DEGRADATION OF BASE COURSE AGGREGATES

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ABSTRACT: Some degradation occurred during handling and compaction of 1200 aggregate samples tested from four sources. Even after degradation, however, the gradation still averaged within specification limits. Effects of degradation found in this study on pavement performance are unknown, but the aggregate's engineering properties presumably would be affected by the gradation change.

KEY WORDS: degradation (aggregate), aggregate analysis, aggregate testing, aggregates (physical properties), compaction, compaction characteristics, gradation, gradation analysis.

DEGRADATION OF BASE COURSE AGGREGATES

This project was undertaken at the request of W. W. McLaughlin, to determine changes in aggregate gradation from the time accepted by the Department's inspectors as produced, through testing in place on the roadway for record as required by the Bureau of Public Roads in PPM 20-6.2.

This report summarizes results obtained during testing of some 1200 aggregate samples obtained from four different sources, to determine their possible degradation during handling and compaction. Sampling was begun at several other sources, but due to circumstances beyond our control proper continuity of procedure was not possible and the work was discontinued. Samples were tested for gradation as produced and after being compacted to required density on the roadway using a sufficient number of tests to obtain a statistically meaningful comparison between the two conditions. In all cases the aggregates were hauled to the job site within a few days after testing at the stockpile.

The four sources tested were selected on the basis of estimated uniformity of gradation and durability of the aggregates produced. A brief description of each follows:

1. Ann Arbor, Ginsley Pit No. 81-77 was selected for its reported uniform aggregate gradation. It appeared to contain good sound aggregate and the producer had no apparent problem producing 22A gravel. The total quantity tested at this pit was 37,662 tons. The aggregate was used for shoulder construction on I 94, with 24,586 tons tested after compaction on the grade.

2. St. Johns, Kneeland Pit No. 19-18 was also selected for its reported uniform aggregate gradation. This pit also appeared to contain good, sound aggregate and the producer had no apparent problem making 22A. The total quantity tested at the time of production was 38,300 tons. The gravel was used for a cushion layer between an old concrete pavement and new bituminous surface. Total quantity of base tested after compaction was 37,389 tons.

3. Maple Rapids, Fitzpatrick Pit No. 18-44 was selected because of difficulty the producer anticipated in meeting 22A specifications. The 3- to 7-percent minus-200 material limits were modified for this project to

allow up to 10-percent minus-200 material. The pit appeared to contain good sound aggregate but the producer in some cases had difficulty keeping below the 10-percent maximum allowable minus-200 material limit, and in other cases keeping above the 3-percent minimum limit. The gravel was used for the base course of a bituminous pavement. The total quantity of aggregate tested at the pit was 120,645 tons and on the roadbed, 80,498 tons.

4. Mason, Jewett Pit No. 33-93 was selected for its reported high sandstone aggregate content which could make it susceptible to degradation on the larger sieves. No 22A aggregate was produced at this pit, but 24A was in production and was tested instead. The producer had trouble ejecting excess sand and had to add special sand ejection equipment. In addition, he had trouble crushing aggregate that would pass the 1-in. sieve and be retained on the 3/4- and 3/8-in. sieves. The gravel was used for construction of selected subbase. The total quantity of aggregate tested at the pit was 36,525 tons and on the grade, 25,212 tons.

To determine the gradation of the base gravel at production, approximately one sample was collected per 400 tons of accepted gravel produced. Samples were selected from the stockpile, using random sampling procedures. Those obtained from the roadbed were taken at a rate of approximately one sample per 200-ft length of 24-ft wide base. In the case of shoulders, one sample was obtained per 500-ft length of shoulder. Here, too, random sampling procedures were used. All roadbed samples were collected after compaction was completed and just before the start of priming or paving, as the case might be.

Table 1 lists gradation data obtained from this study and indicates the degree to which one can be sure differences are certain and not due simply to chance. Figures 1 through 4 are curves for average aggregate gradations both at the pit and on the road. Specification limits are included to illustrate the relationship between the gradations and specifications.

Material from the St. Johns pit was compacted for several days, but the contractor could not obtain required density. The job was left for several weeks, during which the base was tested; the results are labeled as "Road Test 1" in Table 1. Later, the contractor returned to the project and succeeded in obtaining acceptable density. The base was again tested to determine if any degradation might have occurred solely as a result of the additional compactive effort. These second sets of base samples are labeled "Road Test 2" in Table 1.

As the table and graphs indicate, there is definite degradation of the aggregates during placement and compaction. The amount and the sieves on which this takes place vary with each test site. Although average pit and road materials met specifications in all but one case--where the minus-200 material on the road exceeded 7 percent by a small amount--considerably more individual road samples did not meet specifications. Using results from all four pits, the number of individual samples failing to meet minus-200 requirements increased from 6.5 percent at the pit to 25 percent after placement on the road. In the case of the St. Johns (Kneeland) Pit, about 70 percent of the road samples were above 7 percent in minus-200 material.

Not all changes in gradation were due to degradation. In some cases, very high fines contents were found to be due to truck traffic tracking mud to the grade from haul roads. Most of the mud was removed during grading, but large quantities of fines were ground and filtered into the base as a result of the heavy traffic. Such conditions, although affecting individual locations, had little effect on average results.

The effect on gravel engineering properties caused by degradation, of the magnitudes found in this study, will vary with the type of gravel under consideration. However, it can be expected that degradation will result in reduced permeability, increased density, and a change in shear strength.

Based on the results of this study, the following conclusions are warranted:

1. A significant degradation of aggregates takes place during handling and compaction. This degradation is usually from the 3/8-in. sieve down, with a maximum minus-200 increase ranging from 1 to 2.4 percent.

2. In one test (Fig. 2), additional compaction subsequent to original compaction resulted in a further degradation of about 0.5 percent passing the No. 200 sieve.

3. Even after degradation, average results showed the materials still to be within specification limits. However, as average values of a group approach their specification limits more individual values will exceed these limits. This could be an important consideration in those cases where quality evaluation is based on individual tests rather than on the average of a group.

4. About 25 percent of all individual samples from the roadway showed minus-200 values higher than specification limits. Some were due to tracking of mud onto the grade by vehicles. The extreme case of individual sample degradation was the St. Johns (Kneeland) Pit, where 70 percent of the samples did not meet the minus-200 requirement after compaction on the road.

5. The effects of the degradation found in this study on the performance of pavements are not known. It is reasonable to assume, however, that the engineering properties of the aggregate would be affected somewhat by the change in gradation.

TABLE 1
SUMMARY OF AGGREGATE TEST DATA

Location	Sieve Size	Gradation, percent passing: Speci-fications	Gradation, percent passing: Pit	Gradation, percent passing: Road	Degradation, percent (Pit vs. Road)*
Ann Arbor, Ginsley Pit (No. 81-77)	1 in.	100	100.0	100.0	--
	3/4 in.	90-100	99.4	99.6	0.2 VS
	3/8 in.	65-85	69.6	76.8	7.2 VS
	No. 10	30-45	36.1	43.0	6.9 VS
	No. 200	3-7	4.8	6.6	1.8 VS
	Samples Tested		103	76	
Maple Rapids Fitzpatrick Pit (No. 19-44)	1 in.	100	100.0	100.0	--
	3/4 in.	90-100	97.1	97.0	-0.1 NS
	3/8 in.	65-85	69.2	71.0	1.8 VS
	No. 10	30-45	38.8	40.8	2.0 VS
	No. 200	3-10	6.6	8.3	1.7 VS
	Samples Tested		370	320	
Mason Jewett Pit (No. 33-93)	1 in.	100	100.0	100.0	--
	3/4 in.	--	94.9	95.4	0.5 PS
	3/8 in.	65-85	71.3	74.8	3.5 VS
	No. 8	30-55	43.9	47.9	4.0 VS
	No. 30	--	30.2	32.7	2.5 VS
	No. 200	3-7	5.5	6.5	1.0 VS
	Samples Tested		103	76	

Location	Sieve Size	Gradation, percent passing: Speci-fications	Gradation, percent passing: Pit	Gradation, percent passing: Road Test 1	Gradation, percent passing: Road Test 2	Degradation, percent*: Pit vs. Road Test 1	Degradation, percent*: Pit vs. Road Test 2	Degradation, percent*: Toad Test 1 vs. Road Test 2
St. Johns Kneeland Pit (No. 19-18)	1 in.	100	100.0	100.0	100.0	--	--	--
	3/4 in.	90-100	98.5	98.4	98.6	-0.1 NS	0.1 NS	0.2 PS
	3/8 in.	65-85	74.1	73.9	74.5	-0.2 NS	0.4 NS	0.6 PS
	No. 10	30-45	39.1	40.7	42.2	1.6 VS	3.1 VS	1.5 VS
	No. 200	3-7	5.0	6.9	7.4	1.9 VS	2.4 VS	0.5 S
	Samples Tested		78	88	77			

* Statistical significance refers to the possibility that the difference occurring in gradation from pit to road was due to chance in sampling. It does not refer to any possible effect this difference might have on engineering properties of the material. The following guide was used to determine statistical significance:

Significance of Results	Possibility (percent) that Difference Could Arise by Chance in Sampling
VS = very significant	0.5 or less
S = significant	5.0 to 0.5
PS = possibly significant	25.0 to 5.0
NS = not significant	More than 25.0

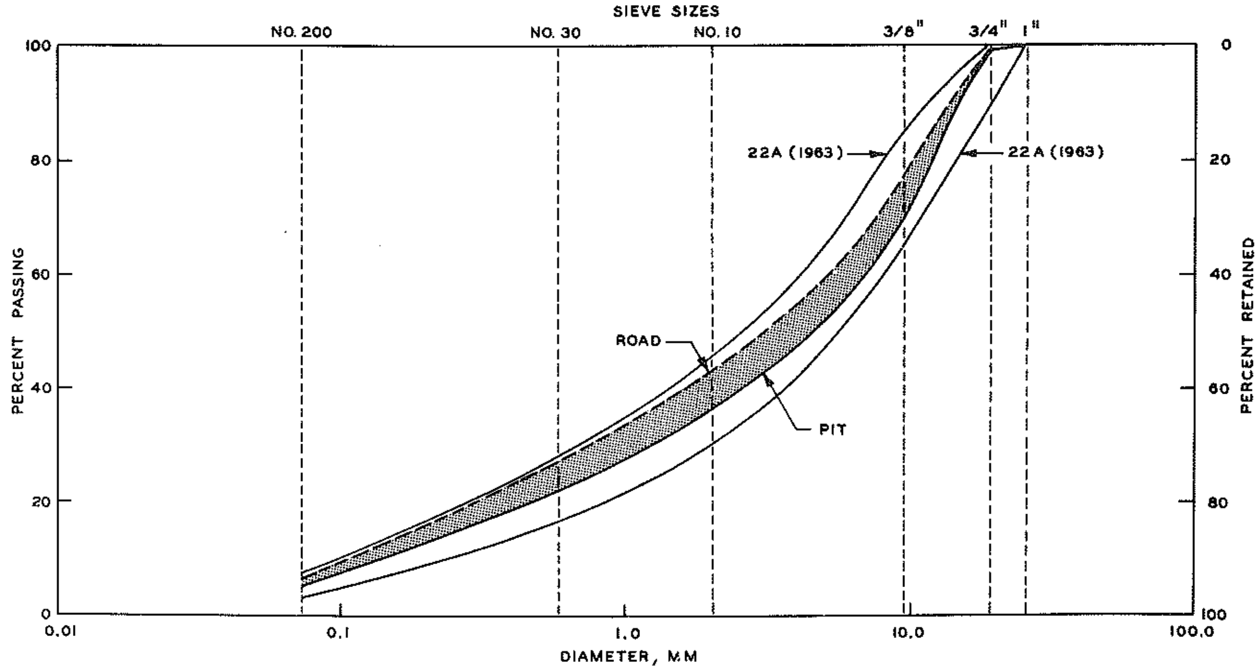

Figure 1. Degradation of aggregate from "Ann Arbor" (Ginsley Pit, No. 81-77).

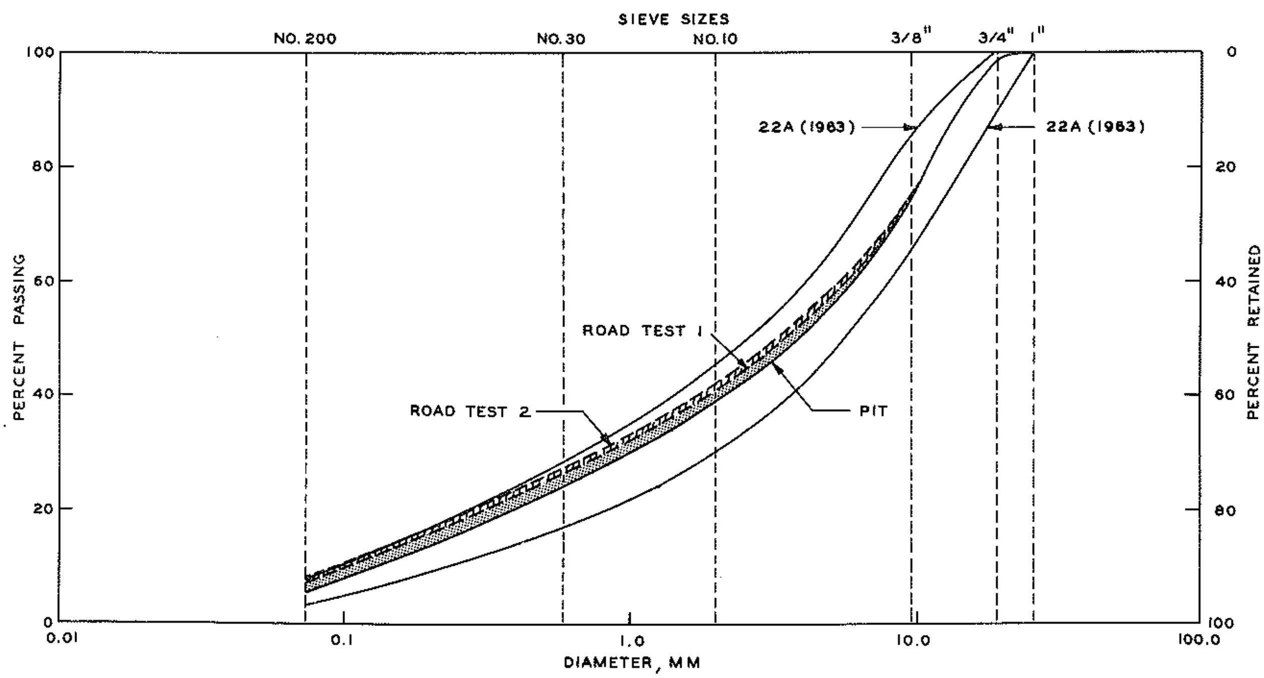

Figure 2. Degradation of aggregate from "St. Johns" (Kneeland Pit, No. 19-18).

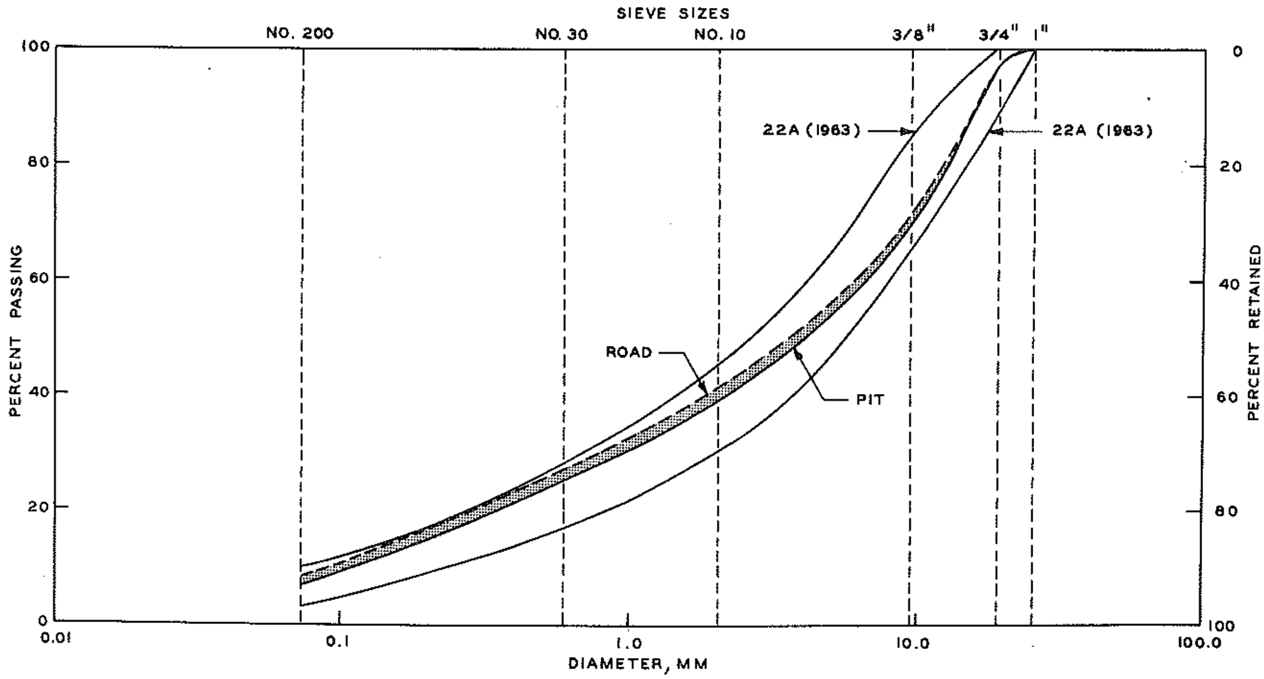

Figure 3. Degradation of aggregate from "Maple Rapids" (Fitzpatrick Pit, No. 19-44).

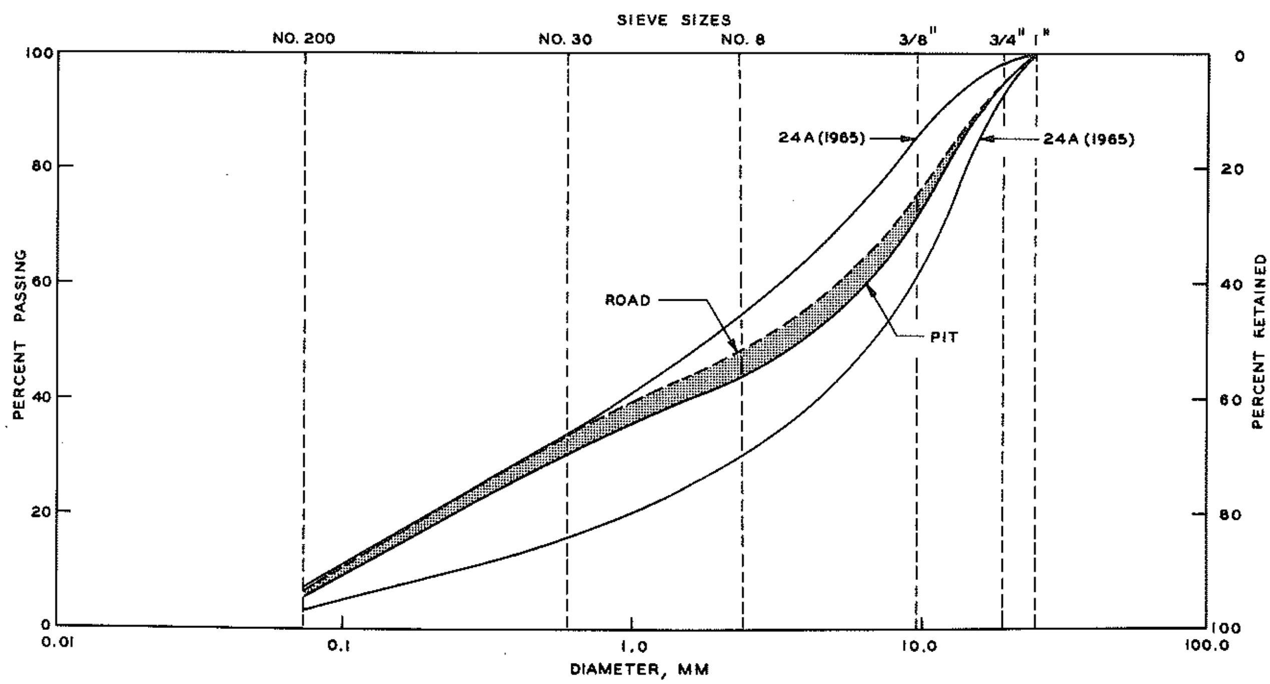

Figure 4. Degradation of aggregate from "Mason" (Jewett Pit, No. 33-93).