PFP and QCP Random Density Procedure
Appendix E.3

Effective: April 1, 2009
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Density tests using cores shall be obtained at the frequency specified in the Hot Mix Asphalt Quality Control for Performance (QCP) and Pay for Performance (PFP) Using Percent within Limits special provisions. The random test locations shall be determined as follows:

A) The random core locations shall be taken at the randomly selected test location within each density testing interval. Prior to paving, the random test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's approved software program. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Disclosing the information prior to finish rolling would be in direct violation of federal regulations. Once random test locations are determined by the Engineer, it may be necessary to alter the random test locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations and provide documentation to the Contractor upon completion of the project.

Each core location shall be randomly located both longitudinally and transversely within each density testing interval. Each core location within the density testing interval shall be determined with two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1.0 ft into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft from the left edge of the **paving lane**. In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges or cold joints between lanes, the **paving lane** is defined as the total combined width of the lanes paved in that single pass. If the **paving lane** width is greater than 20 ft, the density intervals shall be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in (75 mm).

Longitudinal Location: To determine the longitudinal location of a core, multiply the length of the prescribed density interval by the random number selected from the Random Number table.

Transverse Offset: Determine the random transverse offset as follows:

1. PFP. The effective lane width of the paving lane shall be used in calculating the transverse offset. The effective lane width is determined by subtracting 1.0 ft for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft.) The effective lane width is reduced by 1.0 ft for each confined longitudinal joint with longitudinal joint sealant (LJS) (i.e. If a 12.0 ft wide paved lane has one unconfined edge without LJS and one confined edge with LJS, the effective lane width would be 10.0 ft). Determine the transverse offset by multiplying the effective width by the random number selected from the Random Number table.

The transverse offset is measured from the left physical edge of the paved lane to locate the core on the pavement. If the left edge is unconfined or located immediately above LJS, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement.

Random locations that fall within 4.0 inches of a confined edge shall be moved to 4.0 inches off the edge. Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. three-ft wide left shoulders, driveways, etc.) are not considered part of the paved mainline mat. See PFP example calculation herein.

The core density location for the outer 1.0 ft of an unconfined edge without LJS will be randomly selected within each 0.5 mile section for each unconfined edge. Longitudinal joint testing shall be located at a distance equal to 4.0 in. (100 mm), from each pavement edge.

2. QCP. The entire width of the paving lane shall be used in calculating the transverse offset in all cases except those with LJS applied at the longitudinal joint. If LJS is applied, the effective lane width is reduced 1.0 ft for each longitudinal joint with LJS. If the left edge is located immediately above LJS, it will be omitted by adding 1.0 ft to the calculated transverse offset measurement. No offset movement is to be used for random locations that lie within 1.0 ft from an unconfined edge without LJS. Cores taken within 1.0 ft from an unconfined edge without LJS will have 2.0% density added for pay adjustment calculation purposes. Random locations that fall within 4.0 in. of an edge shall be moved to 4.0 in. off the edge. See QCP example calculation herein.

B) This process shall be repeated for all density intervals on a given project.

C) Moving Core Locations.

There are two scenarios in which random core locations may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed under Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

1) Case 1. In the event the random core location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the core in order to avoid the obstacle. Using the same random transverse offset, the core location will be moved longitudinally, ± 15 feet to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random core location lands at the same longitudinal location as the temporary mark, the core will be moved 5 feet in the direction toward the paver at the same transverse offset. In the case of an asphalt scab (i.e. thin layer of less than 0.5 inches of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The core location will then be moved to a longitudinal distance 5 feet past the end of the defect toward the paver.

D) Example Calculations.

PFP Example.

This **PFP** example illustrates the determination of the core locations within the first mile of a lot.

Given 1.5 in. thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined without LJS and the right edge unconfined with LJS. The random numbers for the longitudinal direction are 0.917, 0.289, 0.654, 0.347, and 0.777. The random numbers for the transverse direction are 0.890, 0.317, 0.428, 0.998, and 0.003.

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft, for each unconfined edge, from the entire paved lane width. In this case only the right edge is unconfined, so subtract 1.0 ft from the entire paved lane width of 13.0 ft.

Effective Width = 13.0 ft minus 1.0 ft = 12.0 ft

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The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the near edge of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	12.0 x 0.890 = 10.7 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	12.0 x 0.317 = 3.8 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	12.0 x 0.428 = 5.1 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	12.0 x 0.975 = 11.7 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	12.0 x 0.003 = 0.0 ft = **0.3 ft**[1/]

1/ The 0.0 ft for Core #5 was moved in to 0.3 ft due to the 4 in. minimum from the edge requirement.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given 1.5" thickness would require a density testing interval of 0.2 miles. The pavement consists of a 13.0 ft-wide mat with the left edge confined with LJS and the right edge unconfined without LJS. The random numbers for the longitudinal direction are 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are 0.007, 0.059, 0.996, 0.515, and 0.101.

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the width of the paved lane minus 1.0 ft for the left edge confined with LJS (12.0 ft).

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The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the near edge of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Transverse Location
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(12.0 x 0.007) + 1.0 = 1.1 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(12.0 x 0.059) + 1.0 = 1.7 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(12.0 x 0.996) + 1.0 = 13.0 ft = **12.7 ft**[1/]
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(12.0 x 0.515) + 1.0 = 7.2 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(12.0 x 0.101) + 1.0 = 2.2 ft

1/ The 13.0 ft offset for Core #3 was move in to 12.7 ft due the 4 in. minimum from the edge requirement. Since this core is within 1 ft from an unconfined edge 2% will be added to the measured core density.

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.