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MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

PROBLEM OF BACKWATER

Some Observations on Subject Based Upon Development on St. Maurice River—Compárisons Between Poirée Formula and that of Mead

By ROMÉO MORRISSETTE

Assistant District Engineer, Public Works Department of Canada, Three Rivers, Que.

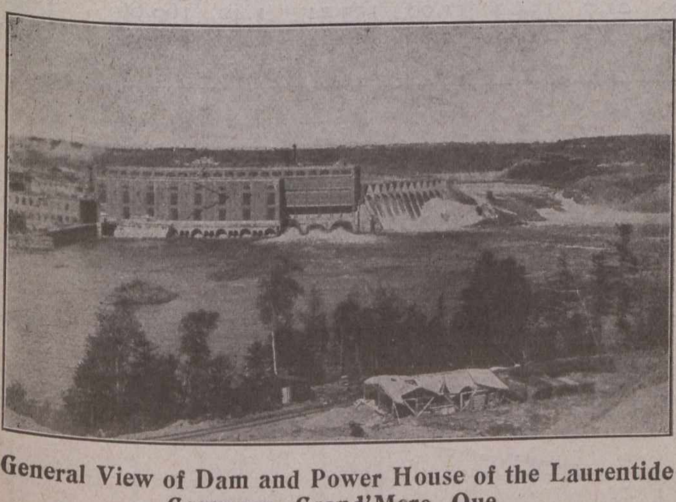
THE problem of backwater above dams is taking every day a larger part in engineering activities on account of the increasing development of water powers on large streams and the construction of important dams in connection therewith.

It brings to the engineer a realizing knowledge that riparian and other rights above falls have to be established by the determination of the highest contour attainable by the water surface under conditions encountered by such damming.

The writer in his leisure moments has studied the question, and the purpose of this paper is mainly to point out by using actual records observed on the River St. Maurice, to what extent the formulas ordinarily employed can be accepted.

In 1913, the Laurentide Company, Limited, undertook the construction of a spillway dam. It was at first designed with the crest fixed at elevation 150, referred to the company datum. Later, during the construction, experience suggested the installation of a gate-controlled spillway under Canadian winter conditions, based on the result obtained at Shawinigan Falls by the Shawinigan Water and Power Company, Limited.

A change to a gate spillway having a crest at elevation 140, estimated to raise the normal water level to elevation 160 was then decided on. The flow of the river other than that required for operation of the turbines is controlled by a number of gates which can be raised at any



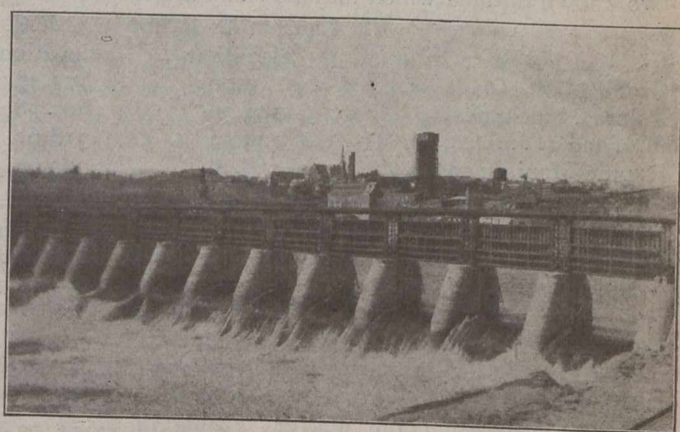
General View of Dam and Power House of the Laurentide Company, Grand'Mere, Que.

moment, eighteen in number, 40 feet in width and the bottom sill of all the gates resting at elevation 140.

Provided the gates were totally opened, different discharges would reach the following elevations:—

10,800 cubic feet per second	....	Elevation 142.90
78,200 " " " "	....	" 150.40
170,000 " " " "	....	" 157.30

But efforts have continuously been made during the last season to keep the water level at nearly a constant elevation independent of the fluctuating flow of the river.



Dam from East Side of River St. Maurice

As the river discharge increased, the number of gates opened was increased proportionately.

The power project called for the installation of eight main power units; and space for two more units, should they be decided on in the future; six of these units requiring a flow of 9,500 cubic feet of water a second under a head of 76½ feet.

The work is now completed and the power development of the Laurentide Power Company, Limited, is at its designed capacity.

The Department of Public Works of Canada has recorded, at different points along the shores above the dam, the fluctuations of the river, and with the aid of the levelling performed by the Quebec Streams Commission (C.E.C. datum), which has kept records of the elevation of each of these gauges, the water levels have been plotted for different discharges of the river.

The River St. Maurice is a series of cascades and falls which are expected to be used for an extensive power development in the future. Being so near one to the other in certain portions of the stream, and leases being granted one at a time in order that each may be utilized to its full value, it is necessary for the government to be very careful in the acceptance of plans for these future developments.

This last year some engineers were of the opinion that in the development of the Les Forges Rapids contemplated by the St. Maurice Lumber Company, the rights of the

Shawinigan Water and Power Company, Limited, at the foot of Les Gres Falls were liable to be affected by backwater. It caused the writer to give special care to the question.

Two formulæ were used, the first from a French author named Poirée, superintendent of public works in France, and the second from the well-known American author, Mead.

The illustration at the foot of this page shows the backwater above the Laurentide Dam in 1917; two cross-sections measured for the use of formulæ and the type of dam at Grand'Mère.

Five and a half miles from Grand'Mère, there was previously a fall of some 8 feet. At 7.25 miles is Pointe Madeleine, where a gauge exists and a cross-section of the river was surveyed; also on the seventeenth mile at Mekinac.

On the twenty-fifth mile, at Rapide Manigance, is another gauge fixed with the purpose of observing the river in its free course before entering the pondage. These gauges have been cut in the solid rock of the cliff existing at the above-mentioned sites.

The different zeros of the gauges are referred to the two known datums which may be summarized as follows:

	Laurentide datum elevation	C.E.C. elevation.
Grand'Mère	0.00	174.28
Pointe Madeleine	133.30	307.58
Mekinac	144.24	318.62
Rapide Manigance	159.26	333.64

With these datums accepted, observations have been conducted at those three places during a complete period of the year 1917 and the accompanying table shows the conditions for each month, *i.e.*, the highest and lowest water stage.

These are with a fair degree of accuracy the existing conditions of the water surface, and the small variances in the fluctuations are attributed to the influence of wind on the water surface. The water level observations taken on June 14th, 1917, were chosen on account of the conditions existing at that stage of the river from the dam to the foot of Rapide Manigance. The company maintains the water at level 155 at the dam site, while on April 25th, the date of the maximum annual discharge, the level was lowered to elevation 152.50.

From this experience it may be deduced that the existing backwater above the Grand'Mère Dam varies from 1.0 foot to 2.5 feet, according to the wind and discharge influences encountered on the river.

As stated above, the first formula used was Poirée's:

$$D = H + h - i\,x + \frac{(i\,x)^2}{4\,h}$$

D being the depth of water attained after raising the surface level, at a certain section of the river distant x from the dam.

h is the natural height of the water below the dam.

H is the raised height of the surface by the erection of the dam.

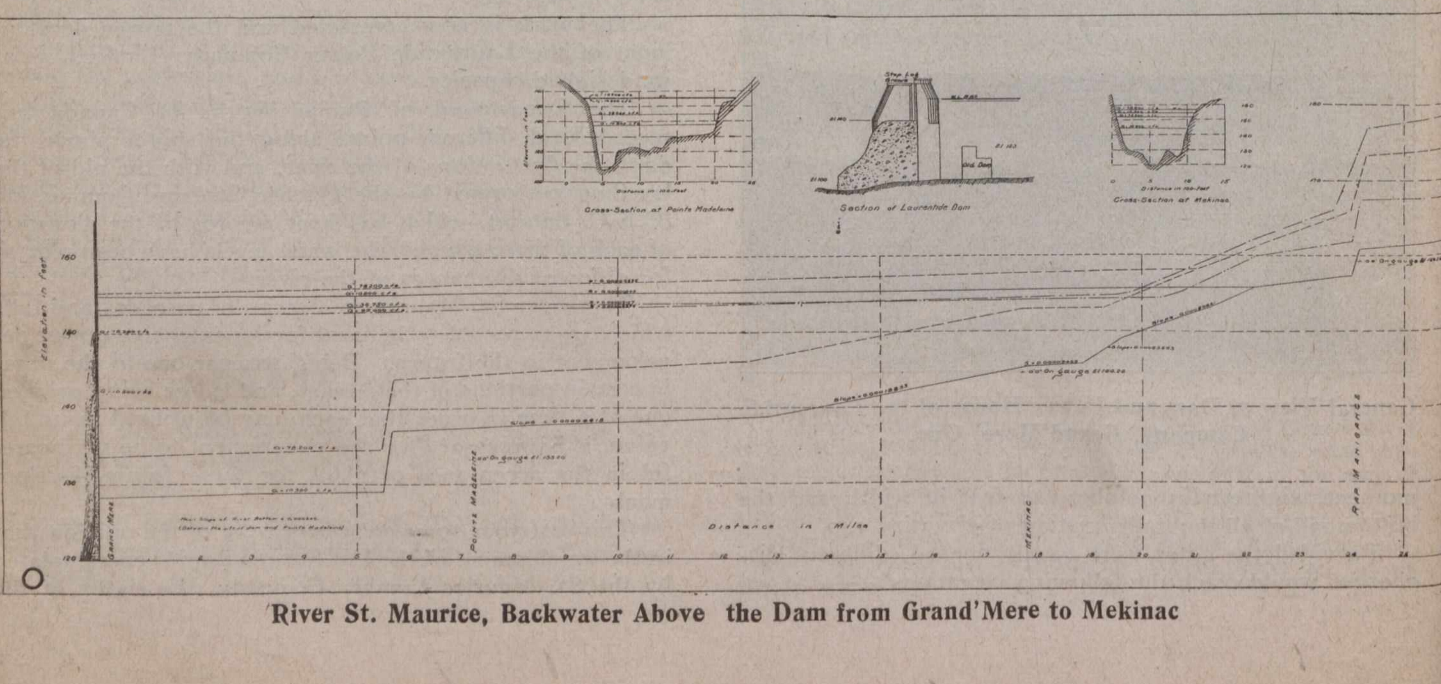
i the slope.

x the distance between the sites considered.

The value of i is determined by taking the mean depth across the section, and great care must be taken to determine the slope, as at certain sections there may be a sudden depression of the river bottom and the additional depth modifies the slope.

The water level being raised 23.1 feet corresponding to H and the depth below the crest of the dam being 26.9 corresponding to h, i = 0.0005491, x = 38,280 feet, then we obtain

Date	Grand'Mère Elevation	Pointe Madeleine Gauge	Pointe Madeleine Elevation	Mekinac Gauge	Mekinac Elevation	Rap. Manigance Gauge	Rap. Manigance Elevation	Remarks
April 29	153.25	20.4	153.6	10.00	154.24	5.00	164.26	Low
April 25	152.50	19.9	153.1	10.25	154.49	14.00	173.26	High
May 1	153.20	20.6	153.8	10.00	154.24	6.00	165.26	Low
May 14	153.90	21.8	155.0	12.00	156.24	10.50	169.76	High
June 3	154.00	21.7	154.9	11.25	155.49	5.60	164.86	Low
June 14	155.40	23.2	156.4	13.20	157.64	11.00	170.26	High
July 30	153.70	21.2	154.4	9.66	153.90	3.75	163.01	Low
July 4	154.10	22.0	155.2	12.10	156.34	8.00	167.26	High
August 28	155.30	22.1	155.3	11.30	155.54	3.32	162.58	Low
August 4	154.50	21.7	154.9	11.50	155.74	4.60	163.86	High
September 22 ...	154.90	22.0	155.2	11.20	155.44	1.32	160.58	Low
September 1 ...	154.20	21.6	154.8	11.40	155.64	3.32	162.58	High
October 1	154.90	21.7	154.9	11.00	155.24	1.40	160.66	Low
October 31	154.00	22.2	155.4	12.00	156.24	5.20	164.46	High



River St. Maurice, Backwater Above the Dam from Grand'Mere to Mekinac

At Pointe Madeleine—

$$D = 50 - .0005491 \times 38{,}280 + \frac{(.0005491 \times 38{,}280)^2}{4 \times 50}$$

$$= 50 - 21.02 + 22.1 = 30.19$$

$$= 30.19 + 21 = 51.19$$

The elevation of the water at Pointe Madeleine will be 156.19.

At Mekinac—

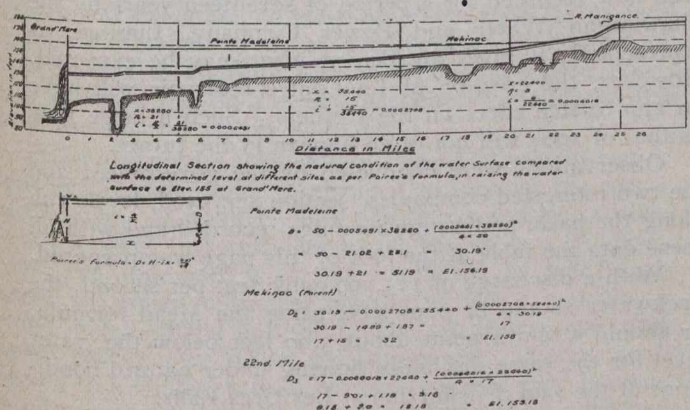
$$H + h = 30.19, \quad i = .0002708, \quad x = 55{,}440$$

$$D_2 = 30.19 - .0002708 \times 55{,}440 + \frac{(.0002708 \times 55{,}440)^2}{4 \times 30.19}$$

$$= 30.19 - 14.99 + 1.87 = 17$$

$$= 17 + 15 = 32$$

The elevation of the water surface at Mekinac is 158.



River St. Maurice, Showing Backwater

It shows that the actual backwater as per the Poirée formula is 3 feet at Mekinac, as the raising of the water at the dam site is considered to remain at elevation 155, while it is 2.24 feet as per observations made of the gauging scales in 1917.

This discrepancy is probably due to the fact that the Poirée formula must have been determined by the largest flow of the river. By the actual problem 78,500 cubic feet per second is the normal discharge, but the maximum one recorded is 170,000 cubic feet per second.

According to Mead, the underlying principle is the comparison of sections, establishing the ratio between the two surfaces, the coefficient of roughness, the velocities under the same quantity of discharge, *i.e.*, when under natural conditions and when an obstruction is located in the river.

The ordinary formula used for opened channel is:

$$Q = Av$$

But by raising the surface level the new condition becomes

$$Q = A'v'$$

Q = discharge.
A = area of the cross-section.
v = velocity in cubic feet per second.

By using the Kutter formula to determine the value of c in the formula

$$v = c\sqrt{rs}$$

where r = hydraulic radius and s = slope, we may substitute

$$Av = A'v'$$

$$Ac\sqrt{rs} = A'c'\sqrt{r's'}$$

Now we can establish the value of h' or the height of the new levels between the dam and the considered site, if h is taken as the difference in elevation between the same two sites under natural conditions. We then deduce

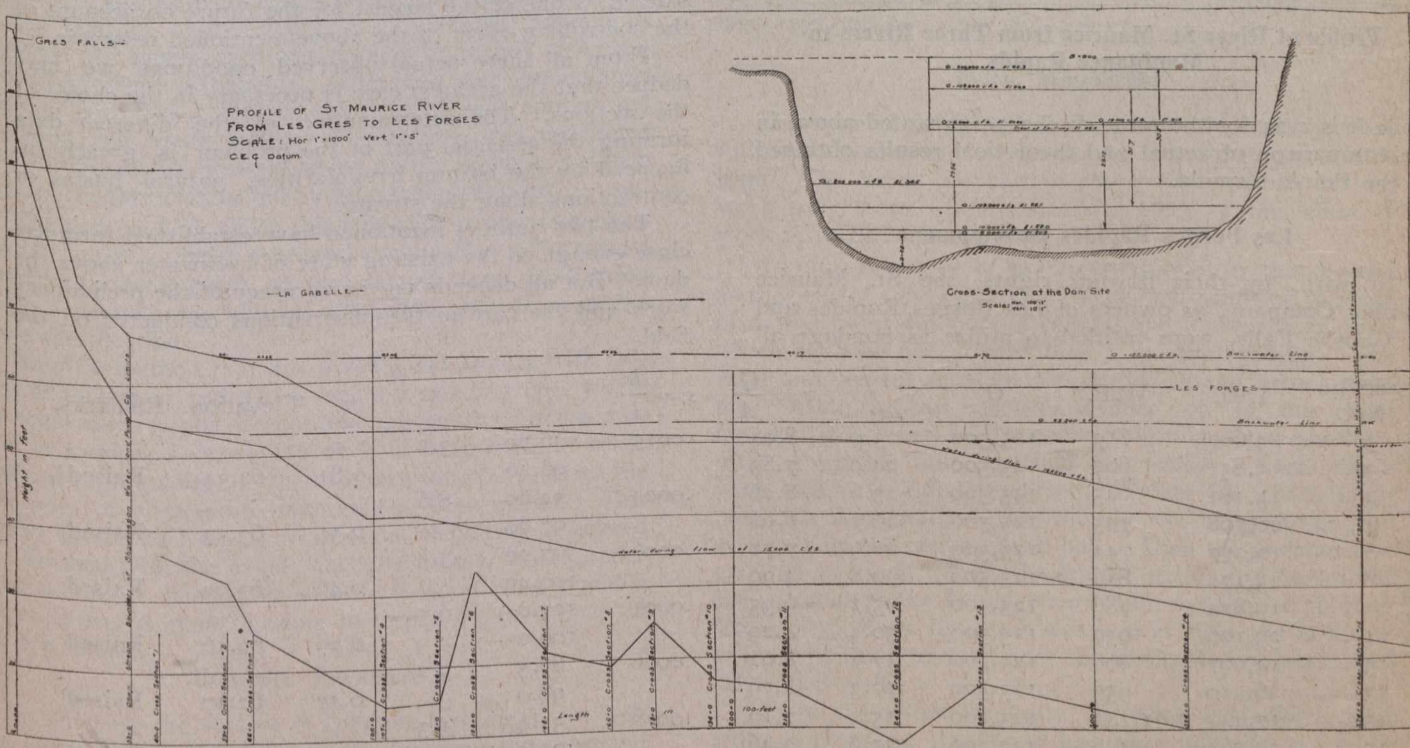
$$h : ac\sqrt{rs} \quad :: \quad h' : a'c'\sqrt{r's'}$$

or

$$h' = \frac{h \times A^2 c^2 r}{A'^2 c'^2 r'}$$

The value of h' will be at Pointe Madeleine:

Area.	W.P.	r	Slope.	c	v	Q	Remarks.
51,289	1,894	27.08	.00002525	58.24	1.54	78,200	Raised
48,636	1,872	24.91	.00000842	15.27	0.22	10,800	Raised
32,268	1,619	19.93	.0005491	23.27	2.42	78,200	Natural
19,469	1,535	12.68	.0005491	6.55	0.55	10,800	Natural



Profile of St. Maurice River from Les Gres to Les Forges. (C.E.C. Datum)

Substituting

$$h' = \frac{23.1 \times 32{,}268^2 \times 19.93 \times 23.27^2}{51{,}289^2 \times 27.08 \times 58.24^2} = 1.07$$

Elevation at the dam site	155.40
Backwater at Pointe Madeleine	1.07
Elevation at Pointe Madeleine	156.47

At Mekinac—

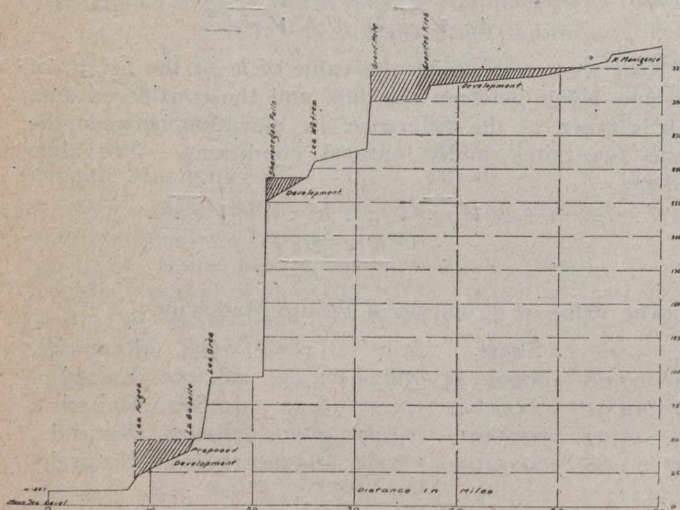
Area.	W.P.	r	Slope.	c	v	Q	Remarks.
27,446	1,088	25.22	.00002525	107.6	2.79	78,200	Raised
22,286	1,050	22.08	.0002708	45.58	3.51	78,200	Natural

Substituting the value in the Mead formula

$$h' = \frac{10.47 \times 22{,}286^2 \times 22.08 \times 45.58^2}{27{,}446^2 \times 25.22 \times 107.60^2} = 109$$

Elevation at Pointe Madeleine	156.47
Backwater at Mekinac	1.09
Elevation at Mekinac	157.56

The actual backwater as per the Mead formula is 2.16 feet at Mekinac, for a discharge of 78,200 cubic feet per second,



Profile of River St. Maurice from Three Rivers to Manigance Rapids

while it is 2.24 for the same discharge as stated above in the comparison of actual and theoretical results obtained by the Poirée formula.

Les Forges Rapides Development

In 1916, by their flowing rights, the St. Maurice Lumber Company, as owners of Les Forges Rapides and La Gabelle Falls, were entitled to utilize as pondage all the area of the River from Les Forges Rapides, and up to a certain division line fixed by the provincial government at the foot of Les Gres Falls, the property of the Shawinigan Water and Power, Limited.

The former company submitted for approval plans of an ordinary concrete spillway dam with a crest at elevation 49.5 (C.E.C. datum), and their engineers maintained that the crest elevation was so designed as not to interfere with the rights of their neighbors, or in other words, they represented that at any time, and under any natural conditions the river at that section was to remain free and the water to pass through, as if no impediment existed below, which the latter contested.

In the table submitted, the percentage of duration of each flow recorded for a period of seventeen years by the Shawinigan Water and Power Company, Limited, is represented; it gives an idea of what may be expected. However, the erection of La Loutre reservoir will have an appreciable effect on the freshets. Such a large flow as that of 1904 will not often happen in the future.

Observations were conducted by the government and the two interested companies, section surveyed, levels run along the basin and gauge readings recorded and with all these data the table at the foot of this page was prepared.

With a discharge of 125,500 cubic feet per second, the backwater should be 2.50 feet, using the Mead formula, or should attain a point about 3.90 feet below the water level for the same discharge flowing under natural conditions at the said division line at Les Gres Falls.

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Average	Percentage of the time
6000 cfs	365	310	365	365	365	356	339	365	352	358	365	348	354	363	354	355	369	346	95%
10000-	296	162	279	308	279	213	161	290	248	263	291	148	259	292	200	167	183	243	67%
20000-	211	110	201	186	161	93	83	201	92	240	138	84	157	176	75	97	96	141	38%
50.000-	61	56	96	40	55	24	31	50	55	66	52	37	66	33	11	33	56	49	13%
100.000-	6	13	13	1	14			5	28	21	8	3	4	13		4	12	9	3%
150.000-		1			2				2	6				2				0.8	0.2%

Table Showing Average Time During Which Different Discharges Occurred for a Period of Seventeen Years

The discharge of 125,500 cubic feet per second is considered as one of the largest for the future on account of the controlling effect of the above-mentioned reservoir.

From all these actual observed conditions we may deduce that the greatest care is necessary in the choice of the sections. The determination of the different data forming the essential part of the problem is greatly influenced by the bottom irregularities, natural basins or contractions along the stream.

The two authors mentioned have established formulas close enough to the existing state of backwater above the dam. But all depends on the accuracy of the preliminary work and the care in the observations conducted on the field.

Section No.	Area.	W.P.	Q	r	$v = \frac{Q}{A}$	$s = \frac{h}{L}$	c	h	h_1	Elevation.	Remarks.
3	15,607	653	125,500	23.9	8.04	.0013	46.70	3.2			
3	15,851	660	125,500	24.0	7.89		96.40		0.81	64.34	Raised
4	15,181	645	125,500	23.6	8.26	.0024	34.60	8.6			
4	20,708	775	125,500	26.7	6.06		97.60		0.51	63.53	Raised
8	16,277	744	125,500	21.9	7.71	.0006	67.00	3.5			
8	25,172	816	125,500	30.8	4.99		100.40		0.46	63.02	Raised
11	19,824	786	125,500	25.2	6.35	.0001	127.0	0.5			
11	29,196	959	125,500	30.4	4.29		100.0		0.39	62.56	Raised
13	14,067	806	125,500	17.4	8.92	.0006	87.4	3.2			
13	26,210	959	125,500	27.3	4.79		98.0		0.47	62.17	Raised
15	17,441	1,144	125,500	15.2	7.19	.0012	51.4	1.3			
15	50,992	1,426	125,500	35.6	2.46		130.0		0.10	61.70	Raised
					.. Dam site					61.60	Raised

RECENT DEVELOPMENTS IN THE DESIGN AND CONSTRUCTION OF ROAD SURFACES

By H. E. Eltinge Breed

(Concluded from last week's issue.)

So far as bituminous macadam when laid in the penetration method is concerned, until the last two years this type of pavement was built in many cases under practically the same specifications for asphalts as for tars. These materials have different characteristics; that is, the asphalt will generally stay fairly well to the surface and quite often in warm weather will bleed up, requiring additional stone surface to take up the excess; on the other hand, the tar has a tendency to work down and, with the subsequent oxidation, to leave no material on the surface which is therefore prone to disintegrate. A number of experiments to alleviate this condition have been tried. One of these was on a road I happened to build and the construction was mainly as follows:

After the proper thickness of stone had been spread it was lightly rolled once to shape it to form to the crown of the road. It was then filled with No. 1 and No. 2 stone in an amount just sufficient to fill the voids. (If, however, the stone used is of such character as will crush under the roller, a smaller amount of No. 1 and No. 2 stone mixed should be used.) The top course was then again rolled, after which the bituminous material (tar), heated to a temperature of between 200 and 300° F., was evenly spread over the surface by the use of an approved pressure distributor, operating under a pressure of 50 lbs. per square inch, or more if necessary. The amount of bituminous material used for this application approximated 1¾ gallons per square yard for a compacted top course 3 inches thick.

The surface was immediately covered with a layer of clean No. 1 and No. 2 broken stone mixed, after which it was again rolled and additional No. 1 and No. 2 broken stone mixed, applied and broomed until the voids in the No. 3 or top-course stone were entirely filled. After this was done, all loose stone was swept from the surface and a seal coat of approximately ½ gallon of bituminous material per square yard was applied by means of an approved pressure distributor. The road was immediately covered with No. 1 broken stone which was spread and broomed and again rolled. The rolling was continued and additional No. 1 stone added until a smooth, uniform and thoroughly compacted surface was produced.

The first road on which this was tried is now two years old and has been under average heavy traffic. The results are exceptionally good, so that all of our penetration work done with tar will be conducted according to the same specification.

Another method that has given good results with this type of pavement and which incurs lower first cost where the local stone is not of good enough quality for top surface, is to place a veneer top of ¾-in. trap rock, or other stone of high quality, on the ordinary top course after the first pour of bituminous material has been made. This course should be from ¾ in. to 1 in. thick and is poured and finished with the usual squeegee course, where under observation it has given uniformly good results and a larger saving is made in using materials for two-thirds of the top course.

Concrete Pavement

In finishing the surface of concrete pavement, the belt has largely taken the place of the finishing machine and also of the floating. It has many advocates because it is cheaper than either of the other methods and at the same time gives a good, smooth, easy riding surface.

Another method of finishing concrete surfaces is by the roller. Its advocates claim that on account of the importance of a proper wet content for concrete the roller, if properly used, will not only give a good finish but also greater strength by taking off the excess water and giving the stiff mixture which it is impracticable to use in most concrete road work. This method, which has been in general use in the city of Macon, Ga., was originally developed to remove any unevenness in the surface.

The concealed type of joint is another method in use to make easier riding qualities over the joints in concrete. It has been impossible always to finish them so as to leave a smooth surface, but when the joints are depressed from an inch to 1½ inches below the pavement this unevenness has been obviated. In Fulton County, Georgia, where the concealed joint has been used, good results have been obtained.

Resurfacing of concrete with 3-in. concrete has been tried with success in Wayne County, Michigan. At the same time this work was done the pavement was widened from 16 to 20 ft. and after a year's wear under average heavy traffic conditions the work is very satisfactory. One interesting feature of this work is that after the old concrete surface had been levelled up it was wet and a mixture of hot Tarvia "A" and "X" poured over it. This spread out in a fine layer and made a joint between the old and the new work. The whole work was resurfaced and while the surface has some cracks no serious ones have developed up to the present time. Milwaukee County, Wisconsin, has also done some of this resurfacing.

Here is another method which saves in cost because it uses in part poor local material and decreases the importation of expensive material: The local material is used in proportions of 1 : 2 : 4 or 1 : 2½ : 5 for the lower 3½ to 4½ ins. of the pavement. On it is placed a top course of concrete 2½ ins. thick composed of trap rock or other tough, durable aggregate in proportions of 1 : 1½ : 3. A fairly dry mix is necessary in this type of construction, but contrary to general expectations the cost of manipulation is increased only to a very slight degree.

Brick, Monolithic

This type of construction has many advocates because full beam action can be developed in a structure of this type. The brick are laid in the green concrete as the work progresses. One successful piece of this class of work is to be found in Paris, Ill.

Another new type of brick construction is that known as the cement sand cushion. The cement sand bed is made of a mixture of one part of cement and four parts of sand which shall be not greater than 1 in. after rolling. The sand and cement must be thoroughly mixed before placing. After the bed has been levelled off in the usual manner, it is rolled with a roller weighing about 300 lbs., after which the brick are laid and rolled. Each day's work has to be fully completed. Before the grout is applied the brick must be thoroughly wet by sprinkling so as to set up the cement sand bed. Then the pavement is grouted as usual. A good example of this can be seen in the entrance to the Pennsylvania Railroad Station in New York City, where the work was laid in 1910 and is in excellent condition to-day under the strain of very heavy and diversified traffic.

There is another tendency in brick surfacing which from an economic standpoint has many advantages. That is the use of 3½-in. or 3-in. brick in place of the ordinary paver which is 4 ins. in depth. In the use of the 3-in. brick there is a saving of one-quarter in the freight charges and a consequent saving of handling. This type of work has been done in a number of instances and has every indication of being satisfactory. Some work under consideration may use 2½-in. and even 2-in. brick and if successful the resulting economies will make brick pavements feasible in many localities.

Laboratory Work in Relation to Road Surfacing

There should be laboratory control in connection with every piece of highway work because to insure good work the materials must be up to some standard which has proven its adequacy in service.

Field tests by the men in charge of the work should be made in a practical manner and in conjunction with those of the laboratory in order that a constant check may be had upon the materials going into the work.

As a matter of cost it may not be entirely practical for every department in its early stages of development to have a fully equipped laboratory, but if there is a sufficient demand for laboratory work to guarantee enough of it, the commercial laboratories in existence would be willing to equip themselves to render this service at a nominal charge. This would stabilize all work done and the amount expended for the service would be the cheapest kind of insurance.

Good slag is essential if it is to be used in any type of pavements. The tests on slag run in the standard stone abrasion machine were not indicative of quality or comparable with different qualities of stone. It was learned that the material worn from the sample during the test filled the corners of the closed pot, and as soon as sufficient material had accumulated, a cushion was formed which greatly reduced the abrasion.

We designed a new pot to remedy this condition. This is of the same size and shape as the standard pot, but it is slotted at intervals to allow the worn-off material to escape and to prevent cushioning. This new test has been very successful in determining qualities of slag.

It has also been used in testing gravel with promising results. The aim in the gravel testing is to determine what gravel is suitable for use as coarse aggregate in concrete road surfacing. The better known gravels of the State, which have been proved successful by service test, have been tested in this machine and the results used as a standard for the judging of other gravels.

In testing gravels, several methods have been tried with charges of steel shot both in the closed and the slotted pot. So far, judging from results obtained, the most reliable method is in using the slotted pot without any charge.

CANADIAN SOCIETY FINANCES

The gross income of the Canadian Society of Civil Engineers was slightly higher in 1917 than for any previous year. The total income was $25,698, as compared with $23,727 in 1916, which was the previous high-water mark.

The expenses for 1917 were $25,210, compared with $20,085 in 1916, so that the excess of receipts over expenditures in 1917 was $488, compared with $3,642 in 1916.

The larger income was due mainly to an increase of over $2,000 in the current fees collected. The larger expenditure was chiefly due to increases of $1,818 in general items, $773 in refunds to branches, and $2,693 in salaries. The salary increase was mainly due to the appointment of a secretary who would devote his entire time to the society's affairs.

In commenting upon the annual statement of the auditors, R. A. Ross, chairman of the finance committee, says: "In spite of greater exertions, the arrears collected are practically the same as for the two previous years, indicating that most of the cream has been extracted. Current fees collected show recovery in spite of war and consequent remission of fees to active service members. . . . In spite, however, of the absence at the front of over 850 members, whose fees would total about $6,000, and of increased salaries, the society is in a position to show a small excess of receipts, which should increase next year when the effects of new activities become evident."

The assets of the society now amount to $111,160, approximately just the same as last year. There is a reduction in cash on hand and in the bank, but this is more than offset by the reduction in accounts payable and by the investment of $1,000 as part payment on a $5,000 Victory Loan bond. The largest asset is the property at 176 Mansfield Street, Montreal, which is valued at $89,041, but on which there is a $20,000 mortgage. The estimated value of arrears of fees is still carried forward at $5,000, which would appear to be warranted by the fact that over $6,000 arrears have been collected each year for the past three years. The cash and investments amount to about $8,000, while books and furniture are valued at nearly $9,000. The liabilities, other than the mortgage, amount to only $4,640.

TORONTO BRANCH, CAN. SOC. C.E.

Prof. Peter Gillespie, of the University of Toronto, has been elected chairman, for the year 1918, of the Toronto Branch, Canadian Society of Civil Engineers. Geo. Hogarth, chief engineer of highways of the province of Ontario, will be secretary, and the executive committee will consist of the following:—

J. R. W. Ambrose, chief engineer of the Toronto Terminals Railway Co.; Willis Chipman, consulting engineer; E. L. Cousins, manager of the Toronto Harbor Commission; Prof. H. E. T. Haultain, of the University of Toronto; E. G. Hewson, division engineer, G.T.R.; and R. O. Wynne-Roberts, consulting engineer.

There are 171 corporate members of the branch at home and about 30 in active military service. Of about 100 junior and student members of the branch, fully three-quarters are in khaki. Therefore, of the entire branch membership, totaling about 300, just about one-third are in the army. In connection with the election just held, 171 ballots were sent out, of which 62 were marked and returned to the secretary by mail or at the meeting last week. About thirty-five members attended the meeting.

SASKATCHEWAN BRANCH, CAN. SOC. C.E.

The annual meeting of the Saskatchewan Branch of the Canadian Society of Civil Engineers was held January 10th, when the following officers were elected:—

Chairman, G. D. Mackie, Moose Jaw; vice-chairman, H. S. Carpenter, Regina; secretary-treasurer, J. N. de Stein, Regina; executive committee, H. R. Mackenzie, Regina; E. G. W. Montgomery, Regina; W. H. Greene, Moose Jaw; C. J. Yorath, Saskatoon; J. E. Underwood, Saskatoon

DRAINAGE OF IRRIGATED LANDS*

By J. L. Burkholder

SEEPAGE usually results in one of two ways, either from a rising of the ground-water above its original level or from the retention of applied irrigation-water by an impervious stratum at a comparatively short distance from the surface. Seepage caused by a general rising of the ground-water usually involves larger areas, and is more common than that caused by impervious strata. In the former case, the underground-water passages, which are sufficient in capacity for the ordinary flow of underground water, are choked by the added irrigation supply, and a gradual ponding in the soil takes place. In the winter, when the irrigation water is wholly or partly shut off, the ground water surface lowers, only to rise

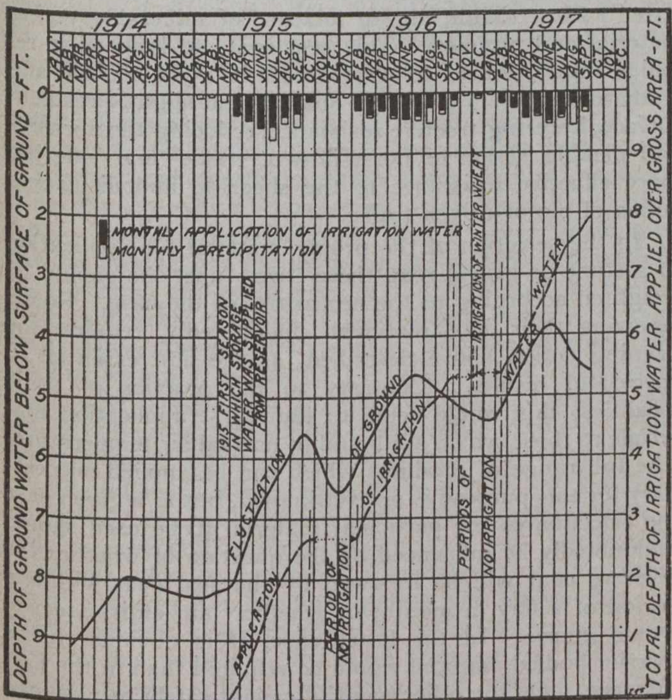


Fig. 1.—Ground-water Fluctuations and Use of Water in Rio Grande Valley

again to a greater elevation during the succeeding irrigation season.

The surface of the ground water is represented by a series of peaks and valleys, which correspond to the seasonal use of water on the land. The peaks increase steadily in height, and finally reach the ground surface at low points. Water stands in these during the irrigation season, only to disappear during the winter. Fig. 1 shows the fluctuation of ground water and the application of irrigation water on 8,500 acres in the Rio Grande valley. The ground-water curve is based on the records of 20 wells in various parts of the tract. The net area irrigated was 5,300 acres, and the average depth of water applied was 4.3 ft., corresponding to 2.7 ft. over the entire 8,500 acres. Where the water stands on the surface, or where the ground-water level is near enough to the surface to be affected by capillary attraction, the resulting evaporation causes the deposition of "alkali" salts.

The flow of underground water, like the flow of surface water, follows the direction of greatest slope, but on account of friction of the soil particles, the movement is slow. If irrigation losses are large, the supply of ground water exceeds the amount handled by natural movement and there is seepage, even on land with a considerable slope.

Deep drains keep the ground-water level at a sufficient depth below the surface to prevent the rise of "alkali". They do not empty the underground reservoir, but simply reduce the peak of the ground-water surface.

A study of Figs. 1, 2 and 3 shows that the loss of a comparatively small quantity of water by deep percolation

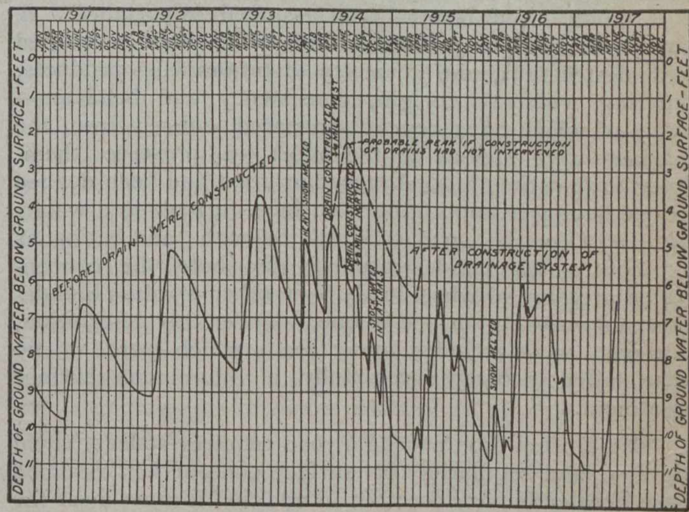


Fig. 2.—Ground-water Fluctuations in Part of Boise Valley, Idaho

necessitates the construction of an extensive drainage system. In Fig. 1, note how closely the curve representing the ground water responds to the use of irrigation water. This curve drops rapidly when irrigation stops, showing the effect of the natural underground drainage.

The financial loss caused by deep percolation does not stop with the construction of a drainage system. Drains

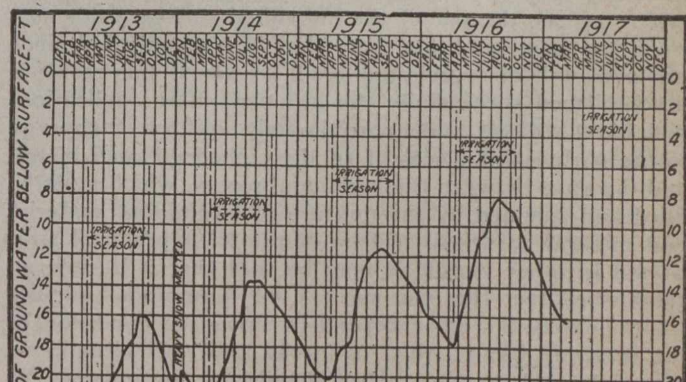


Fig. 3.—Ground Water in Boise Valley, Idaho.

are not a "cure-all" for seepage. After each irrigation a "peak" of ground water remains, the size depending on the care taken by the irrigators. This ground water must spread laterally and enter the drains, if the soils are to be properly aerated and injury from "alkali" prevented. If there is a continual overabundance of water applied this "peak" remains so close to the surface as to make the root space shallow. In addition, much of the plant food is removed by the continual motion of free water in the soil.

*Abstract from "Reclamation Record."

EFFICIENCY OF THE APPLICATION OF BITUMINOUS MATERIALS FOR SURFACE TREATMENTS ON GRAVEL AND BROKEN STONE ROADS*

By Julius Adler

Engineer of Tests, Pennsylvania State Highway Department.

ABOUT ten years ago the dual problem of dust prevention and road preservation—to borrow the commonly used terms—first assumed importance. A large mileage of hard surface roads which were threatened with destruction; and a variety of bituminous products, differing widely in origin, consistency and behavior—many of which have now disappeared entirely from the market—were applied in the effort to preserve them. Prior to that time a good macadam road had been defined as one having a smooth, hard surface, furnishing a watertight roof for the earth subgrade beneath; and acting as a "more or less rigid stratum to distribute the concentrated pressure of wheel loads"—in other words, a foundation and wearing surface in one. Under this description, however, were included many roads which were in no wise suited to carry successfully a bituminous surface treatment.

The present-day macadam road requires at least equal rigidity, and regularity of surface contour has assumed even greater importance; but in addition it must meet the special requirement of presenting a suitable surface for the application of a liquid bituminous material. For the latter purpose there is fairly general agreement as to the necessity for a clean mosaic surface, with a maximum exposed area of tightly locked, coarse road metal and the least possible part of the surface occupied or covered by screenings, dust, or other fine material. If a graded aggregate has been used in the construction or resurfacing of the road it is essential that the distribution of the different sizes shall be uniform, the smaller pieces tending as nearly as possible to assist in locking the larger pieces and to reduce the size of the individual surface voids surrounding them; and that there shall be a complete absence of "pockets" of segregated small sizes. If this result is accomplished successfully the bitumen, after application, will have a direct and approximately uniform anchorage to the surfaces of pieces of solidly embedded road metal, and the gaps between the individual pieces, which must be filled and spanned by the mixture of bituminous material and mineral covering, will be of the least practical size. Stated in other words, it may be said that it is now an established fact that the success of bituminous surface treatments is far more dependent upon the condition of the roadway treated than upon the kind of bituminous material used or any other details in the process of application.

After making reasonable allowance for availability of bituminous materials and for all the differences in the climatic and traffic conditions to which the bituminous surface treated road will be exposed, it appears that a greater and more desirable degree of uniformity of practice in connection with this work will be reached only by more careful inquiry into the real purposes of bituminous surface treatments—leading to a more general agreement among engineers as to the general types of materials and methods to be employed to meet similar sets of conditions. Bituminous surface treatments at first appear to serve a number of distinct purposes in the preservation of the road surface but upon analysis these may be placed into two classes: (*a*) Priming and binding the upper portion of the road crust; (*b*) sealing and smoothing the road surface.

The screenings or fine material occupying the small voids or pockets surrounding the coarser pieces of aggregate must be saturated by the bituminous material to a degree that the particles will adhere to one another as well as to the contact surfaces of the adjacent road metal. This should further result in the formation of an irregular, but continuous, water-proofing layer below the road surface, serving to intercept water, drawn by capillary attraction from the subgrade. Contrasted with this, the sealing action consists in the formation of a continuous film of bitumen or bitumen-coated particles, coating the exposed surfaces of the upper layer of road metal and filling and bridging the gaps between the individual pieces of the latter with a tough, elastic mixture of mineral covering material and bitumen. This seal coat, so long as it remains intact, serves to waterproof the road surface and tends to produce a generally smooth and slightly resilient surface, lowering tractive resistance, reducing the abrasive and picking action of horse-drawn traffic and offering more effective resistance to the shearing and displacing action of motor-driven traffic.

In the selection of the proper material for application to a stone or gravel road these two functions should be weighted according to the necessities of the case. Roads receiving their first treatment undoubtedly require the priming action above described, as the first essential to successful results. Contrary to the practice of some localities, this would seem to limit first application materials to those which are liquid at normal air temperature. The full range of products which can be applied successfully for this purpose is not yet known, but in a given case the selection of the particular material to be used should undoubtedly be influenced by the question of whether the priming coat will be followed by the seal coat within a period of a day, a month, or whether an entire season would elapse. In the latter case, it is obvious that a heavier bodied material would be required than in the first instance. On the other hand, it cannot safely be assumed that all bituminous materials—regardless of character or origin—are necessarily of the same value as primers simply because they are of approximately the same liquid consistency. Observation and experience have taught that there is a considerable difference in behavior in this respect, and while no specifications as yet attempt to cover definitely this particular point, it has been suggested that a study of the surface tension of different products of about the same consistency be made, since this property bears a direct relation to the height to which a liquid will rise in a capillary tube, which may also be regarded as a measure of its ability to creep down into the irregular capillary tubes formed between the fine particles of mineral matter in a road surface.

In this same connection it should be remembered that just as the usual "hot application" bituminous material is liquid only so long as it retains its heat, similarly, many products which are liquid at normal temperature may remain so only so long as they retain their volatile constituents. If the latter are lost too quickly, the bituminous material will thicken so rapidly as to fail to serve its purpose as a primer. If, as is frequently the case, a bituminous material for first application must serve not only as a primer, but also provide sufficient surface sealing so that the road may safely carry a season's traffic, the most desirable product is that which is so constituted that,

*Paper presented before Section "D" of the American Association for the Advancement of Science, December 28th, 1917.

while not changing in consistency too rapidly upon exposure to the air, it will nevertheless leave a residue of heavier consistency on the road surface to serve as a cementing material for a partial seal coat.

Considering the second case, if the bituminous material is to serve almost entirely in the production or maintenance of a seal coat, the character of the residual bituminous material finally left on the road surface is the most important factor to be considered. Insofar as consistency at the time of application is concerned, the necessity for a material liquid at ordinary air temperature is largely removed where priming or penetrating qualities are required. There is, however, a greater assurance of a complete union between the old and newly applied material, and of an enlivening of the former (in the case of roads which have been treated in previous seasons), with the use of this class of material. If a liquid material is to be used for this purpose, it becomes quite important, from the standpoint of the convenience of the travelling public, that it should contain a considerable percentage of volatile material, since a product of the reverse character, placed and held on the surface of a fairly impervious road, creates a slippery and unsafe condition which requires excessive time for correction because of its slow volatilization. These considerations indicate that a given liquid bituminous product can hardly be equally suitable for use both as a priming and sealing material. Whether a hot or cold application material is used in seal coat, or retreatment work, the essential point is that the original bituminous material, or the final residue from it, shall be of the proper consistency, adhesive, pliable and elastic, and retain these properties under temperature changes, aging, and exposure to traffic and atmospheric agencies.

The influence of the character or quality of the road metal on the success of bituminous surface treatments is still an uncertain factor. Material of an argillaceous character; that is, argillaceous sandstones or limestones, slates and argyllite, and bank gravel with a high clay content, have been noted to affect the results adversely. This may be due largely to the usual presence of earthy or shaley material in the screenings used in bonding the road, and again to the smooth, highly polished surfaces of the fragments of some of these varieties of rock. Hard, crystalline, metamorphic rocks, of the general character of gneiss, are difficult to bond with their own screenings and are slow in forming a solid, impervious crust. The road surface frequently ravels in spots under traffic before the first bituminous application is made, thus interfering with the complete success of the treatment. Occasional instances have also been noted of stone so soft as to be crushed by the weight of traffic beneath the bituminous seal, causing a local breaking up of the bituminous seal. In general, however, the requirements for stone for surfaces intended to receive bituminous treatments are less exacting than in the case of waterbound macadam, and a hard limestone may be used with the same bituminous material and under almost as severe traffic conditions, and give as successful results as trap rock.

The completed surface treatment is immediately subjected to the destructive influence of traffic, atmospheric and climatic agencies. As regards traffic, it is evident that the life and completeness of the bituminous seal depend entirely or directly upon the ability of the underlying road crust to furnish complete and uniform support. Surface treatments for at least the first few years of their application can scarcely be regarded as more than films; and however perfect or elastic this film may be it is questionable, in view of its small depth and the impact which must be transmitted to the piece of road metal beneath, whether it can reasonably be expected to withstand the pounding of the hoofs and wheels of heavy horse-drawn traffic or the shearing action of heavily laden solid-tired trucks, especially when acting in the presence of a coating of mud or melting snow or ice on the road surface. In this connection, excellent examples of bituminous surface treated roads in suburban sections of cities in which a real estate development unexpectedly begins, have been seen to deteriorate rapidly; while on the other hand, inferior roads in localities where the surface is blanketed with snow or ice, which remains from the early part of the winter to the final spring thaw, are found to be preserved in excellent condition.

It will always be difficult to define the exact localities in which bituminous surface treated roads can be relied upon to meet all requirements because of the uncertainty of changes in the amount and character of traffic resulting from unexpected developments in industrial operations of all sorts as well as temporary severe increases resulting from a condition such as previously mentioned. On the other hand, systematically maintained, bituminous treated roads have been found to be an entire success under the condition for which they were originally designed; that is, for large amounts of motor traffic. In an analysis of the cost of such roads in Maryland in 1917, Mr. H. G. Shirley has shown that the annual maintenance cost per mile of bituminous surface treated roads divided by the annual tonnage passing over the road is less for main automobile traffic routes than for any other set of traffic conditions. Experience up to date may be said to have demonstrated that insofar as traffic is concerned the well-built bituminous surface treated road will give satisfactory service in many localities where there is reasonable assurance of a continued preponderance of pneumatic-tired motor traffic with lesser amounts of solid-tired motor and heavy horse-drawn traffic.

As regards climatic conditions, it has already been suggested that roads of this type built and maintained by similar methods, apparently encounter the most adverse condition when exposed to a winter climate which includes alternate freezing and thawing, coupled with the maintenance of traffic over the road throughout the winter and early spring season; while the reverse condition may act as an actual preservative of a bituminous surface treatment.

All bituminous materials will deteriorate to some degree on a complete bituminous seal, and have been found to contain a very appreciable amount of moisture during the early spring, drawn undoubtedly from the road, under freezing temperature, which does more damage to bituminous surface films than any other natural agency,—especially in the case of roads which, as a result of careless construction, etc., do not conform to some of the requirements previously described. As a further illustration of the importance of frost action, it is reported that in extreme southern States it is possible to maintain bituminous treated gravel roads as a permanent form of construction, insofar, of course, as this type can be called permanent; while in certain New England States, with careful attention to drainage, it is found impossible to hold the impervious bituminous surface on gravel roads subjected to the heaving and consequent settling of the spring break-up. There is no assurance, of course, that the gravel in the two cases is of equal quality, but all indications point to this as an illustration of the limitations imposed by climatic conditions upon the possible success of this type of construction.

Assuming that traffic and climatic conditions are reasonably favorable to this class of work, it still remains to be determined what are its further limitations. Improved methods of construction, more attention to details in the construction of the road and better selection and application of bituminous materials, on the one hand, may to some degree widen even its present range of usefulness. Repeated annual treatments, however, introduce problems which are not yet entirely solved. More or less heavy, unstable carpets of bituminous material produced during some of the early stages of this work proved entirely unsuccessful. Successive applications (varying very considerably with the kinds of material used and the nature of the traffic over the road) show indications of producing a similar condition only modified by the facts that the general character of the materials in use is now more suitable than some of the early ones, and that the production of a carpet by a succession of thin layers thoroughly united, and having good adhesion to the surface beneath, is more apt to produce a stable combination. On the other hand, attempts to re-surface old macadam roads with bituminous concrete mixtures, where the mineral aggregate is scientifically graded and the bitumen of selected consistency and quality, have been found not to meet with the unfailing results which should be expected from the type of construction under discussion.

From an economical standpoint it may, under some conditions, be demonstrated that there is a possible saving in the construction, or more frequently the resurfacing, of an existing macadam road, to be maintained by systematic surface treatments, as compared to the construction of one of the higher priced and so-called permanent types of surfaces. Generally speaking, however, it will be found that the combined cost of an annual bituminous treatment with the caretaker or patrol system, totalling from $500 to as high as $1,000 per mile of 16-ft. roadway in various localities, represents an annual charge in excess of the maintenance, interest on the difference in first cost, and depreciation on a road of greater initial cost, consequently the most apparent recommendation for the bituminous treated road lies in its relatively low first cost, making possible a larger total mileage with the same outlay.

Present hopes for enlarging the field of success and usefulness of this type of work lie in the more careful construction of the original road, more scientific selection of bituminous materials so as best to serve the two functions considered as necessary, and the adoption of systematic and continuous maintenance, so that it may become possible to preserve at least a considerable proportion of these roads in satisfactory condition with fewer than annual complete re-treatments and at a consequent lower annual maintenance cost.

CHARTER MEMBERS, CAN. SOC. C.E.

Of the nineteen charter members of the Canadian Society of Civil Engineers, only six are now living, *viz.*, Sir John Kennedy, of Montreal; Hugh David Lumsden, of Orillia, Ont.; Brig.-Gen. Henry Norlande Ruttan, of Winnipeg; Sir Collingwood Schreiber, of Ottawa; Percival W. St. George, of Montreal; and Herbert Wallis, of Montreal. All six are in consulting practice.

Sir John Kennedy is a past president and honorary member of the society. H. D. Lumsden is a member and past president. General Ruttan is a member and past president. Sir Collingwood Schreiber is an honorary member and was a councillor in 1887 and 1888. P. W. St. George is a member and was vice-president in 1894, 1898, 1899 and 1900. Mr. Wallis is a member and past president.

THE DIFFUSION OF SEWAGE*

FROM experiments made by the Metropolitan Sewage Commission of New York in the laboratory and in the open harbor several interesting conclusions were drawn. In still water, sewage will first rise toward the surface or fall toward the bottom, depending upon the relative specific gravity of the two liquids. In sea water it will rise, while in fresh water it will remain for a longer period about the level of discharge. Diffusion begins at once and is more rapid the less the salinity of the water. It probably bears some relation to the form of the jet, but at this stage it is of less importance than the mixing action due to currents. Where turbulent eddies occur mixing is rapid and the buoyant tendency due to the difference in specific gravity is obliterated. After this initial mixing further tendency toward putrefaction is usually deferred for at least several hours.

It was observed that when discharged into an equal mixture of sea and fresh water sewage rises from depths not exceeding 30 ft. so that it will probably be visible at the surface; but from depths of over 40 ft. it will probably not be seen unless discharged in very large volumes, although much depends upon the existence of subsurface currents.

A high salinity of the water retards diffusion. Streams of sewage are diffused more slowly in tidal waters than in rivers of fresh water. Moreover, salinity increases the upward tendency in submerged effluents so that they reach the surface more promptly and hence with less opportunity for diffusion. For these reasons and because the saponification of the soaps in sewage renders it more nearly opaque, because its capacity for dissolved oxygen is less and because any decomposition of sludge deposits gives rise to more offensive odors in salt water than fresh, the latter is generally a more favorable medium into which to discharge sewage.

The effluent from a submerged outlet in salt or brackish water rises to the surface in the form of a cone, spreads rapidly in a thin sheet so that at a moderate distance there is usually little evidence of pollution below a foot or two from the surface, although the line of demarcation of the sewage field may be quite definite for a considerable distance.

With a septic sewage, high temperature, and a stream low in dissolved oxygen, conditions favor putrefaction, and particular pains should be taken to secure rapid diffusion. The desirability of this is becoming recognized in the construction of submerged sewer outlets.

At Moon Island, 50,000,000 gallons of crude sewage from Boston is discharged near the surface on the first two hours of ebb tide. The sewage is dark, septic, foul in appearance and with a strongly offensive odor, although gross pollution is confined to the upper 5 ft. in depth of water. Discoloration of the water at times covers 1,000 acres, half of which may be called "offensive," and extends for a distance of over 1½ miles from the outlet.

A marked improvement is observed in the continuous discharge of 60,000,000 gallons per day off Deer Island from the North Metropolitan system. The discoloration is hardly noticeable below 2 ft. from the surface and little evidence of sewage is ordinarily found beyond a distance of 900 ft.

This marked improvement over the Moon Island outlet is attributable to the fresher condition of the sewage and its continuous discharge at correspondingly lower rates.

*From an article by Kenneth Allen, Engineer of Sewage Disposal, Board of Estimates and Apportionment of New York City, in the December Polytechnic.

But even here the sewage field may be detected as much as 1½ miles from the outlet under certain conditions.

The more recent two outlets from the South Metropolitan system near Peddocks Island, Boston, marked a further improvement in being placed at a depth of some 30 ft. of water at low tide. Here 53,000,000 gallons per day are discharged continuously, but there is no marked discoloration more than 30 ft. from the outlet.

The discharge of 67,000,000 gallons of the sewage of Washington from two outlets at a depth of about 28 ft. in the Potomac River is difficult to detect at the surface and the same may be said of that from the three outlets at Hamburg where 53,000,000 gallons per day enter the Elbe. In these examples there are the additional advantages of a discharge into fresh water, and in dividing up the flow between two or more outlets.

The Deer Island outlet in Boston Harbor is being extended 300 ft. into water 52 ft. deep at low tide. For about 240 ft. this is of 7-ft. cast-iron pipe converging to 4 ft. at the extreme end. The last 126 ft. is composed of lengths having openings near the middle and in the top directed forward by which the discharge will take place at 14 orifices including the end of the last pipe.

It has been proposed to construct outlets for the Passaic Valley sewer in New York Upper Bay, conical in shape, diverting upward and with a spiral flange on the inside for the purpose of delivering the sewage in the form of a thin, hollow cone. This, it was expected, would provide a large surface of contact with the bay water immediately after discharge.

Another feature of the Passaic Valley outlet is in providing multiple outlets. This has frequently been proposed in order to secure rapid diffusion, but has seldom been carried out. At Toronto, the outfall was carried out about 3,200 ft. from shore to a depth of 21 ft. The last 500 ft. was tapered from a diameter of 5 ft. to one of 2 ft. and perforated with 4-in. orifices 4 ft. 4 ins. apart.*

Another example of multiple outlets is in the new outfall at Cleveland where 70,000,000 gallons are discharged daily one-half mile from shore at a depth of 30 ft. from 6¾-in. holes, spaced 7½ ft. apart on each side of the tapered outlet pipe and 45° above the horizontal diameter.†

There is an advantage in a high velocity of discharge, but as this involves loss of head it cannot often be made use of unless the sewage is pumped. A horizontal is preferable to a vertical direction for the jet as it offers a greater opportunity for diffusion during the ascent to the surface, after which this proceeds more slowly.

At Copenhagen, to secure a similar result, there are provided two openings 6 ins. wide by 4 ft. long near the outer end of the new 43-in. wood stave outlet pipe, by which the upward discharge of 33,000,000 gallons per day will take place in the form of a thin sheet.

The area of pollution increases at a higher rate than the volume of discharge so that the interception of large volumes of sewage to a single outlet is unwise if the conditions are unfavorable for sufficient diffusion and dilution.

With so many factors involved it is impossible to formulate precise rules for the location and design of sewer outlets to secure prompt diffusion, but the principles to be followed are well known and may be summarized as follows:—

1. Locate the outlet in water: (*a*) as nearly fresh as possible, (*b*) as nearly saturated with oxygen as possible, (*c*) with the swiftest possible current, (*d*) at as great a depth as possible.

2. Discharge the sewage so as to secure as intimate a contact with the water on discharge as possible. This may be prompted by special orifices and by multiple outlets.

*As the flow, which is now about 55,000,000 U.S. gal. per day, caused a backing up by the increased friction, the outer 400 ft. of this outfall sewer have been removed.

†Another outlet of "Lock-Joint" concrete pipe is now under construction at Cleveland. This will be 84-in. in diameter for 2,400 ft. and then decreasing to 48-in. in another 1,000 ft. Also, at Lakewood, O., a similar outfall of 1,100 ft. of 36-in. pipe decreasing to 30-in. and 24-in. in the next 400 ft. has been laid to a depth of 20-ft. of water. Diffusion is promoted by 44-in. holes near the top of the pipe spaced about 7 ft. apart.

EFFECT OF MOUTHPIECES ON FLOW OF WATER

An elaborate series of tests was recently made by Fred B. Seely on the effect of mouthpieces on the flow of water through a submerged short pipe. These experiments were made with the advantage of the excellent hydraulic equipment of the Engineering Experiment Station of the University of Illinois, and the results have been issued as Bulletin No. 96 from the Station. The data are given in detail, and are reduced to mathematical expression, accompanied by tables and curves. The conclusions reached are the following:—

The preceding discussion has shown that the losses accompanying the flow of water depend largely upon the state of its motion, and this in turn is influenced by many factors, the effects of which often can be but roughly estimated. While the results of the experiments tend to define the range of such effects for certain conditions of flow, additional experiments would be necessary to establish all the inferences that have been suggested. The conclusions here given, however, seem justified:—

(*a*) As applying to conditions likely to be met in engineering practice, the value for the head lost at the entrance to an inward-projecting pipe, that is, without entrance mouthpiece and not flush with the wall of the reservoir, is 0.62 of the velocity-head in the pipe ($0.62 \frac{v^2}{2g}$) instead of $0.93 \frac{v^2}{2g}$, as usually assumed. To put it in another form, the coefficient of discharge for a submerged short pipe with an inward-projecting entrance is 0.785 instead of 0.72 as given in nearly all books on hydraulics. Further, the lost head at the entrance to a pipe having a flush or square entrance is 0.56 of the velocity-head in the pipe ($0.56 \frac{v^2}{2g}$) instead of $0.49 \frac{v^2}{2g}$ as usually assumed. In other words, the coefficient of discharge for a submerged short pipe with a flush entrance is 0.80 instead of 0.82, as given by nearly all authorities.

(*b*) The loss of head resulting from the flow of water through a submerged short pipe when a conical mouthpiece is attached to the entrance end, may be as low as 0.165 of the velocity-head in the pipe ($0.165 \frac{v^2}{2g}$) if the mouthpiece has a total angle of convergence between 30° and 60° and an area of ratio of end-sections between 1 to 2 and 1 to 4, or somewhat greater. In other words, the coefficient of discharge for a submerged short pipe with an entrance mouthpiece, as specified above, is 0.915.

(*c*) The loss of head which occurs when water flows through a submerged short pipe having an entrance mouthpiece varies but little with the angle of the mouthpiece if the total angle of convergence is between 20° and 90°, and if the area-ratio is between 1 to 2 and 1 to 4, or somewhat more. The loss of head for any mouthpiece within this range would be approximately 0.20 of the velocity-head in the pipe ($0.20 \frac{v^2}{2g}$). There is, therefore, little advantage to be gained by making an entrance mouthpiece longer than that corresponding to an area-ratio of 1 to 2. Thus, an entrance mouthpiece, with a total angle of convergence of 90° and the length of which is only 0.2 of the diameter of the pipe, gives approximately $0.20 \frac{v^2}{2g}$ for the loss of head.

(*d*) The amount of velocity-head recovered by a conical mouthpiece when attached to the discharge end of a submerged short pipe depends largely upon the angle of divergence of the mouthpiece, but comparatively little upon the length of the mouthpiece. This is true for lengths greater than that corresponding to an area-ratio of 1 to 2 and for total angles of divergence of 10° or more. The amount of velocity-head recovered decreases rather rapidly as the angle of divergence increases from a total angle of 10° to 40°. At or near 40° the amount of velocity-head recovered rather abruptly falls to approximately zero.

(*e*) A conical discharge mouthpiece, having a total angle of divergence of 10°, and an area-ratio of 1 to 2, when attached to a submerged short pipe, will recover 0.435 of the velocity-head in the pipe, which is 58% of the theoretical amount of recovery possible.

(*f*) The amount of velocity-head recovered by a diverging or discharge-mouthpiece, when attached to a submerged short pipe, is considerably more when a converging or entrance-mouthpiece is also attached than it is when the entrance end of the short pipe is simply inward-projecting; that is, with no mouthpiece attached. This excess in the velocity-head recovered diminishes rather rapidly as the angle of the discharge-mouthpiece increases, and it becomes zero for a discharge-mouthpiece having a total angle of divergence of approximately 40°. This increase in the velocity-head recovered is probably due to the effect of smooth flow in the pipe as the water approaches the discharge-mouthpiece. The smooth flow allows the mouthpiece to recover more of the velocity-head in the pipe than when a more turbulent flow exists; this increase amounts to as much as 33% in the case of the discharge-mouthpiece having a total angle of divergence of 10° and an area-ratio of 1 to 2.

While these conclusions are drawn from experiments on the flow of water through a particular short pipe having various entrance and discharge conditions, it is felt that the results of the experiments are applicable in a general way to a large variety of cases in engineering practice where the contraction and expansion of a stream of water occurs.

The deductions made are capable of use in connection with the loss of head which occurs when a stream contracts or expands under differing conditions of flow and they show the marked effect that turbulence of flow may have upon the amount of head lost, and they also have a direct bearing upon problems in hydraulic practice that involve the contraction and expansion of a stream in flowing through passages. Comparatively little experimental work has been done hitherto to determine the value of conical mouthpieces of various angles and lengths in reducing the lost head at the entrance to and discharge from a submerged pipe, particularly for mouthpieces of the sizes and proportions comparable with those met in engineering practice. The need for such experiments was apparent. The minimizing of the lost head due to the contraction and expansion of a stream may be of considerable importance in many hydraulic problems; for example, the intake of a pipe, particularly when the pipe is of short length and of large diameter, the suction and discharge-pipes of a low-head pump, the reduction or expansion from one pipe to another of different diameter or of different shape, the passages through a large valve, the passages through locomotive water-columns, the draft-tube to a turbine, the connection from a centrifugal pump to a main, the sluice-ways through dams, the slat-screens at head-gates, culverts, and short tunnels, jet-pumps, the Boyden diffuser as formerly used for the outward-flow turbine, the Venturi meter, the suction and discharge pipes of dredges, and the guide vanes and runner of a turbine. Losses due to this cause are difficult to estimate and easy to overlook. Even where such losses are in themselves of little consequence as compared with other quantities involved, they may have an important influence upon subsequent losses on account of the turbulent motion started by the contraction or expansion. The efficiency of a drainage-pump or other low-head pump, for example, may be increased by an entrance-mouthpiece on the suction-pipe because it allows the pump to receive the water in a smoother condition of flow. It is well known that a turbine must receive the water from the guide-vanes without shock if, in the subsequent flow through the runner, the energy of the water is to be absorbed efficiently by the turbine. The loss of head through a Venturi meter may be considerably increased if the meter is placed too short a distance downstream from a valve, elbow, or other obstruction or cause of disturbance in the pipe. The friction-factor for a pipe following an obstruction or bend may be changed by the disturbance thus caused; the lost head at the entrance to a pipe, particularly when projecting inward, may be more than that ordinarily assumed for a tube three diameters long. There is but little definite knowledge on the subject of the effect of abnormal conditions, and it offers a large scope for investigation. The fact that a comparatively small change in the form of the blades of a turbine-runner may result in a large effect on the efficiency of the turbine should prove suggestive when estimating the probable effect of turbulent flow in less severe or critical cases. It is also worth mentioning in this connection that the recent advances in turbine design have been due largely to the attention given to the approach-channels to the guide-vanes and to the design of the draft-tube.

The flow of water usual in engineering practice is rather turbulent. The general equation of energy, or Bernoulli's theorem, so generally used in hydraulics, applies only when the particles of water move with uniform velocity in parallel stream-lines. Although this condition of flow seldom occurs, satisfactory analyses may often be made by using an average velocity and introducing empirical constants. A very slight change in the conditions under which flow takes place may cause a large difference in the behavior of the water. There is always danger in extending the use of experimental data or empirical constants to apply to conditions of flow different from those under which the data were obtained.

Regular passenger train traffic over the new Quebec bridge has been inaugurated. The service was opened January 6th, when a train from Moncton used this route. Hereafter trains will leave the Union Station in Quebec City daily for Montreal and eastern points via the bridge.

Walter H. Morrison, an English engineer who has arrived in New York from Siam on his way home to England, says that the new railroad from Bangkok to Penang, in the Malay Straits, has just been completed, and will be open for passenger traffic next April. The distance of the new road is about 700 miles, and has been laid through tropical scenery.

THE MANUFACTURE OF RICHE GAS FROM WOOD IN THREE RIVERS, P.Q.

By L. H. Bacque, B.Sc.
Gas Engineer, Toronto

[NOTE.—"The Riché patents have expired," says Mr. Bacque, "and the process can be used by anyone." Mr. Bacque is well qualified to discuss the process as used in Three Rivers, as he built the Riché plant in that city in 1900, in co-operation with a French engineer, and managed it until 1909, when it was purchased by a newly organized natural gas company. The new owners, says Mr. Bacque, allowed the Riché plant to deteriorate, and after a fire, they did not rebuild it. The natural gas soon became exhausted and the company withdrew from Three Rivers, and since that time the city has had no public gas supply. Mr. Bacque does not advocate the Riché process for large cities, but he believes that it has merit for small town supplies, particularly in view of the increasing coal problems.—EDITOR.]

THE following notes on the manufacture of gas from wood in the city of Three Rivers, P.Q., by the Riché reinverted distillation process, will no doubt prove interesting to those who have had any doubts heretofore as to the possibility of making a commercial success of any manufactured gas other than that which is made from coal.

In the particular instance under consideration, the gas was made from wood because wood was both abundant and cheap; but it can be made equally readily out of almost any suitable organic matter and gathers additional interest from the fact that it can be readily manufactured from peats and lignites, both of which fuels the government is now studying with a view to finding some suitable industrial use for them.

Before attempting any comparisons, it will be well to go into the cost of manufacturing the gas from wood.

Originally, the builders gave the following guarantees with the plant, *viz.*: that 3 kilogs (6.6 lbs.) of air-dried wood, carrying not more than 25 per cent. humidity, would yield one cubic metre (35.3 cu. ft.) of 320 B.t.u. gas and a by-product of 270 grammes of charcoal; the gas to give the hour horse-power, measured on brakes, when used in a gas engine of good make.

This was practically equivalent to 1,000 cu. ft. of gas for $\frac{6.6 \times 1{,}000}{35.3}$ or 186.9 lbs. of wood costing $\frac{186.9 \times P}{2{,}000}$; where P is the cost of air dried wood, carrying not more than 25 per cent. humidity per ton of 2,000 lbs.

To get at the price of the gas, the value of the charcoal by-product, whatever it may be in the district, must also be deducted from the cost of the wood.

At a later date, the above guarantees were modified and expressed in terms more readily understood in Canada. They were:—

That 1,000 cu. ft. of 320 B.t.u. gas and a by-product of 18 lbs. charcoal would be produced by the distillation of 100 lbs. of air-dried wood, with 45 lbs. of coal as fuel.

Taking the conditions which existed in Three Rivers, where wood weighing 3,250 lbs. to the cord cost $6.50 per cord or $4 per ton of 2,000 lbs., and coal cost $4.50 per ton of 2,240 lbs., the cost price of the gas becomes:—

Cost of the wood, $\frac{100 \times 4.00}{2{,}000}$ or 20 cents.

Cost of the coal, $\frac{45 \times 4.50}{2{,}240}$ or 9.04 cents,

Or a total cost per 1,000 cu. ft. of 29.04 cents.

From this there is to be deducted the local value of the by-product of 18 lbs. of charcoal, which is:

$$\frac{18 \times Y}{2{,}000} \text{ or } \frac{9 \times Y}{1{,}000}$$

Y being the local value of same per ton of 2,000 lbs.

The above figures, it must be noted, represented the guarantees given by the builders, but much better results were usually obtained in actual practice, and notably in the plant built in Three Rivers, where the conditions were as follows:—

Cost of coal per ton (2,240 lbs.)	$ 4.50
Cost air-dried wood (25% hum.) per ton, 2,000 lbs.	4.00
Charcoal: 90% of product sold for (ton, 2,000 lbs.)	14.00
" 10% of product sold for (ton, 2,000 lbs.)	8.00

and the results actually obtained with the plant were: 1,000 cu. ft. of gas and 19.5 lbs. of charcoal for 90 lbs. of aid-dried wood and 39 lbs. of coal, which makes the cost of the gas figure out as follows:—

Cost of wood .... $\frac{90 \times 4.00}{2{,}000}$ or 18 cents per M.

Cost of coal .... $\frac{39 \times 4.50}{2{,}240}$ or 7.8 cents per M.

Or a total cost for wood and coal of.. 25.8 cents per M.

From this, there is to be deducted the value of the charcoal product, which is as follows:—

90% yields .... $\frac{19.5 \times 90 \times 14.00}{100 \times 2{,}000}$ or 12.25 cts. per M.

10% yields .... $\frac{19.5 \times 10 \times 8.00}{100 \times 2{,}000}$ or 0.78 cts. per M.

Total return for charcoal .... 13.03 cts. per M.

which, being deducted from the former figure of 25.8 cents, gives as the net cost of the gas, 12.77 cents per 1,000 cu. ft.

Now, to make a comparison of the relative cost of coal gas and Riché gas, let us take as a basis of comparison the yield per ton in gas and by-products of both wood and coal.

Taking the usual conditions prevailing in this market for coal gas where the average yield of gas is 10,000 cu. ft. per ton, of coke 1,300 lbs. per ton, of ammonia 5 lbs. per ton, and of tar 7 gals. per ton, the average return in gas and by-products from one ton of coal becomes:—

10,000 cu. ft. gas at $1.87½ per M.	$18.75
1,300 lbs. coke at $5 a ton	3.25
5 lbs. of ammonia at 6 cents a lb.	.30
7 gals. of tar at 3 cents a gal.	.21
Or a total yield per ton in cash of	$22.51

The cost price of this gas and of the by-products for fuel is:—

1 ton of coal	$4.50
500 lbs. of coke	1.25
	$5.75

leaving net profit on 10,000 ft. of gas, $16.76.

Making the same calculation for Riché wood gas, per ton of 2,000 lbs. wood, we get:—

Yield of gas per ton $\frac{2{,}000}{90}$ or 22,220 cu. ft.

Requiring in order to make them, 22,220 × 39 or 867 lbs. coal, making the cost of gas for fuel:—

Cost of wood distilled (2,000 lbs.)	$4.00
Cost of coal burnt $\frac{867 \times 4.50}{2,240}$	1.74
Or, for 22,220 cu. ft.	$5.74

From this gas we get the following returns, on the basis of prices which existed in Three Rivers:—

22,220 ft. of gas at $1.00 per M.		$22.22
Charcoal	$\frac{90 \times 14.00 \times 390}{100 \times 2,000}$ or	2.46
Charcoal	$\frac{10 \times 8.00 \times 390}{100 \times 2,000}$ or	.17
		$24.85

Deducting from which the cost of the gas for fuel, we have a net profit from the gas made from a ton of wood, $19.11.

A comparison of the heat efficiency of both processes will reveal the fact that it is much greater in the case of the coal than in that of the wood. This is due to the fact that in the Riché wood process, a large amount of steam and hydro-carbons present in the wood absorb a large amount of the available heat for their transformation into fixed gases.

The fact remains, nevertheless, that the ton of wood yields 7,110,000 British thermal units available in the gas, whereas the ton of coal only produces 6,000,000.

Without going too deeply into minor details, it may be added that in Three Rivers, where conditions, though favorable in some cases, were otherwise costly enough to overcome in other respects the general expenses attaching to the manufacture and distribution of the gas were approximately as follows:—

	Cost per M. (Cents.)
Fuel for a make of 40,000 ft.	12.77
Labor for a make of 40,000 ft.	11.11
Maintenance retorts (labor and material)	10.92
Maintenance mains, etc.	6.85
Interest on capital invested	25.65
Sinking fund of 1 per cent.	5.13
Salaries, rents, etc., etc.	22.50
Cost of gas delivered to consumers	94.93

This price being established for gas made from wood, a comparison of the composition of lignites, peats and woods will bring out the striking similarity in the chemical composition of all three products, and make it easy for the lay mind to realize that the gas obtained from one of the products is the same as that obtained from the others, when treated by the same process.

The following table gives the average products obtained from each one of them by distillation, after they have been dessicated at a temperature of 200° C.:—

	Lignites.	Peats.	Woods.
Fixed carbon	39 %	30 %	22.3%
Gases by distillation	30	36	33.4
Tars	5	7.5	8
Acid liquids	15	14.5	33.6
Ash and sundries	11	10.5	2.7
Nitrogen	..	1.5	..
	100.0%	100.0%	100.0%

Now, taking the gaseous contents alone, shown in the above component parts, we get further evidence of the great similarity of the three products from the point of view of their gas-producing capacity. The following table, giving the per cent. composition of these gases by volume, makes this plain:—

Comparison by Volume of Gaseous Products of Distillation

	Lignites.	Peats.	Woods.
C_2H_4	4 %	2.5%	......
CH_4	19 %	7.0%	13.102%
HC vapors	1 %	1.5%	1.572%
H	31 %	40.0%	32.599%
CO	26 %	30.0%	23.794%
CO_2	15 %	14.0%	26.939%
Nit.-O, etc.	4 %	5.0%	1.994%
	100.0%	100.0%	100.000%

Now, taking as a sample, some Cardiff colliery lignite, for instance, carrying 20% humidity and 40% fixed carbon, in addition to its gaseous content, this sample will give exactly the same gas as product of its distillation by the reinverted process as wood does.

Approximately, also, the same quantity of lignite as of wood, will suffice to yield the 1,000 cu. ft. of gas, being in this instance about 150 lbs. instead of the 39 lbs. coal and 90 lbs. wood previously used.

This will give us $\frac{150 \times 1.50}{2,000}$ or 11.25 cents per M. as the cost price of the gas, where this lignite is worth $1.50 per ton of 2,000 lbs.

The value of the coke obtained will vary, of course, with the nature of the lignites used, but its value in any event will always be that of a good carbon fuel, which, figured on the basis of a price proportionate to that of the lignite for its own calorific value, will give us in this case $\frac{1.50 \times 15,000}{8,767}$ or $2.65 per ton of 2,000 lbs., if we allow 8,767 British thermal units as the heating value of the lignite and 15,000 as that of the coke made.

When distilling peats, it will not be possible to apply the reinverted distillation process in a single closed retort; it will become necessary to distil the material in one retort and send the products of distillation over red-hot carbon of some kind, which will have to be provided in a separate retort. This is due to the fact that the product of the carbonization of peat is simply a powder which will neither stand up sufficiently well in the retort nor allow the gases coming from the distillation to pass through it.

It is sincerely to be hoped that such a simple, cheap and convenient industrial application of three fuels so abundant in our country, will not be entirely overlooked, especially after recent developments in the coal business have revealed in such a striking manner how utterly dependent we are on our neighbor's good-will for our supplies of coal.

In a lecture entitled "The Economics of Bridge Design," Dr. J. A. L. Waddell, at the School of Engineering, Kansas University, said the question of what is the economic limit of length of simple-truss spans as compared with cantilevers is still a moot one. Professors Merriman and Jacoby place it in the neighborhood of 600 feet, but the speaker had occasion to compare simple-truss spans of 700 feet and 800 feet with the corresponding cantilever structures, and had found the former more economic. The continuity of cantilever spans in resisting wind loads lowers the requirements for minimum width from one-twentieth to about one-twenty-fifth of the greatest span length, and hence, because of substructure considerations, gives an advantage to the cantilever type that in certain extreme cases more than offsets its disadvantages of greater weight of truss metal.

Letters to the Editor

Erection of the Quebec Bridge

Sir,—In recent issues of your magazine I have noticed articles by Mr. A. J. Meyers, a member of the staff of the Board of Engineers, describing the erection equipment and centre span lifting devices used in connection with the erection of the Quebec Bridge, but note with regret that credit was not given to the St. Lawrence Bridge Company, who originated and developed the design and worked out the details for this equipment.

I would like to take this opportunity of stating that the plans for the superstructure and the entire plant and equipment used in connection with the erection of the bridge were worked out in the offices of the St. Lawrence Bridge Company, who, according to the terms of the contract, were entirely responsible for its successful completion, and great credit is due their engineers for the work they have done in this respect, since they had little or no precedent to guide them.

C. N. MONSARRAT,
Chairman and Chief Engineer,
Board of Engineers, Quebec Bridge.

Montreal, January 19th, 1918.

Provincial Consulting Engineering

Sir,—With reference to the editorial which appeared in *The Canadian Engineer* of December 13th, it must be clear to anyone who has read my report that the writer of the editorial does me an injustice. He selects one paragraph, interprets it wrongly, and proceeds to criticize that interpretation as if it were mine. I claim that I have been as anxious as the writer in *The Canadian Engineer* to defend the status of the engineer, and to demonstrate the need for a greater amount of use being made of his services in connection with municipal work in Canada. The report itself reflects that anxiety.

The employment of skilled engineering advice in connection with the planning and development of land instead of continued reliance on those who are not so skilled is advocated throughout the report. At the very beginning, on page 3, I put the scientific planning and development of land in the forefront of the points which need emphasis. That can only be attained if more engineering advice is sought.

On page 74, with regard to railways, I say that the detailed planning of railway lines "is a matter which is safe in the hands of the railway engineers who are entrusted with the work."

On page 155 I refer to the memorandum prepared by a number of well-known engineers on "Industrial Preparedness," and I selected that memorandum for reference out of a great deal of material on the same subject because it was prepared by engineers, and I state in the conclusion of the paragraph: "The memorandum very properly emphasizes that greater use should be made of the engineer and chemist, in whose hands is the material development of modern civilization."

There is a running argument throughout the whole of the report advocating the need for expert administration by engineers.

The paragraph to which your paper objects, is a recommendation made on page 238 arising out of the considerations put forward in Chapter VII. of the report. Turning first to that chapter, I draw your attention to the following quotation (page 180) referring to the need for business enterprise in connection with land development:—

> "In the performance of such a task it is of the highest importance that the business side of the undertaking should be in skilled hands, that the control of all beginnings of development and of the utilization of resources should be under the direction of the highly qualified administrators."

It is obvious that this is an advocacy for the employment of more professional experts, engineers and others, to control development.

Referring to the English system of government, which places more reliance on permanent expert advice than in most countries, I say (page 180):—

> "One result of this system is that an efficient permanent staff of expert administrators has grown up in the old country, in all classes of government, and matters of technical detail are dealt with more largely by experts."

This, again, is an advocacy of the employment of engineering experts to deal with engineering matters.

It will be observed on page 187 that the first fact which I use in support of improving the system of colonization and highway administration is a long quotation from a leading engineer and land surveyor in Saskatchewan, who wrote to me as a result of long experience, pointing out what he calls "the absurdity of the present system."

On page 188 I point out that the co-ordination of the different government departments is needed "so as to secure more efficient and scientific land development," and I go on to say that the planning of the provinces, on the whole, should be undertaken. How could this be done without much more use of consulting and municipal engineers than prevails at present?

In the last paragraph, on the same page, I suggest a Director of Surveys and a Director of Planning for each province, with a skilled staff to deal with all development. All this means placing more reliance on skilled engineering advice, which is the best way to raise the status of the profession.

The following paragraph, on page 196, is a direct recommendation that engineers should be more fully employed on municipal work:—

> "In the rural districts and small towns, there is a tendency to try and manage the complicated and highly technical questions relating to township and town development by men without adequate knowledge or training for the task. Real economy is only possible where a full advantage is taken of skill and experience in carrying out constructive improvements and the work of developing land. It seems to be assumed that municipal affairs can be managed by lawyers, tailors, grocers, and others who, whatever their expert knowledge in their own business, have not—as a rule—the kind of experience and capacity necessary for municipal administration. A tailor who very naturally would not accept the advice of an engineer to cut cloth for a suit of clothes, will act as chairman of a public works committee of a town or village and direct complicated engineering construction requiring many years of special training to understand even its general details."

On page 201 I point out that, if the Federal Government are to take up the question of constructing highways, they should place the administration of road improvement "under an *expert board* instead of under a department of the government." Naturally, I had in mind a board of engineers, as only they would be expert in such a matter.

Far too small a portion of the engineering work in Canadian municipalities is dealt with by trained engineers, either as consultants or as resident engineers.

Municipal boards and provincial boards of health are chiefly appointed from members of the legal and medical professions, who "employ" engineers when they want engineering advice. Taking Ontario as an instance, there are few, if any, engineers holding administrative positions on boards dealing with engineering matters, such as the Railway and Municipal Board and the Provincial Board of Health. Why should engineers not be chosen to act to a greater extent on these bodies as they are in other countries? Why is it that engineers do not insist on representation on expert boards? When in Winnipeg, in 1916, I brought a proposal before the government that the Provincial Board of Health should make its sanitary engineer a member of the board. I have made the same suggestion on other occasions. Surely that was not slighting the engineer.

In the conclusion to Chapter VII., I contend that there should be a more scientific orgainzation of rural life and rural industries; that increased responsibility should be placed on expert permanent officials (i.e., engineers, etc.), and that departments of municipal affairs should be set up in each province with skilled advisers (i.e., engineers chiefly). It is a direct step from this chapter and its conclusions to the general recommendation which is made on pages 237 and 238, to which the editorial refers.

The point of the paragraph to which objection is taken may be summed up as follows:—

That there should be a skilled municipal department in each province, with greater reliance placed on engineers as expert advisers. How does this convey a "slight" on the consulting engineer? The writer of the article quotes the following phrase in a critical manner: "Until there is a skilled municipal department in each province, to advise and help local authorities with engineering advice, we cannot expect satisfactory improvement in the status of the municipal and sanitary engineer nor effective local administration of public works and sanitation."

The above phrase is immediately preceded, on page 241, by the following, which is *not quoted*:—

"Much of the work now being performed by the medical officer of health should be undertaken by the sanitary engineer. The medical officer has full scope for his skill and energy in fields which are essentially his own, and much of the municipal and sanitary engineering work he is doing is a burden of which he would rather be relieved. and which would be more efficiently performed by properly qualified engineering officers giving whole time service."

Is it a slight on the engineer to advocate that more engineers should be employed than at present, and that the status of the profession should be improved? *The Canadian Engineer* has itself devoted a large amount of attention to advocating these two things. I have said not one word nor made any hint that the work of consulting engineers employed in advisory capacities is defective.

In rural districts particularly, and even in many towns, no consulting engineer nor resident engineer is employed. I can quote many examples, but I will merely refer to one town of no less than 8,000 inhabitants within fifty miles of Toronto which has no resident engineer, and does most of its work through contractors directed by amateur committees without the aid of a consulting engineer.

I believe the taxpayers in that town think it is an economy to do without an engineer. Therefore, we have not only to face a situation which means that the citizens of that and hundreds of smaller towns lose largely because of want of engineering advice, but actually do so from the mistaken notion that the engineer is not worth his salary, and that engineering work can be done by anybody. Is it desired that this kind of real "slight" on the engineer should be continued? If so, then I admit I am rightly criticized for expressing my dissatisfaction with such a system.

Incidentally, I may mention two other matters regarding which I have expressed dissent in different parts of Canada. One is the employment of contractors in the double capacity of engineers and contractors, thus placing them in the position of being both employers and employed. In such cases the proper relationship of the contractor and engineer is reversed. The former is the "boss" and employs an engineering assistant to keep him right, whereas he should be doing his work under control of a consulting engineer. A second matter is the expensive habit in Canada of appointing legal arbitrators to determine purely engineering questions—a proceeding which has been largely abandoned in Great Britain, where great economy and efficiency is obtained by the employment of consulting engineers and surveyors as arbitrators. A single engineer can often determine a question which, according to the older method, would require a bench of lawyers, an array of counsel, and a number of expert witnesses. It is in such cases that the "slight" is given to the engineer.

The real objection of the writer seems to be to the proposal that expert departments of municipal affairs be created in each province, on the ground that this reflects on the consulting engineer, who at present is apparently presumed to do the work which would be undertaken by these departments. I have shown that he does not do the work, even in fairly large towns, and that he is not consulted properly, even on provincial boards. On page 197 I also point out that the small municipalities cannot afford to employ expert engineering advice, even if they desired to do so. I say:—

"In view of the enormous expenditure on municipal development it seems extraordinary that there is so little effort made to avoid the waste which results from lack of co-operation and from want of the knowledge which can only be derived from wide experience. Small municipalities, with scattered populations and few resources, have not the means to employ men of adequate skill and are compelled to undertake highly technical work without knowledge of mistakes or successes made by other municipalities. It is no excuse that these small and poor municipalities have inadequate means to employ experts or obtain knowledge; in so far as this lack of means exists the need should be met by the aid of the provincial governments. In view of the great issues and large expenditure involved it is of urgent importance to Canada that each province should have a well-organized municipal department with expert advisers on all kinds of municipal affairs. One of the special tasks of such a department would be to advise and assist small municipalities."

The intention in creating provincial departments of municipal affairs is primarily to secure the more extended employment of the engineer and the increase of his power as an official so that he can effectively apply his knowledge. Such extended employment is necessary to prevent "dishonest officialdom" from continuing evil practices.

In the final paragraph of the editorial there seems to be an objection to engineers serving except in an individual and competitive capacity. That is a point on which opinions among engineers may differ. Personally, I have seen the profession of consulting engineer become strengthened in the Old Country as a result of the more extensive use of the official engineer. Why should this

(Concluded on page 42, Construction News Section)

The Canadian Engineer

Established 1893

A Weekly Paper for Canadian Civil Engineers and Contractors

Terms of Subscription, postpaid to any address:

One Year	Six Months	Three Months	Single Copies
$3.00	$1.75	$1.00	10c.

Published every Thursday by
The Monetary Times Printing Co. of Canada, Limited

JAMES J. SALMOND, *President and General Manager*
ALBERT E. JENNINGS, *Assistant General Manager*

HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT.
Telephone, Main 7404. Cable Address, "Engineer, Toronto."
Western Canada Office: 1208 McArthur Bldg., Winnipeg. G. W. GOODALL, Mgr.

Principal Contents of this Issue

THE PENALTY OF PARASITISM

It is pointed out in biology that certain living creatures have deprived themselves of any individual power of natural defence because they find borrowing too easy. Nature being inflexible in her laws, what is unused or otherwise provided for becomes atrophied; that in daily exercise thereby becomes strengthened. The penalty for disuse is merciless and certain inhibition.

We may not be such stuff as dreams are made of, but creatures of habit we certainly are and to escape penalty constant activity and struggle is the price exacted for continuous success.

The vice of imitation thus reacts upon its practitioner; it is impossible to imitate without suffering individual loss. Wrong thinking is in this respect of less moment than borrowed opinion. Individual thought is less easily led aside but is more amenable to reason because of the mental processes which led up to its conclusions.

To the credit of the trained man everywhere his desire is to originate, not to imitate, and this does not preclude him adding new ideas to his existing stock, but in the process it becomes absorbed and digested and when finally welded with existing idea it issues in a new form.

Obviously it is not the province of everyone to create but the habit of fundamental thinking is one to cultivate, and engineering training, by its insistence upon first principles, tends to this creative habit of mind. The attitude towards work thus engendered builds character and ultimately leads to new ideas. Even routine can be dignified and enlarged by reason of conscious study of reason.

Original thought pays large dividends, while parasitism atrophies he who follows so detrimental a course. There is need and room for more independent thought in every walk of life. It is useless to take over ready-made opinion or to follow without discrimination or reason a set formula or programme for which logic is refused.

Most general problems are as complex as those more directly technical, but the sinking of principle to expediency is not the province of an engineer nor does his training justify such a course. He must make selection from alternatives. This is granted, but he is swayed only by economic or other valid reason in his judgment.

The engineer may in his business be a pure materialist, dealing with objective problems, but in his diagnosis of this and the practical aspect of his work, though he is realist enough, these lead to a mentality flexible and comprehensive. This is a direct result of his training and work scarcely paralleled outside his own profession.

Above all, there are few parasites; to borrow is not easy, and his training rejects where close scrutiny is impossible.

MUNICIPAL WAR PROGRAMMES

The duties devolving upon our city authorities are onerous at all times, but particularly so during the war. The period of readjustment following the war will call for even greater executive ability. The greatest problem, after providing for the present needs of the people, is to arrange for the time when the soldiers will return and when they and the civilians now employed on munitions will be seeking other employment.

The British government has called upon all municipalities to consider this matter, and a large number of them have prepared or are now formulating programmes of public works.

It is a pleasure to note that some public authorities in Canada are organizing schemes of highway construction, but these will take care of but a fraction of the number of men who will be seeking work, and, besides, that class of work will not suit all men. That some authorities are moving, does not constitute a solution of the problem. All municipalities must sooner or later evolve methods of providing work of economic usefulness. Moreover, every well-organized commercial concern will also develop broad plans, or the social cataclysm induced by peace may be very unpleasant in many localities.

BRANCH MEMBERSHIP, CAN. SOC. C.E.

According to the report of council of the Canadian Society of Civil Engineers, the membership of the society's branches at December 31st, 1917, was as follows:—

	Members	Assoc. Members	Juniors	Students	Associates	Total
Calgary	40	9	5	1	1	56
Edmonton	11	30	7	9	—	57
Manitoba	38	90	27	22	—	177
Ottawa	64	120	38	22	2	246
Quebec	20	53	21	13	1	108
Saskatchewan	10	50	4	5	—	69
Toronto	56	137	34	63	6	296
Vancouver	47	71	10	4	1	133
Victoria	26	39	9	2	—	76
	312	599	155	141	11	1,218

PERSONALS

V. C. Moynes, of the Toronto sales staff of the Canada Cement Co., Limited, has enlisted with the Royal Flying Corps.

G. J. Desbarats, Deputy Minister of Naval Service, has been appointed a member of an international board to settle outstanding questions between Canada and the United States respecting international fisheries.

Lieut. Alex. H. Carmichael, of Toronto, a student of Applied Science, class of 1918, has been appointed with his present rank to the 2nd Depot Battalion, 1st C.O.R. Lieut. Carmichael enlisted with the 180th Sportsmen's Battalion.

Major T. R. Loudon, B.A.Sc., in the class of 1904, and formerly a professor in the Faculty of Applied Science, University of Toronto, has been invalided home. Major Loudon went overseas with No. 1 Canadian Construction Battalion. Enlisting with the rank of lieutenant, he received his promotions while on active service, being given his majority in France with his original unit, which is now known as the 1st Canadian Railway Troops.

E. W. Gilman, general manager of the Canadian Ingersoll-Rand Co., Limited, was elected general manager of the Jenckes Machine Co., Limited, of Sherbrooke, P.Q., at a recent meeting of the board of directors of the latter company. The Jenckes company has been reorganized under the presidency of Mr. George Doubleday, of New York City, additional capital having been put into the business by men associated with the Ingersoll-Rand Co. New contracts have been secured which will necessitate the employment of several hundred more workmen.

CAN. SOC. C.E. MEETINGS

There were thirteen meetings of the Canadian Society of Civil Engineers at Montreal during the past year, with papers or addresses as follows:—

"Sheet Asphalt Pavements," by T. Linsey Crossley.

"Canada's Railway Problem and Its Solution," by W. F. Tye.

"Centre Street Bridge, Calgary, Alta.," by G. W. Craig and J. F. Greene.

"Pneumatic Caisson Work for the Foundations of the Petitcodiac River Bridge Piers at Moncton, N.B.," by E. M. Archibald.

"Some Studies on the Methods of Recovering Antimony from Its Ores by Volatilization Processes," by J. A. DeCew.

"Halifax Ocean Terminals," by A. C. Brown.

"Street Railway Negative Return System for the Mitigation of Electrolysis," by Dr. L. A. Herdt and E. G. Burr.

"Present and Possible Products from Canadian Woods," by Dr. J. S. Bates.

"Work on the Panama Canal," by Henry Goldmark.

"Motion Pictures of Munitions Manufacture in Canada," introduced by Brig.-Gen. Sir Alexander Bertram.

"Motion Pictures of Canada's Water Powers," introduced by J. B. Challies.

"The Quebec Bridge," by Lieut.-Col. C. N. Monsarrat.

"The Erection of the Superstructure of the Quebec Bridge," by Geo. F. Porter.

"The Quebec Bridge, Some Views of the Shop Work," by Phelps Johnson.

HONOR ROLL OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS

At the annual meeting of the Canadian Society of Civil Engineers, held this week in Montreal, there was unveiled an honor roll containing 859 names of members who had enlisted for overseas service for the duration of the war. The various classes of membership were represented as follows:—

Honorary Members	1
Members	87
Associate Members	373
Juniors	170
Students	225
Associates	3
Making a total of	859

Of these there have been killed in action or died of wounds:—

Members	5
Associate Members	28
Juniors	13
Students	12
In all	58

MEMBERSHIP, CAN. SOC. C.E.

The membership of the Canadian Society of Civil Engineers has been practically uniform since 1912. Starting in 1887 with a membership of three or four hundred, the total gradually grew until it passed the thousand mark in 1903. The period of maximum growth was between 1903 and 1912, two thousand new members joining in those nine years. Since 1912, the number has remained nearly stationary at about 3,000. The first thousand members joined in sixteen years, the second thousand in five years, the third thousand in four years, and then for the next five years the number was increased hardly at all, largely due to war conditions. The following table shows that about half of the members are in the grade of associate membership:—

	1915.	1916.	1917.
Honorary Members	8	8	10
Members	693	709	720
Associate Members	1,409	1,434	1,469
Associates	34	33	33
Juniors	357	376	361
Students	575	487	497
Total	3,076	3,047	3,090

ALBERTA DIVISION, CAN. SOC. C.E.

The Alberta Division of the Canadian Society of Civil Engineers held its annual meeting December 22nd, 1917, at which time the by-laws were approved and the following officers and executive committee for 1918 were elected:—

Chairman, Wm. Pearce, Calgary; secretary-treasurer, Samuel G. Porter, Calgary; executive committee, F. H. Peters, L. B. Elliott, Edmonton; J. T. Child, Banff; J. G. McGregor, Red Deer.