OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

April 26, 1977

To: L. T. Oehler
Engineer of Research

From: R. W. Muethel

Subject: Petrographic Analysis of Coarse Aggregate: Emmons Pit No. 54-22 (Testing Laboratory Sample No. 76 A-2130), Research Report No. R-1059.

On September 30, 1976 a sample of combined crushed and natural gravel was received by the Department's Testing Laboratory at Ann Arbor. Information accompanying the sample stated that the material was obtained from the Cousineau Gravel, Inc., Emmons Pit No. 54-22, location southwest 1/4 of southwest 1/4, Section 24, T15N-R10W, Mecosta County. The material was submitted to the Laboratory for freeze-thaw durability testing. Petrographic analysis of a portion of the sample was requested by G. H. Gallup.

Summary

Rock Class	Condition of Particles	Percent of Sample
Igneous	Hard, fresh to highly weathered, and non-porous to slightly porous on weathered surfaces	28
Metamorphic	Hard to moderately hard, fresh to moderately weathered, and non-porous to slightly porous	18
Sedimentary	Hard to soft, fresh to highly weathered, and non-porous to porous	54

Approximately 22 percent of the sample was found to be contained in rock type categories having absorption values greater than 1.5 percent.

Detailed tabulations of petrographic composition, specific gravity, and absorption are included in Tables 1 and 2.

Detailed Petrography

Petrographic examination was conducted in general conformance with ASTM C295, "Petrographic Examination of Aggregates for Concrete." Representative portions -- 300 particles -- of each sieve fraction of the sample were identified megascopically, along with acid testing and a scratch test for hardness, and microscopically with a stereomicroscope. Specific gravity and absorption determinations were performed in general accordance with ASTM C127, "Specific Gravity and Absorption of Coarse Aggregate." Determinations included all material analyzed. The following pages contain the rock type descriptions.

TESTING AND RESEARCH DIVISION

R. W. Muethel

Geologist - Materials Research Unit

RWM:bf

TABLE 1
PETROGRAPHIC COMPOSITION
Testing Laboratory Sample No. 76 A-2130

Rock Type	Sieve Fraction Analyzed				Computed Sample Composition
	1 to 3/4-in.	3/4 to 1/2-in.	1/2 to 3/8-in.	3/8 to No. 4	
Granite	18.0	11.0	12.3	10.3	12.9
Diorite	3.0	2.7	1.7	1.7	2.3
Gabbro	11.3	9.0	7.3	6.0	8.4
Basalt	2.7	3.3	2.0	2.3	2.6
Felsite	1.3	2.3	1.7	2.0	1.8
Quartzite	13.0	11.4	8.7	7.7	10.2
Metasediments	8.3	3.3	4.3	6.7	5.7
Tillite	1.0	1.0	3.7	1.0	1.7
Schist	--	--	0.7	0.3	0.2
Limestone	3.3	8.0	8.0	11.3	7.7
Argillaceous Limestone	2.0	1.0	2.0	1.0	1.5
Cherty Limestone	1.0	0.3	0.3	0.3	0.5
Dolomite	17.7	22.3	23.0	23.4	21.6
Argillaceous Dolomite	10.3	13.4	8.3	7.7	9.9
Cherty Dolomite	0.7	3.7	2.3	2.7	2.3
Non-Friable Sandstone	1.0	2.0	1.0	0.3	1.1
Friable Sandstone	--	0.3	--	--	TR
Siltstone	0.7	--	1.7	1.7	1.0
Clay Ironstone	1.0	--	--	--	0.3
Porous Chert	3.7	4.0	9.0	9.3	6.5
Dense Chert	--	1.0	2.0	4.3	1.8
Totals, percent	100.0	100.0	100.0	100.0	100.0

NOTE: Computed sample composition is based upon counts of 300 particles contained in each of the sieve fractions noted.

TABLE 2
SPECIFIC GRAVITY AND ABSORPTION DATA
Testing Laboratory Sample No. 76 A-2130

Rock Type	Specific Gravity			Absorption, percent	Composition, Percent by Weight
	Bulk, dry	Bulk, ssd	Apparent		
Granite	2.64	2.66	2.68	0.48	14.8
Diorite	2.91	2.92	2.94	0.46	3.3
Gabbro	2.93	2.95	2.99	0.66	11.8
Basalt	2.96	2.97	2.99	0.32	3.5
Felsite	2.71	2.73	2.77	0.84	1.5
Quartzite	2.63	2.64	2.66	0.36	10.8
Metasediments	2.69	2.70	2.71	0.35	6.5
Tillite	2.71	2.71	2.72	0.21	1.2
Schist	2.38	2.48	2.63	4.00	0.1
Limestone	2.64	2.66	2.70	0.86	5.2
Argillaceous Limestone	2.52	2.59	2.69	2.47	1.5
Cherty Limestone	2.58	2.62	2.68	1.54	0.7
Dolomite	2.72	2.75	2.82	1.31	19.3
Argillaceous Dolomite	2.65	2.71	2.82	2.17	11.6
Cherty Dolomite	2.53	2.60	2.73	2.95	1.5
Non-Friable Sandstone	2.47	2.53	2.62	2.31	1.3
Friable Sandstone	2.40	2.49	2.62	3.37	0.1
Siltstone	1.96	2.20	2.56	11.90	0.5
Clay Ironstone	2.36	2.64	3.31	12.14	0.6
Porous Chert	2.37	2.45	2.59	3.69	3.8
Dense Chert	2.46	2.51	2.60	2.21	0.4
Total Sample	2.68	2.72	2.78	1.21	100.0

NOTE: Values are computed from determinations made on all sample material contained in the categories noted.

IGNEOUS ROCKS

Rock Type	Granite	Diorite	Gabbro
Color	mottled pink to white or buff, and gray or dark green to black	mottled white to buff or pink, and gray to black	mottled buff to yellowish brown, and dark green to black
Texture	medium to very fine grained	medium to very fine grained	medium to very fine grained
Luster	dull to subvitreous	dull	dull
Hardness	hard: Mohs 7 to 6	hard: Mohs 7 to 6	hard: Mohs 6
Porosity	non-porous	non-porous	non-porous to slightly porous on weathered surfaces
Particle Shape	angular to subrounded	angular to subrounded	angular to subrounded
Particle Surface	fresh to slightly weathered, rough to moderately smooth, dented to ridged	fresh to moderately weathered, rough to moderately smooth, dented to ridged	fresh to highly weathered, rough to moderately smooth, dented or pitted to ridged

Rock Type	Basalt	Felsite
Color	dark gray or green to black	pink, gray, green, and mottled buff and green to gray
Texture	very fine grained to micro-crystalline	very fine grained to micro-crystalline
Luster	dull	dull
Hardness	hard: Mohs 6	hard: Mohs 6 to 7
Porosity	non-porous	non-porous
Particle Shape	angular to rounded	angular to subrounded
Particle Surface	fresh to slightly weathered, rough to smooth, dented to ridged	fresh to slightly weathered, rough to smooth, dented to ridged

METAMORPHIC ROCKS

Rock Type	Quartzite	Metasediments	Tillite
Color	white to transparent; buff; pink to purple; gray; green; and mottled white to buff, and gray to green	gray; green; reddish brown to purple; and mottled gray and green	medium gray to green
Texture	medium to very fine grained	very fine grained to micro-crystalline	microcrystalline ground-mass with a porphyritic appearance
Luster	vitreous to dull	dull	dull
Hardness	hard: Mohs 7	hard to moderately hard: Mohs 7 to 5	moderately hard: Mohs 5
Porosity	non-porous	non-porous	non-porous
Particle Shape	angular to subrounded	angular to subrounded	angular to subrounded
Particle Surface	fresh to slightly weathered, rough to smooth, dented to ridged	fresh to slightly weathered, rough to smooth, dented to ridged	fresh to slightly weathered, rough to smooth, dented to ridged

METAMORPHIC ROCKS (Cont.)

Rock Type	Schist
Color	mottled buff and gray
Texture	very fine grained
Luster	dull to silky
Hardness	moderately hard
Porosity	non-porous to slightly porous
Particle Shape	angular to tabular
Particle Surface	fresh to moderately weathered, moderately smooth, dented to ridged

SEDIMENTARY ROCKS

Rock Type	Limestone	Argillaceous Limestone	Cherty Limestone
Color	buff; brown; and mottled buff to gray and brown to yellowish brown	buff to gray; and mottled buff and gray	mottled buff and gray to brown
Texture	very fine grained to micro-crystalline	very fine grained to micro-crystalline	very fine grained to micro-crystalline
Luster	dull	dull to earthy	dull
Hardness	moderately hard: Mohs 3	moderately hard to soft: Mohs 3 to 2-1/2	hard to moderately hard: Mohs 7 to 3
Porosity	non-porous to slightly porous	non-porous to finely porous	non-porous to finely porous
Particle Shape	angular to rounded	subangular to subrounded	angular to subrounded
Particle Surface	fresh to highly weathered, rough to smooth, dented to ridged	moderately to highly weathered, rough to moderately smooth, dented to ridged	fresh to highly weathered, rough to moderately smooth, dented to ridged
Remarks	A few particles are partially lime-incrusted.		Particles contain chert nodules, silicified fossils, or disseminated siliceous material.

SEDIMENTARY ROCKS (Cont.)

Rock Type	Dolomite	Argillaceous Dolomite	Cherty Dolomite
Color	gray; buff; and mottled buff and gray	buff; gray; and mottled buff and gray to yellowish brown	gray; buff; and mottled buff and gray
Texture	very fine grained to micro-crystalline	very fine grained to micro-crystalline	very fine grained to micro-crystalline
Luster	dull	earthy to dull	dull
Hardness	moderately hard: Mohs 3-1/2 to 3	moderately hard to soft: Mohs 3-1/2 to 2-1/2	hard to moderately hard: Mohs 7 to 3-1/2
Porosity	non-porous to finely porous	non-porous to finely porous	non-porous to finely porous
Particle Shape	angular to rounded	angular to rounded	angular to subrounded
Particle Surface	fresh to highly weathered, rough to smooth, dented or pitted to ridged	fresh to highly weathered, rough to smooth, dented or pitted to ridged.	fresh to highly weathered, rough to smooth, dented to ridged
Remarks	Many particles are weathered to a finely sugary appearance.	A number of particles are weathered to a finely sugary appearance. Some particles are slightly calcitic.	Particles contain siliceous seams or disseminated siliceous material.

SEDIMENTARY ROCKS (Cont.)

Rock Type	Sandstone	Siltstone	Clay Ironstone
Color	pink; gray; buff; and mottled buff or gray and pink	buff to yellowish brown; and gray	yellowish brown; and dark brown
Texture	medium to very fine grained	very fine grained to micro-crystalline	very fine grained to micro-crystalline
Luster	dull	earthy to dull	dull
Hardness	hard to moderately hard: Mohs 7 to 5	moderately hard to soft: Mohs 3-1/2 to 2-1/2	moderately hard: Mohs 4
Porosity	finely porous to porous	finely porous	finely porous
Particle Shape	subangular to rounded	subangular to subrounded	subrounded
Particle Surface	fresh to moderately weathered, rough, dented to ridged	slightly to highly weathered, rough to smooth, dented to pitted	slightly to moderately weathered, moderately smooth, dented
Remarks	One friable particle is included in this category.		Two particles are massive. One particle contains a hard center.

Rock Type	Porous Chert	Dense Chert
Color	buff to white; gray; and mottled buff or white and gray	gray; buff to white; and reddish brown
Texture	very fine grained to microcrystalline	microcrystalline
Luster	dull	dull to vitreous
Hardness	hard: Mohs 7	hard: Mohs 7
Porosity	finely porous to non-porous	non-porous to slightly porous
Particle Shape	angular to subrounded	angular to subangular
Particle Surface	fresh to highly weathered, rough to smooth, dented or pitted to ridged	fresh to slightly weathered, rough to smooth, dented to ridged
Remarks	Particles are composed of nodular chert.	Particles are composed of nodular chert.