CHAPTER 4

SAMPLING AND ANALYSIS OF AGGREGATES

Most of the material in an asphalt concrete mixture 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. In order to accomplish this blending process correctly, it becomes extremely important that the materials to be blended be properly sampled and the gradation or sieve size distribution be accurately determined. In addition, the aggregate properties should be determined on each aggregate component and/or the total blend of the mix.

Sampling for Sieve Analysis

When sampling aggregates to determine the gradation or sieve size (particle size) distribution, it is necessary that they be sampled correctly. The results of a sieve analysis should reflect the condition and characteristics of the aggregate from which the sample is obtained. Therefore, when sampling, it is important to obtain a representative sample. Unless it is truly representative, the tests results apply to the sample only and not to the entire aggregate shipment or stockpile. Accuracy in sampling is equally as important as accuracy in testing.

In many cases representative sampling cannot be made in a single sample, and it may be necessary to take a number of samples to obtain a true picture of the properties of a stockpile or source of material. As the maximum particle size in the aggregate increases, the size of the sample must increase to maintain accuracy in testing. Test sample sizes for Fine and Coarse aggregates are found in AASHTO T-27 (page 4-10). In addition, the number and types of tests determine the size sample needed.

There are three principal aggregate sampling points that are of concern at an asphalt plant. These are (1) the source of materials, (2) the stockpile, and (3) the hot storage bin. The first two will be discussed in this section and the third in the section on batch plants

When sampling at the source of materials, it would be well to remember one general rule. It is easier to obtain a representative sample from the production stream, such as from the conveyor belt, than from trucks, storage bins or stockpiles. If the sample is taken from the conveyor belt, it should be removed from the entire cross-section of the belt. The same would be true when sampling from the chutes of bins.

Getting a sample from a stockpile is not easy, and great care must be taken to obtain a truly representative sample. Segregation usually occurs when the material is stockpiled and the coarser particles will roll to the base of the pile. Samples of coarse aggregates from stockpiles should be taken at or near the top and base, and some intermediate point. To prevent further segregation while sampling, a board may be shoved into the pile just above the sampling area.

Another method of sampling coarse materials is to expose the face of the stockpile from the top to the bottom, with a front-end loader. The samples are then taken from the exposed face. Another method is to have the overhead loader take a scoop from bottom to top and dump the material in a convenient location for sampling. The sample bag is then filled randomly from around the scoop of material. Fine aggregate may be sampled with a sampling tube approximately 1¼ inch (30 mm) in diameter and 6 feet (2 meters) long. If a stockpile of sand is to be sampled, it is usually only necessary to remove the dry layer where the segregation occurs and sample the damp material below.

Procedures for sampling are described in AASHTO T 2.

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 asphalt paving mixtures are given in figure 4-1.

NOMINAL DIMENSIONS OF U. S. STANDARD SIEVES
AASHTO M 92

SIEVE DESIGNATION		NOMINAL SIEVE OPENING
1-1/2 in	(37.5mm)	1.50 in.
1 in.	(25.0mm)	1.00 in.
3/4 in.	(19.0mm)	0.750 in.
1/2 in.	(12.5mm)	0.500 in.
3/8 in.	(9.5mm)	0.375 in.
No. 4	(4.75mm)	0.187 in.
No. 8	(2.36mm)	0.093 in.
No.16	(1.18mm)	0.0469 in.
No.30	(600µm)	0.0234 in.
No.50	(300µm)	0.0117 in.
No.100	(150µm)	0.0059 in.
No.200	(75µm)	0.0029 in.

Figure 4-1

Sieve sizes to be used for the various type mixtures are designated in the specifications. See Section 211.03, Table II-13. Gradations are expressed on the basis of 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 gradations are:

(a) **Coarse aggregate** - All the material retained on and above No. 4 (4.75 mm) sieve.

(b) **Fine aggregate** - All the material passing the No. 4 (4.75 mm) sieve.

(c) **Mineral dust** - That portion of the fine aggregate passing the No. 200 (75 μm) sieve.

(d) **Mineral filler** - A finely divided mineral product, at least 70 percent of which will pass the No. 200 (75 μm) sieve.

NOTE: Some aggregate test procedures require material to be split at the No. 4 (4.75 mm) sieve.

Procedure for Sieve Analysis

Dry sieve analysis and washed sieve analysis are two methods of determining proportions of various particle sizes in a mineral aggregate. The washed sieve analysis is the method used in Virginia for asphalt mixes, and is the one that will be discussed in this section. Standard procedures for running the sieve analysis are given in AASHTO T 27 and AASHTO T 11. Regardless of the size of the aggregate, the procedure for running a sieve analysis is basically the same. The steps for this procedure are outlined as follows:

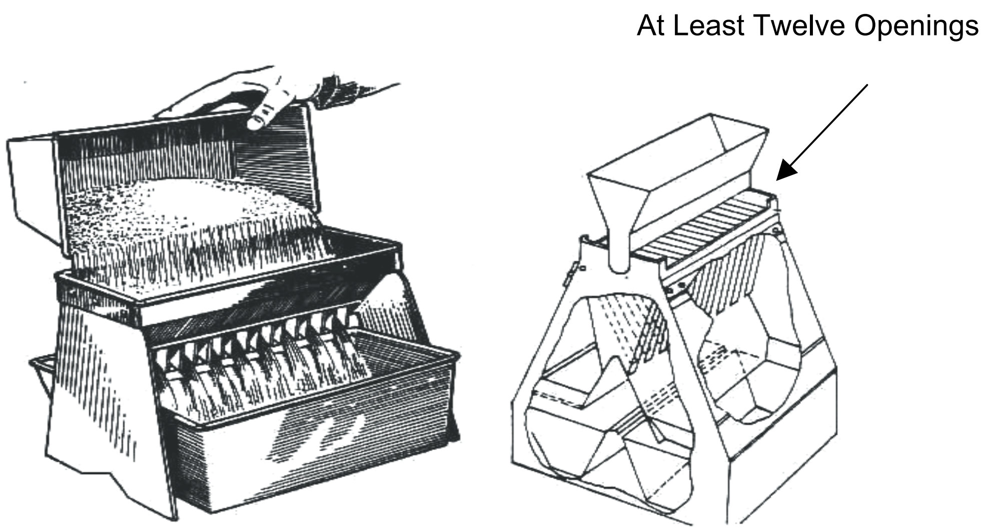
1. Use <u>correct sieve sizes</u> for the type mix to be produced as required.

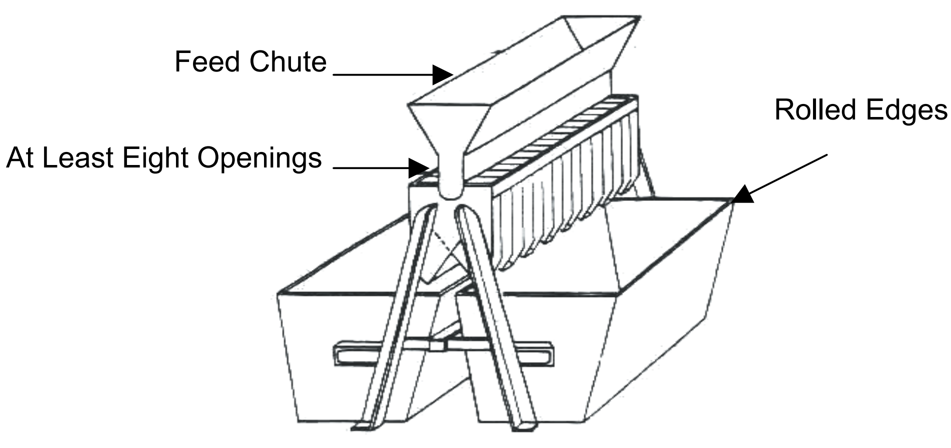
2. Obtain a <u>representative sample</u> of the material from the original sample by either a sample splitter or the quartering method. See (a) and (b) below. Reduce the sample to a size that can be handled on the balance and sieves, also, according to maximum stone size. Reference AASHTO T 27.

(a) **Sample Splitter** (Figure 4-2) - Sample splitters shall have an even number of equal width chutes, but not less than a total of eight for coarse aggregate, or twelve for fine aggregate, which discharge alternately to each side of the splitter. The splitter shall be equipped with two receptacles to hold the two halves of the sample following splitting. It shall be equipped with a hopper or straightedge pan which has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material.

Place the field sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced into the chutes, approximately equal amounts will flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the receptacles below. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other receptacle may be reserved for reduction in size for other tests.

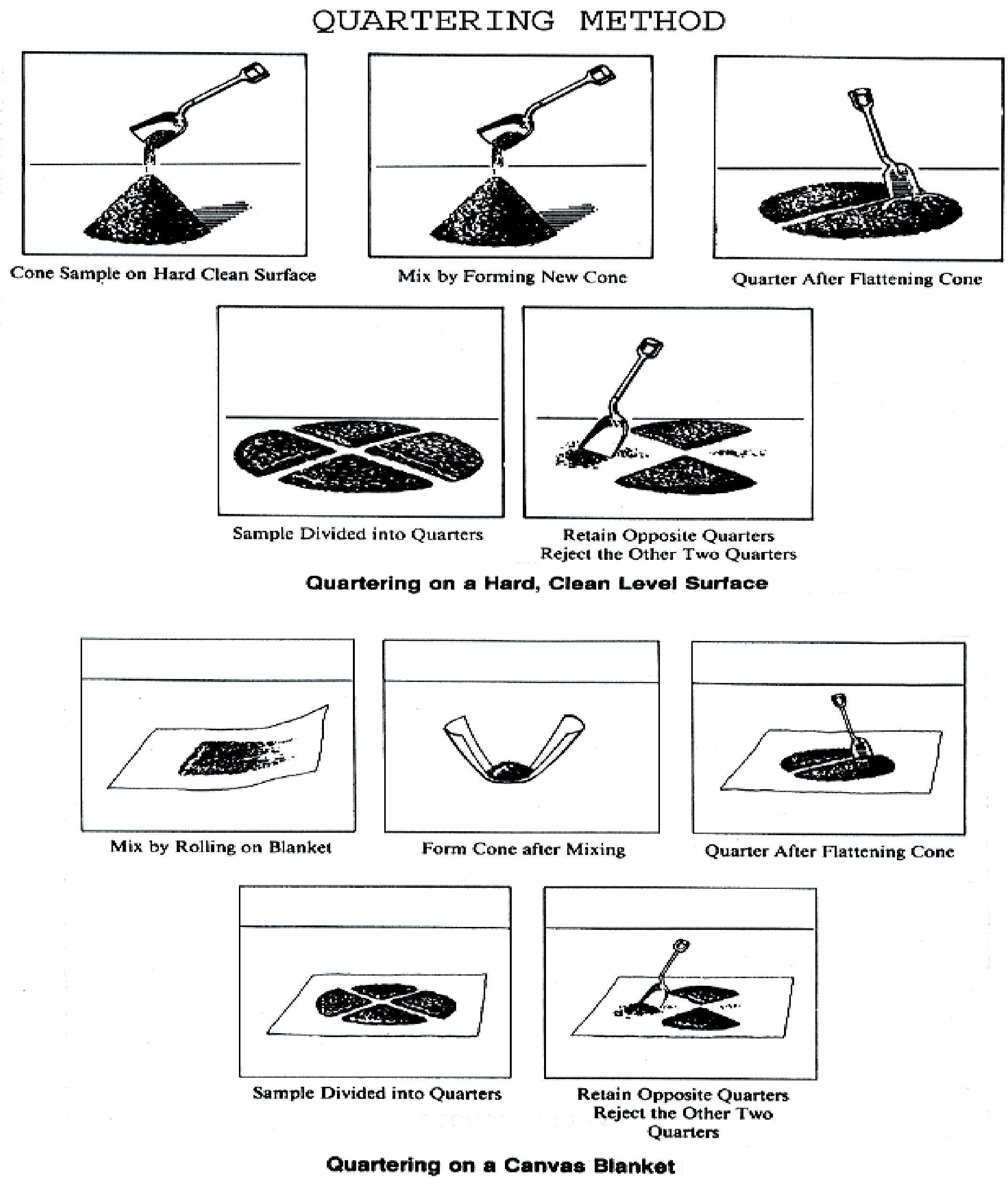
Small Sample Splitter for Fine Aggregates





Large Sample Splitter for Coarse Aggregates

Sample Splitters
Figure 4-2



Quartering Method
Figure 4-3

(b) Quartering Method (Figure 4-3) - The following method of sample size reduction by quartering is outlined for use when a conventional sample splitter is not available.

(1) Distribute a shovel full of the aggregate as uniformly as possible over a hard, clean, level surface or tight weave canvas. Continue to distribute shovels full 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-ended 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) If desired, store the portion that has been set aside for possible check testing.

3. **Dry aggregate sample thoroughly.** The samples are dried to constant weight on a hot plate or in an oven at a temperature of 230ºF (110ºC).

4. **Accurately weigh the dried sample**. Extreme care must be taken to avoid any loss of the 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 500g, 1000g, etc. Use the entire reduced and dried sample.

5. **Record the total dry weight of the sample**.

6. **Wash the sample** over a nest of two sieves, the upper being a No. 16 (1.18mm) mesh sieve and the lower being a No. 200 (75µm) mesh sieve, being careful not to lose any. Continue washing until the water is clear. Reference AASHTO T-11.

7. **Dry the sample** to constant weight on a hot plate or in an oven at a temperature of 230ºF (110ºC), then accurately weigh and record.

8. **Separate the sample into individual sizes** using the proper sieves. The sieves normally used are the standard round 8 inch sieves with the coarse sieve at the top; each sieve below is finer; with the finest sieve, a No. 200 (75µm), at the bottom. A pan is placed below the No.200 sieve to retain any fine material that may pass this sieve. The dried and weighed sample is placed on the top sieve, and the entire nest of sieves is placed in a shaker that produces a motion. That motion assists gravity in dividing the material into different sizes. It will take approximately 7 to 10 minutes of shaking to separate the material.

9. **Weigh and record the weights retained on each sieve**. For example, suppose a particular gradation required a maximum size of 1/2 in (12.5mm) Upon examination of this sieve and the next smaller sieve, the 3/8 in (9.5mm), no material was found retained. This would then be recorded in the "weight retained" column of the work sheet, as "0" for these two sieves. The No. 4 (4.75mm) sieve is then checked, the material carefully removed, placed on the balance and the weight is recorded. The material retained on the No. 4 sieve is then removed from the balance. Repeat this procedure for each sieve.

Example:

Total dry weight of sample before washing = 501

Dry weight of sample after washing = 484

Sieve	Weight Retained (Grams)	Percent Retained	Total Percent Passing
1/2 in (12.5 mm)			
3/8 in (9.5 mm)	0		
#4 (4.75 mm)	4		
#8 (2.36 mm)	37		
#30 (600 µm)	283		
#50 (300 µm)	141		
#200 (75 µm)	16		
pan wt	3		
Wt. sieved =	484		

Weight of material retained on each sieve

Dry weight of sample after washing

10. **<u>Calculate the percent retained on each sieve</u>**. In accordance with AASHTO-T27 record the values to the nearest 0.1 percent (0.1%) of the total original dry sample mass. To find percent retained:

$$\textbf{Percent Retained} = \frac{\textbf{Wt. on the Sieve}}{\textbf{Total dry Wt. of Sample}} \times 100$$

This is performed for each sieve size and the end figures entered in the "Percent Retained" column of the work sheet.

The "Total Dry Wt. of Sample" is sample weight before washing.

Total dry weight of sample before washing = **501**

Dry weight of sample after washing = **484**

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

Sieve	Weight Retained (Grams)	Percent Retained	Total Percent Passing
1/2 in (12.5 mm)			
3/8 in (9.5 mm)	0	0	
#4 (4.75 mm)	4	0.8	
#8 (2.36 mm)	37	7.4	
#30 (600 µm)	283	56.5	
#50 (300 µm)	141	28.1	
#200 (75 µm)	16	3.2	
Pan wt.	3		
Wt. sieved =	484		

$$\frac{4}{501} \times 100 = 0.8\%$$

$$\frac{37}{501} \times 100 = 7.4\%$$

$$\frac{283}{501} \times 100 = 56.5\%$$

$$\frac{141}{501} \times 100 = 28.1\%$$

$$\frac{16}{501} \times 100 = 3.2\%$$

11. **<u>Calculate the total percent passing each sieve.</u>** To determine this figure, subtract the percent retained on each sieve from the percent passing the next larger sieve. This is performed for each sieve and entered in the "Total Passing" column of the work sheet. (see page 4-9) In accordance with AASHTO-T27 record the values to the nearest 0.1 percent (0.1%) of the total original initial dry sample mass.

To Find Total Percent Passing:

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

% Passing - % Retained = % Passing

Sieve	Weight Retained (Grams)	Percent Retained	Total Percent Passing
1/2 in (12.5 mm)			
3/8 in (9.5 mm)	0	0	100
#4 (4.75 mm)	4	0.8	99.2
#8 (2.36 mm)	37	7.4	91.8
#30 (600 μm)	283	56.5	35.3
#50 (300 μm)	141	28.1	7.2
#200 (75 μm)	16	3.2	4.0
Pan wt.	3		
Wt. sieved =	484		

100.0 %	Passing	3/8" Sieve
- 0.8 %	Retained	No. 4 Sieve
99.2 %	Passing	No. 4 Sieve

99.2 %	Passing	No. 4 Sieve
- 7.4 %	Retained	No. 8 Sieve
91.8 %	Passing	No. 8 Sieve

91.8 %	Passing	No. 8 Sieve
- 56..5 %	Retained	No. 30 Sieve
35.3 %	Passing	No. 30 Sieve

35.3 %	Passing	No. 8 Sieve
- 28.1 %	Retained	No. 50 Sieve
7.2 %	Passing	No. 50 Sieve

7.2 %	Passing	No. 50 Sieve
- 3.2 %	Retained	No. 200 Sieve
4.0 %	Passing	No. 200 Sieve

Note: For acceptance, percentages should be to the nearest whole number, except if the percentage passing the No 200 sieve is less than 10 percent, it must be reported to the nearest one tenth of a percent(0.1 percent) (AASHTO T-27).

Test Sample Size for Fine and Coarse Aggregate

Fine Aggregate – The minimum size of the test sample of aggregate, after drying, shall conform to AASHTO T 27

Aggregate with at least 95 percent passing a No. 8 (2.36 mm) sieve - **100 grams**

Aggregate with at least 85 percent passing a No. 4 (4.75 mm) sieve - **500 grams** and more than 5 percent retained on a No.8 (2.36 mm) sieve.

Coarse Aggregate – The weight of the test sample of coarse aggregate shall conform to AASHTO T 27.

Nominal Maximum Size Square Openings in.	**(mm)**	**Minimum Weight of Test Sample, lb**	**(kg)**
3/8	(9.5)	2	(1)
1/2	(12.5)	4	(2)
3/4	(19.0)	11	(5)
1	(25.0)	22	(10)
1 ½	(37.5)	33	(15)
2	(50)	44	(20)
2 ½	(63)	77	(35)
3	(75)	130	(60)
3 ½	(90)	220	(100)
4	(100)	330	(150)
5	(125)	660	(300)

Sampling for Aggregate Properties

Sampling of aggregate for consensus property testing shall come from either each individual aggregate component or the total blend. Care should be taken to obtain a representative sample. Once the sample has been obtained, sieving should be performed to obtain the appropriate size sample material for testing.

Testing for Aggregate Properties

As part of the Superpave Mix Design System, specific characteristics of fine and coarse aggregates have been defined. They are as follows:

Fine Aggregate	**Test Method**
Fine Aggregate Angularity (FAA)	AASHTO T304 Method A
Sand Equivalent (SE)	AASHTO T 176
Coarse Aggregate	
Coarse Aggregate Angularity (CAA)	ASTM D 5821
Flat & Elongated (F/E)	ASTM D 4791*

**Flat and Elongated shall be performed on crushed gravel except that aggregate sizes larger than No. 4 (4.75 mm) sieve will be measured at 5:1 maximum to minimum dimension.*

For the Superpave Design System, as part of the job-mix formula, the aggregate Supplier or Asphalt Producer shall perform the consensus property tests. In addition, the consensus property tests shall be tested and reported at the frequency specified in Section 211.05. The values used for acceptance of these properties are denoted in Section 211.02 and are mix dependent. For RAP portions of a mixture, all consensus properties except sand equivalent will be reported.

In addition to aggregate consensus property testing, as part of the job-mix formula, the aggregate supplier or asphalt producer shall perform aggregate specific gravity tests. Aggregate specific gravities shall be tested and reported at the frequency specified in Section 211.05. The Department has established a policy for testing these properties due to use of blended aggregate stockpiles with substantial portions of fine and coarse material in a single stockpile. To conduct testing on a stockpile, the stockpile has to have 10% or more material within the definition of coarse or fine material subject to the test.

Note: the Asphalt Producer has the option of performing aggregate quality tests on stockpiles or on the blend of each mix.

An example would be a stockpile that contains 40% material retained on or above the No. 4 (4.75 mm) sieve (60% of the material would pass the No. 4 sieve). That portion retained on the No. 4 sieve would be tested for Flat and Elongated and Coarse Aggregate Angularity. That portion passing the No. 4 sieve would have to be tested for Sand Equivalent and if more than 10% of the total aggregate passes the No. 8 (2.36mm) sieve, then that portion would be tested for Fine Aggregate Angularity.

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Study Questions

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

   A. fineness modules
   B. sieve analysis
   C. yield
   D. moisture analysis

2. Coarse aggregate used in Asphalt Concrete is defined as all the material retained on or above the:

   A. No.4 (4.75 mm) sieve
   B. No.8 (2.36 mm) sieve
   C. No.100 (.150 mm) sieve
   D. No.200 (.075 mm) sieve

3. A relatively small portion of material having the same physical properties as the group or lot from which it is taken is called a:

   A. Stratified random sample
   B. Representative sample
   C. Random sample
   D. None of the above

4. Fine aggregate used in Asphalt Concrete is defined as all material passing the:

   A. No. 4 (4.75 mm) sieve
   B. No. 8 (2.36 mm) sieve
   C. No. 100 (.150 mm) sieve
   D. No. 200 (.075 mm) sieve

5. What is the most important thing in sampling of materials?

6. What determines the size sample required to run a sieve analysis?

7. What are two methods of reducing an aggregate sample to size for testing?

Study Questions (continued)

8. How would you prepare a sample for sieve analysis?

9. Washed sieve analysis is a method used in Virginia for asphalt mixes for determining proportions of various particle sizes in a mineral aggregate?

   A. True
   B. False

10. The purpose of the washed sieve analysis is to separate the amount of material finer than what size sieve?

11. Which dry weight is used to calculate the percent retained?

    A. Total dry weight of sample before washing.
    B. Dry weight of sample after washing.

12. As a check against sample loss when running a sieve analysis, the combined grams on each individual sieve, in the weight retained column, should equal the:

    A. Total dry weight of sample before washing.
    B. Dry weight of sample after washing.

13. How are the different sizes of aggregate in a sample separated?

14. When conducting a sieve analysis, after the total sample has been shaken, the weight of material retained on each sieve size is recorded .

    A. True
    B. False

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Problem No. 1
Determining Gradation

Complete the following analysis.

Total dry weight of aggregate before washing 1043.7 grams
Dry weight of aggregate after washing 1030.7 grams

Sieve	Wt. Retained on each sieve	% Retained	% Passing
3/4 in	0		
1/2 in	0		
3/8 in	0		
No. 4	1.5		
No. 8	98.9		
No. 30	470.7		
No. 50	353.2		
No. 200	103.3		
Pan	3.1		

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Problem No. 2
Determining Gradation

Complete the following analysis.

Total dry weight of aggregate before washing 1474.1 grams
Dry weight of aggregate after washing 1328.3 grams

Sieve	Wt. Retained on each sieve	% Retained	% Passing
3/4 in	0		
1/2 in	0		
3/8 in	0		
No. 4	16.4		
No. 8	379.5		
No. 30	532.4		
No. 50	172.1		
No. 200	205.1		
Pan	22.7		

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Problem No. 3
Determining Gradation

Complete the following analysis.

Total dry weight of aggregate before washing 1917.8
Dry weight of aggregate after washing 1815.0

Sieve	Wt. Retained on each sieve	% Retained	% Passing
2 in	0		
1 ½ in	0		
1 in	154.8		
3/4 in	191.9		
1/2 in	243.1		
3/8 in	148.1		
No. 4	381.3		
No. 8	353.9		
No.30	211.1		
No. 50	85.7		
No. 100	29.3		
No. 200	15.8		

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Problem No. 4
Determining Gradation

Complete the following analysis.

Mix Type 12.5E

Total dry weight of aggregate before washing 1075.0 grams
Dry weight of aggregate after washing 1017.8 grams

Sieve	Wt. Retained on each sieve	% Retained	% Passing
2 in	0		
1-1/2 in	0		
1 in	0		
3/4 in	0		
1/2 in	13.3		
3/8 in	102.3		
No. 4	305.8		
No. 8	126.0		
No. 30	299.7		
No. 50	103.4		
No. 100	43.3		
No. 200	24.0		

CHAPTER 4
SAMPLING AND ANALYSIS OF AGGREGATES
Problem No. 5
Determining Gradation

Complete the following analysis.

Mix Type SM-12.5D

Total dry weight of aggregate before washing 1179.9
Dry weight of aggregate after washing 1143.2

Sieve	Wt. Retained on each sieve	% Retained	% Passing
2 in			
1-1/2 in			
1 in			
3/4 in	0		
1/2 in	0		
3/8 in	73.2		
No. 4	362.0		
No. 8	202.9		
No. 30	259.3		
No. 50	161.4		
No. 100	61.7		
No. 200	22.7		