1 INTRODUCTION

Safety

Terminology

Rounding

Mean

Standard Deviation

Volumetrics

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

HMA has been called surprisingly by many different names. Bituminous paving mix(ture), bituminous concrete, bituminous mix(ture), asphalt paving mix(ture), asphalt mix(ture), asphaltic concrete or plain "asphalt" are just a few of the synonyms used for this material. The term "hot mix asphalt" 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.

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			
HMA Temperature	X			
Sand Equivalency	X			
Tensile Strength	X			
VFA	X			
Binder Content		X		
Control Limits		X		
Density (Pavement)		X		
Dust/Effective Binder		X		
Five-Point Moving Average		X		
Gradation		X		
Target Mean		X		
VMA		X		
Air Voids		X		
Draindown			X	
HMA Moisture			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 $\sum$ 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	
11.6	-1.0	1.00	
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

$$\text{First Average} = \frac{4.8 + 5.3 + 5.0 + 4.7 + 5.1}{5}$$

$$= \frac{24.9}{5} = 5.0$$

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

$$\text{Second Average} = \frac{5.3 + 5.0 + 4.7 + 5.1 + 5.5}{5}$$

$$= \frac{25.6}{5} = 5.1$$

Next, the 5.3 is dropped and 4.6 is added:

$$\text{Third Average} = \frac{5.0 + 4.7 + 5.1 + 5.5 + 4.6}{5}$$

$$= \frac{24.9}{5} = 5.0$$

VOLUMETRICS

Hot mix asphalt properties are most affected by volume not weight; however, production and testing of HMA 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/ft^3
G = Specific Gravity
62.416 = Density of Water in lb/ft^3 at 77° F

Volume

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

where:

V = Volume in ft^3
W = Weight in lb
G = Specific Gravity
62.416 = Density of Water in lb/ft^3 at 77° F