CANADA
DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
WILLIAM MCINNES, DIRECTING GEOLOGIST.

MEMOIR 106

No. 88, GEOLOGICAL SERIES

ad Materials in a Portion of Vaudreuil County, Quebec, and along the St. Lawrence River from the Quebec Boundary to Cardinal, Ontario

BY
R. H. Picher

OTTAWA
GOVERNMENT PRINTING BUREAU
1918

No. 1728

Single Copy Pamphlet Covers

Cover Size	Photo Mount Maximum Capacity ½″	Photo Mount Maximum Capacity 1″	Leatherboard Maximum Capacity ½″	Leatherboard Maximum Capacity 1″
7″ x 5″	No. 4340	No. 4360	No. 4380	No. 4400
8″ x 6″	4341	4361	4381	4401
9″ x 6″	4342	4362	4382	4402
9½″x 6½″	4343	4363	4383	4403
10″ x 7″	4344	4364	4384	4404
10″ x 8″	4345	4365	4385	4405
11″ x 8½″	4346	4366	4386	4406
12 x 8″	4347	4367	4387	4407
12 x10″	4348	4368	4388	4408
13″ x 8¼″	4349	4369	4389	4409
13½″x10″	4350	4370	4390	4410
14″ x 8½″	4351	4371	4391	4411
14″ x10″	4352	4372	4392	4412
15″ x11″	4353	4373	4393	4413
16″ x12″	4354	4374	4394	4414
17″ x11″	4355	4375	4395	4415
18″ x12″	4356	4376	4396	4416

Also made in other cover sizes, capacities and bindings

CANADA

DEPARTMENT OF MINES

HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

WILLIAM MCINNES, DIRECTING GEOLOGIST.

MEMOIR 106

NO. 88, GEOLOGICAL SERIES

Road Materials in a Portion of Vaudreuil County, Quebec, and along the St. Lawrence River from the Quebec Boundary to Cardinal, Ontario

BY

R. H. Picher

OTTAWA
GOVERNMENT PRINTING BUREAU
1918

48365—1

No. 1728

CONTENTS.

	PAGE
Topography	1
St. Lawrence area	1
Geology	1
Vaudreuil area	1
St. Lawrence belt	2
Road materials	2
Vaudreuil area	2
St. Lawrence area	4
Table I. Results of tests upon bedrock	6
Table II. Results of laboratory analyses of textures of gravel and sand aggregates	7
Table III. Results of laboratory analyses of textures of the sand portion of the gravel aggregates	8
Table IV. Results of tests upon gravels and sands	9
Table V. Specification for gravel for waterbound gravel roads	10
Table VI. Recommended specifications for sand for sheet asphalt wearing course	10
Index	11

48365—1½

Road Materials in a Portion of Vaudreuil County, Quebec, and along the St. Lawrence River from the Quebec Boundary to Cardinal, Ontario.

TOPOGRAPHY.

The topography of Vaudreuil county was described in the Summary Report, 1916.

St. Lawrence Area.

East of Cornwall, the country just north of St. Lawrence river lies only a few feet above the water-level of the river, and from 155 to 175 feet above sea-level. The characteristic feature of the country near the St. Lawrence is a series of ridges trending to the northeast, which lie parallel to the direction of the river. They are from 200 to a little over 225 feet in elevation above sea-level. Farther east, toward the Quebec line, the ridges are lower and form small knolls rising a few feet above the flat.

West of Cornwall, the shore is from 15 to 25 feet above the river-level. The land rises gently northward at the rate of 15 feet per mile, and lies at elevations of from 225 to 275 feet above tide. West of Iroquois the divide between the St. Lawrence and Ottawa valleys is about 2 miles from the St. Lawrence river, with an average southward slope of 25 feet per mile. In this section there are a number of low, broad hills from 10 to 30 feet high, with narrow north-south ridges lying on them.

The only important tributary of the St. Lawrence in this belt is Raisin river, which, rising a few miles from the St. Lawrence, runs parallel to it for over 20 miles and empties into it at Lancaster.

GEOLOGY.

Vaudreuil Area.

In the northwestern part of Vaudreuil, surveyed in 1917, there are outcrops of granite and syenite gneisses, unfoliated syenites and syenite porphyries, rhyolites, aplites, and basic dykes. These are all of Pre-Cambrian age and lie in the Rigaud hills. Sixty-five feet of fine-grained, dense dolomites of the Beekmantown are exposed along Rigaud river 4 miles west of Rigaud village.

Over the bedrock there are unconsolidated deposits of glacial and marine clay, beach gravel, and sand. Large areas on the south and west sides of Rigaud mountain are covered with glacial boulder clay. Stratified marine clay occurs along the Ottawa river and in the plain south of Rigaud hills. Terraces of boulders and gravel are found at various elevations in Rigaud hills. A well-known example of this is the Devil's Garden, a deposit of rounded boulders lying in a terrace near the shrine south of Rigaud. Smaller deposits occur in the flat country near the Rigaud hills. A belt of sand lies along the northeastern foot of the mountain, from a point south of Rigaud, to Raquette river north of Martigny. A much larger sand area covers about 22 square miles south of Hudson and west of St. Lazare. Near the south end of the area sections reveal a fine-grained, well stratified, cross-bedded sand.

St. Lawrence Belt.

Beekmantown dolomites and magnesian limestones occur near Cardinal, but none of the exposures are of large extent.* The stone is generally dark grey, fine to medium-grained, and thin-bedded, with a very slight dip north or west. Exposures of Black-River limestones occur in several places north and west of Cornwall, the two more important occurrences lying, respectively, 4 miles north and 5½ miles west of the town. The stone is very dense and almost black in colour. It is massive, but with many pencil-like partings. One mile southeast of Summerstown station, Chazy limestone lies close to the surface over an area of a little over 2 acres. In an old quarry is an exposure of 2 feet of medium and even-grained, light grey, thick-bedded limestone which lies nearly flat.

A large part of the country west of Cornwall is covered with boulder clay; to the east the boulder clay is found more often on the higher land, lying in the form of little ridges and hills. In a few shallow sections it was found to be composed of rounded boulders and angular pebbles in a matrix of fine sand, silt, and clay. The pebbles are largely limestone The matrix is light bluish grey in colour and seems to contain more clay west of Morrisburg than to the east. Small gravel deposits are found in many places and a few large ones occur 6 to 8 miles west of Cornwall where most of them form small, well-marked ridges lying on the western slope of larger boulder clay hills. They are as a rule very bouldery, becoming finer in depth. They contain marine shells, which occur in aggregations and undisturbed layers in the boulders and gravel to depths of 13 feet from the surface. Stratified, blue, marine clay occupies most of the flat country north and east of Cornwall and smaller strips of marine clay were seen west of the town near the river. A narrow belt of sand lies along the shore of the St. Lawrence river for a distance of 15 miles immediately west of Cornwall.

ROAD MATERIALS.

The road materials considered here are deposits of bedrock, boulders, and sand and gravel.

Vaudreuil Area.

In northwestern Vaudreuil there are large deposits of syenite porphyry, syenite, and granite that are apparently of good road-making quality and to the southeast of the mountain gneisses that are probably of inferior grade.

The large boulder deposits of the Rigaud hills would furnish a considerable amount of good stone and there are large amounts of piled field stone south of Point Fortune and around Mount Oscar. Extensive deposits of gravel apparently of good quality occur in several places on the mountain, and other smaller deposits near the Ottawa river.

Samples of the syenite porphyry and granite of Rigaud mountain have been tested and found to be of durable quality.[1] The hornblende syenites are probably also of fairly good quality; the gneisses may not be so durable. There are many million tons of each of these varieties of stone to be had from the Rigaud hills. The dolomite outcropping in the river west of Rigaud has been tested, Table I, and the results, as well as those on other dolomites of the same kind in this region, indicate a durable roadstone. Several thousand cubic yards can be quarried from the north bank of the river at low water-level, without much stripping, but the stone is heavily drift-covered farther back.

There are two important areas of piled field stone in northwestern Vaudreuil and a number of large deposits of unpiled stone in various places on Rigaud mountain. At Point Fortune there is about 40,000 cubic yards in the fences, of which nearly 28,000 cubic yards is under 1 foot in size. The stone has been used on macadam roads in Point Fortune and to a smaller extent in Rigaud with good results. The Mount Oscar area contains a total amount of 22,800 cubic yards of piled boulders, of which 13,200 cubic yards are under 1 foot, the largest amount lying in the eastern part. Macadam roads have been constructed of this stone in St. Redempteur and Ste. Marthe and have given satisfactory service under light traffic. In the Rigaud hills there are large deposits of unpiled boulders without much admixture of small pebbles or sand. These can be obtained without much difficulty. A large proportion of the broken stone roads in Rigaud have been built of stone from the boulder deposit at the Devil's Garden, with a top course of imported limestone screenings in places. The road surfaces have stood up fairly well under light to medium traffic conditions.

The boulders may be grouped into several series according to their composition. In this district they consist mainly of Potsdam sandstone, Beekmantown dolomite, and igneous gneisses. Each of these series was tested separately, their percentages of wear being: igneous gneisses, 2·6 per cent; Potsdam sandstone (fine-grained type), 2·2 per cent; Beekmantown dolomite, 3·4 per cent. The coarse-grained Potsdam sandstone found in some of the fences has a high percentage of wear and is not suitable for road construction. It was found by experiment[2] that the percentage of wear of boulder mixtures made up of a number of series like the above could be safely calculated from the per cent of wear and proportionate amount of each series. Thus, if 50 per cent of a stock pile in this area is of gneiss, 25 per cent of fine-grained Potsdam, and 25 per cent of Beekmantown dolomite, the per cent of wear of the mixture is

$$\frac{50 \times 2\cdot 6 + 25 \times 2\cdot 2 + 25 \times 3\cdot 4}{100} = 2\cdot 7 \text{ per cent.}$$

The composition of most of the fences in this district can be estimated and when

[1] Geol. Surv., Can., Sum. Rept., 1916, p. 206.

[2] Clark, K. A., Sum. Rept., Mines Branch, Dept of Mines, 1918.

that is known the average per cent of wear can be calculated. It is evident that the per cent of wear of most of the mixtures will be 3 or less; that is, the tests indicate that the boulder aggregates are of a durable character.

The large gravel deposits in the Rigaud hills have been developed in a small way only, as their position prevents their transportation to any distance. There are three easily available deposits near the Ottawa river; two of these are immediately south of Point Fortune, and the other 2 miles east of Rigaud.

In Tables II, III, and IV, test numbers 60, 58, 57, and 59, the results of tests upon the physical properties of gravels and sands are given. The value of the gravels in a water-bound macadam, gravel road is influenced by the textures (or grading) as given in Tables II and III and by their percentages of wear and cementing values as given in Table IV. If Table II is compared with Table V, in which the recommended gradings of gravel for gravel macadam roads are given, it will be seen that the gradings of all four approach those in the specifications, although some of the coarse stone could probably be screened out of sample 60 from Point Fortune and No. 51 is rather fine-grained. All of the gravels have high cementing values, but only No. 57, from concession Riviére a la Graisse at Rigaud, is durable enough for any but the lightest traffic. To determine whether or not the sand portion of these gravels is suited for sheet asphalt construction, Table III should be compared with Table VI. To compare the results given in Table III with the specification requirements given in Table VI subtract the total percentages as given for each screen from that for the next smaller screen.

St. Lawrence Area.

The only rock outcrops available for road purposes in the St. Lawrence area occur around Cardinal and north and west of Cornwall. Exposures of Beekmantown dolomite and magnesian limestone north and east of Cardinal would probably furnish over 50,000 yards of stone within a maximum hauling distance of 3 miles from the front road. More than 80,000 cubic yards have been taken from an old quarry on the front road $1\frac{1}{4}$ miles west of Cardinal, mainly for use in the construction of the ship canal, and 20,000 cubic yards are still available, without much overburden. North of Cornwall, over 85,000 cubic yards have been quarried from an exposure of Black River limestone and used largely in the locks and walls of the Cornwall canal. Outcrops are plentiful in the southeast part and over 100,000 cubic yards could probably be quarried without difficulty. The hauling distance to the front road and canal is $4\frac{1}{2}$ miles. More than 200,000 cubic yards of stone have been quarried in five different places in an area of Black River limestone $5\frac{1}{2}$ miles west of Cornwall, but there is practically no more stone available. One-half mile farther south there is a small exposure of the same stone, where about 30,000 cubic yards can be easily quarried The haulage distance to the front road, canal, and railway siding is $1\frac{1}{2}$ miles.

Laboratory tests (Table I) indicate that the Beekmantown dolomites near Cardinal are in most cases durable enough to withstand moderately heavy traffic up to 250 vehicles per day. This stone does not generally bind well in the roads, however, and it is also much less durable where weathering has proceeded far. The Black River limestone near Cornwall is only suitable for light country traffic but should bind well in properly constructed roadways.

Field stone deposits are plentiful along the St. Lawrence, between Lancaster and Aultsville; that is, for a distance of 30 miles. In this area there are over 100,000 cubic yards of piled boulders within 2 miles of the river-road, about 60,000 cubic yards being under 1 foot in size. East of Lancaster there are only about 3,200 cubic yards scattered over a distance of 9 miles along the river. The largest amount of this stone lies between 1 and 2 miles from the front road. Between Aultsville and Cardinal, 20 miles to the west, there are 20,900 cubic yards of piled boulders within 2 miles of the front road, of which 10,700 cubic yards are under 1 foot in size.

Much crushed field stone has been used in the neighbourhood of Cornwall, mainly for repairing old gravel roads, but also for new construction. In nearly every case the stone is put in place in one single course, 9 to 12 inches in thickness, and is not rolled. The same stone would give better results if properly shaped, sprinkled, and rolled.

The field stone in this area consists mainly of mixtures of boulders of igneous gneisses, fine-grained Potsdam sandstone, and Black River limestone. The percentage of wear of samples taken from each of these series in this district was found to be: igneous gneisses 2·7; fine-grained Potsdam sandstone 2·3; Black River limestone 3·6. Combinations of these would have a low percentage of wear; that is, they would make a durable road-bed if the coarse sandstones and weathered boulders were culled out before crushing.

Gravel deposits are common along the St. Lawrence, but only a few are of large extent. The largest deposits occur from 5 to 12 miles west of Cornwall, and a considerable amount of gravel has been obtained from them. At Lancaster and along the front road, there are two deposits of fairly good gravel, from which large amounts have been taken for road work. There has been very little development of the occurrences east of Cornwall, probably because of the poor quality of the material. A deposit of the nature of boulder sand lies $1\frac{1}{4}$ miles north of Cornwall, and as it is the only gravel deposit in the immediate neighbourhood of that town, it has been considerably developed, notwithstanding its poor quality. From 5 to 12 miles west of Cornwall, there are thirteen deposits which have been developed and could furnish many thousand cubic yards of gravel. Their distance to the front road is between $\frac{1}{4}$ and $4\frac{1}{2}$ miles. As a rule the gravel is of fairly good quality, but bouldery in places. Between Aultsville and Morrisburg a few small deposits, from 2 to 6 feet in depth, lie within $2\frac{1}{2}$ to $4\frac{1}{2}$ miles of the main road. North of Morrisburg, there are two well developed deposits of gravel, $4\frac{3}{4}$ miles from the front road. Between Morrisburg and Cardinal there are four occurrences of fairly good gravel with excavations, within 2 miles of the front road.

The deposits in the St. Lawrence belt carry practically no igneous pebbles, but contain from 75 to 90 per cent of limestone and from 10 to 50 per cent of soft pebbles. The relative proportions of boulders, sand, and gravel vary greatly, even within the same deposit.

Gravel has been used for over thirty years on the roads of this district and now sells at from 15 to 25 cents per cubic yard The roads are patched when needed, or are re-surfaced to a thickness of from 9 to 12 feet, but are not rolled. Few of the roads thus gravelled are much better than earth roads, except that they have harder foundations. In a few cases, however, where the gravelling is not older than 2 years and where the subsoil is firm, the surface is in fairly good shape.

The results of laboratory tests for percentage of wear, and cementing value of the gravels, are given in Table IV. The tests show that all the gravels cement well but appear to have a high percentage of wear, indicating that they are suited only to very light country traffic. Most of the deposits examined carry from 25 to 50 per cent of gravel and 75 to 50 per cent of sand. The stone over 3 inches should be discarded and it may be profitable to screen out the excess of sand, but most of the gravels are close enough to the required textures to be used for gravel macadam as they come from the pit.

The textures of the sand[1] portion of these gravels, Table III, fall within the recommended specifications for the textures of sands that are to be used in Portland cement concrete, but they were not tested as to their suitability in other respects.

To determine whether the textures of the sand approach the specifications for sand in the wearing course of sheet asphalt, compare Tables III and VI, pages 8 and 10.

Table I.—Results of Tests upon Bedrock.

Test No.	Location.	Rock species.	Series and formations.	Per cent of wear.	French co-efficient of wear.	Toughness.	Hardness.	Specific gravity.	Water absorbed per cubic foot.
177	Con. Rivière à la Graisse, Rigaud, along Rigaud river	Dolomite	Beekmantown	3·4	11·8	15	17·0	2·81	1·16
172	Lots 5, 6, con. IV, Cornwall tp	Limestone	Black River	3·5	11·4	6	16·6	2·71	0·27
178	Lot 7, con. IV, Cornwall tp	Limestone	Black River	3·3	12·1	8	16·0	2·71	0·16
171	Lot 24, con. IV, Cornwall tp	Limestone	Black River	3·2	12·5	5	16·4	2·71	0·36
169	Lot 26, con. IV, Cornwall tp	Limestone	Black River	3·5	11·4	......	......	2·71	0·17
176	Lot 25, con. I, Matilda tp	Dolomite	Beekmantown	2·7	14·8	10	16·5	2·82	0·97
174	Lot 34, con. II, Matilda tp	Dolomite	Beekmantown	3·2	12·5	11	16·3	2·83	0·98
175	Lot 11, con. I, Edwardsburgh tp	Dolomite	Beekmantown	2·9	13·8	5	15·6	2·82	0·7

[1] "Final report of the joint committee in concrete and reinforced concrete": Proc. Am. Soc. Test. Mater., vol. XVII, 1917, pt. I, p. 216.

The American Society for Testing Materials recommends that not over 30 per cent of the fine aggregate, that is sand under ¼ inch in diameter, shall pass a 50 mesh sieve (practically equivalent to 48 mesh in Table III) and not more than 5 per cent a 100 mesh sieve.

Table II.—Results of Laboratory Analyses of Textures of Gravel and Sand Aggregates.

Location.	Test No.	Total percentages retained on screens with openings of diameter—inches						Sand passing.
		2.	1½	1.	¾.	½.	¼.	¼.
Point Fortune	60	9	26	41	47	54	63	37
Point Fortune	58	5	18	29	34	42	52	48
Con. Rivière à la Graisse, Rigaud	57	0	1	5	11	30	60	40
Con. Raquette, Sud. Rigaud	59	5	20	39	50	61	73	27
Lot 36, con. I, Lancaster	79	5	15	30	38	49	65	35
Lot 36, con. I, Lancaster	63	13	28	42	49	57	67	33
Lots 4, 5, con. III, Charlottenburgh	64	5	16	33	43	55	77	23
Lots 1, 2, con. I, Charlottenburgh	71	13	23	36	44	52	67	33
Lots 23, 24, con. II, Charlottenburgh	65	13	31	50	58	65	75	25
——— Con. II, Charlottenburgh	72	2	10	22	29	40	56	44
Lots 7, 8, con. II, Cornwall	61	8	18	30	37	45	59	41
Lot 10, con. V, Cornwall	62	17	29	42	49	56	64	36
Lot 12, con. V, Cornwall	68	5	7	13	17	23	44	56
Lot 22, con. V, Cornwall	53	23	33	44	49	55	64	36
Lot 25, con. IV, Cornwall	78	5	18	33	41	49	58	42
East bank, lot 25, con. IV, Cornwall	78	5	13	23	32	40	53	47
South bank, lots 33 to 36, cons. V, VI, Cornwall	70	13	26	40	50	65	76	24
Lots 33 to 36, cons. V, VI, Cornwall[1]	55	7	19	35	43	54	67	33
Lots 33 to 36, cons. V, VI, Cornwall[1]	56	13	21	34	42	51	64	36
Lot 27, con. V, Cornwall[4]	.....	.....	.....	.....	.....	.....	.....	.....
Lots 30, 31, con. VI, Cornwall	83a	14	26	37	44	51	61	39
West face, lots 30, 31, con. VI, Cornwall	83b	16	26	38	45	51	61	39
North face, lot 14, con. I, Osnabruck	52	16	28	42	48	55	65	35
Lot 2, con. II, Osnabruck	66	18	34	50	58	65	72	28
Lot 13, con. III, Osnabruck[2]	54	3	11	26	32	42	55	45
Lot 13, con. III, Osnabruck[2]	67	16	28	41	48	57	69	31
Lots 24 to 27, con. IV, Osnabruck[3]	69	12	26	39	45	52	61	39
Lots 24 to 27, con. IV, Osnabruck[3]	73	12	25	39	47	54	63	37
Lots 26, 27, con. III, Williamsburg	50	7	9	25	32	40	51	49
Lot 35, con. IV, Williamsburg	76	9	22	39	48	60	73	27
Lot 35, con. III, Williamsburg	77	12	25	37	45	57	72	28
Lot 1, con. I, Matilda	74	15	30	43	47	55	66	34
Lot 3, con. I, Matilda	75	10	22	37	44	54	67	33
Lot 19, con. II, Matilda	51	10	21	32	38	49	63	37
Lot 5, con. III, Matilda	80	11	21	35	44	55	69	31
Lots 32, 33, con. I, Matilda	82	14	26	47	61	74	84	16
Lots 4, 5, con. III, Edwardsburgh	81	19	32	46	52	60	69	31

[1] Two different places in the same pit.
[2] From two different places in the same pit.
[3] " " "
[4] (Day's pit).

Table III.—Results of Laboratory Analyses of Textures of the Sand Portion of the Gravel Aggregates.

(For the locations of test numbers see Table II.)

Test No.	Total percentages retained on sieves of						Passing 200 mesh.
	8 mesh	14 mesh	28 mesh	48 mesh	100 mesh	200 mesh	
60	19	32	63	88	94	96	4
58	24	56	90	97	98	99	0·6
57	45	52	59	82	98	99	1
59	24	39	63	85	90	93	7
79	40	69	82	85	88	91	9
63	25	54	80	87	90	93	7
64	56	72	78	82	85	89	11
71	35	60	72	80	86	91	9
65	27	42	54	73	82	89	11
72	32	57	75	85	91	94	6
61	27	51	72	89	94	96	4
62	15	29	48	82	94	96	4
68	46	74	81	88	95	97	3
53	17	28	43	83	97	99	1
78	14	28	57	84	92	95	5
78	24	42	61	80	91	96	4
70	45	67	81	86	89	91	9
55	25	39	51	80	95	97	3
56	24	38	49	73	96	98	2
83a	19	35	55	85	95	97	3
83b	19	35	56	88	97	98	2
52	23	41	58	87	96	98	2
66	25	45	60	84	97	99	1
54	26	43	61	86	97	99	1
67	25	42	57	83	95	98	2
69	16	31	52	86	97	99	1
73	17	32	52	85	96	98	2
50	24	43	60	88	95	97	3
76	35	64	83	89	91	93	7
77	36	61	79	88	93	95	5
74	23	36	51	80	89	92	8
75	34	61	82	91	95	97	3
51	34	53	67	80	86	91	9
80	34	53	70	91	96	98	2
82	39	55	62	66	71	79	21
81	24	42	60	84	94	96	4

Table IV.—Results of Tests upon Gravels and Sands.

(For the locations of test numbers see Table II.)

Test No.	Average specific gravity.	Percentage voids.		Wear.		Cementing value.	Remarks.
		Loose.	Compacted.	Percentage.	French coefficient.		
60	2·69	25	22	18·0	2·2	73[1]	
58	2·69	28	25	6·1	6·6	97[1]	
57	2·62	28	27	1·7	23·5	75	
59	2·66	27	24	5·6	7·1	51	
79	2·70	29	25	14·5	2·8	43[1]	
63	2·70	25	22	8·6	4·6	67[2]	
64	2·67	38	36	11·1	3·6	291[1]	Boulder clay.
71	2·66	34	29	4·7	8·5	186[1]	Much clay.
65	2·68	29	25	8·3	4·8	186[1]	"
72	2·71	30	26	9·1	4·4	95[2]	
61	2·73	28	24	11·6	3·5	61[1]	
62	2·69	23	21	5·1	7·8	91	
68	2·67	29	27	5·2	7·7	158	
53	2·70	20	17	6·4	6·3	84	
78	2·72	25	20	....	....	....	East bank.
78	2·72	23	20	7·6	5·3	79[1]	East and south bank mix.
70	2·67	31	26	12·5	3·2	148	Much loam.
55	2·69	23	20	4·8	8·3	106	
56	2·69	21	20	4·0	10·0	111	
83a	2·70	22	19	5·6	7·2	82	
83b	2·70	23	19	9·6	4·2	....	
52	2·69	25	21	16·2	2·5	126[1]	
66	2·70	22	22	2·6	15·4	217[1]	
54	2·70	25	22	7·9	5·1	86	
67	2·71	25	19	7·0	5·7	85	
69	2·69	24	19	5·3	7·6	80	
73	2·69	29	19	3·9	10·3	108	
50	2·70	27	22	13·2	3·0	89	
76	2·72	29	26	8·1	4·9	74[1]	
77	2·71	29	25	5·8	6·9	47[1]	
74	2·68	27	23	19·5	2·1	95[1]	
75	2·71	28	24	6·3	6·4	59[1]	
51	2·71	30	25	9·7	4·1	95[1]	
80	2·72	25	21	8·2	4·9	61[2]	
82	2·77	32	28	7·2	5·6	75	
81	2·77	23	18	13·5	3·0	61	

[1] Dried briquettes, used for the cementing test, slaked after being immersed in water for about one hour.
[2] Dried briquettes slaked quickly on immersion in water.
Briquettes corresponding to the other cementing test values showed little or no tendency to slake even after prolonged immersion.

Table V.—Specification for Gravel for Water-bound Gravel Roads.

Cumulative Percentages Retained on Screens

——	3 in.	2½ in.	2 in.	1½ in.	1 in.	¾ in.	½ in.	¼ in.	Passing 200 mesh.
1. Wearing course.......	......	......	......	0	....	15 to 55	......	60 to 75	5 to 15[1].
" " ..	......	......	0 to 5	......	10 to 55	....	......	50 to 75	5 to 15[2].
2. Base course..........	......	0	......	......	15 to 55	....	......	60 to 75	5 to 15[1].
"	0 to 5	......	......	......	10 to 55	....	......	50 to 75	5 to 15[2].

[1] Recommended by the Amer. Soc. of Civ. Eng., Jan., 1917.
[2] Recommended by the Office of Public Roads, Washington.
Percentages to the nearest 5 per cent.

Table VI.—Recommended[1] Specifications for Sand for Sheet Asphalt Wearing Course.

——	Per cent.
Passing 10-mesh sieve..........	100
Total passing 10-mesh and retained on 40-mesh sieve..........	12 to 50
Passing 10-mesh " " 20-mesh "	2 to 15
" 20-mesh " " 30-mesh "	5 to 15
" 30-mesh " " 40-mesh "	5 to 25
" 40-mesh " " 50-mesh "	5 to 30
" 50-mesh " " 80-mesh "	5 to 40
Total passing 80-mesh sieve and retained in 200-mesh sieve..........	20 to 40
" 80-mesh " " 100-mesh "	6 to 20
" 100-mesh " " 200-mesh "	10 to 25
Passing 200-mesh sieve..........	0 to 5

[1] These specifications are those recommended by the Office of Public Roads and are practically identical with those recommended by the American Society of Civil Engineers.

INDEX.

PAGE

A.

Analyses, textures of gravel and sand aggregates 7
" " sand portion of the gravel aggregates 8

B.

Bedrock, tests upon 6
Beekmantown dolomites 2, 3, 4
Black River limestones 2, 4, 5, 5
Boulder clay 2

C.

Chazy limestone 2
Cornwall 1

D.

Devil's Garden 2
Dolomite 3

G.

Geology 1
Glacial boulder clay 1
Gneisses 2
Granite 2, 3
Gravel 1, 3
" aggregates, analyses of textures of the sand portion 8
" and sand aggregates, analyses of textures 7
" deposits 2, 4, 5
" for waterbound gravel roads, specification for 10
Gravels and sands, tests upon 9

H.

Hornblende syenite 3

I.

Igneous gneisses 3, 5

L.

Lancaster 5

M.

Magnesian limestones 2, 4
Marine clay 1
" shells 2
Mount Oscar area 3

P.

Point Fortune 3
Potsdam sandstone 3, 5

R.

Raisin river 1
Rigaud 1
" mountain 1
Road materials 2

PAGE

S.

St. Lawrence area........ 1, 4
" belt........ 2
Sand........ 1
" and gravel aggregates, analyses of textures........ 7
" for sheet asphalt wearing course, specifications for........ 10
" portion of the gravel aggregates, analyses of textures........ 8
Sands and gravels, tests upon........ 9
Specification for gravel for water-bound gravel roads........ 10
" sand for sheet asphalt wearing course........ 10
Syenite........ 2
" porphyry........ 2, 3

T.

Terraces........ 1
Tests upon bedrock........ 6
" gravels and sands........ 9
Topography........ 1

V.

Vaudreuil area........ 1, 2