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CHAPTER ONE:

INTRODUCTION

Quality Control/Quality Assurance (QC/QA) is often used synonymously with the term Quality Assurance (QA). AASHTO defines Quality Assurance as "All those planned and systematic actions necessary to provide confidence that a product will perform satisfactorily in service." This definition considers QA to be an all encompassing concept which includes quality control (QC), acceptance, and independent assurance (IA).

A better understanding of the QC/QA concept may be made if the characteristics of the specifications are considered. These include:

1. QC/QA recognizes the variation in materials and test methods.
2. QC/QA uses a statistical basis that is applied and modified with experience and sound engineering judgement.
3. QC/QA places the primary responsibility on the Contractor for production control.
4. QC/QA makes a clear delineation between process control and acceptance testing.

The advantages of this type of specification include the proper allocation of responsibility for quality between the Contractor and INDOT, more complete records, and statistically based acceptance decisions. The Contractor has a greater choice of materials and may design the most economical mixtures to meet specifications. Finally, acceptance test results are provided upon completion of the tests during the contract so that the Contractor knows if the operations are producing a quality product.

SAFETY

Safety is the business of everyone on the job. The Technician may be working with hazardous materials and should be alert to proper precautions. This involves having the proper protective equipment and ventilation system in the working place. Knowledge of the proper use of hazardous materials is essential to a safe working environment.

TERMINOLOGY

Asphalt mixture has been called surprisingly by many different names. Hot Mix Asphalt (HMA), bituminous paving mix(ture), bituminous concrete, bituminous mix(ture), asphalt paving mix(ture), , asphaltic concrete or plain "asphalt" are just a few of the synonyms used for this material. The term "asphalt mixture" is used to help standardize the wording and minimize confusion. When the Standard Specifications are referenced in the manual, QC/QA HMA will be used for mixtures in accordance with Section **401**, HMA will be used for mixtures in accordance with Section **402**, and SMA (Stone Matrix Asphalt) will be used for mixtures in accordance with Section **410**.

Asphalt materials include Performance Graded (PG) Asphalt Binders, Asphalt Emulsions, Cutback Asphalt, Utility Asphalt, and Asphalt used for coating corrugated metal pipe. HMA used for Quality Assurance requires PG binders to be used for the asphalt material. The term "binder" is used when referring to this material.

Additional terms related to asphalt mixture include the following:

AASHTO - American Association of State Highway and Transportation Officials

Absorption - The increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass

Actual Binder Content - The binder content determined in accordance with ITM 586 or the total of the binder content determined in accordance with ITM 571 and the binder absorption percent from the DMF

Aggregate Base - A layer of aggregate placed on a subgrade or subbase to support a surface course

Air-Cooled Blast Furnace Slag (ACBF) - Material resulting from solidification of molten blast-furnace slag under atmospheric conditions

Apparent Specific Gravity - The ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Air Voids – Internal spaces in a compacted mix surrounded by asphalt-coated particles, expressed as a percentage by volume of the total compacted mix

Artificial Aggregates - Aggregates that are manufactured or by-products of an industrial process. Blast furnace slag, steel slag and wet bottom boiler slag are examples of by-product artificial aggregates.

Asphalt Emulsion – An emulsion of asphalt and water that contains a small amount of an emulsifying agent. Emulsified asphalt droplets may be either anionic (negative charge), cationic (positive charge), or nonionic (neutral).

ASTM - American Society for Testing and Materials

Base Course – The layer in the pavement system immediately below the binder and surface courses. The base course consists of crushed aggregate or other stabilized material.

Binder – Asphalt that is classified according to the Standard specifications for Performance Graded Asphalt Binder, AASHTO Designation MP1. The binder may be either unmodified or modified asphalt.

Bulk Specific Gravity - The ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight of an equal volume of gas-free distilled water at a stated temperature

Bulk Specific Gravity (SSD) - The ratio of the mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for approximately 15 hours (but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Certified Material - An aggregate product produced in accordance with the Certified Aggregate Producer Program (CAPP) for Department use

Certified Aggregate Producer - A Plant/Redistribution Terminal that meets the requirements of ITM 211, continues to be under the same ownership, and is approved by the Department

Certified HMA Producer - An asphalt mixture plant that meets the requirements of ITM 583, continues to be under the same ownership, and is approved by the Department

Coarse Aggregate - Aggregate that has a minimum of 20 percent retained on the No. 4 (4.75 mm) sieve

Decantation - A test utilizing water to determine the amount of material that is passing the No. 200 sieve. The decantation test is conducted on both fine and coarse aggregate and is usually done in conjunction with the sieve analysis test.

Deleterious - Undesirable aggregate material

Density - The weight per unit volume of a substance

Dolomite - Carbonate rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205

Equivalent Single Axle Load (ESAL) – The effect on pavement performance of any combination of axle loads of varying magnitude equated to the number of 80-kN (18,000-lb.) single-axle loads that are required to produce an equivalent effect.

Fine Aggregate - Aggregate that is 100 percent passing the 3/8 in. (9.5 mm) sieve and a minimum of 80 percent passing the No. 4 (4.75 mm) sieve

Granulated Blast Furnace Slag (GBF) - Glassy, granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water

Independent Assurance – Independent Assurance testing is conducted by District Testing personnel to verify the reliability of the results obtained in acceptance sampling and testing. Certified Asphalt Technicians are checked annually by Independent Assurance Technicians for the sampling and testing procedures that are conducted at the asphalt mixture plant if the plant is producing 402 mixtures.

Intermediate Course – The hot mix asphalt course immediately below the surface course, generally consisting of larger aggregates and less asphalt (by weight) than the surface course

Leveling Course – A course of hot mix asphalt of variable thickness used to eliminate irregularities in the contour of an existing surface prior to placing the subsequent course.

Maximum Particle Size - The sieve on which 100 percent of the material will pass

Mineral Filler - Dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler is required to be in accordance with the gradation requirements for size No.16.

National Institute of Standards and Technology (NIST) - A federal technology agency that develops and applies technology, measurements, and standards for testing equipment

Nominal Maximum Particle Size - The smallest sieve opening through which the entire amount of the aggregate is permitted to pass. The Nominal Maximum Particle Size for asphalt mixtures is defined as one sieve size larger than the first sieve to retain more than 10 percent.

Performance Graded (PG) – Asphalt binder grade designation used in Superpave that is based on the binder’s mechanical performance at critical temperatures and aging conditions

Polish Resistant Aggregates - Dolomite containing less than 10.3% elemental magnesium, crushed limestone, or gravel meeting the requirements of ITM 214. Aggregates meeting these requirements are maintained on the INDOT Approved List of Polish Resistant Aggregates.

Prime Coat – An application of asphalt primer to an absorbent surface. The prime coat is used to prepare an untreated base for an asphalt surface. The prime penetrates or is mixed into the surface of the base and plugs the voids, hardens the top and helps bind the mixture to the overlying course.

Quality Assurance Materials - Certified Materials controlled by aggregate gradations determined by the Certified Aggregate Producer

Quality Control Plan (QCP) - A document written by the Producer that is plant-specific and includes the methods of sampling, testing, calibration, verification, inspection and anticipated frequencies used by the Producer

Qualified Technician - An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program

Reclaimed Asphalt Pavement (RAP) – Excavated asphalt pavement that has been pulverized, usually by milling, and is used like an aggregate in the recycling of asphalt pavements

Reclaimed Asphalt Shingles (RAS) – Pre-consumer asphalt shingles that are a waste from a shingle manufacturing facility or post-consumer asphalt shingles that are tear-off materials from roofs

Specific Gravity - The ratio of the mass of a unit volume of a material to the mass of the same volume of gas-free distilled water at a stated temperature

Standard Specification Materials - Certified Materials controlled by aggregate gradations as defined in the Department Standard Specifications and the construction contract documents

Steel Furnace Slag (SF) - A material derived from the further refinement of iron to steel

Subbase – The course in the asphalt pavement structure immediately below the base course. If the subgrade soil has adequate support, this course may serve as the subbase.

Subgrade – The soil prepared to support a pavement structure or a pavement system. The subgrade is the foundation of the pavement structure.

Superpave – Short for "Superior Performing Asphalt Pavement", a performance-based system for selecting and specifying asphalt binders and for designing asphalt mixtures

Tack Coat – A relatively thin application of asphalt applied to an existing asphalt or concrete pavement surface at a prescribed rate. Asphalt emulsion diluted with water is the preferred type. Tack coat is used to form a bond between an existing surface and the overlying course.

Warm Mix Asphalt (WMA) - WMA represents a group of technologies that allow a reduction in the temperature at which mixtures are produced and placed

Wet Bottom Boiler Slag - A material which is a by-product from coal combustion at electrical generating plant

ROUNDING

The Specifications designate specific quantities of material to be sampled, material test values, and test equipment calibration measurements. As such, a standard method for rounding values is essential. The method required is the "5 up" procedure. There are two rules for rounding numbers:

1. When the first digit discarded is less than 5, the last digit retained should not be changed.

Examples:

2.4 becomes 2
 2.43 becomes 2.4
 2.434 becomes 2.43
 2.4341 becomes 2.434

2. When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.

Examples:

2.6 becomes 3
 2.56 becomes 2.6
 2.416 becomes 2.42
 2.4157 becomes 2.416

The Specifications require that test values and calculations be determined to the nearest decimal place as indicated in Figure 1-1.

| Property | Nearest Whole Unit (0) | First Decimal Place (0.0) | Second Decimal Place (0.00) | Third Decimal Place (0.000) |
|-----------------------------|-------------------------------|----------------------------------|------------------------------------|------------------------------------|
| CAA | X | | | |
| Density (Mix Design) | X | | | |
| FAA | X | | | |
| Asphalt Mixture Temperature | X | | | |
| Sand Equivalency | X | | | |
| Tensile Strength | X | | | |
| VFA | X | | | |
| Control Limits | | X | | |
| Dust/Effective Binder | | X | | |
| Five-Point Moving Average | | X | | |
| Gradation | | X | | |
| Target Mean | | X | | |
| Air Voids | | | X | |
| Binder Content | | | X | |
| Density (Pavement) | | | X | |
| Draindown | | | X | |
| Asphalt Mixture Moisture | | | X | |
| VMA | | | X | |
| Bulk Specific Gravity | | | | X |
| Maximum Specific Gravity | | | | X |

Figure 1-1 Required Decimal Places

MEAN

The simple mathematical average of any group of numbers is the mean. In other words, the mean is the sum of all the measurement values divided by the number of measurements. The symbol for the mean is \bar{x} . As an example, the mean for five numbers would be calculated as follows:

$$\bar{x} = \frac{X_1 + X_2 + X_3 + X_4 + X_5}{5}$$

STANDARD DEVIATION

Whereas the mean is an average of all the data values, the standard deviation is an average value of the dispersion of data from the mean. Standard deviation is usually signified by a small s or the Greek letter Sigma (σ). For the Certified Hot Mix Asphalt Program, s is used.

The procedure used to compute the standard deviation is to subtract the mean from each value, square this difference, sum, divide by one less than the number of values, and take the square root. These steps may be expressed in terms of a formula as follows:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n - 1}}$$

where \bar{x} is the arithmetic mean, n is the number of sample values and Σ indicates the summation of all values.

Note that squaring the deviations from the mean removes the negative signs. Dividing by n - 1 gives us approximately an average squared deviation. Taking the square root puts the result back into the same units as the original values.

Example:

| x_i | $x_i - \bar{x}$ | $(x_i - \bar{x})^2$ |
|-------------|-----------------|------------------------------------|
| 14.3 | 1.7 | 2.89 |
| 11.2 | -1.4 | 1.96 |
| 14.1 | 1.5 | 2.25 |
| 12.6 | 0.0 | 0.00 |
| 12.9 | 0.3 | 0.09 |
| 12.7 | 0.1 | 0.01 |
| 13.2 | 0.6 | 0.36 |
| 11.4 | -1.2 | 1.44 |
| 12.3 | -0.3 | 0.09 |
| <u>11.6</u> | <u>-1.0</u> | <u>1.00</u> |
| 126.3 | | 10.09 (Sum of squared differences) |

$$n = 10$$

$$\bar{x} = \frac{\sum x_i}{n} = 12.6$$

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{10.09}{9}} = \sqrt{1.121} = 1.06$$

FIVE-POINT MOVING AVERAGE

The moving average is a useful tool for tracking trends of the mean. The Certified HMA Producer Program requires that the moving average be the average of the most recent five data points.

For a moving average of five test values, the group of the first five measurements is averaged. When an additional test value is obtained, the first value is dropped, the sixth value is added, and the new group averaged. When a seventh value is obtained, the second value is dropped, and the new group averaged, and so on. An example of this procedure is as follows:

Data: 4.8, 5.3, 5.0, 4.7, 5.1, 5.5, 4.6

$$\begin{aligned}\text{First Average} &= \frac{4.8 + 5.3 + 5.0 + 4.7 + 5.1}{5} \\ &= \frac{24.9}{5} = 5.0\end{aligned}$$

The first number, or 4.8, is dropped and the sixth value, or 5.5, is added and the second average is:

$$\begin{aligned}\text{Second Average} &= \frac{5.3 + 5.0 + 4.7 + 5.1 + 5.5}{5} \\ &= \frac{25.6}{5} = 5.1\end{aligned}$$

Next, the 5.3 is dropped and 4.6 is added:

$$\begin{aligned}\text{Third Average} &= \frac{5.0 + 4.7 + 5.1 + 5.5 + 4.6}{5} \\ &= \frac{24.9}{5} = 5.0\end{aligned}$$

VOLUMETRICS

Hot mix asphalt properties are most affected by volume not weight; however, production and testing of asphalt mixture is by weight. Specific gravity is the means to convert from units of weight to volume. The definition of specific gravity and equations relating specific gravity to density and volume are as follows:

Specific Gravity -- the ratio of the weight of a given volume of an object to the weight of an equal volume of water at 77° F

Density

$$D = G \times 62.416$$

where:

D = Density in lb/ft³

G = Specific Gravity

62.416 = Density of Water in lb/ft³ at 77° F

Volume

$$V = \frac{W}{G \times 62.416}$$

where:

V = Volume in ft³

W = Weight in lb

G = Specific Gravity

62.416 = Density of Water in lb/ft³ at 77° F