EVALUATION OF LIMESTONE FILLER IN GRAVEL MIXTURES OF ASPHALTIC CONCRETE
IOWA STATE HIGHWAY COMMISSION
DEPARTMENT OF MATERIALS

Report for
Research Project R-228

Evaluation of Limestone Filler
in Gravel Mixtures
"Asphaltic Concrete"

Initiated September, 1967
Reported February, 1968

by

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and

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Figure 1. Comparison of standard 1 inch binder course mix with alternate mix.

Figure 2. Comparison of standard 1 inch binder mix and alternate mixture gradations.

Figure 3. Comparison of standard 3/8 inch surface course mix with alternate mix.

Figure 4. Comparison of standard 3/8 inch surface course mix and alternate mix gradations.

Figure 5. Comparison of standard 3/4 inch surface course mix with alternate mix.

Figure 6. Comparison of standard 3/4 inch mix and alternate mix gradations.

Table 1. Comparison of characteristics of standard and alternate mixtures.
INTRODUCTION

This study was designed to provide background information on asphaltic concrete mixtures peculiar to northwest Iowa. This background is necessary to provide the basis for future specifications. There were several projects let in 1967 involving 1", 3/4" and 3/8" mixes of Type "B" asphaltic concrete which specified in part, "... Not less than 40% of the material passing the No. 200 sieve shall be pulverized limestone or mineral filler, but in no case shall the per cent of pulverized limestone or mineral filler passing the No. 200 sieve be less than 2%. No credit will be allowed for limestone in gravel..." Northwest Iowa has no suitable limestone or mineral filler locally available. As a result, this material has to be imported, raising the cost of the mix approximately twenty-five cents per ton. The purpose of this study, therefore, was designed to compare some original job mix samples with alternate mixes from the same local material, but without the addition of pulverized limestone or mineral filler. Since the filler from the crushed gravel does not have the same crushing characteristics or sieve analysis as the pulverized limestone or mineral filler, they could not be compared on an equal percentage basis. Therefore, the alternate mixes were made to conform to the following proposed specification, "No less than 40% of the material passing No. 200 sieve shall be pulverized limestone or mineral filler or a 100% crushed gravel, but in no case shall the per cent of pulverized limestone or mineral filler or a 100% crushed gravel passing the No. 200 sieve be less than 2%."
TESTS AND PROCEDURES

The standard series of tests currently used by the ISHC Materials Laboratory for evaluation of job mixes for regular contract work were used for this study. Marshall stability and flow measurements were made to supplement the standard methods of mix testing. All tests and test procedures followed standards currently provided by A.A.S.H.O. and A.S.T.M.

Specimens were compacted by the Marshall mechanical compactor currently used in the laboratory with 50 blows on each side.

MATERIALS

A. 3/4" Pit Run Gravel with 12.5% minimum crushed particles, NW 1/4 1-92-49, Plymouth County.

B. Lime Dust - Weeping Water, Nebraska, 1-10-11 Cass County, Nebraska.

C. 3/4" Crushed Gravel with 100% crushed particles NW 1/4 1-92-49, Plymouth County.

D. -3/8" Crushed Gravel with 100% crushed particles S 1/2 NW 1/4, 15-90-41, Cherokee County.

E. 1" Crushed Gravel with 100% crushed particles S 1/2 NW 1/4, 15-90-41, Cherokee County.

F. -3/8" Pit Run Gravel with no crushed particles S 1/2 NW 1/4, 15-90-41, Cherokee County.

G. Ag. Lime - Fort Dodge Limestone NW 1/4 SW 1/4 24-89N-29W, Webster County.

H. -3/8" Limestone Chips NW 1/4 SW 1/4 24-89N-29W, Webster County.

I. 3/4" Pit Run Gravel with no crushed particles S 1/2 NW 1/4 15-90-41, Cherokee County.

J. 85-100 Penetration Grade Asphalt Cement, Bituminous Matl. & Supply Co., Tama, Iowa.
AGGREGATE GRADATION (1)

The field grading of these aggregates are as follows:

<table>
<thead>
<tr>
<th></th>
<th>1&quot;</th>
<th>3/4&quot;</th>
<th>3/8&quot;</th>
<th>#4</th>
<th>#8</th>
<th>#30</th>
<th>#200</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>84</td>
<td>71</td>
<td>61</td>
<td>32</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>98</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
<td>42</td>
<td>22</td>
<td>14</td>
<td>7.9</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>100</td>
<td>71</td>
<td>46</td>
<td>23</td>
<td></td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>100</td>
<td>86</td>
<td>11</td>
<td>0.8</td>
<td>0.7</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>F</td>
<td>100</td>
<td>84</td>
<td>70</td>
<td>33</td>
<td></td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>100</td>
<td></td>
<td>98</td>
<td>78</td>
<td></td>
<td>31.0</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>100</td>
<td>54</td>
<td>12</td>
<td>6.0</td>
<td></td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>100</td>
<td>92</td>
<td>78</td>
<td>63</td>
<td>28</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>

MIX PROPORTIONS (1)

Mixtures were prepared with 4%, 5% and 6% A.C. content as follows:

1. 45% of Material E  
10% of Material D  
35% of Material F  
10% of Material G  
   Binder Course

1A. 35% of Material E  
35% of Material D  
30% of Material I  
   Binder Course

2. 15% of Material D  
50% of Material F  
15% of Material G  
20% of Material H  
   Surface Course

2A. 40% of Material D  
60% of Material F  
   Surface Course

3. 80% of Material A  
17% of Material C  
3% of Material B  
   Base, Binder, or  
   Surface Course

3A. 60% of Material A  
15% of Material C  
25% of Material D  
   Base, Binder, or  
   Surface Course
CONCLUSIONS

In applying the findings of this study cognizance must be taken of the fact that this was strictly a laboratory study, very limited in nature; any application or extrapolation of the data to actual situations must be tempered with judgment based on the performance of similar materials and mixtures. The analysis of the laboratory test data resulted in the following conclusions:

1. The alternate mixtures without limestone fines or filler appear to meet all of the other current requirements of the specifications for Type B asphalt concrete as well as the standard specification mixtures.

2. The alternate mixtures appear to have an asphalt demand approximately 1 per cent higher than the standard mixtures.

3. It would appear that the 1 inch binder course mixture (1 and 1A) would be safe for use under all types of traffic volumes and loadings.

4. The characteristics of the 3/8 inch and 3/4 inch mixtures (2, 2A, and 3, 3A) tend to indicate that their usage should be restricted to low and moderate traffic volumes and loadings.

5. The test characteristics of mixtures 1, 1A, 2, and 2A indicate that the mineral aggregate void space is related to the quantity of material passing the No. 50, No. 100 and No. 200 sieves as well as to the compacted density.

6. The findings of this study do not conflict with the results of the studies by Csanyi, et al and Tunnicliff on the effects of fillers in asphaltic concrete.
RECOMMENDATIONS

It is recommended that several experimental primary road projects be let in District 3 utilizing Type B asphaltic concrete mixtures produced under specifications excepting the use of limestone fines or filler if the resulting mixtures meet the standard specification requirements for gradation, voids, and stability.

A study should be initiated to examine more fully the possibility of controlling the mineral aggregate void space required in high type asphaltic concrete mixtures.
DISCUSSION

This portion of the report has been divided into three parts for the sake of clarity and so that the various mixtures may be compared in a direct manner.

Mixtures 1 and 1A, 1” Type B Binder (Refer to Figures 1 & 2 and Table 1)

Mix number 1 was made up to comply with the standard specifications in the usual manner; mix number 1A was made up to comply with all of the standard specifications except the requirement for limestone filler. This modification involved introducing another material (3/4” pit run gravel) and eliminating the 3/8” pit run gravel and the agricultural lime. The percentages of the constituents were also adjusted. The modified job mix (1A) was comprised, therefore, entirely of local materials; this condition would effect a cost savings and reduce the number of different materials required from four to three.

The gradation curves indicate that mixture number 1A was slightly more densely graded than mixture number 1. Apparently this factor influenced the effect of laboratory compaction; e.g., lab mix 1A at 6 per cent A.C. had a Marshall density of 2.39 and lab mix No. 1 at 6 per cent had a density of 2.43. Generally an increase is observed in Marshall density on field mix samples; in this case a greater increase would be expected in mix No. 1A. This is due to the fact that the void level of mix No. 1 is already quite low at 5 and 6 per cent A.C. A 3-point (0.03) increase in density would reduce the void level in mix No. 1A to near the level observed in mix No. 1.

The Hveem stability data indicates that mix No. 1 is less stable than mix No. 1A. The Marshall stability and flow data does not corroborate these findings. These mixtures appear to be virtually identical when compared on the basis of Marshall test measurements.
Mixture No. 1 exhibited a higher level of (VMA)* aggregate voids filled by 5 to 10% with asphalt than did mix No. 1A. The VMA for the two mixtures differed by 1 to 2 per cent with mix No. 1A being more open. The gradation curves indicate that mix No. 1A was more densely graded than mix No. 1, but the density achieved by laboratory compaction did not close up mix No. 1A as much as mix No. 1. The sag in the gradation curve for mix 1A in the vicinity of the number 50 and 100 mesh sieves tends to indicate that additional void space is available for binder in this mixture. Aggregate combinations providing adequate void space for sufficient binder to assure durability as well as stability are most desirable.

Mixtures 2 and 2A, 3/8" Type B Surface (Refer to Figures 3 & 4 and Table 1)

These mixtures were made up to comply with the requirements outlined previously. Mix No. 2 included limestone fines as required by the specifications and mix No. 2A was made with local gravels.

The density of the 50 blow Marshall specimens was considerably higher for mix No. 2 than for mix No. 2A. This differential varied from 9 to 12 points (0.09 to 0.12). The variations and/or differences observed in the gradations of the two mixtures do not provide a basis for rationalizing the differences in density. The inverse relationship of compacted density to combined aggregate specific gravity also provides no corroboration. Therefore, the only factors left which could influence or cause the observed disparity are particle shape and compactive effort.

To test the supposition that a change in compactive effort would affect the density of mix No. 2A, additional specimens were prepared at 5 per cent A.C. with 75 blow Marshall compaction. An increase in density of 5 points (0.05) was observed. This increase in density reduced the air void level to 10.0%; the 50 blow Marshall specimens tested previously indicated

* VMA - per cent by volume of voids in mineral aggregate
an air void level of 12 1/2 per cent. The moderate increase in density obtained from the additional compactive effort tends to indicate that the substitution of crushed gravel and pit run gravel for limestone chips and agricultural limestone is responsible in part for raising the compaction resistance. This generally speaking is not observed in the field. Gravel mixes generally compact more easily during construction than do mixtures containing a high percentage of crushed limestone.

When the void and stability data are compared for these two mixtures, mix No. 2 exhibited more strength (stability) than mix No. 2A, although the air void percentages become critical at moderate asphalt contents. Due to the fact that these fine, dense graded mixtures are placed in thin lifts (3/4 inch), stability or strength as currently measured may not be a critical matter. The relationship of asphalt content, air voids, and initial compaction may be far more important. If this is true, mix No. 2A which indicates an asphalt demand approximately 1 per cent above mix No. 2 might prove to be more durable under traffic and weathering. Mixtures utilizing higher asphalt contents which result in heavier films of binder are generally preferred over lean mixtures which result in thin films of binder.

Mixtures 3 and 3A, 3/4" Type B, Base or Surface (Refer to Figures 5 & 6 and Table 1)

These mixtures which could be used for wearing surfaces or upper base courses were prepared as outlined previously. Mix No. 3 was prepared with a filler (3%) from Weeping Water, Nebraska; mix No. 3A was made up of local materials.

The differential in density observed in the comparisons between mix Nos. 1 and 1A and Mix. Nos. 2 and 2A is also quite apparent when mix Nos. 3 and 3A are compared. Due to the fact that the factors influencing or causing the differential in density have been discussed previously, additional comments do not appear to be required.
The Hveem and Marshall stability data indicate that these mixes are quite similar. The shape of the stability curves establish a tendency towards erratic behavior not directly related to the asphalt content. Due to the stability levels (Hveem 57 to 70, Marshall 667 to 1217), it would not appear to be advisable to place these mixtures on roads subjected to high volumes of heavy traffic.

The air void levels in mix No. 3A averaged approximately 4 per cent higher than the void levels observed in mix No. 3. Mix No. 3A also exhibited higher VMA percentages and lower VMA filled with A.C. percentages. These test observations may be attributed in part to the lower compacted density obtained for mix No. 3A; other differences and variations such as gradation and particle shape are factors which must be considered even though they cannot be identified quantitatively.
References

1. Iowa State Highway Commission Standard Specifications, 1964, as amended by Supplemental Specifications, Division II.


Mix No. 1
% AC by wt. of Mix
4 5 6

Mix No. 1A
% AC by wt. of Mix
4 5 6

FIGURE I

Density
2.40

2.30

60
Hveem Side Pressure
40

2000
Marshall Stability lbs.
1500

10
% Total Voids
5

100
% VMA Filled
50

17.0 16.8 16.3

% VMA 18.9 17.6 18.5
**FIGURE 2**

**GRADATION CHART**

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY

<table>
<thead>
<tr>
<th>SIEVES</th>
<th>PASSING</th>
<th>RETAINED</th>
<th>WT. %</th>
<th>PASSING</th>
<th>RETAINED</th>
<th>WT. %</th>
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<td></td>
</tr>
<tr>
<td>3/8</td>
<td>68</td>
<td>72</td>
<td>72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td></td>
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<td>25</td>
<td>21</td>
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<tr>
<td>50</td>
<td>16</td>
<td>13.4</td>
<td>13.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>10.6</td>
<td>9.2</td>
<td>9.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>8</td>
<td>7.2</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STATE** Iowa  
**PROJECT NO.** R-228  
**TYPE CONST; LOCATION ON PROJECT**  
Mix No. 1 90% Gravel, 10% Ag. Lime  
Mix No. 1A 100% Gravel  
Lab. Mix

1" Max. Size Type B binder course

**SAMPLING**  
**SAMPLED FROM**  
**SAMPLED BY**  
**DATE**  
**QUANT. REPRESENTED**  
**SIEVED BY**  
**DATE**  
**SIEVE METHOD**  
**REMARKS**

Average of 3 extractions
<table>
<thead>
<tr>
<th>Mix No. 2</th>
<th>Mix No. 2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>% AC by wt. of Mix</td>
<td>% AC by wt. of Mix</td>
</tr>
<tr>
<td>4 5 6</td>
<td>4 5 6</td>
</tr>
<tr>
<td>75 Blow Marshall</td>
<td>75 Blow Marshall</td>
</tr>
<tr>
<td>Density</td>
<td>Density</td>
</tr>
<tr>
<td>2.30</td>
<td>2.20</td>
</tr>
<tr>
<td>70 psi</td>
<td>70 psi</td>
</tr>
<tr>
<td>Hveem lateral pressure</td>
<td>Hveem lateral pressure</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>% Voids</td>
<td>% Voids</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>75 Blow Marshall</td>
<td>75 Blow Marshall</td>
</tr>
<tr>
<td>% Voids</td>
<td>% Voids</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>% VMA</td>
<td>% VMA</td>
</tr>
<tr>
<td>22.5 22.7 21.7</td>
<td>19.4</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>% VMA</td>
<td>% VMA</td>
</tr>
<tr>
<td>Filled</td>
<td>Filled</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>
FIGURE 4

GRADATION CHART

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY 

Mix No. 2

Max. Density Line

Mix No. 2A

<table>
<thead>
<tr>
<th>SIEVES</th>
<th>NO. 2 PASSING %</th>
<th>NO. 2A PASSING %</th>
<th>TOTAL PASSING %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>100</td>
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<td>100</td>
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<tr>
<td>4</td>
<td>81</td>
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<td>50</td>
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<td>17</td>
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<td>100</td>
<td>14</td>
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<td>10.6</td>
</tr>
<tr>
<td>200</td>
<td>10.8</td>
<td></td>
<td>8.7</td>
</tr>
</tbody>
</table>

STATE: Iowa
PROJECT NO.: R-228

TYPE, SOURCE, PRODUCER OF AGG.

3/8" Max. Size Type B Surface Course

TYPE CONST.; LOCATION ON PROJECT

Mix No. 2 65% Gravel, 15% Ag. Lime, 20% L.S., Chips
Mix No. 2A 100% Gravel
Lab Mix.

SAMPLER FROM SAMPLED BY DATE QUANT. REPRESENTED SIEVED BY DATE

SIEVE METHOD REMARKS

Average of 3 Extractions
Mix No. 3
% AC by wt. of Mix
4 5

All 50 Blow Marshall

2.30
Density
2.20

70 psi
Hveem Side Pressure
50

1000
Marshall Stability lbs.
500

18.8 18.7 18.0

% Total Voids
5

% VMA
100

% VMA Filled
50

Mix No. 3A
% AC by wt. of Mix
4 5 6

75 Blow Marshall

50 Blow Marshall

75 Blow Marshall

common point

10

75 Blow Marshall

20.4

75 Blow Marshall

50 Blow Marshall

$ AC
**FIGURE 6**

**GRADATION CHART**

Horizontal scale represents sieve sizes raised to the 0.45 power. "Simplified Practice" sizes indicated by.

<table>
<thead>
<tr>
<th>SIEVE SIZES</th>
<th>PASSING</th>
<th>RETAINED</th>
<th>WT. %</th>
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<tbody>
<tr>
<td>1/2</td>
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<td>91</td>
</tr>
<tr>
<td>3/8</td>
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<td>100</td>
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<td></td>
<td>7.9</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td>6.6</td>
</tr>
</tbody>
</table>

Mix No. 3

Mix No. 3A

Max. Density Line

**STATE** Iowa  **PROJECT NO.** R-228

Type, source, producer of agg.

3/4" Max. size Type B base or surface

Sampled from | Sampled by | Date | Quant. Represented | Sieved by | Date

Type Const; Location on project

Mix No. 3 97% Gravel, 3% L.S. Filler
Mix No. 3A 100% Gravel
Lab. Mix

Sieve Method

Remarks

Average of 3 extractions
### Materials Department Data Sheet

**Table 1**

Comparison of Characteristics (2, 3, 4)

Std. and Modified Type B Asphaltic Concrete

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>1&quot; Binder</th>
<th>3/8&quot; Surface</th>
<th>3/4&quot; Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mix No.1</td>
<td>Mix No.1A</td>
<td>Mix No.2</td>
</tr>
<tr>
<td>Bitumen lbs. per lb. Dry Aggr.</td>
<td>0.0526</td>
<td>0.0526</td>
<td>0.0526</td>
</tr>
<tr>
<td>Hudson A (Fineness)</td>
<td>4.6</td>
<td>4.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Surface Area S.F. per lb.</td>
<td>35.5</td>
<td>31.2</td>
<td>48.4</td>
</tr>
<tr>
<td>Bitumen Index</td>
<td>0.0015</td>
<td>0.0017</td>
<td>0.0011</td>
</tr>
<tr>
<td>*% Voids, Mineral Aggr.</td>
<td>15.8</td>
<td>17.9</td>
<td>17.0</td>
</tr>
<tr>
<td>*% VMA Filled with A.C.</td>
<td>68.5</td>
<td>64.2</td>
<td>66.5</td>
</tr>
<tr>
<td>*% Total Voids in Compacted Mix</td>
<td>4.0</td>
<td>6.4</td>
<td>5.7</td>
</tr>
</tbody>
</table>

*Hudson A = 1/100 of Summation of 10 Std. Screens (% passing by wt.)*

*Surface Area in S.F. per lb. computed from established constants*

*Bitumen Index = Percent A.C. (Aggr. Basis) * 100 x Surf. Area*

*A" following Mix No. denotes modified mix without limestone fines or filler*

*5% A.C. by wt. mixtures @ 50 blow Marshall compaction*