Washington State
Department of Transportation

WSDOT Test Method T 716

Method of Random Sampling for Locations of Testing and Sampling Sites

1. SCOPE

   a. This method outlines the procedure for selecting sampling and testing sites in accordance with accepted random sampling techniques. It is intended that all testing and sampling locations be selected in an unbiased manner based entirely on chance.

   b. Testing and sampling locations and procedures are as important as testing. For test results or measurements to be meaningful, it is necessary that the sampling locations be selected at random, typically by use of a table of random numbers. Other techniques yielding a system of randomly selected locations are also acceptable.

   c. This procedure is divided into several sections:
      - Applications for Hot Mixture Asphalt Density and Challenge Cores, Section 5
      - Applications for Hot Mixture Asphalt (HMA) Sampling, Section 6
      - Applications for Portland Cement Concrete, Section 7
      - Applications for Aggregate and other materials, Section 8

2. Straight Random Sampling vs. Stratified Random Sampling:

   Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within a distinct sublot. Both methods result in random distribution of samples to be tested for compliance with the agency's specification.

3. PROCEDURE

   a. Determine the lot, or sublot size and number of tests per LOT or sublot.

   b. Determine the "X" and/or "Y" random number by using values from the random number table.

   c. Multiply the lot or sublot size by the random number. This will give you the approximate test location within the lot or sublot to do the testing.

4. Stratified Random Sampling

   a. Following determination of the LOT length in Example 1, determine the length increment for individual sublots by dividing by the number of such desired sublots. In the case of Hot Mix Asphalt Pavement this would be five sublots.

   b. Determine random location factors "X" and/or "Y" values by random entry to the table.

c. To determine the location of test No. 1 in sublot No. 1 multiply the sublot increment by the selected "X" or "Y" factor from the Random Number table, then add this amount to the beginning location. Test locations within each of the subsequent sublots are determined by calculating the fractional location within the sublot interval then adding the increment of the preceding sublot.

d. For irregular lot or sublot sizes at the end of production, determine the location by dividing the final increment into 5 equal parts and define a test location within each.

5. APPLICATIONS FOR HOT MIX ASPHALT DENSITY AND CHALLENGE CORES (ENGLISH UNITS)

Note: For metric projects refer to Appendix A.

a. Determine the LOT size and number of tests per LOT. The Standard specifications set the size of a density test lot for Hot Mix Asphalt Pavement to no greater than a single day's production or 400 tons, whichever is less, and require five tests per LOT. At the end of a day's production the final lot may be increased to a maximum of 600 tons.

b. Convert this LOT size to an area segment of the roadway based on the roadway section and depth being constructed for the course being tested. The calculations in Example 1 show how this is performed. Table 1 has been provided to give you recommend lot lengths for standard lane widths at various depths. Lot length needs to be determined to the nearest 100 feet.

Example 1
Sample Computation for Lot Length

Using nominal compacted density of 2.05 tons/cy, and a 400 ton lot:

$$\text{Tons per linear foot} = \frac{(1.0\ (\text{foot}) \times \text{width (feet)} \times \text{depth(feet)}) \times 2.05\ \text{Tons/cy}}{27}$$

$$\text{Tons per linear Foot} = \frac{1.0\ \text{ft} \times 12\ \text{ft} \times 0.15\ \text{ft} \times 2.05\ \text{tons}}{27} = 0.137\ \text{Tons per linear Foot.}$$

$$\text{Lot length} = \frac{400\ \text{Tons}}{0.137\ \text{Tons per linear Foot}} = 2900\ \text{linear Feet}$$

Lane Width	Compacted Depth	Computed Lot Length	Recommended Lot Length
12 feet	0.12	3655	3700
	0.15	2924	2900
	0.20	2193	2200
	0.25	1754	1800
11 feet	0.12	3987	4000
	0.15	3189	3200
	0.20	2392	2400
	0.25	1913	1900

Hot Mix Asphalt Density Test Lot Length
400 Ton lot at 2.05 tons/cubic yard
Table 1

LOT length may also be determined based on Nominal Designated LOT sizes. To utilize this concept, compacted mix volumes equivalent to the designated mix quantity per LOT have been determined using the nominal compacted unit weight of Hot Mix asphalt. These volumes are then converted into Density LOT lengths using the typical lane width and specified compacted depth. The included tables present the values for LOT Lengths based on English units.

c. Determine the locations of the test (or sampling) sites by using values from the random number table (Table 2) to determine the coordinate location on the roadway. In the table, use the "X" values as decimal fractions of the total length of the lot; use the "Y" values as fractions of the width, customarily measured from the right edge of the pavement. The values in the table have been set so that no measurements are taken within 1.5 LF (0.45 m) of the edge of the pavement. Whenever a test location is determined to fall within such an area (i.e., bridge end, track crossing, or night joint) the test location should be moved ahead or back on stationing, as appropriate, by 25 LF (8 m).

Y values are selected so that lateral locations are no closer than 1.5 feet (0.45m) from the edge of a paving strip.

Sequence	X	Y	Sequence	X	Y	Sequence	X	Y	Sequence	X	Y
1	0.290	0.33	26	0.657	0.69	51	0.762	0.65	76	0.434	0.43
2	0.119	0.43	27	0.761	0.27	52	0.285	0.28	77	0.832	0.71
3	0.694	0.32	28	0.389	0.69	53	0.347	0.87	78	0.044	0.73
4	0.722	0.47	29	0.751	0.20	54	0.962	0.75	79	0.235	0.28
5	0.784	0.39	30	0.191	0.77	55	0.203	0.60	80	0.271	0.62
6	0.953	0.15	31	0.006	0.50	56	0.803	0.35	81	0.477	0.85
7	0.576	0.14	32	0.456	0.23	57	0.672	0.17	82	0.267	0.44
8	0.069	0.74	33	0.367	0.85	58	0.306	0.20	83	0.933	0.28
9	0.691	0.86	34	0.025	0.73	59	0.223	0.83	84	0.974	0.87
10	0.973	0.44	35	0.299	0.33	60	0.116	0.58	85	0.600	0.46
11	0.328	0.5	36	0.194	0.25	61	0.768	0.32	86	0.591	0.19
12	0.468	0.78	37	0.936	0.37	62	0.893	0.37	87	0.165	0.77
13	0.183	0.44	38	0.231	0.71	63	0.504	0.66	88	0.668	0.41
14	0.669	0.36	39	0.050	0.74	64	0.043	0.31	89	0.327	0.29
15	0.971	0.71	40	0.584	0.43	65	0.284	0.39	90	0.473	0.51
16	0.336	0.37	41	0.172	0.87	66	0.196	0.15	91	0.598	0.58
17	0.314	0.78	42	0.430	0.87	67	0.742	0.66	92	0.373	0.69
18	0.508	0.44	43	0.704	0.19	68	0.941	0.43	93	0.244	0.24
19	0.347	0.20	44	0.009	0.18	69	0.531	0.31	94	0.831	0.14
20	0.877	0.85	45	0.552	0.17	70	0.478	0.56	95	0.178	0.45
21	0.712	0.17	46	0.626	0.29	71	0.228	0.37	96	0.821	0.46
22	0.193	0.17	47	0.144	0.62	72	0.008	0.48	97	0.124	0.62
23	0.976	0.69	48	0.246	0.13	73	0.002	0.17	98	0.580	0.57
24	0.997	0.63	49	0.055	0.40	74	0.330	0.42	99	0.037	0.24
25	0.930	0.44	50	0.678	0.66	75	0.089	0.20	100	0.700	0.59

Random Numbers with X and Y values
Table 2

d. In order to determine which "X" and "Y" values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits from the most recent standard count on the nuclear density gage. Subsequent "X" and "Y" values are then taken from the lines that follow. Based on the specified sampling frequency, 20 lots can be accommodated by one cycle through the table. Start each shift with a set of values determined by chance in order to obtain random selection.

e. Example 2 shows the calculations for determining the testing location for asphalt pavement density. No Figure 1

Example 2

Test Location Within the LOT for Hot Mix Asphalt Density

For the lot: (12 ft. wide, 0.15 ft. deep, starting at station 168 + 75 with paving progressing ahead on station), Lot length was previously determined as 2,900 LF. Using the last two digits of the standard count, as in the example, 2951, assume "X" and "Y" values from line (51) in table 2: X = 0.762, Y = 0.65.

For the first test:

Beginning station: 168 + 75
Sublot length increment: 580 × 0.762 = 442
Width offset: 12 × 0.65 = 7.8 ft. (from right edge)
Location is: station: (168+75) + 442 = 173 + 17, 7.8 ft. from right edge

For the Second test:

Beginning station: (168 + 75) + (580) = 174 + 55
Sublot length increment: 580 × 0.285 = 165
Width offset: 12 × 0.28 = 3.4 ft. (from right edge)
Location is: station: (174 + 55) + 165 = (176 + 20), 3.4 ft. from right edge

For the Third test:

Beginning station: (168 + 75) + 580 + 580 = 180 + 35
Sublot length increment: 580 × 0.347 = 201
Width offset: 12 × 0.87 = 10.4 ft. (from right edge)
Location is: station: (180 + 35) + 201 = (182 + 36), 10.4 ft. from right edge

6. APPLICATIONS FOR HOT MIX ASPHALT (HMA) PAVEMENT MIXTURE

a. Determine the sublot size. The Standard Specifications define a lot as the total quantity of material or work produced for each job mix formula (JMF). The sublot size for HMA gradation, binder content, and/or volumetrics is a maximum of 800 tons, and shall be determined to the nearest 100 tons. At the end of production, the final sublot may be increased to a maximum of 2 times the sublot quantity calculated. Sampling of binder shall be every other mixture sample.

b. Determine the locations of the test (or sampling) sites as defined in Section 3 using random numbers from table 3, or from another Random Number Generator. Do not sample from the first or last 25 tons. Once the two-digit number is selected the corresponding four-digit number becomes the factor for determining the selection of the next sample. Random sample tonnage may be adjusted per sublot to accomodate field testing. Adjustments to random sample tonnage should be documented.

X	X	X	X	X
(1) 0.186	(21) 0.256	(41) 0.201	(61) 0.508	(81) 0.431
(2) 0.584	(22) 0.753	(42) 0.699	(62) 0.884	(82) 0.509
(3) 0.965	(23) 0.108	(43) 0.785	(63) 0.648	(83) 0.962
(4) 0.044	(24) 0.626	(44) 0.874	(64) 0.398	(84) 0.315
(5) 0.840	(25) 0.885	(45) 0.604	(65) 0.142	(85) 0.721
(6) 0.381	(26) 0.418	(46) 0.087	(66) 0.962	(86) 0.637
(7) 0.756	(27) 0.320	(47) 0.334	(67) 0.516	(87) 0.056
(8) 0.586	(28) 0.098	(48) 0.189	(68) 0.615	(88) 0.905
(9) 0.480	(29) 0.791	(49) 0.777	(69) 0.226	(89) 0.195
(10) 0.101	(30) 0.717	(50) 0.704	(70) 0.881	(90) 0.981
(11) 0.282	(31) 0.868	(51) 0.946	(71) 0.369	(91) 0.600
(12) 0.957	(32) 0.583	(52) 0.426	(72) 0.001	(92) 0.044
(13) 0.377	(33) 0.385	(53) 0.266	(73) 0.744	(93) 0.433
(14) 0.456	(34) 0.465	(54) 0.791	(74) 0.229	(94) 0.762
(15) 0.778	(35) 0.101	(55) 0.711	(75) 0.906	(95) 0.678
(16) 0.243	(36) 0.285	(56) 0.122	(76) 0.413	(96) 0.347
(17) 0.578	(37) 0.829	(57) 0.895	(77) 0.827	(97) 0.274
(18) 0.966	(38) 0.998	(58) 0.371	(78) 0.984	(98) 0.114
(19) 0.373	(39) 0.539	(59) 0.221	(79) 0.641	(99) 0.480
(20) 0.834	(40) 0.060	(60) 0.011	(80) 0.068	(100) 0.685

Random Numbers
Table 3

c. In order to determine which random values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits of the ignition furnace calibration.

d. Example 3 shows the calculations for determining the testing location for HMA WSDOT Form DOT 350-160 will calculate the testing location for you.

Example 3
Test Location for a Sublot of HMA

The Ignition Furnace calibration is 0.45%. Use 45 as the starting point to enter the random number table 3. The starting random number is 0.604.

For the First test point:

Beginning tonnage: 0
Sublot increment: 800 × 0.604 = 483
Testing tonnage is at: 483 tons

For the Second test point:

Beginning tonnage: 800
Sublot increment: 800 × 0.087 = 70
Testing tonnage is at: 800 + 70 = 870 tons

For the Third test point:

Beginning Tonnage: 800 + 800 = 1600
Sublot increment: 800 × 0.334 = 267
Testing tonnage is at: 1600 + 267 = 1867 tons

For the Fourth test point:

Beginning Tonnage: 1600 + 800 = 2400
Sublot increment: 800 × 0.189 = 151
Testing tonnage is at: 2400 + 151 = 2551 tons

7. APPLICATIONS FOR PORTLAND CEMENT CONCRETE

a. Determine the sublot size. The Standard Specifications states after two successive tests indicate that the concrete is within specified limits; the sampling and testing frequency may decrease to one for every five truck load. Concrete samples other than initial load samples or samples for questioned acceptance will be taken from each sublot by a random selection. Random selection will be accomplished by using the random number table 3. For each day of concrete delivery and placement a new random number will be selected and the process repeated.

b. Determine the locations of the test (or sampling) sites as defined in Section 3 using random numbers from table 3, or from another Random Number Generator. Do not sample concrete from the first ½ cubic yard of the truck.

c. In order to determine which random values should be used, enter the table on a line chosen by chance. As a suggestion, select a line corresponding to the last two numbers on the first civilian license plate you see or other acceptable random means. Subsequent "X" values for following sublots on the same day are taken from the lines, which follow. Start each day with an "X" value determined by chance in order to obtain a random selection.

d. Example 4 shows the calculations for determining the testing location for Portland Cement Concrete.

Example 4
Test Location for a Sublot of Portland Cement Concrete

For this example the random number selected is "37." Enter the random number table 3 at (37) and the corresponding four-digit number is 0.829, this is the factor.

Based on the delivery of 10 cubic yard loads to the project. This would be adjusted by the quantity of concrete actually being delivered per load.

Next five trucks loads => 10 CY x 5 = 50 CY

50 CY x 0.829 = 41 CY to be sampled

20 CY (first two trucks) + 41 CY = sample at the 61 CY point

Therefore, the sample will be taken from the truck containing the 61st CY. (This would be samples from the first ⅓ of the truck) After approximately ½ CY of concrete has been discharged the sample should be taken. This is actually the seventh truckload delivered to the project this day as the first two truckloads were sampled before the random selection process started.

The next sample would be taken at random number "38." Enter the random number table 3 at (39) and the corresponding four-digit number is 0.998, this is the factor.

Based on the delivery of 10 cubic yard loads to the project. This would be adjusted by the quantity of concrete actually being delivered per load.

Next five trucks loads => 10 CY x 5 = 50 CY

50 CY x 0.998 = 50 CY to be sampled

20 CY (first two trucks) 50 CY (from first random test) + 50 CY = sample at the 120 CY point . (This would be samples from the last ⅓ of the truck)

The next sample would be taken at random number "39." Enter the random number table 3 at (38) and the corresponding four-digit number is 0.539, this is the factor.

Based on the delivery of 10 cubic yard loads to the project. This would be adjusted by the quantity of concrete actually being delivered per load.

Next five trucks loads => 10 CY x 5 = 50 CY

50 CY x 0.539 = 27 CY to be sampled

20 CY (first two trucks) 50 CY (from first random test) + (50 CY from second random test)

+ 27 CY = sample at the 147 CY point. (This would be samples from the middle to last ⅓ of the truck)

8. APPLICATIONS FOR AGGREGATE AND OTHER MATERIALS

   a. Determine the lot or sublot size according to the contract documents. The lot or sublot shall be determined to the nearest 100 tons.

   b. Determine the locations of the test (or sampling) sites as defined in Section 3 using random numbers from table 3, or from another Random Number Generator.

   c. In order to determine which random values should be used, enter the table on a line chosen by chance. The first two or last two digits of the next automobile license plate you see is one way to select the entry point. Another way is to start a digital stopwatch and stop it several seconds later, using the decimal part of the seconds as your entry point.

      Sampling from a Belt or Flowing Stream: Example: The specification calls for one sample from every 1000 Tons of aggregate. If the random number is 0.371, the sample would be taken at (0.371) (1000 Tons) = 371 Tons.

      Sampling from Haul Units: Example: The specification calls for the samples to be based on a number of haul units. Determine the number of hauling units that comprise a lot. Multiply the selected random number(s) by the number of units to determine which unit(s) will be sampled.

      If 20 haul units comprise a lot and one sample is needed, using the random number 0.773, the sample would be taken from the (0.773) (20) = 15.46, or 15th haul unit.

Sampling from a Roadway with Previously Placed Material: Example: The specification calls for a sample from a location on a job. The process as defined in Section 5, Applications for Asphalt Paving Density should be used where a X and Y measurement is needed to determine the testing location.

Appendix A

APPLICATIONS FOR HOT MIX ASPHALT DENSITY AND CHALLENGE CORES

a. Determine the LOT size and number of tests per LOT. The Standard specifications set the size of a density test lot for Asphalt Pavement to no greater than a single day's production or approximately 400 tonne, whichever is less, and require five tests per LOT. At the end of a days production and the final lot is greater than 400 tonne, it should be broken up into two lots.b. Convert this LOT size to an area segment of the roadway based on the roadway section and depth being constructed for the course being tested. The calculations in Example 1 show how this is performed. Table 1 has been provided to give you recommend lot lengths for standard lane widths at various depths. Lot length needs to be determined to the nearest 30 meters.

Example 1
Sample Computation for Lot Length (Metric Units)

Using nominal compacted density of 2 439 kg/m3, compacted depth of 40 mm and paving width of 3.6 m:

Lot Length:

400 tonnes equate to 400 000 kg

Cross-section pavement area: 3.6 m wide, 0.040 m (40 mm) deep = 0.144 m2

Unit weight per meter length = 0.144 m^2 × 2439 kg/m^3 = 351.2 kg/m

Length = 400 000 kg/351.2 kg/m = 1138.9 m round to 1140 m

Sublot length = 1140 m × 0.2 = 228 mthe paving involved.

Lane Width	Compacted Depth	Computed Lot Length	Recommended Lot Length
3.6 meters	40 mm	1139	1140
	45 mm	1012	1010
	60 mm	759	760
	75 mm	607	610
3.3 meters	40 mm	1242	1240
	45 mm	1104	1100
	60 mm	828	830
	75 mm	663	660

Hot Mix Asphalt Density Test Lot Sizes
Metric Units 400 tonne lot at 2 439 kg/m^3 = 164 m^3
Table 1

LOT length may also be determined based on Nominal Designated LOT sizes. To utilize this concept, compacted mix volumes equivalent to the designated mix quantity per LOT have been determined using the nominal compacted unit weight of Hot Mix Asphalt pavement. These volumes are then converted into Density LOT lengths using the typical lane width and specified compacted depth. The included tables present the values for LOT Lengths based on English units.

c. Determine the locations of the test (or sampling) sites by using values from the random number table (Table 2) to determine the coordinate location on the roadway. In the table, use the "X" values as decimal fractions of the total length of the lot; use the "Y" values as fractions of the width, customarily measured from the right edge of the pavement. The values in the table have been set so that no measurements are taken within 1.5 LF (0.45 m) of the edge of the pavement. Whenever a test location is determined to fall within such an area (i.e., bridge end, track crossing, or night joint) the test location should be moved ahead or back on stationing, as appropriate, by 25 LF (8 m).

d. In order to determine which "X" and "Y" values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits from the most recent standard count on the nuclear density gage. Subsequent "X" and "Y" values are then taken from the lines that follow. Based on the specified sampling frequency, 20 lots can be accommodated by one cycle through the table. Start each shift with a set of values determined by chance in order to obtain random selection.

e. Example 2 shows the calculations for determining the testing location for asphalt pavement density. No Figure 1

Example 2

Test Location Within the LOT for Hot Mix Asphalt Pavement Density (Metric Units)

For the lot defined above (3.6 m wide, 1140 m long) starting at station 10 000.00 m

Using the last two digits of the standard count. Determine the "X" and "Y" values from line (51) in the table: X = 0.762, Y = 0.65 (these are illustrative examples only. Table format and generation have been randomized so that each replication of the table will vary).

Beginning station: 10 000.00
Sublot length increment: 228 × 0.762 = 173.7 m
Width offset: 3.6 × 0.65 = 2.3 m (from right edge)
Location is station: 10 000 + 173.7 = 10 173.7, 2.2 m from right edge