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Studies in Surface Area Proportioning Method

Hydro-Electric Power Commission of Ontario Satisfied That Surface Area Method of Proportioning Materials of Mortars and Concretes Is Correct in Principle—Fineness Modulus Varies as Surface Area—Not Necessary to Obtain Actual Surface Area of Aggregate

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WHEN the writer first seriously studied the paper "Proportioning the Materials of Mortars and Concretes by Surface Area of Aggregates" (see *The Canadian Engineer* for July 4th and 18th, 1918), he was impressed with both its simplicity and its adaptability. It seemed to him to contain certain salient points found lacking to a large extent in any other method with which he was then acquainted, and it was the lack of these points which had caused the greatest difficulty in the field. If this method could be applied to proportioning concrete it would provide:—

1.—A means of accurately estimating the strengths of concretes produced from any combination of cement and aggregate; and

2.—A means of maintaining a constant strength with the fluctuations in grading inevitable with natural materials, and a foundation upon which to build a simple and inexpensive system of laboratory and field tests for determining the relative concrete-making values of materials, and the proportions in which they must be combined to give desired results.

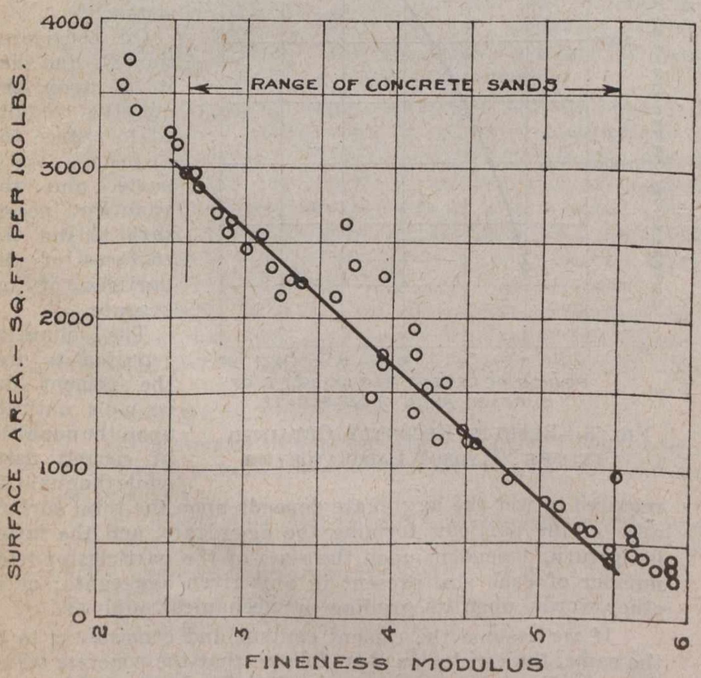

FIG. 1—RELATION BETWEEN FINENESS MODULUS AND SURFACE AREA OF FINE AGGREGATES

This method of proportioning possesses the further advantage that the underlying theory is so simple that it can be explained to and is appreciated by even the laborers on concrete work.

The lack of these important features is in a great measure accountable for the attitude of construction men towards any methods of concrete proportioning other than "rule of thumb."

The field engineer is a man with a practical turn of mind who has to do mainly with men of a type impatient with involved methods and hampering restrictions. A method, to gain his respect, must give him an unequivocal answer to the question, "How much cement must I use under the conditions existing on this work to get the results which are required of me?"

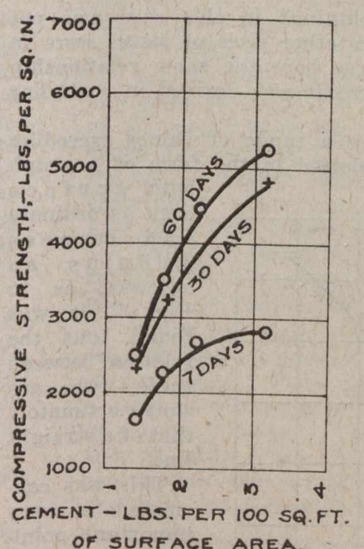

FIG. 2—RELATION OF COMPRESSIVE STRENGTH OF MORTARS TO WEIGHT OF CEMENT (EDWARDS, 1918)

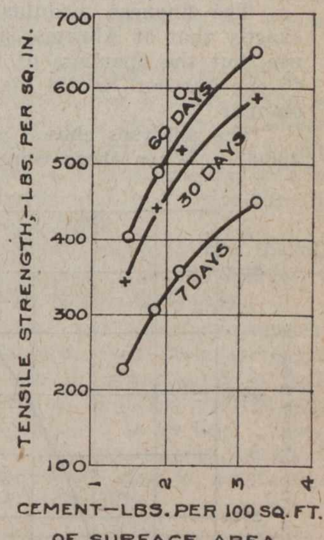

FIG. 3—RELATION OF TENSILE STRENGTH OF MORTARS TO WEIGHT OF CEMENT (EDWARDS)

When a method is proposed which will not give him a direct answer to this, he loses faith in it, which is quite natural when you appreciate his point of view. He is interested in ways of getting certain desired results and he expects your method, the tool with which he is expected to work, to do this or else he is a little contemptuous of it. If its theory and application is at all involved, he is apt to become skeptical and to consider it only a tool to be used by experts and scientists.

Any method of proportioning which does not take cognizance of this attitude will never gain his support, no matter how meritorious it may be, and without his unqualified support it is very difficult to get results.

Contemplation of the above conditions led naturally to the consideration of experimental proof of the applicability of the surface-area method of proportioning concrete, but realizing the time and expense involved in such tests if properly carried out, it was decided to make some further studies of this method before recommending any action along this line.

The work of D. A. Abrams in his researches on concrete at the Lewis Institute, in Chicago, have established many important facts concerning concrete, and it was felt that the surface-area method, to be worthy of consideration, had to be in agreement with these facts. Consequently, the first study undertaken was to connect the work of Abrams with that of Edwards. The results obtained from this study show the work of these two investigators to be in entire agreement, Abrams' work throwing much light on Edwards' results and vice versa.

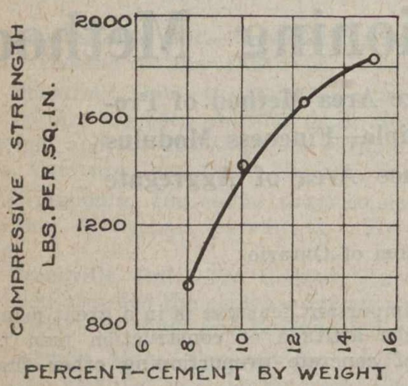

FIG. 4—RELATION OF COMPRESSIVE STRENGTH OF CONCRETE TO WEIGHT OF CEMENT (FULLER & THOMPSON)

The first step taken was to determine if any relationship existed between Abrams' fineness modulus and the surface area of a sand. This was done by calculating the fineness modulus and surface area of fifty representative sands, the mechanical analyses of which were assumed.

The fineness modulus obtained in this case was not exactly that of Abrams, since other sizes of sieves were in use, but the openings of these bore the same relationship to one another as did his and it was derived in a similar manner.

The analyses chosen gave a range of values exceeding 400%. When these were plotted in the form of a graph with surface area as ordinate and fineness modulus as abscissa, as in Fig. 1, it was found that the relation between these two are approximately that of a straight line.

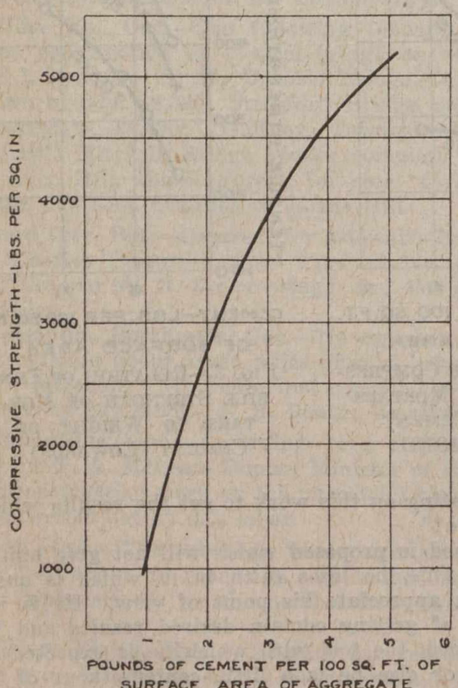

FIG. 5—VALUES OF *S* PLOTTED IN RELATION TO CEMENT PER UNIT OF SURFACE AREA

This was considered a very important point, for might it not be possible that the success which had been obtained with the fineness modulus in estimating the strength of and in proportioning concrete mixtures was due to this? It seems extremely likely, for so far as is known to the writer, no explanation of the reason for the success of the fineness modulus has ever been advanced accounting satisfactorily for its remarkable properties.

As a proof that the fineness modulus was not the same as the surface area of a material, but only a happy approximation of it, a formula for each was worked out as follows:—

Let us consider a set of six sieves, Nos. 1, 2, 3, 4, 5 and 6, the diameters of the openings of which decrease by one-half with each succeeding sieve in the set. It was found by actual experiment with a set of sieves having this ratio that the surface area per gram of material passing a certain sieve and retained on the next finer, was double that retained on that sieve but passing the next coarser. If, therefore, we take x as being the surface area per gram of the material lying between Nos. 1 and 2, $2x$ will be the surface area per gram of that between Nos. 2 and 3, $4x$ between that of Nos. 3 and 4, etc. Let a, b, c, d, and e be the percentages remaining between the different sieves as in Table I., then the fineness modulus is $(5a+4b+3c+2d+e)/100$, and the surface area per unit volume is $16ex+8dx+4cx+2bx+ax$. In other words the two have no mathematical relation, one to the other. Fig. 1 would lead one to suspect this, as but few of the points fall exactly on the line drawn.

TABLE 1.

Sieve Nos. Pass Ret'd on	Mechanical Analysis, % Remaining Between Sieves.	% Retained on Each Sieve.	Surface Area Per Unit of Volume.
1—2	a	a	ax
2—3	b	$a+b$	$2bx$
3—4	c	$a+b+c$	$4cx$
4—5	d	$a+b+c+d$	$8dx$
5—6	e	$a+b+c+d+e$	$16ex$
Total —	100		

Abrams has also shown that the strength of a concrete or mortar mixture depends upon the ratio of the volume of water to the volume of cement in that mixture. Strength is, therefore, a function of the water content of the mix. Upon what does the quantity of water depend, assuming that we use only sufficient to give a workable consistency?

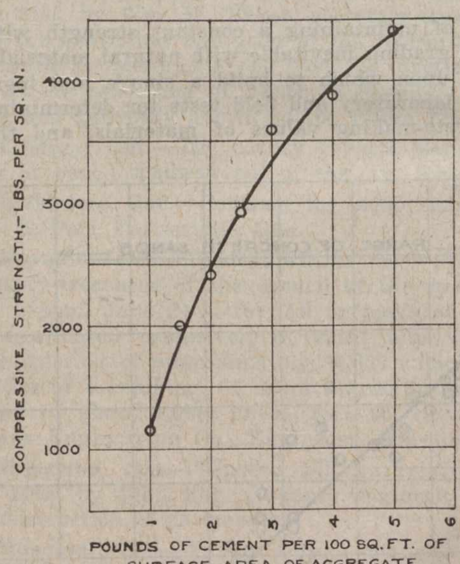

FIG. 6—RESULTS RECENTLY OBTAINED IN THE "HYDRO" LABORATORY

On consideration, we find that it is upon the quantity required to reduce the cement to a paste, plus the quantity necessary to wet the surfaces of the particles of aggregate.

The quantity required to wet the cement depends entirely upon the quantity of cement used, while the quantity required to wet the aggregate depends upon the total surface area of the particles forming the aggregate, and the latter is, in turn, dependent upon the sizes of the particles and the number of each size present in any given aggregate; or in other words, upon its grading or mechanical analysis.

If we assume the cement content and consistency to be the same, the conclusion then follows that the concrete which is made from the aggregate having the least surface area will require the least water in excess of that required to wet the cement, and will, consequently, be the strongest.

Strength depends upon the "water-cement" ratio and yet increases in strength may be obtained by increasing the cement content of a concrete. This can be explained by the fact that an additional quantity of cement in a concrete requires an additional quantity of water only sufficient to properly moisten the additional cement used, and therefore the total water does not increase in the same ratio as the total cement. That is to say, the water-cement ratio decreases, with a consequent increase in the strength of the concrete.

With these facts in mind, we can derive a formula for the amount of water required to give a desired consistency:—

Let W=the total quantity of water required (cu. ft.);

C=the amount of cement required (cu. ft.);

x=the "water factor" of the cement, or the volume of water (cu. ft.) required to reduce 1 cu. ft. of cement to a paste;

a=the surface area of the aggregate used (sq. ft.), divided by 100;

n=the "water factor" of the aggregate, or the volume (cu. ft.) of water required to wet each 100 sq. ft. of its surface area.

Then, $W=xC+na$ .... (1.)

This may be simplified if na is taken to equal L, L being, therefore, the water required to wet the aggregate in any given case. The equation then becomes

$W=xC+L$ .... (2.)

which is the most convenient form for general use.

From Abrams' experiments we have found that the relation of compressive strength to the water and cement is given by the equation $S=A/B^R$, in which S=compressive strength in pounds per square inch; A and B are constants depending on age, materials and other conditions affecting the cement; and $R=W/C$, or "water-cement" ratio.

Substituting for W in equation 2, we have

$R=(xC+L)/C=x+L/C$ .... (3.)

which gives by transposition,

$L=C(R-x)$ .... (4.)

and

$C=L/(R-x)$ .... (5.)

By means of these formulas we are able to deduce several interesting conclusions which, if the premises are sound on which the formulas are based, should be capable of experimental proof. With the consistency or plasticity of a mix maintained constant, let us first determine the relationship between the compressive strength of a concrete and its cement content. In this case, since the plasticity is maintained uniform, the quantity of water required to wet the surfaces remains the same, and the only change in the quantity of water occurs in that part necessary to properly moisten the cement. Let us consider a numerical example in which the following conditions govern:—

The amount of water required to wet the cement=22% by weight; the surface area of combined aggregate is 2,400 sq. ft.; the amount of water required to wet the aggregate is 0.75 lbs. per 100 sq. ft. of surface area of aggregate; cement proportioned on the basis of 1, 2, 3, 4 and 5 lbs. per 100 sq. ft. of surface area of aggregate; and $S=14{,}000/7^R$. Our constants then become $a=24.00$, $n=0.75$, and therefore $L=0.75\times24/62.5=0.288$ cu. ft.

x=weight of 1 cu. ft. of cement, multiplied by the amount of water required to wet the cement for normal consistency, divided by the weight of 1 cu. ft. of water. Therefore,

$x=87.5\times0.22/62.5=0.308$ cu. ft.

(The standard Canadian bag of cement weighs only 87.5 lbs., but is assumed in these calculations to contain 1 cu. ft. of cement.)

C for the first case, in which the cement is proportioned 1 lb. per 100 sq. ft. of surface area, is equal to $1\times24/87.5=0.274$, and the water-cement ratio becomes

$R=0.308+0.288/0.274=1.358$ (from Equ. 3), and

$S=14{,}000/7^{1.358}=1{,}074$ lbs. per sq. in.

Similarly R and S can be calculated for each of the other ratios of cement to surface area given. The result of such calculation is given in Table II.

Plotting the values of S, we obtain the curve given in Fig. 5, although this relation is not that reported by Edwards in his paper last year; but when Edwards' charts were examined after Fig. 5 was obtained, it was found that he had been misled into believing this a straight line relation by the limited range covered by his tests, and that actually four of the six sets of points shown on his charts could be better expressed by curves similar to that of Fig. 5 than by the straight lines actually shown in his paper. Figs. 2 and 3 show these.

The results of other investigators were likewise consulted and the same relation was found to hold. Among these were the results obtained by Messrs. Fuller and Thompson, some of which are shown in Fig. 4.

TABLE II.

Cement, Lbs. per 100 Sq. Ft. Surface Area.	Cement, C, in Cu. Ft.	Water-Cement Ratio, R.	Compressive Strength, S, Lbs. per Sq. In.
1	0.274	1.358	1,074
2	0.548	0.833	2,770
3	0.822	0.658	3,900
4	1.096	0.571	4,605
5	1.370	0.518	5,100

Fig. 6 shows results recently obtained in the laboratories of the Hydro-Electric Power Commission of Ontario, from a test covering the same range of proportions assumed in the calculated set of Table II.

In the case just discussed, the grading of the aggregate and the consistency of the mix were constant, and the relationship between the compressive strength of a concrete and its cement content was found. If instead, the aggregate varied but the consistency and compressive strength were to be maintained constant, how should the cement content be proportioned to bring this about?

For each strength there is a constant ratio of volume of water to volume of cement, hence the first requisite for constant strength is that this ratio be maintained constant. Secondly, with a change in grading there is a change in surface area and a corresponding change in the amount of water needed to wet the aggregate.

Let us now consider the formula $C=L/(R-x)$. For any given strength R is constant, and as long as the nature of the cement does not change, x is constant. Therefore C varies directly with L, but since $L=na$ where n is a constant for any particular aggregate, L varies directly with a, and therefore C also varies directly with a, or with the surface area of a unit volume of aggregate.

Hence to maintain a constant strength and therefore a constant R, it is necessary to proportion the cement, C, on the basis of the surface area of the aggregate.

Table III. shows in detail a number of aggregates having different mechanical analyses with their corresponding surface areas. These are shown proportioned to maintain a constant water-cement ratio, R, of 0.728, and the quantity of cement is given which is required to do this. The relation of volume or weight of cement to each 100 sq. ft. of the surface area of the aggregate used is constant, as is shown in the last column of Table III.

TABLE III.

Surface Area of Aggregate, Sq. Ft.	Cement, C, Cu. Ft.	Cement Total Weight, Lbs.	Cement, Lbs. per 100 Sq. Ft. Surface Area.
1,600	0.457	40	2.5
2,000	0.571	50	2.5
2,400	0.686	60	2.5
2,800	0.800	70	2.5
3,200	0.914	80	2.5

Some criticism of the surface area method of proportioning has been offered because the value of the surface area obtained by Edwards' calculations was not the true surface area of the material. It was held that the aggregate particles are neither true spheres nor have they smooth surfaces, and since it is thus impossible to obtain their actual surface areas, the value for the surface area obtained is of no use.

This was given consideration, and after some experimental studies upon the uniformity of sand particles, the conclusion was reached that it is not essential that we know the exact surface area, for if we can determine a value for each case which has a constant relation to the actual surface area, the amounts of cement used in proportioning can be stated in terms of this value equally as well as in terms of the actual surface area.

It seems reasonable to assume that the actual surface area in a cubic foot of particles of any particular size coming from a certain source, is the same as another cubic foot of similar sized particles from the same source; it being very probable that there would be equal numbers of each of the many possible shapes of particles present in both cases, and the studies referred to herein have confirmed this assumption.

Another source of criticism has been the fact that the cement is itself made up of minute particles which do not form a continuous unbroken covering for the aggregate but, like the aggregate, simply make contact with these particles and with one another. Consideration of this point led to the conclusion that with a uniform distribution of cement the number of cement particles in contact with any particle of aggregate is a function of the area of its surface, and hence this criticism offers no serious objection to the method.

The studies described above appear to offer conclusive evidence that the surface area method of proportioning is correct in principle. However, it was considered essential that its application to concrete be studied experimentally, and this work is now under way in the laboratories of the Hydro-Electric Power Commission of Ontario, under the direction of the writer. It is not possible to give any account of these experiments at the present time except to say that the results so far obtained bear out these theoretical deductions fully, and although the experiments are not yet completed, the results have been so encouraging that the method is being tried out in a practical way on a considerable scale upon several of the construction jobs of the Commission.

Tests Do Not Bear Out Surface Area Method?

Six Criticisms of Capt. Edwards' Theories—Areas of Finest Particles Cannot be Satisfactorily Dealt With—Separate Treatment for Each Aggregate—Laborious Computations Necessary—Not Clear How Method Can be Applied to Simplest Problems

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IN designing concrete mixtures, three elements must be kept in mind: (1) Workability; (2) strength, or other desirable property; and (3) cost. In usual circumstances, each of these three factors is an absolute limitation on the makeup of the concrete. If cost were no item, concrete of any desired strength and workability could be secured by using rich mixtures. In order to reduce the cost to a minimum, we use as much aggregate as feasible. The degree of workability required depends on the nature of the work and the methods used in handling and placing. The workability of concrete is one of its prime advantages and a certain degree of workability is absolutely essential. In order to reduce to a minimum the cost of handling and placing, a satisfactory degree of workability may be secured by using a little more water than is necessary, and an aggregate of somewhat greater fineness than that known to produce maximum strength of concrete. In designing concrete mixtures, the engineer must work out a nice balance between the strength, cost and workability in order to secure an economical building material.

Twofold Function of Water

It has been pointed out that the function of water in concrete is twofold: (1) To hydrate the cement; (2) to form a plastic mass.

The quantity of water required to hydrate the cement has not been definitely determined; it is probable that not more than 25 to 40% of the water in ordinary concrete is necessary for this purpose.

Tests made in this laboratory have shown that with given materials and conditions of test the quantity of mixing water used determines the strength of the concrete so long as the following conditions are observed: (1) Concrete is plastic with the method of placing used; (2) aggregate not too coarse for quantity of cement used; (3) mixture not so wet that all water cannot be held by the concrete.

Regardless of the size or grading of the aggregate, the amount of cement or the consistency of the concrete, the "water-ratio" may be used as a measure of the strength of the concrete. In other words, it makes no difference *why* the water-ratio is changed; the fact that it *is* changed within the limits stated above produces a definite result. Other properties of concrete, such as wearing resistance, modulus of elasticity, etc., have been found to follow similar laws.

Captain Edwards has not given sufficient weight to the fundamental relation between the water content and the strength of concrete. He states in his original paper that "the surface-area method of proportioning concrete assumes as its basic principle that the physical properties are primarily dependent upon the relation of volume of cementing material to the surface areas of the aggregates." It seems to me that the tests reported fail to bear out this assumption. On the other hand, many different series of tests made in this laboratory have shown that the quantity of cement is *not* a criterion of the strength of the concrete unless at the same time we take into account the quantity of water used. A 1:9 mix may be as strong as a 1:2 mix. In other words, it is the *ratio of water to cement* that determines the strength of the concrete. Table III. shows one way in which the quantity of cement may be varied 400 to 600% without producing any appreciable effect on strength so long as the water-ratio is constant. Much greater variations in cement content could have been made had it seemed desirable.

The "water formula" for concrete cannot be reduced to the simple form given by Captain Edwards, if it is to be of general application. The water formula given in Bulletin No. 1 takes account of the following six factors: (1) Relative consistency of concrete (workability factor); (2) normal consistency of cement; (3) the mix (volume of cement); (4) size and grading of aggregate (measured by the fineness modulus); (5) absorption of aggregate; (6) moisture contained in aggregate.

Another term is necessary when an admixture is used. The items, with the exception of (1) and (4) can be readily determined for given materials. The amount of water required under (1) will depend on the nature of the work, the method of placing the concrete, etc. Any method which will give a *proper* distribution of the water due to the size and grading of the aggregate should give satisfactory results. This Captain Edwards has endeavored to accomplish by means of the surface-area factor, while we have used the fineness modulus of the aggregate.

Where the Methods Differ

The fineness modulus is the sum of the percentages in the sieve analysis of the aggregate, divided by 100. Sieves from the Tyler standard screen scale are used. The percentages are expressed in terms of the quantity of aggregate by weight or volume *coarser* than each of the sieves. For a particle of a given size the surface area and the fineness modulus bear a direct relation to each other, since they are both simple functions of the diameter. The surface area varies as the square of the diameter, while the fineness modulus is a logarithmic function of the diameter. The relation is not so simple when we come to deal with graded aggregates. The discrepancy in this case becomes so great that both of these methods cannot be correct for a wide range of conditions.

The "Slump" Test

A further discussion of the quantity of water required on the basis of the grading of aggregate may be of interest. The plasticity or workability of the finished concrete is the only criterion which can be used in comparing the water requirements of different mixes, gradings, etc. We have used the "slump" test for this purpose. This consists of moulding the 6 by 12-in. cylinder in a smooth steel form by puddling the concrete in 4-in. layers with a ¾-in. steel bar, leveling off with a bricklayer's trowel, then immediately removing the form, without opening it, by a steady, upward pull. The shortening of fresh concrete from its original length, measured in inches, is the "slump."

The water which must be added, due to the presence of the aggregate, aside from that absorbed, may be divided into two portions: (1) To form a surface film on aggregate; (2) to make a thin cement paste which will produce a plastic mix with the aggregate. The total quantity of water required for this purpose can be determined experimentally by measuring the additional water necessary to produce a given plasticity in a concrete mixture as compared with that required for neat cement. By using different quantities of aggregate and different sizes and grading we arrived at the term, $0.30/1.26^m$, in our water formula which takes account of this factor. (It will be noted that this term gives a relation between water and fineness modulus similar to the water-strength curve in Fig. 1 of Bulletin No. 1.) The total quantity of water required for this term in an ordinary concrete mixture is about 8% by volume of concrete, or 40 to 50% of the total. This quantity is known to give satisfactory results. There is no reason why the water necessary to thin the cement paste should not be charged to the cement instead of the aggregate; however, the latter method seems more logical, since it is the presence of the aggregate and its size and grading that necessitate the addition of water to produce a mix of the same plasticity.

Quantity of Water Required

Let us see how much the quantity of water which must be charged to the aggregate (aside from that absorbed) is dependent upon surface area. Earl Pettijohn has shown (*Journ. Am. Chem. Soc.*, April, 1919) that the thickness of the surface film of standard Ottawa sand is 0.00003 in. at the point when free water begins to form. This means that 18 cc. (about 1/20 pint) of water would be required to produce the surface film on a cubic foot of standard sand and a much smaller quantity for ordinary concrete aggregates. The water required for this purpose is negligible. In other words, practically the entire quantity of water necessary on account of size and grading of aggregates must be charged to thinning the cement paste.

Ordinary mixes require water-ratios of 0.75 to 1.00; the value for neat cement with a normal consistency of 23% by weight is 0.35. In other words, the cement in concrete contains two to three times as much water as that required for normal consistency. It is the dispersion of the cement particles which results from the addition of water that is responsible for the rapid reduction in strength found in the wetter mixes.

How must the thinness of this paste be varied in order to produce a plastic mix with aggregate of different size and grading? Upon thinning the paste by adding water, we observe the following phenomena: (1) Increased plasticity; (2) change in volume.

The increased plasticity arising from adding water needs no demonstration. The volume of paste is first reduced, then increased as water is added to cement. Table I. herewith shows the effect with a standard cement weighing 94 lbs. per cu. ft.

That the *volume* of paste is an important factor in producing plasticity of mix can readily be seen from the fact that plasticity can be increased by increasing the quantity of cement and using relatively less water; in other words, a given degree of plasticity is produced by a low water-ratio or a rich mix and a high water-ratio with a lean mix. Just what effect the actual quantities of paste have on workability under the extreme conditions of mix, etc., has not been determined.

TABLE I.—VOLUME OF CEMENT PASTE

Water Added to One Volume of Dry Cement.		
Water-Ratio.	In Terms of Normal Consistency.	Volume of Cement Paste.
0.35	1.00	0.87
0.40	1.14	0.89
0.50	1.43	0.98
0.60	1.71	1.06
0.75	2.14	1.20
1.00	2.90	1.42
1.50	4.3	1.93
2.00	5.7	2.40
3.00	8.6	3.20

Current Theories Declared Wrong

Current theories of concrete are generally based on the idea that the quantity of paste is dictated by the voids in the aggregate, with a certain surplus. Four weaknesses in this theory may be mentioned: (1) The voids in the aggregate can be varied widely without producing any change in the quality of concrete; (2) the grading of aggregate which gives greatest strength in concrete gives higher voids than are found in other gradings of lower strengths; (3) concrete of highest strength may contain visible voids; (4) the strength and other desirable properties of the concrete depend on the *quality* of the paste and is little affected by the *quantity*, so long as we have sufficient to produce a workable mix.

The influence of the cement-water mixture on the plasticity of concrete is, then, a function jointly of the plasticity and volume of the paste. We have seen that the strength is a function of the water-ratio (volume of water to volume of cement) and that the strength of concrete decreases as the water-ratio increases; hence, in order to secure the highest grade of concrete at the lowest cost it is necessary to secure a given condition of plasticity with a minimum water-ratio. What condition with reference to the size and grading of the aggregate will give the desired result? It is obvious that this is a most complex relation if we consider the almost infinite variety of sizes and gradings which may be made from a single aggregate. Captain Edwards has used the surface areas as a satisfactory measure. It seems to the writer that the radius of curvature of the particles and the number of points of contact (or near contact) between adjacent particles are the factors which are primarily responsible for the additional water which is necessary, due to the presence of the aggregate. Both of these factors are functions of the diameter; the radius of curvature is one-half the diameter if we assume that aggregate of spherical form is being used. Since particles of all sizes are mixed at random, and there is no systematic arrangement, it is impossible to analyze the problem in a way that will enable us to compute the number of points of contact. The only practical method, then, is to determine the relation by trial. The fineness-modulus method was arrived at in this way. It was discovered from a study of mortar strength tests of about 1,000 different sands mixed to a uniform plasticity, and stored and tested under uniform conditions.

The water formula given in our Bulletin No. 1 is of a rational form and can be applied to any combination of concrete materials. Its development was an evolution extending over several years. These formulas were numbered in the order of their derivation as they were modified from time to time on the basis of experience. The above formula is No. 11. It is based on the experience of many thousand tests. I do not mean to be understood as believing that this formula is exact and will require no further modification. On the other hand, subsequent experience may dictate certain changes.

The formula has been subjected to many severe tests by applying it to aggregates of the most diverse character. A recent series of tests using four different coarse aggregates (graded No. 4 sieve to 1½ in.) and the same sand gave the following results (Table II.) for 1: 4 mixes:—

TABLE II.—STRENGTH OF CONCRETE FROM FOUR AGGREGATES

Coarse Aggregate.	Compressive Strength (Pounds per Square Inch.)
Pebbles	3,620
Crushed limestone	3,830
Crushed slag	3,750
Crushed granite	3,850

Tests were made on 6 by 12-in. cylinders at the age of three months. Twenty-one different gradings were used for each coarse aggregate. Specimens were stored under two conditions. Each value given above is the average of 105 tests. The water for these concretes was proportioned by the formula given above. The fact that with similar gradings and water properly controlled we secure uniform plasticity and strength is a severe test of the formula, when it is considered that we are comparing spherical and crushed materials of widely different characteristics. The absorption of the aggregate was also different in each case. Many serious errors have been made by experimenters in comparing the concrete-making qualities of different aggregates. The wide variations reported in the strength of the concrete made from different materials can almost invariably be traced to failure to take account of differences in size or grading, and to neglect of the absorption of aggregates.

Due to Different Cause

The sand-mortar tests in Captain Edwards' paper, which were mixed with 1 volume of cement for each 13 sq. ins. of calculated surface area of the sand, gave mortars of fairly uniform strengths at three different ages. These tests are interpreted as proving that the surface area of the aggregate is a proper basis for proportioning mortar and concrete mixtures. It is the writer's view that the uniformity in strength is due to an entirely different cause. Since both the water and cement were proportioned on the basis of the surface area of the aggregates, he obtained a uniform water-ratio, which is solely responsible for the uniform strength. This is the result to be expected so long as all of the mixtures were plastic and none of the aggregate gradings was too coarse for the quantity of cement used.

Tests Do Not Check

It is unfortunate that it was not feasible to include in our Bulletin No. 1 all of the data on which the conclusions were based. It is the writer's belief, however, that the tests given in Table 2 of the bulletin bring out a fatal limitation of the surface-area method of dealing with proportioning of aggregates. Twenty-seven different gradings of the same aggregate were used. The gradings were made to vary over a wide range, but had one property in common; that is, the fineness modulus was uniform. They were mixed with the same proportions of cement and water. The strengths for two different consistencies showed a mean variation from the average of about 3%, and a maximum variation from the average of about 10%. The corresponding values for surface areas are 43% and 110% respectively. If the water proportioning of these tests had been based on Captain Edwards' formula the water-ratios of the concrete would range from 0.39 to 0.57, an extreme variation of 69%, and would have made a great difference in the plasticity of the concrete. It is true that these tests were made with a view to determining whether or not a uniform strength of concrete was obtained with such wide variations in the sieve analysis of the aggregates. However, the plasticity or workability of the concrete did not differ materially.

The surface-area values in our table were calculated from the diagrams given in Captain Edwards' paper. It was necessary to estimate the areas of the sand particles below the 100-mesh sieve, and wide variations may be due to this cause. In certain of the tests as much as 10% of the aggregate was sand finer than the 100-mesh sieve. The surface area of this portion which we must estimate or neglect entirely is probably considerably greater than the entire surface area of many other gradings in the same group. The quantities of water given by Captain Edwards' formula are only 60 to 70% of those required for the materials used in this laboratory. It was impossible to mix concrete using the water given by his formula.

Some Recent Tests

Table III. herewith gives the results from a portion of some recent tests in this laboratory. Two leaner and two richer groups of mixtures are omitted. The quantity of materials required for each specimen, beginning with the 0-1½ in. aggregate and a mix of 1: 2½: 5, 1: 2: 4, 1: 1½: 3, etc., was calculated. The coarser sizes of aggregate were dropped in turn, but we retained exactly the same quantity of cement and water. The final mixes in terms of volume of cement and total aggregate are given in Col. 2 of the table. It is obvious that the richer mixes in each group are much more plastic than the leaner ones, and that equal workability was not secured. As in all other tests in these investigations the concrete for each cylinder was mixed separately by hand. Each value is the average of five tests made on various days. The second series of tests is not yet completed; however, the tests which have been made show a greater uniformity in strength than those in Table III., due to slight readjustments of certain constants in the water formula. These tests confirm the conclusion based on many other series: Namely, that *the widest variations may be made in the mix, consistency, and size of aggregate without any change in strength so long as the water-ratio is unchanged* and the above limitations are not violated.

Which is Simpler, Sounder?

It seems to the writer that any comparison of the surface-area and fineness-modulus methods must be reduced to the following two factors: (1) Which rests on the more sound experimental basis? (2) Which is the more simple to apply?

As stated above, the whole question of the comparison between the two methods resolves itself into that of determining which will give the better distribution of water in a mix, so far as the size and grading of the aggregates are concerned. Both of these methods make use of the sieve analysis of the aggregate. However, it seems to the writer that there is more variation in the underlying principles than is suggested by Captain Edwards.

Surface Area Method's Disadvantages

It appears to the writer that the following disadvantages accompany the use of the surface-area method: (1) Areas of the finest particles of sand cannot be computed; (2) crushed aggregate requires a greater quantity of water for the same grading than pebbles of a spherical form; (3) if the surface-area method were strictly interpreted it would require separate treatment for practically each kind of aggregate; (4) the method requires laborious computation, with the resulting chance of error; (5) it is not clear how the method can be applied to the simplest problems which arise in the course of designing concrete mixtures; for instance, to determine the best proportions of given fine and coarse aggregates for a concrete mixture; (6) it has not been shown that there is any theoretical reason why the surface-area method gives more nearly correct results than other methods which have been proposed.

Applies to Limited Range

If the surface-area method is correct, it would seem to be a serious fault that the areas of the finest particles cannot be satisfactorily dealt with. It seems probable that in extreme cases the areas of the particles finer than the 100-mesh sieve would be in excess of the combined areas of

Table III.—Effect of Size and Grading of Aggregate and Consistency of Concrete

Compression tests
Age at test, 28 days
Sand and pebble aggregate

Six by 12-in. cylinders, hand-mixed concrete
Stored in damp sand; tested damp
Each value is the average of five tests made on various days

		Water		Aggregate				Surface Area		Concrete			
Ref. No. (1)	Mix by Volume (2)	Relative Consistency (3)	Ratio to Cement (4)	Size, Inches (5)	F.M.* (6)	Weight, Pounds per Cubic Foot (7)	Density (8)	Square Inches per Pound of Aggregate (9)	Square Inches per Pound of Cement (10)	Weight, Pounds per Cubic Foot (11)	Density (12)	Yield† (13)	Compressive Strength, Pounds per Square Inch (14)
						Nominal Mix for 0–1½-inch aggregate, 1:2½:5							
15	1:6.7	1.00	0.91	0–1½	5.67	125	0.755	923	8,280	152	0.846	0.978	1,640
16	1:5.4	1.05	0.91	0–¾	5.09	124	0.743	1,052	7,500	151	0.828	1.006	1,800
17	1:3.7	1.13	0.91	0–⅜	4.10	121	0.725	1,737	8,300	145	0.768	1.115	1,760
18	1:2.5	1.21	0.91	0–4	2.99	112	0.671	2,601	7,750	139	0.696	1.241	1,950
19	1:2.2	1.23	0.91	0–8	2.58	108	0.648	3,056	7,730	136	0.669	1.299	1,630
20	1:1.9	1.29	0.91	0–14	2.24	105	0.629	3,695	7,840	134	0.643	1.377	1,940
21	1:1.2	1.50	0.91	0–28	1.81	102	0.611	4,494	5,860	135	0.603	1.685	2,000
												Average	1,820
						Nominal Mix for 0–1½-inch aggregate, 1:2:4							
22	1:5.4	1.00	0.80	0–1½	5.67	126	0.755	923	6,680	152	0.842	1.003	2,230
23	1:4.3	1.05	0.80	0–¾	5.09	124	0.743	1,052	5,980	150	0.814	1.050	2,130
24	1:2.9	1.13	0.80	0–⅜	4.10	121	0.725	1,737	6,480	144	0.754	1.183	2,550
25	1:2.0	1.20	0.80	0–4	3.00	112	0.671	2,604	6,210	139	0.690	1.322	2,160
26	1:1.7	1.22	0.80	0–8	2.58	108	0.648	3,056	5,970	136	0.658	1.418	2,280
27	1:1.5	1.26	0.80	0–14	2.24	105	0.629	3,695	6,180	132	0.625	1.522	2,440
28	1:0.9	1.47	0.80	0–28	1.81	102	0.611	4,494	4,390	135	0.594	1.937	2,400
												Average	2,310
						Nominal Mix for 0–1½-inch aggregate, 1:1½:3							
29	1:4.0	1.00	0.69	0–1½	5.67	126	0.755	923	4,950	152	0.832	1.054	3,100
30	1:3.2	1.04	0.69	0–¾	5.09	124	0.743	1,052	4,450	149	0.799	1.120	2,970
31	1:2.2	1.11	0.69	0–⅜	4.10	121	0.725	1,737	4,930	144	0.743	1.273	3,390
32	1:1.5	1.16	0.69	0–4	3.00	112	0.671	2,601	4,650	139	0.679	1.463	3,270
33	1:1.3	1.20	0.69	0–8	2.58	108	0.648	3,056	4,570	136	0.651	1.570	3,220
34	1:1.1	1.22	0.69	1–14	2.24	105	0.629	3,695	4,540	132	0.615	1.740	3,200
35	1:0.7	1.37	0.69	0–28	1.81	102	0.611	4,494	3,410	129	0.565	2.308	2,930
36	1:0	1.92	0.69	....	Neat	...	.....	.....	.....	132	0.467	.....	3,230
												Average	3,160

*Fineness modulus of aggregate.
†Yield was calculated on the basis of the original volume of dry aggregate.

the coarser sizes. Our experience indicates that the quantity of water required for these fine sands is not in proportion to the amount that would be suggested by the surface areas.

The area of a tetrahedron is 25 to 30% greater than that of a sphere of the same volume, or one having a diameter equal to the height of the tetrahedron. Our experience in testing concrete made of crushed aggregates as compared with rounded pebbles does not indicate that there is any discrepancy in the quantity of water required, as would be suggested by the surface-area method.

The computation of surface-areas begins at practically the same point where the determination of the fineness modulus ends. There appears to be little room for question as to which of the proposed methods is the more simple in application.

No doubt, the surface-area method could be worked out so that it would apply over a limited range. In fact, almost any function of the size of particle could be used in this way. This would be equivalent to representing a portion of the curve by a line or by an arc of different curvature.

(Note.—The foregoing article by Prof. Abrams is abstracted from a letter to the editor of "Engineering News-Record," of New York, and was written in reply to a letter by Capt. Edwards defending the surface-area method of proportioning mortars and concretes. It is of special and timely interest owing to the announcement by Mr. Young of his tests supporting Capt. Edwards' method. It is to be hoped that we will be able to publish in early issues further discussion by Capt. Edwards and Mr. Young of the points raised by Prof. Abrams.—Editor).

ASPHALT ASSOCIATION ENGAGES ENGINEERS

PROMINENT federal, state and municipal engineers are included in the newly-formed staff of the Asphalt Association, whose headquarters have been established at 15 Maiden Lane, New York City, under the direction of J. E. Pennybacker, secretary.

There will be a Research and Technical Department managed by Prevost Hubbard, Chief of the Research and Testing Division of the United States Bureau of Public Roads prior to his affiliation with the association. Mr. Hubbard is one of the foremost authorities in the United States on research work in all classes of bituminous materials and is the author of standard text books on the subbect.

Field engineers who will devote their attention to aiding state, county, and municipal authorities in the working out of their highway problems, include Fred W. Sarr, who was Deputy State Highway Commissioner of New York in charge of the maintenance, repair and reconstruction of all state and county highways comprised in New York's system.

A. T. Rhodes, for years street commissioner of Worcester, Mass., and later secretary of the Granite Paving Block Manufacturers' Association, and who is vice-president of Massachusetts Highway Association, will look after the New England territory and other eastern points. Mr. Rhodes' practical experiences included the design and installation of the city asphalt plant at Worcester and the construction of the asphalt pavements of that city.

At the Chicago office of the association, J. B. Hittell, formerly city engineer of Chicago, and president of the Illinois Society of Engineers, will be in charge of the work of the association in the middle western states.

A branch office will soon be established in Atlanta, in Canada and elsewhere, and announcements will be made of the engineers selected for the various posts.

The Supreme Court of Canada has dismissed the appeal of the city of Toronto from the decision of the Board of Railway Commissioners for Canada, concerning the application of the Toronto Terminals Railways Co., for authority to lay and maintain steam lines across various city streets. The new Union Station will now be heated by the exhaust steam from the Toronto Electric Light Co.'s plant.

A. S. Clarson, general secretary of the Association of Canadian Building and Construction Industries, is soliciting subscriptions of $100 and upwards from prospective direct members of the association. These contributions are being solicited to meet the expenses of the association until formal adoption of constitution and by-laws, after which the officers of the association hope to be able to meet expenses out of the regular fees to be collected from a definite list of members.

The Engineer's Library

COMPRESSED AIR PLANT

REVIEWED BY PROF. R. W. ANGUS
University of Toronto

By **Robert Peele**, Mining Engineer and Professor of Mining in the School of Mines, Columbia University. Published by John Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London. Renouf Publishing Co., Montreal, Canadian sales agents; 485 pages, 6 by 9 ins.; 246 figures; cloth. Price, $4.25 net.

This very useful book, dealing with compressed air matters, has reached its third edition, and is a deserving book on the subject. The use of compressed air by civil, mining, mechanical and other classes of engineers makes a good book on the subject very desirable, and Professor Peele has supplied the need very well The work is divided by the author into two parts: I., Production of Compressed Air and II., Transmission and Use of Compressed Air. The first part deals with the different styles of compressors and their details and also the general theory of the compressor. The types of compressors discussed include wet and dry compressors, multi-stage compressors, hydraulic compressors, along with such details as valves of the several types, receivers, regulators, governors, etc. Several chapters are devoted to the performance of compressors, the standards of comparison, calculation of the horse-power required, altitude compression, explosions in cylinders, etc.

In the second part of the book, dealing with the transmission of compressed air, the first chapter treats of the methods of computing the losses in the pipe line due to friction. This is followed by chapters dealing with compressed air engines, effect of clearance, work done, volume of air required, freezing of air, reheating and many kindred matters. Many applications of compressed air are also given and discussed, such as drills, coal cutting machines, channelling machines, pumps using compressed air, air-lift pumps and compressed air haulage.

The book has been written in such a way that it should be easily read by practising engineers, and much of it could be readily understood by the non-technical man. It is well illustrated by 246 figures and has been brought well up-to-date.

ELECTRICAL PHENOMENA IN PARALLEL CONDUCTORS

REVIEWED BY PROF. HAROLD W. PRICE
University of Toronto

By **Dr. Frederick Eugene Pernot.** Published by John Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London. Renouf Publishing Co., Montreal, Canadian sales agents; 332 pages, 6 by 9 ins.; 83 figures; cloth. Price, $4.00 net.

This book is a plea for rigorous methods of developing formulas for the solution of problems on power transmission over long lines. The argument is that the rigorous formulas in suitable form are often more convenient for calculation than supposedly simpler approximate ones; and, further, that an understanding of exact methods develops ability to devise and use approximate solutions, where necessary because of complexity, with proper judgment as to their limitations.

This first volume on the subject is introductory to future volumes on complicated line systems, and therefore deals with single-line problems. The book is excellently set up for convenience of the reader, and is replete with illustrative diagrams and sample problems completely solved.

In addition to much mathematical explanation regarding methods and formulas, many real problems are considered. For example: Long, leaky, direct-current lines; experimental measurement of line constants of long alternating-current power lines, also telephone circuits; relations between load power-factor and maximum efficiency of long lines for specified constant load, for varying loads as illustrated by a daily load curve, etc.; voltage regulation and control; propogation constants; change of shape of voltage and current wave forms along a line; analysis of motion of oscillograph vibrators to evaluate errors in amplitude and phase of wave records due to inertia of strips and mirror, damping fluid, resonance, etc., at normal and harmonic frequencies; and many other problems.

As previously stated, the reader is not left with formulas alone, but is carried through solutions of practical problems, with curves illustrating the nature of results to be expected between assumed limiting conditions.

The book is well worth consideration by those interested in its field. From an artistic point of view, the printer's work on formulas, diagrams and general style is beautifully done.

PUBLICATIONS RECEIVED

VITAL STATISTICS.—By G. C. Whipple. Published by John Wiley & Sons, Inc., New York City. First edition, 1919; 517 pages and flexible cover; 4½ by 7 ins. Price, $4 net.

THE CHEMICAL ANALYSIS OF ROCKS.—By Henry S. Washington. Published by John Wiley & Sons, Inc., New York City. Third edition, revised and enlarged; 271 pages and cover; 6 by 9 ins.; cloth. Price, $2.50 net.

"HYDRO'S" ANNUAL REPORT.—Eleventh annual report (volume 1) of the Hydro-Electric Power Commission of Ontario, for the year ended October 31st, 1918; 320 pages, 6½ by 9½ ins., numerous illustrations, several charts and large map of province, showing generating stations and transmission lines. This report comprises five sections, as follows: Legal proceedings, transmission systems, operation of systems, construction work and general activities.

BRONZE PRODUCTS OF QUALITY FOR ENGINEERING PURPOSES.—Well illustrated catalogue published by American Manganese Bronze Co., of Holmesburg, a suburb of Philadelphia, Pa. Printed in two colors on coated paper, 8½ by 11 ins., 36 pages and cover; illustrating bronze castings, ingots, forgings, sheets, rods, rolls and shapes, both of manganese bronze and of other commercial grades of bronze. Among the many interesting castings illustrated are 72-in. shaft caps for the Catskill aqueduct, centrifugal pump casings, turbine runners, valves and valve stems, worms and worm gears, bridge bearings, marine propellers, valve nozzles, etc.

York Township, Ont., has decided to instal its own systems of water works and sewers instead of waiting further for connections with Toronto's systems. The district will be drained toward the Don River, where a sewage disposal plant will be built. Water will be secured from the Scarboro Township plant which will soon be built.

H. E. T. Haultain, professor of mining engineering at the University of Toronto, was the recipient of a McLaughlin six-cylinder automobile last week upon his retirement as vocational officer for Ontario, Department of Soldiers' Civil Re-establishment. Five hundred members of the staff assembled at the armories to present Prof. Haultain with the car as a tribute to his work. Of the members of the staff, 92% are returned soldiers. D. D. Eppes, head of the "After-Care Department" for Ontario, in presenting the car recalled the fact that the retiring vocational officer had entered the re-establishment movement in its early days, and he paid tribute to the part Prof. Haultain had played in the development of the movement and in the sympathetic handling of the returned men.

TOWN PLANNING INSTITUTE OF CANADA

THE first general meeting of the Town Planning Institute of Canada was held May 31st, in the Russell Hotel, Ottawa. Thomas Adams, chairman of the Provisional Council, presided.

The following members were present: Thomas Adams, Dr. E. Deville, Dr. C. Klotz, N. Cauchon, J. B. Challies, F. D. Henderson, C. P. Meredith, H. L. Seymour, R. H. Millson, W. D. Cromarty, D. Ewart, B. B. Parry, F. C. Todd, Thos. Fawcett, A. H. Hawkins, S. E. Farley, A. Buckley and E. T. B. Gillmore.

The first business of the meeting was the confirmation of the provisional membership. The chairman announced that the list comprised fifty-two provisional members.

Sir Lomer Gouin and Hon. N. W. Rowell were elected as honorary members.

The following were elected as associate members, subject to the execution of certain further formalities in connection with forms of application:—

Associate Members

Architects:—Richard H. Millson, James P. Hynes, William D. Cromarty, David Ewart, George A. Ross, W. Herbert George, Charles H. C. Wright, Ramsay Traquair, Percy E. Nobbs, Arthur A. Stoughton, Robert H. Macdonald, Edward Maxwell and Colborne F. Meredith.

Engineer:—R. S. Lea, William M. Tobey, George H. Ferguson, Horace L. Seymour, William H. Powell, Charles A. Bigger, John L. Rannie, Christopher J. Yorath, Arthur G. Dalzell, George Phelps, James A. Walker, William A. McLean, Percival H. Mitchell, Noulan Cauchon, James White, John B. Challies and Lionel C. Charlesworth.

Surveyors:—Francis D. Henderson, Thomas Fawcett, Edouard Deville, Wilbert H. Norrish, William A. Begg, Ernest B. Normon, Thomas A. McElhanney, Albert H. Hawkins, Carl Engler, Athos C. Narraway, Sidney N. Farley and Otto Klotz.

Landscape Architects and Town Planners:—Frederick G. Todd, Alfred V. Hall, H. B. Dunnington-Grubb and Thomas Adams.

Legal Associate Members

Thomas B. McQueston and James A. Ellis.

Associates

G. Frank Beer, Dr. W. H. Atherton, A. Buckley and E. T. B. Gillmore.

The chairman presented a report on some features of the City Planning Conference held at Niagara Falls during the last week of May. The institute, he said, had been well represented at the conference, considering the existing small membership. The conference was called under the auspices of the cities of the Niagara frontier and was international in its purpose and significance. It had fallen to his lot to present a paper on "The Regional Survey as the Basis for Town Planning." The subject dealt with the district twenty miles on either side of the Niagara River, covering an area of 1,000 sq. miles, and with the aid of seven or eight diagrams, the paper set forth the basic conditions that require to be considered with regard to the whole district. He thought that the consideration of the subject might lead to the formation, on both sides of the river, of an International Town Planning Commission dealing with the whole of that region. This would mean a big scheme and one of world-wide value. The scheme should have special interest to professional men, as it would enlist the services to a large extent of surveyors, engineers and architects.

A discussion took place on the question of the formation of local branches and local representation. Mr. Todd suggested that the provisional council seemed to be largely composed of Ontario men and that Montreal was not very well represented. On that ground he foresaw some difficulty in the formation of a Montreal branch.

The chairman explained that this point had been discussed; that the provisional council was appointed to carry on the work of organization for the first year, and that it had seemed necessary that the membership should be largely drawn from Ottawa in order to make it possible to conduct business. He also explained that the organization was started in Ottawa and they had no assurance that anyone in Montreal would join them. The council, however, was merely provisional, and at the end of the first year it would be easier to elect a wider representation. Local branches would have to be formed in Montreal and Toronto, and proper representation given on the council.

Mr. Henderson: There were two members suggested for Montreal and there is still a vacancy.

Mr. Adams: We could fill that vacancy. I suggest that it be left to the consideration of the council. With regard to further nominations the members should send in recommendations.

The matter was left to the council.

Prospects of the Institute

Mr. Adams addressed the meeting upon "Prospects of Town Planning Institutes in Canada." He referred to the progress made in forming institutes in Britain and the United States, and to the special difficulties Canada had to meet in attempting to create any organization on the basis of conditions in these countries.

In Great Britain there was practically no such thing as a "town planner" prior to 1909. In that year the Town Planning Act was passed by the government and there arose a need for men as town planners. In 1913 the Town Planning Institute was formed. It consisted of the architects, surveyors and engineers in Great Britain who were prominently identified with town planning.

"They have this advantage," said Mr. Adams, "that Britain is a small place and meetings can be held frequently and they have been very successful. They hold about eight meetings yearly, and they have presented papers which are published and form very interesting and valuable literature on the subject. An annual volume is issued with a subscription of two guineas for members and one guinea for associates.

"In Britain, when a town wishes to have a scheme prepared, if it has not an engineer who is also a town planner, then an expert town planner is asked to assist. The city engineers of the chief cities are prominent members of the institute.

British Institute is Successful

"It is strictly a professional institute and there has been no difficulty in separating the associate from the professional members. Some of the associates, however, have studied town planning for many years, but are not professionally qualified. These include Henry Vivian, chairman of Copartnership, Ltd., H. R. Aldridge, who has written a very comprehensive book on the subject, and Ewart Culpin, secretary of the Garden Cities and Town Planning Association. None of these men were eligible as professional members, but were elected as associates. The institute was formally established as a professional organization and has brought into existence a definite scheme of instruction in town planning. An examination syllabus has been issued, and the aim was that no one could become a member without examination. They have also a school of civic design in Liverpool University and a professorship of town planning in London. In regard to professional work, they have issued a scale of charges for town planning work. Members of the Town Planning Institute were recently elected housing commissioners. Raymond Unwin, an ex-president, is now chief architect of the government in respect of its housing schemes that involve an expenditure of $600,000,000 to $1,000,000,000. G. L. Pepler, a vice-president and first secretary, is town planning inspector to the Local Government Board. Professor Abercrombie, librarian of the institute, is editor of the 'Town Planning Review,' and head of the Liverpool School of Civic Design, and Professor Adshead, the president, is professor of town planning in London, and adviser on town planning to the Prince of Wales.

"In the institute we had, as first librarian, Professor Geddes, whose collection of town planning material was sunk by one of the German raiders on its way to India. He had collected material costing $12,500, which was all lost. The institute immediately set to work to collect duplicates as far as possible and these were sent out to him in India. Professor Geddes is not an architect or a surveyor, but has high academic qualifications as a regional planner. He has done great work in India and has published several large volumes on town planning in India through the Indian Government.

United States Town Planners

"The development of the town planner in England has proceeded rapidly. The beginning in the United States was not so satisfactory from a scientific point of view. It came about in a different way. In Britain, we started to promote a school of town planning with a view to creating a trained class of professional men. In the United States there has been no deliberate objective of that kind, until very recently.

"The National Conference on City Planning in the United States was first held twelve years ago. The chairman is F. L. Olmsted, who is an able landscape architect, and a man whose name is widely honored. He has been chairman for twelve years. That itself has been a weakness. I do not think a chairman should hold an office more than one year. The organization is weak in its architectural and engineering membership. There has been a tendency, probably quite unconscious, rather to confine town planning to landscape architects and there is now a good deal of leeway to make up in order to interest the engineer and the architect. Two years ago I suggested that a city planning institute be formed. This year a step has been taken to separate professional functions from propaganda. But the council of the institute is the same as the council of the conference which is engaged in what may be termed propaganda. I do not approve of that combination.

"In Canada, I think we have started out in the right way. The chief question I have to deal with to-night is what prospect is there for those of us who are interested professionally in the subject that there will be sufficient scope for using our knowledge of town planning? We have the great difficulty of planning for a small population in an immense area. Great Britain has about 50,000,000, America over 100,000,000. We have our 8,000,000 scattered over a larger territory than the United States. We shall have to be content to grow slowly as a profession. A small population means a smaller number of practitioners. There will be the difficulty of getting sufficient reward for professional work in Canada to make it practical for men to train for the profession. But while we are a small country, we are a growing country and a town planner has to deal with growth, and our government has promoted the best housing scheme of all the governments. In Great Britain they are spoon-feeding the population with their housing schemes. It has dangers and it is not so sound economically as ours. I have had letters from two sources sustaining this claim. Mr. Campbell, a member of the Town Planning Institute and city engineer of Edinburgh, has just written to me, to say that he is satisfied that the Canadian scheme is based on sounder economic principles than the Scotch scheme which had been made for Scotland by the English Government. Mr. Taylor, of the firm of Mann and MacNeille, of New York, says in a letter:—

Compliments for Housing Scheme

"'We wish to express our unqualified admiration for the completeness, practicability and simplicity of the administration methods outlined in the data received from you. We believe this to be the most practicable step toward the provision of good housing by Federal co-operation which has yet been taken in any country.'

"We have opportunities here because we are beginning at an early stage in the development of the country. On the other hand we have the disadvantage of a smaller population and lack of appreciation of professional capacity.

"The other day I was going over the deep cut being laid between the Rapids and Queenston by the Hydro-Electric Commission and was informed by the engineer that somebody had applied to him for a job. He had said to him, 'Well, I could give you $80 a month.' The young fellow had looked rather glum. 'Well, if you think that is not enough, that is the best I can do. Is there anything else you can do?' 'I have been accustomed to boring,' said the applicant. He was referred to the engineer in charge of the boring. Later the engineer met him and said: 'Have you got something?' 'Yes,' was the reply. 'I am boring at $130 a month.' There was a man with a university training. He had to take the work of a skilled laborer in order to get a decent salary. What encouragement is there for a youth to go to the university and learn a profession? Railway men are earning up to $3,000 a year. Many of the engineers have to be content with $2,000. If a man is to be a town planner he has to take his four years' course in architecture and engineering, and then a post-graduate course of a year in town planning. You get a man to take a five years' course and then you meet this difficulty of having his services valued as a skilled laborer who can learn his job in a few months.

"But there is no question town planning will come to be appreciated.

Specialists Needed in Future

"There are some hopeful signs of this fact. First, we have the surveyors who almost to a man are now recognizing that they have to take up the question of topographical survey in a more extended way. Then we have also, to consider that regional planning is a thing that has come to stay in England and the United States and that it is one of the things that is very much needed in this country. Many industries are spreading over areas that have no reference to municipal boundaries at all. You cannot town plan even Ottawa with 100,000 inhabitants, unless you take in about half a dozen municipalities. If you wish to zone Ottawa, or to insist upon proper building by-laws, it cannot be done unless Westboro and Eastview have the same restrictions; otherwise people would skip the boundaries and build as they like. In the regional planning, which I hope we may take up as a subject of special study, we require a surveyor and an engineer to prepare the regional survey as the basis for the regional plan. The surveyor should become our chief man in the regional survey. You cannot town plan unless you know what the existing conditions are. You have to find out what is the basis on which you wish to build your town planning. The engineer comes in to assist the surveyor with the collection of data concerning roads, railway transportation, sewage disposal and water supply. For this we need a regional survey in which we shall need specialists in the future. We need the regional survey to present us with the exact data we require to prepare our plan.

Survey Made at Niagara

"We had a survey made in the Niagara district. We wanted the facts, and there was need to obtain correct information, and the surveyor and engineer supplied us with such information. We have information collected regarding railways, waterways, highways, sewage disposal, power, etc. One municipality may have its sewage disposal on higher level than another, and become a watershed sending down polluted sewage to the other. When you have finished with your survey, you must bring in the landscape architect. The engineer and the landscape architect present us with the regional plan as the basis for general development. The landscape architect will deal with the park system in a general way. The Niagara district should have a parkway from Buffalo right down to Lake Ontario. Along the Niagara River, it touches five or six municipalities.

"When the regional plan is prepared, then town planning commissions have to be appointed for the municipal areas within the region. The different towns will each have their own local engineer to fit in his plan with the regional plan. He will know where the other plan touches his. Then the architect will finish the job commenced by the others, fix residential areas, group buildings, arrange the minor street system, and bring to a climax a definite scheme, when the lawyer also will appear and an Act of Parliament will follow.

"All this needs considerable organization and professional talent of varying degree. There is a field big enough for all the talents. We can bring it to bear, if we get the teaching we require in the universities, and we can also show that such money is well spent. If the services we are able to give are properly appreciated, we shall be able, as we apply courage and vision, to convince the people of Canada that we have a big contribution to make in the application of science to the making of a strong country, and the building of a strong race, living in houses not only comfortable but in right relation to industries, means of recreation and sources of power. Then proper organization and planning will help to give the people the right foundation, and build up this country in such a way that there will be less to regret in looking back than is the heritage of older countries."

Discussion

Mr. Challies: I would like to say a word or two about development of water power in Canada in relation to town planning. The Department of the Interior, since the inception of the water power branch, has been trying to interest these corporations and to get them to consider their project from both the standpoints of the town planner and the architect.

I think we have secured excellent results so far. We find power companies are quite willing to do anything reasonable, consistent with the question of construction costs.

We asked them to retain an architect to go over their engineering plans, and we find them quite willing. The Vancouver Power Company for instance has a chief engineer of some vision who retained an architect and had the power house designed by him, with the result that to-day it is one of the beauty spots of British Columbia. He had also some of his intake work designed by the architect, and it has been accepted by other architects as a little architectural gem.

Since the town planning movement got started in Canada, we have also endeavored to get the power companies to lay out the immediate surrounding of their developments.

Only in one case have we received any opposition. Winnipeg absolutely refused to consider our suggestion. The result has been that in a $4,500,000 power project, twenty-five miles from Winnipeg, twelve or fifteen hundred acres of land have been flooded, with the timber standing there dying. It is a most lamentable condition of affairs. They also refused to consider having the power house and incidental work under the supervision of an architect. To-day they have a power house which you could not describe better than by the term "barn." In another case on that river a private company have accepted our suggestions and the result is, about fifty-five miles from Winnipeg, their plant is an oasis in the desert. They have a little park that is comparable to a portion of our driveway. They have laid out about fifteen acres as a park; fourteen or fifteen cottages have been built from special designs by the architect and other residences of a more pretentious character. The cost of the lay-out of the park was less than $3,000. The workmen do not need to go to Winnipeg to feel that they are in civilization.

Park Along Winnipeg River

The power situation on the Winnipeg River is that we have many complete surveys all along the river. The territory is similar to the territory on the Ottawa River. We have come to the conclusion that if the increase in the use of power from that river is projected into the future it is only a matter of twenty-five or twenty-six years when practically all the capacity of the river will be developed. We are insisting in all future development that the lay-out must be treated on town planning lines, that all of the work must be submitted to an architect and if this is done consistently the result will be that in twenty-five or twenty-six years there will be a continuous park along that river comparable to the regional project of the Niagara River.

I was interested in what Mr. Adams said about propaganda; I think there is propaganda and impropaganda, to use a moving picture term. It seems to me we must indirectly educate the public to feel that town planners must be employed and try to make the public understand the situation. On the Winnipeg River, for example, when it was suggested ten years ago, that a town planner or architect should be employed, we were almost laughed out of court. But the fact that one company in Vancouver did employ a town planner was appreciated by those who knew about it. If you ask the average engineer whether a town planner should be consulted, he would say no. If the engineer says that, what can we expect from the public?

Must Educate the Public

Mr. Gillmore: There are eight million people in Canada and most of them know nothing about town planning. I think that collective propaganda is very much needed, good hot propaganda. The big mill men and landlords don't care anything about it. To my mind proganda is the whole question. If local branches are to be organized there must be a constitution whereby they can have a regular representation upon the central committee. I should also like to ask why artists are not included. Why should a Royal Academy man not have a place?

Mr. Millson: In working on the Renfrew proposition for a civic centre, it came to my mind several times that the awakening interest in town planning is a very fine thing for all of us. If town planning means that different constructive professions are to be able to come together to exchange viewpoints it is going to be a very good thing for us. We must not forget the need of education. I think the question of local branches is very important. The central organization cannot do all the educational work.

Mr. Cauchon: There is no doubt of the need for general education among the people on the subject of town planning. Since 1909, we have been pounding away at the subject. Here in Ottawa, the only way was by propaganda. At Hamilton and London, I was requested to take the public into my confidence and prepare them for the scheme. I gave many lectures and talked a great deal. The report was presented. The public were better able to judge. The result was that the corporations and even the town council passed the scheme unanimously. At London, the same request was made to educate the public. You are in a dual position; you must do the work and educate the public.

Mr. Seymour: Some of the previous speakers have referred to the matter of propaganda. I do not see any reason why the subject matter of succeeding meetings and legitimate propaganda cannot go hand in hand. What could be better than a talk on civic centres by Mr. Millson, who has successfully planned a civic centre for Renfrew; what better propaganda could we have for a civic centre?

Criticizes "Hydro's" Power Canal

Then, too, a paper by Mr. Cauchon on the relation of the steam railway to town planning, with Hamilton and London for examples; and Mr. Challies could tell us at one of our meetings about water power development with comprehensive planning of the whole project and architectural treatment of the power buildings. I believe that these concrete examples would be much better material for propaganda than anything that could be given of an abstract nature. I should like to take the opportunity to congratulate Mr. Challies on the stand he has taken with regard to power development under the supervision of the Dominion Government. While Mr. Challies is a member of the Engineering Institute of Canada he has also the advantage of architectural training which is probably the reason for his interest in proper planning and architectural treatment of power development.

The thing that impressed me most in the Niagara Frontier regional area was the apparent lack of planning in connection with the Hydro-Electric Commission's power development. A $25,000,000 scheme is being carried out with practically no regard to its effect on the immediate locality. Niagara Falls, Ontario, is being made an island by the eight and one-half miles of open cut. This wide open gash will in some places have a depth from the ground surface to the level of the water in the channel of 100 ft. I understand that more than one engineer of international repute has claimed that a tunnel would have been more economical and as suitable from an engineering standpoint as an open cut.

But the point I wish to make is not whether a tunnel in this case would be better than an open cut, but that in deciding which should have been used, all factors, not merely the strictly engineering one, should have been considered, just as Mr. Challies is doing in connection with the Dominion power developments.

Summary of Further Discussion

Dr. Otto Klotz recalled the story of Lord Kelvin, who, on a visit to Niagara Falls, in 1897, in connection with the meetings of the British Association for the Advancement of Science, said that he hoped to see the time when all the waters of Niagara Falls would be used for power and not a drop would go over the Falls to waste.

Dr. Deville felt that some form of propaganda, or at least education for the public, was necessary. He gave as an example the case of a land sub-division in Ottawa, where he had been approached to have the necessary plans made. He negotiated with an Ontario land surveyor and found out what it would cost to have the proper survey made and plans registered. The parties for whom he obtained the information seemed to be quite amazed and indignant at the price charged and seemed to wonder why some of the doctor's assistants could not do this in their spare time in the office.

Alfred Buckley said he was conscious of a kind of distress by any disparagement of what had been called propaganda. He had spent some years at Letchworth and had been greatly impressed by the sociological significance of the town planning movement. In Canada it had seemed to him that something more intensive was needed even than what was implied in the word education. He was disposed to use the word evangelism. As a mere question of policy it was notorious that men's minds were often reached through their emotions, and psychology and sociology were sciences as well as town planning. Mr. Cauchon had argued that the basis of the movement was ethical and the speaker agreed. He would risk a paradox by suggesting that the greatest of all forces was inertia. He was not blind to the need for professional organization and the co-relation and co-operation of the different sciences involved, which were the machinery and executive of the movement, but a convinced people was necessary for progress and there was an enormous amount of work to be done in Canada in this direction.

The chairman, in replying to the discussion, said he did not object to propaganda of the right kind. Education of the public by means of practical demonstrations of town planning was not only legitimate, but was the most effective means of carrying on propaganda.

WATER STORAGE ON ST. MAURICE RIVER

THE great benefit derived from water storage is soon to be further demonstrated on the St. Maurice River, where a large water-power undertaking will soon be started. The increased power made possible at the various sites on this river by the La Loutre reservoir, the largest but one in the world, is a strong incentive to prospective power users. It is estimated that the conserved water thus made available represents a total increase of over 500,000 h.p.

The proposed development above referred to is reported to be in connection with the operations of the St. Maurice Paper Co., the latter having leased two sites in the lower portion of the rivêr, known as Les Forges and La Gabelle. It is intended to combine these two, giving a total effective head of 33 ft., while the regulated flow from the La Loutre reservoir increases the power now available at this site, namely, 20,000 h.p., to 42,000 h.p.

Another proposition reported in this connection is the construction of a hydro-electric plant utilizing the combined sites of La Gabelle and Les Grès, the latter site being controlled by the Shawinigan Water and Power Co. The latter power company would carry out the development and supply hydro-electric power to the St. Maurice Paper Co. under a special contract.—From "Conservation," the monthly bulletin published by the Commission of Conservation, Ottawa.

ELECTRIFICATION OF CANADA'S RAILWAYS

By L. G. Denis
Hydro-Electric Engineer, Commission of Conservation

THE question is often asked, "Why are not more of our railways electrified?" It is pointed out that Ontario and Quebec, abounding in water-powers from which cheap hydro-electric energy can be made available wherever required, are coal-less, and the coal necessary to operate our steam roads in these, our largest provinces, has to be hauled long distances, and almost all of it has to be imported from the United States.

In view of these facts it would seem at first sight hard to explain why all our railways, at least within these provinces, have not already been electrified. Although electric tramways and interurban electric railways have rapidly developed in our thickly populated districts, yet the electrification of heavier traffic roads has been confined mainly to very short distances in connection with operations imposed by special conditions, such as the Montreal terminal and Mount Royal tunnel of the Canadian National Railway, the St. Clair tunnel of the Grand Trunk, and the Detroit tunnel of the Michigan Central.

An explanation is found in the fact that, although electricity fills every requirement of railway service, the problem of electrification is not one of mere ability to secure cheap power, but is governed rather by the volume of traffic or amount of power necessary to operate the line. To use electricity, a large investment in equipment and installation must be made, and this is little less for sparse than for dense traffic. Electrification has so far proceeded slowly, even in the United States, because railroad executives were not convinced that the advantages to be gained are always worth the cost. From their angle it is purely an economic question, with the amount of traffic as the principal factor. But, for us, there is also a national aspect in that it means substituting the utilization of our own water-powers for the importation of foreign coal.

When a section of railway has become ripe for electrification, the additional advantages gained by the conversión are almost numberless. In a recent paper before the American Institute of Electrical Engineers, Calvert Townley states: "The service performed on the electrified sections comprises practically every kind of railroad transportation. The Bluefield division of the Norfolk and Western Railroad in West Virginia is an example of an important coal road operating through the mountains. The Chicago, Milwaukee and St. Paul 440-mile main line, through Idaho and Montana, demonstrates what can be done by a transcontinental carrier on a large scale with through traffic, both freight and passenger. The New York, New Haven and Hartford Railroad stretch of 73 miles between New York and New Haven shows how through freight and a heavy passenger traffic can be taken care of on the most congested four-track section of an important eastern carrier and what is possible for complicated freight-yard operation, while the New York Central and the Pennsylvania out of New York city are splendid examples of our greatest modern passenger terminal electrifications."

*From "Conservation," the monthly bulletin published by the Commission of Conservation, Ottawa.

William Cross, 262 Garden Ave., Toronto, is now secretary of the employment bureau of the Toronto Branch, Engineering Institute of Canada.

R. C. Desrochers, secretary, department of public works, Ottawa, has called for tenders until July 2nd for nurses' home at the Sir Oliver Mowat Sanitorium, Kingston. Plans and specifications are on file at the offices of the chief architect, department of public works, Ottawa; Power & Son, architects, Kingston; the superintendent of Dominion buildings, Postal Station "F," Toronto; and the overseer of Dominion buildings, central post-office, Montreal, Que.

WATER POWERS OF QUEBEC

By Arthur Amos
Chief of the Hydraulic Service, Province of Quebec

Nature has proved most generous in the way of hydraulic resources in the province of Quebec. The government of Canada estimated, after an investigation, that the available water power of the country would reach almost 19,000,000 h.p., at the low stage of the rivers, not including the northern part of the country, of which 6,850,000 h.p. are in the province of Quebec. Of this, about 875,000 h.p. has been developed, and, as a result, large towns have sprung up on the sites which, but a few years ago, were forests. A few examples of this kind are afforded in the following towns: Grand 'Mère, with a population of 8,200; Shawinigan, 10,000; La Tuque, 4,000.

The Quebec Streams Commission of the provincial government is making a detailed examination of the drainage basins of a number of rivers of the province in order to report to the government on the possibilities and advantages of water storage in such watersheds. The field of their studies has already covered the following rivers: The St. Maurice, the St. François, the Ste. Anne (de Beaupré), the Chaudière, the Harricana, the Bell, the Assomption, etc.; also the following lakes: Des Commissaires, Jacques-Cartier, Kénogami, St. Jean, etc.

Two important storage dams have already been built. The La Loutre dam at the head of the St. Maurice constitutes what is probably the largest artificial reservoir in the world, its capacity, when full, being 160,000,000,000 cubic feet, and the water area 300 square miles. The storage will permit a regulated permanent flow of over 12,000 cubic feet per second at Shawinigan. In round figures, 1,000,000 permanent horse-power are now available on this river. The St. François dam, although of less importance—(it is expected to store about 12,000,000,000 cubic feet when filled to its utmost)—will very materially assist the numerous pulp and other mills along this water course.

The report of the commission on Lake St. John is also most interesting. If a dam were built at its outlet, the water powers on the Grande-Décharge or on the Petite-Décharge would nearly be trebled, about 800,000 h.p. becoming then available.

To show the progress of water power development, the most important works might be enumerated:—

River.	Place.	Company.	H.P.
Ottawa	at Hull	Ott. & H.P. & M. Co.	22,600
“	“ “	E. B. Eddy	14,124
“	“ “	Hull Elec. Co.	2,740
(Brewery Crk.)	“ “	City of Hull	1,000
Du Lièvre	“ Buckingham	J. McLaren Co. Ltd. .	8,125
Du Nord	“ Mt. Rolland	Rolland Paper Co. ...	1,500
“	“ St. Jerôme	“	1,300
“	“ “	J. C. Wilson, Ltd.	954
“	“ Lachute	“	1,200
Rouge	“ Table Rock	Hawk. El. L. & P. Co.	1,500
“	“ Bell Falls	“	4,000
St. Lawrence	“ Valleyfield	Montreal Cotton Co. .	7,860
(Beauharn. Canal)	“ St. Timothée	Can. Light & P. Co. .	30,400
St. Lawrence	“ Lach. Canal	Steel Co. of Canada .	1,800
“	“ “	Ogilvie Fl. Mills Co. .	2,627
“	“ “	St. Paul Ld. & Hyd. Co.	954
“	“ Soulange C.	Civ. Inv. & Ind. Co. ..	15,000
“	“ Les Cèdres	“	129,600
“	“ Lachine Rs.	“	12,800
Richelieu	“ Chambly	....	19,200
Yamaska	“ Farnham	....	1,500
St. François	“ D'Israéli	Cie. Hydr. St. Franç. .	4,300
“	“ Weedon	City of Sherbrooke ..	1,000
“	“ East Angus	Brompton P. & P. Co.	10,400
“	“ Bromt'ville	“	10,100
“	“ Windsor	Canada Paper Co. ...	5,025
Ouatapéca	....	“	450
St. François	at Drum'ville	Southern Can. P. Co. .	2,400
Magog	“ Sherbrooke	“	3,975
“	“ Rock Forest	City of Sherbrooke ..	2,960
“	“ Drum. F'lls	“	3,960
“	“ Magog	Dominion Textile	2,250
St. Maurice	“ Shawinigan	Shawinig. W. & P. Co., North Aluminum Co., Belgo Pulp & P. Co. .	216,500
Shawinigan	“ Grand Mere	City of Grand 'Mere .	1,000
St. Maurice	“ Grand Mere	Laurentide Power Co.	120,000
“	“ La Tuque	Brown Corporation ..	3,500
“	“ La Loutre	Que. Streams Com. ...	1,100
Batiscan	“ St. Narcisse	North Sh. Power Co. .	1,500
Ste. Anne	“ St. Raymond	News Pulp and P. Co.	4,160
Jacques-Cartier	“ Donnacona	Donnacona Paper Co.	6,000
“	“ Pont Rouge	“	1,150
“	“ St. Gabriel	Q.R.L.H. & P. Co.	2,200
Montmorency	“ Montmorency	“	7,625
Chaudière	....	“	4,800
Ste. Anne	“ St. Féréol	Laurentian Power ...	24,000
Malbaie	“ Malbaie	Nairn Falls P. & P. .	8,790
Chaudière	“ Mégantic	Lake Megantic Pulp .	2,050
“	“ Break'ville	John Breakey Reg'd. .	1,150
Du Sud	“ Montmagny	Basin El. L. & Power	1,250
Du Loup	“ Fraserville	Riv. du Loup Pulp ..	2,850
Rimouski	“	Price Bros. & Co., Ltd.	3,500
Shipshaw	“	“	10,800
Au Sable	“ Kenogami	“	27,000
“	“ Jonquières	“	6,700
“	“ “	City of Jonquières ...	900
Ha! Ha!	“ Grande Baie (Upper pl't)	La Cie d'Energ. Elec. du Saguenay	1,300
“	“ Grande Baie (Lower pl't)	“	1,200
Chicoutimi	“ Pont Arneault	“	2,675
“	“ Chicoutimi	Chicoutimi Pulp Co. ..	20,020
Ouiatchouan	“ Ouiatchouan	“	7,300
Ste. Marguerite	....	Gulf Pulp & Paper ..	12,900
			831,524

Besides the above, there are many other water powers of less importance. The total amount developed in the province, according to an investigation carried out last year by the Hydraulic Service of the Province of Quebec, is over 830,000 h.p. The investigation having covered only the plants developing 1,000 h.p. or more, there is good reason to believe that the total amount developed in Quebec is close to 875,000 h.p.

The undeveloped water powers of Quebec, it is estimated, would total about 6,000,000 h.p. at the low stage of the rivers, not including the northern parts of the province.

No doubt, many of the sites lend themselves to comparatively inexpensive developments while others would be so costly as to make it almost impossible at present to develop them. Some of the more important rivers, with the approximate estimated undeveloped power, are given in the list on the next page.

To obtain authorization for the utilization of a water power in the province of Quebec application must be made to the Hon. Minister of Lands and Forests, accompanied by a statement setting forth the information mentioned below.

But before indicating the conditions on which water powers are leased or granted, it is necessary to briefly explain within what limits the administration is permitted by jurisprudence to act, and why it is sometimes necessary to obtain two titles, one from the Crown and the other from a private individual, for the same property.

Under present legislation, the rivers of this province are considered as being of two classes:—

1. Those which are navigable and floatable;
2. Those which are neither navigable nor floatable.

The beds of navigable and floatable rivers are vested in the Crown, as represented by the provincial government;

and, therefore, the water powers form part of the public domain.

The beds of non-navigable and non-floatable rivers are either private property or form part of the public domain. They are private property when the lands bordering them have been granted by the Crown previous to the year 1804; on the contrary, they remain part of the Crown domain, as in the case of navigable rivers, if the lands bordering them have been sold since that date, because, under an act of the legislature, reservation in favor of the Crown is always made, since that date, of a strip of land three chains wide on the banks of non-navigable and non-floatable rivers. From this it will be seen that in the case of non-navigable and non-floatable rivers, the fact of being a riparian owner makes one also in many cases the owner of the bed of the river and of the water powers thereon.

LIST OF THE MORE IMPORTANT RIVERS IN QUEBEC, WITH APPROXIMATE (ESTIMATED) UNDEVELOPED H.P.

		H.P.
1.	Batiscan	20,000
2.	Chicoutimi	10,000
3.	Chamouchouane (or Ashuapmuchuan)	100,000
4.	Eastmain	300,000
5.	Gatineau	200,000
6.	Grande-Péribonca	300,000
7.	Hamilton ....over	500,000
8.	Harricana	200,000
9.	L'Assomption	10,000
10.	Lièvre (Riv. du)	80,000
11.	Loup (Riv. du)	7,000
12.	Maskinongé	7,000
13.	Manicouagan	500,000
14.	Métabetchouane	10,000
15.	Mistassini	200,000
16.	Nottaway	300,000
17.	Ouareau	5,800
18.	Ottawa	300,000
19.	Ouiatchouane	8,000
20.	Outarde	150,000
21.	Petite-Cascapédia	5,000
22.	Quinze	100,000
23.	Rouge	30,000
24.	Rupert	200,000
25.	Saguenay (Grande-Décharge)	800,000
26.	Sault-au-Cochon	10,000
27.	Saint-François	30,000
28.	Sainte-Anne (de Beaupré)	7,500
29.	St. Lawrence (Theoretical power between Lake St. Francis and Montreal Harbor) of which less than 200,000 are developed	2,500,000
	Total (less 200,000)	6,690,300

Now, the character of a navigable river not being defined with strict precision, the consequence is that differences of opinion sometimes arise and, in order to avoid litigation, it may be to the advantage of the purchaser to obtain the government's rights on the one hand, and those of the riparian owner on the other. Such cases evidently occur only in the older parts of the province, which have long been settled; the title from the Crown is sufficient everywhere else.

Therefore, in order to secure a waterfall for any purpose whatever, if there be any doubt as to the character of the rivers, the applicant should, first of all, send a petition to the Department of Lands and Forests, with a statement setting forth:—

(a) His name, address and occupation:

(b) A description of the lake or river from which the water is to be used, and stating in what range, township and county;

(c) The height of the fall or rapid of such lake or river, at high and low stages, with corresponding discharges of water per second in cubic feet;

(d) A plan of the lake or river showing location of falls or rapids, and a sketch plan of proposed works.

If the applicant be an incorporated company, the statement, shall, in addition to the foregoing information, set forth:—

(a) The name of the company;

(b) The names of the directors and officers of the company, and their places of residence.

On receipt of the foregoing information, and after considering same, the Minister of Lands and Forests will state the conditions on which the water power may be leased or granted, if he approves of the nature of the work to be carried out.

Such conditions usually depend on the importance of the water-powers and on their geographical situation.

As a rule, two alternatives are taken into consideration: If the water-power cannot develop more than 200 h.p., the government sells, for a fixed price, a lot in the river bed with the lots of land on the banks, if owning any, including the power that can be developed. This transaction may be made final by the granting of Letters Patent, and when this is done, the grantee becomes entirely independent of the government.

When the capacity exceeds 200 h.p., the concession generally takes the form of an emphyteutic lease. The conditions of such leases are, as much as possible, similar and about as follows:—

1. Duration of the lease, from 25 to 99 years, according to the importance of the water-power and to the amount of capital required for its development;

2. Payment of a yearly rental which does not vary during the term of the lease, for the land granted counting from the date when the contract was signed;

3. An additional yearly charge of from 10 to 35 cents per h.p. developed according to the geographical situation of the site of the water-power; such charge being payable from the time the power is produced;

4. The above charge is subject to revision every 21 years counting from the signing of the contract;

5. Delay of two years for beginning works and two further years for producing power;

6. The lessee to make a deposit in money or in securities as a guarantee of good faith of the carrying out of the contract. Such deposit may be forfeited if the conditions are not fulfilled; but it may be repaid after a certain time, in the contrary case;

7. Lastly, the grantee must submit plans of his works, mills, etc., to the department previous to their installation, and when such installation is completed, he must keep the department informed of the quantity of power produced.

Of course, the government retains the right to verify the fulfilment of these conditions and should they not be fulfilled, the lease may be cancelled.

When authorization is obtained by a lease from the provincial government, the grantee may proceed with his works on the condition that he shall not interfere with navigation, if any is really carried on; for, in that case, the plans must be approved by the federal government, whose duty is to specially protect such navigation and, consequently, to prevent the erection of anything that may impede it.

Machinery caused about 32% of all the accidents in the Province of Ontario last year, according to the annual report just issued by the Workmen's Compensation Commission. The handling or moving of objects caused 28% of the accidents, and falls of workmen, 10%. The most prolific individual causes were saws, which caused 892 accidents; lathes, 891; presses, 813; hoisting apparatus, 785; abrasive wheels, 781; belts, pulleys, chains and sprockets, 390, of which 7 were fatal; planers, jointers, and edgers, 260; shapers, moulders, and headers, 121; shafting, couplings, and set screws, 75, of which 6 were fatal. Falls from vehicles caused 260; collapse of support, 276; hot and inflammable substances, 1,018; falling objects, 1,256; and runaway animals, 98.

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PRINCIPAL CONTENTS

BRITISH INSTITUTION OF CIVIL ENGINEERS WILL RECOGNIZE "TORONTO" DEGREES

UNLESS he be a graduate of a *recognized* university, any applicant for membership in the Institution of Civil Engineers of Great Britain must pass an examination. McGill and many other universities throughout the world are on the list of educational plants so recognized by the Institution. For some reason which was never clearly understood, the University of Toronto was unable to secure the addition of its name to this "recognized" list. Graduates of the University of Toronto have long felt aggrieved in regard to this discrimination, but correspondence could not accomplish the desired result. Some months ago it was again urged editorially in *The Canadian Engineer* that the Institution lend a sympathic ear to Toronto's claims, and the suggestion was made that Colonel (now General) C. H. Mitchell be asked to interview the Council of the Institution and ascertain the nature of the stumbling-block that was in Toronto's way. Col. Mitchell was in England at the time. It was known that he had been asked to head Toronto's engineering faculty upon his return home. It seemed that he was the right man in the right place to get the matter nicely adjusted.

Sir Robert Falconer, president of the University of Toronto, noticed the suggestion and wrote a letter of thanks to *The Canadian Engineer*, saying that he would get into immediate communication with Col. Mitchell, and would ask him to spare the necessary time if at all possible.

In an interview last week, Sir Robert Falconer and Gen. Mitchell told *The Canadian Engineer* that the whole difficulty is in connection with the matriculation requirements of the University of Toronto, which in certain very minor points do not meet the Institution's standards. These points can be very readily adjusted, said Sir Robert, and Gen. Mitchell had promised the Institution that they would at once be so adjusted, and the officers of the Institution have consequently agreed that "Toronto" will be added to the list of "recognized" universities just as soon as certain formalities are arranged.

REGIONAL PLANNING AT NIAGARA

AT a recent meeting of the newly-organized Town Planning Institute, a full report of which appears on another page of this issue, H. L. Seymour, of Ottawa, spoke very deprecatingly about the "apparent lack of planning in connection with the Hydro-Electric Commission's power development" at Niagara Falls. He said that a $25,000,000 scheme is being carried out apparently without any regard to its effect on the immediate locality, and he deplored the fact that Niagara Falls, Ont., is being made an island by 8½ miles of "wide open gash."

"I understand that more than one engineer of international repute," said Mr. Seymour, "has claimed that a tunnel would have been more economical and as suitable from an engineering standpoint as an open cut. But the point I wish to make is not whether a tunnel in this case would have been better than an open cut, but that in deciding which should have been used, all factors, not merely the strictly engineering one, should have been considered."

Why has Mr. Seymour assumed that all factors were not considered? *The Canadian Engineer* is informed authoritatively that regional and town-planning considerations were given very careful thought in the plan for the whole scheme.

As to the tunnel, this alternative was most fully considered. It was a subject of study, discussion and debate among the "Hydro" engineers and their consulting engineers for many months. Mr. Seymour undoubtedly spoke in good faith when he voiced his belief that more than one engineer of international repute had claimed that a tunnel would have been more economical and just as suitable from an engineering standpoint, but it is possible that he spoke from hearsay. It is not likely that any engineer of true international repute would make an assertion of that kind without having devoted months to the study of surveys and alternative designs for the two schemes, and to the best of our knowledge and belief, at least, no engineer has made such a study excepting those connected with the "Hydro."

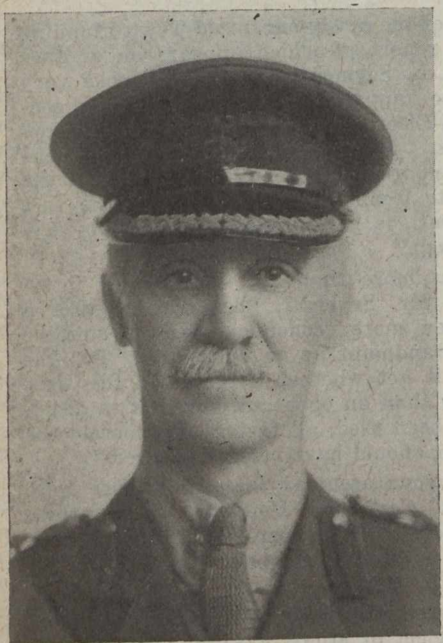
Some day the Town Planning Institute may be able to persuade the men who designed and are building the Chippawa-Queenston power canal, to present papers to the institute explaining the scenic features of the design and possibly outlining some of the reasons why the tunnel alternative was abandoned.

REDUCTION OF WATER WASTE

LAST week *The Canadian Engineer* published an article by the water commissioner of Buffalo, N.Y., who told about the marked reduction in water consumption that was effected by means of pitometer surveys. That article should be a lesson in economy for all water works superintendents and municipal engineers. Consumption and waste in Buffalo had once reached 339 gallons daily per capita,—truly a shocking figure. The city desired to build a filtration plant, but recognized the necessity of first reducing the waste. The pitometer surveys, combined with house-to-house inspection, were very effective, reducing the pumpage to less than 125,000,000 gallons a day. The good work will undoubtedly be kept up by periodical surveys to avoid recurrence of underground leaks, and metering to prevent sheer carelessness by consumers. Water works departments have at their disposal the means to stop practically all waste of water, and every department should have enough initiative and interest in economy to make prompt use of all those means, including inspection, surveys and metering.

PERSONALS

COL. H. J. LAMB, of Windsor, Ont., has been appointed superintending engineer for the Province of Ontario, Department of Public Works of Canada. Col. Lamb's headquarters will be in Toronto. He is a graduate of the Royal Military College, Kingston, Ont., president of the Royal Military College Club, and a member of the Engineering Institute of Canada. Col. Lamb just recently returned home after four years and eight months of service overseas. Before enlisting he was district engineer at Windsor, Ont., for the Department of Public Works. He enlisted August 10th, 1914, and went overseas in September as a general staff officer with the first Canadian division. He served in France on the general staff of the first and third divisions until invalided to England in March, 1917. From April, 1917, to April, 1919, he was Deputy Assistant Director of Field Works at the war office, London, and had charge of much of the work in connection with the construction of aerodromes throughout Great Britain and Ireland. He was twice mentioned in despatches and received the D.S.O.



CAPT. F. A. DALLYN, sanitary engineer of the Board of Health of the Province of Ontario, who has been in Siberia for several months in charge of sanitation and housing for the Canadian expeditionary force, has landed at Vancouver on his way home. Upon his return to Toronto, Capt. Dallyn will resume his duties with the provincial department.

A. M. E. E. CONVENTION AT NIAGARA

Superintendents and Managers of Publicly-Owned Electrical Utilities Hold Third Convention and Make Tour of the Chippawa-Queenston Power Canal

AT Niagara Falls, Ont., last week there was held the third annual convention of the Association of Municipal Electrical Engineers of Ontario. Thursday morning, June 19th, was devoted to registration, the first meeting being called to order at 2.30 p.m., when President O. H. Scott, manager of the Hydro-Electric System at Belleville, Ont., delivered his presidential address.

Secretary Clement reported that there had been an increase of 19 members since the last convention. There are now 104 publicly-owned utilities in the association. All excepting about 10 of these are "hydro" municipalities. Fifteen new commercial members have been secured since the last convention, making a total of 33 commercial members. The registration at the convention was about 225, and fully 150 delegates attended each of the business meetings.

R. C. McCollum, auditor of municipal accounts, Hydro-Electric Power Commission of Ontario, read a paper Thursday afternoon on "The Routine Handling of Consumers' Accounts." In the evening the convention dinner was held at the Clifton, and was addressed by A. Monro Grier, K.C., of Toronto, president of the Canadian Electrical Association, who spoke on unity and co-operation, urging all employees of public utility corporations to do their own work well and faithfully.

Movement to Effect Standardization

W. L. Goodwin, of the General Electric Co., New York, and Samuel A. Chase, of the Westinghouse Electric & Manufacturing Co., East Pittsburg, Pa., spoke Friday morning, June 20th, on "The Goodwin Plan." These two addresses, together with the enthusiastic discussion on them, occupied the whole morning. As a result of the discussion on Mr. Chase's paper, which made a strong plea for standardization, a committee was appointed to secure the standardization of plugs and receptacles for all electrical appliances sold in Canada.

The president was elected as a representative of the association to confer with other associations and with manufacturers and dealers to effect some scheme of practical co-operation in the standardization of all appliances, and also of voltages, periodicity, etc., of distribution systems, so that appliances bought in one town can be used in another.

C. E. Schmenger, engineer of distribution, Toronto Hydro-Electric System, read a paper Friday afternoon on "Overhead Distribution Systems."

Motored Along Power Canal

Saturday morning the delegates assembled at the Clifton Hotel at 9.30 o'clock, and as guests of the Hydro-Electric Power Commission were taken in automobiles and motor trucks on a tour of inspection of the Chippawa-Queenston power canal.

The work of assembling the plant and organization for this great undertaking has been very difficult, and the maximum progress in excavation has not yet been obtained. Nevertheless, the delegates were all greatly pleased with the way the work is progressing.

Probably more than 2,000,000 cu. yds. of earth have been moved, out of the total of 11,000,000 cu. yds. that will have to be excavated before the job is completed. Of the 4,000,000 cu. yds. of rock work, upwards of 1,000,000 cu. yds. have been moved.

Rapid Progress at Forebay

The huge power-driven shovels, which were specially made for this job, are working to capacity. Drilling and blasting are progressing rapidly at the forebay site. The forebay will probably be complete before the end of the season, ready to begin work next year on the construction of the power-house. Marked changes are being made in the landscape at the St. David's disposal area, where quite a little trouble is being experienced in track maintenance owing to the rapid settlement of the dumped material.

At the first convention of the Association of Municipal Electrical Engineers at Niagara Falls in June of last year, the delegates were taken on a tour of inspection of the canal on one of the construction trains, but this year they were able to see all the work from automobiles, as the Commission has built a road paralleling the canal for its entire length, and also leading to the St. David's disposal area. For this purpose rock has been utilized from the giant Traylor crushing plant, which has a daily capacity of 2,000 cu. yds. of crushed stone.

A professional meeting of the Engineering Institute of Canada will be held July 10th to 12th, in Edmonton, Alta. About 100 members are expected to be present. Last year's summer professional meeting was held in Saskatoon. The program for the Edmonton meeting includes a wide range of technical subjects and open discussions on various matters of interest to the engineers of the western provinces. The Edmonton members of the institute are now making arrangements for the meeting.