MICHIGAN
STATE HIGHWAY DEPARTMENT
Lansing 13
Charles M. Ziegler
State Highway Commissioner

INTEROFFICE COMMUNICATION April 25, 1952

TO: W. W. McLaughlin
Testing and Research Engineer

SUBJECT: Investigation of Klumpp Aggregates
Research Project 51 A-11; Report No. 176

As a result of the widespread occurrence of pits and popouts on the relocation of US-112 at Jackson, an investigation was initiated last year at your request to determine the suitability of aggregates from the Klumpp Brothers pit for further use in concrete construction. In July, 1951, 600 lbs. of gravel was obtained from stock piles of various gradings, and on November 5, an additional 300-lb. sample of 6A gravel was brought to the laboratory for testing. In addition to these samples of aggregate, several beam ends from construction projects containing 6A and 10A coarse aggregate from the same pit were brought in for accelerated durability tests. The gravel was tested alone and in concrete.

Tests on Gravel Only

Tests on the gravel included petrographic analysis, lithological count, soundness by two methods and miscellaneous tests on deleterious constituents.

Results of the petrographic analysis of the sample taken July 15, 1951, are given in Table I. The large proportion of chert and non-durable particles is significant, as may be seen in Table 2 where the petrographic analysis has been applied to four synthetic gradings to give representative average counts of deleterious material. A comparison of Klumpp coarse aggregate with two other sources of satisfactory quality is shown in Table 3. Although within specifications, the content of deleterious particles is high compared to the others.

The most evident source of trouble in the Klumpp gravel is the relatively large percentage of iron-bearing siltstone and sandstone found in this deposit. This constituent was picked out and tested separately, and was found to have a bulk specific gravity of 2.40 and absorption of 10.75 percent as compared to 2.65 and 0.8 - 1.5 percent respectively for normal aggregates. The quality of produced aggregate at the pit was improved somewhat by hand picking the oversize material before crushing. Specific gravity of the objectionable particles ranged from 2.45 to 2.52 with absorptions of 3.49 to 7.14 percent. Obviously, these particles would tend to rise to the surface during placing and finishing and they are, of course, extremely unsound. This fact alone accounts for the unsightly pitted surfaces found on recent projects where Klumpp aggregates were used.

Soundness tests were performed on various sieve fractions both by freezing and thawing in water and in magnesium sulphate. The results of these tests are given in Table 4, which includes also the magnesium sulphate soundness for Green Oak and Cheney coarse aggregates. Twenty-five cycles of freeze and thaw were approximately equivalent to five cycles of magnesium sulphate, but the soundness test gives no definite clue to the field performance of the aggregate in this instance.

Tests on Gravel in Concrete

Freezing and thawing tests were run on 3- by 3- by 15-in. beams made of different coarse aggregate gradings in both regular and air-entraining concrete, using Boichot sand in all mixes. Figure 1 shows the results obtained on beams made of regular concrete with average 6A, 10A and 17A gradings of Klumpp gravel compared with the range of values from seven other aggregates considered to be of acceptable quality. The Klumpp beams lasted only about a third as long as the others in this test and developed an unusual number of popouts over all faces of the beams.

Figure 2 represents tests run on Klumpp gravel in regular concrete with various deleterious constituents picked as completely as possible by hand. The overall durability of the beams was not improved to any great extent by picking out the obvious objectionables, which probably indicates that there are other characteristics contributing to the basic weakness of these aggregates and that removal of deleterious material by visual methods will not completely solve the problem.

Durability tests of air-entrained mixtures are shown in Figure 3. Here, the three gradings of Klumpp aggregate are compared with 6A from the Marshall Creek pit which was being tested concurrently. The air contents of the concrete containing aggregates from the two sources were in the same range -- namely, 4.2 and 5.0 percent respectively -- but the Klumpp beams deteriorated 50 percent in about 100 cycles of freezing and thawing while the Marshall Creek beams suffered no loss at all in the same period.

Tests on Beam Ends from Construction Projects

For futhher information, beam ends from routine flexural tests were brought in to the laboratory for examination from two construction projects where Klumpp aggregates were used last summer. One set was from a culvert on Project FI 38-48, C5, north of Jackson, and the other from a series of concrete base patches on M-50 near Napoleon, Projects F 38-16, C6, M 46-10, C7, and F 46-10, C8. Transit mix concrete was used in the culvert, with Klumpp 10A and 2NS and Peninsular cement. The patching projects contained Klumpp 6A, 2NS and Peninsular cement.

These two series of beams exhibited a marked difference in durability at the outset. The patching mix showed only the characteristic failure of cherty and non-durable constituents of the coarse aggregate, the mortar remaining intact through 55 cycles of freezing and thawing. The culvert mix, on the other hand, failed rapidly with a 10-percent loss in weight at 55 cycles accompanied by complete unsoundness throughout the specimens. The upper surfaces and cut faces of the two concretes are shown in Figure 4. (Pictures A through D.) On examination by the camera lucida method, the culvert beams of Series 4 were found to contain about 1 percent of entrained air against 2 percent for the patching mix, which correspond to air contents of fresh concrete at approximately 2 and 3 percent respectively. This fact, along with the somewhat leaner mortar (b/b_0 of 0.70 and 0.80 for the two concretes respectively) accounts for the observed difference in resistance to freezing and thawing.

Summary and Recommendations

It is evident, from field experience and laboratory durability tests, that Klumpp coarse aggregates should not be used in their present form in concrete surfacing mixtures. Unlimited use of these aggregates for highway Class A concrete might be possible through a beneficiation process of some kind, say by sink-float or centrifugal impact methods, which would effectually reduce the percentage of deleterious constituents, if such methods should prove economically feasible. Hand picking oversize material is not sufficient.

Two alternatives are open for limited use of coarse aggregates from this source: -

1. Permit only one of the separated sizes, 10A, of pavement coarse aggregate, prohibiting the use of both 4A and 6A from this pit for concrete surfacing; and

2. Allow the use of this coarse aggregate of any specification grading in subsurface concrete, such as bases and patches for subsequent surfacing.

As a final general comment, it should be noted that the laboratory durability tests show a strong possibility that coarse aggregate from the Klumpp pit may give trouble even in the limited applications suggested above, because of the expansion which always accompanies a lack of durability regardless of its cause. We would probably not be justified in altogether condemning the source, however, until this possibility is either verified or disproved by the performance in service of concrete used in such special cases.

E. A. Finney
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in charge of Research

TABLE I

PETROGRAPHIC ANALYSIS OF UNPICKED GRAVEL

Rock Type	Percent by Weight in Each Sieve Fraction No. 4-1/2	1/2-3/4	3/4-1	1-1-1/2
Granite	11.4	11.6	13.6	15.4
Diorite	8.2	9.0	7.5	5.7
Basalt	11.7	13.3	10.0	12.7
Felsite	5.0	3.4	8.1	5.7
Quartzite	5.8	5.4	4.4	4.6
Limestone and Dolomite	43.7	44.9	43.2	34.5
Chert	5.5	2.7	2.8	2.1
Soft, non-durable	3.2	3.3	3.7	5.5
Hard, absorbent	2.0	1.2	1.8	2.1
Crusted material	3.5	5.3	5.0	11.8

TABLE 2

Lithological Count Based on Average MSHD Gradings
and Petrographic Analysis of Gravel Fractions

Grading	Crusted Material	Soft, Non-durable (1)	Hard, Absorbent (2)	Chert (3)	Sum (1) (2) (3)
4A	10.0	4.9	2.0	2.5	9.4
6A	6.2	3.8	1.8	3.7	9.3
10A	4.3	3.3	1.7	4.1	9.1
17A	4.2	3.3	1.7	4.4	9.4

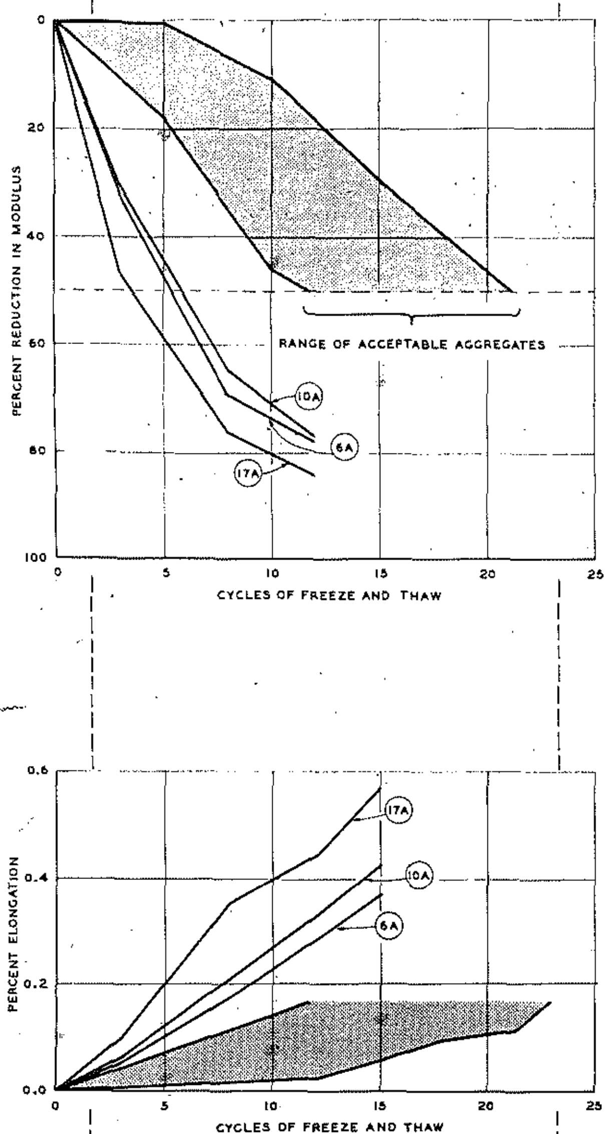


FIGURE 1

LABORATORY DURABILITY TESTS
OF KLUMPP AGGREGATES
IN NON-AIR-ENTRAINED CONCRETE

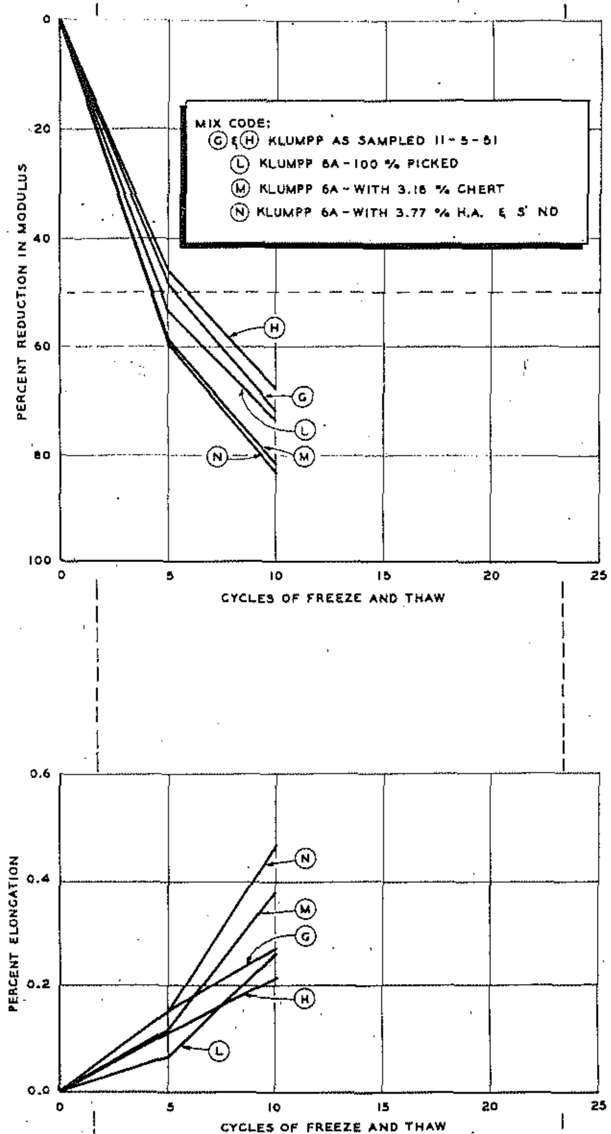


FIGURE 2

LABORATORY DURABILITY TESTS
OF PREPARED KLUMPP AGGREGATES
IN NON-AIR-ENTRAINED CONCRETE

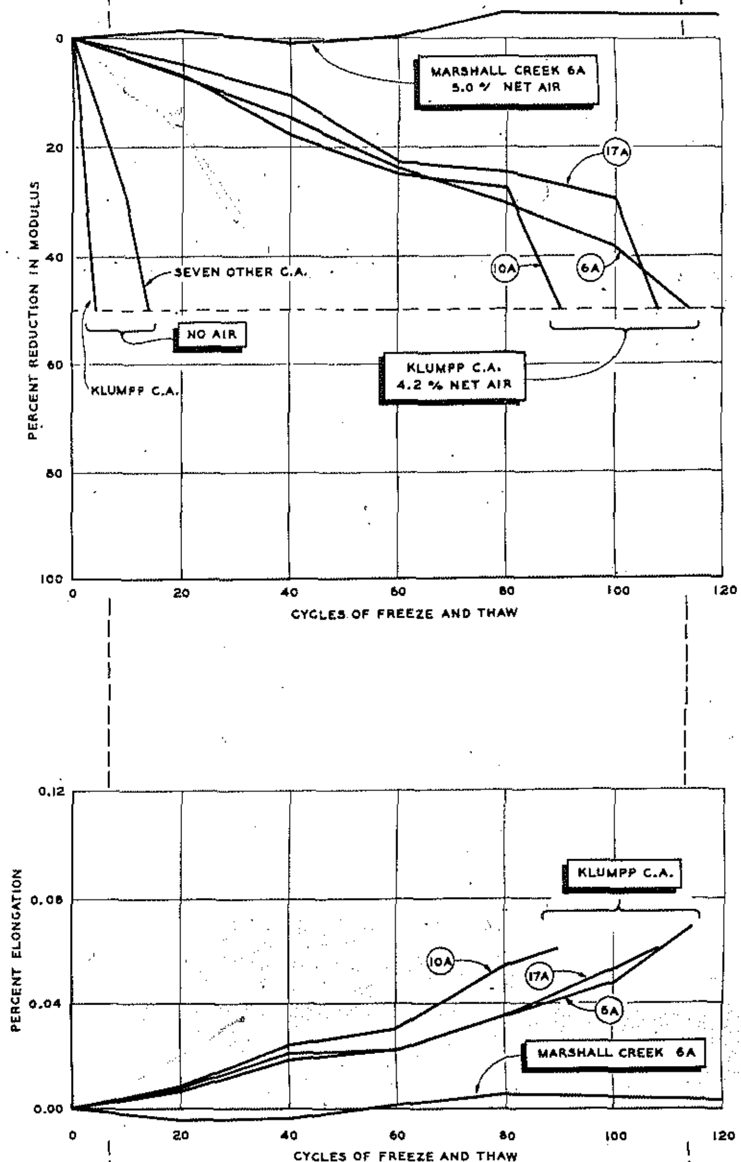
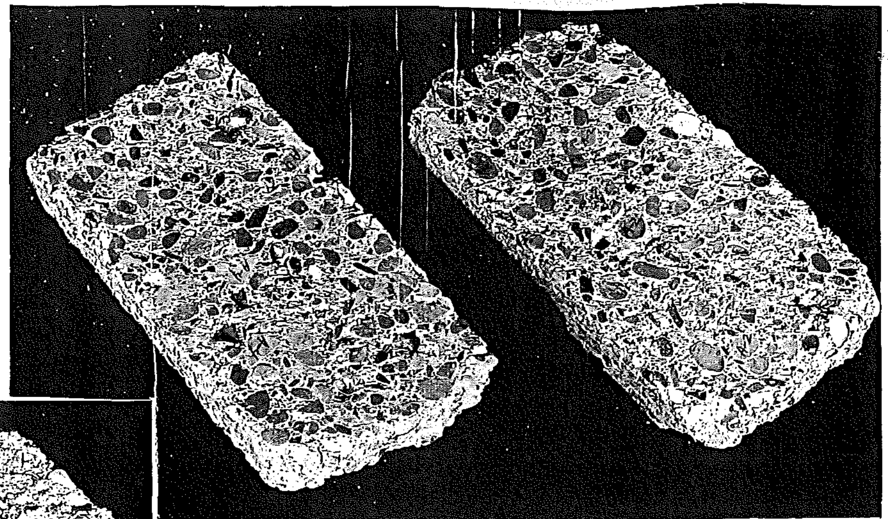
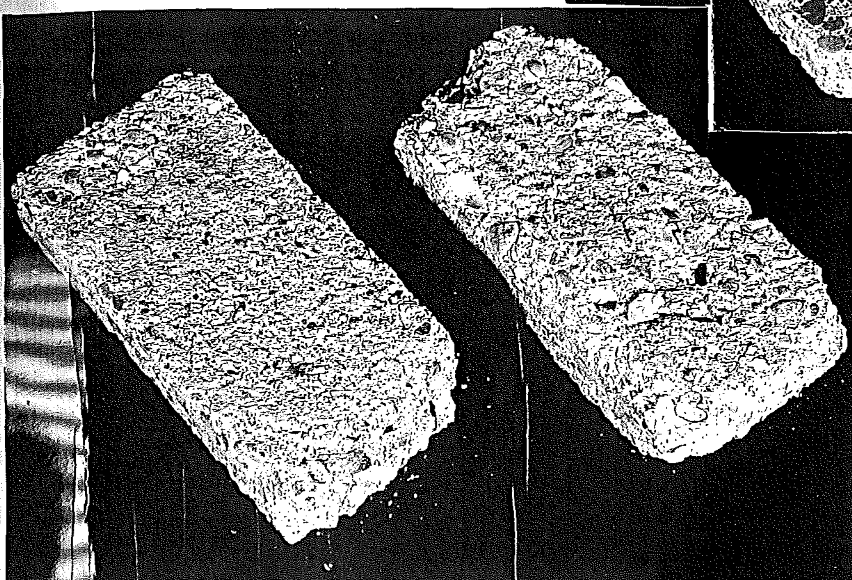


FIGURE 3

LABORATORY DURABILITY TESTS
OF KLUMPP AGGREGATES
IN AIR-ENTRAINED CONCRETE

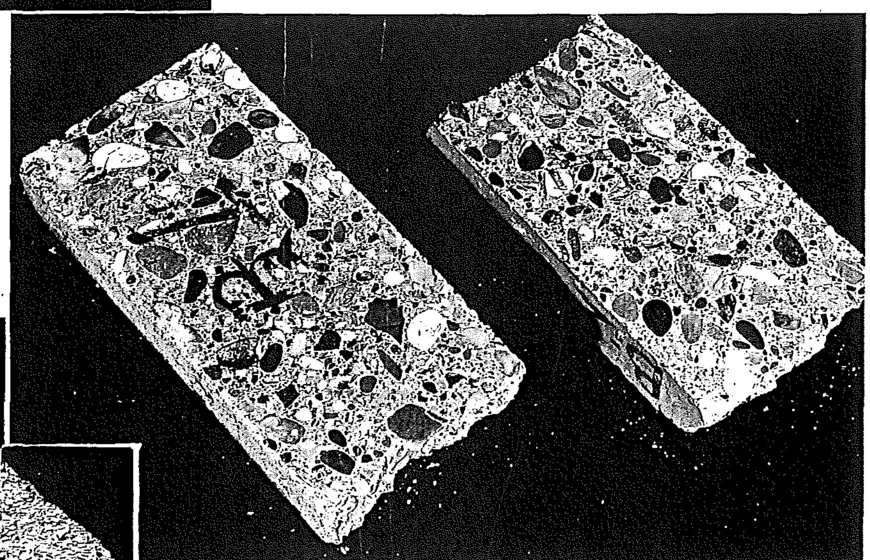
A. Cut faces of Culvert Concrete, Project FI 38-46, C5. Note general disintegration of mortar.

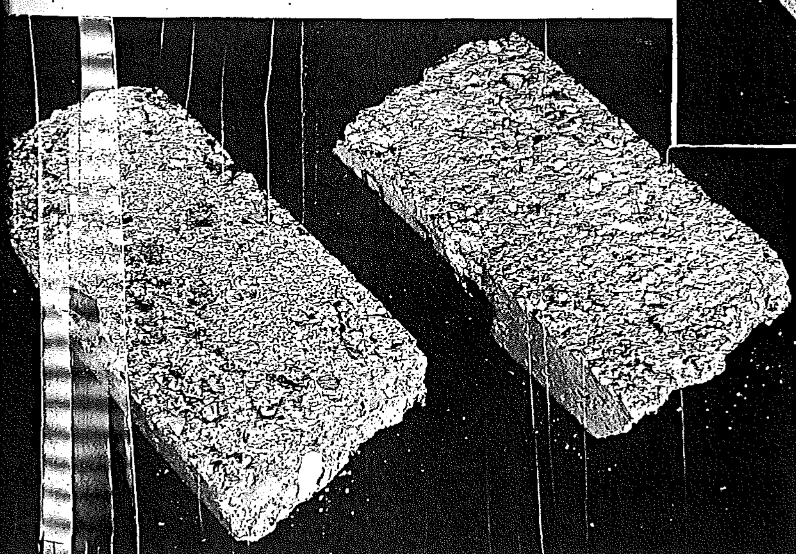




B. Top surfaces of Culvert Concrete, Project FI 38-48, C5.

C. Cut faces of patching Concrete, Project F 38-16, C6. Sporadic Failure of non-durables, but mortar sound and intact.





D. Top surface of patching concrete, Project F 38-16, C5. Characteristic popping of non-durable particles.

Figure 4. Condition of Field Molded Beams After 55 Cycles of Freezing and Thawing in Water.