STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

Report of Investigations No. 121

PHYSICAL PROPERTIES OF CARBONATE AGGREGATE FROM OHIO

by

David A. Stith

Columbus
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ODNR
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David A. Stith

ABSTRACT

Twenty-six limestone and dolomite samples were collected in 1977 and 1978 in a program to characterize the physical properties of Ohio aggregate. Testing of the samples included size analysis, sodium sulfate and freeze-thaw soundness, Los Angeles abrasion, specific gravity, absorption, and chemical analysis.

INTRODUCTION

During the last half-century, demand for limestone aggregates for road and construction uses has more than tripled in Ohio, from a little under 10 million tons in 1929 to over 33.5 million tons in 1979 (Ohio Department of Industrial Relations, 1931, 1980). As construction practices become more complicated and more sophisticated, it becomes increasingly necessary to know as much about an aggregate as possible. A more complete knowledge of the properties of the carbonate aggregates of Ohio may promote the discovery of new uses and should help prevent the loss of present uses to high-priced imported aggregates.

In the past 50 years few data have been published in an easily accessible form on the physical properties of carbonate aggregates from Ohio. Woolf (1953) lists data on thousands of samples from all over the country. Most of this information is either very old or is on slag or gravel. Carr and others (1970) compiled data and made statistical correlations on the physical, petrographic, and chemical properties of the Brassfield Limestone. Their study included seven samples from Ohio. The single recent report (Stith, 1969) published by the Ohio Department of Natural Resources, Division of Geological Survey (OGS) combined some physical testing with a literature review of the requirements for exposed aggregate and terrazzo. The testing laboratory of the Ohio Department of Transportation examines numerous samples every year but these data generally are not published.

In 1976 the Survey started acquiring equipment in order to establish a program of aggregate testing. Initially the program involved testing stockpile samples from existing aggregate facilities. This paper presents the results of tests on the first two sets of samples collected.

The first set of 10 samples was obtained primarily to set up the equipment and the various test procedures. After tests were completed on these samples a number of references from the National Cooperative Highway Research Program (NCHRP) were obtained (Hudson and Waller, 1969; Miller-Warden Associates, 1967a, 1967b; and West and others, 1970). These additional references contained numerous recommendations about the problems of sampling and testing aggregate. Several points in the sampling procedure for the second set of 16 samples were changed according to the guidelines established in the above papers.

ACKNOWLEDGMENTS

The author expresses his appreciation to the managements of those quarries sampled in this study. Thanks go to Bruce Mason and Richard Lucas, France Stone Company, and to Stuart Schwotzer, Ohio Department of Transportation, for discussions on aggregate sampling and testing.

AGGREGATE SPECIFICATIONS

Several organizations list specifications for aggregate. The American Society for Testing and Materials (ASTM) gives standard specifications for the general use of aggregates in concrete. The American Railway Engineering Association (AREA) lists specifications for railroad ballast. The American Association of State Highway and Transportation Officials (AASHTO) and the Ohio Department of Transportation (ODOT) list specifications for the use of aggregates in highway construction.

The ASTM standards (1981) give both physical-property specifications and applicable test methods for fine and coarse aggregate. The ASTM major requirements and limits for coarse aggregate (ASTM C 33) are listed in table A1 of Appendix A. The grading requirements in ASTM C 33 are the same as those listed by ODOT and AASHTO and are shown with the ODOT information in table A3 of Appendix A.

The AREA lists specifications and test methods for railroad ballast as part of its manual on railroad construction (AREA, 1980). A summary of these specifications is given in table A2 of Appendix A. The test methods specified by the AREA manual are the appropriate ASTM methods.

AASHTO (formerly American Association of State Highway Officials, AASHO) also publishes both specifications and testing methods for aggregate (AASHO, 1970). Unlike ASTM, AASHTO lists different sets of specifications for a number of different types of concrete, surface courses, and base courses. The AASHTO test methods are very similar to the ASTM methods.

ODOT biennially publishes construction and material specifications for roadway construction in the state of Ohio (ODOT, 1981). Like AASHTO, ODOT lists different sets of specifications for different categories of aggregate use. However, ODOT uses slightly different categories than AASHTO. The test methods required in these specifications are basically AASHTO methods. The general specifications applicable to coarse aggregate are given in table A3 of Appendix A. The coarse-aggregate sizes listed in these specifications are the same as the sizes listed by ASTM and AASHTO. Specific grading requirements for the many categories are listed in the section for the particular category and are not reviewed here. However, size No. 57 is the most commonly required standard gradation for concrete and surface courses.

METHODS

Insofar as possible, testing was done in accordance with procedures outlined by ASTM or by AASHTO (table 1). The testing procedures used for the two sample sets were virtually identical. The changes resulting from the NCHRP references affected primarily the sampling and size-analysis procedures for the second set of samples.

TABLE 1.—*Test procedures*

Test	Method used	
	ASTM(1976)	AASHO(1966)
Sieve analysis	C 136-71	
Soundness (5 cycle, Na_2SO_4)	C 88-73	
Soundness (freeze-thaw, 50 cycle, total immersion)	C 666-76	T 103-62
Abrasion (Los Angeles)	C 131-69(75) & C 535-69(75)	
Specific gravity/absorption	C 127-73	

Field samples of processed aggregate were collected from stockpiles of active crushed-stone producers throughout the state (fig. 1). The appropriate size of crushed stone available at each locality was selected to give the maximum amount of material smaller than 1½ inches and greater than a No. 4 screen[1]. This was a No. 57 aggregate in most cases. The first 10 samples, collected in 1977, weighed 150 to 170 pounds each and were collected as small shovelsful randomly taken from the surface of the stockpile. The procedure as modified for the second set of samples utilized a large scoop, 9 inches long by 6 inches wide, which held approximately 8 pounds of rock. Increments were taken randomly with the scoop until a total sample weight of 200 to 250 pounds was obtained. In addition, a technique already in use in the aggregate industry was used to provide a statistically more

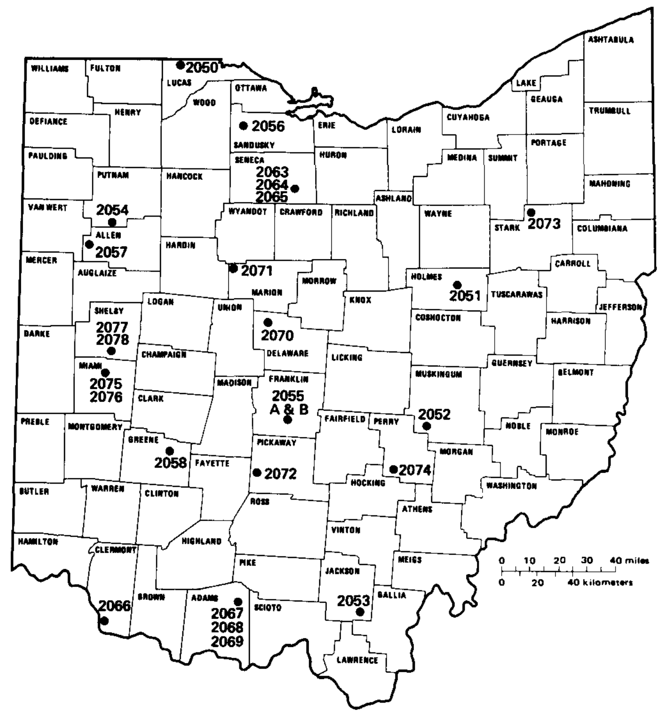

FIGURE 1.—Location of sampled quarries.

reliable sample from a large stockpile (Bruce Mason, oral commun., 1978). In this method a small sampling subpile is constructed with several partial loads taken from the main pile by a bucket or front-end loader. This small pile is mixed and flattened by the loader. The field sample is then taken from the subpile with the sampling scoop. This subpile technique was used for more than half the samples taken in 1978.

Three of the 1978 samples (nos. 2063, 2064, and 2065) were taken from the same stockpile to test the effectiveness of the sampling subpile and the scoop-obtained increment. The sampled stockpile was a large, single-layer, truck-dumped pile. Sample no. 2063 was taken as 10 separate test portions, each composed of three increments (scoopsful), each increment taken from a different position in the pile. Sample no. 2064 was taken as one large sample with one increment taken from each of the increment positions of sample no. 2063. Sample no. 2065 was sampled with the scoop from a small sampling subpile constructed by a front-end loader.

Sieve analyses were run on splits of the field samples to provide the gradation of the actual sample tested and to provide material from each size to make up specific gradations required for some of the tests (soundness, abrasion, etc.). Sample reduction and splitting for sieve analyses and other tests requiring original gradation were done with a riffle splitter. Sieve-analysis splits from the 1977 samples weighed 50 to 70 pounds and those from the 1978 samples weighed 80 to 90 pounds.

Soundness was evaluated by two test methods, standard sulfate and freeze-thaw. Sodium sulfate was the salt used in the sulfate method. The temperature of the solution tank was maintained at 20° to 22°C during the test. Freeze-thaw tests were run in a Logan freeze-thaw machine (Stith, 1969).

[1] Screen numbers refer to the numbered sieves of the U.S. Standard Sieve Series.

The method used was a combination of AASHTO and ASTM methods (table 1). Aspects of the method adopted from AASHO T 103-62 (test of aggregate) were the test-sample gradation, the test sieves, total-immersion-in-water procedure, and 50-cycle duration. Procedures from ASTM C 666-76 (test of concrete) were the use of automatic-cycling equipment, temperature limits of 0° F and 40° F, and cycle time of 4 hours or less.

Abrasion resistance was determined using a Los Angeles testing machine. The test-sample gradation (A, 3/8 to 1 1/2 inches; B, 3/8 to 3/4 inch, and 3, 3/4 to 1 1/2 inches) most like the sample gradation was used for most of the samples. For four samples (nos. 2053, 2056, 2067, and 2073) sufficient material was present in enough sieve sizes to run two test gradations. After abrasion testing of the 1977 set, several samples were weighed both washed and unwashed. As the ASTM procedure indicated, the washing after testing caused a difference in loss of 0.2 percent or less. The remaining 1977 samples and all of the 1978 samples were therefore weighed without washing after testing and all abrasion results are reported as without washing.

Specific gravity and absorption were determined on single size fractions, 3/8 to 1 1/2 inches or 3/8 to 1 inch, on the 1977 samples. These tests were run on single or multiple fractions on the 1978 set, based on the amount of material available in the different fractions for each sample (table B3, Appendix B).

Splits of most of the samples were pulverized for chemical analysis. Major and minor element analyses were done by a mixture of atomic absorption and emission methods. Sulfur was determined by iodometric titration.

RESULTS AND DISCUSSION

Results of the physical tests and the chemical analyses are shown in Appendix B. Measured section descriptions and sampling comments are given in Appendix C. Although the same type of equipment was used, the freeze-thaw results from this study are not directly comparable to the data from the previous OGS project (Stith, 1969). The earlier tests were done on different gradings; the 3/8- to 3/4-inch size was only 300 grams; and the test sieves were different, 3/4 and 3/8 inch instead of 5/8 and 5/16 inch.

One of the main difficulties in characterizing any property of a crushed stone is obtaining a representative sample of the material (Miller-Warden Associates, 1967a). Because of time, storage, and material-handling restrictions, this project was limited to a single, relatively low weight sample from each stockpile selected. The sampling and testing recommendations from the NCHRP references—200- to 250-pound field sample, sampling scoop, 6- to 8-pound sample increment, and 85-pound size-analysis test portion—were adopted in 1978 along with the separate sampling subpile to provide as representative a sample as possible.

Inspection of the data from sample nos. 2063, 2064, and 2065 (see Methods section and Appendix B) shows that representative sampling was accomplished. Table 2 lists the size analyses of the 10 separate test portions of sample no. 2063 and shows the variation possible in very small samples taken from different positions in a large stockpile. The size analysis for sample no. 2063 listed in Appendix B is the composite total, by weight, for the entire 10-portion sample. Size data for sample nos. 2064 and 2065 were from 80- to 85-pound test portions riffled from the field samples.

TABLE 2.—*Size analyses, sample no. 2063*

Test portion	Amounts finer than each laboratory sieve (square openings)[1], weight percent					
	1	3/4	1/2	3/8	No. 4	No. 8
A	100	89.9	45.8	19.3	5.8	4.7
B	100	83.2	38.4	16.8	4.8	4.0
C	100	91.4	43.9	16.8	2.8	2.1
D	100	87.8	38.3	15.5	3.7	2.9
E	100	90.5	48.5	21.5	6.3	4.8
F	100	82.9	36.1	13.4	3.6	2.9
G	100	81.2	29.3	9.8	3.3	2.9
H	100	81.4	28.9	9.2	2.8	2.5
I	100	81.5	27.6	9.0	3.2	2.7
J	100	88.2	41.4	15.2	4.4	3.3

[1] In inches, except where otherwise indicated. No. 4 and No. 8 refer to sieves of the U.S. Standard Sieve Series.

Gradation of a crushed stone is a plant-dependent property, not a stone-dependent one. Size analyses listed in Appendix B are given to show the material analyzed, not as a physical property of the rock.

The study of the Brassfield Limestone by Carr and others (1970) found a number of relationships between physical and chemical properties of the stone. These relationships include negative correlations between absorption and specific gravity, between soundness loss and $CaCO_3$ content, and between abrasion loss and insoluble residue content, as well as a positive correlation between absorption and soundness loss. In a continuing study of Illinois aggregate, Harvey and others (1978) correlated the soundness loss of more than 100 samples to various physical, chemical, and petrographic properties. They divided the samples into eight subclasses based on dolomite and alumina content and presence or absence of laminations. Using stepwise-multiple-regression analysis they determined equations to predict soundness loss for a number of their classes and subclasses using absorption, specific gravity (dry), Rockwell hardness, and dolomite content.

The results of this OGS study show several strong to weak correlations. There is a strong negative correlation between absorption and bulk specific gravity for both limestone and dolomite, a weak negative correlation between sulfate soundness loss and $CaCO_3$ content for limestone, and weak positive correlations between abrasion loss and both absorption and sulfate soundness loss for dolomite. Most of these correlations are considered tentative because of the relatively small number of samples in this study and the diverse lithologies represented.

Although this project was designed to determine physical properties of Ohio carbonate rocks, two of the tests performed are two of the primary tests required to determine aggregate quality for highway and railroad construction. On the basis of Los Angeles abrasion and sulfate soundness loss, almost all of the samples in this study should be acceptable for all or some uses in highway construction and over half should be suitable for railroad ballast (tables A2 and A3, Appendix A; table B2, Appendix B). Eighteen samples (nos. 2050, 2051, 2052, 2053, 2054, 2055A, 2055B, 2057, 2058, 2063-2065, 2068, 2069, 2070, 2071, 2072, 2074, 2077, and 2078) should be suitable for all highway uses. Sample no. 2076 should be of marginal use under ODOT specifications 515[2] but suitable for all other uses. Sample no. 2066 should be suitable and sample no. 2067 of marginal use under ODOT specifications 305, 405, 406, and 409. Sample nos. 2066 and 2067 as well as sample no. 2056 should be suitable for use under ODOT specifications 703.04. Sample no. 2073 should be suitable for use under ODOT specifications 304. Fourteen samples (nos. 2051, 2052, 2053, 2054, 2055A, 2055B, 2057, 2058, 2068, 2069, 2071, 2074, 2077, and 2078) should be suitable for railroad ballast.

[2]ODOT specifications numbers refer to individual construction or material specifications (Ohio Department of Transportation, 1981).

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APPENDIX A.–AGGREGATE SPECIFICATIONS

TABLE A1.–*ASTM specifications*[1] *for coarse aggregate for concrete*

Class designation	Type or location of concrete construction	Maximum allowable percent						
		Clay lumps and friable particles	Chert (less than 2.40 sp gr SSD)[2]	Sum of clay lumps, friable particles, and chert (less than 2.40 sp gr SSD)[2]	Material finer than No. 200 sieve[3]	Coal and lignite	Abrasion[4]	Magnesium sulfate soundness (5 cycles)[5]
1S	Footings, foundations, columns, and beams not exposed to the weather; interior floor slabs to be given coverings	10.0	–	–	1.0	1.0	50	–
2S	Interior floors without coverings	5.0	–	–	1.0	0.5	50	–
3S	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	5.0	7.0	1.0	0.5	50	18
4S	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures subject to frequent wetting	3.0	5.0	5.0	1.0	0.5	50	18
5S	Exposed architectural concrete	2.0	3.0	3.0	1.0	0.5	50	18

[1] Modified from American Society for Testing and Materials, 1981, ASTM C 33-81, table 3. ASTM C 33-81 lists specifications for each of several regions of the U.S. based on severity of weathering in the region. Because Ohio is in the Severe Weathering Region, only those specifications are listed here.

[2] These limitations apply only to aggregates in which chert appears as an impurity. They are not applicable to gravels that are predominantly chert. Limitations on soundness of such aggregates must be based on service records in the environment in which they are used. SSD refers to specific gravity determinations on a saturated-surface-dry basis.

[3] If the material finer than the No. 200 (75-micrometers) sieve is essentially free of clay or shale, this percentage may be increased to 1.5. A greater amount of material passing the No. 200 sieve may be permitted, provided the amount passing the No. 200 sieve in the fine aggregate is less than the specified maximum. In such case, the sum of the amounts finer than the No. 200 sieve from the separate fine and coarse aggregates shall not exceed the sum of the weighted maximum amounts permitted for the coarse plus fine aggregate.

[4] Crushed air-cooled blast-furnace slag is excluded from the abrasion requirements. The compact unit weight of crushed air-cooled blast-furnace slag shall be not less than 70 lb/ft^3 (1120 kg/m^3). The grading of slag used in the unit-weight test shall conform to the grading to be used in the concrete. Abrasion loss of gravel, crushed gravel, or crushed stone shall be determined on the test size or sizes most nearly corresponding to the grading or gradings to be used in the concrete. When more than one grading is to be used, the limit on abrasion loss shall apply to each.

[5] The allowable limits on soundness shall be 12 percent if sodium sulfate is used.

TABLE A2.–*AREA ballast specifications*[1]

Maximum allowable weight percent

Soft and friable pieces	5 percent
Material finer than No. 200 sieve	1 percent
Clay lumps	0.5 percent
LA abrasion loss	40 percent
Sodium sulfate soundness loss (5 cycles)	7 percent
Flat or elongate particles[2]	5 percent

Grading requirements

Size no.	Nominal size, square openings[3]	Amounts finer than each laboratory sieve (square openings)[3], percentage by weight									
		3	2½	2	1½	1	¾	½	⅜	No. 4	No. 8
24	2½-¾	100	90-100		25-60		0-10	0-5			
3	2-1		100	95-100	35-70	0-15		0-5			
4	1½-¾			100	90-100	20-55	0-15		0-5		
5[4]	1-⅜				100	90-100	40-75	15-35	0-15	0-5	
57	1-No. 4				100	95-100		25-60		0-10	0-5

[1] Modified from American Railway Engineering Association (1980).
[2] Length of particle is equal to or greater than five times the average thickness.
[3] In inches, except where otherwise noted. Numbered sieves are those of the U.S. Standard Sieve Series.
[4] Same as ASTM/AASHTO size No. 56.

TABLE A3.–*ODOT coarse-aggregate specifications*[1]

703 AGGREGATE

703.01 General. Soundness. When the major portion of the unsound material in a coarse aggregate acquires a mud-like condition when tested for soundness, the maximum loss shall be 5 percent for all uses.

Stockpiles. Stockpiling and loading methods shall be such as to permit ready identification of the aggregates and to minimize segregation. Sites for stockpiles shall be clean prior to storing materials. Aggregates shall not be removed from stockpiles within 1 foot of the ground until final cleanup of the work and no material which has become mixed with foreign matter or other sizes or grades of aggregates shall be used.

Aggregates shall be handled in such a manner that the moisture content will be reasonably uniform for each day's run. If necessary, in order to secure uniformity of moisture content of the aggregates, stockpiling will be required.

Open-hearth and Basic-oxygen Furnace Slags. All open-hearth and basic-oxygen furnace slags shall be furnished to a size meeting the specified grading requirements of the use item to which it will be incorporated, and stockpiled for a period of not less than 6 months prior to use. New material shall not be added to the stockpile during the 6-month aging period, or prior to or during delivery from the stockpile to the project. Any addition of new material to a stockpile will require initiation of a new aging period before any material from that stockpile may be used. Prior or during the stockpiling operation, these materials shall have water added to provide a uniform moisture content not less than their absorbed moisture and the stockpile shall be maintained in a moist condition during the required stockpiling period.

The Contractor shall furnish the Engineer with a certificate stating that the slag material stockpiling requirements have been complied with for all such material furnished to the work. This certification shall include the estimated yardage, the detailed location, and the beginning and ending dates of the aging periods, of each stockpile. The certification shall be submitted with sufficient lead time, prior to intended use, to allow for inspection, sampling, and testing.

Size. Aggregate shall conform to the size specified in the material specification, the construction item, or as shown in AASHTO M 43.

Method of Test. Aggregate shall be tested by the following methods:

Amount finer than No. 200 sieve	S1004*
Clay lumps	S1017*
Coal and lignite	AASHTO T113
Crushed pieces	S1021*
Deleterious materials	S1029*
Effect of organic impurities on strength of mortar	AASHTO T71
Liquid limit	AASHTO T89
Percentage of wear, Los Angeles abrasion test	AASHTO T96 or ASTM C535
Plasticity index	AASHTO T90
Sieve analysis	S1004*, S1005*
Sieve analysis of mineral filler	S1030*
Sodium sulfate soundness test, 5 cycles	AASHTO T104
Specific gravity and percent absorption for coarse aggregate	S1031*
Unit weight	AASHTO T19

*Supplement on file in the Office of the Director.

703.02 Aggregate for Portland Cement Concrete

Coarse Aggregate. 1. The coarse aggregate shall be washed gravel, crushed carbonate stone, or crushed air-cooled blast-furnace slag.

2. Physical properties.

Percent of wear, Los Angeles test, maximum (stone or gravel)	40
Unit weight, compacted, minimum pounds (slag)	70
Loss, sodium sulfate soundness test, percent, maximum:	
305	15
451, 452, 511, 519, 603, 604, 613, 622, 704 & 706	12
515	10

Deleterious substances shall not exceed the following:

	Percent by weight	
	Superstructure	All other concrete
Soft pieces	2.0	3.0
Coal and lignite	0.25	1.0
Clay lumps	0.25	0.25
Pieces having length greater than 5 times the average thickness	15	15
Shale and shaly material	0.5	1.0
Other deleterious substances, such as limonitic concretions, alkali, metallic particles, and chert which disintegrates in 5 cycles of the soundness test	0.5	1.0

3. Amount finer than No. 200 sieve. The percentage of material finer than the No. 200 sieve in the aggregate portion of the concrete mix shall not exceed the following:

TABLE 703-1
SIZES OF COARSE AGGREGATE
(AASHTO M 43)

Size no.	Nominal size, square openings[1]	Amounts finer than each laboratory sieve (square openings)[1], percentage by weight														
		4	3½	3	2½	2	1½	1	¾	½	⅜	No. 4	No. 8	No. 16	No. 50	No. 100
1	3½ to 1½	100	90 to 100		25 to 60		0 to 15		0 to 5							
2	2½ to 1½			100	90 to 100	35 to 70	0 to 15		0 to 5							
24	2½ to ¾			100	90 to 100		25 to 60		0 to 10	0 to 5						
3	2 to 1				100	90 to 100	35 to 70	0 to 15		0 to 5						
357	2 to No. 4				100	95 to 100		35 to 70		10 to 30		0 to 5				
4	1½ to ¾					100	90 to 100	20 to 55	0 to 15		0 to 5					
467	1½ to No. 4					100	95 to 100		35 to 70		10 to 30	0 to 5				
5	1 to ½						100	90 to 100	20 to 55	0 to 10	0 to 5					
56	1 to ⅜						100	90 to 100	40 to 75	15 to 35	0 to 15	0 to 5				
57	1 to No. 4						100	95 to 100		25 to 60		0 to 10	0 to 5			
6	¾ to ⅜							100	90 to 100	20 to 55	0 to 15	0 to 5				
67	¾ to No. 4							100	90 to 100		20 to 55	0 to 10	0 to 5			
68	¾ to No. 8							100	90 to 100		30 to 65	5 to 25	0 to 10	0 to 5		
7	½ to No. 4								100	90 to 100	40 to 70	0 to 15	0 to 5			
78	½ to No. 8								100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5		
8	⅜ to No. 8									100	85 to 100	10 to 30	0 to 10	0 to 5		
89	⅜ to No. 16									100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	
9	No. 4 to No. 16										100	85 to 100	10 to 40	0 to 10	0 to 5	
10	No. 4 to 0[2]										100	85 to 100				10 to 30

[1] In inches, except where otherwise indicated. Numbered sieves are those of the U.S. Standard Sieve Series.
[2] Screenings.
NOTE: Where standard sizes of coarse aggregate designated by two- or three-digit numbers are specified, the specified gradation may be obtained by combining the appropriate single-digit standard-size aggregates by a suitable proportioning device which has a separate compartment for each coarse aggregate combined. The blending shall be done as directed by the laboratory.

	Percent by weight	
	Superstructure	All other concrete
Where the finer-than-No.-200-sieve material from the coarse aggregate consists of the dust of fracture essentially free from clay and shale	3.4	3.8
Where the finer-than-No.-200-sieve material from the coarse aggregate may consist of or include material other than dust of fracture	2.0	2.2

703.04 Aggregate for:

(1) Bituminous aggregate base, 301
(2) Aggregate base, 304
(3) Slope and channel protection, 601

1. The coarse aggregate for bituminous aggregate base used in combination with rigid pavement shall be of crushed carbonate stone, crushed gravel, or crushed air-cooled blast-furnace slag. The coarse aggregate for bituminous aggregate base used in flexible pavements shall be of crushed carbonate stone, crushed gravel, or crushed air-cooled slag. The fine aggregate for bituminous aggregate base shall be natural sand or sand manufactured from stone, gravel, or air-cooled slag.

2. Physical properties.	301	304	601
Percentage of wear, Los Angeles test, maximum (stone or gravel)	50	50	50
Unit weight, compacted, pounds minimum (slag)	65	–	65
Loss, sodium sulfate soundness test, percent maximum	15	15	15
Percentage of fractured pieces, minimum	40	90	90

Deleterious substances shall not exceed the following:

	Percent by weight 301
Soft pieces	3.0
Coal and lignite	1.0
Clay lumps	0.25
Pieces having a length greater than 5 times the average thickness	15
Shale, shaly material, and chert which disintegrates in 5 cycles of the soundness test	2.5

Gravel used under 304 shall be crushed from material retained on the ½-inch sieve.

Under 304, the portion of aggregate passing the No. 40 sieve shall have a maximum liquid limit of 25 percent and a maximum plasticity index of 6.

703.05 Aggregate for:

(1) Asphalt concrete, 402, 403, 404 and 412
(2) Bituminous cold mix, 405
(3) Bituminous road mix, 406
(4) Prime coat, 408
(5) Seal coat, 409

Coarse Aggregate. 1. The coarse aggregate shall be crushed carbonate stone, crushed air-cooled slag, or washed crushed gravel.

2. Physical properties.

Percentage of wear, Los Angeles test, maximum (stone or gravel)	40
Unit weight, compacted, minimum pounds (slag) 402, 403, 404, 405, 406, 407, 408, 409 and 412	70
Loss, sodium sulfate soundness test, percent, maximum:	
402, 403, 404 and 412	12
405, 406 and 409	15
Percent by weight of fractured pieces, minimum	40

Deleterious substances shall not exceed the following:

	Percent by weight
Soft pieces	3.0
Coal and lignite	1.0
Clay lumps	0.25
Amount finer than No. 200 sieve	3.0
Pieces having a length greater than 5 times the average thickness	15
Shale, shaly material, and other deleterious substances, such as limonitic concretions, alkali, and chert which disintegrates in 5 cycles of the soundness test	2.5

[1] Modified from Ohio Department of Transportation (1981).

APPENDIX B.–ANALYTICAL RESULTS

TABLE B1.–*Sieve analyses*

Sample no.	Size no.	Amounts finer than each laboratory sieve (square openings)[1], percentage by weight										
		2½	2	1½	1	¾	½	⅜	No. 4	No. 8	No. 40	No. 200
2050	57				100	87.2	22.7	7.7	5.1	4.9		
2051	57			100	99.9	66.5	25.6	9.4	1.5	1.4		
2052	67/57				100	89.6	39.8	13.6	2.5	2.1		
2053	467		100	99.7	84.1	62.8	34.1	18.8	4.7	1.8		
2054	57				100	87.7	37.6	14.5	3.5	2.7		
2055A	4		100	97.4	59.9	13.0	3.1	2.7				
2055B	57				100	83.8	14.8	3.3	1.6	1.5		
2056	[2]		100	94.6	62.7	38.3	13.2	6.6				
2057	4			100	65.3	15.0	1.5	1.3				
2058	57				100	84.5	44.8	20.6	5.4	5.1		
2063	57				100	86.0	38.3	15.0	4.1	3.3		
2064	57				100	85.2	36.6	13.5	3.6	2.9		
2065	57				100	88.3	39.4	16.2	5.4	4.1		
2066	[3]			100	30.0	2.7	1.3	1.2				
2067	[4]	100	98.7	89.3	68.1	50.1	23.2	11.1	6.8			
2068	57				100	91.1	40.2	12.0	3.3	2.2		
2069	57				100	92.2	45.8	14.7	2.7	1.4		
2070	57				100	97.4	57.4	20.5	3.6	2.8		
2071	57				100	87.6	29.8	5.7	2.6	2.5		
2072	57				100	78.1	24.9	6.4	1.8	1.5		
2073	B304		100	89.6	61.8	47.8	37.2	33.7	24.6		8.8	5.8
2074	4		100	91.8	36.9	6.6	1.4	1.2				
2075	[5]		100	99.8	24.0	6.1	4.5	4.2	3.9			
2076	4			100	32.3	3.5	1.9	1.8				
2077	57			100	98.6	71.8	23.8	7.6	3.5	3.2		
2078	57			100	99.2	70.9	20.2	5.8	3.3	3.2		

[1] In inches, except where otherwise indicated. Numbered sieves are those of the U.S. Standard Sieve Series.
[2] Lime kiln feedstock, <3 inches, >½ inch.
[3] "1½" size (≈size No. 4).
[4] Fluxstone, <3 inches, >½ inch.
[5] Fluxstone, no size given.

TABLE B2.—*Soundness and abrasion loss*

Sample no.	Loss, in percent, in various size ranges[1]											
	Sodium sulfate soundness test					Freeze-thaw soundness test				Los Angeles abrasion		
										Grading[3]		
	2½-1½	1½-¾	¾-⅜	⅜-No. 4	Tw[2]	1½-¾	¾-⅜	⅜-No. 4	Tw[2]	A	B	3
2050			7.85		7.8		0.40		0.4		37.8	
2051		3.23	3.60	1.82	3.3	0.63	1.15	0.67	0.9		20.9	
2052			6.46	4.03	6.1		4.94	3.86	4.8		23.4	
2053		5.49	5.46	3.70	5.1	1.23	4.05	4.99	3.2	25.6	24.6	
2054		0.72	1.40	1.35	1.3	0.27	0.30	0.50	0.3		23.6	
2055A		5.63	5.77		5.6	0.70	1.15		0.8			35.3
2055B		4.77	4.60		4.6	0.47	0.95		0.9		29.2	
2056		6.10	10.32		7.7	0.23	0.25		0.2	46.3		52.7
2057		4.00	5.25		4.2	1.17	0.75		1.1			21.7
2058		2.32	1.76	3.04	2.1	0.30	0.55	0.84	0.6		34.7	
2063		10.54	8.19	8.02	8.5	3.82	2.68	3.35	2.9		34.8	
2064		14.20	8.14	7.70	9.0	3.48	3.29	2.29	3.2		35.0	
2065		11.33	8.77	7.31	8.8	2.35	2.00	2.80	2.2		35.2	
2066		12.65			12.6	5.04			5.0			31.5
2067		15.31	10.35		12.8	0.40	1.19		0.8	42.7	40.2	
2068		6.07	4.64	4.36	4.7	0.43	0.63	0.90	0.6		31.7	
2069		9.66	5.64	4.96	5.8	1.72	2.27	2.39	2.2		30.0	
2070			8.41	8.11	8.4		0.71	0.80	0.7		32.7	
2071		1.38	1.23		1.2	0.26	0.26		0.3		33.4	
2072		9.20	6.44		7.0	2.27	1.24		1.5		27.5	
2073	4.84	7.58	12.08	10.31	8.4	0.59	3.70	5.64	1.8	19.9	19.2	
2074		3.02	4.61		3.1	2.12	2.63		2.2			29.8
2075		2.19			2.2	0.53			0.5			59.6
2076		9.89			9.9	1.85			1.8			36.0
2077		4.61	4.85		4.8	0.69	1.03		0.9		32.2	
2078		4.94	4.76		4.8	0.60	0.69		0.7		36.9	

[1] In inches, except where otherwise indicated. No. 4 refers to the U.S. Standard Sieve Series.
[2] Total weighted average based on original sample gradation.
[3] A, ⅜ to 1½ inches; B, ⅜ to ¾ inch; 3, ¾ to 1½ inches.

TABLE B3.—*Specific gravity and absorption*

Sample no.	Size[1]	Specific gravity			Absorption (percent)
		Bulk (dry)	Bulk (saturated surface dry)	Apparent	
2050	1-3/8	2.49	2.57	2.72	3.36
2051	1 1/2-3/8	2.66	2.68	2.72	0.73
2052	1-3/8	2.64	2.67	2.72	1.12
2053	1 1/2-3/8	2.64	2.67	2.71	0.98
2054	1-3/8	2.68	2.71	2.76	1.08
2055A	1 1/2-3/8	2.57	2.61	2.68	1.60
2055B	1-3/8	2.60	2.65	2.72	1.72
2056	1 1/2-3/8	2.48	2.56	2.70	3.29
2057	1 1/2-3/8	2.64	2.69	2.78	1.81
2058	1-3/8	2.54	2.60	2.70	2.38
2063	1-3/4	2.56	2.61	2.71	2.18
	3/4-1/2	2.55	2.61	2.71	2.27
	1/2-3/8	2.55	2.61	2.72	2.45
	3/8-No. 4	2.53	2.60	2.73	2.86
	Tw	2.55	2.61	2.71	2.37
2064	1-3/8	2.56	2.62	2.72	2.30
	3/8-No. 4	2.53	2.60	2.73	2.87
	Tw	2.55	2.61	2.72	2.36
2065	1-3/8	2.56	2.61	2.71	2.23
	3/8-No. 4	2.54	2.61	2.72	2.68
	Tw	2.55	2.61	2.71	2.28
2066	1 1/2-3/8	2.67	2.69	2.73	0.82
2067	2-1 1/2	2.47	2.54	2.66	2.92
	1 1/2-3/8	2.51	2.58	2.69	2.70
	Tw	2.50	2.57	2.69	2.73
2068	1-3/8	2.51	2.57	2.68	2.42
	3/8-No. 4	2.49	2.57	2.69	2.97
	Tw	2.51	2.57	2.68	2.47
2069	1-3/8	2.61	2.66	2.75	1.85
	3/8-No. 4	2.61	2.67	2.77	2.15
	Tw	2.61	2.66	2.75	1.89
2070	1-3/8	2.50	2.58	2.70	3.00
	3/8-No. 4	2.48	2.57	2.72	3.52
	Tw	2.50	2.58	2.71	3.09
2071	1-3/8	2.59	2.64	2.72	1.83
2072	1-3/8	2.62	2.66	2.74	1.62
2073	1 1/2-1	2.54	2.59	2.67	1.91
	1-1/2	2.54	2.60	2.68	2.05
	1/2-No. 4	2.47	2.54	2.66	3.00
	Tw[2]	2.53	2.58	2.67	2.18
2074	2-3/8	2.69	2.70	2.74	0.67
2075	1 1/2-3/8	2.61	2.64	2.69	1.16
2076	1 1/2-3/8	2.67	2.72	2.79	1.60
2077	1 1/2-3/8	2.61	2.66	2.75	1.98
2078	1 1/2-3/8	2.50	2.57	2.69	2.82

[1] In inches, except where otherwise indicated. No. 4 refers to the U.S. Standard Sieve Series. Tw is total weighted average based on original sample gradation.
[2] Range is 1 1/2 inches to No. 4 sieve.

TABLE B4.–*Chemical analyses*

Sample no.	Weight percent										
	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	SrO	MnO	TiO_2	S
2050	55.7	41.8	2.70	0.092	0.18	0.035	0.011	0.014	0.022	0.005	0.058
2051	91.2	2.01	3.53	1.04	1.30	0.12	0.011	0.073	0.13		0.35
2052	83.9	6.31	6.93	1.38	1.73	0.35	0.062	0.061	0.074		0.14
2053	90.8	1.60	2.48	0.24	2.87	0.024	0.013	0.11	0.11		0.79
2054	54.6	43.8	1.28	0.42	0.17	0.13	0.052	0.010	0.006	0.015	0.084
2055A	88.8	6.66	2.57	0.26	0.30	0.046	0.013	0.014	0.080		0.20
2055B	72.2	23.9	2.29	0.24	0.30	0.070	0.024	0.015	0.021		0.16
2056	54.5	44.6	0.38	0.068	0.060	0.031	0.030	0.006	0.006	0.004	0.021
2057	52.5	42.8	2.91	1.17	0.43	0.38	0.046	0.008	0.007	0.048	0.22
2058	52.5	43.7	2.07	0.43	0.43	0.16	0.061	0.007	0.012	0.033	0.19
2064	74.3	20.6	2.76	0.45	0.30	0.11	0.008	0.014	0.030		0.19
2066	86.1	2.22	6.74	1.70	1.00	0.35	0.064	0.13	0.065		0.34
2067	54.2	44.7	0.30	0.070	0.40	0.024	0.030	0.012	0.013		0.095
2068	53.9	44.6	0.53	0.13	0.49	0.058	0.034	0.012	0.013		0.13
2069	53.9	43.5	0.75	0.21	0.51	0.10	0.034	0.013	0.015		0.096
2070	71.8	24.8	2.20	0.28	0.23	0.044	0.011	0.014	0.024		0.074
2071	54.6	44.3	0.41	0.12	0.17	0.096	0.047	0.041	0.009		0.055
2072	80.1	18.9	0.70	0.10	1.12	0.058	0.028	0.014	0.021		0.78
2073	52.6	1.21	40.5	3.14	2.32	0.61	0.16	0.041	0.11		0.19
2074	81.4	10.5	5.43	1.02	2.03	0.26	0.031	0.022	0.089		0.035
2075	84.2	13.6	1.13	0.32	0.43	0.083	0.009	0.014	0.036		0.11
2076	58.8	32.0	5.69	1.62	1.09	0.61	0.044	0.010	0.043		0.51
2077	52.2	43.4	2.03	0.36	0.49	0.32	0.044	0.009	0.015		0.18
2078	53.3	43.8	1.11	0.24	0.39	0.23	0.043	0.011	0.013		0.047

APPENDIX C.–SAMPLING DATA

TABLE C1.–*Sampling dates and locations*[1]

Sample designation[2]	Date of sampling	County	Township	Ohio Coordinate System location x (ft)	y (ft)	Zone
48-2050	8/3/77	Lucas	Sylvania	1,660,000	743,500	North
38-2051	9/7/77	Holmes	Hardy	2,168,800	335,600	North
60-2052	9/8/77	Muskingum	Newton	2,115,600	682,800	South
40-2053	9/20/77	Jackson	Madison	1,991,000	330,600	South
69-2054	9/22/77	Putnam	Sugar Creek	1,527,600	449,800	North
25-2055A & B	9/23/77	Franklin	City of Columbus	1,854,000	690,000	South
72-2056	10/3/77	Sandusky	Madison	1,770,700	630,700	North
02-2057	10/6/77	Allen	Spencer	1,484,700	411,600	North
29-2058	10/12/77	Greene	Cedarville	1,637,200	635,300	South
74-2063, 74-2064, 74-2065	7/11/78	Seneca	Bloom	1,867,500	508,300	North
13-2066	8/22/78	Clermont	Washington	1,514,300	328,200	South
01-2067, 01-2068, 01-2069	10/3/78	Adams	Meigs	1,755,000	345,000	South
21-2070	10/12/78	Delaware	Radnor	1,818,100	252,600	North
51-2071	10/18/78	Marion	Grand	1,746,400	371,200	North
65-2072	10/20/78	Pickaway	Perry	1,804,100	588,800	South
76-2073	10/27/78	Stark	Lake	2,311,400	464,500	North
64-2074	10/30/78	Perry	Monday Creek	2,048,500	592,900	South
55-2075, 55-2076	10/31/78	Miami	Staunton	1,516,900	777,200	South
75-2077, 75-2078	10/31/78	Shelby	Orange	1,522,500	811,800	South

[1] See figure 1, p. 2, for map of locations.
[2] The first two digits of each sample designation are OGS file numbers and refer to the county where the sample was collected. The final four digits are the actual sample number used throughout the report.

TABLE C2.–*Sample descriptions and sampling comments*

OGS stratigraphic section no.	Sample no.	Descriptions and comments
		Detroit River Group (Devonian), probably basal 10' of Dundee Limestone >100' Section not measured
	2050	Quarry face perpendicular to strike, 6-8° of dip in quarry. Worked in 2 levels, lower bench ≈40', upper bench ≈35'. Stone mixed at crusher, 1 load from upper level to 4 loads from lower level.
16503		Putnam Hill limestone (Pennsylvanian) 5' Limestone, dark-gray, fine-grained to very fine grained, argillaceous, medium- to thick-bedded
	2051	Sampled stockpile represents entire section.
16571		Maxville Limestone (Mississippian) 10' Limestone, brown, very fine grained, medium- to thick-bedded 10'5" Limestone, gray, fine- to medium-grained, medium- to thick-bedded; black shale partings in lower half 2'1" Limestone, gray, fossiliferous. Shale, black 3' Limestone, gray, very fine grained, massive; dolomitic at base; green argillaceous inclusions 3'10" Dolomite and dolomitic limestone, light-gray, very fine grained, laminated, porous; some shale partings 7'3" Limestone, gray and olive-gray, very fine grained, thick-bedded, laminated in lowermost 3'
	2052	Sampled stockpile represents entire section.
16572		Vanport limestone (Pennsylvanian) 2'6" Limestone, dark-gray to black, very fine grained, argillaceous; becoming more shaly toward top 5'11" Limestone, brownish-gray, fine- to medium-grained, thin- to thick-bedded
	2053	Sampled stockpile represents entire section.
16573		Salina dolomite undifferentiated (Silurian) <10" Dolomite, gray and brownish-gray, dense, structureless 16'7" Dolomite, brown and brownish-gray, microcrystalline, fine- to coarse-vugular porosity, medium-bedded, generally stromatolitic. Uppermost 60 to 65" consists of lower thin brecciated unit, middle thin, banded stromatolitic unit, and upper thick brecciated unit 8' Dolomite, brown and brownish-gray, fine-vugular porosity, laminated in part, mottled in part, thin- to medium-bedded 5'2" Dolomite, gray and brownish-gray, dense, laminated, thin- to medium-bedded
	2054	Sampled stockpile represents entire section.
16574		Columbus Limestone (Devonian) 26' Limestone, light- to medium-gray, very fine grained to coarse-grained, thin- to thick-bedded, fossiliferous. Upper level of quarry ≈22½' Limestone, gray, medium- to thick-bedded. Top of lower level of quarry 6½' to 9' Limestone, tan to gray. In three beds of variable thickness, lowest bed highly coralline 22½'+ Limestone, dolomitic, brown and brownish-gray, fine-grained, medium-bedded to massive. Chert nodules in upper 10'. Bottom of quarry
	2055A	Sampled stockpile represents upper level of quarry (26' of Columbus Limestone).
	2055B	Sampled stockpile represents lower level of quarry (50'+ of Columbus Limestone).
16577	2056	Lockport Dolomite (Silurian) ≈40' Detailed section not measured, quarry floor flooded. Operator says ≈40' of dolomite in three layers, upper and lower "normal" dolomite and middle zone of larger grain size, soft, crumbly dolomite.

TABLE C2.—*Sample descriptions and sampling comments*—Continued

OGS stratigraphic section no.	Sample no.	Descriptions and comments
16575	2057	Tymochtee Dolomite (Silurian) ≈4' Dolomite, gray and brownish-gray, very fine grained to fine-grained, laminated; argillaceous partings. Top of lowest level of quarry 10" to 16" Dolomite, brownish-gray, very fine grained to fine-grained, nodular calcite concretions 20'6" Dolomite, medium-gray, very fine grained, thin- to medium-bedded, dense, carbonaceous partings; ripple marks, mud-cracks, and channeling present. Bottom of quarry Sampled stockpile represents lowermost 20'6" of lowest level of quarry.
16576	2058	Cedarville Dolomite (Silurian) 20'9" Dolomite, gray, mottled and banded dark-gray, very fine grained to fine-grained, medium-bedded to very thick bedded, bedding indistinct in part; very porous. Top of lower level of quarry Springfield(?) Dolomite (Silurian) 12'6" Dolomite, banded light- and dark-gray and brownish-gray, thin- to medium-bedded Euphemia(?) Dolomite (Silurian) 8'5" Dolomite, mottled and banded light- and dark-gray, very fine grained to fine-grained, porous. Lowermost 20" medium to coarse grained, crinoidal. Bottom of lower level of quarry Massie(?) Shale (Silurian) ≈6' Claystone, dark-gray, fossiliferous, limestone nodules. Exposed in sump Sampled stockpile represents entire lower level of quarry, 41'8" of Cedarville, Springfield(?), and Euphemia(?) Dolomites.
16595	2063 to 2065	Delaware Limestone (Devonian) 3½'+ Limestone, light- to dark-gray, fine-grained, thin-bedded; abundant chert. Not worked 4'2½" Limestone, medium-gray, fine-grained, thin- to medium-bedded, faintly laminated. Top of active face of upper level of quarry 11'6" Limestone, light- to medium-gray, very fine grained to fine-grained, thin- to medium-bedded, fossiliferous Columbus Limestone (Devonian) 10'3" Limestone, tan and brownish-gray, very fine grained to medium-grained, medium- to thick-bedded, fossiliferous. Bottom of upper level of quarry Sampled stockpile represents upper level of quarry, 26' of Columbus and Delaware Limestones.
16597	2066	Cynthiana (Point Pleasant) Limestone (Ordovician) 6' to 7' Limestone, gray to dark-gray, fine- to coarse-grained, thin- to medium-bedded. Interbedded with dark-gray to black shale Current production and sample represent 6 to 7' bench in bottom of pit. Top of the bench is ≈53' below the estimated Cynthiana/Eden contact. Production material run through primary crusher; $<3/4$" material discarded and $>3/4$" material run through secondary crusher; sampled stockpile fed from secondary crusher.
16601		Sections measured at 3 separate working locations in quarry. *location A* lower Tymochtee Dolomite (Silurian) 6'6" Dolomite, thin-bedded to laminated, stromatolitic in part. Top of bench 8'10" Dolomite, brown, massive in part, brecciated in part, stromatolitic 4' Dolomite, brown and gray, digitate algal structures Greenfield Dolomite (Silurian) 8'10" Dolomite, brown, thin- to medium-bedded, stromatolitic, laminated in part; contorted bedding in uppermost 1' 4'6" Dolomite, tan to buff, massive, contorted bedding in part 9'2" Dolomite, tan to buff, thin- to medium-bedded, laminated in part. Base covered by talus

TABLE C2.–*Sample descriptions and sampling comments*–Continued

OGS stratigraphic section no.	Sample no.	Descriptions and comments
		location B
		Greenfield Dolomite (Silurian)
		5'+ Dolomite, tan to buff, very fine grained to microcrystalline, thick- to medium-bedded, laminated in part. Top of bench
		5'2" Dolomite, dark-brownish-gray, fine-grained to microcrystalline, massive. Same as 4'6"-thick unit at location A
		10'5" Dolomite, gray, very fine grained, thin- to thick-bedded, laminated in part. Base of bench
		location C
		Peebles Dolomite (Silurian)
		41' Dolomite, light-gray, fine-grained to microcrystalline, massive, vuggy. Top of bench
		5'2" Dolomite, light-olive-gray to medium-gray, fine-grained to microcrystalline, thin- to thick-bedded, porous. Bottom of bench
	2067	Sampled stockpile represents entire section at location C, Peebles Dolomite.
	2068	Sampled stockpile represents entire section at location B, Greenfield Dolomite.
	2069	Sampled stockpile represents entire section at location A, lower Tymochtee and Greenfield Dolomites.
16592		Columbus Limestone (Devonian)
		2'2" Limestone, light-brown and light-gray, fine- to medium-grained, thin-bedded, bedding wavy to nodular; very fossiliferous. Top of bench
		1'6" Limestone, brownish-gray, medium- to coarse-grained, very thin bedded to thin-bedded, bedding nodular to rubbly; numerous horn corals (bioherm?)
		10'8" Limestone, light-brown, fine-grained, thin- to medium-bedded, bedding wavy to nodular; cross bedded and channeled; very fossiliferous
		8'11" to 9'6" Limestone, gray and brown, fine-grained, medium-bedded, sparsely to very fossiliferous
		1'10" to 2'4" Limestone, gray, fine- to medium-grained, fossiliferous, vuggy, petroliferous
		12'6" Limestone, gray, fine-grained, massive to thick-bedded, sparsely to moderately fossiliferous in part
		1" to 18" Limestone, light- to dark-brown, dolomitic and laminated in part, shaly and nodular in part
		11' Limestone, medium- to dark-brown, very fine grained, dolomitic in part, thin- to thick-bedded
	2070	Sampled stockpile represents entire section.
16596		Lockport Dolomite (Silurian)
		≈12' Dolomite, gray and tan, fine-grained, thin- to medium-bedded, slightly porous. Top of bench
		7' Dolomite, banded and mottled light- to medium-gray, fine- to medium-grained, medium-bedded to massive, porous, vuggy
		5'2" Dolomite, mottled and banded cream and light- to dark-gray, fine- to medium-grained, massive, porous
		6' Dolomite, banded and mottled light- and medium-gray, fine- to medium-grained, massive, very porous
		12'4" Dolomite, banded and mottled light- to medium-gray, fine-grained, massive, moderately porous
	2071	Sampled stockpile represents entire section.
16598		Columbus Limestone (Devonian)
		6' Limestone, brown, fine-grained, medium- to thick-bedded, fossiliferous. Top of quarry
		2' Limestone, grayish-brown, fine- to medium-grained, thin- to medium-bedded, coralline
		5'6" Limestone, white to gray, coarse-grained, massive, fossiliferous, conglomeratic in basal 3"
		Salina dolomite undifferentiated (Silurian)
		2'8" Dolomite, medium-brown, lithographic, very thin bedded to thin-bedded
		4' Dolomite, light-brown, sublithographic, laminated in part, brecciated in part; discontinuous bedding
		2'9" to 3'6" Dolomite, light- to dark-brown, lithographic to sublithographic

TABLE C2.–*Sample descriptions and sampling comments*–Continued

OGS stratigraphic section no.	Sample no.	Descriptions and comments
		3'6" Dolomite, medium- to dark-brown, very fine grained to sublithographic, thin-bedded, brecciated in part, laminated in part. Thickens greatly, mainly at expense of above two units
		3'6" Dolomite, gray and brownish-gray, fine-grained to sublithographic, laminated in part, brecciated in part; sparse chert nodules
		Salina "C"(?), Tymochtee(?) dolomite (Silurian)
		2'6" Dolomite, medium- to dark-gray, very fine grained to sublithographic, very thin bedded to medium-bedded; carbonaceous shale partings. Base of quarry.
	2072	Sampled stockpile represents entire section.
16594		Vanport limestone (Pennsylvanian)
		8½' Limestone, light- to dark-gray, sublithographic to fine-grained, argillaceous, laminated, medium-bedded, nodular
	2073	Sampled stockpile represents entire section.
16593		Maxville Limestone (Mississippian)
		4'9" to 6'10" Limestone, dolomitic, gray and brownish-gray, very fine grained to sublithographic, massive. Approximately 100 yards to east unit thins to 2 to 3' thick and is mottled and brecciated with green clay (bed #4)
		3'10" to 4'4" Limestone, gray and brownish-gray, sublithographic, thin- to medium-bedded; greenish-gray shale and shaly limestone partings (bed #3)
		4" to 16" Limestone, brown and brownish-gray, lithographic, very thin bedded to medium-bedded; greenish-gray shale and shaly limestone partings; brecciated in part (bed #2)
		1'8" to 3'8" Limestone, gray and greenish-gray, fine-grained, argillaceous, massive (bed #1)
	2074	Current production and sample come from new pit approximately 1,850' northwest of measured section. Pit is small and face, walls, and floor mainly covered by blast talus. There appears to be 3½ to 4' of brecciated sublithographic limestone (like bed #4) overlying 6'+ of medium-bedded sublithographic limestone (like bed #3). Total thickness of section at production pit is unknown as base of wall and floor of pit are covered.
16599		Euphemia Dolomite (Silurian)
		9' Dolomite, gray, fine-grained, thin- to medium-bedded, slightly porous; bedding irregular to nodular. Top of uppermost bench
		Laurel Dolomite (Silurian)
		3'2" Dolomite, brownish-gray, very fine grained to fine-grained, thin- to medium-bedded
		Osgood Shale (Silurian)
		2' Mudstone, gray, laminated. Base of uppermost bench
		Dayton Formation (Silurian)
		10' to 10'5" Dolomite, gray and brownish-gray, very fine grained to fine-grained, thin- to thick-bedded. Top of middle bench
		Brassfield Formation (Silurian)
		2'6" to 2'9" Limestone, slightly dolomitic, gray, fine- to medium-grained, medium-bedded. In second bench
		6" to 18" Limestone, gray and red, coarse-grained, crinoidal, coralline. Quarry floor variable, base of middle bench in places and top of lowest bench in places
		4'4" to 5' Limestone, light-gray and pink, coarse-grained, medium- to thick-bedded, cross-bedded, crinoidal
		17'6" Limestone, light-gray and pinkish-gray, medium- to coarse-grained, massive to thick-bedded. Base of lowest bench
	2075	Sampled stockpile represents lowest bench, ≈22' of Brassfield Formation.
	2076	Sampled stockpile represents middle bench, Dayton Formation and uppermost 3-4' of Brassfield Formation.

TABLE C2.—*Sample descriptions and sampling comments*—Continued

OGS stratigraphic section no.	Sample no.	Descriptions and comments
16600		Cedarville Dolomite (Silurian)
		≈35' Dolomite, thin-bedded to massive. Not currently worked
		7'+ Dolomite, gray and brownish-gray, massive, very porous and vuggy. Top of upper bench
		Springfield Dolomite (Silurian)
		8' Dolomite, gray and brownish-gray, fine- to medium-grained, thin- to medium-bedded, porous; moderate amount of chert nodules and layers in upper half. Base of upper bench
		4' Dolomite, gray, fine-grained, medium- to thick-bedded, porous. Top of lower bench
		Euphemia Dolomite (Silurian)
		9' Dolomite, brownish-gray and cream, banded and mottled, massive, very porous
		Laurel Dolomite (Silurian)
		4' Dolomite, gray, mottled, fine-grained, medium-bedded, dense. Base of lower bench
	2077	Sampled stockpile represents lower bench, Laurel, Euphemia, and lower Springfield Dolomites.
	2078	Sampled stockpile represents upper bench, upper Springfield and lower Cedarville Dolomites.