Review of Oregon Department of Transportation Asphalt Mixture Density Requirements and Associated Pay Factors

Performed by David Newcomb and Jon Epps, TTI
Stat Spec

• Statistical specifications are used to help us evaluate the acceptance of materials and processes that vary.
• They allow us to account for variance not related to the Contractors materials and processes.
• PWL is defined as the percentage of tests in a lot falling above the lower specification limit and beneath the upper specification limit.
PWL Specs

- Percent within limits specs allow a given percent of test results to fall below the lower spec limit.
- For density (one sided) 95% within limits assumes up to 5% will be below the minimum.
- Mean and Standard deviation along with the number of test results are used to determine PWL.
For Whole Distribution

If this distribution is right, then 5% of the time the test results will show density below 92%.
Why accept material below the spec limit?

- We use PWL to fairly account for variability outside the contractors control.
- Up to 50% of the variance is often associated with sampling and testing.
- Using Mikes data for variance of T209 and the Nuclear gauge in combination can yield +/- 0.5% compaction for just 1 standard deviation, at 2s you get +/- 1.1%.
Variability

• So for a single operator, one gauge, combined with a single tester performing a rice gravity

• A “true mean” density of 92% can have a 2s variation of 90.9% to 93.1% just owing to testing variability
For Density

- A test result is the average of 5 random individual tests taken in the sublot.
- So for 95% within limits 5 out of 100 sublots would be expected to be below the lower spec limit.
- A test result below the lower spec limit is not (necessarily) non-specification.
Why?

- 5 random tests are inadequate to define the true mean and the true standard deviation.
- The 5 random tests are not intended to define the true mean of the sublot.
- Their purpose is to provide 1 “test result” needed to estimate the true mean and standard deviation of the lot.
PWL Specs

- Typical standard deviations for asphalt compaction based on individual test results are around 1.5%,
- For an average of 5 tests per subplot this equates to about 0.68%
- 95% within limits for density will have on average of 5 sublots below 92% out of 100 and will receive a pay factor of 1.03 with a mean of 93.1% and $s = 0.68\%$
Does Sublot Belong to Lot?

Separating this sublot out would not be appropriate if it is statistically part of the lot population.

Frequency

Maybe.

Lot

Sublot

91.8 93.1

Density
Required mean for 100 PWL and $s = 0.68$

<table>
<thead>
<tr>
<th>Number of Sublots (n)</th>
<th>Quality Level</th>
<th>mean density for 100% within limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.79</td>
<td>93.2</td>
</tr>
<tr>
<td>10</td>
<td>2.65</td>
<td>93.8</td>
</tr>
<tr>
<td>20</td>
<td>3.2</td>
<td>94.3</td>
</tr>
<tr>
<td>50</td>
<td>3.54</td>
<td>94.4</td>
</tr>
<tr>
<td>100</td>
<td>3.7</td>
<td>94.5</td>
</tr>
</tbody>
</table>
The Problem

• Current spec defines any sublot with mean density <92\% as non-spec
• PM can choose to separate this sublot out for analysis
• Stat spec is not designed or capable of determining pay for this situation and can only give pay factors < 0.75 (remove and replace)
• There is currently no rational approach to evaluating sublots near or below lower limit
The Problem

- Sublots can (and should) be separated out when they are found not representative of the whole lot.
- Being above or below the lower limit is not by itself adequate means to make that determination.
So....

• The current spec as written is in direct conflict with the design and intent of stat spec
• Sublots should only be separated if they are not representative of the entire lot population
• That determination normally needs to be made by statistical analysis
Solution

- Contract with outside “expert” consultant to develop rational approach to identifying and evaluating sublots that statistically do not “fit” the Lot population
- TTI, nationally recognized experts in Jon Epps and Dave Newcomb, Knowledge of National trends and methods
Does Sublot Belong to Lot?

Frequency

Probably Not

Sublot

Lot

β

Density