ATT-48/22, CORRECTION FACTORS, Nuclear Moisture-Density Measurements

1.0 SCOPE

This method describes the procedures for determining correction factors for moisture content and density, applicable to measurements made with a nuclear moisture-density gauge. The correction factor has to be re-established whenever the soil type changes, for each lift, agg source change, or gradation changes. A typical construction project will have several Nuclear Gage Correction Factors.

2.0 EQUIPMENT

Refer to Section 2.0 Equipment of ATT-11, DENSITY, In Place, Nuclear Method.

If testing asphalt concrete pavement, refer to Section 2.0 Equipment of ATT-5, CORING, and ATT-7 or ATT-6, DENSITY, Immersion Method.

If testing fine grained soil or sand-base cement stabilized base course, refer to Section 2.0 Equipment of ATT-8, DENSITY, In-Place, Balloon Method.

Data Sheet: Nuclear Gauge Correction Factors, such as MAT 6-54

3.0 PROCEDURE

3.1 Application

Moisture and density correction factors must be determined before the results obtained by a nuclear moisture-density gauge can be used to accept or reject work, or can be accepted as cause for an appeal on ACP EPS contracts.

A nuclear gauge density correction factor is obtained by correlating nuclear gauge densities to core densities, or volutester densities, performed on the same site locations. A moisture correction factor is obtained by correlating gauge moisture contents to standard moisture contents (oven-dried for soils, or burner-dried for CSBC mixes).

In this procedure, 10 sites are tested. The nuclear wet density (and moisture, if required) of each site is obtained. Then an ACP core is taken, or a volutester density test is performed, at the same location as the nuclear gauge test.

A density and moisture nuclear gauge correction factor must be determined at the beginning of each project, *and:*

a) for each significant soil type,

b) for each lift,

c) for a change in designation, or class, or source of aggregate,

d) for any significant change in the gradation of the aggregate,

e) after each approved change in the job mix formula,

f) for each individual nuclear moisture-density gauge.

Moisture correction factors are not required for ACP and ASBC. For these materials, the moisture content would be increased by the amount of asphalt present, as the gauge picks off the hydrogen content of the material, and both asphalt and water contain hydrogen.

Consultants must submit to the Project Manager the most recent calibration data (as per ASTM D 2950, Density of Bituminous Concrete in Place by Nuclear Method, ANNEXES, A1, Calibration), and the correction factor data for each correction factor obtained for the project.

3.2 Test Sites: In-Place Nuclear Densities and Moisture Contents

1. Select an area of the roadway uniform both vertically and horizontally in moisture content, density and classification.

2. On Form MAT 6-54 (see Figure 1), record the Nuclear Gauge Manufacturer and Model #, Gauge Serial #, Moisture Standard Count, and the Density Standard Count as directed in ATT-11.

3. Select the density mode that will be used for the majority of tests on the job and record it on Form Mat 6-54. Record BS, for backscatter mode, or record DT, for the direct transmission mode. For Direct Transmission, include the depth of measurement, e.g., 50, 100, 150, 200, 250 or 300 mm.

4. Prepare a test site for the nuclear gauge, as directed in ATT-11, Section 3.4.

5. Use a one minute count time (or as recommended by the manufacturer) to obtain the Wet Density and Moisture Content for Site #1. Record the Wet Density on “Site Number 1, Count #1” on row A1, and record the Moisture Content on “Site Number 1, Count #1”, on row G1.

   NOTE: Do not retrieve moisture contents on asphalt bound aggregates or if a moisture correction factor is not required.

6. Take a second 1-minute count and then record the Wet Density on “Site Number 1, Count #2” on row A2, and the Moisture Content on “Site Number 1, Count #2”, on row G2.

7. Immediately adjacent to the nuclear test site if the Direct Transmission mode was used, or on it, if the Backscatter mode was used, perform an in-place density test, as directed in ATT-5 (Coring) and ATT-7 (Density) for ACP, or ATT-8 (Density) for soils or CSBC.

8. Repeat steps 4 to 7 until a total of 10 sites have been tested.

3.3 Correction Factor of Soils or CSBC

If testing soils or cement stabilized base course, for each test site:

1. Weigh the mass of material (dug from each density hole) contained in each plastic density pail.

   The Density Correction Factor is derived from the wet density measurements. The material can be discarded once the soils have been weighed, if a moisture correction factor is not required.

2. Calculate each in-place wet density as directed in ATT-8, Density, Balloon Method. The wet mass is divided by the volume of the test hole to obtain the wet density in kg/m^3. Record the “Average Balloon or Sand Cone Method or CSBC Core Wet Density” on line “D”, or record the “Average Asphalt Concrete Core Dry Density” on line “E”.

3. If a moisture correction factor is required:

   a) Obtain a moisture content sample using the material from the corresponding density pail as directed in ATT-8, Density, Balloon Method.

   b) Process the moisture content sample as directed in ATT-15, MOISTURE CONTENT, Oven Method, for soils, or ATT-14, MOISTURE CONTENT, Open Pan Method, for aggregates.

   c) Calculate the AVERAGE Oven Dry or Open Pan Moisture Content of all 10 samples in % and record this average on line “J”.

3.3.1 Density Correction Factor

1. Calculate the average of the twenty “Nuclear Wet Density” readings from the 10 sites (lines “A1” & “A2”) and record as “Average Nuclear Wet Density” (line "C").

2. If testing soils, or cement stabilized base courses, calculate the average of the in-place volutester wet densities from the 10 test sites and record as the “Average Balloon Method Wet Density” (line"D").

3. Calculate the “Density Correction Factor” in kg/m^3 (line "F") as follows:

   = Average Balloon Method Wet Density - Average Nuclear Wet Density

4. If the Average Nuclear Wet Density (line "C") is higher than the Average Standard Density (line "D"), the “Density Correction Factor” (line "F") is negative. The correction factor must be subtracted from all subsequent nuclear gauge wet density readings on that material type to yield the Corrected Wet Density.

5. If the Average Nuclear Wet Density (line "C) is lower than the Average Standard Density (line "D"), the Density Correction Factor (line "F") is positive. The correction factor must be added to all subsequent nuclear gauge wet densities on that material type to yield the Corrected Wet Density.

Alberta Transportation	NUCLEAR GAUGE CORRECTION FACTORS			
	PROJECT NO. :	HWY 40:30	MATERIAL TYPE :	SANDY CLAY
	CONTRACT NO. :	22334	DATE TESTED :	1-Jan-2014
	PROJECT FROM :	WILDHAY RIVER	QA CONSULTANT :	WOLVERINE CONSULTING
	PROJECT TO :	S. of ALTA RESOURCES RWY	PRIME CONSULTANT :	DETAIL CONSULTING
MAT 6-54 / 14	CONTRACTOR :	SANDYS CONSTRUCTION	**ATT-48, CORRECTION FACTORS, Nuclear Gauge**	

NUCLEAR GAUGE DENSITY		GAUGE TYPE	TROXLER 3430	BS or DT 50, 100, 150, 200 mm					DT 50		
		GAUGE SERIAL #	37666	DENSITY STD COUNT		1985	MOISTURE STD COUNT			679	
		SITE NUMBER	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A. NUCLEAR WET DENSITY (kg/m^3)	A1.	COUNT #1	1740	1747	1718	1731	1745	1722	1729	1735	1729	1729
	A2.	COUNT #2	1750	1757	1728	1741	1755	1732	1739	1745	1739	1739
B. AVERAGE of COUNTS 1 & 2 (A1 & A2)	kg/m^3	AVERAGE	*1745*	*1752*	*1723*	*1736*	*1750*	*1727*	*1734*	*1740*	*1734*	*1734*
C. AVERAGE NUCLEAR WET DENSITY	kg/m^3	SITES 1-10	***1738***									

DENSITY CORRECTION FACTOR			
C. AVERAGE NUCLEAR WET DENSITY		kg/m^3	1738
D. AVERAGE BALLOON or SAND METHOD or CSBC CORE WET DENSITY or		kg/m^3	1756
E. AVERAGE ASPHALT CONCRETE CORE DRY DENSITY		kg/m^3	
F. NUCLEAR GAUGE DENSITY CORRECTION FACTOR	((D or E) - C)	± kg/m^3	**+ 18**

NUCLEAR GAUGE MOISTURE CONTENT												
		SITE NUMBER	1	2	3	4	5	6	7	8	9	10
G. NUCLEAR MOISTURE CONTENT (%)	G1.	COUNT #1	13.5	14.0	14.0	13.5	14.4	14.0	13.5	14.5	13.8	14.1
	G2.	COUNT #2	13.7	13.8	14.2	13.7	14.3	13.8	13.7	14.3	13.6	14.3
H. AVERAGE of COUNTS 1 & 2 (G1 & G2)	%	AVERAGE	*13.6*	*13.9*	*14.1*	*13.6*	*14.4*	*13.9*	*13.6*	*14.4*	*13.7*	*14.2*
I. AVG. NUCLEAR MOISTURE CONTENT	%	SITES 1-10	***13.9***									

MOISTURE CORRECTION FACTOR			
I. AVERAGE NUCLEAR GAUGE MOISTURE CONTENT		%	13.9
J. AVERAGE OVEN DRY or OPEN PAN MOISTURE CONTENT		%	14.9
K. NUCLEAR GAUGE MOISTURE CONTENT CORRECTION FACTOR	J - I	%	**+ 1.0**

REMARKS ______________________ MATERIALS TECHNOLOGIST(S) R. JONES

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FIGURE 1

3.3.2 Moisture Correction Factor

1. Calculate the average of the twenty "Nuclear Moisture Content" readings from the 10 sites (line "G") and record as "Average Moisture Content" (line "I").

2. When the 10 standard moisture content samples have dried, calculate the average standard moisture content in % for the test sites, then record as "Average Oven Dry or Open Pan Moisture Content" (line"J").

3. Calculate the "Nuclear Gauge Moisture Content Correction Factor" (line "K") in % as follows:

= Average Oven Dry or Open Pan Moisture Content - Average Nuclear Moisture Content

4. If the "Average Nuclear Moisture Content" in % (line "I") is higher than the "Average Oven Dry or Open Pan Method Moisture Content" in % (line "J"), the Moisture Content Correction Factor (line "K") is negative.

   A negative correction factor must be subtracted from all subsequent gauge moisture contents on that material to yield the corrected moisture content.

   This type of factor results from hydrogenous materials in the soil and is constant regardless of the moisture of the soil at the time of testing.

7. If the "Average Nuclear Moisture Content" (line "I") is lower than the "Average Oven Dry or Open Pan Moisture Content (line "J"), the Moisture Content Correction Factor (line "K") is positive.

   A positive correction factor must be added to all subsequent gauge moisture contents on that material to yield the corrected moisture content.

   This type of factor results from when there are neutron absorptive materials present in the soil. The factor will vary depending on the moisture condition of the sample tested. This variation is insignificant for the normal range of moisture contents used in construction practice.

3.4 Density Correction Factor of ACP

If testing asphalt concrete pavement, for each test site, proceed as follows:

1. Determine the dry density of each core as directed in ATT-7, DENSITY, Immersion Method, Saturated Surface Dry Asphalt Concrete Specimens, or ATT-6, DENSITY, Immersion Method, Waxed Asphalt Concrete Specimens.

2. Plot a graph of each site's core dry density (horizontal x-axis) versus each site's nuclear gauge wet density (vertical y-axis), as shown in Figure 2.

4. Use linear regression to draw a curve through the plotted points. Extend the line in both directions, so that it will cover the full range of possible densities for the project.

   The minimum acceptable linear regression "r" value is 0.7. If "r^2" is less than 0.49, review the nuclear gauge testing procedure and retest the sites which are obviously in error.

   The ACP Density Correction Factor Graph is later used to determine the segments corrected nuclear wet density (or its corresponding core dry density).

ACP EPS NUCLEAR GAUGE DENSITY CORRECTION FACTOR GRAPH

CORE DRY DENSITY vs NUCLEAR WET DENSITY

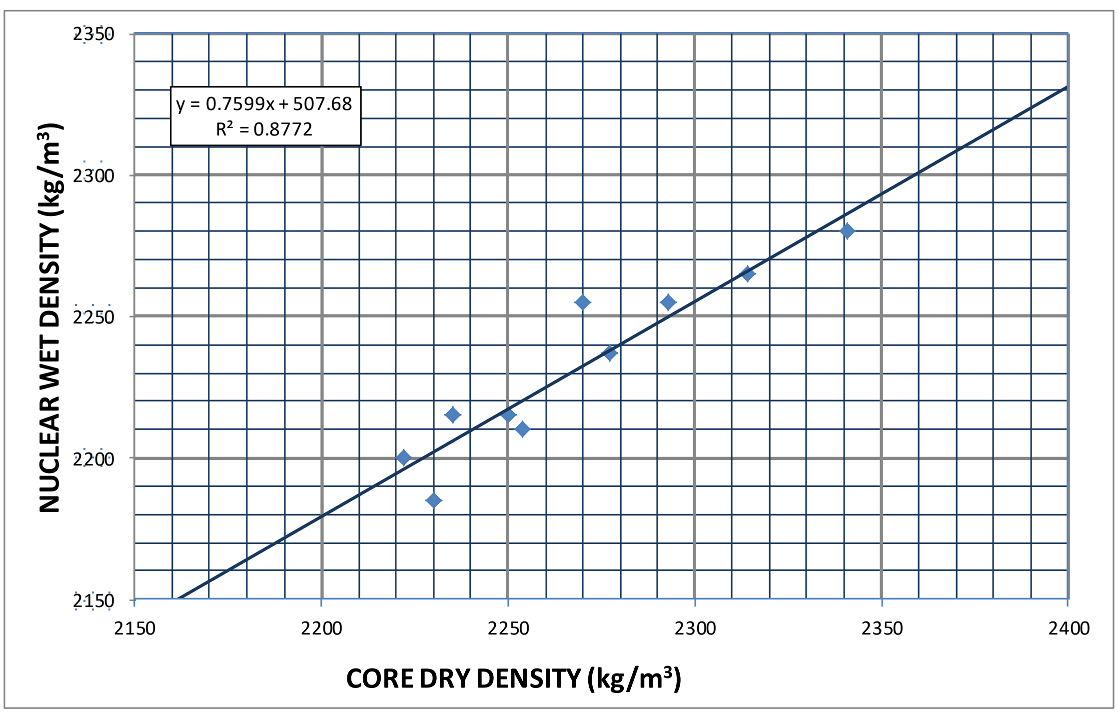

FIGURE 2

4.0 HINTS AND PRECAUTIONS

1. Carefully select the test area to ensure there is no stratification of soils or aggregates, e.g. one layer of soil or aggregate placed over another layer of different classification and characteristics.

2. Moisture correction factors cannot be made on asphalt bound materials.

3. For sand-base cement stabilized mixtures, the interval from the time that water was introduced into the mix at the plant to the time that the measurements were taken on the road must be approximately the same for all subsequent tests. This is because hydrated moisture is measured by the gauge, but not by the oven.

4. The gauge count in the backscatter density mode is strongly influenced by surface density. Therefore, site preparation and surface voids are a critical source of error when testing in the backscatter mode.

5. Factors such as inherent procedural differences, surrounding or background materials, etc., may contribute to differences between nuclear densities and densities obtained using the balloon or core methods.

6. Several errors can occur between the calculated gauge moisture contents and the actual oven dried moisture content. These occur primarily, where the soil contains:

    a) hydrogenous substances (e.g., organic materials) elements of low atomic weight (e.g., helium, nitrogen, lithium, etc.), or water bound in crystalline form (e.g., gypsum) which will be interpreted as moisture, causing the gauge to read high, or

    b) materials composed of iron or iron oxides, and rarely encountered elements such as boron or cadmium, all of which have an infinity for thermal neutrons, causing the gauge to read low.

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