PROCEDURE FOR RECOVERY OF ASPHALT CEMENT

IN

MARSHALL METHOD DESIGN SPECIMENS

Report R72-1

January 1972

VERMONT DEPARTMENT OF HIGHWAYS

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ABSTRACT

A recent investigation conducted by the Bituminous Concrete Section of the Materials Division has resulted in a more accurate procedure for recovering asphalt cement from asphaltic test mixtures. This procedure will insure more meaningful Marshall Method design results in the future.

INTRODUCTION

The primary design method for Bituminous Concrete Mixtures used by the Vermont Department of Highways is the Marshall Method. Employing this method requires the design and examination of various types of bituminous concrete trial mixtures at the Department's Materials Laboratory. The equipment used in the Laboratory to produce these mixtures is similar in theory to the apparatus used in the field at an actual hot mix plant. The Laboratory mixing device is a 12 quart capacity electric mixer (Fig. 1) and the asphalt cement used is heated electrically and added to the aggregate through a single nozzle (Fig. 2). The 2000 - 4000 gram test batches produced in the laboratory are in consistency, temperature, and substance, the same as the one to six ton batches produced by contractor's full sized plants in the field. An important function of this method is the addition and recovery of a known amount of asphalt cement. This function has not been consistent in the past due to various difficulties encountered during the mixing process.

Because of the many variables incolved in weighing, mixing, and extracting the asphalt cement, this report outlines the numerous procedures involving these steps that were used until the margin of error was reduced to an acceptable level. The deviation between the amount of asphalt added and recovered had previously varied from 0.0% to approximately 0.5%, which in a 4000 gram batch would be from zero to 20 grams. It has been shown that a lower deviation can be achieved by using a specific sampling procedure.

PROCEDURE & RESULTS

STEP I

The following refers to Table I:

The first area checked for possible error was the extraction process. A known amount of Ottawa sand and known amounts of asphalt cement were put unmixed into a large extractor bowl and extracted. This particular procedure was carried out four times. For the first test (A) the asphalt cement added to the Ottawa sand was 4.8%, after the extraction (Aa) 4.9% asphalt was recovered. In the second sample (B) the asphalt cement added was 5.4%, after being extracted (Bb) 5.4% was recovered. For the third test (C) the asphalt cement added was 7.9%, after being extracted (Cc) 8.0% was obtained. For the last test in Step I (D) 8.3% asphalt cement was added, and after being extracted (Dd) 8.3% asphalt was obtained. From these tests the average deviation* was .05% indicating that the extraction process is not the primary source of error.

*Deviation as referenced to here is the amount of discrepancy between the percent of asphalt originally added to create the test mixture and the amount recovered by extracting that same test mixture.

STEP 2

The following refers to Table II:

In Step 2 there were two tests that were performed. Known quantities of Ottawa sand and asphalt cement were put into the electric mixer and mixed for one minute. Two size "0" scoops of this material were removed from the mixing apparatus and put into a small extractor bowl and extracted. In test (E) there was 4.9% asphalt put in the mix and only 4.6% (Ee) was recovered. For test (F) 4.81% was added to the Ottawa sand and 4.3% (Ff) was recovered. The results were not very good as the average deviation was 0.43% or 4.3 grams in a 1000 gram sample.

STEP 3

The following refers to Table III:

Known quantities of asphalt cement and Ottawa sand were put in the mixing apparatus and mixed for one minute. Scoops of mix were then taken from the mixing bowl. The bowl, paddle, spatula and all equipment were weighed, then everything was washed clean with xylol. Care was taken to put all of the mixture (including that portion washed off equipment) into the small extractor bowls and extracted. In this step a total of five tests were performed. In tests (G) and (H) six grams were unaccounted for in the recovery of a 2000 gram sample. This loss of six grams in both tests (G) and (H) were never accounted for. However, the balance was checked and zeroed, everything was reweighed and three more tests were processed. The average deviation for the next three tests was 0.02% which was very satisfactory. With test (I) the same amounts of sand and asphalt as were used in tests (G) and (H) the amount recovered was the same as added. In test (J) the sand recovered was the same amount as was started with but the asphalt content had increased from 7.25% actual asphalt content to /.32%. In test (K) the results were very good with 8.09% asphalt added and recovered.

STEP 4

The following refers to Table IV:

For the next phase of the experiment specific quantities of bank run sand and asphalt cement were placed in the mixer and mixed for one minute. As in Step 3, all implements and apparatus were washed clean. Again, all the mixture was extracted. In test (L) 6.09% asphalt was asked for and (L1) 6.09% asphalt was recovered. In test (M) 800% asphalt was added and (mm) 8.14% was recovered. The average deviation was 0.07% which is acceptable. It is mentioned at this time that the deviation may be attributed at some times to the fact that the balance used was overloaded when the bowl and ingredients were weighed together. A new and large balance has been ordered that will have the capacity and accuracy to do this type of work in the future.

STEP 5

The following refers to Table V:

A bank run sand was combined again in known quantities with a known amount of asphalt cement. The mixture was removed from the mixing bowl and placed on a sampling board. Two scoops were then taken from opposite sides of the circular pile of hot mix and extracted. In this step 8.00% asphalt (N) was designed with 7.44% (Nn) recovered. The deviation was 0.56% which is unacceptable, so no more samples were run in this manner.

STEP 6

The following refers to Table VI:

Next, 8.00% asphalt (O) was added to the bank run sand. The sand and asphalt cement were then combined in the electric mixer. After mixing for one minute, the sides of the bowl were scrapped when the mixture was still hot. After being scraped the bowl was inverted and slammed against the sampling board to remove as much of the material as possible. Scoops were then taken from opposite sides of the circular sample pile and placed in a small extraction bowl. The asphalt cement was then extracted (Oo) and 7.96% was recovered. In test (P) 8.02% asphalt was added and 7.80% (Pp) was recovered. For the last test (Q) in Step 6, 8.00% asphalt was added and 8.00% (Qq) was recovered. The average deviation in this case was 0.11% which in a 1000 gram sample would equal 1.1 grams. This is an acceptable figure.

STEP 7

The following refers to Tables VII A,B and C:

In all previous testing the materials used were asphalt cement and some kind of sand. For the next phase of experimentation different sizes of aggregates were graded. A mix was then designed and blended to create an actual sample of Bituminous Concrete as it is used on Vermont Highways. The types of mixes made were Types II, III and IV.

For Type II mix, which contains aggregate of 3/4" maximum size, aggregates were graded and mixes were designed with 5.0%, 5.5% and 6.0% asphalt and batch weights were drawn up for 4000 gram samples.

The same procedure was followed for Types III (½" maximum size aggregate) and IV (3/8" maximum size aggregate) with three different percentages of asphalt cement in each type.

The sampling procedure mentioned in Step 6 was the method that was used in testing of Type II, III and IV.

For Type II with 5.0% (B-1) actual asphalt content called for, 5.1% was recovered. Test B-2 and B-3 were discredited after it was found out that the mixing bowl after being used on B-1 was not reweighed, giving us unpredictable results. Test B-4 and B-5 were then run with 6.0% and 5.5% actual asphalt respectively. The recovered results were 6.0% and 5.4% thus giving an acceptable average deviation of 0.07%.

The acutal asphalt content for Type III was 6.0%, 6.5% and 7.0% and 6.1%, 6.5% and 6.8% respectively were recovered giving an acceptable average deviation of 0.10%

In Type IV, 6.5%, 7.0% and 7.5% asphalt were asked for and 6.4%, 6.8% and 7.1% asphalt was recovered. The average deviation was .2%, which is unacceptable. Realizing that the 6.4% was only a 0.1% deviation and the other two tests were outside this deviation, it was decided that a new Type IV mix with another source of aggregate should be tested (another source of aggregate only because the original aggregate was used up in the preceeding steps). The asphalt content of 6.5%, 7.0% and 7.5% were still asked for and 6.5%, 7.0% and 7.6% were recovered, the average deviation for the three tests was 0.03% which is acceptable

Some important steps in the test mixing procedure that should be mentioned are heating of the mixing bowl, paddle, and sampling scoops. These implements are heated to a temperature approximately the same as the test batch to help maintain a mix temperature of 300°F-325°F.

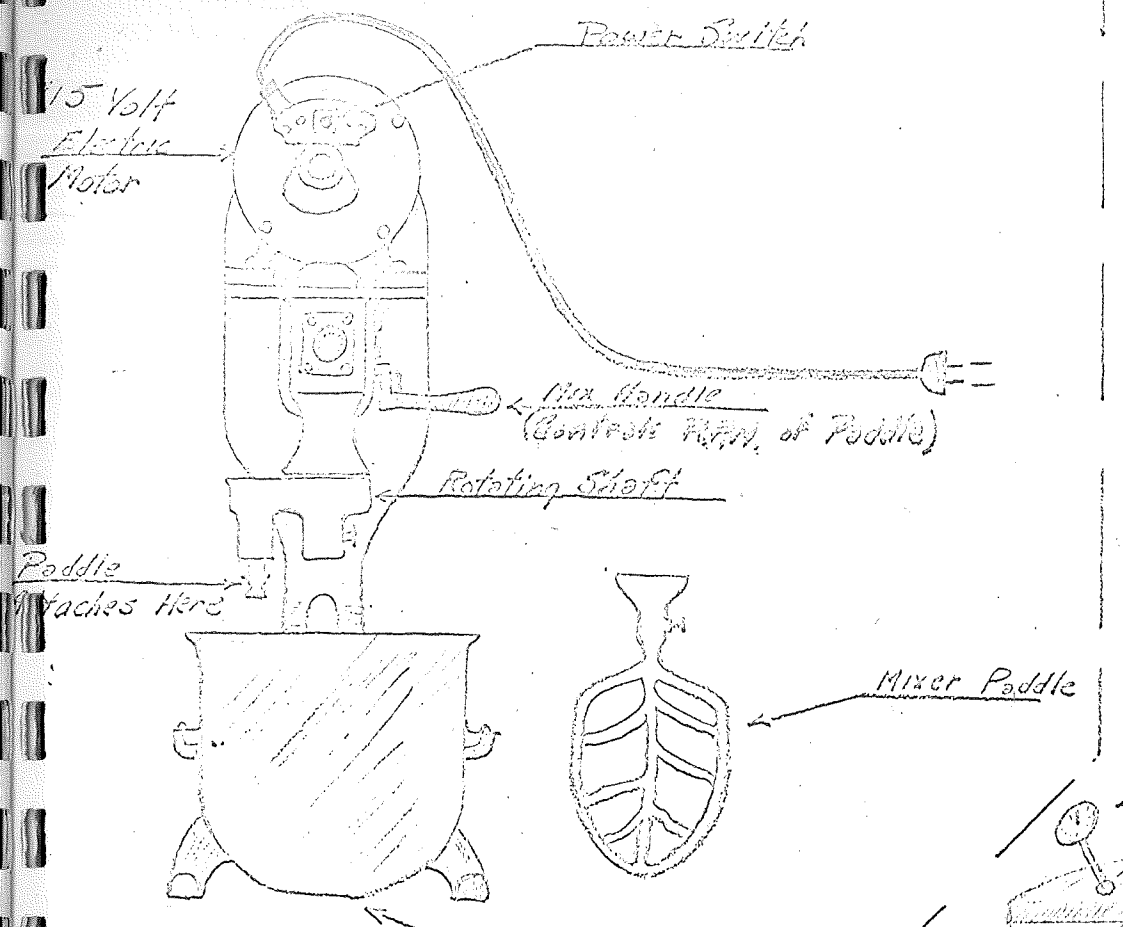
When the asphalt cement is added to the mixing bowl containing the preheated mineral aggregate, it is done so while the bowl containing the aggregate is on the torsion balance so as to permit direct weighing of the aggregate, bowl, and asphalt. In previous experiments, test batches using a separate container to measure out specific amounts of asphalt cement was not considered accurate enough. The reason was that some of the asphalt remained on the sides and bottom of the container after it was emptied into the mixing bowl. As a result, the exact percentage of Ac that was desired was not being introduced. By using the new procedure the margin of error involved in adding the proper amount of asphalt to the test batches, is practically eliminated.

CONCLUSION

After completing all seven steps in the recovery procedure, it was felt that the most efficient and accurate method used was in steps number six and seven. Here the mixing bowl is scraped and slammed forcibly on the sampling board after which two scoops are taken from opposite sides of the pile of hot mix just emptied and extracted. The average deviation from the desired value for nine tests in step seven was .07% or less than 1 gram in a thousand. This is the best accuracy obtainable with the present balances. This method also takes the least amount of time without sacrificing the much needed accuracy required.

ELECTRIC MIXER

FIG #1.



Asphalt Heater & Reservoir

FIG. #2.

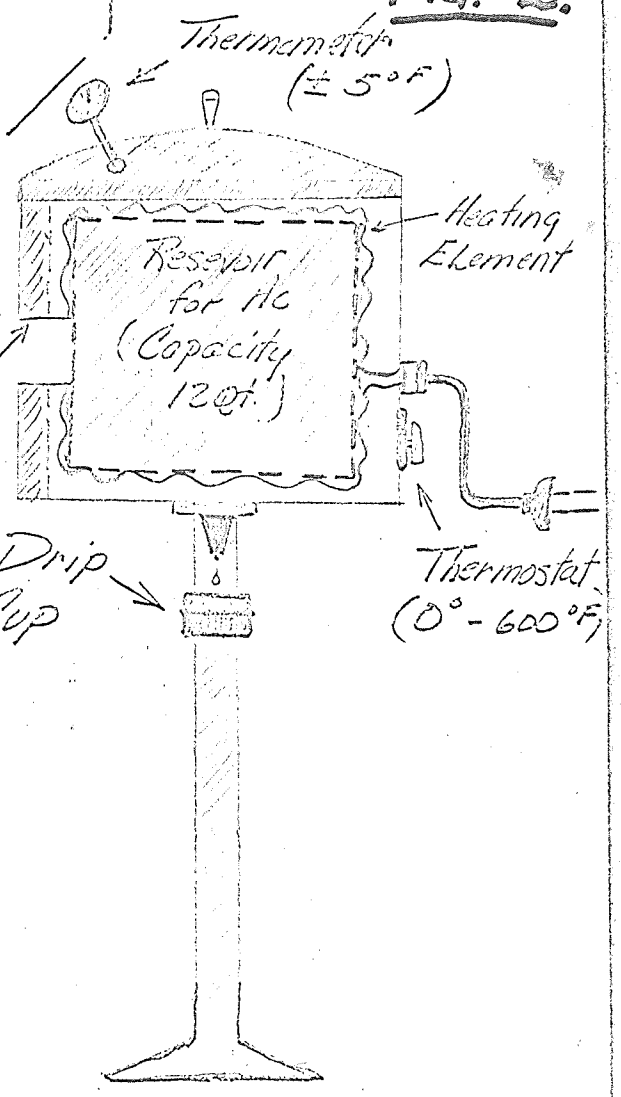
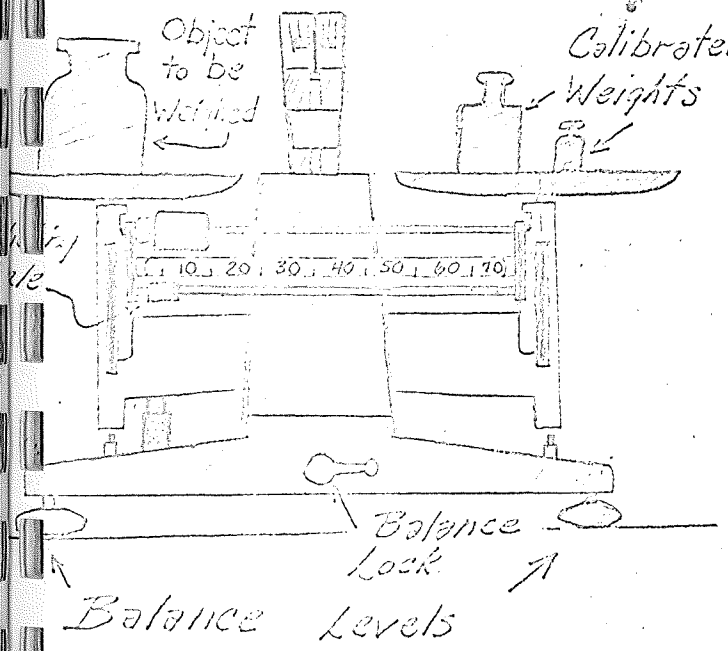


FIG #3.



Asphalt Addco

A
BOWL AND MIX 3142
BOWL 2092
MIX 1050
–AGGREGATE 1000
50 = 4.8 % BITUMEN
÷ MIX 1050

B
BOWL AND MIX 3149
BOWL 2092
MIX 1057
–AGGREGATE 1000
57 = 5.4 % BITUMEN
÷ MIX 1057

C
BOWL AND MIX 3178
BOWL 2092
MIX 1086
–AGGREGATE 1000
86 = 7.9 % BITUMEN
÷ MIX 1086

D
BOWL AND MIX 3182
BOWL 2092
MIX 1090
–AGGREGATE 1000
90 = 8.3 % BITUMEN
÷ MIX 1090

TABLE

Asphalt Extractor

Aa
BOWL AND MIX
BOWL
MIX 1050
–AGGREGATE 999
51 = 4.9 % BITUMEN
÷ MIX 1050

Bb
BOWL AND MIX
BOWL
MIX 1057
–AGGREGATE 1000
57 = 5.4 % BITUMEN
÷ MIX 1057

Cc
BOWL AND MIX
BOWL
MIX 1086
–AGGREGATE 999
87 = 8.0 % BITUMEN
÷ MIX 1086

Dd
BOWL AND MIX
BOWL
MIX 1090
–AGGREGATE 1000
90 = 8.3 % BITUMEN
÷ MIX 1090

TABLE H

Asphalt Added

E
BOWL AND MIX _____
BOWL _____
MIX 4203
−AGGREGATE 4000
203 = 4.94 % BITUMEN
÷ MIX 4208

F
BOWL AND MIX _____
BOWL _____
MIX 4207
−AGGREGATE 4000
207 = 4.81 % BITUMEN
÷ MIX 4207

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE 3

Asphalt Extracted

Ea
BOWL AND MIX _____
BOWL _____
MIX 1284
−AGGREGATE 1225
59 = 4.6 % BITUMEN
÷ MIX 1284

Fa
BOWL AND MIX _____
BOWL _____
MIX 1116
−AGGREGATE 1068
48 = 4.3 % BITUMEN
÷ MIX 1116

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE 4

ASPHALT ADDED

G

BOWL AND MIX _____
BOWL _____
MIX 2009
−AGGREGATE 1880
129 = 6.42 % BITUMEN
÷ MIX 2009

H

BOWL AND MIX _____
BOWL _____
MIX 2001
−AGGREGATE 1880
121 = 6.05 % BITUMEN
÷ MIX 2001

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE 37

ASPHALT EXTRACTED

G9

BOWL AND MIX _____
BOWL _____
MIX 2003
−AGGREGATE 1880
123 = 6.14 % BITUMEN
÷ MIX 2003

H6

BOWL AND MIX _____
BOWL _____
MIX 1995
−AGGREGATE 1880
115 = 5.76 % BITUMEN
÷ MIX 1995

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE 37

ASPHALT ADDED

I
BOWL AND MIX
BOWL
MIX 2000
–AGGREGATE 1830
120 = 6.00 % BITUMEN
÷ MIX 2000

J
BOWL AND MIX
BOWL
MIX 2005
–AGGREGATE 1860
145 = 7.25 % BITUMEN
÷ MIX 2005

K
BOWL AND MIX
BOWL
MIX 2002
–AGGREGATE 1840
162 = 8.09 % BITUMEN
÷ MIX 2002

BOWL AND MIX
BOWL
MIX
–AGGREGATE
= % BITUMEN
÷ MIX

ASPHALT EXTRACTED

Ii
BOWL AND MIX
BOWL
MIX 2000
–AGGREGATE 1880
120 = 6.00 % BITUMEN
÷ MIX 2000

Jj
BOWL AND MIX
BOWL
MIX 2007
–AGGREGATE 1860
147 = 7.32 % BITUMEN
÷ MIX 2007

Kk
BOWL AND MIX
BOWL
MIX 2003
–AGGREGATE 1841
162 = 8.09 % BITUMEN
÷ MIX 2003

BOWL AND MIX
BOWL
MIX
–AGGREGATE
= % BITUMEN
÷ MIX

TABLE II (cont.)

TABLE 37

ASPHALT ADDED

L

BOWL AND MIX _____

BOWL _____

MIX 2002

–AGGREGATE 1880

122 = 6.09 % BITUMEN

÷ MIX 2002

M

BOWL AND MIX _____

BOWL _____

MIX 2000

–AGGREGATE 1840

160 = 8.00 % BITUMEN

÷ MIX 2000

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

ASPHALT EXTRACTED

LI

BOWL AND MIX _____

BOWL _____

MIX 2063

–AGGREGATE 1881

122 = 6.09 % BITUMEN

÷ MIX 2063

LIm

BOWL AND MIX _____

BOWL _____

MIX 2002

–AGGREGATE 1839

163 = 8.14 % BITUMEN

÷ MIX 2002

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

TABLE IV

12813

Asphalt Added

N

BOWL AND MIX _____

BOWL _____

MIX 2000

—AGGREGATE 1840

160 = 8.00 % BITUMEN

÷ MIX 2000

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

TABLE 37

Asphalt Extracted

Nn

BOWL AND MIX _____

BOWL _____

MIX 699

—AGGREGATE 647

52 = 7.44 % BITUMEN

÷ MIX 699

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

—AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

TABLE 4

ASPHALT ADDED

Q

BOWL AND MIX _____
BOWL _____
MIX 2000
–AGGREGATE 1840
160 = 8.00 % BITUMEN
÷ MIX 2000

P

BOWL AND MIX _____
BOWL _____
MIX 4001
–AGGREGATE 3680
321 = 8.02 % BITUMEN
÷ MIX 4001

Q

BOWL AND MIX _____
BOWL _____
MIX 4000
–AGGREGATE 3680
320 = 8.00 % BITUMEN
÷ MIX 4000

BOWL AND MIX _____
BOWL _____
MIX _____
–AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

ASPHALT EXTRACTED

Qe

BOWL AND MIX _____
BOWL _____
MIX 823
–AGGREGATE 758
65 = 7.9 % BITUMEN
÷ MIX 823

Pp

BOWL AND MIX _____
BOWL _____
MIX 1193
–AGGREGATE 1100
93 = 7.8 % BITUMEN
÷ MIX 1193

Qq

BOWL AND MIX _____
BOWL _____
MIX 975
–AGGREGATE 897
78 = 8.0 % BITUMEN
÷ MIX 975

BOWL AND MIX _____
BOWL _____
MIX _____
–AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE 37

TABLE 37A

ASPHALT ADDED

B-1
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 5.0 % BITUMEN
÷ MIX _____

B-4
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 6.0 % BITUMEN
÷ MIX _____

B-5
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 5.5 % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

ASPHALT EXTRACTED

B-1
BOWL AND MIX _____
BOWL _____
MIX 907
−AGGREGATE 861
46 = 5.1 % BITUMEN
÷ MIX 907

B-4
BOWL AND MIX _____
BOWL _____
MIX 1017
−AGGREGATE 951
61 = 6.0 % BITUMEN
÷ MIX 1017

B-5
BOWL AND MIX _____
BOWL _____
MIX 1023
−AGGREGATE 968
55 = 5.4 % BITUMEN
÷ MIX 1023

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE III
TYPE A MIX

TABLE

ASPHALT ADDED

T-1
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 6.0 % BITUMEN
÷ MIX _____

T-2
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 6.5 % BITUMEN
÷ MIX _____

T-3
BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = 7.0 % BITUMEN
÷ MIX _____

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

ASPHALT EXTRACTED

T-1
BOWL AND MIX _____
BOWL _____
MIX 1122
−AGGREGATE 1054
68 = 6.1 % BITUMEN
÷ MIX 1122

T-2
BOWL AND MIX _____
BOWL _____
MIX 1076
−AGGREGATE 1006
70 = 6.5 % BITUMEN
÷ MIX 1076

T-3
BOWL AND MIX _____
BOWL _____
MIX 1092
−AGGREGATE 1018
74 = 6.8 % BITUMEN
÷ MIX 1092

BOWL AND MIX _____
BOWL _____
MIX _____
−AGGREGATE _____
_____ = _____ % BITUMEN
÷ MIX _____

TABLE III B
MIX TYPE III

TABLE 3

ASPHALT ADDED

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = 6.5 % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = 7.0 % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = 7.5 % BITUMEN

÷ MIX _____

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

TABLE ___

ASPHALT EXTRACTED

BOWL AND MIX _____

BOWL _____

MIX 816

–AGGREGATE 763

53 = 6.5 % BITUMEN

÷ MIX 816

BOWL AND MIX _____

BOWL _____

MIX 883

–AGGREGATE 821

62 = 7.0 % BITUMEN

÷ MIX 883

BOWL AND MIX _____

BOWL _____

MIX 821

–AGGREGATE 759

62 = 7.6 % BITUMEN

÷ MIX 821

BOWL AND MIX _____

BOWL _____

MIX _____

–AGGREGATE _____

_____ = _____ % BITUMEN

÷ MIX _____

TABLE VII C
MIX
Type H