

INDIANA DEPARTMENT OF TRANSPORTATION

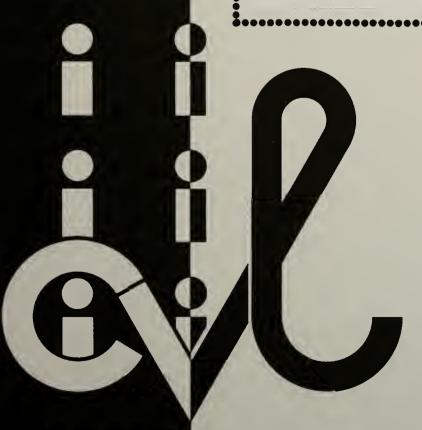
JOINT HIGHWAY RESEARCH PROJECT

JHRP-91/1

Final Report

APPLICATION OF A RAPID ASPHALT CONTENT TEST TO SLAG MIXES

Douglas Winslow





PURDUE UNIVERSITY



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FINAL REPORT

Application of a Rapid Asphalt Content Test to Slag Mixes

To: Harold Michael, Director

Joint Highway Research Project

From: Douglas Winslow

8 January 1991

Project No.: C-36-6KK

File No.: 2-5-37

Attached is the final report on an INDOT Study entitled "Application of a Rapid Asphalt Content Test to Slag Mixes". The research was funded by the Toll Road Division of INDOT. This report includes results from both laboratory and field experiments into the possible use of a rapid test for asphalt content of mixes containing slag aggregate. The report is forwarded for acceptance by INDOT.

Respectfully submitted,

Douglas Winslow

cc:

A. Altschaeffl J. Chameau W. Chen W. Dolch A. Fendrick J. Fricker D. Halpin	G. Henneke K. Hoover C. Letts C. Lovell D. Lucas J. McLaughlin D. Nelson	P. Owens B. Partridge C. Scholer G. Shoener K. Sinha C. Venable T. White
D. Halpin	D. Nelson	T. White

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Application of a Rapid Asphalt Content Test to Slag Mixes

by

Douglas Winslow

Joint Highway Research Project

Project No.: C-36-6KK

File No.: 2-5-37

Prepared for an Investigation

Conducted by

Joint Highway Research Project Engineering Experiment Station Purdue University

in cooperation with the

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> Purdue University West LaFayette, Indiana 47907

> > 8 January 1991

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INTRODUCTION

The current test used by the Indiana Department of Transportation, INDOT, for determining the asphalt content of a bituminous paving mixture is a vacuum extraction that takes about one hour to complete. Such a lengthy test can allow a large amount of mix to be produced and placed while the test is being done. It also limits the number of tests that an inspector can perform. It is obviously desirable to have a faster test.

There are several faster tests available. One uses a commercially available "nuclear gage" that determines the moderation of neutrons by the asphalt. Another disperses the asphalt in a large volume of solvent and determines the amount of asphalt dispersed. These tests have been used successfully with mixes containing non-slag aggregates and with chlorinated solvents.

However, in northern Indiana, slag is used commonly as an aggregate in bituminous paving mixtures. Slag is typically much more porous than other common aggregates. So, it is able to absorb, and hold, more asphalt cement. This may add to the difficulties when rapidly analyzing a bituminous mixture for its asphalt content. Furthermore, INDOT wishes to use a non-chlorinated, biodegradable asphalt solvent. Such a solvent may not be able to disperse the asphalt rapidly.

The fast tests have not been used by INDOT for the analysis of mixtures containing slag, or with non-chlorinated solvents. It was the objective of the research that is reported here to try the faster tests with these constraints and to advise INDOT on their suitability for use by inspectors.

The research consisted of two segments. In the first, laboratory tests were performed using the rapid tests. These tests were conducted on small, carefully made bituminous mixes having accurately known asphalt contents. The second segment consisted of having INDOT inspectors use the most promising of the two rapid tests in field trials to assess its applicability.

LABORATORY TESTING

The laboratory portion of the research was conducted by the INDOT Research Division. The first portion involved the calibration of the rapid test methods with mixtures of known asphalt content. Three different mixtures were used. These were, in INDOT parlance, a #5 Base, a #8 Binder and a #11 Surface mix. In all cases, the mixtures were made completely with slag aggregate from Northern Indiana. The aggregate quantities used in each of these mixes are given in Tables 1, 2 and 3.

Table 1
#5 Base Mix Aggregate Gradation

Aggregate Size	Amount (g)
1 1/2" - 1"	1000
1"- 3/4"	1500
3/4" - 1/2"	1900
1/2" - 3/8"	600
3/8" - #4	600
#4 - #8	900
#8 - #16	800
#16 - #30	1400
#30 - #50	700
#50 - #100	400
#100 - #200	100

Table 2
#8 Binder Mix Aggregate Gradation

Aggregate Size	Amount (g)
1"- 3/4"	1200
3/4" - 1/2"	3800
1/2" - 3/8"	700
3/8" - #4	300
#4 - #8	1000
#8 - #16	1000
#16 - #30	800
#30 - #50	600
#50 - #100	300
#100 - #200	200

Table 3
#11 Surface Mix Aggregate Gradation

Aggregate Size	Amount (g)
1/2" - 3/8"	600
3/8" - #4	2800
#4 - #8	1400
#8 - #16	900
#16 - #30	1200
#30 - #50	2300
#50 - #100	600
#100 - #200	100

All calibration mixtures were made using an AC-20 asphalt cement from a single source. Each mixture type was prepared at five different asphalt contents. In this report, asphalt content is always calculated and reported as the percentage of the total mixture mass that is asphalt. The asphalt contents of the calibration mixtures are given in Table 4.

The three series of mixtures described above were used to calibrate the two rapid test procedures. In the case of the "nuclear gage", each mixture was tested with a Troxler

Table 4
Asphalt Contents of Calibration Mixtures

Mixture Type	Asphalt Contents (%)
#5 Base	4.0, 4.2, 4.5, 4.8, 5.1
#8 Binder	4.1, 4.4, 4.7, 5.0, 5.2
#11 Surface	5.5, 5.8, 6.2, 6.7, 7.0

3241-C Asphalt Content Gage in accordance with the manufacturer's instructions. Moderated neutron counts were accumulated for 16 minutes for each calibration mixture. In the case of the rapid dispersion test, each mixture was tested in accordance with the procedures previously developed for that test [1] except that BIOACT DG-1 was used as the solvent.

From the outset, the rapid dispersion test gave results with excessive scatter. It became apparent that this test would not provide useful data with the BIOACT solvent.

Therefore, it was dropped from further testing.

The "nuclear gage" yielded reasonably satisfactory calibration curves. These are shown in Figure 1. The actual data points for each mixture type are displayed in the figure along with a third-order polynomial line that best fits the data. This line is calculated by the "nuclear gage's" software during the calibration procedure, and is used by the gage during tests. The binder mixes have more scatter than would probably be desirable for acceptance testing of mixes in the field. However, it was felt that the curve was adequate for purposes of the laboratory tests.

The "nuclear gage" procedure was then subjected to further testing in the laboratory.

In this phase of the lab work, mixes were prepared with accurately known asphalt

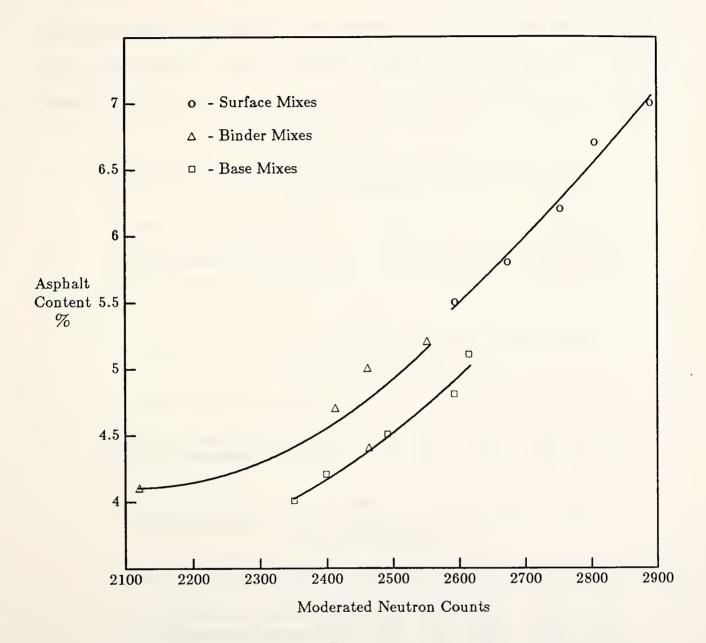


Figure 1
"Nuclear Gage" Calibration Curves

contents that were usually different from those used to obtain the calibration curves. Five mixes, at differing asphalt contents were prepared for each of the three mix types. These were tested in the "nuclear gage" using the calibration, and the results were compared to the known asphalt contents. Then these 15 mixes were made a second time and tested again. For these tests, neutron counts were accumulated for only 4 minutes

for each sample. This shorter time was selected for these tests since some preliminary studies showed that longer accumulation times did not improve the accuracy significantly. The results of this phase of the lab work are given in Tables 5, 6, and 7.

Table 5 Laboratory Asphalt Content Determinations Using "Nuclear Gage" (#5 Base Mixtures) 4.90 5.104.20 4.50 4.70 Actual Asphalt Content (%) 4.77 4.84 Trial #1 Measured Content (%) 4.24 4.24 4.68 Trial #2 Measured Content (%) 4.88 5.01 4.53 4.64 4.34 Table 6 Laboratory Asphalt Content Determinations Using "Nuclear Gage" (#8 Binder Mixtures) 4.40 4.70 4.90 5.105.40Actual Asphalt Content (%) Trial #1 Measured Content (%) 4.91 4.92 5.20 5.14 4.495.54 Trial #2 Measured Content (%) 4.34 4.93 4.81 5.03Table 7 Laboratory Asphalt Content Determinations Using "Nuclear Gage" (#11 Surface Mixtures) 6.20 6.40 6.705.70 6.00Actual Asphalt Content (%)

These lab test results are also summarized in Figure 2. In the figure, the solid line represents an exact correlation between the known and measured asphalt contents. The dotted lines form a band within which the measured asphalt content differs from the true content by no more than \pm 0.3% asphalt. Most of the test results fall within this band. It is felt that some of the scatter in the results may be due to problems with

6.08

5.88

Trial #1 Measured Content (%)

Trial #2 Measured Content (%)

5.86

6.00

5.85

6.68

6.25

6.62

7.67

6.86

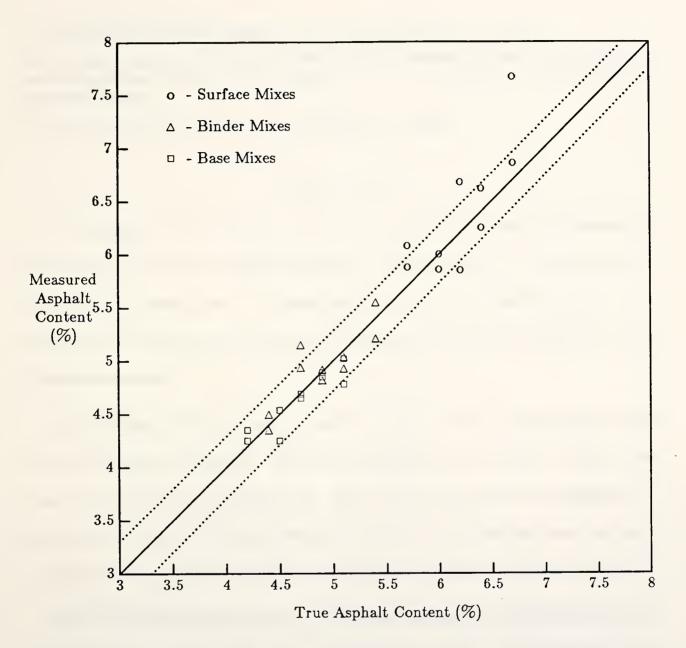


Figure 2
Laboratory Asphalt Content Determinations Using "Nuclear Gage"

taking a representative sample from a comparatively small, laboratory size, batch of a mix. It seems likely that this sampling problem would not be so acute when obtaining a sample from a large quantity of mix produced at a plant.

The results of the laboratory phase of the research were these:

- 1. The rapid dispersion test does not work well with the BIOACT solvent.
- 2. The "nuclear gage" provides an accurate method of determining the asphalt content of bituminous mixes made with slag aggregates when the manufacturer's instructions are followed carefully.
- 3. The "nuclear gage" is fast and comparatively easy to use.

FIELD TESTING

The findings of the laboratory phase of the work where presented to representatives of the INDOT Toll Road Division and LaPorte District. They were also instructed in the use of the "nuclear gage". The technique was then used by these two groups to test mixes containing slag aggregates that were being placed under contracts during the 1990 construction season.

The Toll Road Division tested one material: a #11 surface mix that contained both fine and coarse slag aggregate. The design asphalt content was 6.0%. The mix was tested 7 times with the "nuclear gage". However, extraction tests were performed on samples from the job that were obtained at different times and that were not exact companion samples. The results of the Toll Road measurements are given in Table 8.

The LaPorte District also used the "nuclear gage" on one mix: a #11 surface mix that contained a coarse slag aggregate and a natural sand fine aggregate. The design asphalt content of the mixes was 6.6%. They conducted eight tests on samples that were companions to ones on which the standard extraction test had been performed. Their results are given in Table 9.

In general, both groups got results with the "nuclear gage" that are comparable to those from the standard extraction test. However, as a rule, the "nuclear gage" gives an

Table 8
Toll Road Tests on #11 Surface Mixtures

Design Asphalt Content	6.0%
Extraction Test Results	5.7% - 6.0%
"Nuclear Gage" Results	6.18% 6.10% 6.30% 6.16% 6.15% 6.15%

Table 9
LaPorte Division Tests on #11 Surface Mixtures

Extraction	"Nuclear Gage"
Result (%)	Result $(\%)$
5.9	5.8
6.1	6.2
6.1	6.3
6.1	6.3
6.2	6.3
6.3	6.3
6.4	6.2
6.4	6.3

asphalt content that is 0.1 - 0.2% greater than the extraction. This is probably to be expected. The porous aggregate is likely to hold some asphalt during extraction and this asphalt will not be recorded. However, the nuclear gage will find and include all asphalt within the mix.

Both groups found the "nuclear gage" to be both fast and easy to use. Once a calibration curve, similar to one of the ones shown in Figure 1, was established, they found that a single test took less than 10 minutes. This compares very favorably with

the 1 hour or more required for an extraction.

The "nuclear gage" has advantages other than speed over the standard extraction test. One big plus is that it does not require the inspector to make any decisions. During an extraction test, the inspector must decide when sufficient solvent has been used to have extracted essentially all of the asphalt. He or she must also continue to dry the remaining aggregate until an equilibrium weight has been reached. With the "nuclear gage", the inspector merely fills the sample chamber, starts the count and reads the resulting asphalt content. No decisions are required, or allowed, by the testing technique.

Another advantage of the "nuclear gage" is that it uses no solvent. INDOT has started using non-chlorinated, biodegradable solvents that are less inimical than older solvents. However, these solvents still pose a disposal problem. It is clearly better to do away with the solvent entirely. In addition, the solvent is reasonably expensive at \$7 - \$8 per gallon. Indeed, the savings in the cost of the solvent over time will ameliorate the initial cost of a "nuclear gage".

The only significant disadvantage to the "nuclear gage" is its cost of about \$7000. This is about 10 times the cost of extraction equipment. However, this cost must be compared to the value of the material being tested. Over the lifetime of the instrument its initial cost will be a minuscule fraction of the value of the tested pavement. Further, if a single problem due to a wrong asphalt content is detected by an instrument, the savings will far exceed the cost of equipping an inspector with a "nuclear gages". In addition, the portability of the gage may reduce the number of instruments that will be

needed to cover the required test sites.

CONCLUSIONS

- 1. The "nuclear gage" provides an accurate method of determining the asphalt content of bituminous mixes made with slag aggregates.
- 2. This testing technique is about an order of magnitude faster than the conventional extraction test.
- 3. The "nuclear gage" is superior to extraction in that it does not require, or permit, any decisions on the part of the inspector.
- 4. It is also superior because it uses no solvent with the attendant costs and disposal problems.
- 5. INDOT personnel found the "nuclear gage" to be easy to use in actual field applications during construction.

REFERENCES

1. J.J. Martinez and D.N. Winslow, "A Rapid Test for Asphalt Content of Bituminous Mixtures", Journal of Testing and Evaluation, Vol. 14, 1986, p. 28-32

APPENDIX - EXTRACTION TESTS

The objective of this research project was the application of fast tests to mixes with slag aggregate. However, some of the laboratory mixes were also tested for asphalt content using vacuum extraction and the biodegradable solvent. The extraction tests were outside the scope of the research, but are reported here because they proved to be interesting. The results of these tests are given in Tables 10, 11 and 12 and they are summarized in Figure 3.

Table 10
Laboratory Asphalt Content Determinations Using Vacuum Extraction
(#5 Base Mixtures)

Actual Asphalt Content (%)			4.50		
Measured Asphalt Content (%)	3.57	3.62	3.82	5.14	5.46

Table 11
Laboratory Asphalt Content Determinations Using Vacuum Extraction
(#8 Binder Mixtures)

Actual Asphalt Content (%)	4.10	4.40	4.70	5.00	5.20
Measured Asphalt Content (%)	2.99	4.88	4.40	4.40	4.76

Table 12
Laboratory Asphalt Content Determinations Using Vacuum Extraction
(#11 Surface Mixtures)

Actual Asphalt Content (%)	5.50	5.80	6.20	6.70	7.00
Measured Asphalt Content (%)	5.07	5.68	6.25	6.29	7.12

It is obvious that the vacuum extraction gave results that were inferior to those of the "nuclear gage" as shown in Figure 2. Only a few of the data points fall within the ± 0.3% band. The majority of the data fall outside of the band with the measured asphalt content being generally less than the true content. It is likely that much of this

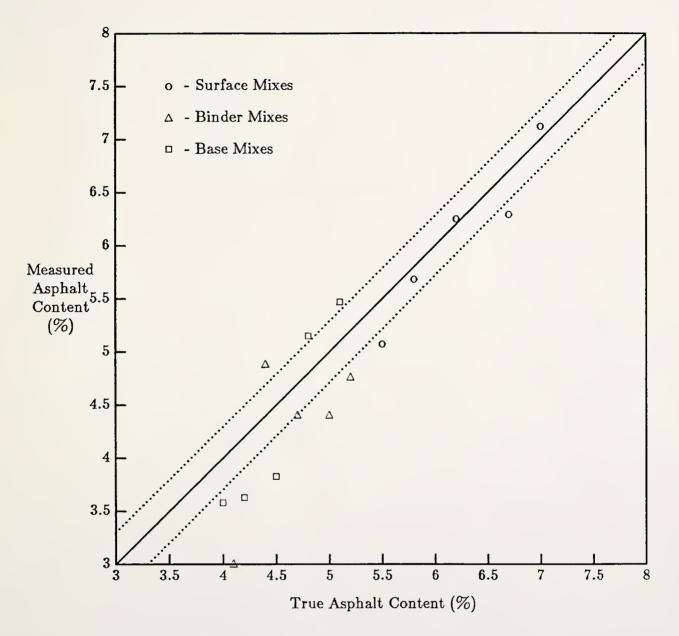


Figure 3
Laboratory Asphalt Content Determinations Using Vacuum Extraction

deviation is due to some of the asphalt being retained by the porous, slag aggregate. Whatever the reason for the deviation, it appears that the vacuum extraction test is not as good at determining the total asphalt content of these mixes as is the "nuclear gage".

