DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

OFFICE OF MATERIALS

Geology Section



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R - 264

# A LABORATORY INVESTIGATION OF AN ACCELERATED POLISHING METHOD FOR DETERMINING THE SKID RESISTANCE POTENTIAL OF AGGREGATES

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ABSTRACT

An initial feasibility study indicated that the "Purdue Accelerated Polishing Method" gave repeatable results when testing the skid resistance of laboratory specimens. The results also showed a rough correlation with the field performance of the same aggregate sources. The research was then expanded to include all available asphalt aggregates. The results of the expanded study indicated that the method is not presently capable of developing and measuring the full skid potential of the various aggregate sources. Further research in the area of polishing times and/or pressures is needed.

# INTRODUCTION

Coarse aggregates contribute significantly to the skid resistant properties of an asphalt surface in several ways. For example, fine grained aggregates can polish easily under traffic, and thus possess poor skid resistant properties, while coarser grained aggregates polish less, thus providing a more skid resistant surface. Also, the use of aggregate sources containing particles of varying degrees of hardness or wearability can produce a pavement surface possessing good skid properties due to the macrotexture developed.

The field determination of skid numbers is a necessary operation from many standpoints, but when trying to assess an aggregate's skid characteristics it offers several limitations, i.e., the aggregate may not have been used in a project; the time required to obtain and analyze test data; construction variables; and post construction variables, such as daily traffic. Thus, a laboratory method is needed that can simulate the polishing action of traffic while holding the other variables to a minimum. If such a method can be developed, then skid numbers determined on laboratory specimens could be used to categorize the various aggregates as to their potential skid resistant properties when used in asphaltic construction.

## PURPOSE AND SCOPE

The purpose of this investigation was to evaluate the "Purdue Accelerated Polishing Method" as a laboratory method for duplicating field conditions. The investigation was conducted on an open ended basis so that it could be terminated or expanded at any time. The initial phase was to determine the polishing characteristics of ten aggregate sources and correlate these charactieristics to field performance. If a significant ocrrelation was found,the investigation was to continue until all major geologic types or sources were evaluated. The research proposal for the project is found in Appenix A.

When this study began, no standardized laboratory procedures existed in the literature for the various aspects. Thus, much of the early part of the study was involved with developing procedures and methods.

## MATERIALS

The materials used in the initial phase were selected from sources that had sufficient field usage to categorize them as to polishing susceptability. Ten sources were selected to represent a range of skid properties or polishing susceptibility. Since these factors depend upon aggregate characteristics, the sources selected also represented a range of mineralogies, texture, etc. After completion of the initial phase, all available aggregates were incorporated into an expanded study.

## LAB PROCEDURE

The laboratory procedures developed and followed in the study are found in Iowa State Highway Division, Materials Office, Laboratory Manual, Vol. 1. Specifically, Test Method No. Iowa 218-A, "Preparation of Specimens for Determining the Polishing Characteristics of an Aggregate" and Test Method No. Iowa 914-A, "Method of Test for Determining Surface Frictional Properties with the British Portable Skid Tester". As mentioned earlier, these procedures were developed in the Iowa Highway Division Materials Laboratory without the benefit of published guidelines. Thus, they differ in part from the procedure outlined in ASTM E 303-74 which was published after the study was well under way. The data supporting the differences are discussed and shown later in this report. Copies of the two Iowa procedures are found in Appendix B and a brief description of the procedures will be given here.

### Specimen Preparation

Aggregate samples were evaluated by incorporating them into three six-inch diameter by two-inch high asphaltic concrete test specimens. The specimens were made to Type "A" asphalt specifications with a 1/2" mixture size and were compacted as closely as possible to Marshall densities.

### Polishing Procedure

An accelerated polishing device was used to polish the surface of the test specimens to simulate the polishing action of traffic. The device consisted of a drill press with a three-inch diameter rubber polishing pad mounted in the chuck. The specimens were placed on a ball bearing turntable and the polishing pad pressed against the surface of the specimen by applying a 3,000 gram load to the operating arm of the drill press. Water and abrasive dust were applied to the specimen surface while the polishing pad was rotating on it. The specimens were polished for ten minutes using #400 Carborundum grit and for ten minutes using #600 grit.

### Skid Testing Procedure

The BPN (British Portable Tester Number) values were determined for the various sources using the British Portable Tester. Numbers were obtained at various stages during the polishing procedure as reported in the data tables. The actual testing procedure was modified several times as discussed in the TEST RESULTS AND INTERPRETATION section of the report.

## TEST RESULTS AND INTERPRETATION

### Initial Phase

The initial phase of the investigation consisted of determining whether the polishing procedure could produce surfaces that varied in their skid resistant properties in the same relative proportion as their actual field performance. As the work progressed, several distinct areas of investigation evolved and will be reported on separately, although all are reflected in the final results and conclusions of the initial phase.

## Mix Design

After reviewing the typical gradations for several mix sizes, it was decided that the 1/2 inch mix would be used for the study. The optimum asphalt content was determined for each individual aggregate source tested. Initially, the natural sand was pre-screened to remove all plus No. 8 material and the quantity to be used was standardized. However, the preparation and testing of several trial specimens indicated that even with long periods of polishing the coarse aggregate was not being exposed. The coarse aggregate/fine aggregate proportions were changed to 70-30 and the polishing time and pressure were changed until coarse aggregate was exposed. Two aggregates with widely different field skid properties were tested but showed little difference in final polished values. Further specimens were made eliminating the natural sand and these had polished values that varied in proportion to their field values. On this basis, the natural sand fraction of the mixes was eliminated and the specimens prepared from all stone with the following grading:

| Sieve | % Passing |
|---|---|
| 0.525" | 100 |
| 3/8" | 80 |
| #4 | 55 |
| #8 | 37.5 |
| #16 | 25 |
| #30 | 20 |

Polishing Susceptibility

The first series of specimens tested had such large within source variation that a second set of specimens was prepared. While the second set was being polished, it was observed that aggregate particles were being dislodged. The laboratory procedure at this time involved the placing of the specimen's surface in solvent to remove the asphalt film from the specimen surface and the aggregate particles. Apparently, the solvent was softening the asphalt matrix too much for the specimen to be immediately subjected to polishing. By allowing the specimens to set overnight, enough solvent evaporated and the asphalt hardened to the point where the specimens could be polished without trouble. The within source variability dropped to acceptable levels after this procedural change. It was also necessary, due to plucking, to substitute limestone fines for quartzite fines when preparing the quartzite specimens. The BPN values for the aggregate sources tested are shown in Table 1. To arrive at the data shown in Table 1, each of the three specimens from a source was subjected to five determinations of its individual BPN value. The five determinations were averaged into a single value for a specimen, and the three specimens averaged for a value for the source.

Table 1.-BPN values for the various sources and test conditions (second series)

| | | | Test Conditions | | | |
|---|---|---|---|---|---|---|
| | | | | After 10 Additional Min. #600 Grit | | |
| Aggregate | | Before Polishing | After 10 Min. #400 Grit | Water Lubricated | 30% Glycerol Lubricated | 60% Glycerol Lubricated |
| Quartzite | | 74 | 53 | 43 | 43 | 43 |
| Sedgewick | fine grained Dolomite | 81 | 56 | 37 | 37 | 37 |
| Ferguson (Eagle City) | fine to medium Limestone | 79 | 56 | 40 | 40 | 38 |
| Ferguson (Maynes Creek) | cherty, fine to medium grained Dolomite | 78 | 55 | 39 | 38 | 37 |
| Ft. Dodge | medium to coarse grained Limestone | 74 | 52 | 36 | 34 | 33 |
| Menlo | fine grained Limestone | 74 | 47 | 31 | 31 | 31 |
| Traprock | | 75 | 56 | 49 | 47 | 42 |
| Davenport | very fine grained Limestone | 75 | 47 | 30 | 30 | 30 |
| Crushed Gravel | | 76 | 54 | 44 | 43 | 41 |
| Logan | fine to medium grained Dolomite | 82 | 61 | 48 | 46 | 43 |

The within-specimen, between-determination variation was quite small as shown in Table 2.

Table 2. - Frequency of within-specimen variations (second series)

| Variation between the five determinations on a single specimen | Frequency |
|---|---|
| 0 BPN units | 41 |
| 1 " " | 93 |
| 2 " " | 8 |
| 3 " " | 6 |
| 4 " " | 2 |

The between-specimen, within-source variations are shown in Tables 3 and 4.

Table 3.- Between-specimen variation (three specimens for each source) (second series)

| Aggregate | Before Polishing | After 10 Min. #400 Grit | Test Conditions: After 10 Additional Min. #600 Grit — Water Lubricated | 30% Glycerol Lubricated | 60% Glycerol Lubricated |
|---|---|---|---|---|---|
| Quartzite | 1 | 3 | 2 | 1 | 1 |
| Sedgewick | 2 | 2 | 4 | 3 | 3 |
| Ferguson (Eagle City) | 1 | 5 | 1 | 1 | 2 |
| Ferguson (Maynes Creek) | 2 | 1 | 2 | 3 | 3 |
| Ft. Dodge | 2 | 2 | 3 | 4 | 4 |
| Menlo | 2 | 2 | 2 | 1 | 1 |
| Traprock | 2 | 6 | 7 | 7 | 6 |
| Davenport | 3 | 5 | 2 | 2 | 0 |
| Crushed Gravel | 1 | 1 | 2 | 2 | 0 |
| Logan | 6 | 4 | 2 | 2 | 4 |



Table 4 Frequency of between-specimen variations, 2nd series

| Variation between the three specimens within a single source | Frequency |
|---|---|
| 0 BPN units | 1 |
| 1 " " | 11 |
| 2 " " | 19 |
| 3 " " | 7 |
| 4 " " | 5 |
| 5 " " | 2 |
| 6 " " | 3 |
| 7 " " | 2 |

The tabulations show that the variability encountered is within acceptable limits.

Tables 5 and 6 give the data arranged in two different ways, both are for the BPN values obtained on the water lubricated surface after polishing was completed.

Table 5 Sources ranked by change in BPN values (second series)

| Aggregate | Change in BPN | Ranking from Field Evaluation | Ranking from Lab. Textural Evaluation |
|---|---|---|---|
| Traprock | 26 | 4 | 2 |
| Quartzite | 29 | 2 | 2 |
| Crushed Gravel | 32 | 1 | 1 |
| Logan Q. | 34 | 2 | 3 |
| Ferguson (Maynes Creek) | 38 | 3 | 2 |
| Ft. Dodge | 38 | 4 | 4 |
| Ferguson (Eagle City) | 39 | 4 | 5 |
| Menlo | 43 | 6 | 7 |
| Sedgewick | 44 | Not Used | 6 |
| Davenport | 45 | 5 | 7 |

Table 6 Sources ranked by polished surface BPN values (second series)

| Aggregate | Final BPN | Ranking from Field Evaluation | Ranking from Lab. Textural Evaluation |
|---|---|---|---|
| Traprock | 49 | 4 | 2 |
| Logan | 48 | 2 | 3 |
| Crushed Gravel | 44 | 1 | 1 |
| Quartzite | 43 | 2 | 2 |
| Ferguson (Eagle City) | 40 | 4 | 5 |
| Ferguson (Maynes Creek) | 39 | 3 | 2 |
| Sedgewick | 37 | Not Used | 6 |
| Ft. Dodge | 36 | 4 | 4 |
| Menlo | 31 | 6 | 7 |
| Davenport | 30 | 5 | 7 |

The field evaluation ranking was based on data obtained with the skid trailer. The lab textural evaluation is based on the visual identification of an aggregate's texture - both the individual particles and the composite sample representing the production from a source. A source may have received a high textural rating based on the coarseness of the individual grains in the particles and/or based on the presence of both hard and soft aggregate particles that could produce varying degrees of wearability in a pavement surface and thus promote the development of macrotexture.

The ranking of the aggregates in both tables was close enough to actual field performance to warrant further testing.

A third series of the same ten aggregates was molded to check on the reproducibility of the second series. The effect of various operators was also introduced at this time. Table 7 gives the results of the third series.

Table 7. - Third series data

| | Series 2 | Series 3 | | |
|---|---|---|---|---|
| Aggregate | Change in BPN | Change in BPN | Operator | Variation from Series 2 |
| Traprock | 26 | 29 | 3 | +3 |
| Quartzite | 29 | 30 | 2 | +1 |
| Crushed Gravel | 32 | 34 | 2 | +2 |
| Logan | 34 | 36 | 3 | +2 |
| Ferguson (Maynes Creek) | 38 | 37 | 1 | -1 |
| Ft. Dodge | 38 | 39 | 1 | +1 |
| Ferguson (Eagle City) | 39 | 39 | 1 | 0 |
| Menlo | 43 | 44 | 3 | +1 |
| Sedgewick | 44 | 44 | 3 | 0 |
| Davenport | 45 | 44 | 2 | -1 |

As the Series 3 specimens were being molded and polished, it was observed that certain aggregates which crushed into elongated particles tended to be orientated parallel to the specimen surface. Thus, their orientation relative to the pendulum slider could affect the aggregate particle contact time during testing, and, therefore, the BPN value obtained. To study this effect, a comparison was made of the variation of the Series 2 specimens (5 determinations) with the variation encountered with Series 3 specimens when determinations were made at the quarter points. Table 8 shows the results.

Table 8. - Variation vs. number of determinations

| | Variation Between Specimens | |
|---|---|---|
| | Series 2 | Series 3 |
| Aggregate | 5 Determinations | 8 Determinations |
| Quartzite | 2 BPN units | 1 BPN unit |
| Menlo | 3 " " | 2 BPN units |
| Traprock | 3 " " | 3 " " |
| Davenport | 2 " " | 3 " " |
| Crushed Gravel | 2 " " | 1 BPN unit |
| Logan Q. | 3 " " | 1 " " |

Based on these results, future testing was done by making eight, quarter point determinations on each specimen.

To check on the aggregate source variability, additional samples were obtained from three sources. Table 9 shows the results.

Table 9. - Variability within aggregate source

| | Change in BPN | | Additional |
|---|---|---|---|
| Aggregate | Series 2 | Series 3 | Samples- |
| Ferguson (Maynes Creek) | 38 | 37 | 37 |
| Ferguson (Eagle City) | 39 | 39 | 36 |
| Ft. Dodge | 38 | 39 | 41 |

Pad Preconditioning and Service Life

In Series 2, the pad was preconditioned by 10 passes over a dry concrete surface, as per the pendulum manufacturer's instructions. The pad to be used in Series 3 was preconditioned in a similar manner and a comparison test of the two was made on a set of specimens.

| | | |
|---|---|---|
| Series 2 pad used | 750 | times previously |
| Series 3 pad used | 0 | times previously |

| | | | |
|---|---|---|---|
| Washed surface | - Series 2 pad | 79 | BPN units |
| " " | - Series 3 pad | 86 | BPN units |
| Polished surface | - Series 2 pad | 42 | BPN units |
| " " | - Series 3 pad | 41 | " " |

Assuming that continued use would bring the condition of the new pad (Series 3) close to that of the Series 2 pad, the test was continued on a different set of specimens.

| | | |
|---|---|---|
| Series 2 pad used | 825 | times previously |
| Series 3 pad used | 75 | times previously |

| | | | |
|---|---|---|---|
| Washed surface | - Series 2 pad | 80 | BPN units |
| " " | - Series 3 pad | 81 | " " |
| Polished surface | - Series 2 pad | 41 | BPN units |
| " " | - Series 3 pad | 48 | " " |

The differences between the condition of the pads appeared to be diminishing on the washed surface, but not on the polished surface; so another set of specimens was tested.

Series 2 pad used 900 times previously
Series 3 pad used 150 times previously

Washed surface - Series 2 pad 71 BPN units
Wa" " - Series 3 pad 74 " "

Polished surface - Series 2 pad 32 BPN units
" " - Series 3 pad 40 BPN units

Obviously the differences were persisting. The Series 2 pad had been on hand several years, while the Series 3 pad was a recent purchase. To check on possible hardening on the rubber, the Durometer hardness test was run on the Series 2 and 3 pads and on two others that were recently purchased. The test results were identical on all pads.

It was decided to go back to the preconditioning of the pads. A mortar block was prepared to serve as a standard surface with which to check the pads. A new pad was preconditioned by five passes over #50 sandpaper and then tested against the other pads on the standard surface. The condition of the new pad did not agree with the others - but the condition of the Series 2 and Series 3 pads did agree, hinting that the mortar block was responsible for some conditioning of the Series 3 pad. The new pad continued to be preconditioned by 10 passes over #150 sandpaper. After this second preconditioning, all pads agreed on the standard surface. It was decided to try the pads on actual specimens and the results were:

Series 2 pad used 975 times previously
Series 3 pad used 225 times previously
New pad used 0 times previously

| | | | |
|---|---|---|---|
| Washed surface | - Series 2 pad | 81 | BPN units |
| " " | - Series 3 pad | 82 | " " |
| " " | - New pad | 78 | " " |

| | | | |
|---|---|---|---|
| Polished surface | - Series 2 pad | 37 | BPN units |
| " " | - Series 3 pad | 43 | " " |
| " " | - New Pad | 38 | " " |

At this time, a procedural change was made to eight determinations (2 at each quarter point) instead of five determinations; data present elsewhere shows that this reduces the test result variabilities.

Two new pads were conditioned by 10 passes over the mortar block that was originally made for a standard surface. These pads will be designated X-1 and X-2. The results were:

| | | | |
|---|---|---|---|
| Series 2 pad | used | 1050 | times previously |
| Series 3 pad | used | 300 | times previously |
| New pad | used | 75 | times previously |
| X-1 pad | used | 0 | times previously |
| X-2 pad | used | 0 | times previously |

| | | | |
|---|---|---|---|
| Washed surface | - Series 2 pad | 77 | BPN units |
| " " | - Series 3 pad | 76 | " " |
| " " | - New pad | 75 | " " |
| " " | - X-1 pad | 49 | " " |
| " " | - X-2 pad | 49 | " " |

It appears that the standard mortar block can quickly condition new pads to the point where their results are compatible with previously used pads. Thus, all new pads will be conditioned by ten passes over a standard mortar block. To stay within reasonable wear tolerances, the pads will be replaced after 500 passes.

<u>Initial Phase Conculsions</u>

1. The specimens should be prepared without natural sand

so as to maximize the effect of the aggregate being tested.

2. After having been placed in the solvent, the specimen should stand overnight to allow the matrix to reharden.

3. Lowered variability of test results and better reproduceability of test results occurred when the determinations on specimen were made at the quarter points.

4. A standard surface and procedure for preconditioning the pads is very necessary.

5. Wetting the polished surface with 30% glycerol solution - offers no advantage over water, and the 60% glycerol solution tends to override the skid resistance of the polished surface and become the dominant factor. Therefore, in any future testing, water is the recommended lubricant.

6. The variability encountered was sufficiently low enough to warrant expansion of the study.

7. The ranking of the BPN results was sufficiently close enough to other evaluation rankings that expansion of the study was warranted.

Expanded Study

The aggregates used and their test results are shown arranged in several different ways in the Appendices.

Appendix C gives the results arranged according to the amount of difference between the initial and polished values. There was some consideration given to using this value as a characterizing number after the initial phase was completed. However, the expanded study showed that quite often aggregates may possess a high initial value and an average final value, thus giving a large difference that does not truly reflect their skid properties. A case in point would be the dolomites, where as a group they have a very high initial and an above-average final resulting in a high difference.

An attempt was made to correlate the results with the skid trailer data. Since the trailer data includes pavements of many different ages, mix sizes, asphalt types, and different years of skid testing, only those 1/2-inch mixes which had been field tested in 1974 and 1975 were selected as being the most comparable with the specimens used in the polishing study. This resulted in the selection of thirteen sources. The correlation coefficient between the field skid data and the amount of change in BPN units was calculated as 0.1381, which indicates essentially no relationship.

Appendix D gives the results arranged according to the final or polished values.

Taking the same sources mentioned earlier, the coefficient of correlation between the field skid data and the final polished value was calculated at 0.601, which indicates that a degree of correlation exists - at least on the thirteen sources compared. It was noticed that several field proven skid resistant aggregates (not included in the thirteen sources in the correlation) fall into the lower end of the ranking shown in Appendix D.

In examining Appendix D, it will be noticed that the final values have a normal distribution. This would indicate: (1) that no differences exist in polishing susceptibility between the specimens, (2) the polishing method is not presently capable of developing the varying degrees of skid resistance of the various aggregates, or (3) the differences in skid resistance of the various aggregates are being masked by grouping all aggregates together for analysis.

Situation 1 is not supported by field evidence. Skid trailer data indicate that differences do exist in polishing susceptibility.

Situation 2, the inability of the method to develop the varying degrees of skid resistance is an area that deserves more attention. The present procedure calls for polishing all aggregates the same amount of time, and it is a distinct possibility that some of the aggregates are being overpolished, tending to group the data too close together.

Situation 3, the gouping of data for analysis was investigated by dividing the aggregates in this study into rock texture groups. This was done since the textural classification of an aggregate is an easy visual procedure, and many reports mention the correlation between texture and skid resistance. The grouping of the different samples and their test results are shown in Appendix E. The six groups used were:

Type 0 Misc. (Crushed Gravels, Traprock, Quartzite)

Type 1 Siliceous Carbonates (Cherty-Sandy)

Type 2 Micritic Limestone (Microcrystalline-Lithographic)

Type 3 Clastic Limestone (Oolitic-Crinoidal-Fossil Clastic)

Type 4 Dolomite (Fine to Coarse Crystalline)

Type 5 Mixed Limestone and Dolomite

The average BPN for each aggregate type is as shown in Table 10.

Table 10. - Average BPN for rock texture group

| | Original | Final |
|---|---|---|
| Type 0 | 81.0 | 43.9 |
| Type 1 | 80.3 | 44.8 |
| Type 2 | 75.4 | 38.1 |
| Type 3 | 76.9 | 39.8 |
| Type 4 | 82.0 | 44.2 |
| Type 5 | 77.9 | 39.4 |

Observation of Table 10 indicates that the different types can be combined into two groups. Subsequent statistical analysis indicated that only these two groups existed, and they represented two significantly different BPN results. The two groups would be:

Group I Highest Final Values

Type 0 Crushed Gravels, Quartzite, Traprock

Type 1 Siliceous Carbonates

Type 4 Dolomites

Group II

Type 2 Micritic Limestones

Type 3 Clastic Limestones

Type 5 Mixed Limestone & Dolomite

It thus appears that the polishing method can develop surfaces of differing skid properties, and data grouping has an effect on interpretation. However, based on field performance, the above grouping does not appear definitive enough. Most clastic limestones, and mixed limestone and dolomite, aggregate sources have good skid resistant properties, based on field usage and they should not normally be classed with the poorer performing micritic or very fine grained limestone.

## Conclusions and Suggestions

The "Accelerated and Polishing Method" can produce surfaces of varying skid properties, but is not presently capable of developing and measuring the full skid potential of the various sources. It is suggested that additional study be done in the area of varying polishing times to prevent potential overpolishing of specimens.

# APPENDIX A

RESEARCH PROPOSAL

R-264

# LABORATORY INVESTIGATION OF THE EFFECT OF VARIOUS COARSE AGGREGATES ON THE SKID RESISTANCE OF ASPHALT SURFACE MIXTURES

## Introduction

It has long been recognized that coarse aggregates play a significant role in the skid resistance of asphalt surface course mixtures. Fine grained limestones polish very rapidly under traffic and are therefore unacceptable for surface course mixtures where a high degree of skid resistance is required. Some dolomitic limestones with coarser grain structures are less susceptible to polishing and tend to provide an adequate skid resistance for longer periods of time. There are, however, many sources of crushed stone within the state of Iowa where no definite chemical or physical parameter identifies it as having polishing or non-polishing characteristics.

An accelerated polishing test is needed that can adequately establish the susceptibility of an aggregate to polish in an asphaltic surface course under traffic.

## Purpose

It is the purpose of this investigation to attempt to identify polishing characteristics of coarse aggregates by an accelerated laboratory method.

## Scope

This investigation shall initially be limited to determining the polishing characteristics of ten (10) aggregate sources and correlating these characteristics to field performance. If such a correlation does exist the project shall continue until all major geologic types or sources are evaluated.

Test Procedure

A. Specimen Preparation

Three 6 in. diameter and 2 in. high specimens shall be prepared for each coarse aggregate. They shall be compacted in such a maner as to be as close to Marshall densities as possible.

Each set of three specimens shall be of a Type "A" surface course mixture, and shall have the same grading and percentage of coarse aggregate as well as the same source and percent of asphalt cement.

B. Polishing Procedure

All specimens shall be polished by mounting them in a mold positioned on a polishing turntable. A 3 in. diameter rubber polishing pad attached to a drill press shall be used to apply pressure to the specimen. Each specimen shall be polished utilizing commercial abrasives.

The polishing shall be accomplished in three stages of five minutes each with contact pressures of 3, 4 and 5 psi. for the first through the third stage respectively.

C. Skid Testing Procedure

Each specimen shall be tested with a British Portable Tester in accordance with ASTM E 303 prior to polishing and after polishing. After polishing and testing with water, the frictional properties will be again determined with the British Portable Tester using a 30% glycerol solution as the lubricant.

D. Aggregate Testing

Each aggregate under investigation shall be examined and tested for Los Angeles abrasion and any geologic parameter deemed to be applicable.

Responsibilities

The Geology Section shall be responsible for selecting and obtaining the aggregates to be studied.

The Special Investigations Section shall be responsible for conducting the tests.

The Materials Administration Section shall be responsible for analyzing the data and preparing the final report.

APPENDIX B

IOWA STATE HIGHWAY COMMISSION

Materials Department

# PREPARATION OF SPECIMENS FOR DETERMINING THE POLISHING CHARACTERISTIC OF AN AGGREGATE

## Scope

This method is intended to describe the preparation of test specimens to be used for evaluating the polishing characteristics of coarse aggregate with the British Portable Skid Tester.

## Procedure

A. Apparatus

1. The following sieves: 0.525", 3/8", #4, #8, #16 and #30.
2. Oven capable of maintaining a constant temperature of 275 ± 5°F.
3. Balance with a capacity of at least 5000 grams and accurate to 1 gram.
4. Mechanical mixer, capable of mixing a 12,000 gram batch.
5. Mold, base and compaction plate, capable of molding a specimen 6 inches in diameter and 2 inches in height.
6. Compacting apparatus as described in Test Method No. Iowa 502.
7. Drillpress, capable of approximately 720 rpm.
8. Turntable, consisting of a base, table top and an adjustable braking system. The 9-1/2 x 9-1/2 x 1/2 in. base is securely attached to the drillpress table. The base has a 0.6 inch centering hole and the top of the base is grooved to center and hold a 5 inch diameter ball bearing system. The 9 inch diameter table top rests on the ball bearing system and is centered with a 0.6 inch diameter shaft 15/16 inch in length. The table top should spin freely. The braking system is mounted to the base and adjusted to the table top to obtain the desired rpm during the polishing operation.
9. 6 inch inside diameter polishing mold and collar, made of brass or other suitable material. The mold and collar shall be made so that the top of the 1-1/2 inch deep mold, when fitted to the bottom of the 2-1/2" deep collar gives an overall depth of 3-1/2 inches. This fitting is obtained by a tongue and groove joint, with a 1/4 inch tongue on the mold fitting into a 1/4 inch groove on the collar.
10. Rubber polishing shoe, made with the same quality rubber as automobile tires. The shoe shall be 3 inches in diameter and 2 inches thick. Three grooves 1/4 inch wide and 1/2 inch deep are cut into the 3 inch diameter polishing surface, dividing the surface into 6 segments of approximate equal area. The shoe is attached to a metal plate of the same diameter having an attached shaft for fitting the drill press chuck.
11. Silicone Carbide Grit, size #400 and #600.

B. Test Procedure

1. Separate the aggregate sample into particle sizes by using the sieves described in A, 1 and dry in an oven for approximately 12 hours at 275°F.
2. Determine the absorption by Test Method No. Iowa 201 on the aggregate built up to the following grading:

| Sieve | % Passing |
|---|---|
| 0.525" | 100 |
| 3/8" | 80 |
| #4 | 55 |
| #8 | 37.5 |
| #16 | 25 |
| #30 | 20 |

3. Build up a 10,000 gram portion of aggregate to the same grading as described above in B, 2. From the results of the absorption test calculate an effective asphalt content of 5.25%. Add this amount of asphalt to the aggregate and mix for not less than 1-1/2 minute.
4. From the mixture, mold a specimen by using the mold, base and compaction plate described in A, 5 and the procedure in Test Method No. Iowa 502, except the compaction apparatus strikes the plate a total of 200 times. (100 times on each side of the specimen) Carefully extrude the specimen from the mold and allow to

cool for not less than 8 hours.

5. Wash the surface of the specimen to be tested in the following manner: place it in a pan containing about 1/2 inch of 1,1,1 trichlorothane for 2 minutes, remove the specimen, brush the surface with a brass or wire brush, and return it to the pan of solvent, repeating this 5 times. Upon completion of this procedure the specimen is removed and its surface is washed with solvent, alcohol, water, brushed and allowed to dry at room temperature for not less than 8 hours.

6. Place the specimen in the polishing mold. If a tight fit is not attained, place a strip of paper around the edge of the specimen and insert it in the polishing mold so that a tight fit is attained.

7. Determine the initial BPN of the specimen according to Test Method No. Iowa 914.

8. Place the collar on the polishing mold and position this assembly in the polishing device. Place the polishing shoe in the drillpress chuck and adjust the base so that the shoe, in polishing position, is approximately 1/16 inch from the edge of the collar.

9. Maintain a contact pressure of 15 psi. on the specimen's surface from the polishing shoe by applying a load of 3000 grams to the end of the drill-press arm. Add 25 ml. of #400 silicone carbide grit and 300 ml. of water on the surface to be polished. Polish the specimen for 10 minutes at a mold speed of 50 rpm. Upon completion of the polishing, remove the specimen and assembly from the turntable, disassemble the collar, wash the test surface with water, and brush with a fiber brush.

10. Perform the final polishing by repeating Step 9 with the exception that the silicone carbide grit, size #400 is replaced with size #600.

11. Determine the final BPN of the specimen according to Test Method No. Iowa 914.

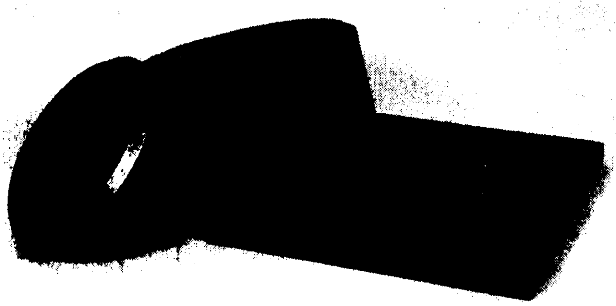

Fig. 1
Mold, Base and Compaction Plate

Fig. 2
Test Specimens for Polishing

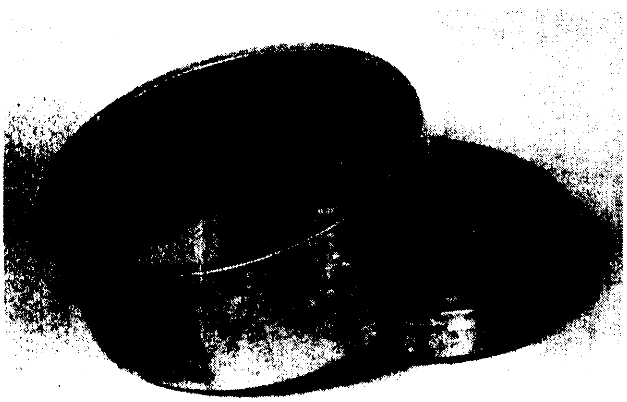

Fig. 3
Polishing Mold and Collar

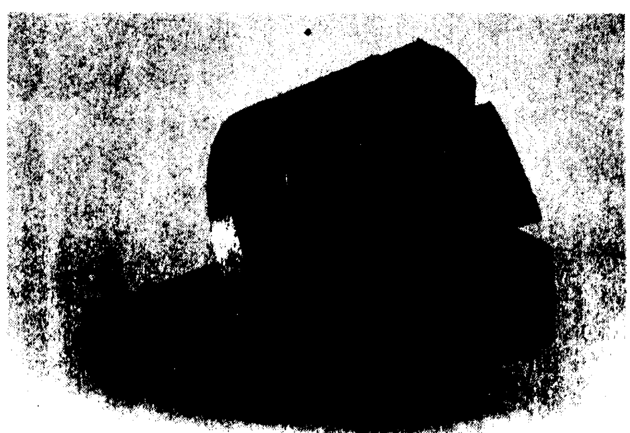

Fig. 4
Rubber Polishing Shoe

Test Method No. Iowa 914-A
May 1974

IOWA STATE HIGHWAY COMMISSION

Materials Department

# METHOD OF TEST FOR DETERMINING SURFACE FRICTIONAL PROPERTIES WITH THE BRITISH PORTABLE SKID TESTER

## Scope

This method is intended to describe the procedure for performing a frictional test on specimens made in the laboratory with the British Portable Skid Tester. This apparatus and procedure are identical to that specified in ASTM E 303-69 with the following exceptions:

A. Apparatus

1. New sliders shall be conditioned prior to use in the following manner. Adjust the tester as in Section 4, "Preparation of Apparatus" and make 10 swings on a dry surface of a mortar block. The mortar block shall have a surface that is at least 3-1/2 x 6 inches. The mortar block shall be made with portland cement, concrete sand and when cured the surface shall be polished with No. 60 grit until the aggregate is exposed.

B. Test Specimen

1. The test specimen shall have a test surface of approximately 6 inches in diameter.

C. Preparation of Apparatus

1. Slide Length Adjustment

   a. Make the adjustment with either one of the pair of head movement knobs and never with the front leveling screws.

D. Procedure

1. Pour water over the specimen until the surface is thoroughly saturated and the excess runs off.

2. Perform at least 1 determination at each quarter point on the diameter of the specimen. Prior to each determination recheck the contact length as in C, pour water on the surface as in D 1, and adjust the slider to make complete contact at the beginning of the test path. Make the adjustment by carefully lowering the pendulum so the slider rests on the surface at the beginning of the test path and return it to the original test position. Without delay complete the test and record the result.

E. Report

1. Report the average of the determinations and express as BPN units.

Notes: Perform the test with the apparatus and specimen positioned on a firm foundation.

Due to the great importance of the apparatus being level, check and adjust it at least after every 4 determinations.

Replace the rubber slider after being used 500 times, or before, if excessive wear is noted.

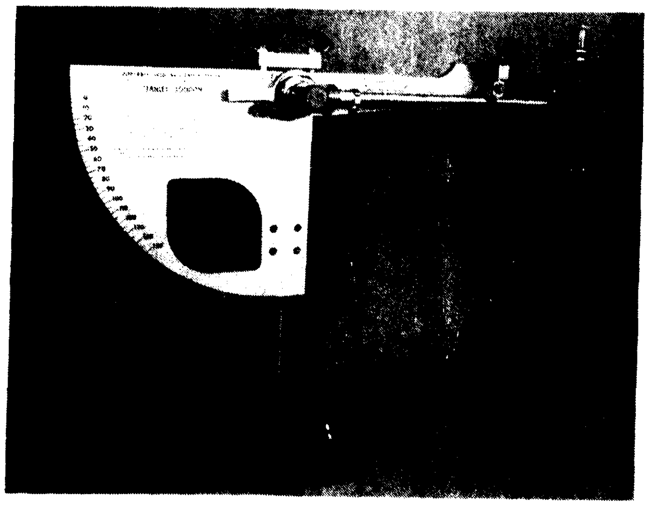

Fig. 1
British Portable Skid Tester
With A Test Specimen in Place

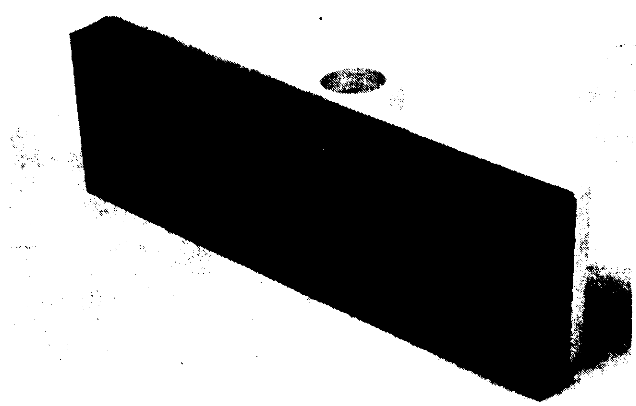

Fig. 2
Rubber Slider

# APPENDIX C

APPENDIX C

| QUARRY | UNIT | SP G | ABS | ABR | WASHED | POLISHED | DIFF | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| JOHNSTON | CRUSHED GR | 2.701 | 0.60 | 21 | 61 | 40 | 21 | |
| STURTZ | CRUSHED GR | 2.708 | 1.48 | 28 | 69 | 47 | 22 | |
| STUCK PIT | CRUSHED GR | 2.640 | 1.61 | 25 | 63 | 40 | 23 | |
| PITSOR PIT | CRUSHED GR | 2.676 | 1.16 | 28 | 64 | 40 | 24 | |
| BROMLEY | CRUSHED GR | 2.676 | 1.03 | 29 | 65 | 37 | 28 | |
| FRANKLIN | SPERGEN | 2.576 | 5.44 | 27 | 84 | 56 | 28 | BED 12 |
| DOUDS MINE | SPERGEN | 2.644 | 2.81 | 40 | 82 | 54 | 28 | BEDS 10A THRU 15 |
| EDDYVILLE | ST GEN | 2.656 | 0.90 | 36 | 76 | 48 | 28 | |
| YOUNG AMCA | WASSONVLE | 2.687 | 2.86 | 33 | 87 | 58 | 29 | CHERTY |
| FARMINGTON | ST L-SPERG | 2.669 | 2.14 | 30 | 81 | 51 | 30 | BEDS 13 THRU 16 |
| SMITH QR | ST LOUIS | 2.684 | 0.70 | 32 | 72 | 42 | 30 | |
| GRAND RIV | BETHANY F | 2.687 | 0.94 | 28 | 70 | 39 | 31 | BEDS 12-15 |
| ROBINS | SOLON | 2.668 | 1.00 | 31 | 75 | 44 | 31 | |
| BAGUS | GOWER | 2.805 | 0.27 | 21 | 80 | 49 | 31 | |
| CEDAR CR | SPERGEN | 2.667 | 2.22 | 30 | 77 | 46 | 31 | |
| FARNSWORTH | WORLAND | 2.699 | 0.91 | 26 | 73 | 42 | 31 | BED 1 |
| LANSING | HOPKINTON | 2.776 | 0.75 | 35 | 83 | 52 | 31 | CHERTY |
| CRAWFORD | RAPID-SLN | 2.718 | 0.83 | 29 | 76 | 44 | 32 | |
| CORNING | ERVINE CR | 2.654 | 0.93 | 29 | 83 | 51 | 32 | BEDS 3-5 |
| COMANCHE | SPERGEN | 2.588 | 4.16 | 32 | 81 | 49 | 32 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PRESTON | HOPKINTON | 2.737 | 1.29 | | 85 | 53 | 32 | CHERTY |
| SWALEDALE | OWEN | 2.813 | 1.10 | 31 | 80 | 48 | 32 | HIGH F&T A |
| VINTON | SOLON | 2.666 | 1.23 | 27 | 77 | 45 | 32 | |
| MILLER | OWEN | 2.687 | 1.12 | 25 | 78 | 45 | 33 | |
| GARNER | OWEN | 2.809 | 0.30 | 25 | 74 | 41 | 33 | FULL FACE |
| SUNDHEIM | HOPKINTON | 2.787 | 0.60 | 36 | 83 | 50 | 33 | CHERTY |
| GARDNER | ST LOUIS | 2.688 | 0.67 | 23 | 74 | 40 | 34 | |
| ATLANTIC | BETHANY F | 2.640 | 1.59 | 26 | 77 | 43 | 34 | BEDS 25 C & E |
| EARLHAM | BETHANY F | 2.614 | 1.76 | 23 | 75 | 41 | 34 | |
| LOGAN | HOPKINTON | 2.754 | 1.06 | 35 | 83 | 49 | 34 | |
| RICEVILLE | CEDAR VAL | 2.682 | 2.16 | 34 | 80 | 46 | 34 | 35FT FACE |
| MEDIAPOLIS | WASSONVLE | 2.653 | 2.05 | 38 | 79 | 45 | 34 | BEDS 15-18 |
| OSAGE | CEDAR VAL | 2.753 | 0.40 | 27 | 79 | 45 | 34 | |
| LEWIS | SPERGEN | 2.734 | 0.53 | 26 | 77 | 43 | 34 | BEDS 6 & 7 |
| FARMERS | HOPKINTON | 2.734 | 0.93 | 35 | 84 | 50 | 34 | |
| KURT | HOPKINTON | 2.799 | 0.33 | 30 | 83 | 49 | 34 | CHERTY |
| EDGEWOOD | HOPKINTON | 2.780 | 0.70 | 36 | 81 | 47 | 34 | |
| DECATUR CY | BETHANY F | 2.634 | 1.41 | 30 | 73 | 38 | 35 | BEDS 11-14 |
| MONTOUR | HAMPTON | 2.721 | 1.16 | 43 | 80 | 45 | 35 | |
| WARNHOLTZ | CORALVILLE | 2.674 | 1.62 | 63 | 81 | 46 | 35 | TOP LEDGE |
| PLANO | EXLINE | 2.673 | 0.30 | 23 | 71 | 36 | 35 | |
| STENNETT | CLAY CREEK | 2.658 | 1.40 | 22 | 75 | 40 | 35 | BED 13 |
| MAXIN | CORALVILLE | 2.668 | 0.84 | 26 | 75 | 40 | 35 | |
| OLLIE | BURLINGTON | 2.686 | 0.13 | 36 | 75 | 40 | 35 | BED 15-18 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WALNUT CTY | COOPER CR | 2.710 | 0.27 | 25 | 75 | 40 | 35 | BED 6 |
| SOUTH C R | GOWER | 2.754 | 0.80 | 27 | 88 | 53 | 35 | ANAMOSA-HOPKINTN |
| STANZEL | ARGENTINE | 2.621 | 1.75 | 36 | 80 | 44 | 36 | |
| BEDFORD | ERVINE CR | 2.377 | 2.62 | 33 | 82 | 46 | 36 | |
| DANVILLE | SPERGEN | 2.657 | 1.10 | 26 | 77 | 41 | 36 | BEDS 13-20 |
| WINTERSET | BETHANY F | 2.614 | 2.30 | 29 | 78 | 42 | 36 | |
| THAYER | BETHANY F | 2.600 | 3.03 | 25 | 76 | 40 | 36 | |
| QUIMBY | SHELL ROCK | 2.726 | 0.73 | 29 | 77 | 41 | 36 | BEDS 1 THRU 10 |
| BROWN | SVILLE | 2.764 | 0.93 | 33 | 83 | 47 | 36 | |
| WEEP WATER | PLATTSMTH | 2.681 | 0.37 | 25 | 74 | 38 | 36 | |
| HAWKEYE | ST LOUIS | 2.678 | 0.68 | 27 | 73 | 37 | 36 | |
| KENDALLVLE | STEWARTVLE | 2.703 | 0.83 | 27 | 78 | 42 | 36 | BEDS 6&7 |
| LECLAIRE | GOWER | 2.783 | 0.33 | 37 | 87 | 51 | 36 | ANAMOSA |
| VERNON | GOWER | 2.740 | 1.09 | 31 | 84 | 48 | 36 | ANAMOSA |
| MAR-JO HIL | SVILLE | 2.766 | 0.57 | 40 | 85 | 49 | 36 | |
| FESTINA | EDGWOOD | 2.659 | 1.65 | 33 | 80 | 44 | 36 | BULLERMAN Q |
| MALCOM M | EAGLE CITY | 2.716 | 1.29 | 35 | 81 | 45 | 36 | |
| DURHAM | ST LOUIS | 2.580 | 1.78 | 22 | 86 | 50 | 36 | ARENACEOUS |
| BLOOM | SOLON | 2.685 | 0.64 | 26 | 78 | 42 | 36 | |
| FERGUSON | HAMPTON | 2.682 | 2.06 | 38 | 85 | 48 | 37 | |
| MCCABE | PROSSER | 2.691 | 0.74 | 30 | 79 | 42 | 37 | 49 FT FACE |
| CRSNT-QRTZ | BFALLS-QTZ | | | | 76 | 39 | 37 | 70/30 |
| DIXON | CEDAR VAL | 2.713 | 1.25 | 31 | 74 | 37 | 37 | FULL 10FT FACE |
| WRAGE | CORALVILLE | 2.748 | 0.44 | 39 | 75 | 38 | 37 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DOWS | MAYNES CR | 2.685 | 1.27 | 34 | 76 | 39 | 37 | |
| CONFIDENCE | EXLINE | 2.693 | 0.34 | 25 | 72 | 35 | 37 | BEDS 1-4 |
| FLORRY | CORALVILLE | 2.721 | 0.67 | 26 | 73 | 36 | 37 | |
| FARMINGTON | ST GEN | 2.724 | 1.68 | 21 | 70 | 33 | 37 | |
| BOONIES | ONEOTA | 2.770 | 0.73 | 34 | 81 | 44 | 37 | |
| JEFFERSON | BETHANY F | 2.654 | 1.42 | 28 | 81 | 44 | 37 | |
| HEINHOLD | ST LOUIS | 2.696 | 1.13 | 25 | 78 | 41 | 37 | |
| COLUMBUS J | WASSENVLE | 2.698 | 3.06 | 31 | 87 | 50 | 37 | CHERTY |
| ALDEN | GIL CITY | 2.656 | 0.67 | 37 | 80 | 42 | 38 | |
| BEHR-LUBBN | GOWER-CVLL | | | | 74 | 36 | 38 | 50/50 |
| LEGRAND | HAMPTON | 2.701 | 0.80 | 33 | 80 | 42 | 38 | |
| WEPKING | CORALVILLE | 2.800 | 0.30 | 22 | 77 | 39 | 38 | BED 4 |
| KOHLER | SHELL ROCK | 2.799 | 0.34 | 23 | 76 | 38 | 38 | BEDS 1 THRU 8 |
| KESWICK | HAMPTON | 2.739 | 1.23 | 28 | 84 | 46 | 38 | IA FALLS E CITY |
| BALLOU | GOWER | 2.779 | 0.30 | 34 | 87 | 49 | 38 | |
| HAWKEYE | SPERGEN | 2.682 | 1.91 | 29 | 82 | 44 | 38 | |
| SMITH QR | SPERGEN | 2.691 | 1.39 | 25 | 82 | 44 | 38 | BEDS 13-16A |
| CONFIDENCE | COOPER CR | 2.690 | 0.85 | 25 | 71 | 43 | 38 | BED 6 |
| WEST SHOP | PROSSER | 2.679 | 0.47 | 26 | 78 | 40 | 38 | |
| PINTS | CORALVILLE | 2.695 | 1.58 | 33 | 83 | 45 | 38 | BEDS 5-13 |
| ARGYLE | ST LOUIS | 2.701 | 0.87 | 50 | 77 | 39 | 38 | BEDS 8-13 |
| LEWIS QR | ST LOUIS | 2.685 | 0.60 | 29 | 77 | 39 | 38 | BEDS 3-5 |
| ELKADER | STEWARTVLE | 2.731 | 1.03 | 39 | 82 | 44 | 38 | |
| GARNER | OWEN | 2.790 | 0.17 | 23 | 78 | 39 | 39 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MCGUIRE | GOWER | 2.787 | 0.67 | 27 | 77 | 38 | 39 | NE 20FT FACE FLR |
| LOGAN | BETHANY F | 2.674 | 0.60 | 25 | 77 | 38 | 39 | |
| FERTILE | CORALVILLE | 2.781 | 0.93 | 30 | 80 | 41 | 39 | |
| LEGRAND | HAMPTON | 2.640 | 1.95 | 30 | 83 | 44 | 39 | |
| FT DODGE | GIL CITY | 2.678 | 0.37 | 33 | 75 | 36 | 39 | |
| BOWSER | GOWER | 2.773 | 0.87 | 38 | 86 | 47 | 39 | |
| FERTILE | CORALVILLE | 2.781 | 0.93 | 30 | 80 | 41 | 39 | BEDS-10-17 |
| WILDE QR | CORALVILLE | 2.735 | 0.44 | 28 | 80 | 41 | 39 | |
| RANDALL | CEDAR VAL | 2.746 | 0.37 | 33 | 76 | 37 | 39 | FULL FACE |
| BRUNS | OWEN | 2.710 | 0.64 | 30 | 79 | 40 | 39 | |
| RANDALL | CEDAR VAL | 2.769 | 0.23 | 22 | 76 | 36 | 40 | PCC LEDGE |
| CHRISTOFSN | STEWARTVLE | 2.654 | 1.19 | 29 | 77 | 37 | 40 | |
| CHRISTOFSN | STEWARTVLE | 2.660 | 1.00 | 25 | 76 | 36 | 40 | BEDS 1,2,3 TOP 4 |
| BEHR | GOWER | 2.734 | 1.69 | 42 | 84 | 44 | 40 | |
| SHAFFTON | GOWER | 2.708 | 0.40 | 30 | 81 | 41 | 40 | ANAMOSA |
| GARRISON | CORALVILLE | 2.732 | 0.57 | 25 | 81 | 41 | 40 | |
| DUBUQUE ST | SVILLE-PSR | 2.786 | 0.83 | 35 | 84 | 44 | 40 | |
| DOWS | EAGLE CITY | 2.717 | 0.27 | 30 | 77 | 37 | 40 | |
| CONKLIN | CORALVILLE | 2.699 | 0.13 | 29 | 81 | 41 | 40 | |
| ALDEN | GIL CITY | 2.668 | 0.40 | 35 | 79 | 39 | 40 | |
| LUBBEN | CORALVILLE | 2.700 | 0.40 | 25 | 74 | 33 | 41 | |
| SULIVAN S | MCCRANEY | 2.702 | 0.37 | 28 | 75 | 34 | 41 | BED 6B |
| KUENNEN | CEDAR VAL | 2.800 | 0.57 | 29 | 81 | 40 | 41 | |
| MEDIAPOLIS | MCCRANEY | 2.654 | 0.43 | 29 | 77 | 36 | 41 | BED 20 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DUENOW | CORALVILLE | 2.771 | 0.30 | 28 | 76 | 35 | 41 | BEDS 6 TO 10 |
| MONTI | HOPKINTON | 2.769 | 0.60 | 36 | 81 | 40 | 41 | |
| MENLO | ARGENTINE | 2.668 | 0.70 | 24 | 76 | 35 | 41 | |
| CRESCENT | BETHANY F | 2.673 | 0.54 | 25 | 75 | 34 | 41 | BED 25 E |
| LOGAN | BETHANY F | 2.674 | 0.60 | 27 | 75 | 34 | 41 | BED 25E |
| WATERLOO S | CORALVILLE | 2.719 | 0.86 | 25 | 80 | 39 | 41 | BEDS 18-23 |
| FERTILE | CORALVILLE | 2.770 | 0.83 | 21 | 81 | 40 | 41 | |
| MOSCOW | WAPSI | 2.796 | 0.30 | 30 | 79 | 38 | 41 | |
| LANGSTRATT | ST LOUIS | 2.695 | 0.73 | 28 | 75 | 34 | 41 | |
| WEPKING | CORALVILLE | 2.741 | 0.84 | 24 | 76 | 35 | 41 | BEDS 1 THRU 3 |
| KESWICK | HAMPTON | 2.683 | 3.13 | 35 | 83 | 41 | 42 | BEDS 13-15 |
| HODGES | GILMORE C | 2.167 | 1.81 | 42 | 78 | 36 | 42 | PCC LEDGE |
| DANNATT | HOPKINTON | 2.755 | 1.23 | 29 | 83 | 41 | 42 | NEW OPENING 35FT |
| GILMORE C | GILMORE C | 2.668 | 0.90 | 32 | 77 | 35 | 42 | 36FT NW |
| SULIVAN SL | BURLINGTON | 2.684 | 0.20 | 42 | 80 | 37 | 43 | BED 18 |
| BAGUS | GOWER | 2.793 | 0.63 | 25 | 83 | 40 | 43 | REEF |
| MITCHELL | GOWER | 2.784 | 0.43 | 32 | 79 | 36 | 43 | REEF |
| LINWOOD | DAV-SP GR | 2.676 | 0.67 | 41 | 74 | 31 | 43 | |
| LINWOOD | DAV-SP GR | 2.676 | 0.67 | 41 | 74 | 31 | 43 | |
| LILLYBRIDG | OWEN | 2.717 | 0.99 | 30 | 81 | 38 | 43 | |
| MOSCOW | DAVENPORT | 2.700 | 0.13 | 29 | 77 | 33 | 44 | BEDS 10-15 |
| LOWDEN | GOWER | 2.749 | 1.30 | 29 | 81 | 37 | 44 | SCHNECKLOTH |
| MOSCOW-ELK | DAVPT-STVL | | | | 80 | 36 | 44 | 50/50 |
| ALDN-SEDGE | GILCTY-HOP | | | | 83 | 36 | 47 | 50/50 |

# APPENDIX D

APPENDIX D

| QUARRY | UNIT | SP G | ABS | ABR | WASHED | POLISHED | DIFF | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| LINWOOD | DAV-SP GR | 2.676 | 0.67 | 41 | 74 | 31 | 43 | |
| FARMINGTON | ST GEN | 2.724 | 1.68 | 21 | 70 | 33 | 37 | |
| LUBBEN | CORALVILLE | 2.700 | 0.40 | 25 | 74 | 33 | 41 | |
| MOSCOW | DAVENPORT | 2.700 | 0.13 | 29 | 77 | 33 | 44 | BEDS 10-15 |
| LOGAN | BETHANY F | 2.674 | 0.60 | 27 | 75 | 34 | 41 | BED 2SE |
| SULIVAN S | MCCRANEY | 2.702 | 0.37 | 28 | 75 | 34 | 41 | BED 6B |
| CRESCENT | BETHANY F | 2.673 | 0.54 | 25 | 75 | 34 | 41 | BED 25 E |
| LANGSTRATT | ST LOUIS | 2.695 | 0.73 | 28 | 75 | 34 | 41 | |
| CONFIDENCE | EXLINE | 2.693 | 0.34 | 25 | 72 | 35 | 37 | BEDS 1-4 |
| GILMORE C | GILMORE C | 2.668 | 0.90 | 32 | 77 | 35 | 42 | 36FT NW |
| DUENOW | CORALVILLE | 2.771 | 0.30 | 28 | 76 | 35 | 41 | BEDS 6 TO 10 |
| WERKING | CORALVILLE | 2.741 | 0.84 | 24 | 76 | 35 | 41 | BEDS 1 THRU 3 |
| MENLO | ARGENTINE | 2.668 | 0.70 | 24 | 76 | 35 | 41 | |
| FT DODGE | GIL CITY | 2.678 | 0.37 | 33 | 75 | 36 | 39 | |
| BEHR-LUBBN | GOWER-CVLL | | | | 74 | 36 | 38 | 50/50 |
| MOSCOW-ELK | DAVPT-STVL | | | | 80 | 36 | 44 | 50/50 |
| ALDN-SEDGE | GILCTY-HOP | | | | 83 | 36 | 47 | 50/50 |
| RANDALL | CEDAR VAL | 2.769 | 0.23 | 22 | 76 | 36 | 40 | PCC LEDGE |
| HODGES | GILMORE C | 2.167 | 1.81 | 42 | 78 | 36 | 42 | PCC LEDGE |
| PLANO | EXLINE | 2.673 | 0.30 | 23 | 71 | 36 | 35 | |
| FLORRY | CORALVILLE | 2.721 | 0.67 | 26 | 73 | 36 | 37 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CHRISTOFSN | STEWARTVLE | 2.660 | 1.00 | 25 | 76 | 36 | 40 | BEDS 1,2,3 TOP 4 |
| MEDIAPOLIS | MCCRANEY | 2.654 | 0.43 | 29 | 77 | 36 | 41 | BED 20 |
| MITCHELL | GOWER | 2.784 | 0.43 | 32 | 79 | 36 | 43 | REEF |
| DIXON | CEDAR VAL | 2.713 | 1.25 | 31 | 74 | 37 | 37 | FULL 10FT FACE |
| RANDALL | CEDAR VAL | 2.746 | 0.37 | 33 | 76 | 37 | 39 | FULL FACE |
| SULIVAN SL | BURLINGTON | 2.684 | 0.20 | 42 | 80 | 37 | 43 | BED 18 |
| BROMLEY | CRUSHED GR | 2.676 | 1.03 | 29 | 65 | 37 | 28 | |
| HAWKEYE | ST LOUIS | 2.678 | 0.68 | 27 | 73 | 37 | 36 | |
| CHRISTOFSN | STEWARTVLE | 2.654 | 1.19 | 29 | 77 | 37 | 40 | |
| DOWS | EAGLE CITY | 2.717 | 0.27 | 30 | 77 | 37 | 40 | |
| LOWDEN | GOWER | 2.749 | 1.30 | 29 | 81 | 37 | 44 | SCHNECKLOTH |
| WEEP WATER | PLATTSMTH | 2.681 | 0.37 | 25 | 74 | 38 | 36 | |
| WRAGE | CORALVILLE | 2.748 | 0.44 | 39 | 75 | 38 | 37 | |
| KOHLER | SHELL ROCK | 2.799 | 0.34 | 23 | 76 | 38 | 38 | BEDS 1 THRU 8 |
| LOGAN | BETHANY F | 2.674 | 0.60 | 25 | 77 | 38 | 39 | |
| MCGUIRE | GOWER | 2.787 | 0.60 | 27 | 77 | 38 | 39 | NE 20FT FACE FLR |
| DECATUR CY | BETHANY F | 2.684 | 1.41 | 30 | 73 | 38 | 35 | BEDS 11-14 |
| MOSCOW | WAPSI | 2.796 | 0.30 | 30 | 79 | 38 | 41 | |
| LILLYBRIDG | OWEN | 2.717 | 0.99 | 30 | 81 | 38 | 43 | |
| WEPKING | CORALVILLE | 2.800 | 0.30 | 22 | 77 | 39 | 38 | BED 4 |
| LEWIS QR | ST LOUIS | 2.685 | 0.60 | 29 | 77 | 39 | 38 | BEDS 3-5 |
| DOWS | MAYNES CR | 2.685 | 1.27 | 34 | 76 | 39 | 37 | |
| WATERLOO S | CORALVILLE | 2.719 | 0.86 | 25 | 80 | 39 | 41 | BEDS 18-23 |
| ARGYLE | ST LOUIS | 2.701 | 0.87 | 50 | 77 | 39 | 38 | BEDS 8-13 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GRAND RIV | BETHANY F | 2.687 | 0.94 | 28 | 77 | 39 | 31 | BEDS 12-15 |
| GARNER | OWEN | 2.790 | 0.17 | 23 | 78 | 39 | 39 | |
| CRSNT-QRTZ | BFALLS-QTZ | | | | 76 | 39 | 37 | 70/30 |
| ALDEN | GIL CITY | 2.668 | 0.40 | 35 | 79 | 39 | 40 | |
| GARDNER | ST LOUIS | 2.688 | 0.67 | 23 | 74 | 40 | 34 | |
| OLLIE | BURLINGTON | 2.686 | 0.13 | 36 | 75 | 40 | 35 | BED 15-18 |
| JOHNSTON | CRUSHED GR | 2.731 | 0.60 | 21 | 61 | 40 | 21 | |
| WEST SHOP | PROSSER | 2.679 | 0.47 | 26 | 78 | 40 | 38 | |
| PITSOR PIT | CRUSHED GR | 2.676 | 1.16 | 28 | 64 | 40 | 24 | |
| STUCK PIT | CRUSHED GR | 2.640 | 1.61 | 25 | 63 | 40 | 23 | |
| WALNUT CTY | COOPER CR | 2.710 | 0.27 | 25 | 75 | 40 | 35 | BED 6 |
| STENNETT | CLAY CREEK | 2.658 | 1.40 | 22 | 75 | 40 | 35 | BED 13 |
| MAYIN | CORALVILLE | 2.668 | 0.84 | 26 | 75 | 40 | 35 | |
| THAYER | BETHANY F | 2.630 | 3.03 | 25 | 76 | 40 | 36 | |
| BRUNS | OWEN | 2.710 | 0.64 | 30 | 79 | 40 | 39 | |
| KUENNEN | CEDAR VAL | 2.800 | 0.57 | 29 | 81 | 40 | 41 | |
| MONTI | HOPKINTON | 2.769 | 0.60 | 36 | 81 | 40 | 41 | |
| FERTILE | CORALVILLE | 2.770 | 0.83 | 21 | 81 | 40 | 41 | |
| BAGUS | GOWER | 2.793 | 0.63 | 25 | 83 | 40 | 43 | REEF |
| CONKLIN | CORALVILLE | 2.699 | 0.13 | 29 | 81 | 41 | 40 | |
| GARRISON | CORALVILLE | 2.732 | 0.57 | 25 | 81 | 41 | 40 | |
| SHAFFTON | GOWER | 2.708 | 0.40 | 30 | 81 | 41 | 40 | ANAMOSA |
| DANNATT | HOPKINTON | 2.755 | 1.23 | 29 | 83 | 41 | 42 | NEW OPENING 35FT |
| KESWICK | HAMPTON | 2.683 | 3.13 | 35 | 83 | 41 | 42 | BEDS 13-15 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GARNER | OWEN | 2.809 | 0.30 | 25 | 74 | 41 | 33 | FULL FACE |
| DANVILLE | SPERGEN | 2.687 | 1.10 | 26 | 77 | 41 | 36 | BEDS 13-20 |
| WILDE QR | CORALVILLE | 2.735 | 0.44 | 28 | 80 | 41 | 39 | |
| EARLHAM | BETHANY F | 2.614 | 1.76 | 23 | 75 | 41 | 34 | |
| QUIMBY | SHELL ROCK | 2.726 | 0.73 | 29 | 77 | 41 | 36 | BEDS 1 THRU 10 |
| HEINHOLD | ST LOUIS | 2.696 | 1.13 | 25 | 78 | 41 | 37 | |
| FERTILE | CORALVILLE | 2.781 | 0.93 | 30 | 80 | 41 | 39 | BEDS-10-17 |
| FERTILE | CORALVILLE | 2.781 | 0.93 | 30 | 80 | 41 | 39 | |
| LEGRAND | HAMPTON | 2.701 | 0.80 | 33 | 83 | 42 | 38 | |
| FARNSWORTH | WORLAND | 2.699 | 0.91 | 26 | 73 | 42 | 31 | BED 1 |
| SMITH QR | ST LOUIS | 2.684 | 0.70 | 32 | 72 | 42 | 30 | |
| KENDALLVLE | STEWARTVLE | 2.703 | 0.83 | 27 | 78 | 42 | 36 | BEDS 6&7 |
| ALDEN | GIL CITY | 2.656 | 0.67 | 37 | 80 | 42 | 38 | |
| MCCABE | PROSSER | 2.691 | 0.74 | 30 | 79 | 42 | 37 | 49 FT FACE |
| WINTERSET | BETHANY F | 2.614 | 2.30 | 29 | 78 | 42 | 36 | |
| BLOOM | SOLON | 2.685 | 0.64 | 26 | 78 | 42 | 36 | |
| LEWIS | SPERGEN | 2.704 | 0.53 | 26 | 77 | 43 | 34 | BEDS 6 & 7 |
| ATLANTIC | BETHANY F | 2.640 | 1.59 | 26 | 77 | 43 | 34 | BEDS 25 C & E |
| CONFIDENCE | COOPER CR | 2.690 | 0.85 | 25 | 71 | 43 | 38 | BED 6 |
| ROBINS | SOLON | 2.668 | 1.00 | 31 | 75 | 44 | 31 | |
| ELKADER | STEWARTVLE | 2.731 | 1.03 | 39 | 82 | 44 | 38 | |
| CRAWFORD | RAPID-SLN | 2.718 | 0.83 | 29 | 76 | 44 | 32 | |
| STANZEL | ARGENTINE | 2.621 | 1.75 | 36 | 80 | 44 | 36 | |
| JEFFERSON | BETHANY F | 2.654 | 1.42 | 28 | 81 | 44 | 37 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| BOONIES | ONEOTA | 2.770 | 0.73 | 34 | 81 | 44 | 37 | |
| SMITH QR | SPERGEN | 2.691 | 1.39 | 25 | 82 | 44 | 38 | BEDS 13-16A |
| HAWKEYE | SPERGEN | 2.682 | 1.91 | 29 | 82 | 44 | 38 | |
| LEGRAND | HAMPTON | 2.640 | 1.95 | 30 | 83 | 44 | 39 | |
| FESTINA | EDGWOOD | 2.659 | 1.65 | 33 | 80 | 44 | 36 | BULLERMAN Q |
| DUBUQUE ST | SVILLE-PSR | 2.786 | 0.83 | 35 | 84 | 44 | 40 | |
| BEHR | GOWER | 2.734 | 1.69 | 42 | 84 | 44 | 40 | |
| PINTS | CORALVILLE | 2.695 | 1.58 | 33 | 83 | 45 | 38 | BEDS 5-13 |
| MONTOUR | HAMPTON | 2.721 | 1.16 | 43 | 80 | 45 | 35 | |
| VINTON | SOLON | 2.666 | 1.23 | 27 | 77 | 45 | 32 | |
| MILLER | OWEN | 2.682 | 1.12 | 25 | 78 | 45 | 33 | |
| MALCOM M | EAGLE CITY | 2.716 | 1.29 | 35 | 81 | 45 | 36 | |
| OSAGE | CEDAR VAL | 2.753 | 0.40 | 27 | 79 | 45 | 34 | |
| MEDIAPOLIS | WASSONVLE | 2.653 | 2.05 | 38 | 79 | 45 | 34 | BEDS 15-18 |
| CEDAR CR | SPERGEN | 2.667 | 2.22 | 30 | 77 | 46 | 31 | |
| WARNHOLTZ | CORALVILLE | 2.674 | 1.62 | 63 | 81 | 46 | 35 | TOP LEDGE |
| RICEVILLE | CEDAR VAL | 2.682 | 2.16 | 34 | 80 | 46 | 34 | 35FT FACE |
| BEDFORD | ERVINE CR | 2.377 | 2.62 | 33 | 82 | 46 | 36 | |
| KESWICK | HAMPTON | 2.739 | 1.23 | 28 | 84 | 46 | 38 | IA FALLS E CITY |
| EDGEWOOD | HOPKINTON | 2.780 | 0.70 | 36 | 81 | 47 | 34 | |
| STURTZ | CRUSHED GR | 2.708 | 1.48 | 28 | 69 | 47 | 22 | |
| BROWN | SVILLE | 2.764 | 0.93 | 33 | 83 | 47 | 36 | |
| BOWSER | GOWER | 2.773 | 0.87 | 38 | 86 | 47 | 39 | |
| EDDYVILLE | ST GEN | 2.656 | 0.90 | 36 | 76 | 48 | 28 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FERGUSON | HAMPTON | 2.632 | 2.06 | 38 | 85 | 48 | 37 | |
| SWALEDALE | OWEN | 2.813 | 1.10 | 31 | 80 | 48 | 32 | HIGH F&T A |
| VERNON | GOWER | 2.742 | 1.09 | 31 | 84 | 48 | 36 | ANAMOSA |
| BAGUS | GOWER | 2.805 | 0.27 | 21 | 80 | 49 | 31 | |
| COMANCHE | SPERGEN | 2.538 | 4.16 | 32 | 81 | 49 | 32 | |
| KURT | HOPKINTON | 2.799 | 0.33 | 30 | 83 | 49 | 34 | CHERTY |
| LOGAN | HOPKINTON | 2.754 | 1.06 | 35 | 83 | 49 | 34 | |
| MAR-JO HIL | SVILLE | 2.766 | 0.57 | 40 | 85 | 49 | 36 | |
| BALLOU | GOWER | 2.779 | 0.30 | 34 | 87 | 49 | 38 | |
| SUNDHEIM | HOPKINTON | 2.787 | 0.60 | 38 | 83 | 50 | 33 | CHERTY |
| FARMERS | HOPKINTON | 2.784 | 0.93 | 35 | 84 | 50 | 34 | |
| DURHAM | ST LOUIS | 2.580 | 1.78 | 22 | 86 | 50 | 36 | ARENACEOUS |
| COLUMBUS J | WASSENVLE | 2.698 | 3.06 | 31 | 87 | 50 | 37 | CHERTY |
| FARMINGTON | ST L-SPERG | 2.669 | 2.14 | 30 | 81 | 51 | 30 | BEDS 13 THRU 16 |
| CORNING | ERVINE CR | 2.654 | 0.93 | 29 | 83 | 51 | 32 | BEDS 3-5 |
| LECLAIRE | GOWER | 2.783 | 0.33 | 37 | 87 | 51 | 36 | ANAMOSA |
| LANSING | HOPKINTON | 2.776 | 0.75 | 35 | 83 | 52 | 31 | CHERTY |
| PRESTON | HOPKINTON | 2.737 | 1.29 | | 85 | 53 | 32 | CHERTY |
| SOUTH C R | GOWER | 2.754 | 0.80 | 27 | 88 | 53 | 35 | ANAMOSA-HOPKINTN |
| DOUDS MINE | SPERGEN | 2.644 | 2.81 | 40 | 82 | 54 | 28 | BEDS 10A THRU 15 |
| FRANKLIN | SPERGEN | 2.576 | 5.44 | 27 | 84 | 56 | 28 | BED 12 |
| YOUNG AMCA | WASSONVLE | 2.687 | 2.86 | 33 | 87 | 58 | 29 | CHERTY |

# APPENDIX E

APPENDIX E

| QUARRY | UNIT | SP G | ABS | ABR | WASHED | POLISHED | DIFF | COMMENTS |
|---|---|---|---|---|---|---|---|---|
| | TYPE 0 MISC | | | | | | | |
| BROMLEY | CRUSHED GR | 2.676 | 1.03 | 29 | 65 | 37 | 28 | |
| JOHNSTON | CRUSHED GR | 2.701 | 0.60 | 21 | 61 | 40 | 21 | |
| PITSOR PIT | CRUSHED GR | 2.676 | 1.16 | 28 | 64 | 40 | 24 | |
| STUCK PIT | CRUSHED GR | 2.640 | 1.61 | 25 | 63 | 40 | 23 | |
| | CR GRAVEL | | | | 76 | 44 | 32 | |
| DELL RPDS | QUARTZITE | | | | 74 | 45 | 29 | |
| DELL RPDS | QUARTZITE | | | | 76 | 46 | 30 | |
| | CR GRAVEL | | | | 80 | 46 | 34 | |
| STURTZ | CRUSHED GR | 2.703 | 1.48 | 28 | 69 | 47 | 22 | |
| DRESSER | TRAPROCK | | | | 75 | 49 | 26 | |
| DRESSER | TRAPROCK | | | | 78 | 49 | 29 | |
| | TYPE 1 SILICEOUS CARBONATES (CHERTY-SANDY) | | | | | | | |
| LANGSTRATT | ST LOUIS | 2.695 | 0.73 | 28 | 75 | 34 | 41 | |
| HAWKEYE | ST LOUIS | 2.678 | 0.68 | 27 | 73 | 37 | 36 | |
| SEDGWICK | HOPKINTON | | | | 81 | 37 | 44 | |
| SEDGWICK | HOPKINTON | | | | 81 | 37 | 44 | |
| LEWIS QR | ST LOUIS | 2.685 | 0.60 | 29 | 77 | 39 | 38 | BEDS 3-5 |
| ARGYLE | ST LOUIS | 2.701 | 0.87 | 50 | 77 | 39 | 38 | BEDS 8-13 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DOWS | MAYNES CR | 2.635 | 1.27 | 34 | 76 | 39 | 37 | |
| FERGUSON | MAYNES CR | | | | 79 | 40 | 39 | |
| WEST SHOP | PROSSER | 2.679 | 0.47 | 26 | 73 | 40 | 38 | |
| GARDNER | ST LOUIS | 2.688 | 0.67 | 23 | 74 | 40 | 34 | |
| DANVILLE | SPERGEN | 2.687 | 1.10 | 26 | 77 | 41 | 36 | BEDS 13-20 |
| HEINHOLD | ST LOUIS | 2.696 | 1.13 | 25 | 78 | 41 | 37 | |
| FERGUSON | MAYNES CR | | | | 79 | 41 | 38 | |
| SMITH QR | ST LOUIS | 2.684 | 0.70 | 32 | 72 | 42 | 30 | |
| LEGRAND | HAMPTON | 2.701 | 0.80 | 33 | 80 | 42 | 38 | |
| LEWIS | SPERGEN | 2.704 | 0.53 | 26 | 77 | 43 | 34 | |
| BOONIES | ONEOTA | 2.770 | 0.73 | 34 | 81 | 44 | 37 | |
| SMITH QR | SPERGEN | 2.691 | 1.39 | 25 | 82 | 44 | 38 | |
| HAWKEYE | SPERGEN | 2.682 | 1.91 | 29 | 82 | 44 | 38 | |
| LEGRAND | HAMPTON | 2.640 | 1.95 | 30 | 83 | 44 | 39 | |
| DUBUQUE ST | SVILLE-PSR | 2.786 | 0.83 | 35 | 84 | 44 | 40 | |
| MONTOUR | HAMPTON | 2.721 | 1.16 | 43 | 80 | 45 | 35 | |
| WARNHOLTZ | CORALVILLE | 2.674 | 1.62 | 63 | 81 | 46 | 35 | TOP LEDGE |
| CEDAR CR | SPERGEN | 2.667 | 2.22 | 30 | 77 | 46 | 31 | |
| EDGEWOOD | HOPKINTON | 2.780 | 0.70 | 36 | 81 | 47 | 34 | |
| FERGUSON | HAMPTON | 2.682 | 2.06 | 38 | 85 | 48 | 37 | |
| COMANCHE | SPERGEN | 2.588 | 4.16 | 32 | 81 | 49 | 32 | |
| KURT | HOPKINTON | 2.799 | 0.33 | 30 | 83 | 49 | 34 | |
| SUNDHEIM | HOPKINTON | 2.787 | 0.60 | 38 | 83 | 50 | 33 | |
| DURHAM | ST LOUIS | 2.580 | 1.78 | 22 | 86 | 50 | 36 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COLUMBUS J | WASSENVLE | 2.698 | 3.06 | 31 | 87 | 50 | 37 | |
| FARMINGTON | ST L-SPERG | 2.669 | 2.14 | 30 | 81 | 51 | 30 | |
| LANSING | HOPKINTON | 2.776 | 0.75 | 35 | 83 | 52 | 31 | |
| PRESTON | HOPKINTON | 2.737 | 1.29 | | 85 | 53 | 32 | |
| DOUDS MINE | SPERGEN | 2.644 | 2.81 | 40 | 82 | 54 | 28 | |
| FRANKLIN | SPERGEN | 2.576 | 5.44 | 27 | 84 | 56 | 28 | |
| YOUNG AMCA | WASSONVLE | 2.687 | 2.86 | 33 | 87 | 58 | 29 | |

TYPE 2 MICRITIC LIMESTONE (MICROCRYSTALLINE-LITHOGRAPHIC)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MOSCOW | DAVENPORT | | | | 75 | 30 | 45 | |
| MENLO | ARGENTINE | | | | 74 | 31 | 43 | |
| FARMINGTON | ST GEN | 2.724 | 1.68 | 21 | 70 | 33 | 37 | |
| LUBBEN | CORALVILLE | 2.700 | 0.40 | 25 | 74 | 33 | 41 | |
| MOSCOW | DAVENPORT | | | | 77 | 33 | 44 | |
| MENLO | ARGENTINE | | | | 77 | 33 | 44 | |
| MOSCOW | DAVENPORT | 2.700 | 0.13 | 29 | 77 | 33 | 44 | |
| CRESCENT | BETHANY F | 2.673 | 0.54 | 25 | 75 | 34 | 41 | |
| LOGAN | BETHANY F | 2.674 | 0.60 | 27 | 75 | 34 | 41 | BED 25E |
| CONFIDENCE | EXLINE | 2.693 | 0.34 | 25 | 72 | 35 | 37 | |
| MENLO | ARGENTINE | 2.668 | 0.70 | 24 | 76 | 35 | 41 | |
| PLANO | EXLINE | 2.673 | 0.30 | 23 | 71 | 36 | 35 | |
| FLORRY | CORALVILLE | 2.721 | 0.67 | 26 | 73 | 36 | 37 | |
| DECATUR CY | BETHANY F | 2.684 | 1.41 | 30 | 73 | 38 | 35 | BEDS 11-14 |
| WEEP WATER | PLATTSMTH | 2.681 | 0.37 | 25 | 74 | 38 | 36 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LOGAN | BETHANY F | 2.674 | 0.60 | 25 | 77 | 38 | 39 | |
| GRAND RIV | BETHANY F | 2.687 | 0.94 | 28 | 73 | 39 | 31 | BEDS 12-15 |
| STENNETT | CLAY CREEK | 2.658 | 1.40 | 22 | 75 | 40 | 35 | |
| WALNUT CTY | COOPER CR | 2.710 | 0.27 | 25 | 75 | 40 | 35 | |
| THAYER | BETHANY F | 2.600 | 3.03 | 25 | 76 | 40 | 36 | |
| EARLHAM | BETHANY F | 2.614 | 1.76 | 23 | 75 | 41 | 34 | |
| WINTERSET | BETHANY F | 2.614 | 2.30 | 29 | 78 | 42 | 36 | |
| FARNSWORTH | WORLAND | 2.699 | 0.91 | 26 | 73 | 42 | 31 | BED 1 |
| CONFIDENCE | COOPER CR | 2.690 | 0.85 | 25 | 71 | 43 | 38 | |
| ATLANTIC | BETHANY F | 2.640 | 1.59 | 26 | 77 | 43 | 34 | |
| JEFFERSON | BETHANY F | 2.654 | 1.42 | 28 | 81 | 44 | 37 | |
| STANZEL | ARGENTINE | 2.621 | 1.75 | 36 | 80 | 44 | 36 | |
| BEDFORD | ERVINE CR | 2.377 | 2.62 | 33 | 82 | 46 | 36 | |
| CORNING | ERVINE CR | 2.654 | 0.93 | 29 | 83 | 51 | 32 | |

TYPE 3 CLASTIC LIMESTONE (OOLITIC-BIOCLASTIC)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FT DODGE | GIL CITY | | | | 71 | 32 | 39 | |
| GILMORE C | GILMORE C | 2.668 | 0.90 | 32 | 77 | 35 | 42 | 36FT NW |
| FT DODGE | GIL CITY | 2.678 | 0.37 | 33 | 75 | 36 | 39 | |
| MITCHELL | GOWER | 2.784 | 0.43 | 32 | 79 | 36 | 43 | |
| FT DODGE | GIL CITY | | | | 74 | 36 | 38 | |
| HODGES | GILMORE C | 2.167 | 1.81 | 42 | 78 | 36 | 42 | PCC LEDGE |
| SULIVAN SL | BURLINGTON | 2.684 | 0.20 | 42 | 83 | 37 | 43 | BED 18 |
| ALDEN | GIL CITY | 2.668 | 0.40 | 35 | 79 | 39 | 40 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| OLLIE | BURLINGTON | 2.686 | 0.13 | 36 | 75 | 40 | 35 | |
| BRUNS | OWEN | 2.710 | 0.64 | 30 | 79 | 40 | 39 | |
| ALDEN | GIL CITY | 2.656 | 0.67 | 37 | 80 | 42 | 38 | |
| BLOOM | SOLON | 2.685 | 0.64 | 26 | 78 | 42 | 36 | |
| CRAWFORD | RAPID-SLN | 2.718 | 0.83 | 29 | 76 | 44 | 32 | |
| ROBINS | SOLON | 2.668 | 1.00 | 31 | 75 | 44 | 31 | |
| VINTON | SOLON | 2.666 | 1.23 | 27 | 77 | 45 | 32 | |
| MILLER | OWEN | 2.682 | 1.12 | 25 | 78 | 45 | 33 | |
| EDDYVILLE | ST GEN | 2.656 | 0.90 | 36 | 76 | 48 | 28 | |

TYPE 4 DOLOMITE (FINE TO COARSE CRYSTALLINE)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LOWDEN | GOWER | 2.749 | 1.30 | 29 | 81 | 37 | 44 | |
| MOSCOW | WAPSI | 2.796 | 0.30 | 30 | 79 | 38 | 41 | |
| MCGUIRE | GOWER | 2.787 | 0.60 | 27 | 77 | 38 | 39 | |
| GARNER | OWEN | 2.790 | 0.17 | 23 | 78 | 39 | 39 | |
| WEPKING | CORALVILLE | 2.800 | 0.30 | 22 | 77 | 39 | 38 | |
| KUENNEN | CEDAR VAL | 2.800 | 0.57 | 29 | 81 | 40 | 41 | |
| FERTILE | CORALVILLE | 2.770 | 0.83 | 21 | 81 | 40 | 41 | |
| BAGUS | GOWER | 2.793 | 0.63 | 25 | 83 | 40 | 43 | |
| MONTI | HOPKINTON | 2.769 | 0.60 | 36 | 81 | 40 | 41 | |
| GARNER | OWEN | 2.809 | 0.30 | 25 | 74 | 41 | 33 | FULL FACE |
| DANNATT | HOPKINTON | 2.755 | 1.23 | 29 | 83 | 41 | 42 | |
| FERTILE | CORALVILLE | 2.781 | 0.93 | 30 | 80 | 41 | 39 | |
| SHAFFTON | GOWER | 2.708 | 0.40 | 30 | 81 | 41 | 40 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| KESWICK | HAMPTON | 2.683 | 3.13 | 35 | 83 | 41 | 42 | |
| ELKADER | STEWARTVLE | 2.731 | 1.03 | 39 | 82 | 44 | 38 | |
| BEHR | GOWER | 2.734 | 1.69 | 42 | 84 | 44 | 40 | |
| KESWICK | HAMPTON | 2.739 | 1.23 | 28 | 84 | 46 | 38 | |
| BROWN | SVILLE | 2.764 | 0.93 | 33 | 83 | 47 | 36 | |
| BOWSER | GOWER | 2.773 | 0.87 | 38 | 86 | 47 | 39 | |
| LOGAN | HOPKINTON | | | | 83 | 47 | 36 | |
| LOGAN | HOPKINTON | | | | 82 | 48 | 34 | |
| SWALEDALE | OWEN | 2.813 | 1.10 | 31 | 80 | 48. | 32 | HIGH F&T A |
| VERNON | GOWER | 2.740 | 1.09 | 31 | 84 | 48 | 36 | |
| BAGUS | GOWER | 2.805 | 0.27 | 21 | 83 | 49 | 31 | |
| BALLOU | GOWER | 2.779 | 0.30 | 34 | 87 | 49 | 38 | |
| MAR-JO HIL | SVILLE | 2.766 | 0.57 | 40 | 85 | 49 | 36 | |
| LOGAN | HOPKINTON | 2.754 | 1.06 | 35 | 83 | 49 | 34 | |
| FARMERS | HOPKINTON | 2.784 | 0.93 | 35 | 84 | 50 | 34 | |
| LECLAIRE | GOWER | 2.783 | 0.33 | 37 | 87 | 51 | 36 | |
| SOUTH C R | GOWER | 2.754 | 0.80 | 27 | 88 | 53 | 35 | |

TYPE 5 MIXED LIMESTONE AND DOLOMITE)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LINWOOD | DAV-SP GR | 2.676 | 0.67 | 41 | 74 | 31 | 43 |
| SULIVAN S | MCCRANEY | 2.702 | 0.37 | 28 | 75 | 34 | 41 |
| DUENOW | CORALVILLE | 2.771 | 0.30 | 28 | 76 | 35 | 41 |
| WEPKING | CORALVILLE | 2.741 | 0.84 | 24 | 76 | 35 | 41 |
| CHRISTOFSN | STEWARTVLE | 2.660 | 1.00 | 25 | 76 | 36 | 40 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RANDALL | CEDAR VAL | 2.769 | 0.23 | 32 | 75 | 36 | 40 | PCC LEDGE |
| MEDIAPOLIS | MCCRANEY | 2.654 | 0.43 | 29 | 77 | 36 | 41 | |
| DOWS | EAGLE CITY | 2.717 | 0.27 | 30 | 77 | 37 | 40 | |
| DIXON | CEDAR VAL | 2.713 | 1.25 | 31 | 74 | 37 | 37 | FULL 10FT FACE |
| RANDALL | CEDAR VAL | 2.746 | 0.37 | 33 | 76 | 37 | 39 | FULL FACE |
| CHRISTOFSN | STEWARTVLE | 2.654 | 1.19 | 29 | 77 | 37 | 40 | |
| LILLYBRIDG | OWEN | 2.717 | 0.99 | 30 | 81 | 38 | 43 | |
| WRAGE | CORALVILLE | 2.748 | 0.44 | 39 | 75 | 38 | 37 | |
| KOHLER | SHELL ROCK | 2.799 | 0.34 | 23 | 76 | 38 | 38 | |
| FERGUSON | EAGLE CITY | | | | 78 | 39 | 39 | |
| WATERLOO S | CORALVILLE | 2.719 | 0.86 | 25 | 80 | 39 | 41 | BEDS 18-23 |
| MAXIN | CORALVILLE | 2.668 | 0.84 | 26 | 75 | 40 | 35 | |
| WILDE QR | CORALVILLE | 2.735 | 0.44 | 28 | 80 | 41 | 39 | |
| QUIMBY | SHELL ROCK | 2.726 | 0.73 | 29 | 77 | 41 | 36 | |
| CONKLIN | CORALVILLE | 2.699 | 0.13 | 29 | 81 | 41 | 40 | |
| FERGUSON | EAGLE CITY | | | | 80 | 41 | 39 | |
| GARRISON | CORALVILLE | 2.732 | 0.57 | 25 | 81 | 41 | 40 | |
| MCCABE | PROSSER | 2.691 | 0.74 | 30 | 79 | 42 | 37 | 49 FT FACE |
| KENDALLVLE | STEWARTVLE | 2.703 | 0.83 | 27 | 78 | 42 | 36 | |
| FESTINA | EDGWOOD | 2.659 | 1.65 | 33 | 80 | 44 | 36 | BULLERMAN Q. |
| OSAGE | CEDAR VAL | 2.753 | 0.40 | 27 | 79 | 45 | 34 | |
| MALCOM M | EAGLE CITY | 2.716 | 1.29 | 35 | 81 | 45 | 36 | |
| MEDIAPOLIS | WASSONVLE | 2.653 | 2.05 | 38 | 79 | 45 | 34 | |
| PINTS | CORALVILLE | 2.695 | 1.58 | 33 | 83 | 45 | 38 | BEDS 5-13 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RICEVILLE | CEDAR VAL | 2.682 | 2.16 | 34 | 80 | 46 | 34 | 35FT FACE |

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| | | | | | |
|---|---|---|---|---|---|
| BEHP-LUBBN | GOWER-CVLL | 74 | 36 | 38 | 50/50 |
| MOSCOW-ELK | DAVPT-STVL | 80 | 36 | 44 | 50/50 |
| ALDN-SEDGE | GILCTY-HOP | 83 | 36 | 47 | 50/50 |
| CRSNT-QRTZ | BFALLS-QTZ | 76 | 39 | 37 | 70/30 |