

# ASPHALT CONTENT STUDIES BY THE NUCLEAR METHOD

Richard L. Grey, Bureau of Materials, Testing and Research,  
Pennsylvania Department of Transportation

## ABRIDGMENT

•A STUDY of asphalt content determination by neutron-thermalization techniques was performed at various bituminous batch plants with a prototype asphalt content gage. The gage had been specifically designed to provide a sensitive measure of bitumen content under field-testing conditions. The neutron-thermalization gage reported had previously been tested in the laboratory on controlled samples.

An investigation was made into gage response for different types of aggregates and also for similar aggregates of varying gradation. Tests were conducted on different batches of asphalt cement of a given manufacture in an attempt to study the variation of hydrogen content inherent in these samples. Results for the calibrated gage were compared to design content figures and extraction results.

This project was initiated to investigate the feasibility of the use of a nuclear device specifically designed to determine asphalt content of bituminous concrete. A previous report by the author (1) covered the initial studies in calibration of the gage and a statistical study of its reliability.

Studies by Lamb and Zoller (2), Varma and Reid (3), Howard and Covault (4), Walters (5), and Qureshi (6) have shown the feasibility of using a neutron gage for asphalt content determination. Very good reliability was achieved by the author in using the nuclear Chicago gage (1) due to several modifications that eradicated problems found by previous studies. Basically these were the inclusion of multiple slow neutron detectors, the achievement of a low background count, and the use of a fairly large source of fast neutrons. The most important of these appeared to be the low background count. Because the overall results are totally dependent on the statistics of radioactive decay, a gage with a low background count (count with no sample in the gage) will result in much better reliability than will a similar gage with high background. It is obvious that a low background count holds this variation to a minimum because any variation of background is included in any count of a material under test. Results indicated a standard deviation of 0.08 percent with this gage for 17 samples compared to carefully controlled design asphalt contents and 0.20 percent with extraction method of bitumen determination (1).

## FIELD-TESTING PROCEDURE

The gage studied in this project and the pan that was used to hold the hot bituminous sample are shown in Figure 1. The gage with sample in the sample cavity prior to test is shown in Figure 2. Sliding the drawer shut positions the sample for test. The associated scaler-timer unit used to receive the raw counts is not shown.

The gage was used at 2 bituminous plants to check the feasibility of testing under field conditions. Samples of bituminous mixes were carefully prepared for calibration of the gage by weighing aggregates and bitumen to the nearest gram in a large mixing bowl and transferring the sample to the gage test pan. Fines and bitumen left in the mixing bowl after transfer to the gage were carefully measured, and the design asphalt content was corrected accordingly. In field practice with the gage tested, several samples of hot bituminous concrete should be prepared to establish a calibration curve for



Figure 1. Gage with pan.



Figure 2. Gage with sample is cavity.

a particular material containing the aggregate and asphalt to be used in actual production. This calibration could then be used to check daily output of material used for construction so long as the mix design remained constant.

Extraction tests run on the materials after nuclear testing indicated a definite negative bias of extraction tests compared to design contents. The results were, therefore, fitted to design figures by least squares to more closely compare the nuclear and extraction results. Results of calibration tests at the 2 plants are given in Table 1.

The aggregates for plant 1 were river gravel and crusher sand with 100 percent passing the  $\frac{1}{2}$ -in. sieve while those for plant 2 were river gravel and crusher sand with 100 percent passing the  $\frac{3}{8}$ -in. sieve. Two different brands of asphalt were used in the two tests.

Actual testing each day required a 10-minute standard count on a standard material supplied with the gage in the morning and afternoon. The average daily standard count was used in calculating the nuclear ratio. The background count was the count with no sample in the gage. rms deviations from design content for the two jobs were  $\pm 0.12$  percent (nuclear) and  $\pm 0.11$  percent (extraction) and  $\pm 0.15$  percent (nuclear) and  $\pm 0.12$  percent (extraction) respectively. The mean deviations of extraction tests compared to design values prior to least squares fit were  $-0.19$  percent and  $-0.48$  percent respectively.

The gage response for different aggregates was evaluated by tests with the gage at 5 plants to substantiate the effect of aggregate type previously reported (1). Results are given in Table 2. Although different gradations of aggregate appeared to show no effect on the gage response, a definite effect was produced by different aggregate materials and possibly aggregate specific gravity, although this was not studied during this project.

Similarly, the effect of hydrogen content variation for different batches of the same

TABLE 1  
CALIBRATION TEST RESULTS

Test	Design Asphalt Content (percent)		Nuclear Ratio		AC <sub>t</sub> (percent)		AC <sub>e</sub> (percent)		AC <sub>e</sub> <sup>1</sup> (percent)	
	Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2
1	5.77	8.04	0.413	0.639	5.59	8.23	5.78	7.44	5.96	7.96
2	6.87	7.03	0.531	0.469	6.68	6.99	6.60	6.38	6.88	6.97
3	7.90	8.93	0.665	0.700	7.91	8.67	7.42	8.44	7.79	8.89
4	5.33	10.17	0.381	0.910	5.30	10.21	5.22	9.78	5.33	10.14
5	4.11	7.93	0.267	0.608	4.25	8.00	4.04	7.64	4.01	8.14

Note: Nuclear ratio = (material cpm - background)/(standard cpm - background); AC<sub>t</sub> =  $1.699 + 9.520$  (nuclear ratio) by least squares; AC<sub>e</sub> = extraction test results; and AC<sub>e</sub><sup>1</sup> =  $-0.5065 + 1.1188$  (AC<sub>e</sub>) by least squares.

TABLE 2  
EFFECT OF VARIOUS AGGREGATES

Test	Aggregate	Maximum Size (in.)	Nuclear Ratio
1	Gravel	1 1/2	0.247
2	Sand and gravel	1/2	0.226
3	Slag	1/2	0.200
4	Sand and gravel	3/8	0.268
5	Gravel	1/2	0.252

TABLE 3  
EFFECT OF HYDROGEN  
CONTENT VARIATION

Test	Nuclear Ratio (pure asphalt cpm/std cpm)
1	3.703
2	3.693
3	3.691
4	3.557
5	3.567

bitumen was evaluated by 5 tests of the same liquid asphalt. Results are given in Table 3. Results indicated that there was a slight difference in hydrogen content for different batches of the same bitumen. A difference in hydrogen content for different brands of bitumen had previously been reported (1).

### CONCLUSIONS

The results of this study indicate the following conclusions:

1. The nuclear method of determining asphalt content by neutron moderation appears as reliable as the standard extraction process for the gage used and the samples studied.
2. The test by nuclear methods can be performed by an individual with limited experience because of its simplicity; however, trained technicians are required to accurately prepare bitumen samples for calibration of the system.
3. After initial calibration, a test for asphalt content can be completely run in 15 minutes by the nuclear method employing the gage studied, compared to an hour or more for an extraction test.
4. There are definite effects on the nuclear test result due to the type of aggregate, but these may be accounted for by simple subtraction. Moisture trapped in the aggregates may similarly be accounted for.
5. There appears to be a slight difference in the hydrogen content of different batches of asphalt cement of given manufacture.
6. For limited samples, no gradation effect was noticed comparing one aggregate of two widely different gradations.
7. The possibility exists of an effect on count rate of slow neutrons due to aggregate specific gravity. This effect should be studied in more detail.

### REFERENCES

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