NDT Technology For Quality Assurance Of HMA Pavement Construction

81

Unbound Materials	HMA Mixtures
1. Develop M-D relationships in the laboratory prior to construction for the unbound material to determine the maximum dry unit weight. Select the target density and water content for compacting the unbound layer.	1. Conduct an HMA mixture design to determine the target gradation and asphalt content. Select the target density and job mix formula for the project mixture or lift being tested. The target job mix formula will likely be revised based on plant produced and placed material.
2. Prepare and compact test specimens at the average water content and dry density expected during construction; based on the project specifications.	2. Prepare and compact test specimens at the target asphalt content and the average density expected during construction; based on the project specifications.
3. Measure the repeated load resilient modulus in accordance with the agency's procedure (AASHTO T307 or NCHRP 1-28A, as required by the MEPDG). Determine the resilient modulus at a selected stress state. The resilient modulus should equal or exceed the value used during design. If the agency does not have a resilient modulus testing capability, the FHWA-LTPP regression equations can be used to estimate the target value, until the laboratory resilient modulus test has been completed (see Equations 1 through 15).	3. Measure the dynamic modulus in accordance with the agency's procedure or the test protocol in accordance with the MEPDG. Determine the dynamic modulus for the test temperature expected during acceptance testing. Two values should be extracted from the test results or master curve; one for the day of paving (an elevated temperature expected after compaction) and the other for one or multiple days following placement. This target value for one or more days following placement will need to be adjusted back to a standard temperature depending on the actual pavement temperature.
4. Define the adjustment factor or ratio for the unbound material to laboratory conditions. Low stress states were used in establishing the ratios for this project.	4. Define the adjustment factor for the HMA mixtures to laboratory conditions. A load frequency of 5 Hz was used in establishing the adjustment ratios for this project.
5. Determine the combined or pooled standard deviation of the modulus for setting up the control limits of the unbound layer for the contractor (see Section 3.3). Establish the action, as well as warning, limits for the statistical control charts; upper and lower control limits (see Section 3.2).	5. Determine the combined or pooled standard deviation of the seismic modulus for setting up the control limits of the HMA mixture for the contractor (see Section 3.3). Establish the action, as well as warning limits for the statistical control charts; upper and lower control limits (see Section 3.2).
6. Determine the upper and lower specification limits (see Section 3.3) for the resilient modulus of the unbound material. This includes the upper and lower specification limits for the resilient modulus of the unbound layer.	6. Determine the upper and lower specification limits (see Section 3.3) for the dynamic modulus of the HMA mixture. This includes the upper and lower specification limits for the dynamic modulus of the HMA mixture.
7. Prepare the statistical control charts.	7. Prepare the statistical control charts.
8. Determine the PWL criteria for different conditions.	8. Determine the PWL criteria for different conditions.

The target value of the control chart for each material is the average value measured in the laboratory in accordance with AASHTO T 307 or the test protocol used by the agency. Both action and warning limits are normally included on the statistical control charts. The upper and lower action limits are set at three standard deviations from the target value, while the warning limits are set at two standard deviations from the target.

3.2.1 Target Modulus or Critical Value

The target value of the control chart for each material and project is the modulus measured in the laboratory. This average laboratory value should be the same as the input to the MEPDG for structural design. Tables 35 and 36 list the target values for the unbound and HMA layers included in the field evaluation projects, respectively.

3.2.2 Combined or Pooled Standard Deviation

The pooled standard deviation was calculated in accordance with the AASHTO R9-03, *Standard Recommended Practice for Acceptance Sampling Plans for Highway Construction.* The pooled standard deviation was determined for each project and unbound material using the NDT results for the areas without anomalies or physical differences. The pooled standard deviations for each project and material are listed in Tables 35 and 36 for the unbound and HMA layers, respectively. These values were used to determine whether the projects were in-control or out-of-control, using the action limits: upper control limits (UCL) and lower control limits (LCL) provided in Tables 35 and 36.

3.3 Parameters for Determining PWL

3.3.1 Determining Quality Indices

The upper and lower quality indices are calculated in accordance with Equations 18 and 19, respectively. The upper and lower specification limits were determined using data from all projects with similar materials.

$$Q_L = \frac{\overline{X} - LSL}{s} \quad (18)$$

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