



*Standard Method of Test
for Reducing Field Samples
of Aggregate to Testing Size*

AASHTO T - 248
CDOT CP - 32




Purpose of Splitting

- These methods provide for reducing large samples of aggregate to measure characteristics in a manner that the smaller test portion is most likely to be a representation of the larger sample, and thus of the total supply



Rocky Mountain Asphalt
Education Center

- Aggregates must be sampled in accordance with T-2 [\[CP-30\]](#)
- Samples must be split properly to obtain representative test specimens



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Methods

- Method A – riffle type splitter
- Method B – quartering
- Method C –
 - selection by scoop ([CDOT](#))
 - miniature stockpile method (AASHTO)

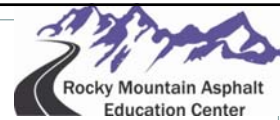
Riffle Apparatus



- Riffle type splitter with variable size openings
- Hopper to retain sample or Flat scoop (feeder pan) equal in length to the overall assembly of chutes
- Collection pans, minimum of two (2), equal in length to the overall assembly of chutes
- Splitter brush to clean chutes of adhering fines



Quartering Apparatus



- 6' x 8' quartering canvas or
- Clean, hard, level surface (AASHTO)
- Flat, square end shovel



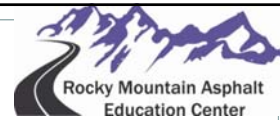
Scoop & Miniature Stockpile Apparatus (Fine Aggregate Only)



- Large flat bottomed mixing pan (CDOT) or a clean, hard, level surface (AASHTO)
- Small, flat, square end scoop (or spoon or sampling thief- AASHTO)

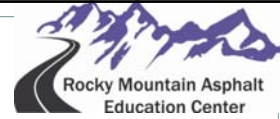


By Riffle Splitter



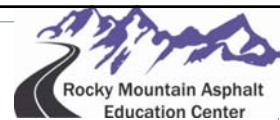
- Riffle splitting is always preferable to hand quartering
- Proper size openings required
- Opening shall permit easy passage of the largest particles in the sample
- For variable splitters the openings should be **1.5 times the size of the largest particles**

Method A – Riffle Splitter



- An **even number** of equal width chutes, but not less than **8** for coarse, or **12** for fine aggregates
- The splitter shall be equipped with a hopper or straight-edged pan which has a width equal or slightly less the overall width of the assembly of chutes
- Sample at SSD or drier
- Two procedures to split sample
 - Hopper
 - Scoop (feeder pan)

Riffle Splitter–Control Flow Hopper (CDOT)



- Sample poured into the closed hopper from the sample container
- Use all material
- Uniformly distribute from edge to edge
- Open release handle and allow the sample to flow freely through the chutes
- The first split that is then reintroduced to the splitter assists in mixing the sample



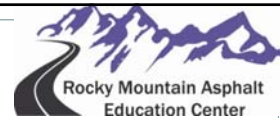
Riffle Splitter–Control Flow Hopper (CDOT)



- Then remove both pans from the splitter
- Save material in one pan for other tests
- Pour half of the remaining pan into the hopper
- Reverse ends of pan
- Pour the remaining sample into the hopper
- Uniformly distribute material in hopper
- Open release handle and allow the sample to flow freely through the chutes
- use alternate pans for further reduction
- Splitting is continued until the sample is reduced to the required specimen size



Riffle Splitter (AASHTO)



- Deposit sample into hopper and uniformly distribute it from edge to edge
- By pulling handle slowly release sample through riffles. Do not allow the chutes to become clogged.

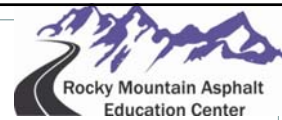


Riffle Splitter (AASHTO)



- Splitting continued from one side until sample reduced to required specimen size

Riffle Splitter by Feeder Pan (CDOT)



- Place entire sample in a large mixing pan and mix thoroughly
- Scoop the material from the pan with the feeder pan
- Uniformly distribute in feeder pan
- First, slowly pour half the sample from one side

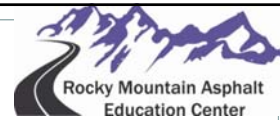
Riffle Splitter by Feeder Pan (DOT)



- Pour the other half from the other side
- Continue until entire sample has been passed through the chutes
- Use alternate pans for further reduction to desired specimen size



Riffle Splitter (AASHTO)



- Place entire sample into large pan and mix thoroughly
- Transfer all material from pan to riffles with feeder pan
- Uniformly distribute in feeder pan from edge to edge
- Pour through riffles slowly to prevent clogging chutes



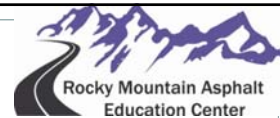
Riffle Splitter (AASHTO)



- Once entire sample has been introduced to riffles use the spare splitter pans to reduce further
- Continue splitting from one side until sample has reached the desired specimen size



Method B -Quartering



- Sample deposited on clean, hard, level surface or canvas ([6' X 8' canvas](#))
- Mix material thoroughly by turning the entire sample over onto itself 3 times



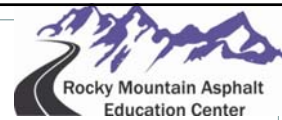
Method B -Quartering



- Material shoveled into cone
- Cone flattened at apex into in circular layer
- Diameter equals approx. 4-8 times the thickness



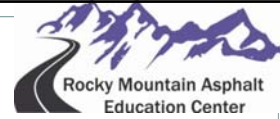
Method B -Quartering



- Uniform thickness
- Sample divided into two equal parts using a Square shovel, pipe or stick under canvas if surface is uneven

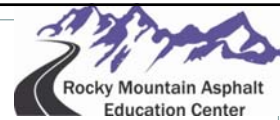


Method B –Quartering



- Procedure repeated at 90 degrees
- Diagonal opposite quarters removed [include all fines]
- Remaining two quarters re-mixed
- Procedure repeated until sample is reduced to required size

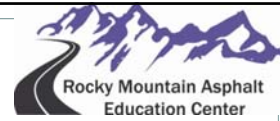
Method C – Miniature Stockpile (CDOT Scoop)



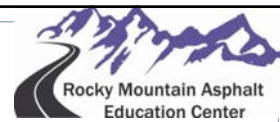
- Only for fine grained materials (minus 3/8 in.(9.5mm))
- Sample should be damp
- Sample deposited into large pan and mixed 3 times
- AASHTO-Conical pile formed. If desired flatten pile (as in quartering)
- Scoop to full depth of material (or from pile- AASHTO)



Method C – Miniature Stockpile (CDOT Scoop)



- Mix and sample to minimize the loss of particles
- Portions selected from five (three) locations
- Portions combined for required weight

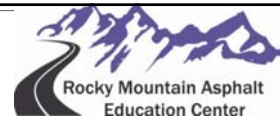


Questions?

THANK YOU

Standard Method of Test
for Materials Finer Than 0.075-mm
(No. 200) Sieve in Mineral Aggregates
by Washing and the Sieve Analysis of
Fine and Coarse Aggregate
CDOT CP - 31
AASHTO T 11 / T 27

Summary



- The weight required (after drying) for this procedure, is based on the nominal maximum particle size
- The -200 wash is performed to remove the finer material from the coarser particles for a more efficient result
- The aggregate gradation is the distribution of particle sizes expressed as a percent of the total weight of the sample
- The gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings and weighing the material retained on each sieve

Apparatus Required

- Balance, with ample capacity and sensitivity (0.1 g)
- Sieves
 - For the -200 wash, a nest of two sieves, the lower a No. 200 and the upper with openings in the range of No. 8 and No. 16
- For the Sieve Analysis, additional sieves, conforming to AASHTO M92 and ASTM E11



- Container, sufficient in size to contain the sample covered with water and to permit vigorous agitation without any loss of the sample or water
- Oven or hot plate.

Test Samples

- Aggregates must be sampled in accordance with [CP-30](#) (T-2)
- Aggregates must be mixed and reduced to test specimen size in accordance with [CP-32](#) (T-248)



CP 31 Sieve Analysis & Materials Finer than the No, 200 by washing

- AASHTO T 11 & T 27 (found in AASHTO portion of handout) shall be used to determine the sieve analysis of fine & coarse aggregates with the following exceptions:
 - Table 31-1 still used for minimum sample mass
 - Moisture Correction process can still be used, according to following procedure

CP 31

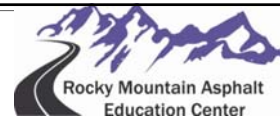
- split material into two approximately equal samples
- dry one to constant mass at 230 degrees F +/- 9 oven or hotplate to determine % moisture.
- determine dry weight of second sample by dividing the wet weight by 100 + % moisture of first sample X 100.

Test Samples-Coarse Aggregate Table 31-1



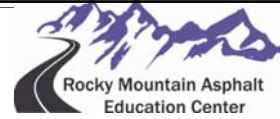
Aggregate Nominal Maximum Size square openings,	Minimum Mass of Test Sample (AASHTO) (kg)	<u>Minimum Mass of Test Sample Lb (kg)</u>
3/8"	2	<u>2.2 (1.0)</u>
1/2"	4	<u>3.3 (1.5)</u>
3/4"	11	<u>4.4 (2.0)</u>
1"	22	<u>5.5 (2.5)</u>
1.5"	33	<u>11.0 (5.0)</u>
2"	44	<u>16.0 (7.5)</u>

Procedure



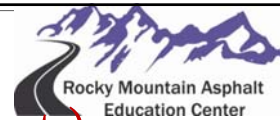
- Dry the sample to constant mass @ 110 ± 5 °C (230 ± 9 °F) and determine the mass of the test sample
- A hot plate is acceptable for drying if the aggregate temperature can be maintained above the boiling point of water
- Use moisture correction method.

Procedure for the -200 wash



- Place the sample into container and cover with water
- Add wetting agent if desired
- Agitate the test sample with sufficient vigor to separate the particles finer than the No. 200 sieve and to bring the material into suspension

Procedure, -200 wash (cont.)



- Immediately pour the wash water over the nested sieves avoiding the decantation of coarser particles of the sample



Procedure, -200 wash (cont)

- The entire sample may be placed into the upper sieve and washed until the coarser fraction is clean, however all water must pass through the No. 200 sieve
- Add a second charge of water (no wetting agent)
- Agitate and decant
- Repeat this operation until the wash water is clear

Procedure, -200 wash (cont.)



- Return all material retained on the sieves to the container
- Dry the washed aggregate to a constant mass at 110 ± 5 °C (230 ± 9 °F)
- A hot plate is acceptable if the aggregate temperature can be maintained above the boiling point of water
- Cool to room temperature, determine and record the dry mass of the material

Before/After Sieve Weight Check

- Weigh & record weight of washed sample after drying prior to placing in the stack
- Weigh & record weight of material from each sieve either individually or accumulatively
- Final total weight should not differ by more than 0.3% of the original dry mass of the washed and dried sample.

$$\left(\text{Difference} \div \text{OriginalDryMass} \right) \times 100 = \leq 0.3\%$$

Sieving Procedure

- Separate the specimen over a series of suitable size sieves, including those required by the specifications, manually or mechanically
- Do not overload sieves
 - 12 inch = Approx. 500g
 - 8 inch = Approx. 200g



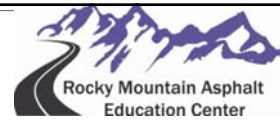
Sieving Adequacy



- Annual calibration of shaker
- Test using different material types
 - Hand shake each individual sieve for additional 1 minute
 - Pan on bottom and lid on top
 - Hold at slightly inclined angle and tap sharply with heel of hand
 - 25 taps at each of 6 locations around the sieve = 150 taps
 - Not more than 0.5% by weight of the total sample can pass

$$\text{Loss} / \text{original dry mass} \times 100 = \leq 0.5\%$$

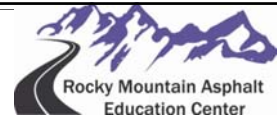
Procedure, Sieve (cont)



- Determine and record the mass of material retained on each sieve to 0.1 g
 - individually
 - cumulatively



Procedure



- Calculate the Moisture content
 $M/C = \frac{\text{Wet} - \text{Dry}}{\text{Dry}}$
- Calculate the original dry mass from the percent moisture when using moisture correction methods

Wetwt ÷ (100 + %M) × 100 = Originaldrywt

- Calculate percent retained to 0.1%

Sievewt ÷ originaldrywt × 100 = %retained

- Calculate the percent passing and report to nearest whole number except No. 200 to 0.1%

100-% retained = % Passing

COLORADO DEPARTMENT OF TRANSPORTATION SIEVE ANALYSIS FOR AGGREGATES NOT SPLIT ON THE NO. 4 SIEVE									
Project No. _____					Project code (State)				
Field location _____									
Field name _____									
Item _____					Class _____				
Station	Test #				Station	Test #			
Specimen wt (dry) B	2383.7				Specimen wt (dry) B	2383.7			
Date					Date				
Sieve	Weight	Percent retained	Percent passing	Specs	Sieve	Weight	Percent retained	Percent passing	Specs
1"	0.0		100		1"	0.0	0.0	100	
3/8"	23.0	1.0	99		3/8"	23.0	1.0	99	
3/16"	253.7	10.6	89		3/16"	230.7	10.6	89	
3/32"	432.1	18.0	81		3/32"	198.4	18.0	81	
#4	832.1	34.9	65		#4	380.0	34.9	65	
#8	1052.1	44.1	56		#8	220.0	44.1	56	
#16	1248.7	52.4	48		#16	198.6	52.4	48	
#30	1489.5	62.5	37		#30	241.0	62.5	37	
#50	1892.1	79.4	21		#50	402.6	79.4	21	
#100	2015.5	84.5	15		#100	123.2	84.5	15	
#200	2258.4	94.8	5.2		#200	244.1	94.8	5.2	
#400	63.1				#400	63.1			
TOTAL	2322.5				TOTAL	2322.5			
Wet weight = (100 + % H2O) × 100 = Dry weight A 2500.3 = (100 + 4.8) × 100 = B 2383.7					Wet weight = (100 + % H2O) × 100 = Dry weight A 2568.3 = (100 + 4.8) × 100 = B 2383.7				

Cumulative Weights

Individual Weights



THE END

Questions???

*Standard Method of Test
for Asphalt Binder Content of
Asphalt Mixtures by the
Nuclear Method
AASHTO T - 287
CDOT CP - 85*

Purpose

- For the quantitative determination of the asphalt binder content in asphalt paving mixtures by testing a sample with a device that utilizes neutron thermalization techniques
- This method is a rapid determination of asphalt content.
- This procedure is sensitive to the type & gradation of aggregate, hydrated lime, percentage & source of binder.

Purpose

- Measures total hydrogen in sample, including any moisture in the form of water.
- Moisture correction must be performed (CP 43)
- When using RAP in mix design, the RAP used in the calibration samples must be uniform in gradation, asphalt content and asphalt type.

Required:

- Samples of binder and aggregate for the calibration process shall be sampled and prepared per procedure
- Field samples of mix for binder content determination shall be obtained and reduced to test specimen size as per CP 55.
- Prior to gauge operation
 - stationary location
 - away from water
 - away from other nuclear testing devices 33 ft (10 m)

Required Apparatus

- content gauge
- metal sample pans 9(clean & undamaged condition)
- metal plate or plywood (or wooden survey stake)
- steel straightedge approx. 18 inches in length
- balance, 33 lb (15 kg), readable to 0.1 g
- large mixing bowl, misc. hand tools
- ovens
- microwave oven (CP - 43) for moisture determination
- thermometer from 50–500 °F (10 to 300 °C)

Procedure Steps

- standardization
- sample preparation
- aggregate count
- calibration
- moisture content
- test

Standardization (background)

- top of gauge free of materials
- gauge empty and clean
- warm-up gauge a minimum of 20 minutes
- obtain background count for 16 min or a minimum 8 min.
- $\pm 1\%$ from previous count
- statistical stability once per month

Sample Preparation

- obtain binder sample from job or supplier
- obtain aggregate samples from job or supplier
- Obtain lime samples from job or supplier
- dry aggregates at 149 ± 8 °C (300 ± 15 F) for a minimum of 3 hours or to constant weight
- heat binder to mixing temperature
- use job mix formula to blend aggregates in the correct proportion

Aggregate Count

- Heat aggregates, bowls, sample pans and tools $300 \pm 15^{\circ}\text{F}$
- fill pan half full
- drop 1 in. four times to compact
- fill pan above rim
- Repeat dropping 1" four times
- level off with straight edge using a sawing motion strike it off so it is level with the rim of the pan
- record weight
- record temperature
- obtain and record count (16 minutes), repeat approximately once per week
- If a significant change is noted in this count $\pm 0.5\%$, a new calibration should be run



Mixing Samples

- Aggregates should be proportioned to the JMF
- Correct amount of lime should also be mixed in with aggregates and sample hydrated before addition of binder
- mix samples with correct amount of properly graded binder
- *How much binder do you add? One formula is:*

$$W_b = (W_s \times P_b) / (100 - P_b)$$

Where: W_b = Weight of binder, W_s = Weight of Stone,
 P_b = Percent of Binder.

Assume 7000g of stone and 5% binder required.

$$\text{Example: } W_b = (7000 \times 5.0) / (100 - 5.0)$$

$$W_b = 35000 / 95$$

$$W_b = 368.4\text{g}$$

Calibration Curve Generation

- Dry aggregates @ $300 \pm 15^\circ\text{F}$
- Proportion dry aggregates as per JMF and place in oven along with binder & all mixing apparatus in oven @ mixing temp. as per PG Binder specified.
- If RAP is being used, the percent binder in the RAP must be known and the gradation of the RAP used must uniformly match the RAP gradation used in the mix design.
- Mix a **minimum of 3 calibration pans**: one @ optimum, one @ +1%, one @ -1% or range expected on the project.
- Fill pan half full
- Level sample
- Fill pan above rim



Calibration Cont'd

- If this is the first pan, the weight that fills the pan well becomes the **base weight** for all the other calibration pans & test samples during production.
- The corners should be filled and normally the optimum pan should be the first pan made during calibration to establish the base weight.
- The sample should then be **compacted** at a temperature between **250 and 300 F**. Obtain and record temperature of first sample to establish the calibration temperature.
- All samples during calibration should then be within ± 10 F of this temperature.

Calibration Cont'd

- Place sample in the gauge and obtain and record a **16 minute count**.
- The result from the calibration pans should result in a **correlation factor of 0.999 to 1.000** to be a valid calibration.
- If less than 0.999, new pans should be mixed and calibration run again.
- Document all calibration information on CDOT form 599 or other approved form.

COLORADO DEPARTMENT OF TRANSPORTATION NUCLEAR ASPHALT CONTENT CORRELATION				
Aggregate source	Rocky Rocks		Date	Correlation no.
Asphalt grade & source	PG 64-22 Koch		Grading	Supplier
Project No.	SEA 054-21		Project code (SAR)	Form 43 #
Background count	Start	Finish	Gauge No.	Job mix formula % AC
	1975	1976	13	5.9
Dry Aggregate Information				
A. Base weight	7250	g	A' Base weight (mix)	7100
B. Gauge count on dry aggregate	1950			
Correlation				
C. Weight of dry aggregate	Cor. Pan 1	Cor. Pan 2	Cor. Pan 3	Cor. Pan 4
	8000	8000	8000	8000
D. Percent asphalt required	4.90	5.9	6.9	7.9
E. Weight of asphalt required ($\frac{C \times D}{100 - D}$)	412.2	501.6	592.9	684.2
F. Desired weight of mix (C + E)	8412.2	8501.6	8592.9	8684.2
G. Actual weight of aggregate and asphalt	8411.9	8501.3	8593.0	8684.7
H. Actual weight of asphalt in mix (G - C)	412.2	501.6	592.9	684.2
I. Actual % of asphalt in mix ($\frac{H}{G} \times 100$)	4.9	5.9	6.9	7.9
J. Gauge count on mix sample	2927	3200	3488	3776
K. Deviation	-0.009	+0.018	-0.009	-0.009
L. Correlation temperature	280			
M. Slope	3.995	Intercept	-6.729	Correlation factor
				.9993
Tested by:				Witnessed by:
Remarks:				Check pan by:
				AC mixed at, %
				5.9
				Gauge count:
				3200
				% AC by gauge:
				5.91

Test Procedure

- Split out 2 samples, one for testing of %AC and one determining the %moisture from the field sample.
- Two methods can be used for determining the %moisture in CP 43: Method A Microwave or Method B Convection Oven.
- Fill pan half full
- Level material in pan
- Finish filling pan to base weight within +/-5 g.

Test Procedure (cont.)

- Check temperature prior to compaction (should be between 250 F and 300 F)
- compact sample
- If using a gauge that does not compensate for temperature, the test sample temperature should be between 180-290°F when placed in the nuclear gauge.
- Obtain 16 min gauge count, record count & %AC from gauge display.

COLORADO DEPARTMENT OF TRANSPORTATION ASPHALT TESTS				Gradation test # : 1	
Project no: STA 054-21		Project code (SAR):		Location:	
AC gauge # : 3	Correlation # : 1.0	Correlation temp.:		Station:	
Supplier: The Best	Rem:	Grading: 2C		Base weight: 7000	
Date:	Time:	Field temp.:		Course: Top	
Background on:	Scale ticket #:	IAT#:	Rep:	10k:	
Job Mix % AC: 5.50	Sample moisture correction	Sieve analysis			
Mass. count: 3075	Tare: 652.3	$\frac{2027.2}{(100 + 2.43)} \times 100 = 1979.1$ Dry wt. (before wash)			
Gauge % AC: 5.71	Wet wt.: 580.2	Sieve	Weight	% Ret.	% Pass
% Moisture: 0.12	Dry wt.: 579.5	1		0.0	100
Corr. % AC: 5.59	Loss: 0.7	3/4	114.6	5.8	94
	% Moisture: 0.12	1/2	410.6	20.7	79
Dry aggregate count: 1993		3/8	997.5	50.4	50
Form #43 Max. specific gravity: 2.470		#4	1295.3	65.4	35
		#10	1477.3	74.6	25
A) Sample weight: 1044.4 (Flask #1)	1070.1 (Flask #2)	#20	1625.1	82.1	18
B) Flask + water + lid: 3275.7	3305.6	#40	1748.1	86.3	12
C) Sample + flask + water + lid: 3890.3	3943.5	#100	1826.9	92.3	8
RICE (Max SpG): 2.476	2.476	#200	1867.9	94.4	5.6
RICE average: 2.476	[A/(A + B - C) = Max SpG]	#200	1954.1		
Fractured Faces (FF)	Moisture correction for Aggregates	Total sieve wt. (TSW)			
A) Total wt.: 997.5	Tare: 632.4	Dry weight (after wash): 1954.8			
B) Fract. agg.: 979.8	Wet wt.: 1873.1	% difference =			
(BA) x 100 = 98 %FF	Dry wt.: 1828.7	(Dry wt. - TSW) / Dry wt. x 100 = 0.04 %			
	Loss: 44.4	Remarks:			
	% Moisture: 2.43				
Form #43 % Aggregate absorption: 2.300					
Sampled by:					
Company:					
Tested by:					
Title:					
Company:					

Test Procedure cont'd

- Correct the %AC from gauge display by subtracting the % moisture (if it is determined that the sample contains moisture) and document on the CDOT form 106 or any approved reporting form.

Questions?????

Thank You

The End



*Standard Method of Test
for*
Bulk Specific Gravity of Compacted
Asphalt Mixtures Using Saturated
Surface-Dry Specimens
[CDOT CP - 44](#)
AASHTO T - 166

Purpose

- This procedure provides methods for determining bulk specific gravity to calculate the percent relative compaction of HMA and air void analysis.
- The Bulk Sp G is also used in determining the correlation factor for nuclear density gauges.

Test Specimens

- CDOT-laboratory molded (method A) or pavement cores (method B)
- AASHTO-laboratory molded (method A) or cored Asphalt pavements (method C)
- **Size of Specimens**
 - Diameter should be at least 4 times the maximum size of the aggregate
 - Thickness at least 1.5 times the maximum size of the aggregate

Specimen Preparation

- Avoid distortion, bending or cracking during and after removal from pavement or mold.
- Stored in safe, cool place.
- Separating specimen layers should be done by sawing or suitable means.

Testing Apparatus required

- balance, with suspension apparatus
- wire of the smallest practical size at the penetration point of the water surface
- water bath with overflow outlet
- flannel or terry cloth towel

Procedure for Method A Laboratory Molded Specimens

- cool specimen to room temperature at $77 \pm 9^{\circ}\text{F}$ ($25 \pm 5^{\circ}\text{C}$)
- check water level
- check water temperature $77 \pm 1.8^{\circ}\text{F}$ ($25 \pm 1.0^{\circ}\text{C}$)
- record dry mass
- immerse specimen in water 4 ± 1 min.
- record immersed mass
- remove specimen from water, blot with freshly wrung out, damp towel and record SSD mass



Cores – The Rapid Method B (CDOT)

- check water level
- check water temperature
- immerse specimen in water 4 ± 1 min.
- record immersed mass
- remove specimen from water, blot with freshly wrung out, damp towel and record SSD mass



Drying Cores to Constant Mass (CDOT Rapid)

- tare pan, record mass of specimen and place pan and specimen into a forced draft oven at 230 ± 9 °F (110 ± 5 C)
- leave $5 \frac{1}{2}$ inch (140 mm) or larger, or porous or wet cores in oven until they can be separated into pieces no larger than 2 inches (50 mm)
- dry the specimens for 3 h and determine the mass
- determine the mass at 2 h intervals until constant mass (no change of more 0.05%) has been attained or 24 hour maximum.
- cool specimen to room temperature and determine the dry mass

Drying Cores to Constant Mass (AASHTO Rapid)

- tare pan, record mass of specimen and place pan and specimen into oven at 110 ± 5 °C (230 ± 9 °F)
- leave sample in oven until it can be broken down into particle size no larger than 6.4 mm (1/4 in.)
- check weight at 2 hr intervals
- constant mass when sample weight does not change more than 0.05 %
- cool specimen to room temperature and determine the dry mass

Method C (CoreDry Test)

- May be used for pavement cores in place of Method B
- May be used on cores containing moisture
- Tested the same day – quick results
- Determine the weight in water and SSD weights as in Method B
- Allowing cores to warm to room temperature, towel blot any free standing moisture on cores.
- Place core on side on wire mesh in vacuum chamber.
- Follow procedure in 11.4 of Method C for use of CoreDry apparatus to obtain dry weight.

Bulk Specific Gravity Calculation

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

where:

A = mass (in grams) of dry sample in air

B = mass (in grams) of SSD sample, in air

C = mass (in grams) of sample in water

Percent Relative Compaction

$$\text{Percent Relative Compaction} = \frac{\text{Bulk Specific Gravity}}{\text{Maximum Specific Gravity}} \times 100$$

Air Voids (Va) Calculation

$$Va = \frac{Rice - Bulk}{Rice} \times 100$$

or

$$Air\ Voids = 100 - \% \text{ Relative Compaction}$$

Convert Specific Gravity (Gs) to pounds per cubic ft (pcf)

CDOT uses:

- Specific gravity x 62.4 = pcf
- Pcf / 62.4 = specific gravity
- Specific gravity x 62.24 = pcf
- Pcf / 62.24 = specific gravity

Questions ??

*Standard Method of Test
for Theoretical Maximum
Specific Gravity of Asphalt
Paving Mixtures*
CDOT CP - 51
AASHTO T - 209

Purpose

- This method covers the determination of the maximum specific gravity of uncompact asphalt paving mixtures.
- This method will assist with determining:
 - relative percent compaction
 - percent air voids

Apparatus Required

- balance, with ample capacity and sensitivity
- heavy walled volumetric flask or other container
- flat, transparent cover plate
- fine wire mesh
- calibrated thermometer, ASTM 17 °C
- vacuum system, 3.7 ± 0.3 kPa, (28 ± 2 mm Hg)
- residual pressure manometer or pressure gauge

Procedure

- flask calibration
- sample preparation
- test
- calculations

Flask Calibration



- Perform once per month
- fill flask with water
- verify water temperature is 77 ± 1 °F (25.0 ± 0.5 °C)
- overflow flask and level off with cover plate
- determine and record the mass of flask, water and cover plate
- identify and record the flasks and cover plate(s)
- Average of last three determinations and record

Sample Preparation

- samples shall be obtained according to (CP-41) T168
- samples shall be split according to (CP - 55) T-248
- the sample size is based on the nominal maximum aggregate size of the mixture (Table 51-1)
- two separately taken identical test specimens shall be obtained and not recombined at any time

**TABLE 51-1:
Required Sample Mass for Various Nominal
Maximum Sizes of Aggregate**

Nominal Maximum Size of Aggregate		Number and Minimum Mass of Specimens
Inches	MM	Specimens X grams
1.5	37.5	2 X 3000g
1	25.0	2 X 1500g
¾	19.0	2 X 1000g
½	12.5	2 X 750g
3/8	9.5	2 X 500g
No. 4	4.75	2 X 500g

Voids Analysis

- If laboratory or field produced specimens are to be compacted for voids analysis using CP-L 5115, the specimens used to determine the theoretical maximum specific gravity should be short-term aged using the same procedure as the specimens being compacted.
- specimens maintained at a temperature above 200 °F (94 °C) for 1 hr or more do not require additional aging.

Sample Prep - Cont.



- Separate the fine particles of each sample so that they are no larger than $\frac{1}{4}$ "
- Take care not to fracture mineral particles
- If mixture is not sufficiently soft to be separated, mixture may be warmed only until they can be so handled
- Cool samples to room temperature

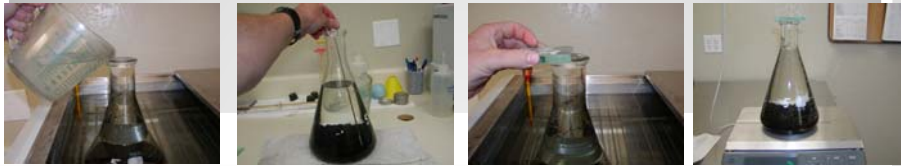
Test

- tare flasks or record mass of each empty flask
- place samples into flasks
- record mass of each sample
- fill flask with water (approx. 25 °C) to a minimum of one inch above sample
- remove entrapped air under a partial vacuum of 3.7 ± 0.3 kPa (28 ± 2 mm Hg) for 15 ± 2 minutes
- agitate the samples and flasks at 2 minute intervals (for 15 ± 5 s) or continuously with mechanical device



Test - Cont.

- turn vacuum off, not faster than 8 kPa/sec (60 mm/s Hg)
- fill flasks with water (@ 25.0 ± 0.5 °C)
- stir sample with rod, if necessary
- Finish filling flask with 77°F water & slip lid onto flask
- Place flask in 77 ± 1 °F (25.0 ± 0.5 °C) water bath
- bring the contents of the flasks to 25.0 ± 1.0 °C (77 ± 1.8 °F), check for air bubbles, remove any found under the lid, replace lid, determine the mass of the flask, water, sample and cover plate for each sample
- the mass shall be determined 10 ± 1 minutes after the vacuum is released



Test - Cont.

- In lieu of a constant temperature bath as per section 6.5, determine the calibration masses at various test temperatures
- determine the final temperature of the samples
- make the appropriate density corrections

Test - Cont.

- If the aggregate is not completely coated:
 - AASHTO- Follow the procedure found in test method T 209 Section 11
 - [CDOT-Follow Method A in Section 8](#)
 - [Method B - is to be used for determining the Effective Specific Gravity for RAP](#)

Calculations

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

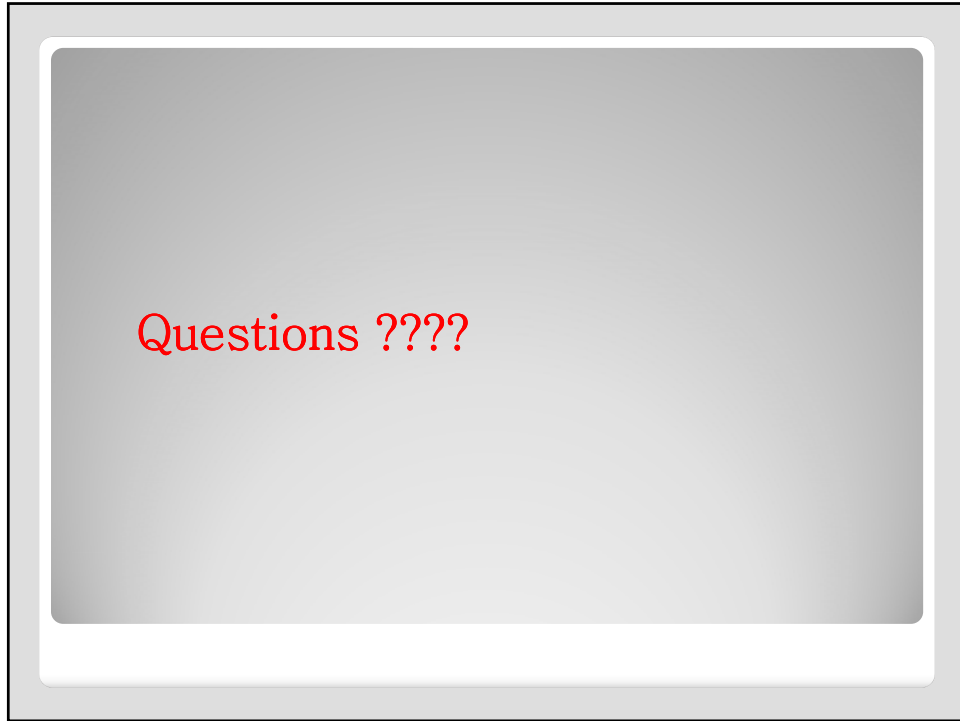
Where:

A = mass of dry samples

E = mass of samples, water, flasks and cover plate(s)

D = calibration masses

[The specific gravities must be within 0.011 of each other for a valid test](#)



Standard Method of Test for Determining the Asphalt

Binder Content of Hot Mix Asphalt by the Ignition Method

AASHTO T 308
ASTM D 6307

[CDOT CP-L 5120](#)

Summary of Test Method

- The asphalt in a HMA sample is burned by ignition at a temperature high enough to ignite the asphalt binder fraction
- Binder content is calculated by
 - dividing the mass loss of the specimen after ignition by the mass of the mixture before ignition
 - the application of the correction factor, and
 - the subtraction of the % of any moisture found
- In Colorado, internal or external scales are used for all final weights

Summary of Test Procedure

- This method determines the asphalt binder content by burning the binder off by ignition, the specimen gradation is then determined with the remaining aggregate residue.
- Not to be used for determining binder content of cores or otherwise obtained samples from existing bituminous pavements.

Overview

- Safety Issues
- Apparatus
- Sampling / Test Specimens
- Calibration
- Test Procedure
- RAP

Safety Issues

- Wear eye protection
- Wear long sleeves
- Wear clean, heat resistant gloves
- Location of furnace

Apparatus

- Forced air ignition furnace, that heats the sample by convection method or infrared heat source ignition method.
- Internal scale units will determine and indicate when the sample reaches a constant weight
- There must be an internal balance thermally isolated from the furnace chamber that is readable to 0.1g



Calibration

- Correction factors will be determined for the binder content and the aggregate loss
- These factors will be determined for each mixture design and when mix ingredients change

Calibration

- This method may be affected by the type of aggregate in the mixture
- A calibration factor must be performed prior to any acceptance testing

Calibration Process

- The calibration process should be repeated each time there is a change in the mixture ingredients
- Prepare three samples proportioned according to the JMF.
- Step One – Perform gradation analysis on an unburned “blank” specimen (no binder)
- Step Two – Prepare two calibration samples at the design asphalt binder content
- Burn the two samples as regular tests.
 - Note – after mixing if the specimens are allowed to cool, heat the material at binder compaction temperature for 30 minutes in separate pan.
 - Do not use the ignition oven baskets, they are not to be preheated before being placed in the ignition oven.

Aggregate Calibration (if degradation of aggregate occurred)

- Perform a gradation analysis on the residual aggregate.
- Compare the gradations of the blank (unburned) specimen and the residual aggregate to evaluate the amount of aggregate breakdown

Aggregate Calibration

- If degradation is suspected—(Section 12 CP-L 5120)
 - Obtain a belt feed of the aggregate from the plant large enough for 4 specimens
 - Determine the gradation of two blank specimens
 - Mix 2 specimens at the design binder content, burn off the binder, perform gradation on residual aggregate
 - Compare the average gradation at each sieve size for the two sets of specimens
 - If the gradation is more than 3% finer than the untreated aggregate on any of the sieves
 - Apply a correction factor to the percent passing each sieve

Calibration Process To Determine the Binder Correction Factor

- Determine the binder content for each sample by calculation
- If the measured difference between the two burned samples is less than 0.15%, calculate the difference in binder content between the actual (optimum) and measured (mixed samples) binder contents for each sample
- The calibration factor is the average of the differences between the actual and the measured asphalt contents for each sample.

Binder Calibration Process

- If the measured difference between the two binder contents (burned samples) is **greater than 0.15%**,
 - Mix up an additional two samples and repeat the procedure
 - Of the now four results, discard the high and low of the four measured asphalt contents.
 - Use the remaining two to calculate the correction factor

Using the Ignition Oven w/ RAP

- The ignition oven can be used to determine the asphalt content of mixes containing RAP
- Prior to performing the mix calibration the percent binder (P_b) of the RAP must be determined by ignition with two RAP samples or the bitumen content from the mix design may be used.
- As with any materials, the sampling of RAP must be done carefully to result in samples that are representative of the larger mass of material.
- The gradation of the samples must be representative, gradation of specimen will affect the asphalt content results.

Calibration Process w/ RAP

- Weight of binder in RAP must be determined.
- As per 9.2.2 the **weight of RAP** required is determined.
- Then 9.2.3 has the formula for **determining the weight of the binder in the RAP**.
- The next step is to determine the **weight of new binder to add**, to result in the desired percent of binder for specimen. Found in 9.2.4.
- 9.3 covers mixing up samples using two or more RAP stockpiles.

Table 1: Size of specimen

Nominal Maximum Aggregate Size(mm)	Sieve Size	Specimen Weight RANGE
4.75	#4	1200 - 1300
9.5	3/8"	1200 - 1300
12.5	1/2"	1500 - 1600
19.0	3/4"	2000 - 2100
25.0	1 "	3000 – 3100*
37.5	1.5 "	4000 – 4100*

* Specimens shall be divided, each part tested, results averaged

Test Procedure

- All production samples must have a moisture correction determination
 - T110 or dry the HMA specimen to to constant weight at 105 ± 5 °C, [\[CP-43 at the specified binder compaction temperature for that mixture, as per Table 43-1 for a minimum of 3 hours\]](#)
- Preheat ignition oven per the manufacturer's directions



Test Specimens

- Weigh and record weight of sample baskets on external scale
- Load test specimens into baskets 1" from sides



Test Specimens

- Record total weight of basket and specimen
- Determine and record the test sample weight
- Enter the sample weight into the furnace computer



Test Procedure

- Zero the internal scale
- Open the chamber door and place the baskets into the furnace.



Test Procedure

- Close chamber door and verify that the total weight (basket and material) equals the external recorded weight **within ± 5 g**
- Differences greater than 5 g, or a failure of the scale to stabilize, indicates the baskets are contacting the furnace wall
- Initiate the test by pressing the start button
- This will lock the chamber door and start the combustion blower



- Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in weight is less than 0.01% for three consecutive minutes)
- Press the stop button to unlock the chamber door

Test Procedure

- Open the chamber door
- Remove the baskets and allow the test specimen to cool sufficiently until it can safely handled
 - If the **internal** scale is being used to determine the percent binder, remove the ticket and report the percent binder
 - If the correction factor was not entered into the furnace, apply the correction factor before reporting the percent binder

Test Procedure

- If the external scale is being used to determine the percent binder;
 - Weigh the basket assembly containing the residual aggregate and record the weight
- The amount of time elapsed between the removal from the furnace and weighing on the external scale should be the same for correction factors and plant produced material (± 5 minutes)

Test Procedure

- Determine the uncorrected asphalt binder content
- Determine the corrected asphalt binder content by applying the Correction Factor and subtracting any moisture content.

Calculations

$$P_{b(\text{corr})} = P_{b(\text{uncorr})} + C_F - P_w$$


Where:

$P_{b(\text{corr})}$ = Asphalt binder content of field produced specimens corrected for the aggregates and asphalt binder sources

$P_{b(\text{uncorr})}$ = Uncorrected asphalt binder, determined by the mass of the test specimen

C_F = Calibration factor, percent by weight of the HMA sample

P_w = Moisture content (percent water)



- Questions
???????



Determining P_b (% of binder) for RAP Calibration Samples

- Calculate the weight of binder in RAP, W_{br}

$$W_{br} = W_{sr} \times P_{br}$$

Where:

W_{sr} = weight of RAP in sample

P_{br} = percent of binder in RAP

Determining Target % of Binder in Mix for RAP Calibration

- Calculate the total weight of binder required,

$$W_b = \frac{P_b(W_s - W_{br})}{100 - P_b}$$

Where:
 P_b = target binder percent
 W_s = weight of aggregate
 W_{br} = weight of binder in RAP

Determining Target % of Binder in Mix for RAP Calibration

- Calculate actual weight of binder required to add to the mix to achieve the target P_b , W_{ba}

$$W_{ba} = W_b - W_{br}$$

Where:
 W_{ba} = actual weight of required binder
 W_b = total weight of required binder
 W_{br} = weight of binder in RAP

Determining Target % of Binder in Mix for RAP Calibration

- Determine the actual weight of the aggregate needed in the sample

$$W_{sa} = W_s - W_{br}$$

Where:

W_{sa} = actual weight of aggregate

W_s = total weight of aggregate

W_{br} = weight of binder in RAP

Determining Target % of Binder in Mix for RAP Calibration Samples

- Calculate the total weight of mixture, W_s , and the actual P_{ba} in the mix sample

$$W_s = W_{sa} + W_{ba} + W_{br}$$

Where:

W_s = total weight of mixture

W_{sa} = actual weight of aggregate needed

W_{br} = weight of binder in RAP

$$P_{ba} = 100 \times \frac{(W_{ba} + W_{br})}{W_s}$$

P_{ba} = actual target % binder in mix sample

W_{ba} = weight of binder to be added to agg & RAP specimen

Standard Method of Test for
Determining Moisture (Water) or
Volatile Distillates Content of
Asphalt Paving Mixtures
CP-43

Scope:

- This procedure covers two (2) methods for the quantitative determination of moisture in Asphalt paving mixtures
- The procedures are intended for the determination of moisture content or volatile fraction of the HMA, in Asphalt paving mixtures
- The methods are intended to apply to samples of Asphalt paving mixtures used in verification and quality control from the points of acceptance designated in the Schedule for the Minimum Materials Sampling, Testing and Inspection

Method A



- Apparatus;
 - Microwave oven - Having variable time and power controls
 - Pyrex dish (or other suitable dish) – capable of holding the entire test specimen being tested
 - Balance – Having sufficient capacity and sensitivity to 0.1g

Method A – Procedure for calibrating the microwave

- Determine the Variable Power setting
 - Set the variable power control to approximately 50% power
 - Place 550 +/-50 ml of water of tap water in a Pyrex container, record the temperature of the water (T1).
 - Set the microwave oven timer for five (5) minutes and heat 550 ml of water. Record the temperature (T2)
 - The difference between the temperature T1 and T2 should be $75^{\circ} \pm 10^{\circ}$ ($42^{\circ}\text{C} \pm 6^{\circ}$)
 - If the difference is too low (or high) increase (or decrease) the variable power setting and repeat the process



Method A – Microwave Procedure

- Place a specimen in a clean, glass, dry, tarred container and obtain the sample mass to the nearest 0.1g
- The sample weight should be
 - **550 +/- 50** g for Grading S and SX mixes
 - **2000** g for Grading SG mixes

Method A - Procedure

- Dry the specimen in the microwave oven using the variable power setting determined previously
- Continue to dry the test specimen until the mass of the specimen does not change after further heating cycles for a 5 minute period
- Care should be taken to avoid overheating the specimen ~ an indication of overheating is blue smoke

Calculations

- Determine the percent moisture to the nearest 0.01% as follows

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

Where A = Wet weight (mass) of test specimen

Where B = Dry weight (mass) of test specimen

Method B

- Drying Oven – Thermostatically controlled forced draft oven
- Specimen container – Capable of holding the entire test specimen being tested
 - Balance – Having sufficient capacity and sensitivity to 0.1g
 - Miscellaneous – Knives, spatulas, scoops, tools, etc., as required in applicable CP's and CP-L's

Method B Procedure (Oven)

- Place the specimen in a clean, dry, tarred container and weigh to the nearest 0.1g
- The sample weight should not be less than
 - 500 g for Grading S and SX mixes
 - 2000 g for Grading SG mixes
- Dry the specimen in the oven at the specified binder compaction temperature for that mixture (See table 43-1), for a minimum of 3 hours
- Remove the specimen and immediately weigh to the nearest 0.1g
- Place the specimen back into the oven to continue drying, checking the mass of the specimen every ½ hour, ±5 minutes.
- The specimen is considered dry when the loss in mass is less than or equal to 0.05%

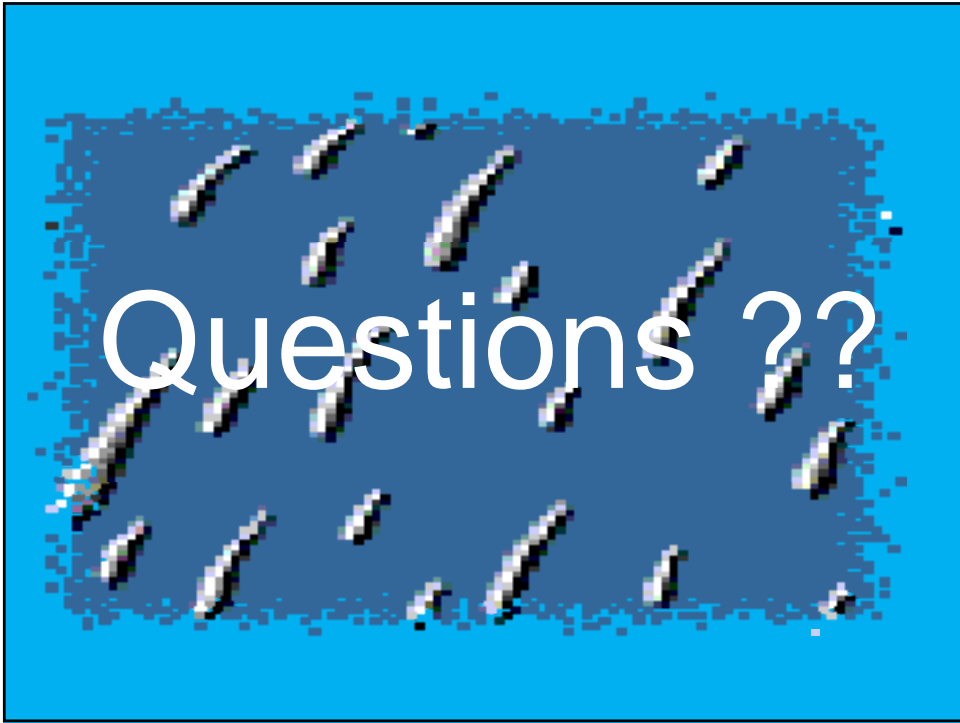
Calculations

- Determine the percent moisture to the nearest 0.01% as follows

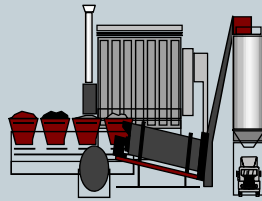
$$\text{Percent Moisture} = \frac{A - B}{A} \times 100$$

Where *A* = Wet weight (mass) of test specimen

Where *B* = Dry weight (mass) of test specimen



CONTROL CHART FABRICATION



Control Charts Assist With Analysis of Test Results

- Does the mix comply with specification limits?
 - Current results vs. previous results
 - Job Mix Formula, JMF (+ /-)
 - Single test vs. moving average

Benefits of Control Charts

- Early detection of trends
- Establish process capability
- Decrease inspection frequency
- Permanent record of quality
- Provide a basis for acceptance
- Instill quality awareness
- Taking corrective measures
- Evaluating data for cost savings
- Recording and reporting

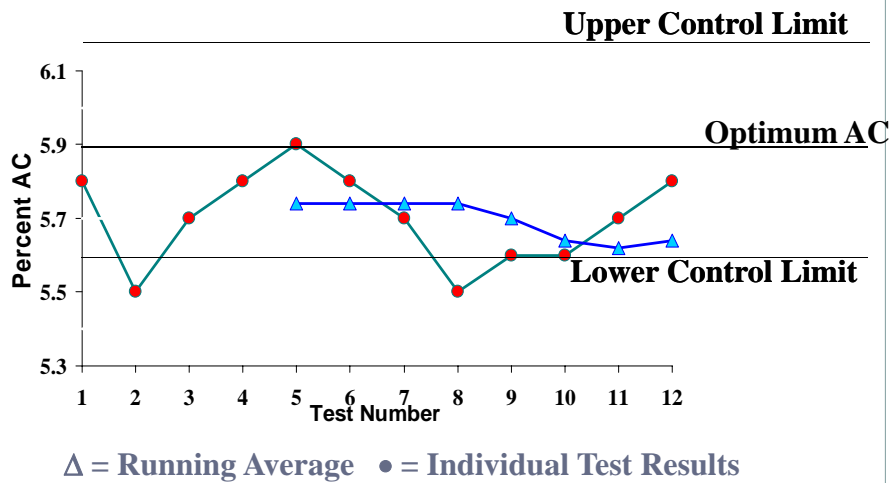
Control Charts

- What is plotted?
 - Each process control test result, tonnage, and tolerance limits
 - Density tests: For intermediate or final compaction to determine roller capabilities

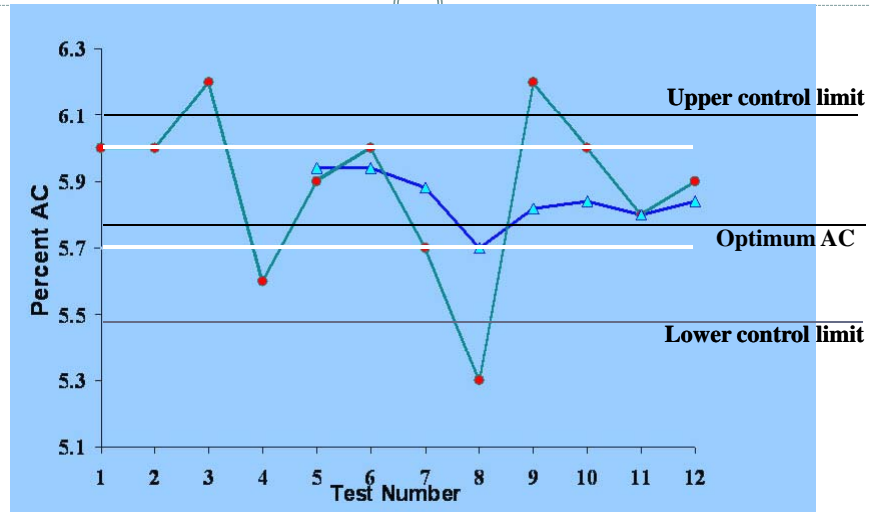
Step 1: Collect % Binder Data

<u>Test No.</u>	<u>Binder %</u>
1	5.8
2	5.5
3	5.7
4	5.8
5	5.9
6	5.8
7	5.7
8	5.5
9	5.6
10	5.6
11	5.7
12	5.8

Sample Test Result Chart



Sample Process Control Chart



Questions ??

