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METHOD OF DETERMINING ASPHALT CONTENT OF BITUMINOUS MIXTURES BY USE OF THE NUCLEAR GAGE

A. SCOPE

This test method describes the procedure for determining the asphalt content of either a conventional bituminous mixture or a recycled mixture by means of an Asphalt Content Gage. The gage operates on the principal of neutron moderation. Fast neutrons emitted by a radioactive source are moderated (slowed) by the hydrogen in the mix. These slowed neutrons are detected, and counts are displayed in inverse proportion to the hydrogen-ion content of the sample.

Part 1 – Conventional Bituminous Mixtures

Part 2 – Hot Recycled Bituminous Mixtures

B. REFERENCES

CT 121	Administrative Instructions for Use of Nuclear Gauges
CT 125	Method of Test for Sampling Highway Materials and Products Used in the Roadway Structural Sections
CT 310	Method of Test for Determination of Asphalt and Moisture Contents of Bituminous Mixtures by Hot Solvent Extraction
CT 362	Method of Determining Asphalt Content in Bituminous Mixtures by Vacuum Extraction
CT 370	Method of Test for Determining Moisture Content of Bituminous Mixtures or Graded Mineral Aggregates Using Microwave Ovens

C. APPARATUS

1. Asphalt Content Gage
2. Ten stainless steel test pans (approximately 230 by 185 by 100 mm). (Figure 1)
3. One balance, 1-kg capacity, accurate to 1 g.
4. Aggregate sample splitter, riffle type (50 mm minimum chute spacing) or equal.
5. Mechanical mixer, Hobart Model A200 or equal, with an 11 L± mixing bowl capacity. (Figure 2)
    a. Standard mixing paddles will have to be modified using flexible spring steel for bowl contact edges to prevent paddle breakage. Stainless steel paddles are also acceptable and available, but rather costly.
6. Microwave oven (approximate interior dimensions of 300 by 400 by 250 mm).
7. Mechanical convection oven capable of heating to 150 ± 6°C (approximate interior dimension of 500 by 500 by 400 mm).
8. Plywood pressing board (250 by 250 by 13 mm).
9. Steel rod – approximately 9.5 mm diameter, bullet-pointed.
10. Gloves, heat resistant.
11. Sample pans, approximately 300 mm in diameter and 65 mm deep.
12. Metal scoop approximately 50 mm wide and 150 mm long.
13. Quick-release dry lubricant (aerosol).

D. PRECAUTIONS

1. A check of the aggregate may be made by obtaining bin or belt samples and preparing and testing a new blank. Notifying the inspector of a change in the count will alert him to possible changes in pit conditions and/or moisture retained by the aggregate.
2. A change of the gage's location can have an effect on the calibration of the gage. Therefore, a new calibration must be completed if the gage is moved. The previously fabricated calibration samples can be used.
3. Before calibrating the gage or taking any measurements of asphalt content, a background count must be taken to alert the operator to any changes of the gage's reliability. If the gage hasn't been moved, the gage readout should be within ± 1% of the value obtained by the 20-

minute stability count or the last background count. Background radiation or hydrogen bearing material (a cup of coffee, people etc.) within 1m of the gage can cause some variation to the readout. If there is a variation of ± 2% or more, after eliminating possible influences, contact the manufacturers service facility for further advice.

4. Samples placed in the 150°C oven shall not be left for more than 4 hours (excluding drying time to remove moisture).

E. HEALTH AND SAFETY

CAUTION: Prior to handling test materials, preforming equipment setups, and/or conducting this method, testers are required to read this section. It is the responsibility of the user of this method to consultant and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

IMPORTANT: Nuclear gages can only be used by licensed operators. The District Radiation Safety Officer maintains a current list of personnel licensed to operate this equipment.

The quantity of radioactive material contained in nuclear gages is relatively small, and the operator may use the gage safely day after day without any health hazard due to radiation. However, all radioactive sources, no matter how small, should be handled with care. In the event that the gage becomes physically damaged such that there may be damage to the source's shielding, immediately notify the Radiation Safety Officer and do not handle or approach the gage.

1. The nuclear asphalt gage shall be operated in accordance with all safety methods and procedures as outlined by the manufacturer, Caltrans Radiation Safety Officer, and California Test 121.
2. Wear heat resistant gloves when fabricating the specimens to avoid burns.
3. When standing on the pressing board to compact the test specimens in the steel pans, hold on to an immovable support as the pan often tends to wobble or tilt.

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

PART 1: CONVENTIONAL BITUMINOUS MIXTURES

A. PREPERATION OF "BLANK" AGGREGATE SAMPLE

1. The size of the sample will be the amount required to fill the test pans. This will vary depending on the specific gravity of the aggregate, and generally will be between 6 and 8 kg; therefore, 8 kg has been selected. Batch two 4 kg samples of aggregate using the gradation and source selected for the project.

   NOTE: Although approximately 7 kg of material will be required to fill a test pan; it is advisable to batch smaller samples to minimize drying time.

2. Use the 150°C oven and dry the two 4 kg samples to a constant mass (1.0 g loss or less in 20 min) or for 48 hours, whichever is less. (In the case of absorptive aggregates [Km values of 1.4 or higher], the 48-hour drying time is sometimes required). Samples removed from the oven for weighing must be permitted to cool 15 min prior to weighing, and the dry material must be processed through the gage in less than 1 hour after removal from the oven.
3.
   - **a.** With a scoop, begin placing the dry aggregate in a tared test pan. Use care so that the coarse and fine material is evenly distributed throughout the pan.
   - **b.** While placing each scoopful in the pan, gently spade the aggregate with the scoop to provide a uniform layer.
   - **c.** When the pan is approximately half filled, raise the pan approximately 25 mm, then drop the pan so that the bottom strikes evenly. Repeat this three times.
   - **d.** Continue filling the pan as indicated in paragraphs 3.a and 3.b until the aggregate is approximately 13 mm above the rim.
   - **e.** Raise and drop the pan approximately 25 mm so that the pan bottom strikes evenly. Repeat three times.
   - **f.** Place a straightedge firmly across the rim of the pan and, using a sawing motion, strike off the surface of the sample so it is flush with the pan's top. If an air gap is visible between the straightedge and the sample, add fine aggregate (9.5 mm by 75 μm) and strike off the sample again.
   - **g.** "Blank" preparation is critical because too much spading can cause a migration of fines to the bottom of the pan and result in excessive sample mass.

4. Weigh the pan and sample to the nearest 1.0 g.
5. Calculate the net mass of aggregate (designate as W_o) by subtracting the pan's tare mass from the total mass.
6. Store pan and aggregate for future gage calibration.

B. PREPERATION OF AC MIXTURES FOR GAGE CALIBRATION

1. Place the asphalt (grade and source to be used on the project) in the 150°C oven for 1 hour minimum (maximum of 3 hours).
2. Batch four 4 kg aggregate samples as per Part 1, Step A.1. Use the same aggregate and gradation used for the "blank" calibration sample.
3. Place all samples in the 150°C oven and dry to constant mass.
4. Preheat two tared stainless-steel test pans and the mixing bowl for 15 min in the 150˚C oven.
5. Remove one of the 4 kg aggregate samples from the oven and add an amount of asphalt that is 1.0 % less than the designated optimum based on the dry aggregate mass. Label this specimen A1.
6. Place test specimen A1 in the preheated bowl of the mechanical mixer and mix until all particles are coated.
7. After mixing, place the sample in a sample pan and place it in the 150°C oven.
8. Remove another 4 kg aggregate sample from the oven, and repeat steps No. 5, 6, and 7. Label this test specimen A2.
9. Remove another 4 kg aggregate sample from the oven and add an amount of asphalt equivalent to a quantity that is 1.0% more than the designated optimum based on dry mass of aggregate. Label this specimen B1.
10. Place test specimen B1 into the preheated bowl (considered preheated if used within 5 min after mixing a previous sample) and mix it until all particles are coated.
11. After mixing, place the sample in a sample pan and place it in the 150°C oven.
12. Remove another 4 kg sample of aggregate from the oven and repeat steps No. 9, 10, and 11. Label this specimen B2.
13. Prepare samples for testing by combining A1 with A2 and B1 with B2 in respective heated stainless-steel test pans as follows:
    - **a.** Remove either specimen A1 or A2 from the oven and, using a scoop, place it immediately into a tared preheated test pan.
    - **b.** Using the 9.5 mm diameter steel rod, rod 20 times (total) around the edges and down the center.

c. Place sufficient material from the remaining "A" specimen in the pan, on top of first specimen, to bring the total net mass of mix in the pan to W_o per A.5.

d. Place the plywood pressing board on the mix and press down until the board touches the pan's rim (usually accomplished by standing on the pressing board, Figure 3). The samples must be prepared while the mix is at least 120°C to obtain proper compaction by pressing. Repeat steps a through d with test specimens B1 and B2.

e. Allow at least 10 min to elapse after plugging in the gage before continuing.

C. CALIBRATION

1. Use the samples fabricated in Part 1, Section B. Follow the instructions provided with the gage.

D. MEASURING ASPHALT CONTENT

1. Obtain sample(s) of bituminous mix (32 kg ±) per California Test 125.
2. Split this sample to obtain 4 kg ± portions, then prepare test specimens as outlined in Part 1, Step B.13.

   NOTE: The mix must be at least 120°C for proper fabrication. If the temperature drops below 120°C, reheat it in the 150°C oven until its temperature is between 120°C and 150°C.

3. Determine the moisture content of the mix per California Test 370. The measured asphalt content must be corrected for moisture content.

   NOTE: If reheating is needed, this moisture content sample must be taken after this reheating.

4. Measure the asphalt content following the instructions in the manual provided with the gage.

PART 2: HOT RECYCLED BITUMINOUS MIXTURES

A. PREPREATION OF "BLANK" AGGREGATE SAMPLE

1. The size of the sample will be the amount required to fill the test pans (Apparatus - Item 2). This will vary depending on the specific gravity of the aggregate and generally will be between 6 and 8 kg; therefore, 8 kg has been selected as the standard mass to batch for the preparation of the

"blank" (sample of RAP and virgin aggregate without the addition of new asphalt). Using the guidelines below, batch two 4 kg samples consisting of RAP and virgin aggregate representing the material to be used on the project (proposed gradation and source).

NOTE: Approximately 8 kg of material will be required to fill the test pan. However, to minimize drying time, it is advisable to batch smaller samples; thus, the following mass should be used for batching:

For a 4000-g total sample (dry)

Recycle Mix Formula	**RAP**	**Virgin Aggregate**
70/30	2800	1200
60/40	2400	1600
50/50	2000	2000

Note: To compensate for moisture, add 25 g of the passing 4.75 mm fraction to each batch.

2. Use the 150°C oven and dry each batch to a constant mass (1.0 g loss or less in 20 minutes). Samples removed from the oven for purposes of checking mass must be permitted to cool at room temperature for 15 min prior to weighing.
3. After samples are dry, combine into two 4 kg batches according to the selected job mix formula and reheat to 150°C.
4. Remove from oven and place one combined 4 kg sample into the mechanical mixer and mix for 3 min or until thoroughly mixed. Repeat mixing for second 4 kg sample.
5. Remove each batch from the mechanical mixer, place in suitable container, and return to 150°C oven.
6. Prepare samples for fabrication and testing in the gage as follows:
    - **a.** Remove a sample from the oven when the mix reaches a minimum temperature of 110°C.
    - **b.** With the use of a scoop, place enough mix from the pan immediately into a tared preheated test pan until it's just over half full.
    - **c.** Using the 9.5 mm diameter steel rod, rod 20 strokes (total) around the edges and down the center.

d. Remove a second pan of mix from the oven and continue filling the test pan until the aggregate (mix) is approximately 13 mm above the pan rim.
e. Using the 9.5 mm diameter steel rod, rod 20 strokes (total) around the edges and down the center just penetrating the first layer.
f. Place a straightedge firmly across the top rim of the test pan and, using a sawing motion, strike off the surface of the sample so it is flush with the pan top.
g. Weigh the pan and sample to the nearest 1.0 g.
h. Calculate the sample mass (designate as W_o) by subtracting the pan tare from the total mass.
i. Store pan and contents for future gage calibration.

B. PREPARATION OF RECYCLED AC MIXTURE FOR GAGE CALIBRATION

1. General

Obtain an average value for the asphalt content of the RAP by measuring (using California Tests 310 or 362) the asphalt content of samples taken from sufficient locations to represent the material. Apply a correction factor by adding 0.2 % to this average value to compensate for sampling and extraction bias.

2. RAP

The RAP stockpile should be periodically checked for asphalt content using the gage. This is done by adding a small amount of new asphalt to one of the calibration samples and the test sample. The preparation procedure is as follows.

a. Obtain approximately 32 kg of material representing the RAP stockpile. Split this to obtain eight 4 kg samples to establish the end points of a calibration curve.
b. Use the 150˚C oven or the microwave oven to dry the test samples to a constant mass (1.0 g loss or less in 20 min).
c. Using the average asphalt content established for the RAP in Part 2, Step B.1, calculate the dry aggregate mass of the sample.

$$\text{Dry Mass} = \left[\frac{\text{RAP Mass x } 100}{100 + \textit{Asphalt Content}}\right]$$

d. Individually place each sample (must be a minimum of 110°C) in the mechanical mixer and mix for 3 min or until thoroughly mixed. Place mixed samples in the 150°C oven.

(1) Add no new asphalt to one sample.

(2) Add 2.0 % new asphalt by dry mass of aggregate to another sample (use the grade of asphalt designated for the project). Record asphalt content as the average value obtained by extraction (Part 2, Step B.1.) +2.0 %.

e. Designate the sample mass calculated in Part 2, Step A – 6 h as Wp for RAP. Fabricate each of the two RAP calibration samples as follows:

(1) Remove a sample pan from the oven when the mix reaches a minimum temperature of 110°C.

(2) Using a scoop, place approximately half of W_p (obtained from e. above) immediately into a tared preheated test pan.

(3) Using the 9.5 mm diameter bullet-pointed steel rod, rod 20 times (total) around the edges and down the center of the pan.

(4) Remove a second pan of mix from the oven and continue filling the pan until the mix is approximately 13 mm above the pan rim.

(5) Adjust the mix net mass by adding or removing mix to equal W_p.

(6) Place a plywood pressing board on the mix and press down until board touches the pan rim (usually accomplished by standing on the pressing board, Figure 3).

(7) Store pan and contents for future gage calibration.

NOTE: Mix *must* be at least 110°C for proper fabrication. If the temperature drops below 110°C, reheat in a 150°C oven until hot enough to fabricate.

f. Follow the instructions provided with the gage and calibrate the gage using the RAP mixes.

3. Recycled AC

After establishing the asphalt content of the RAP, prepare samples as follows:

a. Convert total sample mass to dry aggregate mass using the recycle formula 50/50, 60/40, etc., and the average asphalt content.

b. Add the amount of new asphalt or recycling agent required to prepare the calibration sample (1.0% below optimum and 1.0% above optimum).

c. Refer to Part 1, Steps B.1, and B.3 through B.13 for preparation of samples.

d. Follow the instructions provided with the gage and calibrate the gage using the Recycled AC mixes.

C. MEASURING ASPHALT CONTENT

1. RAP
   a. Obtain a representative 32 kg RAP sample.
   b. Prepare material as follows:
      (1) Quarter out one 8 kg sample.
      (2) Split into two 4 kg samples.
      (3) Dry each sample to a constant mass at 150 ± 6°C, or by use of the microwave oven.
      (4) After drying, add 1.0 % new binder to each 4 kg sample (same grade as used for calibration samples), based on dry mass of aggregate in sample and thoroughly mix in the mechanical mixer.
      NOTE: Periodically check the asphalt content of the RAP. Whenever (if) the gage values differ from the expected value (the previous average + 1 %) by more than 0.7 %, perform another set of extraction tests and recalibrate using the new average asphalt content.
      (5) Continue to paragraph C.3 for preparation of test.
2. Recycled AC
   Obtain a representative street sample (10 kg minimum).
3. Prepare test specimens as follows:
   a. Split two 4 kg ± portions and a 500 g sample of hot material. Using the 500 g sample measure the moisture content per California Test 370.
   NOTE: Mix *must* be at least 110°C for proper fabrication. If the temperature drops below 110°C, reheat in a 150°C oven until hot enough to fabricate.

b. Using a scoop, place approximately 4 kg of RAP (or recycled AC) immediately into a tared preheated test pan.

c. Using a 9.5 mm diameter bullet-pointed steel rod, rod 20 times (total) around the edges and down the center of the pan.

d. Place additional RAP (or recycled AC) into the pan until the mix is approximately 13 mm above the pan rim.

e. Adjust the mix net mass by adding or removing mix to equal Wp for the RAP (or Wo for the recycled AC).

f. Place a plywood pressing board on the mix and press down until board touches the pan rim (usually accomplished by standing on the pressing board, Figure 3).

4. Following the instruction in the gage's manual, obtain the asphalt content of the samples.

   NOTE: This incorporates the calibration data obtained in Part 2, Step B.2. for RAP or Part 2, Step B.3. for recycled bituminous mixtures.

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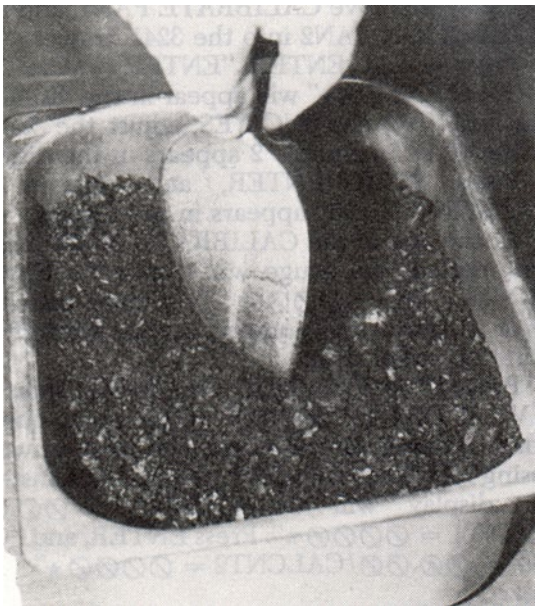

FIGURE 1. Loading Test Pan

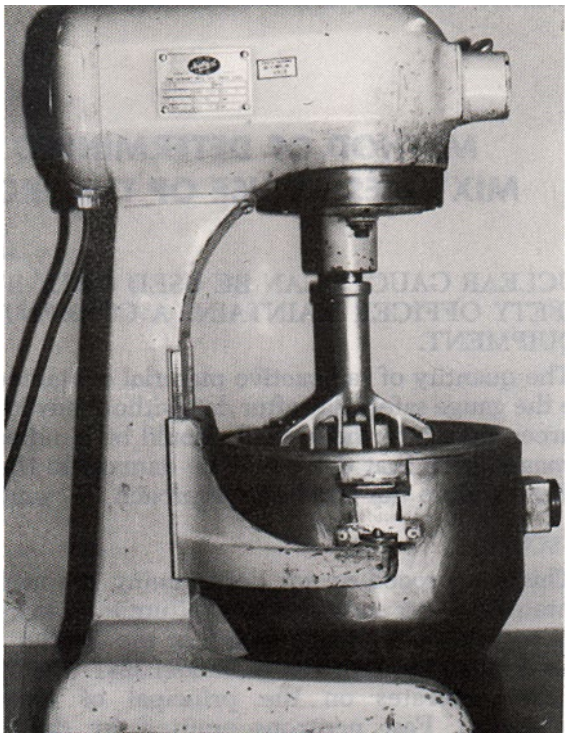

FIGURE 2. Hobart Mixer

FIGURE 3. Standing on Pressing Board for Compaction