessary.



4. Obtain a sample weighing approximately 50 grams from the thoroughly mixed portion of the material passing the No. 40 (425 µm) sieve. Place this material in a mixing dish and mix with 8-10 ml of distilled or demineralized water. The material is mixed by alternately and repeatedly stirring, kneading, and chopping with a spatula. If additional water is needed in the mixture, it shall be added increments of 1-3 ml. It shall then be thoroughly mixed in stiff consistency.

   NOTE: The cup of the Liquid Limit device shall not be used for mixing soil and water.

5. Place a portion of this mixture in the cup of the Liquid Limit device above the spot where the cup rests on the base and, with a spatula, squeeze and spread the material with as few strokes as possible. The material is then leveled and at the same time trimmed to a depth of 1/2 inch (1.0 cm) at the point of maximum thickness.

6. Divide the soil in the cup by firm strokes of the grooving tool along a diameter of the centerline of the cam follower. To avoid tearing the side of the groove or slipping the soil cake on the cup, up to six (6) strokes may be permitted to form this groove. A stroke is considered one motion from back-to-front or front-to-back. The depth of the groove shall be increased with each stroke, and only the last stroke shall scrape the bottom of the cup.

7. The cup containing the soil sample shall be lifted and dropped by turning the crank at the rate of two (2) revolutions per second until the two sides of the sample make contact at the bottom of the groove along a distance of about 1/2 inch (12.5 mm) . The groove must be closed between 20 and 30 blows. If the closure is met between the required blows, remove the material from the cup and return it to the bowl. Do not add any additional water. Repeat steps 5 and 6. If the second closure is between 20 and 30 blows and within 2 blows of the first closure record the number as directed in step 8.

   If the groove closes before 20 blows, the material is too wet and must be discarded or returned to the mixing dish and mixed and kneaded until enough evaporation has taken place for the closure point to fall within an acceptable range . If it takes more than 30 blows to close the groove, the material is too dry and must be returned to the mixing dish. Then add a small increment of water and remix thoroughly.

   NOTE: While the crank is being turned, the base of the machine should not be held.

8. Record the number of blows to close the groove 1/2 inch (12.5 mm) on the worksheet in the "Liquid Limit Section".

9. Remove and place in a suitable container with a close-fitting lid, a slice of soil approximately the width of the spatula (3/4 inch) extending from edge-to–edge of the soil cake, and at right angles to the portion of the groove in which the soil flows together. The covered container and soil shall then be weighed to the nearest 0.1 gram and recorded on the form.

   NOTE: The weight of the empty container and lid should already be recorded on the form in the space marked "Dish".

10. Dry the soil in the container to a constant weight at 230 ± 9°F (110 ± 5°C) and record the weight of the covered container and dry soil. Again, the weight should be recorded to the nearest 0.1 gram.

Liquid Limit	
Dish No. **160**	No. of Blows **28**
Dish & Wet Soil **42.4**	Dish & Dry Soil **38.6**
Dish & Dry Soil **38.6**	Dish **19.4**
Mass of Water	Dry Soil
% Moisture = Mass of Water / Dry Soil x 100 =	
L.L. = =	

11. Calculate the Liquid Limit of the material. First we must determine the weight of the water. To determine the weight of the water, we must subtract the weight of the dish and dry soil from the weight of the dish and wet soil. Record the weight of the water on the form in the space marked "Mass of Water"

12. Secondly, we must determine the weight of the dry soil. To determine the weight of the dry soil, we must subtract the weight of the dish from the weight of the dish and dry soil. Record the weight of the dry soil on the form in the space marked "Dry Soil".

13. We are now ready to calculate the percent moisture or limit at which the soil becomes liquid. To determine the percent of moisture, we divide the weight of the water by the weight of the dry soil and multiply by "100". Record this in the space marked "% Moisture". Since our Liquid Limit Test is based on a standard of 25 blows to close the groove, and if we had a number other than 25, we must use a factor to convert the moisture to what it would have been if the groove had closed at 25 blows.

    A chart of correction factors is supplied to all pugmill laboratories (See page 3-20). By multiplying the percent of moisture by the correction factor, we determine the true Liquid Limit. The Liquid Limit is first recorded to the nearest 0.1 gram on the worksheet, but reported in PLAID to the nearest whole number. 5 or above - round up, 4 or below - round down.

Step (1) **42.4**
- 38.6
3.8

Liquid Limit	
Dish No. 160	No. of Blows 28
Dish & Wet Soil 42.4	Dish & Dry Soil 38.6
Dish & Dry Soil 38.6	Dish 19.4
Mass of Water 3.8	Dry Soil 19.2
% Moisture = Mass of Water / Dry Soil x 100 = 19.8	
L.L. = 20.1 = **20**	

Step (2) **38.6**
- 19.4
19.2

Step (3) % Moisture = $\frac{3.8}{19.2}$ x 100 = 19.8

Step (4) L.L. = 19.8 x 1.014 (factor for 28 blows) = 20.1 = 20

Liquid Limit Chart

L. L. = M(f)

Where : L. L. = Liquid Limit

M = % Moisture

f = Correction Factor

N = Number of Blows

N		f
15	=	0.940
16	=	0.947
17	=	0.954
18	=	0.961
19	=	0.967
20	=	0.973
21	=	0.979
22	=	0.985
23	=	0.990
24	=	0.996
25	=	1.000
26	=	1.005
27	=	1.009
28	=	1.014
29	=	1.018
30	=	1.022
31	=	1.026
32	=	1.030
33	=	1.034
34	=	1.038
35	=	1.042
36	=	1.045
37	=	1.049
38	=	1.052
39	=	1.055
40	=	1.059

Example : % Moisture at 22 blows = 42.3

From Table for 22 blows, f = 0.985

L. L. = 42.3 X 0.985

L. L. = 41.7 = 42

Plastic Limit

Definition: The amount of water (percent of moisture) that it takes for a soil to pass from a semi-solid to a plastic state.

VDOT uses the procedure outlined in AASHTO T-90, except as modified by VTM-7, to perform determine the plastic limit and plasticity index of soils. The modification to the test method regards the sensitivity of the balance used. AASTHO T-90 requires that the balance conform to M 231, Class G1. A Class G1 balance has a readability of 0.01 grams. VTM- 7 states that a balance with a sensitivity of 0.10 grams may be used.

1. To determine the plastic limit, remove an 8-gram portion of the thoroughly mixed material that is to be used for the liquid limit test. The sample may be removed at any time after the material becomes plastic enough to be easily shaped into a ball without sticking excessively to the fingers when squeezed, or at the completion of the liquid limit test.

2. From the 8-gram mass of mixed material, break off a 1.5 - 2.0 gram portion. Squeeze and form the sample into an ellipsoidal-shaped mass and roll this mass between the fingers and a piece of glass or unglazed paper lying on a smooth horizontal surface, with just enough pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position. This operation shall continue until the thread becomes 1/8 inch (3.0 mm) in diameter. At no time shall the operator attempt to produce failure at exactly 1/8 inch (3.0 mm) by either reducing the rate of rolling or increasing the pressure. If a sample cannot be rolled to a thread of 1/8 inch (3.0 mm) on the first attempt, it shall be considered non-plastic and no further testing is necessary. Record NP for non-plastic under "Plastic Limit".

3. Should the sample roll down to 1/8 inch (3.0 mm), break the thread into 6 to 8 pieces and squeeze the pieces together between the thumb and fingers of both hands. Again, shape the material into a uniform mass roughly ellipsoidal shaped and re-roll. Continue this alternate rolling to a thread 1/8 inch (3.0 mm) in diameter, gathering together, kneading, and re-rolling until the thread crumbles under pressure required for rolling the soil no longer can be rolled into a thread. The crumbling may occur when the thread is of a diameter greater than 1/8 inch (3.0 mm). This shall be considered a satisfactory end point, provided this has previously been rolled into a 1/8 inch (3.0 mm) thread.

The crumbling will manifest itself differently with the various types of soils. Repeat steps 2 and 3 until the 8-gram portion of material is completely tested.

4. At the conclusion of the rolling when the sample has finally crumbled, gather the soil, place in a suitable container with a close-fitting lid and weigh. This weight must be recorded to the nearest 0.1 gram on the form in the space marked "Dish & Wet Soil".

   NOTE: The weight of the empty container and lid should already be recorded on the form in the space marked "Dish".

5. Dry the soil in the container to a constant weight at 230 ± 9°F (110 ± 5°C) and re-weigh. Record the weight in the space marked "Dish and Dry Soil". Again, the weight must be recorded to the nearest 0.1 gram.

.

Plastic Limit	
Dish No. 136	
Dish & Wet Soil 36.1	Dish & Dry Soil **33.7**
Dish & Dry Soil **33.7**	Dish 20.0
Mass of Water	Dry Soil
P. L. = Mass of Water / Dry Soil x 100 =	

6. Calculate the Plastic Limit of the Material. First, we must determine the mass of the water. To determine the weight of the water, we must subtract the weight of the dish and dry soil from the weight of the dish and wet soil. Record the weight of the water on the form in the space labeled, **Mass of Water.**

   Secondly, as for the Liquid Limit, we must determine the weight of the dry soil. To determine the weight of the dry soil, we must subtract the weight of the dish from the weight of the dish and dry soil. Record the weight in the space labeled **Dry Soil** on the form.

   We are now ready to calculate the percent of moisture or limit at which the soil becomes plastic. To determine the percent moisture, we divide the weight of the water by the weight of the dry soil and multiply by "100". **A conversion factor is not needed to compute the Plastic Limit.**

The Plastic Limit is first recorded to the nearest 0.1 gram on the work sheet, then round to the nearest whole number. 5 or above - round up, 4 or below - round down.

Step (1) 36.1 - 33.7 = 2.4

Plastic Limit	
Dish No. 136	
Dish & Wet Soil 36.1	Dish & Dry Soil 33.7
Dish & Dry Soil 33.7	Dish 20.0
Mass of Water 2.4	Dry Soil 13.7
P. L. = $\frac{\text{Mass of Water}}{\text{Dry Soil}}$ x 100 = **17.5** = **18**	

Step (2) 33.7 - 20.0 = 13.7

Step (3) % Moisture = $\frac{2.4}{13.7}$ **x 100 = 17.5 = 18**

Plasticity Index

Definition: The numerical difference between the Liquid Limit and the Plastic Limit, we simply subtract the Plastic Limit from the Liquid Limit. If a material is non-plastic, the Plastic Limit is recorded as 0.

Liquid Limit		20%
Plastic Limit	-	18%
Plasticity Index		**2 %**

Optimum Moisture

Dense Graded Aggregates

Optimum moisture content is defined as the water content at which an aggregate mixture will achieve maximum density for a particular compaction method. Even with an understanding of the definition of optimum moisture as stated above, the words optimum moisture have little meaning to a Producer Technician or Inspector unless a measurable value can be found to express optimum moisture. VDOT uses the procedures outlined in AASHTO T-99 Method A, except as modified by VTM-1, to determine the optimum moisture content of aggregate mixtures. Like other moisture contents, optimum moisture is expressed as a percentage.

It is not necessary for the Producer Technician or Inspector to understand the laboratory test method or memorize the test procedure. However, it is very important that they understand the laboratory test results as reported and how they apply to the production and inspection of central-mix mixtures.

A moisture content of optimum moisture plus or minus two (2) percentage points is required by the Virginia Department of Transportation Road and Bridge Specifications in the production of central-mix aggregate mixtures. With this requirement, a need arises for the Producer Technician and Inspector to understand some of the descriptive terms used in referring to optimum moisture.

Note: CMA used for pipe backfill and Hydraulic Cement Stabilized CMA may only have a moisture content of optimum to + two (2) percentage points.

Some of the descriptive terms used are:

(a) Plus 4 material (4.75 mm) - All the material in an aggregate mixture retained on the No. 4 (4.75 mm) sieve.

(b) Minus 4 material (4.75 mm) - All the material in an aggregate mixture passing the No. 4 (4.75 mm) sieve.

(c) Minus 4 (4.75 mm) optimum moisture - optimum moisture of the minus 4 (4.75 mm) material is determined by District Laboratory proctor test (AASHTO T-99).

(d) Plus 4 (4.75 mm) optimum moisture - Optimum moisture of the plus 4 (4.75 mm) material is one percent (1%) of the percentage of the plus 4 (4.75 mm) material, or as directed by the Engineer.

(e) Absorption - Percent of moisture in an aggregate in a saturated surface dry condition (SSD).

(f) Total optimum moisture - The sum of the weighted optimum moistures of the minus 4 (4.75 mm) material and plus 4 (4.75 mm) material.

(g) Moisture Range - Total optimum moisture plus or minus two (2) percentage points.

AASHTO T-99 utilizes only the minus 4 (4.75 mm) portion of an aggregate mixture and may be reported as that of the minus 4 (4.75 mm) material only. In all specifications for dense graded aggregate there must be a percentage of plus 4 (+4.75 mm) material, so it is necessary for the Producer Technician to calculate the total optimum moisture for any type of central mix aggregate mixture.

To Find Total Optimum Moisture

Use this formula $\mathbf{(P_cW_c + P_fW_f)\ 100}$

<u>Obtain the required data.</u>

P_c = % +4 Material expressed as a decimal.

Determine the percent of +4 material by subtracting the percentage of - 4 material (found in the Mechancial Sieve Analysis of Total Sample) from 100 (total sample).

100.0 - 46.4 = 53.6 % + 4 material

Expressed as decimal = **0.536**

W_c = Absorption of +4 Matl. plus 1% expressed as a decimal

Absorption is obtained from the Plant or the Materials Section. 1% moisture is allowed for the + 4 material or as directed by the Engineer.

Absorption = 0.3%

Expressed as decimal 0.003 + 0.01 = **0.013**

P_f = % -4 Material expressed as a decimal (from Sieve Analysis)

-4 material = **46.4**

Expressed as a decimal = **0.464**

W_f = Optimum Moisture of -4 Material expressed as a decimal

Optimum moisture = 10.5%

Expressed as decimal = **0.105**

Calculate the Total Optimum Moisture Content

$$(P_c W_c + P_f W_f)\ 100$$

$$[(\underline{0.536} \times \underline{0.013}) + (\underline{0.464} \times \underline{.105})]\ 100$$

$$[\underline{0.007} + \underline{0.049}]\ 100$$

0.056 x 100 = **5.6**

Calculate Moisture Range:

5.6		5.6
- 2.0		+ 2.0
3.6	to	**7.6**

Gradation Worksheet

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)		%		63.0 mm (2 ½)		%	
50.0 mm (2)		%		50.0 mm (2)		%	
37.5 mm (1 ½)		%	**100.0%**	37.5 mm (1 ½)		%	
25.0 mm (1)	**1155**	**20.5%**	**79.5%**	25.0 mm (1)		%	
19.0 mm (3/4)	**470**	**8.3%**	**71.2%**	19.0 mm (3/4)		%	
9.50 mm (3/8)	**860**	**15.2%**	**56.0%**	9.50 mm (3/8)		%	
4.75 mm (4)	**540**	**9.6%**	**46.4%**	4.75 mm (4)		%	
2.0 mm (10)	**445**	**7.9%**	**38.5%**	2.0 mm (10)		%	**100.0%**
.850 mm (20)		**8.5%**	**30.0%**	.850 mm (20)	**36.9**	**22.2%**	**77.8%**
425 mm (40		**6.2%**	**23.8%**	425 mm (40	**26.6**	**16.0%**	**61.8%**
.250 mm (60)		**3.7%**	**20.1%**	.250 mm (60)	**15.9**	**9.6%**	**52.2%**
.180 mm (80)		**1.8%**	**18.3%**	.180 mm (80)	**7.8**	**4.7%**	**47.5%**
.150 mm (100)		**1.3%**	**17.0%**	.150 mm (100)	**5.8**	**3.5%**	**44.0%**
. 075 mm (200)		**4.6%**	**12.4%**	.075 mm (200)	**19.8**	**11.9%**	**32.1%**
Total	**5640**	**12.4%**		Total	**166.1**	**32.1%**	

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **160**	No. of Blows **28**	Dish No. **136**		Liquid Limit **20** %
Dish & Wet Soil **42.4**	Dish & Dry Soil **38.6**	Dish & Wet Soil **36.1**	Dish & Dry Soil **33.7**	Plastic Limit **18** %
Dish & Dry Soil **38.6**	Dish **19.4**	Dish & Dry Soil **33.7**	Dish **20.0**	Plasticity Index **2** %
Mass of Water **3.8**	Dry Soil **19.2**	Mass of Water **2.4**	Dry Soil **13.7**	
% Moisture = Mass of Water / Dry Soil x 100 = **19.8**		P.L. = **Mass of Water** / Dry Soil x 100 = **17.5** = **18**		Optimum Moisture Content Total Soil **5.6** % -4.75 mm (-4) Portion **10.5** % Maximum Density Total Soil kg/m³(lbs/ft³) -4.75 mm (-4) Portion kg/m³(lbs/ft³)
L.L. = **20.1 = 20**				

Wet Weight = 5922 grams **% Moisture 5.0** **Moisture Range 3.6 – 7.6** **Absorption 0.3**

Knowledge Check

Chapter 3 Sampling and Testing Aggregates

1. The fine gradation is washed over the:

   A. No. 10 (2.00 mm) sieve
   B. No. 40 (425 µm) sieve
   C. No. 100 (150 µm) sieve
   D. No. 200 (75 µm) sieve

2. The sieve size that separates the coarse material from the fine material is the:

   A. No. 40 (425 µm) sieve
   B. No. 10 (2.00 mm) sieve
   C. No. 80 (180 µm) sieve
   D. No. 100 (150 µm) sieve

3. The fine gradation sample should weigh between:

   A. 75 and 100 grams
   B. 100 and 125 grams
   C. 125 and 200 grams
   D. 200 and 300 grams

4. A process in which an aggregate is separated into its various sizes by passing it through screens of various openings for the purpose of determining the distribution of the quantities separated is:

   A. Fineness Modulus
   B. Sieve analysis
   C. Moisture analysis
   D. Yield

5. The minimum dry weight of a sample of central mix aggregate that contains +19.0 mm (3/4 inch) material should be:

   A. 2000 grams
   B. 4000 grams
   C. 5000 grams
   D. 8000 grams

6 Two acceptable ways of splitting a sample are by a sample splitter and by the quartering method.

   A. True
   B. False

7. What is the temperature range at which the fine gradation is dried?

8. The fine material is shaken for how many minutes?

9. The total sample is computed to the nearest _____ percent?

10. The numerical difference between the liquid limit and plastic limit is the plasticity index.

   A. True
   B. False

11. The liquid limit and plastic limit tests are run on material passing the:

   A. No. 10 (2.00 mm) sieve
   B. No. 40 (425 µm) sieve
   C. No. 80 (180 µm) sieve
   D. No. 200 (75 µm) sieve

12. The moisture content at which a soil changes from a semi-solid to a plastic state is the liquid limit.

    A. True
    B. False

13. In determining the liquid limit and plastic limit, the portion of the wet sample used must be dried at a temperature not to exceed 140°F (60°C) .

    A. True
    B. False

14. Which tests are performed on dense graded aggregates?

15. What are the requirements for water used in the liquid limit and plastic limit test?

16. How many blows per second is the cup on the liquid limit device dropped?

17. To determine the moisture content in the liquid limit test a slice of soil approximately the width of the spatula extending from edge to edge of the soil cake at right angles to the groove, and including that portion that flowed together must be taken.

    A. True
    B. False

18. When determining the plastic limit, the soil is rolled to a thread of ____.

19. VDOT Specifications require that central mixed aggregate be shipped at optimum moisture ± percentage points.

    A. 5
    B. 4
    C. 3
    D. 2

Problem No. 1
Moisture Calculation

Complete the following moisture determination problem and give the moisture content in percent.

Dish & Wet Material	700 grams
Dish & Dry Material	680 grams
Dish	200 grams

Problem No. 2
Moisture Calculation

In an effort to determine the moisture content of a material, a sample of the material was taken and found to weigh 1346 grams. The sample was then dried to a constant weight and reweighed. The dried sample was found to have a weight of 1240 grams. Using this information, calculate the percent of moisture.

Problem No. 3

Below is a sample of an Aggregate Subbase Material, Type I, Grading No. 21A. Complete the worksheet for gradation, liquid limit, plastic limit, plasticity index, optimum moisture content and moisture range.

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)		%		63.0 mm (2		%	
50.0 mm (2)		%		50.0 mm		%	
37.5 mm (1 ½)		%		37.5 mm (1		%	
25.0 mm (1)		%		25.0 mm		%	
19.0 mm (3/4)	**252**	%		19.0 mm		%	
9.50 mm (3/8)	**2352**	%		9.50 mm		%	
4.75 mm (4)	**1241**	%		4.75 mm		%	
2.0 mm (10)	**1017**	%		2.0 mm		%	
.850 mm (20)		%		.850 mm	**39.7**	%	
425 mm (40		%		425 mm	**23.2**	%	
.250 mm (60)		%		.250 mm	**13.4**	%	
.180 mm (80)		%		.180 mm	**9.2**	%	
.150 mm (100)		%		.150 mm	**6.4**	%	
. 075 mm (200)		%		.075 mm	**18.8**	%	
Total	**9334**	%		Total	**174.2**	%	

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **14**	No. of Blows **26**	Dish No. **19**		Liquid Limit %
Dish & Wet Soil **87.1**	Dish & Dry Soil **84.1**	Dish & Wet Soil **80.1**	Dish & Dry Soil **78.0**	Plastic Limit %
Dish & Dry Soil **84.1**	Dish **72.8**	Dish & Dry Soil **78.0**	Dish **69.4**	Plasticity Index %
Mass of Water	Dry Soil	Mass of Water	Dry Soil	
% Moisture = Mass of Water / Dry Soil x 100 =		P.L. = Mass of Water / Dry Soil x 100 =		Optimum Moisture Content Total Soil % -4.75 mm (-4) Portion **10.3** % Maximum Density Total Soil ________ kg/m³(lbs/ft³) -4.75 mm (-4) Portion____ kg/m³(lbs/ft³)
L.L. =				

Wet Weight = **9847** grams   % Moisture ___   Moisture Range ______   Absorption = **0.3**

Chapter 3 Sampling and Testing Aggregates

Problem No. 4

Below is a sample of an Aggregate Subbase Material, Type I, Grading No. 21A. Complete the worksheet for gradation, liquid limit, plastic limit, plasticity index, optimum moisture content and moisture range.

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)		%		63.0 mm (2 ½)		%	
50.0 mm (2)		%		50.0 mm (2)		%	
37.5 mm (1 ½)		%		37.5 mm (1 ½)		%	
25.0 mm (1)		%		25.0 mm (1)		%	
19.0 mm (3/4)	**357**	%		19.0 mm (3/4)		%	
9.50 mm (3/8)	**1448**	%		9.50 mm (3/8)		%	
4.75 mm (4)	**913**	%		4.75 mm (4)		%	
2.0 mm (10)	**1011**	%		2.0 mm (10)		%	
.850 mm (20)		%		.850 mm (20)	**57.8**	%	
425 mm (40		%		425 mm (40	**24.8**	%	
.250 mm (60)		%		.250 mm (60)	**16.0**	%	
.180 mm (80)		%		.180 mm (80)	**8.7**	%	
.150 mm (100)		%		.150 mm (100)	**6.3**	%	
. 075 mm (200)		%		.075 mm (200)	**19.5**	%	
Total	**6136**			Total	**190.0**		

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **21**	No. of Blows **28**	Dish No. **10**		Liquid Limit %
Dish & Wet Soil **52.1**	Dish & Dry Soil **48.9**	Dish & Wet Soil **79.9**	Dish & Dry Soil **77.8**	Plastic Limit %
Dish & Dry Soil **48.9**	Dish **33.7**	Dish & Dry Soil **77.8**	Dish **67.4**	Plasticity Index %
Mass of Water	Dry Soil	Mass of Water	Dry Soil	
% Moisture = Mass of Water x 100 = Dry Soil		P. L. = Mass of Water x 100 = Dry Soil		Optimum Moisture Content Total Soil % -4.75 mm (-4) Portion 10.5 % Maximum Density Total Soil ____ kg/m^3(lbs/ft^3) -4.75 mm (-4) Portion ____ kg/m^3(lbs/ft^3)
L.L. =				

Wet Weight = **6449** grams % Moisture ______ Moisture Range ____________ Absorption = **0.6**

Chapter 3 Sampling and Testing Aggregates

Problem No. 5

Below is a sample of an Aggregate Subbase Material, Type I, Grading No. 21A. Complete the worksheet for gradation, liquid limit, plastic limit, plasticity index, optimum moisture content and moisture range.

Mechanical Analysis of Total Sample				Mechanical Analysis of Soil Mortar			
Sieve Sizes	Grams Retained	Percent Retained	Percent Passing	Sieve Sizes	Grams Retained	Percent Retained	Percent Passing
63.0 mm (2 ½)		%		63.0 mm (2 ½)		%	
50.0 mm (2)		%		50.0 mm (2)		%	
37.5 mm (1 ½)		%		37.5 mm (1 ½)		%	
25.0 mm (1)		%		25.0 mm (1)		%	
19.0 mm (3/4)	**267**	%		19.0 mm (3/4)		%	
9.50 mm (3/8)	**2650**	%		9.50 mm (3/8)		%	
4.75 mm (4)	**1343**	%		4.75 mm (4)		%	
2.0 mm (10)	**1103**	%		2.0 mm (10)		%	
.850 mm (20)		%		.850 mm (20)	**44.6**	%	
425 mm (40		%		425 mm (40	**28.4**	%	
.250 mm (60)		%		.250 mm (60)	**15.8**	%	
.180 mm (80)		%		.180 mm (80)	**10.2**	%	
.150 mm (100)		%		.150 mm (100)	**7.6**	%	
. 075 mm (200)		%		.075 mm (200)	**21.2**	%	
Total	**8893**			Total	**200.0**		

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **3**	No. of Blows **22**	Dish No. **5**		Liquid Limit %
Dish & Wet Soil **88.2**	Dish & Dry Soil **85.4**	Dish & Wet Soil **80.2**	Dish & Dry Soil **78.2**	Plastic Limit %
Dish & Dry Soil **85.4**	Dish **72.0**	Dish & Dry Soil **78.2**	Dish **68.1**	Plasticity Index %
Mass of Water	Dry Soil	Mass of Water	Dry Soil	
% Moisture = Mass of Water x 100 = Dry Soil		P. L. = Mass of Water x 100 = Dry Soil		Optimum Moisture Content Total Soil % -4.75 mm (-4) Portion **10.8** % Maximum Density
L.L. =				Total Soil ______ kg/m^3(lbs/ft^3) -4.75 mm (-4) Portion ____kg/m^3(lbs/ft^3)

Wet Weight = **9418** grams % Moisture ____ Moisture Range _________ Absorption = **0.7**

4 Acceptance of Materials

Acceptance

Sampling and testing for determination of gradation, liquid limit and plasticity index, and cement content of material, if stabilized, will be performed at the plant and normally no further sampling or testing will be performed for these properties. However, should visual examination reveal that the material in any load is obviously contaminated or segregated, that load will be rejected without additional sampling or testing of the lot. In the event it is necessary to determine the gradation or Atterberg Limits or cement content of the material in an individual load, one sample (taken from the load) will be tested and the results compared to the requirements of Section 208.03 Table II-10, Table II-11 (for one test) and Sec. 307.05(b)(2). The results obtained in the testing of a specific individual load will apply only to the load in question.

Most of the material in a pavement is aggregate. The aggregate contributes strength and stability to the completed pavement. All of the particles needed in the aggregate that will meet specifications and do the job usually cannot be found in a single material; therefore, it becomes necessary to blend different sizes and materials in the proper quantities to produce the desired gradation.

Cement Stabilized Aggregate

Hydraulic Cement can be added to Aggregate Base, Subbase or Select Material to give added strength to the pavement. The cement used must be Type I, I-P or II. The water used in mixing the cement stabilized material must have a pH between 4.5 and 8.5. (Section 307.02 a & b)

The material cannot be shipped to the project until the temperature is 40°F in the shade and rising. (Section 307.04)

Once production has started the contractor has 1 hour from the time of mixing at the plant to have material on the subgrade and start compaction. All compaction must be completed within 4 hours after the water was added at the plant. (VDOT Road. & Bridge Spec. Section 307.05)

Road & Bridge Specifications Section 208.01

Table II-9
Design Range for Dense Graded Aggregates
Amounts Finer Than Each Laboratory Sieve (Square Openings[1]) (% by Weight)

Size No.	**50 mm** 2 inches	**25 mm** 1 inch	**9.5 mm** 3/8 inch	**2.00 mm** No. 10	**425 µm** No. 40	**75 µm** No. 200
21 A	100	94-100	63-72	32-41	14-24	6-12
21B	100	85-95	50-69	20-36	9-19	4-7
22	---	100	62-78	39-56	23-32	8-12

[1] In inches

Road & Bridge Specifications Section 208.03

TABLE II-10
Process Tolerances for Each Laboratory Sieve (%)

No. Tests	**Top Size**	**25.0 mm 1 in.**	**19.0 mm 3/4 in.**	**9.5 mm 3/8 in.**	**2.00 mm No. 10**	**425 µm No. 40**	**75 µm No. 200**
1	0.0	±10.0	±14.0	±19.0	±14.0	±8.0	±4.0
2	0.0	±7.1	±10.0	±13.6	±10.0	±5.7	±2.9
3	0.0	±5.6	±7.8	±10.6	±7.8	±4.4	±2.2
4	0.0	±5.0	±7.0	±9.5	±7.0	±4.0	±2.0
8	0.0	±3.6	±5.0	±6.8	±5.0	±2.9	±1.4

Road & Bridge Specifications Section 208.03

TABLE II-11
Atterberg Limits

Max. Liquid Limit		Max. Plasticity Index	
No. Tests	Subbase and Aggregate Base Type I and II	Subbase Sizes No. 21A, and 22 and Aggregate Base Type II	Aggregate Base Type I and Subbase Size No. 19
1	25.0	6.0	3.0
2	23.9	5.4	2.4
3	23.2	5.1	2.1
4	23.0	5.0	2.0
8	22.4	4.7	1.7

(b) Atterberg Limits: Atterberg limits shall conform to the requirements of Table II-11 when tested in accordance with the requirementts of VTM-7.

Process Tolerance Cement Stabilized Aggregates

No. Tests averaged	Percent Below Design Allowed
1	1.6
2	1.1
3	0.9
4	0.8

Acceptance Calculations for Gradation, Liquid Limit, Plasticity Index, and Cement Content

As previously stated, acceptance, for gradation, liquid limit, plasticity index and cement content will be based upon a mean (average) of the results of tests performed on samples taken in a stratified random manner from each lot. The procedure for calculating the acceptance or failure for gradation, liquid limit, plasticity index, and cement content is as follows:

Step 1. Obtain job-mix formula. The job-mix formula should be that formula as found on Form TL-127 as submitted by the Contractor/Technician for the type mixture being produced.

Example: Stabilized Aggregate Base Type I, No. 21A.

Job-Mix Sieves	Total % Passing
2 in. (50 mm)	100.0
1 in. (25 mm)	95.0
3/8 in. (9.5 mm)	67.0
No. 10 (2.00 mm)	38.0
No. 40 (425 µm)	21.0
No. 200 (75 µm)	10.0
L.L.	Max. 23
P.I.	Max. 2
Cement	4.0%

Note: One week may be required by the Department to evaluate a new job-mix formula.

Step 2. Determine number of tests performed on quantity of material for acceptance. Usually the quantity of material tested for acceptance is a lot (2000 or 4000 Tons), which requires 4 tests (one for every 500 or 1000 Tons).

Example: Lot = 2000 or 4000 Tons = 4 Tests

Step 3. Calculate Acceptance Range. To calculate the acceptance range, the process tolerance for the number of tests performed is applied to the job-mix.

Acceptance Range = Job-Mix Process Tolerance

Example: (4 Tests)

Job-Mix Sieves	Total % passing	Tolerance	Acceptance Range
2 in. (50 mm)	100.0	0.0	100.0
1 in. (25 mm)	95.0	± 5.0	90.0-100.0
3/8 in. (9.5 mm)	67.0	± 9.5	57.5-76.5
No. 10 (2.00 mm)	38.0	± 7.0	31.0-45.0
No. 40 (425 µm)	21.0	± 4.0	17.0-25.0
No. 200 (75 µm)	10.0	± 2.0	8.0-12.0
L.L.			Max. 23
P.I.			Max. 2
Cement	4.0	-0.80%	Min. 3.2%

Step 4. Calculate mean (average) of Test results. This is done for each job-mix sieve, Liquid Limit, Plasticity index, and cement content.

$$\text{Mean (average)} = \frac{\text{Sum of Test Results}}{\text{Number of Tests}}$$

Example:

Sample No.	1	2	3	4	Aver.	Acc. Lower	Range Upper	Job-Mix
SIEVE SIZE								
2 in. (50 mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 in. (25 mm)	93.6	94.6	94.1	89.4	92.9	90.0	100.0	95.0
3/8 in. (9.5 mm)	69.0	70.7	63.9	63.6	66.8	57.3	76.3	67.0
No. 10 (2.00 mm)	42.0	41.6	36.3	36.8	39.2	31.0	45.0	38.0
No. 40 (425 µm)	24.4	23.9	20.0	21.1	22.4	17.0	25.0	21.0
No. 200 (75 µm)	9.4	8.8	7.0	7.7	8.2	8.0	12.0	10.0
L.L.	20	16	27	17	20		23.0	23.0
P.I.	0.0	0.0	0.0	0.0	0.0		2.0	2.0
Cement	3.9	4.2	3.8	4.1	4.0	3.2		4.0

Step 5. Compare mean (average) of test results to acceptance range**.**

Example: The averages of the lot are within the acceptance range. This lot passes.

Adjustment System - for Aggregate Base and Subbase

Adjustments for Gradation, Atterberg Limits and Cement Content

In the event a lot of material does not conform to the acceptance requirements, adjustment points will be determined as follows:

Sieve No.	Adjustment Points For Each 1% That The Gradation Is Outside The Process Tolerance
2 in. (50 mm)	1
1 in. (25 mm)	1
3/4 in (19 mm)	1
3/8 in (9.5 mm)	1
No. 10 (2.00 mm)	1
No. 40 (425 µm)	3
No. 200 (75 µm)	5

Atterberg Limits	Adjustment Points For Each 1% That The Atterberg Limits Exceed The Maximum Permitted In Table II-11
Liquid Limit	3
Plasticity Index	7
Cement Content	10

In the event the total adjustment is 8.0 percent or less for cement content material, and the Contractor does not elect to remove and replace the material, the unit bid price paid for the material will be reduced at the rate stated herein. The adjustment will be applied to the tonnage represented by the samples: however should any one sample fail by more than 1.6 percent below the design cement content that portion of the lot must be removed from the road. (Section 307.05)

In the event the total adjustment for a lot is greater than twenty-five (25) points, the failing material shall be removed from the road. In the event the total adjustment is twenty-five (25) points or less and the Contractor does not remove and replace the material, the unit price paid for the material will be reduced 1% of the unit price bid for each adjustment point. The adjustment will be applied to the tonnage represented by the sample or samples.

Sample No.	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
Sieve Size									
2 in. (50 mm)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
1 in. (25 mm)	99.0	99.0	100.0	100.0	99.5	90.0	100.0	95.0	
3/8 in. (9.5 mm)	77.0	88.0	74.1	78.2	79.3	57.5	76.5	67.0	F
No. 10 (2.00 mm)	43.0	40.8	42.2	42.6	42.2	31.0	45.0	38.0	
No. 40 (425 µm)	24.0	23.8	23.6	24.4	24.0	17.0	25.0	21.0	
No. 200 (75 µm)	13.8	13.9	13.8	13.6	13.8	8.0	12.0	10.0	F
L.L.	20	21	21	20	20		23.0	23.0	
P.I.	0.0	0.0	0.0	0.0	0.0		2.0	2.0	
Cement	3.3	2.7	3.1	2.9	3.0	3.2		4.0	F

Sample Calculations for Adjustments:

Step 1. Compute adjustment on 3/8 in. (9.5 mm) Sieve. Refer to the adjustment point table for gradation and note that, for the 3/8 in. (9.5 mm) sieve, a one point adjustment for each 1% that the gradation is outside the acceptance range is applied.

79.3	Average 3/8 in. (9.5 mm) sieve	1.0	Adjustment for each 1%
-76.5	Upper Acceptance Range	x 2.8%	Outside Acceptance Range
2.8%	Outside Acceptance Range	2.8	Adjustment Points 3/8 in. (9.5 mm) sieve

Step 2. Compute Adjustment on No. 200 (75 µm) sieve. Refer to the adjustment point table for gradation and note for the No. 200 (75µm) sieve, a 5 point adjustment for each 1% that the gradation is outside the acceptance range is applied.

13.8	Average No. 200 (75 □m) sieve	5.0	Adjustment for each 1%
-12.0	Upper Acceptance Range	x 1.8	% Outside Acceptance Range
1.8%	Outside Acceptance Range	9.0	Adjust. Points No. 200 (75 □m) sieve

Step 3. Compute Adjustment on Cement Content. Refer to Specifications and note that one adjustment point will be applied for each 0.l% the material is out of the process tolerance. This statement means that 10 adjustment points will be applied for each 1% that the material is out; however, the maximum allowable adjustment is 8.

3.2	Lower Acceptance Range	10	Adjustment for each 1%
- 3.0	Average Cement Content	x 0.2	% Outside Process Tolerance
0.2 %	Outside Process Tolerance	2.0	Adjustment Points Cement Content

Step 4. Compute Total Adjustment. The total adjustment is the sum of the adjustments for gradation, L.L., P.I. and Cement Content. In our example, we had no adjustments applied for L.L. and P.I.

2.8	Adjustment 3/8 in. (9.5 mm) Sieve
9.0	Adjustment No. 200 (75 □m) Sieve
+ 2.0	Adjustment Cement Content
13.8	Total Adjustment points for Gradation and Cement Content

Section 207.01

TABLE II-6
Design Range: Select Material, Type I
% by Mass of Material Passing

3 in. (75 mm) Sieve	2 in. (50 mm) Sieve	No. 10 (2.00 mm) Sieve	No. 40 (425 µm) Sieve	No. 200 (75 µm) Sieve
100	95-100	25-55	16-30	4-14

Section 207.02

TABLE II-7
Process (P) and Range (R) Tolerance: Select Material, Type I
Tolerance on Each Laboratory Sieve (%)

	3 in. (75 mm)		2 in. (50mm)		No. 10 (2.00mm)		No. 40 (425µm)		No. 200 (75µm)	
No.Test	P	R	P	R	P	R	P	R	P	R
1	0.0		±4.0		±15.0		±10.0		±6.0	
2	0.0	0.0	±3.0	5.0	±10.5	18.5	±7.0	13.0	±4.0	8.5
3	0.0	0.0	±2.5	5.5	±8.5	22.0	±5.5	15.0	±3.5	10.0
4	0.0	0.0	±2.0	6.0	±7.5	23.5	±5.0	16.5	±3.0	10.5
8	0.0	0.0	±1.5	7.0	±5.5	26.5	±3.0	18.5	±2.0	12.0

Adjustment System - Select Material, Type I

In the event a lot of material does not conform to the acceptance requirements, adjustment will be determined as follows:

Sieve No.	Adjustment Points For Each 1% That The Gradation Is Outside The Process/Range Tolerance	
	Process	Range
3 in. (75 mm)	1	1
2 in. (50 mm)	1	1
No. 10 (2.00 mm)	1	1
No. 40 (425µm)	3	3
No. 200 (75 µm)	5	5

Atterberg Limits	Adjustment Points
Liquid Limits	3
Plasticity Index	7

In the event the total adjustment, (EXCLUDING range adjustment) for the lot is greater than 25 points, the failing material shall be removed from the road. In the event the total adjustment, (EXCLUDING range adjustment) is 25 points of less and the Contractor does not elect to remove and replace the material, the unit price for the material will be reduced 1% for each adjustment point. The adjustment will be applied to the tonnage represented by the sample or samples.

Adjustment Calculations on Select Material:

Sample No.	1	2	3	4	Avg.	Range	Lower	Upper	Job-Mix	P/F
Sieve Size										
3 in.(75 mm)	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	
2 in. (50 mm)	100.0	90.4	95.1	100.0	96.4	9.6	96.0	100.0	98.0	**F**
No.10 (2.00 mm)	50.0	35.4	40.2	42.3	42.0	14.6	32.5	47.5	40.0	
No. 40 (425 µm)	35.0	22.1	25.2	30.4	28.2	12.9	17.0	27.0	22.0	**F**
No. 200 (75 µm)	17.0	11.0	13.1	15.4	14.1	6.0	7.0	13.0	10.0	**F**
L.L.	22	21	22	22	22			23.0	23.0	
P.I.	3.5	0.0	0.0	3.1	1.7			5.0	5.0	

Adjustments are computed as follows:

2 in. (50 mm) sieve: actual range 9.6
maximum range allowed – 6.0
outside acceptance range 3.6

adjustment for each % 1.0
total adjustment 1.0 x 3.6 = **3.6**

No. 40 (425 µm) sieve: average % passing 28.2
upper acceptance range - 27.0
outside acceptance range 1.2

adjustment for each % 3.0
total adjustment 3.0 x 1.2 = **3.6**

No. 200 (75 µm) sieve: average % passing 14.1
upper acceptance range - 13.0
outside acceptance range 1.1

adjustment for each % 5.0
total adjustment 5.0 x 1.1 = **5.5**
Total Lot Adjustment: **3.6 + 3.6 + 5.5 = 12.7**

To: Date: ______________________________

From: Project: ______________________________

Subject: Price Adjustment Route :____________County ______________

for Non-Compliance FHWA# ______________________________

Producer: ______________________________

Type of Material: ______________________________

Tons Represented: ______________________________

Date Shipped: ______________________________

The above material does not conform to our requirements by the results below:

Control Test Report Number	Sieve Size	Test Results	Acceptance Range	Fails By	Adjustment Points
	3 in. (75 mm)				
	2 in. (50 mm)				
	1 in. (25 mm)				
	3/4 in. (19 mm)				
	3/8in. (9.5 mm)				
	No. 10 (2 mm)				
	No. 40 (425 µm)				
	No. 200 (75 µm)				
	L.L.				
	P.I.				
	Total Adjustment Points:				

District Materials Engineer

CY: State Materials Engineer
Resident Engineer
District Contract Administrator
Project Inspector
Contract
File

Adjustments for Variability (Standard Deviation)

The Producer shall control the variability of his product in order to furnish a uniform mix. When the quantity of any one type material furnished a project exceeds 4000 tons, the variability of the total quantity furnished will be determined on the basis of the standard deviation for each sieve size. In the event the standard deviation is within the limits shown in the Standard Deviation Table, Table II-12, the unit bid price for the material will be adjusted as indicated hereinafter. Standard deviation computations will not be made separately on more than two job-mixes for the same type material unless a change is requested by the Department.

The unit bid price will be reduced by 0.5% for each adjustment point applied for standard deviation.

The disposition of material having standard deviations larger than those shown in Table II-12 will be determined by the Engineer.

TABLE II-12
Standard Deviation

	No. of Payment Adjustment Points for Each Sieve Size		
Sieve Size	1 Adjustment Point for Each Sieve Size	2 Adjustment Points for Each Sieve Size	3 Adjustment Points for Each Sieve Size
2 in. (50.0 mm)	0.6-1.5	1.6-2.5	2.6-3.5
1 in. (25.0 mm)	4.6-5.5	5.6-6.5	6.6-7.5
3/4 in.(19.0 mm)	5.6-6.5	6.6-7.5	7.6-8.5
3/8 in. (9.5 mm)	7.1-8.0	8.1-9.0	9.1-10.0
No. 10 (2.00 mm)	5.6-6.5	6.6-7.5	7.5-8.5
No. 40 (425 µm)	3.6-4.5	4.6-5.5	5.6-6.5
No. 200 (75 µm)	3.1-4.0	4.1-5.0	5.1-6.0

Control Charts

A control chart is a graphical record of data taken from a repetitive process. The process is in statistical control when repeated measurements from the process behave as random samples dispersed about a target value.

The control chart used for central mix aggregate is based on the bell shaped (normal) curve; the control guides are obtained from standard deviations for the particular sieves. By using these guides and plotting the individual test results, the Producer can predict when the process is getting out of control by using the warning signals that are shown on the chart. When one test results exceeds the number one warning signal, which is 2 standard deviations from the job-mix, the Producer should investigate his process. The reason is that approximately 95% of the material should fall within this range.

When 3 consecutive test results exceed the number 2 warning signal, which is one standard deviation from the job-mix, the Producer should also investigate his process. The reason is that approximately 68% of the material should fall within this range.

When 11 consecutive test results fall on the same side of the job-mix, the Producer should also investigate his process. Eleven (11) is the statistical number that could indicate the job-mix was set on the wrong side and the Producer is not getting full benefit of the process tolerances.

Plotting Control Charts

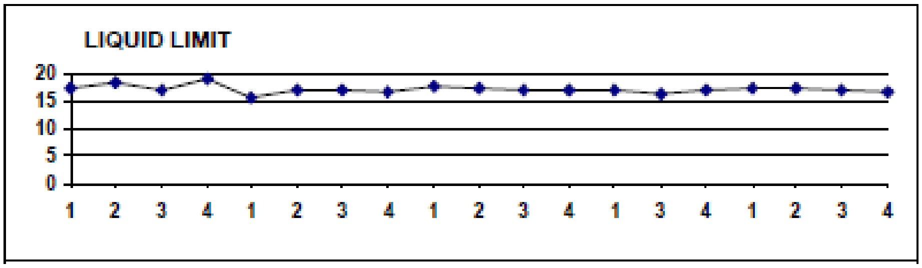
Control Charts are now available in MITS/PLAID. The producers can elect to use the control charts furnished in the system or plot his own Control Charts. If he so desires, we will furnish and set-up the charts, and help him get started in the plotting. The Plant Quality Control Technician will be required to plot the Control Charts.

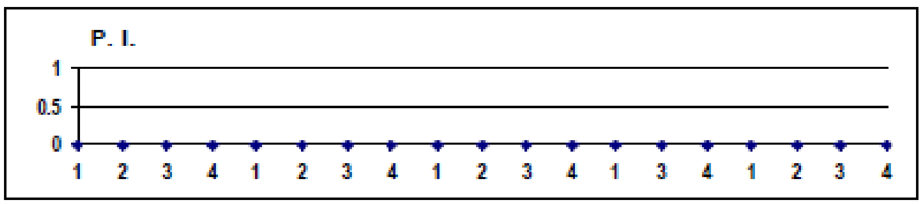
1. Fill out heading as indicated.
2. Fill in proper job-mix values for appropriate sieves from job-mix formula.
3. Control guides for all sieve sizes are listed at the bottom of sheet. Draw in Control Guides on appropriate Control Sieves in different colors. Example: Red lines for one-point controls and blue lines for three-point controls.
4. As soon as test values have been obtained on an individual sample, plot these values on their proper Control Sieve Chart.

5. After all four samples of a lot have been run, average the test results and plot these over the fourth test number of the lot. Test averages must be plotted in a different color than individual test results.

Project or Maintenance No.__________________
Contractor__________________________
Aggregate Size________________________

Location:
From______________________
To ________________________
District __________________

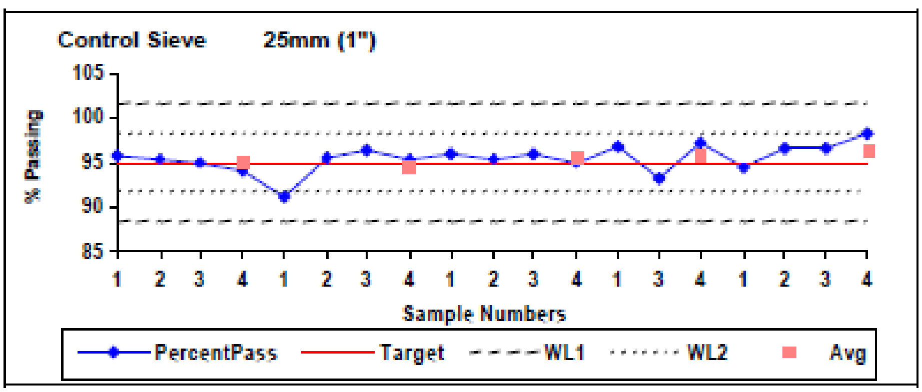




CONTROL GUIDES

WARNING SIGNALS

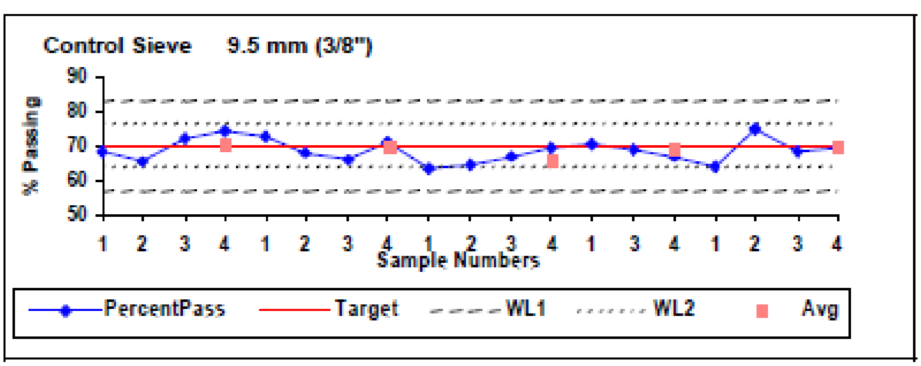
(1) 1 PT. BEYOND ± 6.7%
(2) 3 CONSECUTIVE PTS. BEYOND ± 3.3%
(3) 11 CONSECUTIVE PTS. ON SAME SIDE OF JOB MIX.



CONTROL GUIDES

WARNING SIGNALS

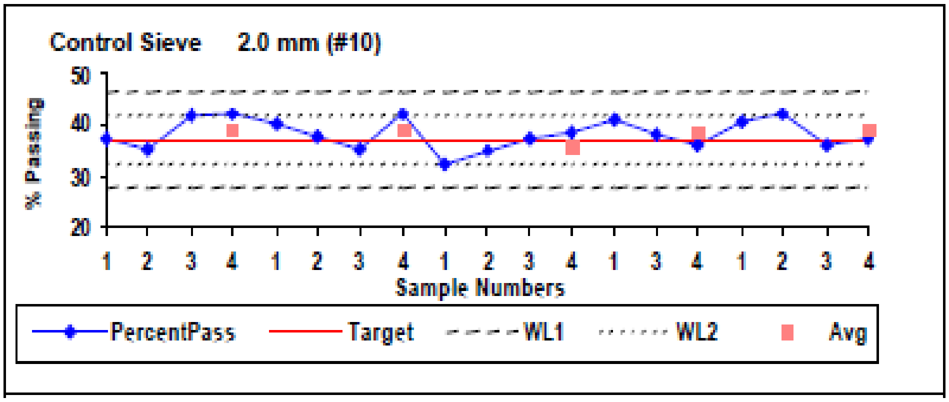
(1) 1 PT. BEYOND ± 12.7%
(2) 3 CONSECUTIVE PTS. BEYOND ± 6.3%
(3) 11 CONSECUTIVE PTS. ON SAME SIDE OF JOB MIX.



CONTROL GUIDES

WARNING SIGNALS

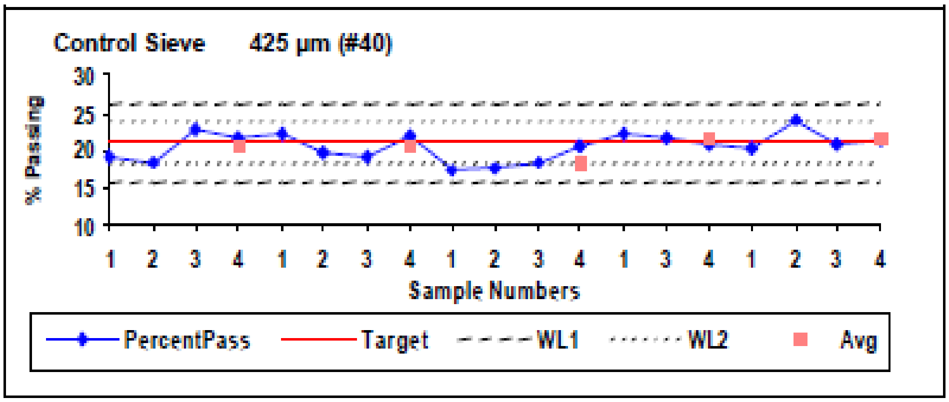
(1) 1 PT. BEYOND ± 9.3%
(2) 3 CONSECUTIVE PTS. BEYOND ± 4.7%
(3) 11 CONSECUTIVE PTS. ON SAME SIDE OF JOB MIX.



CONTROL GUIDES

WARNING SIGNALS

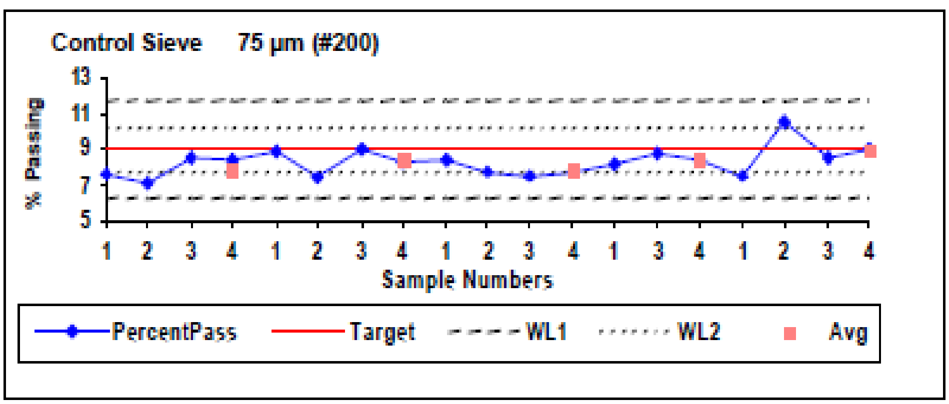
(1) 1 PT. BEYOND ± 5.3%
(2) 3 CONSECUTIVE PTS. BEYOND ± 2.7%
(3) 11 CONSECUTIVE PTS. ON SAME SIDE OF JOB MIX.



CONTROL GUIDES

WARNING SIGNALS

(1) 1 PT. BEYOND ± 2.7%
(2) 3 CONSECUTIVE PTS. BEYOND ± 1.3%
(3) 11 CONSECUTIVE PTS. ON SAME SIDE OF JOB MIX.



Referee System

(a) In the event the test results obtained from one of the four samples taken to evaluate a particular lot appear to be questionable, the Contractor may request that the results of the questionable sample be disregarded, where upon he shall perform tests on five additional samples taken from randomly selected locations on the project where the lot was placed. In the event the Engineer determines that one of the four test results appear to be questionable, the Department will perform tests on five additional samples taken from randomly selected locations on the projectwhere the lot was placed. The test results of the three original (unquestioned) samples will be averaged with the tests results of the five project samples and the mean of the test values obtained for the eight samples will be compared to the requirements for the mean of eight tests as shown in Table II-10 and Table II-11.

(b) In the event the Contractor questions the mean of the four original test results obtained for a particular lot, the Contractor may request approval to perform additional testing of that lot. In the event the Engineer determines that the mean of the four original test results are questionable, the Department will perform additional testing of that lot.The test results of the original four samples will be averaged with the test results of four additional samples taken from randomly selected locations on the project where the lot was placed and the mean of test values obtained for the eight samples will be compared to the requirements for the mean result of eight tests as shown in Table II-10 and Table II-11. If the Contractor requests further tests, the Contractor shall sample and test the material in accordance with Department approved procedures.

In the event the mean of the test values obtained for the eight samples conforms to the requirements for the mean results of eight tests, the material will be considered acceptable. In the event the mean of the test values obtained for the eight samples does not conform to the requirements for the mean result of eight tests, the lot will be adjusted in accordance with adjustment rate specified in Section 208.08. The provisions of this Section will not be applicable to mixes containing cement or other admixtures that alter the characteristics of the material. For Select Material the final mean results will be compared to the requirements for the mean of 8 tests as shown in the Select Material, Type I, Process and Range Tolerance and Allowable Limits.

Knowledge Check
Chapter Four - Acceptance of Materials

1. What types of Portland Cement are allowed in stabilized Central Mix aggregates?

    A. Type I and Type II
    B. Types I, I-P and III
    C. Types I, I-P and II
    D. Types I-P, II and III

2. What are the specification requirements for water used in cement treated aggregates?

3. In the production of cement stabilized aggregate, no one sample shall have a cement content below design by more than ____ percent.

    A. 1.1%
    B. 1.3%
    C. 1.6%
    D. 1.8%

4. If the total adjustment (excluding range adjustment) for the lot is greater than 25 points the failing material has to be removed from the road.

    A. True
    B. False

5. The maximum time interval between manufacture of cement treated aggregate and final shaping and compaction is _____.

6. Is it permissible to accept central-mix aggregate by visual inspection?

7. It is the Department's policy to require the producer to plot his own Control Charts.

    A. True
    B. False

8. If the job-mix formula on the 3/8 in. (9.5 mm) sieve is 68% passing, what is the acceptance range?

9. Can the acceptance range on a sieve fall outside of the Design Range for that particular sieve?

10. The contractor must accept the price adjustment.

    A. True
    B. False

11. The ambient air temperature must be at least_____ before production can start for cement stabilized material.

    A. 50°F
    B. 32°F
    C. 40°F
    D. 90°F

12. A lot is usually an average of:

    A. 2 samples
    B. 6 samples
    C. 8 samples
    D. 4 samples

13. Standard Deviation and variability are the same thing.

    A. True
    B. False

14. The Referee System can only be implemented by the contractor.

    A. True
    B. False

Knowledge Check
Chapter 4 - Acceptance of Material
Problem No. 1

Complete the following test report and calculate the percent of unit price adjustment.
Type Mix – Stabilized Aggregate Base Type I, No.21A

Sample No.	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
Sieve Size									
2 in. (50 mm)	100	100	100	100				100	
1 in. (25 mm)	96	100	98.5	100				97	
3/8 in. (9.5 mm)	70.9	67.3	74.9	62.8				67	
No.10 (2.00mm)	40.7	39.4	45	34.5				39	
No.40(425µm)	22.5	21.5	25.4	19.7				24	
No.200(75µm)	11.2	13.1	10.4	10.8				10	
L.L.	22	19	21	20				23	
P.I.	2	0	1	0				2	
Cement	3.9	3.2	2.5	2.7				4	

Knowledge Check
Chapter 4 - Acceptance of Material
Problem No. 2

Complete the following test report and calculate the percent of unit price adjustment.
Type Mix – Stabilized Aggregate Base Type I, No.21A

Sample No.	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
Sieve Size									
2 in. (50 mm)	100	100	100	100				100	
1 in. (25 mm)	100	98	96	97.4				95	
3/8 in. (9.5 mm)	70.8	67.1	62.8	66.7				67	
No.10 (2.00mm)	45	34.5	39.4	38.2				39	
No.40(425µm)	21.3	25.4	20.8	24.1				24	
No.200(75µm)	14.1	9.8	11.1	10.2				10	
L.L.	25	20	21	20				23	
P.I.	6	0	0.5	0				2	
Cement	3.3	2.5	2.9	2.9				4	

Knowledge Check
Chapter 4 - Acceptance of Material
Problem No. 3

Complete the following test report and calculate the percent of unit price adjustment.
Type Mix – Stabilized Aggregate Base Type I, No.21A

Sample No.	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
Sieve Size									
2 in. (50 mm)	100	100	100	100				100	
1 in. (25 mm)	94.2	91.6	94.4	97.1				94	
3/8 in. (9.5 mm)	68.5	67.4	70.6	61.3				67	
No.10 (2.00mm)	34.2	32.4	34.8	40.9				34	
No.40(425µm)	15.8	14.4	14.5	21.6				16	
No.200(75µm)	8.8	8.7	8	9.9				11	
L.L.	21	19	20	29				23	
P.I.	0	0	0	4				2	
Cement	3.3	2.7	2.5	3.5				4	

5 TEST RESULTS INPUT FORMS

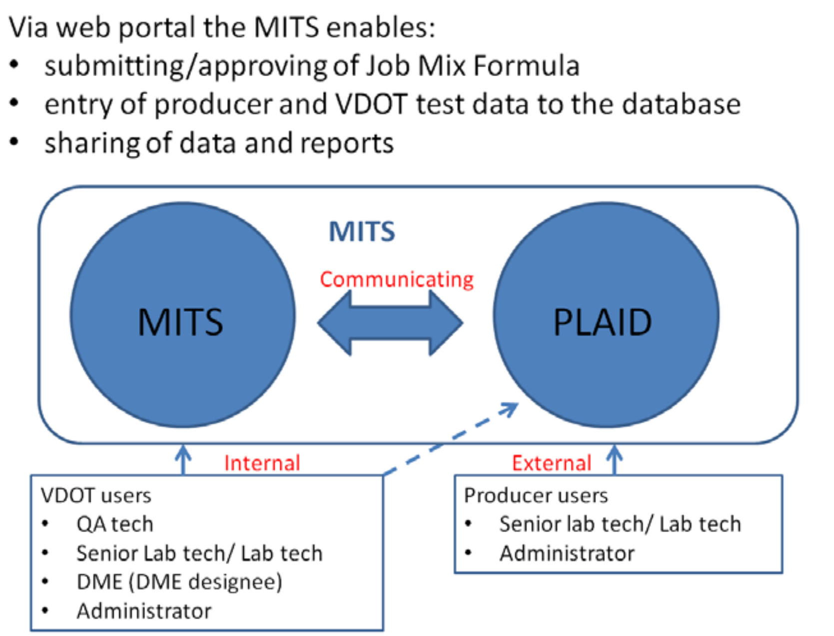
Note: This chapter is only intended as a general guide for data input in PLAID. VDOT Materials personnel will provide you with instruction.

Producer Lab Analysis and Information Details (PLAID)

The Producers Lab Analysis and Information Details (PLAID) application is part of the Materials Information Tracking System(MITS).

PLAID: used by Producers

MITS: used by VDOT



The purpose of this application is to allow Producers to submit the Job Mix Formula (TL-127) for VDOT approval and; to enter the sample test data along with Lot details (TL-52).

NOTE: You will need to get access permissions from your VDOT representative.

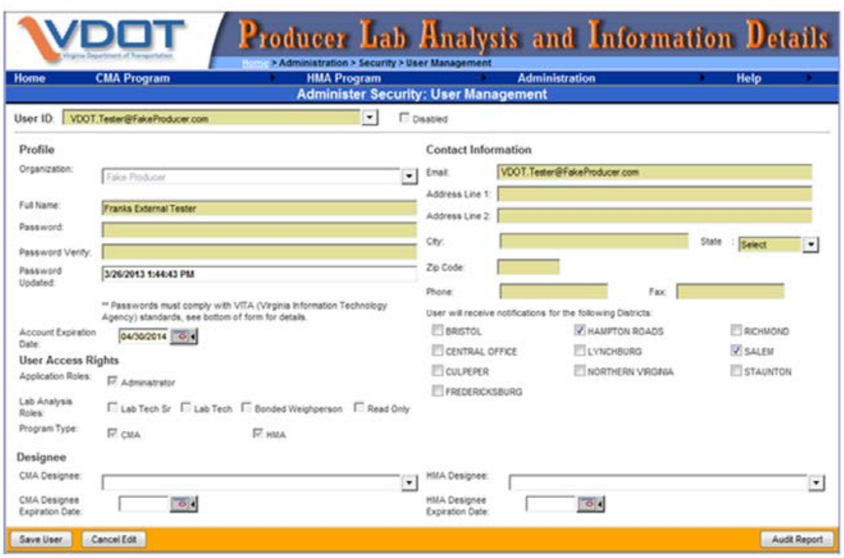
The link for PLAID: https://plaid.vdot.virginia.gov/

Main Menu

1. Home
2. CMA Program
   - Design
     - TL 127
     - Recall TL 127
   - Lot
     - Lot detail
     - Recall lot
   - Project
     - Project detail
     - Recall Project
3. HMA Program
4. Administration
   - Security
     - User Management
   - Report
     - Producer
     - Plant
5. Help
   - Online Manual
   - Printable Manual

5

Administration –User Management

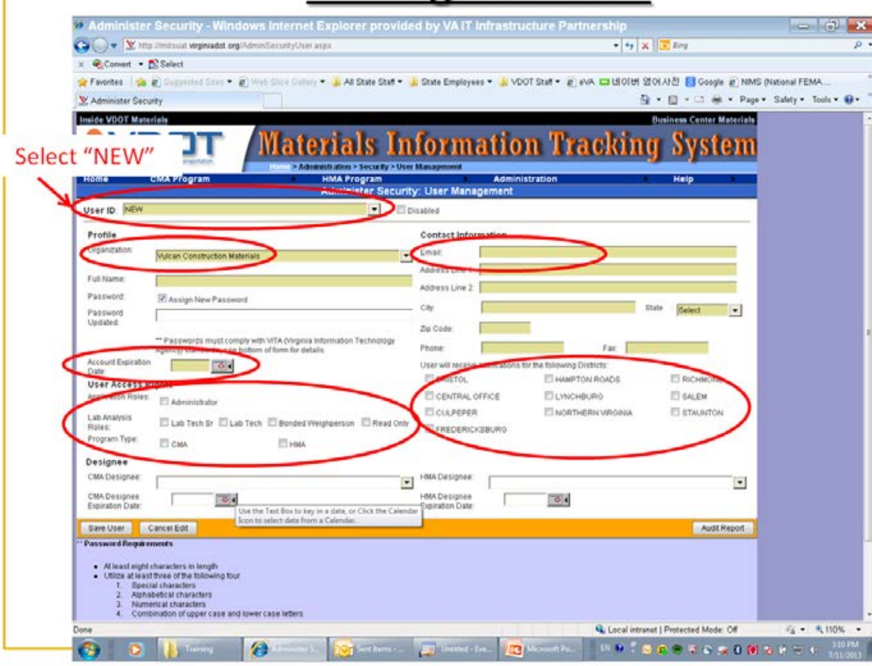


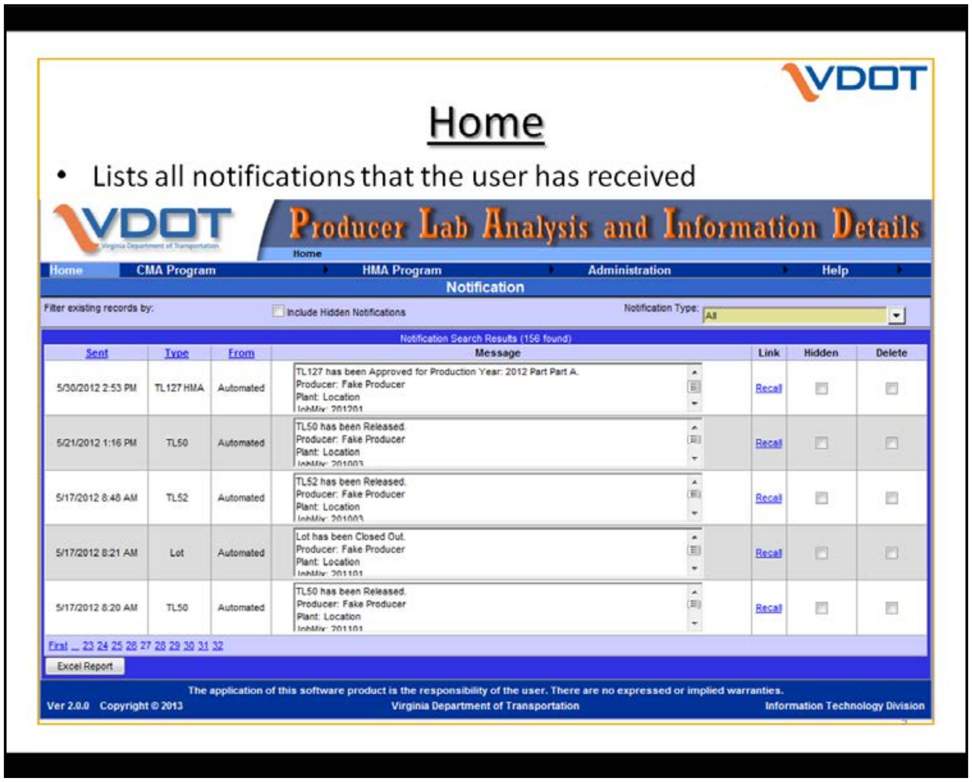
6

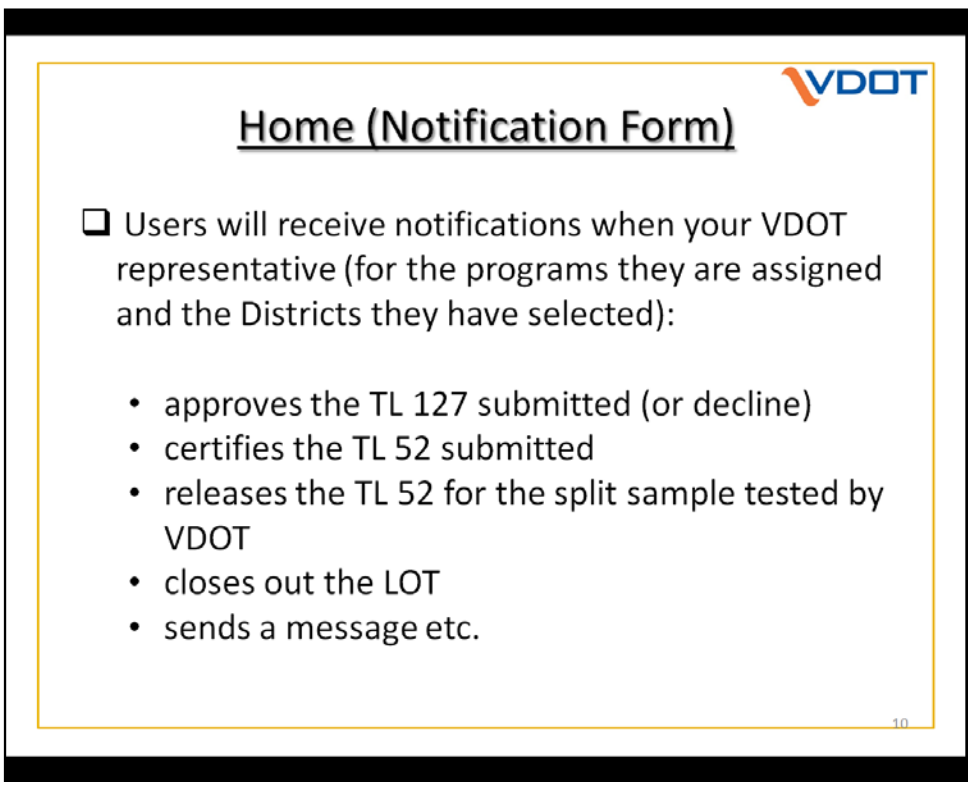
User Access Right

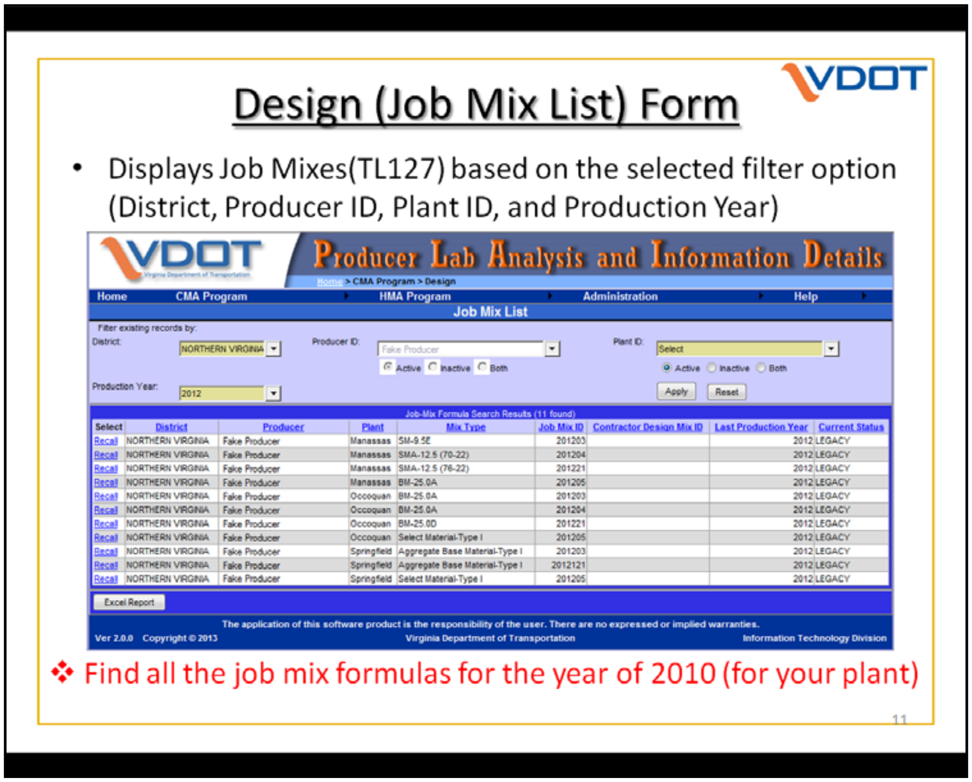
- Application Role
  - Administrator : can see other user profiles and add or modify them (assign new password)
    - New producer accounts are disabled until a VDOT user approves the account
- Lab Analysis Role
  - Lab Tech Sr (can enter and submit JMF or TL 52 ; complete Lot)
  - Lab Tech (can only enter JMF or TL 52)
  - Bonded Weight Person
  - Read Only
- Program type
  - CMA
  - HMA

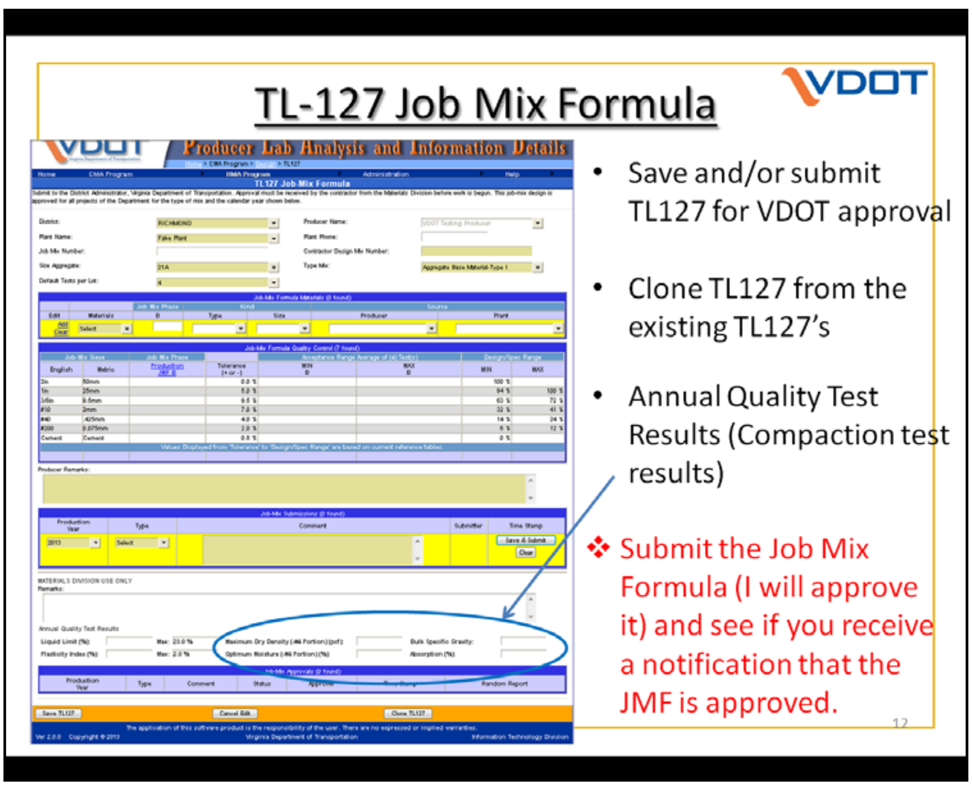
Adding new user

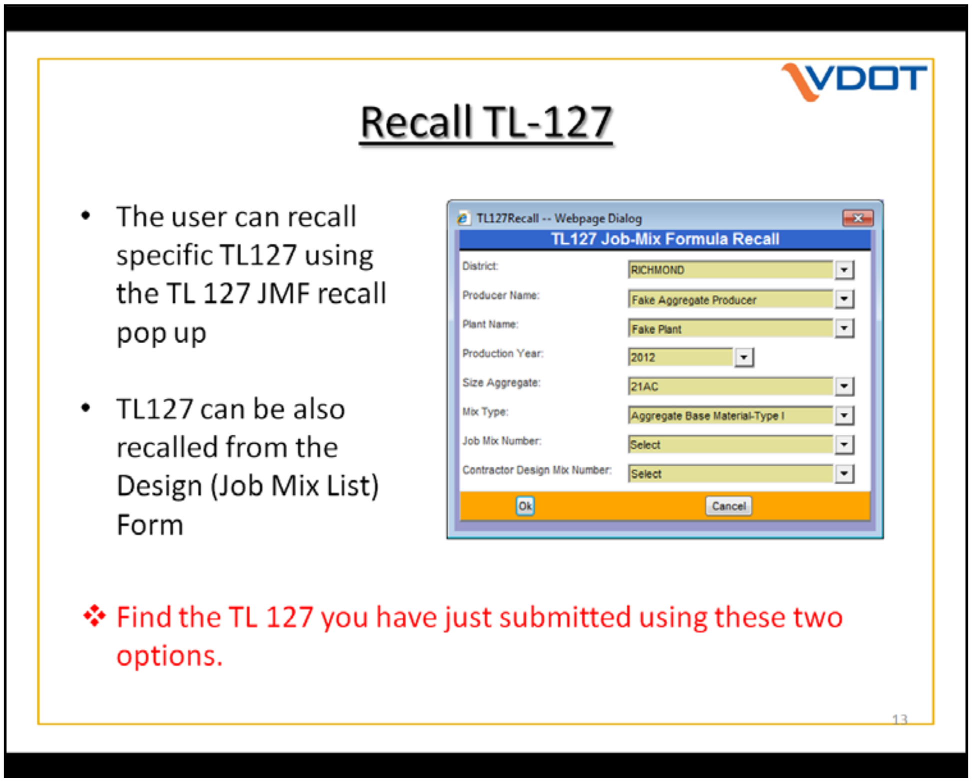


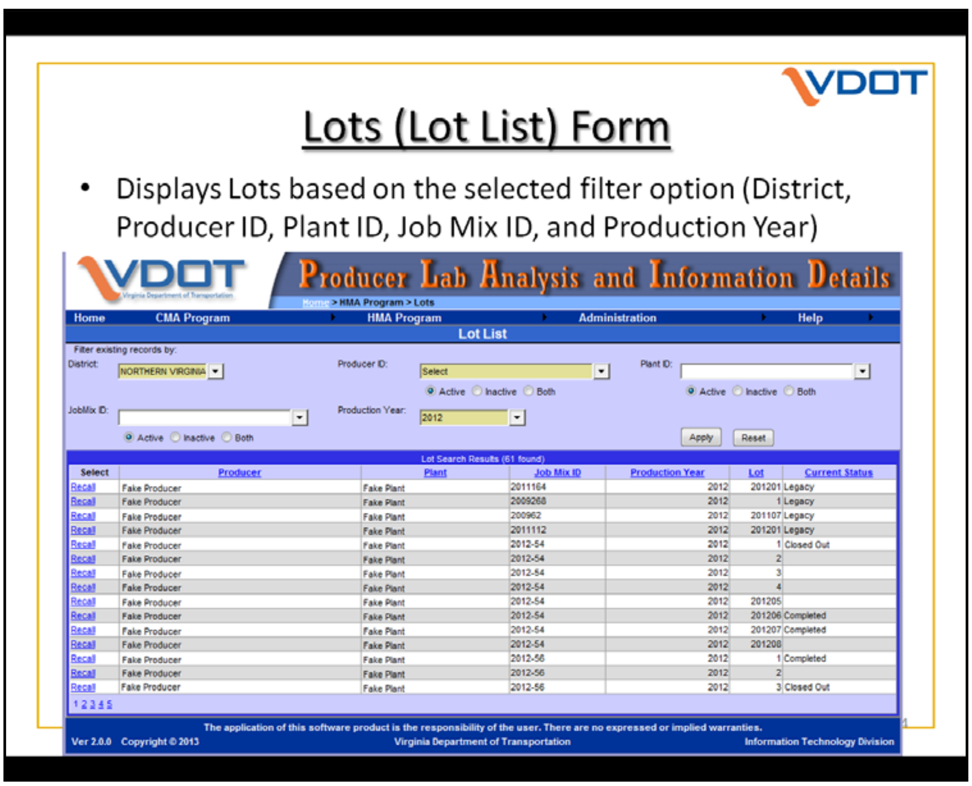

VDOT
Home
Lists all notifications that the user has received
VDOT
Producer Lab Analysis and Information Details
Home
Home
CMA Program
HMA Program
Administration
Help
Notification
Filter existing records by:
Include Hidden Notifications
Notification Type:
All
Notification Search Results (156 found)
Sent
Type
From
Message
Link
Hidden
Delete
5/30/2012 2:53 PM
TL127 HMA
Automated
TL127 has been Approved for Production Year: 2012 Part Part A.
Producer: Fake Producer
Plant: Location
Recall
5/21/2012 1:16 PM
TL50
Automated
TL50 has been Released.
Producer: Fake Producer
Plant: Location
Recall
5/17/2012 8:48 AM
TL52
Automated
TL52 has been Released.
Producer: Fake Producer
Plant: Location
Recall
5/17/2012 8:21 AM
Lot
Automated
Lot has been Closed Out.
Producer: Fake Producer
Plant: Location
Recall
5/17/2012 8:20 AM
TL50
Automated
TL50 has been Released.
Producer: Fake Producer
Plant: Location
Recall
First ... 23 24 25 26 27 28 29 30 31 32
Excel Report
The application of this software product is the responsibility of the user. There are no expressed or implied warranties.
Ver 2.0.0 Copyright © 2013
Virginia Department of Transportation
Information Technology Division

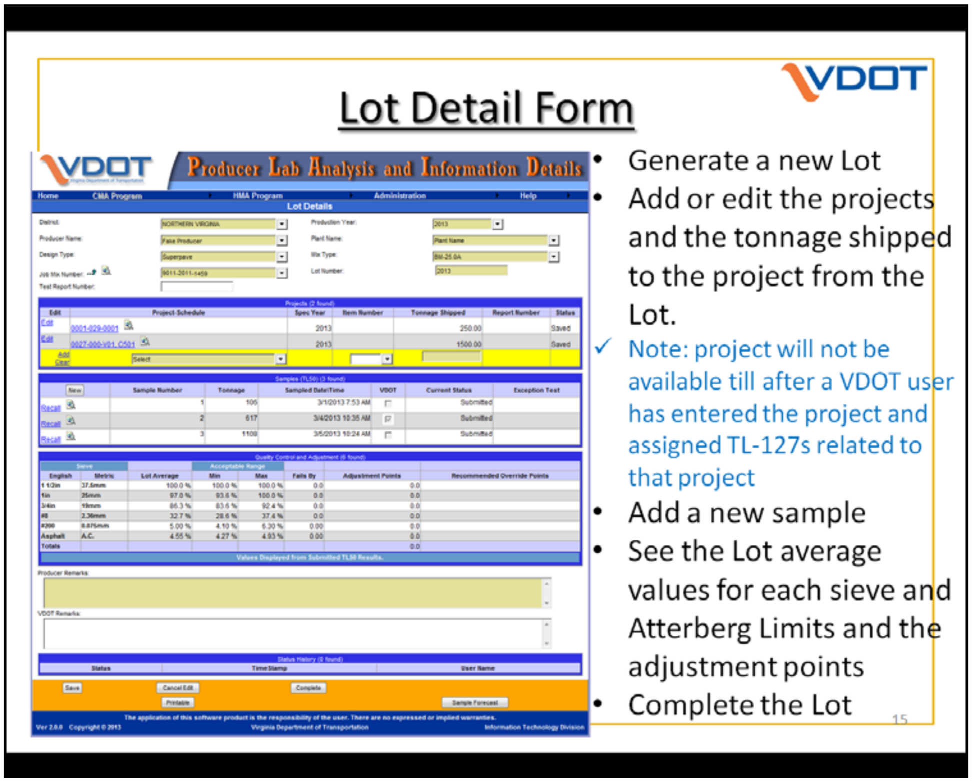

VDOT
Home (Notification Form)
Users will receive notifications when your VDOT representative (for the programs they are assigned and the Districts they have selected):
approves the TL 127 submitted (or decline)
certifies the TL 52 submitted
releases the TL 52 for the split sample tested by VDOT
closes out the LOT
sends a message etc.
10

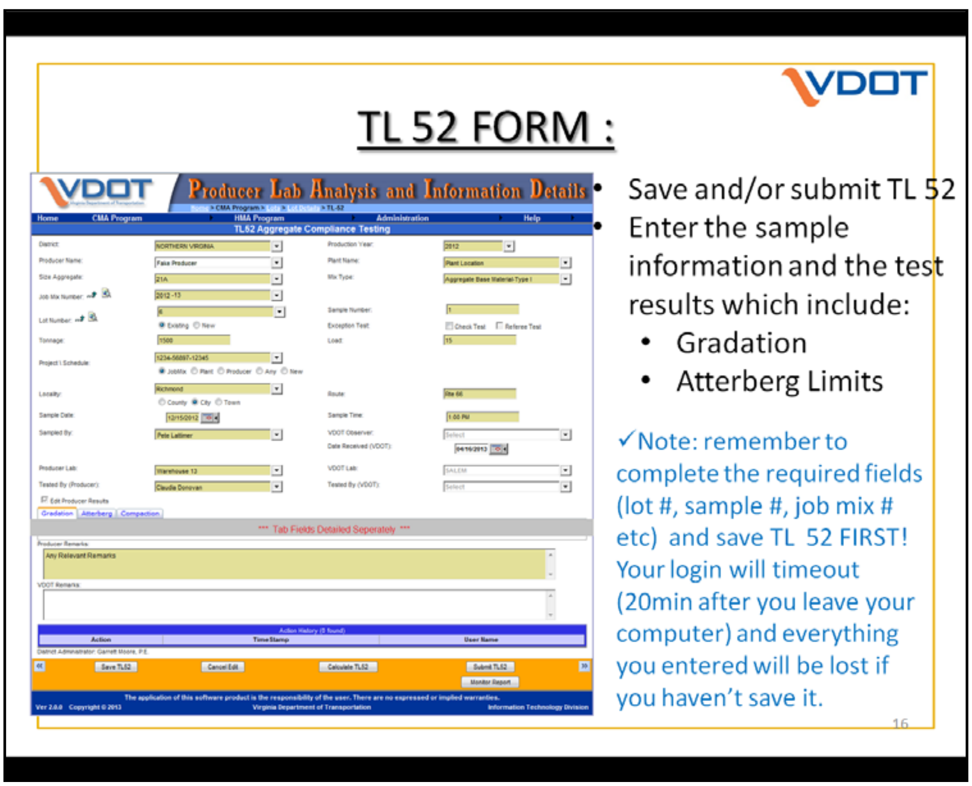

Design (Job Mix List) Form
VDOT
• Displays Job Mixes(TL127) based on the selected filter option (District, Producer ID, Plant ID, and Production Year)
Producer Lab Analysis and Information Details
Job Mix List
❖ Find all the job mix formulas for the year of 2010 (for your plant)


TL-127 Job Mix Formula
VDOT
Producer Lab Analysis and Information Details
• Save and/or submit TL127 for VDOT approval
• Clone TL127 from the existing TL127's
• Annual Quality Test Results (Compaction test results)
❖ Submit the Job Mix Formula (I will approve it) and see if you receive a notification that the JMF is approved.


VDOT
Recall TL-127
• The user can recall specific TL127 using the TL 127 JMF recall pop up
• TL127 can be also recalled from the Design (Job Mix List) Form
TL127Recall -- Webpage Dialog
TL127 Job-Mix Formula Recall
District: RICHMOND
Producer Name: Fake Aggregate Producer
Plant Name: Fake Plant
Production Year: 2012
Size Aggregate: 21AC
Mix Type: Aggregate Base Material-Type I
Job Mix Number: Select
Contractor Design Mix Number: Select
Ok
Cancel
❖ Find the TL 127 you have just submitted using these two options.
13


VDOT
Lots (Lot List) Form
• Displays Lots based on the selected filter option (District, Producer ID, Plant ID, Job Mix ID, and Production Year)
Producer Lab Analysis and Information Details
Home > HMA Program > Lots
Home
CMA Program
HMA Program
Administration
Help
Lot List
Filter existing records by:
District: NORTHERN VIRGINIA
Producer ID: Select
Plant ID:
Active Inactive Both
JobMix ID:
Production Year: 2012
Apply
Reset
Lot Search Results (61 found)
Select Producer Plant Job Mix ID Production Year Lot Current Status
Recall Fake Producer Fake Plant 2011164 2012 201201 Legacy
Recall Fake Producer Fake Plant 2009268 2012 1 Legacy
Recall Fake Producer Fake Plant 200962 2012 201107 Legacy
Recall Fake Producer Fake Plant 2011112 2012 201201 Legacy
Recall Fake Producer Fake Plant 2012-54 2012 1 Closed Out
Recall Fake Producer Fake Plant 2012-54 2012 2
Recall Fake Producer Fake Plant 2012-54 2012 3
Recall Fake Producer Fake Plant 2012-54 2012 4
Recall Fake Producer Fake Plant 2012-54 2012 201205
Recall Fake Producer Fake Plant 2012-54 2012 201206 Completed
Recall Fake Producer Fake Plant 2012-54 2012 201207 Completed
Recall Fake Producer Fake Plant 2012-54 2012 201208
Recall Fake Producer Fake Plant 2012-56 2012 1 Completed
Recall Fake Producer Fake Plant 2012-56 2012 2
Recall Fake Producer Fake Plant 2012-56 2012 3 Closed Out
1 2 3 4 5
The application of this software product is the responsibility of the user. There are no expressed or implied warranties.
Ver 2.0.0 Copyright © 2013
Virginia Department of Transportation
Information Technology Division


Lot Detail Form
Generate a new Lot
Add or edit the projects and the tonnage shipped to the project from the Lot.
Note: project will not be available till after a VDOT user has entered the project and assigned TL-127s related to that project
Add a new sample
See the Lot average values for each sieve and Atterberg Limits and the adjustment points
Complete the Lot
15


TL 52 FORM :
Save and/or submit TL 52
Enter the sample information and the test results which include:
Gradation
Atterberg Limits
Note: remember to complete the required fields (lot #, sample #, job mix # etc) and save TL 52 FIRST! Your login will timeout (20min after you leave your computer) and everything you entered will be lost if you haven't save it.
16

TL 52 FORM –Gradation Tab :

- Enter the weight retained on each sieve as an input; percent retained and percent passing will be calculated based on the weights entered.
- Will see the results for the split sample done by VDOT and the D2S

Gradation | Atterberg | Compaction

Producer Values

Report Number: 12345678901234567890
Date Testing Complete: 04/16/2013
Lab Tracking Number: 1234567890
Total Aggregate Weight (g): 1500.0
Fines Aggregate Weight (g): 110.0

VDOT Values

Report Number:
Date Testing Complete:
Lab Tracking Number:
Total Aggregate Weight (g):
Fines Aggregate Weight (g):

Job-Mix Formula Quality Control (14 found)

Sieve			Producer					VDOT					D2S
English	Metric	JMF	Weight Retained (g)	Percent Retained	Percent Passing	Percent Retained (-#10)	Percent Passing (-#10)	Weight Retained (g)	Percent Retained	Percent Passing	Percent Retained (-#10)	Percent Passing (-#10)	Percent Passing
3in	75mm			0.0 %	100.0 %								
2 1/2in	63mm			0.0 %	100.0 %								
2in	50mm	100.0 %	0.0	0.0 %	100.0 %								
1in	25mm	95.0 %	85.0	5.7 %	94.3 %								
3/4in	19mm		53.0	3.5 %	90.8 %								
3/8in	9.5mm	67.5 %	500.0	33.3 %	57.5 %								
#4	4.75mm		200.0	13.3 %	44.1 %								
#10	2mm	37.0 %	10.0	0.7 %	43.5 %								
Mechanical Analysis of -#10 Sieve													
#20	0.85mm		0.0	0.0 %	43.5 %	0.0 %	100.0 %						
#40	.425mm	18.0 %	20.0	7.9 %	35.6 %	18.2 %	81.8 %						
#60	0.25mm		15.0	5.9 %	29.7 %	13.6 %	68.2 %						
#80	0.18mm		10.0	4.0 %	25.7 %	9.1 %	59.1 %						
#100	0.15mm		60.0	23.7 %	2.0 %	54.6 %	4.5 %						
#200	0.075mm	8.0 %	5.0	2.0 %	0.0 %	4.6 %	0.0 %						
Totals	(+#10)		848.0					0.0					

Producer Values — JMF Cement: 4.0 % Cement Content: 1.5 %

VDOT Values — Cement Content: D2S Cement:

17

TL 52 FORM –Atterberg Limits Tab:

- Enter Atterberg Limits test results (Liquid Limit, Plastic Limit, and Plasticity Index)

✓ Note: Atterberg Limits will be defined as Non- Plastic (NP) if no input is entered

Gradation | Atterberg | Compaction

Liquid Limit

Property	JMF	Producer	VDOT	Criteria Max
Weight of Dish (g)		1.0		
Weight of Dish + Wet Soil (g)		11.0		
Weight of Dish + Dry Soil (g)		8.0		
No. of Blows		5		
Weight of Water (g)		3.0		
Weight of Dry Soil (g)		7.0		
Percent Moisture	0.0 %	42.9 %		
Liquid Limit	23.0 %	35.3 %		23.0 %

Plastic Limit

Property	JMF	Producer	VDOT	Criteria Max
Weight of Dish (g)		1.0		
Weight of Dish + Wet Soil (g)		10.0		
Weight of Dish + Dry Soil (g)		9.0		
Weight of Water (g)		1.0		
Weight of Dry Soil (g)		8.0		
Plastic Limit		12.5 %		
Plasticity Index	2.0 %	22.8 %		2.0 %

18

TL 52 FORM – CompactionTab:

- Display the annual quality test results done by VDOT
- Producer user will only have Read access to this form, allowing them to review released information and use the links for navigation

Gradation | Atterberg | Compaction

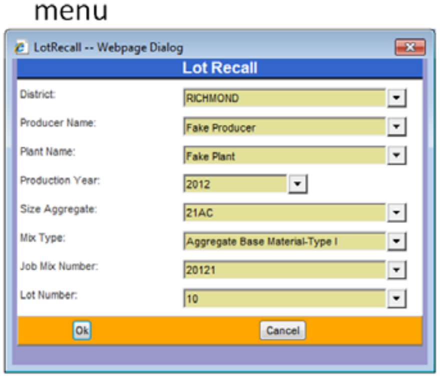
Compaction		
Property	JMF	VDOT
Bulk Specific Gravity	0.50	
Absorption (%)	1.2 %	
Optimum Moisture Content (-#4 Portion)	2.0 %	
Retained (+#4 Portion) (%)		55.87 %
Optimum Moisture Content Total Sample		1.6 %
Maximum Density (-#4 Portion) (pcf)	1.5	
Maximum Density Total Sample		3.2

❖ Create a lot for the JMF that is just approved, enter the test results onto TL 52, and submit TL 52

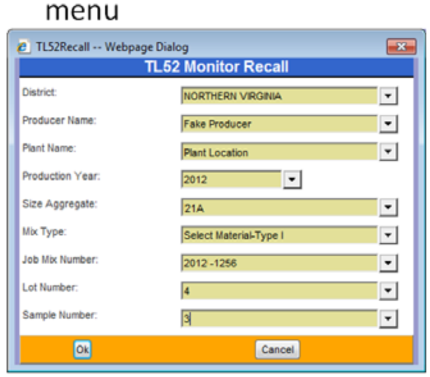
19

Recall Lot and Recall TL 52

- The user can recall specific Lot using the "Recall Lot" menu



- The user can recall specific TL 52 using the "Recall TL52" menu

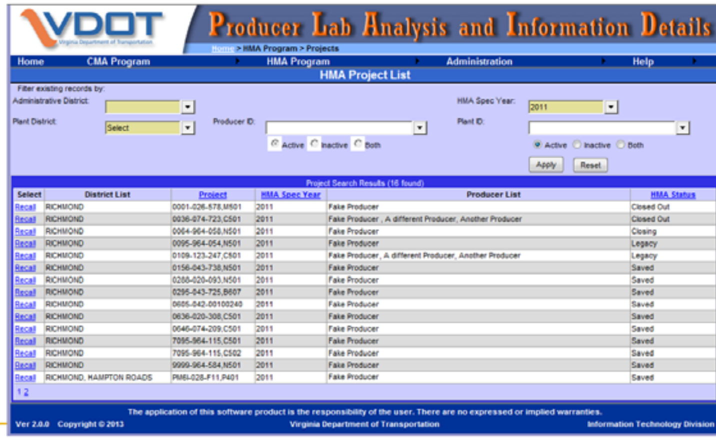


❖ Recall the lot that you has created
❖ Recall TL 52 that you has submitted

20

Projects (Projects List) Form

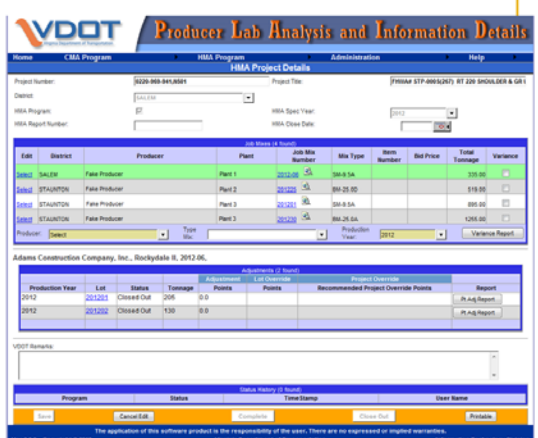
- Display Projects based on the selected filter option (Administrative District, CMA Spec Year, Plant District, Producer ID, Plant ID)



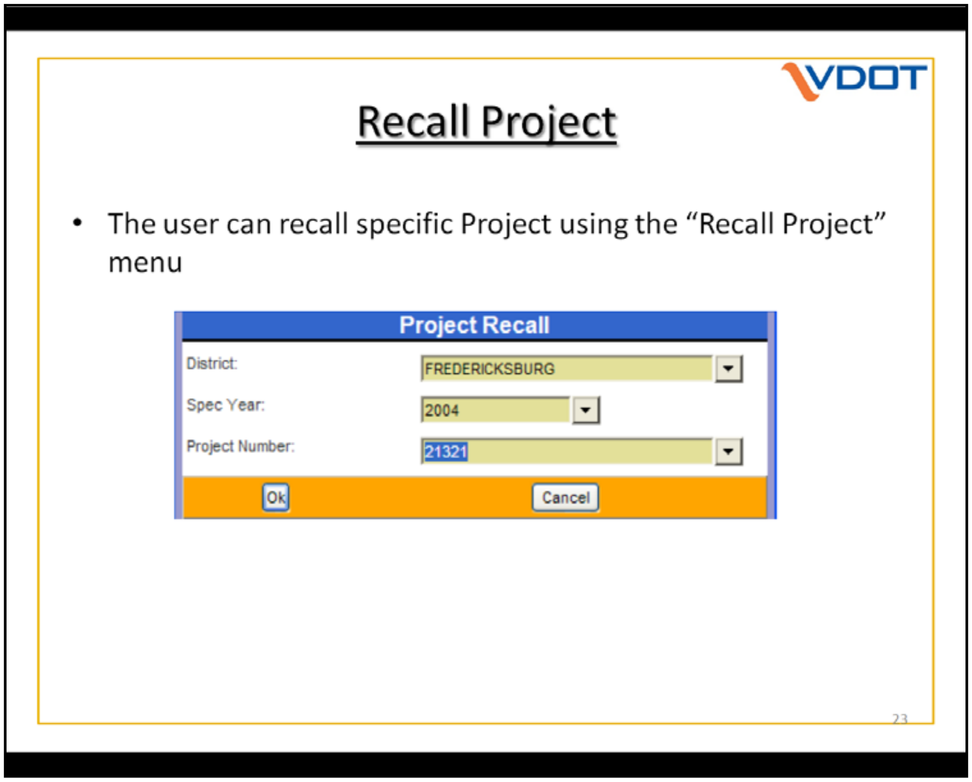
21

Projects Details Form

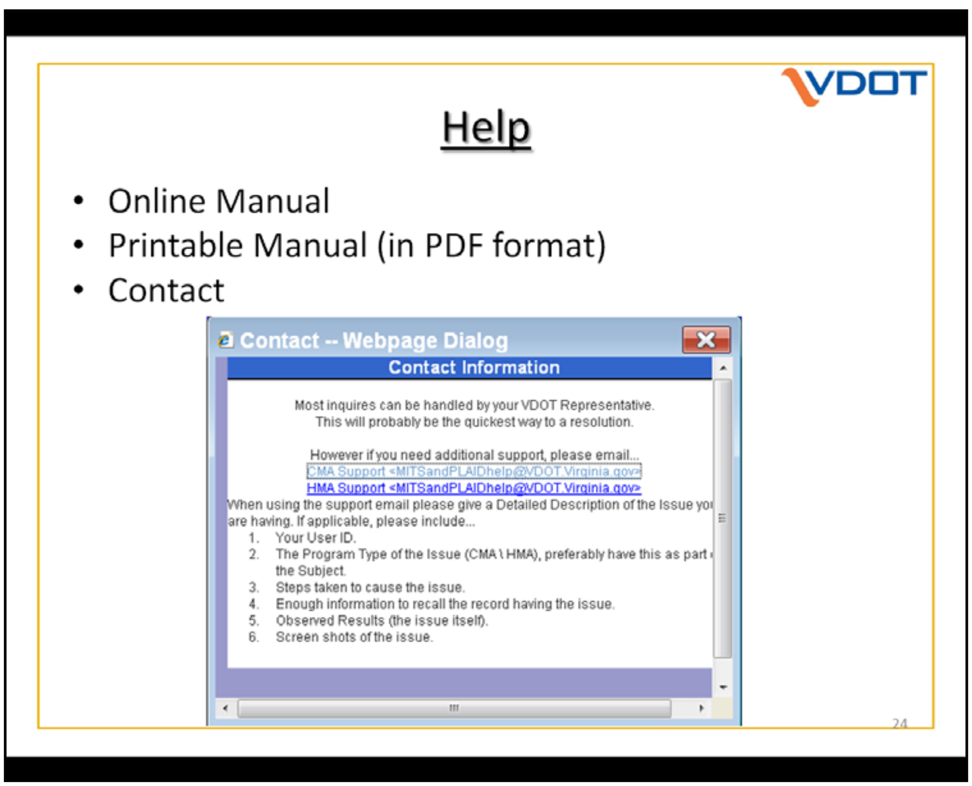
- Display the Job Mixes and the total tonnage used for the project
- Producer user will only have Read access to this form, allowing them to review released information and use the links for navigation



22



VDOT
Recall Project
• The user can recall specific Project using the "Recall Project" menu
Project Recall
District:
FREDERICKSBURG
Spec Year:
2004
Project Number:
21321
Ok
Cancel
23



VDOT
Help
• Online Manual
• Printable Manual (in PDF format)
• Contact
Contact -- Webpage Dialog
Contact Information
Most inquires can be handled by your VDOT Representative.
This will probably be the quickest way to a resolution.
However if you need additional support, please email...
CMA Support <MITSandPLAIDhelp@VDOT.Virginia.gov>
HMA Support <MITSandPLAIDhelp@VDOT.Virginia.gov>
When using the support email please give a Detailed Description of the Issue yo
are having. If applicable, please include...
1. Your User ID.
2. The Program Type of the Issue (CMA \ HMA), preferably have this as part
the Subject.
3. Steps taken to cause the issue.
4. Enough information to recall the record having the issue.
5. Observed Results (the issue itself).
6. Screen shots of the issue.
24

This page intentionally left blank.

A

Pay Quantities

Method of Computing Pay Quantities of Pugmill Mixed Material

To illustrate the method of computing pay quantities of central-mix aggregate with or withoutcement, let us assume that 500 tons of material was shipped containing 10 percent total moisture and 4 percent cement. (The test for total moisture must be made on a sample of material obtained by the Plant Quality Control Technician after all water has been added to the mix in the pugmill and after the material is ready for job shipment. This test must be conducted periodically during a day's operation.) Assume also that the average optimum moisture of the material is 6 percent. (This information is furnished by the District Materials Engineer.)

Step 1 - Determine Total Allowable Moisture Optimum Moisture + 2% = Total Allowable Moisture 6% + 2% = Total Allowable Moisture 8% = Total Allowable Moisture
Step 2 - Determine the Dry Weight of the Aggregate Tons Shipped / (1 + % Avg. Moist.) = Dry Wt. of Aggregate 500/ (1 + 10%) = Dry Weight of Aggregate 500/ (1 + .10) = Dry Weight of Aggregate 500/ (1.10) = Dry Weight of Aggregate 454.55 = Dry Weight of Aggregate
Step 3 – Determine the Pay Quantity Dry Weight of Aggregate x (1 + % Allowable Moisture) = Pay Quantity 454.55 x (1 + 8.0%) = Pay Quantity 454.55 x (1 + .08) = Pay Quantity 454.55 x (1.08) = Pay Quantity 490.91 = Pay Quantity

This is the total combined tonnage that should be computed as the amount eligible for payment. Notes should be made on the input form (Form TL-52A) and on the weighpersons Daily Summary Sheet showing the average optimum moisture and the total moisture, in order that the proper corrections for payment may be made later in the net weight recorded on the weigh ticket and in materials notebooks. If material is stockpiled after production, it will be necessary to perform tests for total moisture and record results on the above indicated forms at the time of shipment of the material to the project. If the moisture in the stockpile is below the minimum required (optimum minus 2 percent), either the stockpiles must be sprinkled to bring the moisture within allowable limits or the District Materials Engineer may require the material to be run through the pugmill again. Computations for the pay quantity should be carried out to the same decimal point as the pay item.

Appendix A   Pay Quantities
Knowledge Check

1. A plant produced 406 tons of material at a moisture content of 9.6%. If the optimum moisture was 6.0%, give the weight in tons of stone and moisture that may be paid for.

2. A plant produced 333 tons of mix at a moisture content of 10.6%. If the optimum moisture was 7.0%, give the weight in tons of stone and moisture that may be paid for.

This page intentionally left blank.

B VTM -40, Titration & Cement Plant Calibration

Virginia Test Method - 40

Determining Cement Content of Freshly Mixed Cement-Aggregate Mixtures

November 1, 2000

1. Scope

   1.1 This method of test is intended for determining the cement content of cement-aggregate mixtures sampled at the central mix aggregate plant.

   1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Apparatus

   2.1 Balance - A balance having a capacity of at least 1,000 grams with a sensitivity of at least 0.1 gram.

   2.2 Timer - A timer with a capacity of 10 minutes or more and a sensitivity of at least 0.1 second.

   2.3 Glassware - 25 ml graduated cylinder, 1,000 ml cylinder, 2000 ml volumetric flask, 50 ml burettes, 10 ml volumetric pipettes, 250 ml Erlenmeyer flasks, medicine droppers.

   2.4 Plasticware - 2 qt. polyethylene containers with snap-on covers, 12 in. diameter plastic funnel, 5 gal. polyethylene bottles for ammonium chloride, 5 gal. polyethylene bottles for demineralized water.

2.5 Burette Stand for 50 ml burette.

2.6 Magnetic Stirrer and Stirring Bar.

2.7 Stirring Rods - Glass stirring rods approximately 12 in. long.

2.8 Indicator Paper - Supply of indicator paper, pH range from 10 to 14.

2.9 Pipette Filler.

2.10 Sample Splitter - Maximum size l l/2 in.

3. Reagents

3.1 Ammonium Chloride Solution (10%) - Transfer 1893 g of U. S. P. granular ammonium chloride (NH_4C1) to a 5-gal. plastic bottle.

Make up to 5 gallons with distilled or demineralized water and mix well.

3.2 EDTA Solution (0.1 M) - Dissolve 74.5 g of reagent grade disodium (ethylenedinitrilo) tetraacetate dehydrate ($Na_2C_{10}H_{14}N_2O_82H_2O$) powder in about one litre of warm, distilled or demineralized water in a beaker. Cool to room temperature, transfer quantitatively to a 2-liter volumetric flask and make to the mark with distilled or demineralized water. Store in polyethylene bottle.

3.3 Hydroxy Napthol Blue may be used as the indicator.

3.4 Sodium Hydroxide Solution (50%) - Add 500 g of reagent grade sodium hydroxide (NaOH) pellets in 600 ml of distilled or demineralized water and allow to cool to room temperature. Dilute to one litre with distilled or demineralized water. Store in plastic bottle. Dilute 1:1 with distilled or demineralized water for use. Caution: Solution shall be mixed in the order given to avoid spontaneous reaction.

3.5 Triethanolamine Solution (20%) - Dilute 100 ml of reagent grade triethanolamine ($HOCH_2CH_2$) 3 N to 500 ml with distilled or demineralized water.

4. Procedure for Preparing Calibration Curve

4.1 From the materials to be used for construction, prepare 3 sets of duplicate samples at the design moisture content and containing the following amounts of cement:

Set 1. Two (2) samples at 75 percent of the design cement content.

Set 2. Two (2) samples at 100 percent of the design cement content.

Set 3. Two (2) samples at 125 percent of the design cement content.

Using a sample size of 600 grams for each sample, compute the quantities of aggregate, cement and water as follows:

$$Wa \text{ (total weight of aggregate, g)} = \frac{\text{Sample Size}}{(1 + M/100)(1 + C/100)}$$

$$Wr \text{ (weight of material retained on No. 4 sieve)} = \frac{R}{100} \times W_a$$

$$Wf \text{ (weight of material passing No. 4 sieve, g)} = W_a - W_r$$

$$Wc \text{ (weight of cement, g)} = \frac{C}{100} \times W_a$$

$$Vw \text{ (volume of water, ml)} = \frac{M}{100} (W_a + W_c)$$

Where:

M = design moisture content, percent by dry weight

C = cement content, percent by dry weight of aggregate, and

R = percent material retained on No. 4 sieve.

For each sample, mix the aggregate and cement thoroughly to a uniform color. Add the water and mix thoroughly.

Titrate each 600 g sample as described under Procedure for Titration. After titrating the 6 samples, construct a graph showing ml of EDTA solution vs. per cent cement by weight using average figures from Sets 1, 2, and 3.

A separate calibration curve shall be prepared for each brand, type and source of cement. When Type I-P is used, a separate calibration curve shall be prepared for each shipment in which the percent of fly ash varies by more than ±3.0 per cent from the quantity for which a curve has been established. (See page B-6)

5. Procedure for Test Samples

5.1 At the central mix aggregate plant, samples of the cement-aggregate mixture shall be taken at the completion of mixing. The samples are to be tested immediately or placed in covered plastic containers and tested within one hour of the completion of mixing.

For testing, weigh a 600 g portion and titrate as described under Procedure for Titration.

Note 1 - If a correction is to be made for variations in moisture content, determine the moisture content (M') of a separate portion of the material passing a No. 4 sieve. Computation for the correction are given under Calculations, Note 4.

6. Procedure for Titration

6.1 Place each 600 g sample in a 2-qt. polyethylene container and add 1,200 ml ammonium chloride solution. Place cover on the container and shake the mixture for 2 minutes (±2 seconds). Allow the mixture to settle for 4 minutes (±2 seconds). Pipette a 10 ml aliquot of the supernatant solution into a 250 ml Erlenmeyer flask and add 100 ml of distilled or demineralized water. While thoroughly mixing on a magnetic stirrer, add drops of sodium hydroxide solution until a pH between 13.0 to 13.5 is obtained as measured by the indicator paper. Use stirring rod to transfer drops of solution to indicator paper, add 4 drops of triethanolamine solution and then add about 0.2 g of the indicator powder. While the solution is being stirred on the magnetic stirrer, titrate with EDTA and record the quantity in ml to a pure blue endpoint.

Note 2 - A sharper endpoint may sometimes be obtained by adding approximately half of the anticipated quantity of EDTA solution before the addition of sodium hydroxide.

Note 3 - All equipment must be kept scrupulously clean by thorough rinsing with distilled or demineralized water. All reagents must be stored in polyethylene containers.

7. Calculations

Read the cement content by dry weight directly from the calibration curve corresponding to the titration results in ml of EDTA for the test sample.

Note 4 - Variations of moisture content (above 2%) will have a slight effect on the accuracy of test. Correction for moisture variation may be computed as follows:

$$C' = \frac{1 + M'/100\ C}{1 + M/100}$$

Where: C' = percent cement corrected for moisture variation,

C = percent cement determined from test sample,

M' = percent moisture of test sample as determined in Paragraph 5, Note 1, and

M = design moisture content.

GENERAL INFORMATION

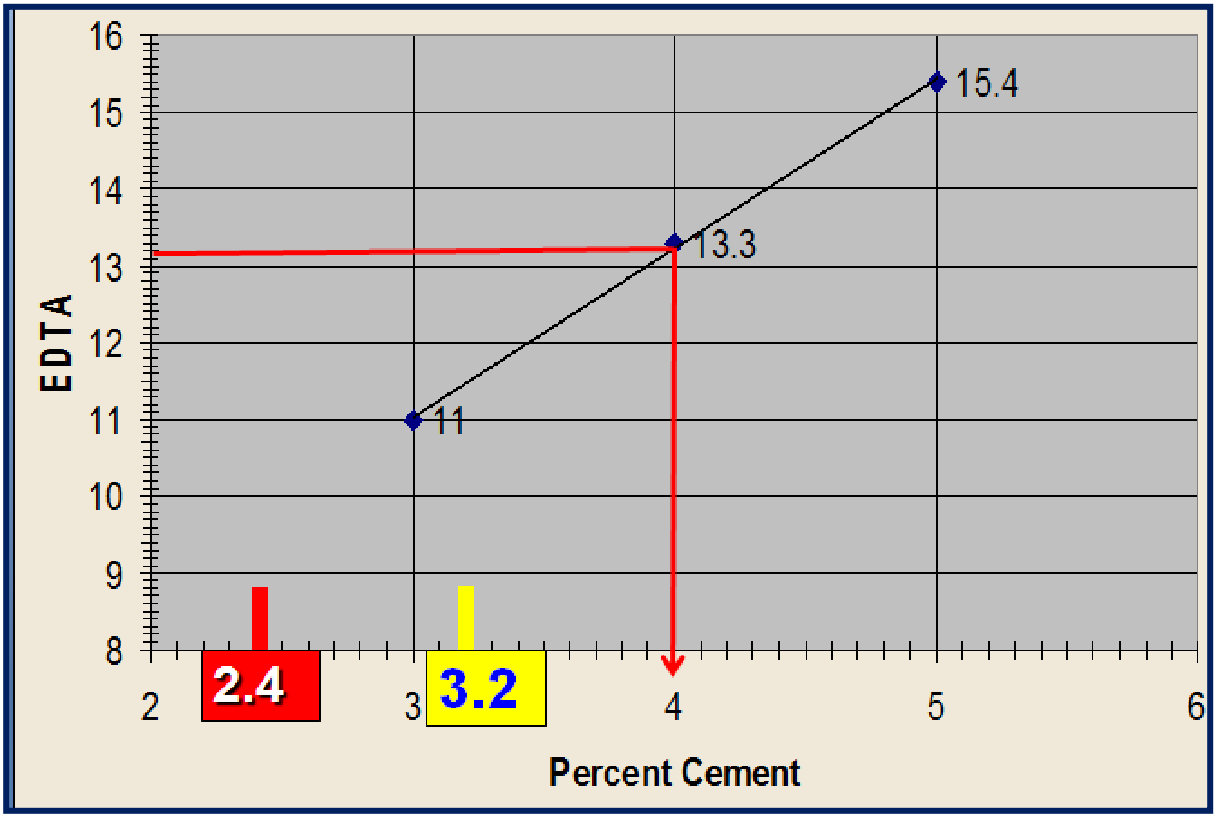
8. Miscellaneous

8.1 Size of sample - Obtain a 10 lb. sample. Split this sample over a splitter until about a 600 g sample is obtained. Weigh exactly 600 g as sample size for testing.

8.2 Sampling

8.2.1 In all cases, samples shall be taken in a stratified random manner.

8.2.2 When sampling from a truck, the truck should be divided into quadrants and the 4 samples shall be taken from randomized quadrants.


16
15
14
13
12
11
10
9
8
EDTA
15.4
13.3
11
2.4
3.2
2
3
4
5
6
Percent Cement

Cement Content Test Reagents and Steps

Step	Reagents	Reaction	Danger	Sensitivity
1	600 g Aggregate			0.1 g
2	1200 ml Ammonium	Extracts Calcium (Ca)	No	No
3	100 ml Distilled - Demineralized Water	Dilutes	No	No
4	Sodium Hydroxide	To bring pH to 13-13.5 because change in color will only take place at this pH.	Yes	No
5	4 drops Triethanolamine	Takes care of possible interference by (Fe) and (Mg) by forming a complex compound.	No	No
6	0.2 g Cal Red or Hydroxynapthol Blue	An indicator absorbs all but pink color; therefore, looks pink to begin with.	No	No
7	EDTA	Reacts with Calcium (Ca) then the first excess drop will react with indicator to change its absorption of light. Now it will absorb all but blue; therefore it looks blue.	No	No

A central mix aggregate plant is a relatively simple operation. Here two or more aggregates, having different gradations, are blended together to produce an aggregate mixture that meets Gradation and Atterberg Limits specifications for a particular application or size.

Aggregate is removed from storage, or stockpiles, proportioned and thoroughly mixed. This aggregate mixture is then stockpiled for future use or hauled to the job site.

Aggregate Feed Supply

Aggregate feed is the first major component of the central mix aggregate plant. The aggregate feeder may be charged by one or a combination of the following methods:

1. Open top bins with two, three, or four compartments, usually fed by a crane with a clamshell bucket or a front-end loader.

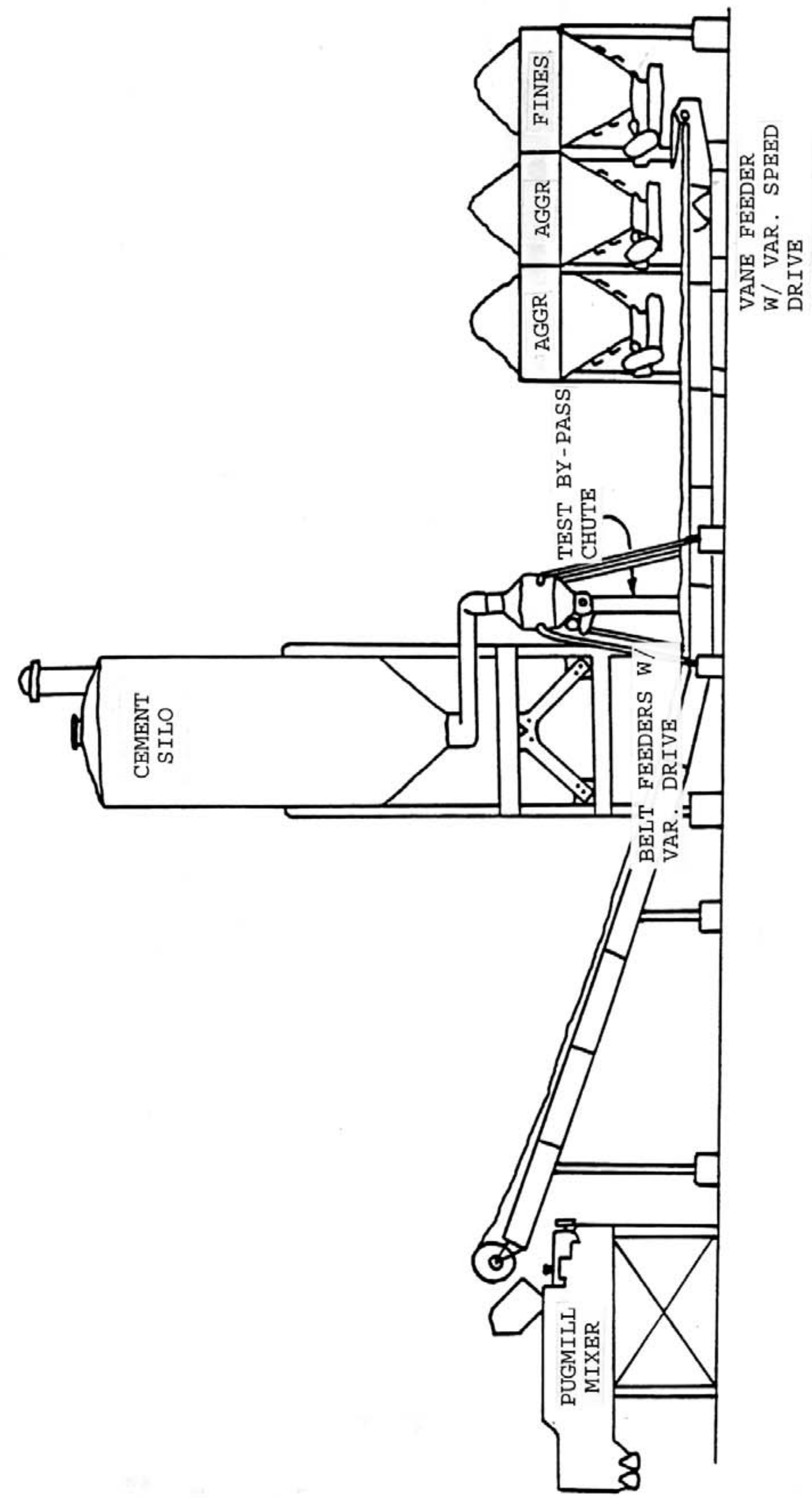
2. Tunnel under stockpiles separated by bulkheads. Materials are stockpiled over the tunnel by belt conveyor, truck, crane, or front-end loader.

3. Bunkers or large bins. These are usually fed by trucks, car unloaders, or bottom-dump freight car emptying directly into the bunkers.

The aggregate feed is one of the critical control points in the production flow-line. It is significant that, while most of the problems in central-mix aggregate plant production occur in the mixer or pugmill, the causes can usually be traced back to the aggregate feed.

When charging the aggregate bins, care should be exercised to minimize segregation and degradation of the aggregate. These can be prevented by taking the same precautions as for proper stockpiling. There should be sufficient material in all bins to provide a positive and uniform flow. Except for very large bins, no single bin should be run less than half-full, nor should any bin be loaded to overflow.

When the aggregate feed is stockpiled over a tunnel and belt, care should be taken in handling material over the feeders. The use of bulldozers should be discouraged. The reason they are discouraged is that on stockpiles there is serious danger of segregation and degradation. Vibrations from the bulldozer can cause fine particles in the stockpile to filter down into a layer which will be pushed to the feeder. Also, continuous abrasive action by the aggregate particles being moved about by the bulldozer, and the grinding action of its tracks, can cause degradation in both the coarse and fine aggregate stockpiles.


FINES
AGGR
AGGR
VANE FEEDER W/ VAR. SPEED DRIVE
TEST BY-PASS CHUTE
CEMENT SILO
BELT FEEDERS W/ VAR. DRIVE
PUGMILL MIXER

If the stockpile level above the tunnel is maintained by a dragline or clamshell, the operator must be careful not to pick up material from the same position in the stockpile in successive withdrawals.

When a front-end loader is used, the operator should be cautioned not to pick up material from the storage stockpile at ground level.

When trucks are used to charge the bin, they should deposit their loads directly above the feeder.

When the stockpile is replenished by overhead belts, the flow of material should be controlled by baffles or perforated chimneys.

Aggregate Feeders and Controls

Aggregate feeder units are located beneath the storage bins or stockpiles or in positions that assure a uniform flow of aggregate. Feeder units have controls that can be set to produce a uniform flow to the aggregate elevator. Generally, belt and vibratory feeders are best for accurate metering of the fine aggregates. Coarse aggregates usually flow satisfactorily with any type of feeder.

For a uniform output from the central-mix aggregate plant, input must be accurately measured. The importance of feeding the exact amounts of each size aggregate into the pugmill at the correct rate of flow cannot be overemphasized.

Cement Silo and Proportioning Devices

On certain projects, the plans will specify that the aggregate to be used in the pavement structure is to be stabilized by a chemical agent, usually cement. In these cases, an additional component needs to be added to the central-mix aggregate plant. This possible component of a central-mix aggregate plant is relatively simple. It usually consists of a standard cement silo with some type of proportioning attachment. The proportioning attachments or devices are either a simple gate control on the bottom of the silo or a variable-speed screw feeder or vane feeder. These devices must be calibrated to proportion at the desired rate.

The cement silo and proportioning device are located so that the stabilizing material (cement) can be proportioned onto the aggregate elevator belt prior to the discharge of the material into the pugmill.

Water Metering

All central mix aggregates, prior to use in road construction, must have the proper moisture content (i.e. optimum moisture ± 2% points) to aid in compaction of the material on the road. This moisture content also helps hydrate the cement in cement stabilized aggregates. To insure proper moisture, central-mix aggregate plants are equipped with some type of water proportioning system. Water proportioning can be achieved by either a sophisticated water metering device or a simple water control valve calibrated by trial and error.

Water is introduced to the aggregate mixture at the input end of the pugmill through a spray bar. This spray bar emits a fine spray of water for the full width of the pugmill.

Pugmill

A twin pugmill-type mixer is commonly used in all modern central-mix aggregate plants. This unit is mounted directly beneath the aggregate elevator, and high enough so that it may discharge the mixture into the truck or other hauling unit.

Mixing

When aggregates are discharged from the aggregate elevator and deposited in the pugmill, some mixing takes place. The mixing time begins when the flow of material from the aggregate elevator is deposited in the pugmill.

The mixing time should be as long as is necessary to get a uniform distribution of aggregate sizes. Speed of the mixer shafts and the arrangement and pitch of the paddles are factors governing mixing efficiency.

Upon completion of the mixing time, the bottom of the pugmill mixer opens up and discharges the contents into a truck or other hauling equipment.

Knowledge Check
Appendix B Titration, VTM-40

1. The Producer shall furnish a motorized screen shaker for:

   A. Fine aggregate gradation analysis.
   B. Coarse aggregate gradation analysis.
   C. Coarse and fine aggregate gradation analysis.

2. To determine the cement content of cement aggregate mixtures by the Titration Method, samples shall be taken at the:

   A. Beginning of mixing.
   B. Completion of mixing.
   C. Completion of compaction on the road.
   D. Prior to mixing

3. When dealing with sodium hydroxide solution, you should always pour the solution into distilled or demineralized water to prevent a spontaneous reaction.

   A. True
   B. False

4. The method used to determine the cement content of cement aggregate mixtures is:

   A. Reflux Method.
   B. Centrifuge Method.
   C. Titration Method.
   D. Marshall Method.

5. In determining the cement content by the Titration Method, the sample for testing should weigh 600 grams.

   A. True
   B. False

C MODIFIED ACCEPTANCE PROGRAM

Modified Acceptance Program Control Plan

Open Graded Coarse and Fine Aggregates

Aggregate Producers shall be responsible for controlling their product for gradation and Atterberg Limits, in accordance with the plan outlined herein, when producing any type aggregate, other than Type I Select Material or any type subbase or base dense graded, central-mixed aggregates specified respectively in Secs. 207 and 208 of the Road and Bridge Specifications. Approval of the Producer's Quality Control (QC) Plan shall in no way relieve the Producer or Contractor of responsibility for complying with all of the requirements of the contract or specifications. The QC Plan shall meet the following specific requirements.

Sampling Rate

The QC sampling rate shall be one sample per 1000 tons per size of material produced. It is recognized that due to production schedules, past performance and perhaps other factors, this rate may be changed for a particular operation. Therefore, the actual rate for a specific location shall be at the discretion of the District Materials Engineer.

Sampling Method

With the requirements of quality assurance and Producer certification of aggregate, the method of obtaining aggregate samples for grading tests becomes more critical. Therefore, the only way statistics will be meaningful is for the sampling, by both the Department and the Producer, to be performed in a similar manner.

Samples shall be obtained from each size material produced. These samples shall be selected from barges, conveyor belts, or stockpiles or as approved by the Engineer. Sampling and testing shall be performed by qualified personnel.

Sampling of aggregate shall follow the procedures outlined in AASHTO T2 as modified herein. The shovel used for sampling of aggregates shall be a square nose shovel of spade design with slightly built up edges and back, capable of penetrating full depth into the stockpile. A short handle with butt handle grip is needed to obtain the leverage to remove the sample from the stockpile. The sample size should be as noted on page 5-5.

For source approval sampling, segregation of the individual particles is not important, for they will be recombined into the testing sizes needed in the laboratory. Therefore, for coarse aggregate, a sample of approximately 40 lbs. (20 kg) each of No. 8 and No. 57, if available, will generally be sufficient to conduct quality tests. For fine aggregate, a single 40 lb (20 kg) is sufficient.

To determine gradation compliance, the sampler shall take care to follow the procedures outlined above exactly. When safe to do so, samples shall be taken at a point other than in stockpiles to reduce the error inherent with stockpile segregation. A sample of approximately 10 lbs. (5 kg) is typically sufficient for fine aggregate and one of 30 lbs. (15 kg) for coarse aggregate. Open-graded aggregates and Grade A fine aggregate shall be tested for minus 200 material by washing prior to the dry gradation being performed.

All verification samples shall be packed and marked in accordance with Sec. 203 of the Manual of Instructions (MOI), using Form TL-10, as outlined in Sec. 800 of the MOI. Special care shall be taken to ship the aggregate in a secure container or sample bag free of contaminants.

Four types of sampling are permitted; belt sampling, stockpile sampling, miniature stockpile sampling and tube sampling. See Chapter 2 of this manual for details.

The importance of sampling is equivalent to the importance of good quality control. The primary concern of sampling is to take samples that will represent the stockpile as closely as possible and will determine as accurately as practical the properties of the complete stockpile.

Acceptance of Materials

Materials which fail to meet the specification requirements shall not be shipped to State projects or for State uses under any circumstances.

All materials meeting the applicable specification requirements may be shipped as accepted based on the Producer's certification, which, among other things, shall state that the required tests by the Producer have been performed and have met the specification requirements of the material. See Section 204 of the Manual of Instructions and the Road and Bridge Specification.

The Producer shall furnish to the Department a copy of the test results for each size material produced.

The Producer shall keep all records pertinent to the production for a period of one year and they shall be available for review by the Engineer.

Verification

The Department through the District Materials Engineer will visually inspect stockpiles of produced materials. When deemed necessary by the Department, verification testing may be performed to verify the adequacy and accuracy of the Producer's quality control plan. When requested by the Materials Representative, samples shall be taken by the Producer in the presence of the Materials Representative, and then either quartered or introduced through a sample splitter with each party conducting the test on their half. Verification tests shall be conducted in the VDOT Laboratory or by AMRL-accredited consultant laboratories. The verification test results shall be compared to the Producer's test results.

The verification test results shall no way be used to judge acceptance. The Producer's half of the verification sample may serve as its production sample for that 1000-ton lot. If the comparisons indicate verification test results are not in relatively close agreement with the Producer's results, an investigation shall be made to determine the reason for the difference. In the event it is determined that the Producer's test results are not representative of the product, the Producer shall take corrective action to alleviate any problems identified. If corrective action is not performed in a timely manner or does not alleviate problems identified, the Department may withdraw approval of the Producer's QC plan.

General

The Producer's quality control plan shall include a system by which the District Materials Engineer shall be advised as to the amount and size of material shipped to each project or order. If the Producer's quality control plan is found to be unsatisfactory, the Department may withdraw approval of the program.

Dry Riprap - Contractors shall furnish and place the class of dry riprap specifed on the plans. Alhough dry riprap is primarily mechanically sized during production as other aggregates are, the acceptance of riprap relies primarily on visual inspection for size and percentages to meet the Department's specifications. Thus to avoid project delays and minimize material rejections the Project Inspector is to use the following procedures:

Stockpiled Dry Riprap - Verify the size and acceptability of the material at the quarry prior to shipment.

Dry Riprap to be shipped as it is produced - Establish by visual inspection with the Contractor and the Producer the size and percentages required to meet the Department's specifications.
The Contractor shall furnish samples of the minimum and maximum size riprap at the project site to be used for visual comparison of riprap delivered to the project and a sample should be maintained at the quarry for the Producer's benefit. In event a shipment is questionable as to specification conformance, the District Materials Engineer shall make the final determination as to acceptability.

Sizes No. 1, No. 2, No. 3 and Gabion Stone

Except for use in hydraulic cement concrete, aggregate size No. 1, No. 2, No. 3 and Gabion Stone shall be inspected visually for size, cleaniness and general conformance to the specified gradation. Gradation testing shall be performed by the Department in the event of dispute.

Aggregate Gradation

As previously stated in Chapter 3 the grading of an aggregate is determined by a sieve analysis in which the particles are divided into various sizes by sieves. The sieves for grading coarse aggregate are:

COURSE AGGREGATE SIEVES	FINE AGGREGTE SIEVES
75 mm (3 in.)	4.75 mm (No. 4)
63 mm (2 ½ in.)	2.36 mm (No. 8)
50 mm (2 in.)	1.18 mm (No. 16)
37.5 mm (1 1/2 in.)	600 µm (No. 30)
25 mm (1 in.)	300 µm (No. 50)
19.0 mm (3/4 in.)	150 µm (No. 100)
9.5 mm (3/8 in.)	75 µm (No. 200)
4.75 mm (No. 4)	

For any test to be valid, it should be run on a sample that is representative of the total material to be used or, as it is in concrete, the total stockpile. The method of obtaining a representative sample for aggregate gradations has been previously explained in Chapter 3.

The representative sample must now be reduced to the proper size for testing by either the quartering method, or by use of a sample splitter. Both methods reduce the sample to approximately half the size each time it is used.

The sample size is determined by the size of the aggregate as shown below.

Nominal Maximum Size Aggregate	Minimum Test Sample Size (grams)
No. 8 (2.36 mm)	300
No. 4 (4.75 mm)	300
No. 3/8 (9.5 mm)	1,000
½ in. (12.5 mm)	2,000
3/4 in. (19.0 mm)	5,000
1 in. (25.0 mm)	10,000
1 ½ in. (37.5 mm)	15,000
2 in. (50.0 mm)	20,000

In a sieve analysis, a nest of sieves is placed in a mechanical vibrator with the smallest openings on the bottom and largest on top. A dry representative sample of aggregate is weighed and placed in the top sieve and the nest of sieves are vibrated until all particles are separated.

The fraction of material retained on each sieve is weighed cumulatively, and the cumulative percent retained and percent passed each screen is calculated. The results are compared with the gradation range of the specification to determine if the aggregate meets gradation requirements.

(Note: In a fine aggregate sieve analysis, the test sample is washed over the No. 200 (75 µm) sieve and the portion retained on the No. 200 (75 µm) is dried and the loss recorded.)

Grading a Sand

Sieve Analysis Example

The following sieve analysis is for a sample of natural sand not subject to abrasion and meets Virginia Department of Transportation requirements for Grading "A" Sand.

In this example, the cumulative weight retained on each sieve was determined in the sieve analysis. The first step is to calculate the cumulative percent retained on each sieve. Divide the cumulative weight retained by the total weight of the sample, and multiply the answer by 100 (converts decimal to percent).

Sieve Size	Cumulative Grams Retained	Cumulative % Retained	% Passing	VDOT Specs. (% Passing)
9.5mm (3/8 in.)	0.0	0.0	100	100
4.75mm (No. 4)	6.2	1.0	99	95-100
2.36mm (No. 8)	108.5	18.1	82	80-100
1.18mm (No. 16)	228.7	38.2	62	50-85
600µm (No. 30)	355.5	59.4	41	25-60
300µm (No. 50)	476.3	79.6	20	5-30
150µm (No. 100)	551.9	92.2	8	0-10
75µm (No. 200)	583.6	97.5	2.5	0-5
Total Wt.	598.7	100.0		

For Example:

4.75 mm (No. 4) sieve cumulative % retained =

Cumulative weight retained: 6.2 grams = 0.0103 X 100 = 1.0%
Total weight of sample: 598.7 grams

After finding the cumulative percent retained on each sieve, we subtract the cumulative percentage retained on each standard sieve from 100 to obtain the percent passing, as illustrated below:

9.5 mm (No. 3/8 in.) sieve: 100.0 - 0.0 = 100%
4.75 mm (No. 4) sieve: 100.0 - 1.0 = 99%

The percent passing is compared to the VDOT specification range to determine if the sample passes. Road & Bridge Spec. - Section 202.02

TABLE II-1
Fine Aggregate

Grading	**Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Mass)**							
	3/8 in. 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 30 600 µm	No. 50 300 µm	No. 100 150 µm	No. 200 75 µm
A	Min. 100	95-100	80-100	50-85	25-60	5-30	Max. 10	
B	Min. 100	94-100					Max. 10	
C	Min. 100	94-100				Max. 25		

Material	% by Weight	Test Method
Clay lumps	0.25	T112
Shale, mica, coated grains, soft or flaky particles	1.0	T113
Organic material	0	T21
Total material passing No. 200 sieve by washing[1]		T11 and T27
For use in concrete subject to abrasion	3	
For other concrete	5	

[1]In the case of stone sand, if the material passing the No. 200 sieve is dust of fracture essentially free from clay or shale, the percentages shown for use in concrete subject to abrasion and in other concrete may be increased to 5.0% and 7.0%, respectively.

Example: No.57 Sieve Analysis

Sieve Size	Grams Retained	% Retained	% Passing	VDOT Specs. (% Passing)
37.5 mm (1 1/2 in.)	0.0	0.0	100	100
25.0 mm (1 in.)	97.7	1.0	99	95 - 100
19.0 mm (3/4 in.)	1087.8	10.8	88	
12.5 mm (1/2 in.)	4269.8	42.5	46	25 - 60
9.5 mm (3/8 in.)	2286.3	22.8	23	
4.75 mm (No. 4)	1805.2	18.0	5	0 – 10
2.36 mm (No. 8)	210.7	2.1	3	0 – 5
Total Wt.	10037.5			

25.0 mm (1 in.) sieve % retained =

Weight retained: 97.7 grams = 0.0097 X 100 = 1.0%
Total weight of sample: 10037.5 grams

After finding the percent retained on each sieve, we subtract the percentage retained on each standard sieve from 100 to obtain the percent passing, as illustrated below:

37.5 mm (1 1/2 in.) sieve 100.0 - 0.0 = 100%
25.0 mm (1 in.) sieve 100.0 - 1.0 = 99%

The percent passing is compared to the VDOT specification range to determine if the sample passes.

Crusher Run

(a) Grading - Grading shall conform to the following when tested in accordance with the requirements of AASHTO T27:

% by Mass of Materials Passing Sieve

Size No.	63 mm 2 ½ in.	50 mm 2 in.	37.5 mm 1 ½ in.	25.0 mm 1 in.	19.0 mm 3/4 in.	4.75 mm No. 4
24	Min. 100	95±5				32±18
25			Min. 100	95±5		32±18
26				Min. 100	95±5	38±22

(b) Atterberg Limits - The liquid limit shall be not more than 25. The plasticity index shall be not more than 3. Tests will be performed in accordance with the requirements of VTM-7.

(c) Soundness Loss - Soundness loss shall conform to the requirements of Table II-4 for aggregate bases. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

(d) Abrasion Loss - Abrasion Loss shall be not more than 45 percent. Tests will be performed in accordance with the requirements of AASHTO T96. (c) Soundness Loss - Soundness loss shall conform to the requirements of Table II-4 for aggregate bases. Tests will be performed in accordance with the requirements of AASHTO T103 or T104.

TABLE II-3
Sizes of Open-Graded Coarse Aggregates

Va. Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)														
	4 in.	3-1/2 in.	3 in.	2-1/2 in.	2 in.	1-1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No.16	No. 50	No. 100
1	Min. 100	90-100		25-60		Max. 15		Max. 5							
2			Min. 100	90-100	35-70	Max. 15		Max. 5							
3				Min. 100	90-100	35-70	0-15		Max. 5						
357				Min. 100	95-100		35-70		30-Oct		Max. 5				
5						Min. 100	90-100	20-55	Max. 10	Max. 5					
56						Min. 100	90-100	40-85	Oct-40	Max. 15	Max. 5				
57						Min. 100	95-100		25-60		Max. 10	Max. 5			
67							Min. 100	90-100		20-55	Max. 10	Max. 5			
68							Min. 100	90-100		30-65	25-May	Max. 10	Max. 5		
7								Min. 100	90-100	40-70	Max. 15	Max. 5			
78								Min. 100	90-100	40-75	25-May	Max. 10	Max. 5		
8									Min. 100	85-100	30-Oct	Max. 10	Max. 5		
8P									Min. 100	75-100	30-May	Max. 5			
9										Min. 100	85-100	Oct-40	Max. 10	Max.5	
10										Min. 100	85-100				10-30

Knowledge Check

Chapter 5 Modified Acceptance

1. What is the rate of sampling under the Modified Acceptance Plan for Open Graded Aggregates?

   A. one per 500 tons
   B. one per 1000 tons
   C. one per 1500 tons
   D. one per 2000 tons

2. The sample taken for open graded aggregates accepted under the Modified Acceptance Plan is taken from:

   A. Conveyor Belt
   B. Stockpile
   C. Barge
   D. All of the above

3. Does the Quality Control Technician have to be certified?

   A. Yes
   B. No

4. All Open-Graded Aggregates must have a job-mix submitted before production can start.

   A. True
   B. False

Problem No. 1 Sieve Analysis

Open Graded Aggregates

Check the following sieve analysis of a sample of natural sand for use in concrete not subject to abrasion and determine if it meets Virginia Department of Transportation requirements for Grading "A" Sand. Circle the sieve(s) not passing, if any.

Sieve Size	Cumulative Grams Retained	Cumulative % Retained	% Passing	VDOT Specs. (% Passing)
9.5 mm (3/8 in.)	0.0			
4.75 mm (No. 4)	16.6			
2.36 mm (No. 8)	64.5			
1.18 mm (No. 16)	214.1			
600 μm (No. 30)	389.2			
300 μm (No. 50)	483.0			
150 μm (No. 100)	543.4			
75 μm (No. 200)	565.0			
Total Wt.	573.0			

Does this sample pass? Yes________ No________

Problem No. 2 Sieve Analysis
Open Graded Aggregates

Check the following sieve analysis of a sample of 57s and determine if it meets Virginia Department of Transportation requirements. Circle the sieve(s) not passing, if any.

Sieve Size	Grams Retained	% Retained	% Passing	VDOT Specs. (% Passing)
37.5 mm (1 1/2 in.)	0.0			
25.0 mm (1 in.)	0.0			
19.0 mm (3/4 in.)	703.2			
12.5 mm (1/2 in.)	4544.7			
9.5 mm (3/8 in.)	2247.8			
4.75 mm (No. 4)	2250.6			
2.36 mm (No. 8)	116.1			
Total Wt.	10120.7			

Does this sample pass? Yes________ No________

This page intentionally left blank.

D Knowledge Check Answers

Chapter 2 Quality Assurance Program

Answers

1. What determines the lot size for a specified material accepted under the Statistical QA Program?

   D. A and B

2. A normal lot is represented by how many test samples?

   D. 4

3. The Producer's Technician is responsible for making batch adjustments.

   A. True

4. The job-mix formula is approved by the:

   C. District Materials Engineer

5. The Project Inspector is responsible for the submission of the job-mix formula.

   B. False

6. One of the duties of the District Materials Engineer's CMA staff technician is to provide technical guidance to the Producer's Technician.

   A. True

7. The inspection, sampling, and testing of the aggregates for conformance with the VDOT Specifications are the responsibilities of the:

   C. Producer's Technician

8. Must the Producer's Technician in a plant producing Aggregate Base, Subbase and Select Material, Type I be certified CMA Technicians?

   A. Yes

9. When must the job-mix formula be submitted by the Producer?

   Before production begins.

10. How long does the Department have to evaluate a job-mix formula change?

    Up to one week.

11. A system that allows resampling and retesting where there is doubt that the original test results are valid is the:

    A. Referee System

12. A chart that is set up to alert the Producer when to investigate his process is a Control Chart.

    A. True

13. The job-mix Formula for Aggregate Bases, Subbases, and Select Material, Type I is chosen from the:

    B. Design Range

14. In the production of cement stabilized aggregate, no one sample shall have a cement content more than 1.3 percent below that stated on the job-mix formula.

    B. False

15. Is it permissible to accept Central Mix Aggregate by visual inspection?

    B. No

16. Who approves the source and quality of materials for use in Central Mix Aggregates?

    The Materials Division

17. Who is required to furnish a plant laboratory?

    The Producer

18. The job acceptance sample for central-mix aggregate bases, subbases and select material is taken from:

    B. Mini-stockpile

19. What is the difference in taking a sample of stabilized and non-stabilized material?

    Non-stabilized material is sampled when the ton comes up for testing. Stabilized material is tested for cement content when the ton comes up and then the cement is cut off and the sample is pulled from the next truck that has no cement in the mixture for gradation.

20. Does the Plant Quality Control Technician run job acceptance samples when the producer is stockpiling?

    B. No

Chapter 3 Sampling and Testing Aggregates

Answers

1. The fine gradation is washed over the:

   D. No. 200 (75 µm) sieve

2. The sieve size that separates the coarse material from the fine material is the:

   B. No. 10 (2.00 mm) sieve

3. The fine gradation sample should weigh between:

   C. 125 and 200 grams

4. A process in which an aggregate is separated into its various sizes by passing it through screens of various openings for the purpose of determining the distribution of the quantities separated is:

   B. Sieve analysis

5. The minimum dry weight of a sample of central mix aggregate that contains +19.0 mm material should be:

   C. 5000 grams

6. Two acceptable ways of splitting a sample are by a sample splitter and by the quartering method.

   A. True

7. What is the temperature range at which the fine gradation is dried?

   230 ± 9° F (110 ± 5° C)

8. The fine material is shaken for how many minutes?

   7 to 10

9. The total sample is computed to the nearest______percent?

   Tenth

10. The numerical difference between the liquid limit and plastic limit is the plasticity index.

    A. True

11. The liquid limit and plastic limit tests are run on material passing the:

    B. No. 40 sieve (425 µm)

12. The moisture content at which a soil changes from a semi-solid to a plastic state is the liquid limit.

    B. False

13. In determining the liquid limit and plastic limit, the portion of the wet sample used must be dried at a temperature not to exceed 140°F (60°C) .

    A. True

14. Which tests are performed on Dense Graded Aggregates?

    Gradation, Liquid Limit and Plastic Limit.

15. What are the requirements for water used in the liquid limit and plastic limit test?

    Distilled and demineralized.

16. How many blows per second is the cup on the liquid limit device dropped?

    two per second

17. To determine the moisture content in the liquid limit test a slice of soil approximately the width of the spatula extending from edge to edge of the soil cake at right angles to the groove, and including that portion that flowed together must be taken.

    True

18. When determining the plastic limit, the soil is rolled to a thread of <u>1/8 inch (3.1 mm)</u>.

19. VDOT Specifications require that Central Mixed Aggregate be shipped at optimum moisture ________

    ± 2

Chapter 3 Sampling and Testing Aggregates
Problem No.1

Complete the following moisture determination problem and give the moisture content in percent.

Dish & Wet Material 700 grams
Dish & Dry Material 680 grams
Dish 200 grams

$$\begin{array}{r} 700 \\ \underline{-200} \\ 500 \end{array} \qquad \begin{array}{r} 680 \\ \underline{-200} \\ 480 \end{array} \qquad \frac{500 - 480}{480} \times 100 = \frac{20}{480} \times 100 = 0.042 \times 100 = 4.2\%$$

Chapter 3 Sampling and Testing Aggregates
Problem No.2

In an effort to determine the moisture content of a material, a sample of the material was taken and found to weigh 1346 grams. The sample was then dried to a constant weight and reweighed. The dried sample was found to have a weight of 1240 grams. Using this information, calculate the percent of moisture.

$$\frac{1346 - 1240}{1240} \times 100 \qquad \frac{106}{1240} \times 100 = 0.085 \times 100 = 8.5\ \%$$

Chapter 3 Sampling and Testing Aggregates

Problem No.3

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAIN ED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)				37.5 mm (1 ½)			
25.0 mm (1)			**100.0**	25.0 mm (1)			
19.0 mm (3/4)	**252**	**2.7%**	**97.3**	19.0 mm (3/4)			
9.50 mm (3/8)	**2352**	**25.2%**	**72.1**	9.50 mm (3/8)			
4.75 mm (4)	**1241**	**13.3%**	**58.8**	4.75 mm (4)			
2.0 mm (10)	**1017**	**10.9%**	**47.9**	2.0 mm (10)			**100.0**
.850 mm (20)		**10.9%**	**37.0**	.850 mm (20)	**39.7**	**22.8%**	**77.2**
425 mm (40		**6.4%**	**30.6**	425 mm (40	**23.2**	**13.3%**	**63.9**
.250 mm (60)		**3.7%**	**26.9**	.250 mm (60)	**13.4**	**7.7%**	**56.2**
.180 mm (80)		**2.5%**	**24.4**	.180 mm (80)	**9.2**	**5.3%**	**50.9**
.150 mm (100)		**1.8%**	**22.6**	.150 mm (100)	**6.4**	**3.7%**	**47.2**
. 075 mm (200)		**5.2%**	**17.4**	.075 mm (200)	**18.8**	**10.8%**	**36.4**
Total	**9334**	**17.5%**		Total	**174.2**	**36.5%**	

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **14**	No. of Blows **26**	Dish No. **19**		Liquid Limit **27**%
Dish & Wet Soil **87.1**	Dish & Dry Soil **84.1**	Dish & Wet Soil **80.1**	Dish & Dry Soil **78.0**	Plastic Limit **24**%
Dish & Dry Soil **84.1**	Dish **72.8**	Dish & Dry Soil **78.0**	Dish **69.4**	Plasticity Index **3**%
Mass of Water **3.0**	Dry Soil **11.3**	Mass of Water **2.1**	Dry Soil **8.6**	
% Moisture = Mass of Water x 100 = **26.5** Dry Soil		P.L. = Mass of Water x 100 = **24.4** Dry Soil		Optimum Moisture Content Total Soil **6.6** % -4.75 mm (-4)Portion **10.3 %** Maximum Density Total Soil____ kg/m³(lbs/ft³) -4 75 mm(- 4)Portion___k/g/m³(lbs/ft³)
L.L. = **26.6 = 27**		P.L. = **24**		

Wet Weight = **9847** grams % Moisture **5.5** Moisture Range **4.6% - 8.6%** Absorption 0.3

Chapter 3 Chapter 3 Sampling and Testing Aggregates

Answers

Problem No. 4

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)				63.0 mm (2 ½)			
50.0 mm (2)				50.0 mm (2)			
37.5 mm (1 ½)				37.5 mm (1 ½)			
25.0 mm (1)			**100.0**	25.0 mm (1)			
19.0 mm (3/4)	**357**	**5.8%**	**94.2**	19.0 mm (3/4)			
9.50 mm (3/8)	**1448**	**23.6%**	**70.6**	9.50 mm (3/8)			
4.75 mm (4)	**913**	**14.9%**	**55.7**	4.75 mm (4)			
2.0 mm (10)	**1011**	**16.5%**	**39.2**	2.0 mm (10)			**100.0**
.850 mm (20)		**11.9%**	**27.3**	.850 mm (20)	**57.8**	**30.4%**	**69.6**
425 mm (40		**5.1%**	**22.2**	425 mm (40	**24.8**	**13.1%**	**56.5**
.250 mm (60)		**3.3%**	**18.9**	.250 mm (60)	**16.0**	**8.4%**	**48.1**
.180 mm (80)		**1.8%**	**17.1**	.180 mm (80)	**8.7**	**4.6%**	**43.5**
.150 mm (100)		**1.3%**	**15.8**	.150 mm (100)	**6.3**	**3.3%**	**40.2**
. 075 mm (200)		**4.0%**	**11.8**	.075 mm (200)	**19.5**	**10.3%**	**29.9**
Total	**6136**	**11.7%**		Total	**190.0**	**29.9%**	

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **21**	No. of Blows **28**	Dish No. **10**		Liquid Limit **21** %
Dish & Wet Soil **52.1**	Dish & Dry Soil **48.9**	Dish & Wet Soil **79.9**	Dish & Dry Soil **77.8**	Plastic Limit **20** %
Dish & Dry Soil **48.9**	Dish **33.7**	Dish & Dry Soil **77.8**	Dish **67.4**	Plasticity Index **1** %
Mass of Water **3.2**	Dry Soil **15.2**	Mass of Water **2.1**	Dry Soil **10.4**	
% Moisture = Mass of Water / Dry Soil x 100 = 21.1		P.L. = Mass of Water / Dry Soil x 100 = **20.2**		Optimum Moisture Content Total Soil **6.5** % -4.75mm (-4) Portion **10.5** % Maximum Density Total Soil ____ $kg/m^3 (lbs/ft^3)$ - 4.75mm(-4) portion____ $kg/m^3 (lbs/ft^3)$
L.L. = **21.4** = **21**		P.L. = **20**		

Wet Weight = **6449** grams % Moisture **5.1** Moisture Range **4.5 – 8.5** Absorption **0.6**

Chapter 3 Sampling and Testing Aggregates

Problem 5

MECHANICAL ANALYSIS OF TOTAL SAMPLE				MECHANICAL ANALYSIS OF SOIL MORTAR			
SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING	SIEVE SIZES	GRAMS RETAINED	PERCENT RETAINED	PERCENT PASSING
63.0 mm (2 ½)		%		63.0 mm (2 ½)		%	
50.0 mm (2)		%		50.0 mm (2)		%	
37.5 mm (1 ½)		%		37.5 mm (1 ½)		%	
25.0 mm (1)		%	**100.0**	25.0 mm (1)		%	
19.0 mm (3/4)	**267**	**3.0%**	**97.0**	19.0 mm (3/4)		%	
9.50 mm (3/8)	**2650**	**29.8%**	**67.2**	9.50 mm (3/8)		%	
4.75 mm (4)	**1343**	**15.1%**	**52.1**	4.75 mm (4)		%	
2.0 mm (10)	**1103**	**12.4%**	**39.7**	2.0 mm (10)		%	**100.0**
.850 mm (20)		**8.9%**	**30.8**	.850 mm (20)	**44.6**	**22.3%**	**77.7**
425 mm (40		**5.6%**	**25.2**	425 mm (40	**28.4**	**14.2%**	**63.5**
.250 mm (60)		**3.1%**	**22.1**	.250 mm (60)	**15.8**	**7.9%**	**55.6**
.180 mm (80)		**2.0%**	**20.1**	.180 mm (80)	**10.2**	**5.1%**	**50.5**
.150 mm (100)		**1.5%**	**18.6**	.150 mm (100)	**7.6**	**3.8%**	**46.7**
. 075 mm (200)		**4.2%**	**14.4**	.075 mm (200)	**21.2**	**10.6%**	**36.1**
Total	**8893**	**14.3%**		Total	**200.0**	**36.1%**	

Liquid Limit		Plastic Limit		Physical Characteristics of Soil
Dish No. **3**	No. of Blows **22**	Dish No. **5**		Liquid Limit **21** %
Dish & Wet Soil **88.2**	Dish & Dry Soil **85.4**	Dish & Wet Soil **80.2**	Dish & Dry Soil **78.2**	Plastic Limit **20** %
Dish & Dry Soil **85.4**	Dish **72.0**	Dish & Dry Soil **78.2**	Dish **68.1**	Plasticity Index **1** %
Mass of Water **2.8**	Dry Soil **13.4**	Mass of Water **2.0**	Dry Soil **10.1**	
% Moisture = Mass of Water / Dry Soil x 100 = 20.9		P.L. = Mass of Water / Dry Soil x 100 = **19.8**		Optimum Moisture Content Total Soil **6.4** % -4.75 mm (-4) Portion **10.8** % Maximum Density Total Soil _____ kg/m³(lbs/ft³) -4.75 mm (-4)Portion___ kg/m³(lbs/ft³)
LL = 20.6 = 21.0		P.L. = 20		

Wet Weight = **9418** grams % Moisture **5.9** Moisture Range **4.4 – 8.4** Absorption **0.7**

Chapter 4 Acceptance of Material

Answers

1. What types of Portland Cement are allowed in stabilized Central-Mix aggregates?

   C. Types I, I-P and II

2. What are the specification requirements for water used in cement treated aggregates?

   pH 4.5 to 8.5

3. In the production of cement stabilized aggregate, no one sample shall have a cement content below design by more than ___ percent.

   C. 1.6%

4. If the total adjustment (excluding range adjustment) for the lot is greater than 25 points the failing material has to be removed from the road.

   A. True

5. The maximum time interval between manufacture of cement treated aggregate and final shaping and compaction is <u>4 hours</u>.

6. Is it permissible to accept central-mix aggregate by visual inspection?

   No

7. It is the Departments policy to require the producer to plot his own Control Charts.

   A. True

8. If the job-mix formula on the 9.5 mm (3/8 in.) sieve is 68% passing, what is the acceptance range?

   58.5 to 77.5

9. Can the acceptance range on a sieve fall outside of the Design Range for that particular sieve?

   yes

Chapter 4 Acceptance of Material

Answers

10. The contractor must accept the price adjustment.

    B. False

11. The ambient air temperature must be at least before production can start.

    C. 40°F

12. A lot is usually an average of:

    D. 4 samples

13. Standard Deviation and variability are the same thing.

    A. True

14. The Referee System can only be implemented by the contractor.

    B. False

Chapter 4 Acceptance of Material

Problem No. 1

Answers

Complete the following test report and calculate the percent of unit price adjustment.

Type Mix - Stabilized Aggregate Base Type I, No. 21A

Sample No. Sieve Size	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
50 mm (2 in.)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	P
25 mm (1 in.)	96.0	100.0	98.5	100.0	98.6	92.0	100.0	97.0	P
9.5 mm (3/8 in.)	70.9	67.3	74.9	62.8	69.0	57.5	76.5	67.0	P
2.00 mm (No. 10)	40.7	39.4	45.0	34.5	39.9	32.0	46.0	39.0	P
425 µm (No. 40)	22.5	21.5	25.4	19.7	22.3	20.0	28.0	24.0	P
75 µm (No.200)	11.2	13.1	10.4	10.8	11.4	8.0	12.0	10.0	P
L.L.	22	19	21	20	21		23.0	23.0	P
P.I.	2	0	1	0	0.8		2.0	2.0	P
Cement	3.9	3.2	2.5	2.7	3.1	3.2		4.0	F

Price Adjustment:

3.2	Lower Acceptance Range	10	Adjustment for each 1%
-<u>3.1</u>	Average Cement Content	x <u>0.1</u>%	Outside process tolerance
0.1%	Outside Process Tolerance	1.0%	Price adjustment for cement content

Chapter 4 Acceptance of Material
Problem No. 2
Answers

Complete the following test report and calculate the percent of unit price adjustment.

Type Mix - Stabilized Aggregate Base Type I, No. 21A

Sample No. Sieve Size	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
50 mm (2 in.)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	P
25 mm (1 in.)	100.0	98.0	96.0	97.4	97.9	90.0	100.0	95.0	P
9.5 mm (3/8 in.)	70.8	67.1	62.8	66.7	66.9	57.5	76.5	67.0	P
2.00 mm (No. 10)	45.0	34.5	39.4	38.2	39.3	32.0	46.0	39.0	P
425 µm (No. 40)	21.3	25.4	20.8	24.1	22.9	20.0	28.0	24.0	P
75 µm (No.200)	14.1	9.8	11.1	10.2	11.3	8.0	12.0	10.0	P
L.L.	25	20	21	20	22		23.2	23.0	P
P.I.	6	0	1	0	1.8		2.0	2.0	P
Cement	3.3	2.5	2.9	2.9	2.9	3.2		4.0	F

Price Adjustment:

3.2	Lower Acceptance Range	10	Adjustment for each 1%
-2.9	Average Cement Content	x 0.3%	Outside process tolerance
0.3%	Outside Process Tolerance	**3.0%**	Price adjustment for cement content

Chapter 4 Acceptance of Material

Problem No.3

Answers

Complete the following test report and calculate the percent of unit price adjustment.

Type Mix - Stabilized Aggregate Base Type I, No. 21A

Sample No. Sieve Size	1	2	3	4	Aver.	Lower	Upper	Job-Mix	P/F
50 mm (2 in.)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	P
25 mm (1 in.)	94.2	91.6	94.4	97.1	94.3	89.0	99.0	94.0	P
9.5 mm (3/8 in.)	68.5	67.4	70.6	61.3	67.0	57.5	76.5	67.0	P
2.00 mm (No. 10)	34.2	32.4	34.8	40.9	35.6	27.0	41.0	34.0	P
425 µm (No. 40)	15.8	14.4	14.5	21.6	16.6	12.0	20.0	16.0	P
75 µm (No.200)	8.8	8.7	8.0	9.9	8.9	9.0	13.0	11.0	F
L.L.	21	19	20	29	22		23.0	23.0	P
P.I.	0	0	0	4	1.0		2.0	2.0	P
Cement	3.3	2.7	2.5	3.5	3.0	3.2		4.0	F

Price Adjustment:

No. 200 (75 µm)

9.0	5
<u>-8.9</u>	<u>x 0.1%</u>
0.1%	0.5

Cement:

3.2	10
<u>-3.0</u>	<u>x 0.2%</u>
0.2%	2.0

Total Price Adjustment:

0.5% adjustment on the No. 200 (75 µm) sieve
+<u>2.0%</u> adjustment for cement content
2.5% Total adjustment

Appendix A Pay Quantities

Answer

Problem No. 1

A plant produced 406 tons of material at a moisture content of 9.6%. If the optimum moisture was 6.0%, give the weight in tons of stone and moisture that may be paid for.

Step 1. Determine the Total Allowable Moisture

Optimum Moisture + 2% = Total Allowable Moisture
6% + 2% = Total Allowable Moisture
8% = Total Allowable Moisture

Step 2. Determine the Dry Weight of the Aggregate

Tons Shipped / (1 + % Avg. Moist.) = Dry Weight of Aggregate
406 / (1 + 9.6%) = Dry Weight of Aggregate
406 / (1 + .096) = Dry Weight of Aggregate
406 / (1.096) = Dry Weight of Aggregate
370.44 = Dry Weight of Aggregate

Step 3. Determine the Pay Quantity

Dry Weight of Aggregate x (1 + % Allowable Moisture) = Pay Quantity
370.44 x (1 + 8.0%) = Pay Quantity
370.44 x (1 + .08) = Pay Quantity
370.44 x (1.08) = Pay Quantity
400.08 = Pay Quantity

Appendix A Pay Quantities

Answer

Problem No. 2

A plant produced 333 tons of mix at a moisture of 10.6%. If the optimum moisture was 7.0%, give the weight in tons of stone and moisture that may be paid for.

Step 1. Determine the Total Allowable Moisture

Optimum Moisture + 2% = Total Allowable Moisture
7% + 2% = Total Allowable Moisture
9% = Total Allowable Moisture

Step 2. Determine the Dry Weight of the Aggregate

Tons Shipped / (1 + % Avg. Moist.) = Dry Weight of Aggregate
333 / (1 + 10.6%) = Dry Weight of Aggregate
333 / (1 + .106) = Dry Weight of Aggregate
333 / (1.106) = Dry Weight of Aggregate
301.08 = Dry Weight of Aggregate

Step 3. Determine the Pay Quantity

Dry Weight of Aggregate x (1 + % Allowable Moisture) = Pay Quantity
301.08 x (1 + 9.0%) = Pay Quantity
301.08 x (1 + .09) = Pay Quantity
301.08 x (1.09) = Pay Quantity
301.08 x (1.09) = Pay Quantity
328.18 = Pay Quantity

Appendix B VTM-40,Titration
Answers

1. The Producer shall furnish a motorized screen shaker for:

   C. Coarse and fine aggregate gradation analysis.

2. To determine the cement content of cement aggregate mixtures by the Titration Method, samples shall be taken at the:

   B. Completion of mixing.

3. When dealing with sodium hydroxide solution, you should always pour the solution into distilled or demineralized water to prevent a spontaneous reaction.

   A. True.

4. The method used to determine the cement content of cement aggregate mixtures is:

   C. Titration Method.

5. In determining the cement content by the Titration Method, the sample for testing should weigh 600 grams.

   A. True.

Appendix C Modified Acceptance Production

Answers

1. What is the rate of sampling under the Modified Acceptance Plan for open-graded aggregates?

   B. one per 1000 tons

2. The sample taken for open graded aggregates accepted under the Modified Acceptance Plan is taken from:

   D. All of the above

3. Does the Quality Control Technician have to be certified?

   B. No

4. Sieve analysis on open-graded aggregates are accumulated.

   A. True

5. All open-graded aggregates must have a job-mix submitted before production can start.

   B. False

Appendix C Modified Acceptance Production Answers

Problem No.1

Check the following sieve analysis of a sample of natural sand for use in concrete not subject to abrasion and determine if it meets Virginia Department of Transportation requirements for Grading "A" Sand. Circle the sieve(s) not passing, if any.

Sieve Size	Cumulative Grams Retained	Cumulative % Retained	% Passing	VDOT Specs. (% Passing)
9.5 mm (3/8 in.)	0.0	0.0	100	100
4.75 mm (No. 4)	16.6	2.9	97	95-100
2.36 mm (No. 8)	64.5	11.3	89	80-100
1.18 mm (No. 16)	214.1	37.4	63	50-85
600µm (No. 30)	389.2	67.9	32	25-60
300 µm (No. 50)	483.0	84.3	16	5-30
150 µm (No. 100)	543.4	94.8	5	0-10
75 µm (No. 200)	565.0	98.6	1.4	0-5
Total Wt.	573.0			

Does this sample pass? **Yes**

Appendix C Modified Acceptance Production Answers

Problem No.2

Check the following sieve analysis of a sample of 57s and determine if it meets Virginia Department of Transportation requirements. Circle the sieve(s) not passing, if any.

Sieve Size	Grams Retained	% Retained	% Passing	VDOT Specs. (% Passing)
37.5 mm (1 1/2 in.)	0.0	0.0	100.0	100
25.0 mm (1 in.)	0.0	0.0	100.0	95 - 100
19.0 mm (3/4 in.)	703.2	6.9	93	
12.5 mm (1/2 in.)	4544.7	44.9	48	25 - 60
9.5 mm (3/8 in.)	2247.8	22.2	26	
4.75 mm (No. 4)	2250.6	22.2	4	0 – 10
2.36 mm (No. 8)	116.1	1.1	3	0 – 5
Total Wt.	10120.7			

Does this sample pass? **Yes**

E Proficiency Test

AASHTO T2	Sampling Aggregates
AASHTO T248	Reducing Samples of Aggregate to Testing Size
AASHTO T255	Total Moisture Content of Aggregate by Drying
AASHTO T27	Sieve Analysis of Fine & Coarse Aggregate
AASHTO T11	Materials Finer than No. 200 in Mineral Aggregates by Washing
AASHTO T89	Determining the Liquid Limit of Soils
AASHTO T90	Determine Plastic Limit & Plasticity Index of Soils

AASHTO T2-91
SAMPLING OF AGGREGATES

<u>Selection of Method</u> – Student must demonstrate one method and be able to list the remaining methods for the proctor.

PROCEDURE
Sampling from Stockpiles – Using this method, the technician must demonstrate sampling each of the following materials listed below. (Coarse aggregate, fine aggregate and coarse and fine aggregate).
Coarse aggregate:
Board shoved vertically into the stockpile just above sampling point?
Increments taken from the top third, mid-point, and bottom third of the volume of the pile?
Fine aggregate:
Outer layer removed and sample taken from underlying material?
Appropriate sampling tube randomly inserted to obtain increments?
Minimum of five increments taken?
Coarse and Fine Aggregate:
Increments combined to form field sample?
Size of field sample equals or exceeds minimum mass needed or stated in Table 1?
Sampling from Roadway (Base and Subbase)
Samples taken randomly using a method such as Practice D 3665?
Specific areas clearly marked from which each increment will be removed? (a metal template placed over the area is helpful)
At least three approximately increments taken from roadway at full depth?
Care taken to exclude any underlying material not part of material being sampled?
Increments combined to form field sample?
Minimum size of field sample equals or meets minimum mass needed or as determined from Table 1?

AASHTO T2-91

SAMPLING OF AGGREGATES

PROCEDURE
Sampling from Transportation Units
Coarse Aggregate:
Three or more trenches made across the unit at points that will, from visual appearance, give a reasonable estimate of the characteristics of the load?
Trench bottom is approximately level and at least 0.3 m (1 ft) in width and in depth below the surface?
Minimum of three increments taken from approximately equally spaced points along each trench?
Material obtained by pushing a shovel downward in to the material?
Fine Aggregate:
Appropriate sampling tube inserted to remove the predetermined number of increments?
Coarse and Fine Aggregate:
All increments combined to form a field sample?
Minimum size of field sample equals or meets minimum mass needed or as determined from Table 1?
Sampling from a Flowing Aggregate Stream (Bins or Belt Discharge)
Sampling from the Conveyor Belt

AASHTO T2-91
SAMPLING OF AGGREGATES

TABLE 1 Size of Samples	
Maximum Nominal Size Of Aggregates[A]	**Approximate Minimum Mass of Field Samples, lb (kg)[B]**
Fine Aggregate	
No. 8 (2.36 mm)	25 (10)
No. 4 (4.75 mm)	25 (10)
Coarse Aggregate	
3/8 in (9.5 mm)	25 (10)
1/2 in (12.5 mm)	35 (15)
3/4 in (19.0 mm)	55 (25)
1 in. (25.0 mm)	110 (50)
1 1/2 in (37.5 mm)	165 (75)
2 in. (50 mm)	220 (100)
2 ½ in. (63 mm)	275 (125)
3 in. (75 mm)	330 (150)
3 ½ in. (90 mm)	385 (175)

[A] For processed aggregate the nominal maximum size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.

[B] For combined coarse and fine aggregate (for example, base or subbase) minimum weight shall be coarse aggregate minimum plus 25 lb (10 kg).

AASHTO T248-02
REDUCING SAMPLES OF AGGREGATE
TO TESTING SIZE

PROCEDURE
Selection of Method – Student must demonstrate one of the test methods and be able to list the remaining two methods for the proctor.
Method A - Splitting
1. Material spread uniformly on feeder?
2. Rate of feed slow enough so that sample flows freely through chutes?
3. Material in one pan re-split until desired weight is obtained?
Method B - Quartering
1. Sample placed on clean, hard, and level surface? (See **Note** below)
2. Mixed by turning over 3 times with shovel or by raising canvas and pulling over pile?
3. Conical pile formed?
4. Pile flattened to uniform thickness and diameter?
5. Diameter about 4 to 8 times thickness?
6. Divided into 4 equal portions with shovel or trowel? (See **Note** below)
7. Two diagonally opposite quarters, including all fine material, removed?
8. Cleared space between quarters brushed clean?
9. Process continued until desired sample size is obtained?
Note: The sample may be placed upon a canvas quartering cloth and a stick or pipe may be placed under the cloth to divide the pile into quarters.
Method C - Miniature Stockpile Sampling (Fine Aggregate Only)
1. Sample placed on clean, hard, and level surface?
2. Material thoroughly mixed by turning over three times?
3. Small stockpile formed?
4. At least 5 grab samples taken at random with sampling thief, small scoop, or spoon?

AASHTO T255-00
TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING

Apparatus
1. Source of heat: A. If close temperature control is required: (1) Ventilated oven, maintains 110±5°C (230±9°F) B. If close temp. control is not required (one of the following): (1) Electric or gas hot plate? **or** (2) Electric heat lamps? **or** (3) Ventilated microwave oven?
2. Sample container: (a) Not affected by heat? (Nonmetallic for microwave use) (b) Of sufficient volume? (c) Of such shape that depth of sample does not exceed 1/5 of least lateral dimension?
3. Stirrer, metal spoon or spatula of convenient size?
4. Balance, readable to 0.1% of sample mass or better?
PROCEDURE
1. Representative test sample obtained?
2. Test sample mass conforms to following:? No. 4 - .5 kg, 3/8 in. - 1.5 kg, ½ in. - 2 kg, 3/4 in. - 3 kg, 1 in. - 4 kg, 1 ½ in. - 6 kg, 2 in. - 8 kg, 2 ½ in. - 10 kg
3. Mass determined to nearest 0.1 percent of original dry mass?
4. Loss of moisture avoided prior to determining the mass?
5. Sample dried by a suitable heat source? Heat source: ___________________
6. If heated by means other than a controlled temperature oven, is sample stirred to avoid localized overheating? (Stirring optional for microwave use)
7. Sample dried to constant mass and mass determined to nearest 0.1 percent of the total original dry sample mass?

AASHTO T27-99

SIEVE ANALYSIS OF FINE & COARSE AGGREGATE

Apparatus		
1. Sieves - See General Apparatus sieve page.		
2. Balance: AASHTO: Readable to 0.1% of sample mass?		
3. Mechanical sieve shakers (Optional), meet adequacy of sieving requirements?		
4. Oven, maintains 110 ± 5° C (230 ± 9° F)?		
PROCEDURE		
Student does not have to demonstrate shaker time efficiency check. Student will describe the procedure to proctor. It is suggested that student run base mix sample.		
Mixtures of Fine and Coarse Aggregate - Sample size the same as sample for coarse aggregates?		
Fine Aggregate	Initial mass:	Final mass:
1. Sample obtained by T248?		
2. Minimum sample mass 300 g?		
3. (Optional) If T11 is used, does the dry nest include a 75-µm (No. 200) sieve?		
4. Sample dried to constant mass at 110 ± 5° C (230 ± 9° F)?		
5. AASHTO: Mass determined to nearest 0.1 percent of original dry mass? **Note**: If specimen consists of material leftover after T11 then Step 5 does not apply because it is assumed that total specimen mass was determined as part of that test.		
6. AASHTO: Sieving continued until not more than 0.5% by mass of the total specimen passes a given sieve during one minute of continuous hand sieving?		
Sieve size:	**Mass retained on sieve:**	**Mass passing sieve:**
7. Residue on each sieve weighed to 0.1% of original dry mass?		
8. Sieves not overloaded - mass of residue on each sieve [finer than 4.75-mm (No. 4) sieves] less than 7 kg/m^2 of sieving surface (**200** g for 8" diameter sieve, 511 g for 12" diameter sieve)		
9. Total mass of material after sieving agrees with mass before sieving to within 0.3% (If not, do not use for acceptance testing)?		
10. Percentages calculated to the nearest 0.1% and reported to the nearest whole number (except 75-µm - if less than 10%, percentages reported to nearest 0.1%)?		
11. Percentage calculations based on original dry sample mass, including the passing 75-µm fraction (if T11 was used)?		

AASHTO T27-99

SIEVE ANALYSIS OF FINE & COARSE AGGREGATE

PROCEDURE		
Coarse Aggregate	**Initial mass:**	**Final mass:**
1. If whole field sample is not used, is test sample obtained by T248?		
2. Sample dried to constant mass at 110 ± 5° C (230 ± 9° F)?		
3. AASHTO: Mass determined to nearest 0.1 percent of original dry mass? **Note**: If specimen consists of material leftover after T11 then Step 3 does not apply because it is assumed that total specimen mass was determined as part of that test.		
4. Minimum sample mass: 3/8 in. - 1 kg; 2 in. - 2 kg; 3/4 in. - 5 kg; 1 in. - 10 kg; 1 ½ in. - 15 kg; 2 in. - 20 kg; 2 ½ in. - 35 kg; 3 in. - 60 kg; 3 ½ in. - 100 kg?		
5. If hand sieving, particles not forced to pass through openings?		
6. AASHTO: Sieving continued until not more than 0.5% by mass of the total specimen passes a given sieve during one minute of continuous hand sieving?*****		
Sieve size:	**Mass retained on sieve:**	**Mass passing sieve:**
7. Residue on each sieve weighed to 0.1 percent of original dry mass?		
8. Sieves not overloaded: (a) Mass of residue on each sieve [finer than 4.75-mm (No. 4) sieves] does not exceed 7 kg/m^2 of sieving surface (**200** g for 8" diameter sieve 511 g for 12" diameter sieve) (b)Mass of residue on each sieve [for 4.75-mm (No. 4)sieves and larger] does not exceed 2.5 x (sieve opening, mm) x (effective sieving area, m^2)?		
9. Total mass of material after sieving agrees with mass before sieving to within 0.3% (If not, do not use for acceptance testing)?		
10. Percentages calculated to nearest 0.1% and reported to nearest whole number?		
11. Percentage calculations based on <u>original</u> dry sample mass, <u>including</u> the passing 75-µm fraction (if T11was used)?		
***** Check by hand with 8-in. diameter sieve.		

AASHTO T11-97
MATERIALS FINER THAN 75-µm (No. 200) SIEVE
IN MINERAL AGGREGATES BY WASHING

Apparatus

1. Balance:AASHTO: Readable to 0.1% of sample mass?

2. Sieves (Nest of two):
   (a) 75-µm (No. 200)?
   (b) AASHTO: Protective sieve 2.36 mm (No.8) to 1.18 mm (No. 16)?

3. Container, size and condition OK?

4. Oven, maintains 110±5°C (230±9°F)?

5. Mechanical washing apparatus (optional):
   (a) Results are consistent with those obtained using manual methods?
   (b) Degradation of the sample is avoided?

Student may either hand wash or use a mechanical washer to perform the test. Student must demonstrate Method A and list the remaining method for the proctor.

PROCEDURE Method A – Washing with Plain Water

Student washed sample: by hand _____ mechanical washer _____

1. Test sample obtained by T248?

2. Test sample mass conforms to following table?

Nominal Maximum Size	Minimum Mass, g
No.4 or finer	300
3/8 in	1000
3/4 in	2500
1 ½ in or larger	5000

Note: If same sample is to be tested as in T27, minimum mass should conform to requirements of that method.

3. Test sample dried to constant mass at 110±5°C (230±9° F)?

4. Test sample mass determined to 0.1 percent of the original dry sample mass?

5. Placed in container and covered with water?

6. Contents of container vigorously agitated?

7. Complete separation of coarse and fine particles?

8. Wash water poured through sieve nest?

9. Wash water free of coarse particles?

10. Operation continued until wash water is clear?

11. Material on sieves returned to washed sample?

AASHTO T11-97
MATERIALS FINER THAN 75-µm (No. 200) SIEVE
IN MINERAL AGGREGATES BY WASHING

PROCEDURE - continued
12. Excess water decanted from washed sample only through the 75-µm sieve (No. 200 sieve)?
13. Washed aggregate dried to constant mass at 10±5°C (230±9°F)?
14. Washed aggregate mass determined to 0.1 percent of the original sample mass?
15. Calculation: % less than 75 µm = $\frac{\text{Orig. dry mass - Final dry mass}}{\text{Original dry mass}}$ X 100?
16. Method B – Washing with a Wetting Agent

AASHTO T89-02
DETERMINING THE LIQUID LIMIT OF SOILS

Apparatus
1. Grooving Tools (a) Gage end (square) 9.8 mm – 10.20 mm? (b) Cutting edge width 1.9 – 2.1 mm? (c) Curved end thickness 9.9 – 10.1 mm? (d) Radius of curve 22.2 mm (7/8 in.)? (e) Curve length approximately 90°?
2. Liquid Limit Device (a) Maker? (b) Hand Operated? (c) Electric 1.9-2.1 drops/second? (d) Base of hard rubber? (e) Base diameter mm AASTHO 125 ± 5 x 150 ± 5 x 50 ± 5? (f) Base has four feet made of resilient material? (g) Brass cup thickness 1.9 – 2.1 mm? (h) Cup depth 26-28 mm (i) Little or no groove in cup? (j) Rim not worn to less than ½ original thickness? (k) Cam and followers not worn excessively? AASHTO: Point of contact on cup or base less than 3 mm diameter?
3. Porcelain Dish or similar mixing dish, about 115 mm in diameter?
4. Spatula or pill knife about 75 to 100 mm long & 20 mm wide?
5. Water Content Containers (a) Resistant to corrosion, disintegration, and weight change? (b) Close-fitting lids?
6. Balance Class G1 [readable to 0.01 g]? **VTM – 7 a balance sensitive to 0.1 gram may be used.**
7. Oven maintains 110±5°C (230±9°F)?

AASHTO T89-02

DETERMINING THE LIQUID LIMIT OF SOILS

Sample Preparation - AASHTO only:
1. Sample obtained by T87 or T146?
2. Sample was dried at 60°C (140°F)?
3. Sample consists of about 50 g of soil passing 425-µm (No. 40) sieve?
4. Soil mixed with 8 to 10 mL of distilled or demineralized water in mixing dish (other than brass cup)? **Note:** Tap water may be used for routine testing if comparative tests indicate no differences in results using tap and distilled water.
5. Mixing done by stirring, kneading and chopping with spatula?
6. Additional increments of water added (1 to 3 mL) until mass is uniform and has stiff consistency?
7. No additional dry soil added to wet sample once testing has begun?
8. If too wet, sample either discarded or mixed to evaporate water?
9. **AASHTO T89 Method A** is used for Referee Testing.
PROCEDURE Method B
1. Liquid limit device previously inspected for wear and height of cup drop checked?
2. Part of mixture put in cup and spread with spatula until 10 mm deep at maximum thickness?
3. As few strokes of spatula as possible used?
4. Care taken to avoid entrapment of air bubbles?
5. Excess soil returned to mixing dish?
6. Unused wet soil in storage dish covered during test?
7. (Using curved grooving tool): Soil in dish divided through centerline of follower with no more than six strokes of curved tool and only last stroke of grooving tool scrapes bottom of cup? ***Or*** (Using flat grooving tool): Groove formed in soil by drawing tool, beveled edge forward, through soil on a line joining highest point through lowest point on the rim of the cup? **Note:** Several strokes may be used, or precut groove with spatula and use tool to bring cut to final dimension.
8. Soil in dish divided through centerline of follower with no more than six strokes of curved tool?
9. Only last stroke of grooving tool scrapes bottom of cup?
10. Tearing along groove and slippage of cake avoided?

AASHTO T89-02
DETERMINING THE LIQUID LIMIT OF SOILS

Method B (continued)
11. Cup lifted and dropped twice per second until bottom of groove closes about 13 mm (0.5 in.) in 22 to 28 blows? **Note:** Closures between 15 and 40 blows acceptable if variations of ± 5% of the true liquid limit are tolerable to the lab. Note if lab accepts anything other than 22 to 28 blows.
12. Base of device not held with hand while turning crank?
13. Soil in cup immediately returned to mixing dish, and no additional water added?
14. Steps 2 through 10 repeated?
15. Closure in 22 to 28 blows?
16. Number of blows recorded for second closure?
17. Moisture specimen is taken after second groove closure (if closure is in acceptable range and within ± 2 blows of the first closure)?
18. Slice of soil, width of spatula, extending across cake at right angles to groove and including portion that flowed together removed from dish and placed in container?
19. Container and soil weighed to 0.01 g? **VTM –7 – a balance sensitive to 0.1 gram may be used.**
20. Water content determined according to T265?
21. Water content calculated to nearest whole percent by: $\% \text{ moisture} = \frac{\text{mass of water}}{\text{mass of oven dry soil}} \times 100$?
22. Liquid limit calculated by one of the methods in Section 14 (nomograph, multicurve, slide rule, etc.)?

AASHTO T90-00
DETERMINING THE PLASTIC LIMIT
AND PLASTICITY INDEX OF SOILS

Apparatus
1. Porcelain Dish or similar mixing dish, about 115 mm in diameter?
2. Spatula or pill knife about 75 to 100 mm long and 20 mm wide?
3. Rolling surface: (a) AASHTO Ground glass plate or smooth unglazed paper?
4. Plastic limit rolling device (optional): (a) Made of acrylic? (b) Top plate and bottom fixed plate of suitable dimensions for properly rolling specimens? (c) Designed so top plate slides freely on side rails without wobbling? (d) Heights of side rails: AASHTO 3.20 ± 0.25 mm + thickness of unglazed paper attached to bottom plate?
(e) Unglazed paper that does not add foreign matter (fibers, paper fragments) to soil during test attached to top and bottom plates (AASHTO only: attached by spray-on adhesive or self-adhesive backing)?
5. Water Content Containers: (a) Resistant to corrosion, disintegration, & weight change? (b) Close-fitting lids?
6. Balance Class G1 [readable to 0.01 g]? **VTM – 7 a balance sensitive to 0.1 gram may be used.**
7. Oven maintains 110±5°C (230±9°F)?

AASHTO T90-00
DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

PROCEDURE
Student must tell proctor under what circumstances 20 grams of –40 material is appropriate for use and when an 8 gram portion of –40 material would be used.
1. AASHTO: Sample is either about 20 g of minus 425-µm (No. 40) material obtained by T87 or T146, or about 8 g of liquid limit material?
2. Sample was dried at 60°C (140°F)?
3. If 20-g sample of dry material (AASHTO only): (a) Mixed with distilled or demineralized water in mixing dish? (b) Approximately 8-g ball formed?
4. A 1.5 to 2-g portion of the 8-g ball selected and formed into ellipsoidal mass?
5. Alternate procedure (using plastic limit rolling device): (a) Ellipsoidal mass placed on bottom plate and top plate placed in contact with mass? **Note:** More than one soil mass can be rolled simultaneously in the device. (b) Simultaneous downward force and back and forth motion applied to top plate so plate comes in contact with side rails within 2 minutes? (c) Soil thread not allowed to contact side rails during rolling?
6. Mass rolled between fingers or palm and plate/paper (or between top and bottom plate of rolling device) to form 3-mm diameter thread?
7. Rate of rolling between 80 to 90 strokes per minute (counting stroke as one complete motion of hand forward and back to the starting position)?
8. Mass rolled for no more than two minutes to obtain thread diameter of 3 mm?
9. When thread diameter is 3 mm, thread broken into several pieces?
10. Pieces squeezed together between thumbs and fingers into an ellipsoidal mass?
11. Steps 4 through 9 repeated until thread crumbles and soil can no longer be rolled into a thread? **Note:** Crumbling may occur when thread diameter is greater than 3 mm.

This page intentionally left blank.