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The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Analysis of Concrete-Proportioning Theories

Data Upon Which Abrams' Fineness Modulus and Edwards' Surface Area Methods Are Based Show Validity of Water-Cement Ratio Theory and Demonstrate That Fineness Modulus Varies With Surface Area—Tests All Agree But Interpretations Differ

By RODERICK B. YOUNG

Engineering Materials Laboratory, Hydro-Electric Power Commission of Ontario

IN the last eighteen months, much new information has been published on the laws underlying concrete mixtures, and at least two different methods of proportioning based on this new data have been proposed. These two methods, the "fineness modulus method" of Prof. Duff A. Abrams, and the "surface area method" of Lewellyn N. Edwards, have been described in detail in *The Canadian Engineer*. The two methods would seem to be conflicting. The discussion both for and against, which the publication of these methods has occasioned, and the direct contradiction of their basic principles made by the engineers of the Bureau of Standards, has further tended to strengthen this impression and to obscure the fact that the published data of the different parties to this controversy, if not the conclusions derived therefrom, are in striking agreement.

Prof. Abrams' method is based primarily upon a relationship which he has discovered between the compressive

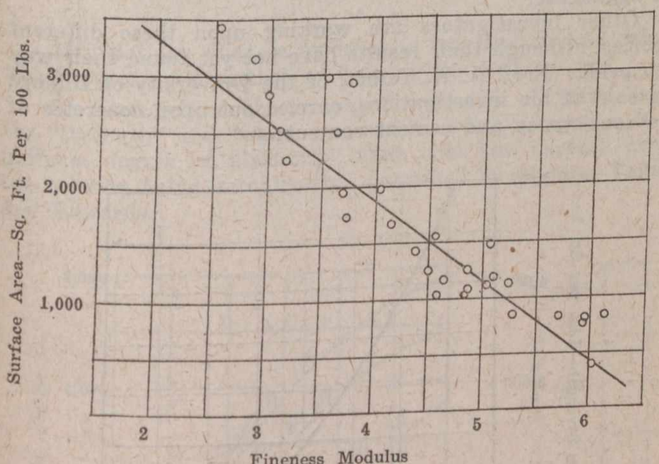

FIG. 1—RELATION BETWEEN FINENESS MODULUS AND SURFACE AREA OF GRADED AGGREGATES (FROM H. E. P. C. TESTS)

strength of a concrete and the ratio between the volume of water and volume of cement used in producing it. He claims that for given concrete materials, the strength depends on only one factor, the ratio of water to cement, called for convenience the water-cement ratio, that this relation holds so long as the concrete is workable, and that the character of the aggregate makes little difference so long as it is clean and not structurally deficient, and so long as proper account is taken of differences in their absorptive qualities. From this he concludes that the size and grading of the aggregate, and the quantity of cement, are of no importance except in so far as these factors influence the quantity of mixing water required to produce a workable concrete.

The fineness modulus of an aggregate is obtained from its sieve analysis. The percentages of material coarser than each of the sieves used, is summed and the result divided by 100. Prof. Abrams has standardized on a particular set of sieves, the basic sieve of which is the No. 100, having a sieve

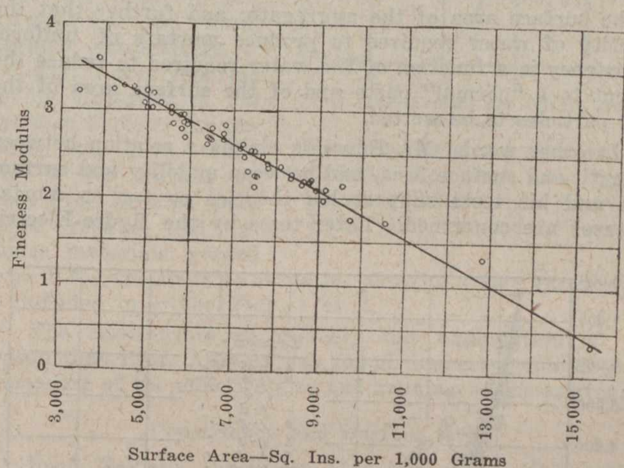

FIG. 2—MR. EDWARDS' DIAGRAM SHOWING RELATION BETWEEN SURFACE AREA AND FINENESS MODULUS

opening of 0.0058 in. In each succeeding sieve of the series, the opening is double the width of the preceding one.

Prof. Abrams claims that this fineness modulus enables one to interpret properly the sieve analyses of an aggregate, and that all aggregates of the same fineness modulus require the same quantity of water to produce a mix of the same

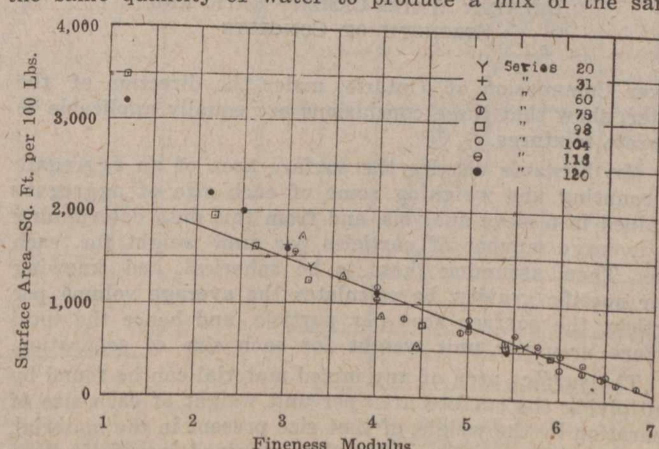

FIG. 3—RELATION BETWEEN FINENESS MODULUS AND SURFACE AREA—DERIVED FROM RESULTS OF PROF. ABRAMS' TESTS

plasticity and to give concrete of the same strength, so long as the aggregate is not too coarse for the quantity of cement used. This, he says, is because the fineness modulus simply reflects the changes in water-cement ratio necessary to produce a given plastic condition.

Mr. Edwards' method is based on the theory that for uniform plasticity and uniform strength, the cement varies

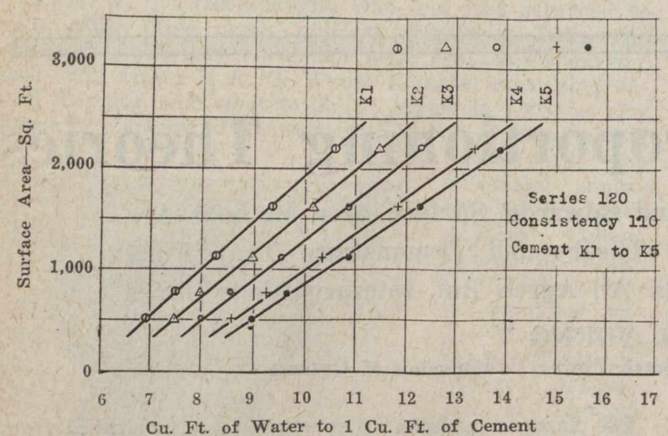

Fig. 4—Relation Between Mixing Water and Surface Area to Give Constant Plasticity (Derived From Prof. Abrams' Tests)

as the surface area of the aggregate; and further that the quantity of water required to produce mortars of uniform consistency is a function of the water required to reduce the cement to a "normal" paste and of the surface area of the sand particles to be wetted.

In other words, Mr. Edwards claims a relation between strength and surface area, and between mobility and surface area and his tests support his theories so far as mortar mixtures are concerned. Later tests by the Hydro-Electric

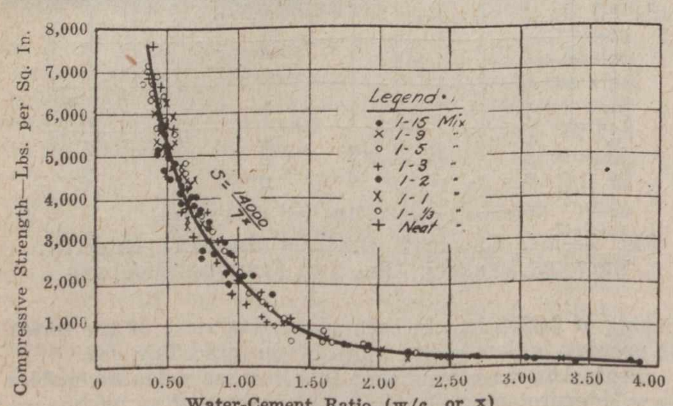

Fig. 5—Prof. Abrams' Diagram Showing Relation Between Water-Cement Ratio and Strength of Concrete

Power Commission of Ontario, under the direction of the writer, show that these conclusions are equally applicable to concrete mixtures.

Mr. Edwards obtains the surface area of an aggregate by counting and weighing some of each size of aggregate obtained in a sieve analysis, and from this data determining the average number of particles per unit weight for each size. Then, assuming these to be spherical, and knowing their specific gravity, he calculates the average volume per particle, the surface area per particle, and hence the total surface area per unit weight for each size of separation.

The surface area of any mixed material can be found by multiplying the surface area per unit weight of each size of separation by the weight of that size present in the material, and adding these. The value thus obtained is not the true surface area, for the latter cannot be obtained, as the particles are not true spheres, are variable in shape and have not smooth surfaces. However, this value undoubtedly bears a constant relation to the true surface area, and for all practical purposes is equally as useful.

The Bureau of Standards, Washington, D.C., made a limited series of tests to check the findings of these investigators. As a result the Bureau claims that the water-cement ratio is only an incidental relation of no direct value to the engineer in proportioning concrete, that a wide difference in strength is found with constant water-cement ratio and that there is no relation between surface area and strength. These conclusions directly contradict the findings of the two last-mentioned investigators.

At a later time, however, the Bureau makes this interesting statement: "Our tests indicate that for constant flow-

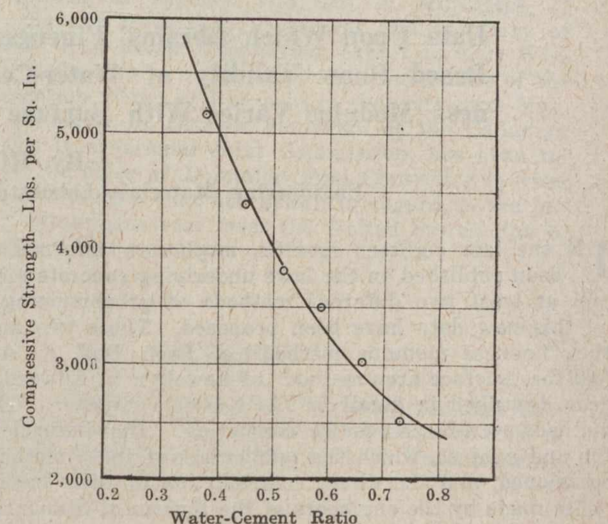

Fig. 6—Relation Between Water-Cement Ratio and Strength of Concrete (Platted From Mr. Edwards' Tests)

ability the water required varies with the surface area of the aggregate."

Other investigators are working upon these different theories, although their results have not yet found their way into print. Prof. A. N. Talbot, of the University of Illinois, has said of his investigations, carried out upon concretes of one consistency and cement content:—

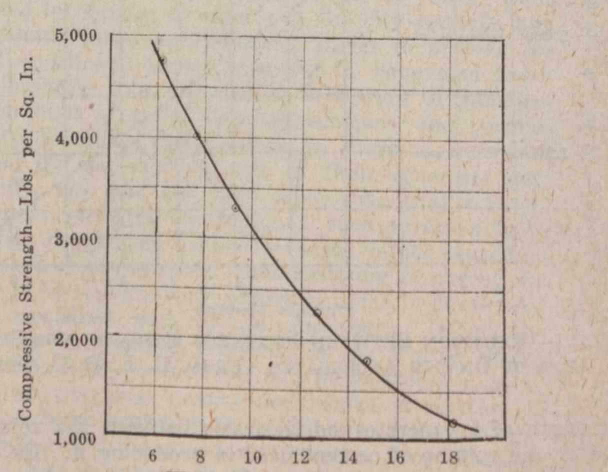

Fig. 7—Relation Between Water-Cement Ratio and Strength of Concrete (Platted From Bureau of Standards' Tests)

"The tests indicate that for an aggregate having a given size of particles, the amount of mixing water required to produce a concrete of a given consistency, or mobility, is equal to a constant plus a term which is dependent upon the surface area. The tests show that the strengths of these concretes, made up to have the same mobility, are also dependent upon the surface area. Concretes having the same water-cement ratio give nearly the same strength through a part of the range of water-cement ratio values, but for each maximum size of particle, the results diverge from the main curve,—this occurring at places along the curve which vary with the maximum size of particle and which are quite far apart."

The Hydro-Electric Power Commission of Ontario has been conducting investigations along similar lines. Some of the conclusions so far reached are:—

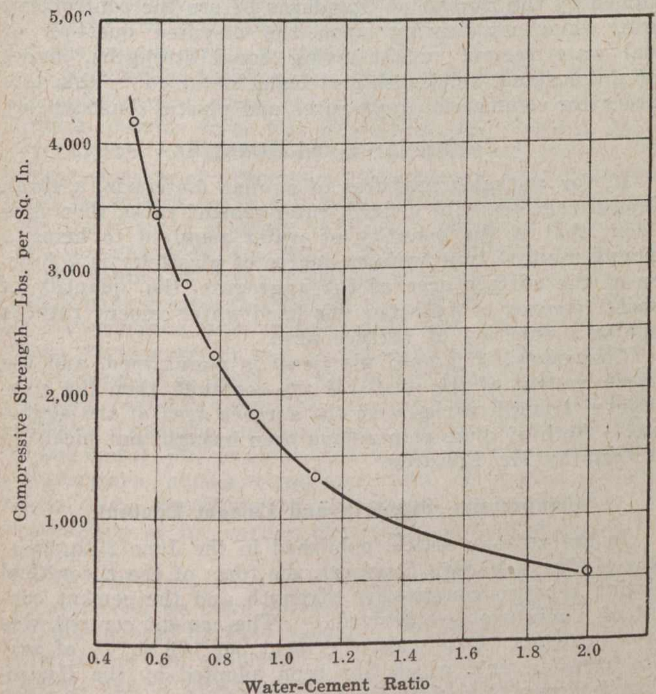

FIG. 8—RELATION BETWEEN WATER-CEMENT RATIO AND STRENGTH OF CONCRETE (H. E. P. C. TESTS)

1. That the fineness modulus is but another and somewhat approximate method of defining the surface area.

2. That within the range of workable mixtures, both the "strength" and "water required to bring a mixture to a uniform degree of plasticity" vary with the surface area, the relation being actually that described by Messrs. Talbot and Edwards.

3. That there is a fixed relation between water-cement ratio and strength for mixtures of the same cement, same aggregate and same age.

Fineness Modulus and Surface Area

Fig. 1 shows the relation found when the fineness moduli of mixed aggregates are platted against their surface areas as determined by the Edwards method.

This figure is similar to one given by the writer in *The Canadian Engineer*, June 26th, 1919, issue, except that it covers materials from dust to 1½ ins., while the former included only sands graded from dust to ¼ in. In the article just referred to, algebraical expressions for both the fineness modulus and surface area were derived, and it was shown that no mathematical relation exists between them. While an infinite number of values of fineness modulus may be found for any one value of surface area, and vice versa, yet it is a remarkable fact that for the materials ordinarily encountered, fineness modulus varies approximately with the surface area.

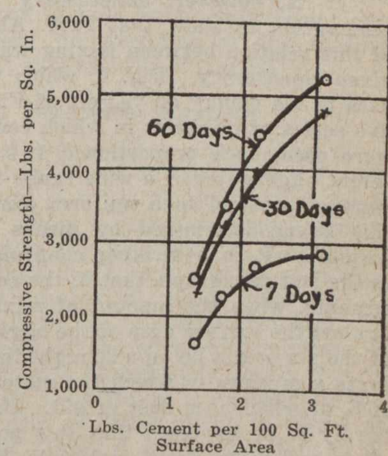

FIG. 12—RELATION BETWEEN CEMENT CONTENT AND COMPRESSIVE STRENGTH (PLATTED FROM MR. EDWARDS' TESTS)

Figs. 2 and 3 show similar curves obtained from the data of Mr. Edwards and Prof. Abrams, respectively.

Fig. 2 was reported by Mr. Edwards in *The Canadian Engineer* for October 9th, 1919, while Fig. 3 was worked up from Prof. Abrams' published results, and includes materials graded from 0-No. 28 sieve to 0-1½-in. sieve, a wider range than is included in either Figs. 1 or 2.

The relationship is probably the explanation of the reason that Prof. Abrams has found fineness modulus to be a measure of the effective size and grading of the aggregate.

Consistency and Surface Area

Prof. Talbot's conclusion that the water in concretes of equal cement content, necessary to produce a concrete of a given consistency, is equal to a constant plus a term which

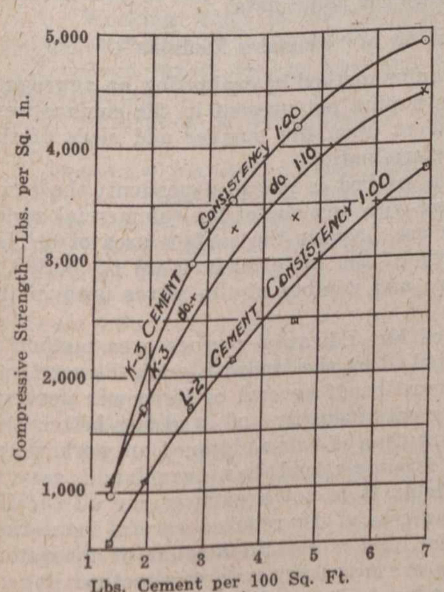

FIG. 9—*Derived from Prof. Abrams' Tests*

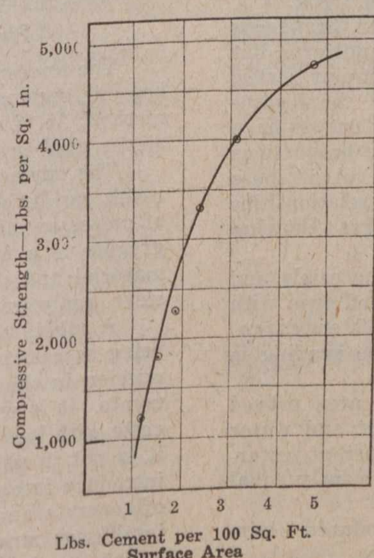

FIG. 10—*Derived from Bureau of Standards' Tests*

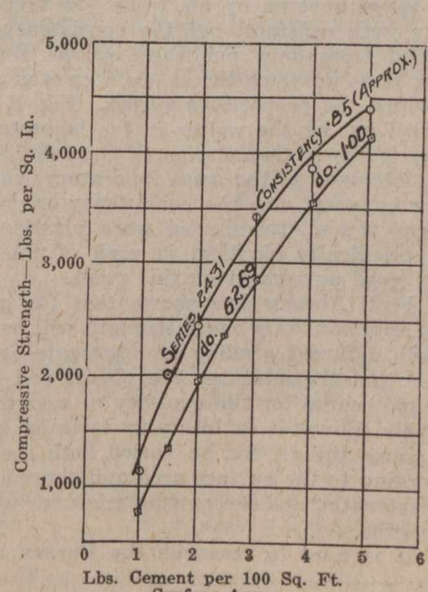

FIG. 11.—*H. E. P. C. Tests*

RELATION BETWEEN CEMENT CONTENT AND COMPRESSIVE STRENGTH OF CONCRETE is dependent on the surface area, is the same conclusion arrived at by Mr. Edwards in his study of mortars. The writer's studies of both theoretical and experimental data corroborate this conclusion. The engineers of the Bureau of Standards confirm this partially when they state that their tests indicate that for constant flowability the water required varies with the surface area of the aggregate. Prof. Abrams uses his fineness modulus to proportion mixtures to a given consistency, and to do this uses a formula in which the water required is the sum of a quantity dependent on the amount of cement used and a quantity varying with the fineness modulus. Assuming fineness modulus to be another way of stating surface area, or vice versa, it is evident that the work of each of these investigators point to the same end.

Unnecessary to Make Assumption

It is, however, unnecessary to make the foregoing assumption to show that Prof. Abrams' results bear proof of this relation between mixing water and surface area at a given consistency. Fig. 4, which was worked up from the data in his paper* on "Effect of Fineness of Cement," shows five series of mixtures in which cements of different fineness were used, each proportioned 1:4 by volume with six different aggregates of a wide range in grading. The mixtures were all gauged to a uniform consistency, the water to do this being determined by means of Prof. Abrams' water formula. It is a striking confirmation of the law outlined in the last paragraph, that in the case of each of the different cements, when the amount of mixing water used is platted against the surface area of the aggregate in the mixtures, five of the six points lie on a straight line. The sixth point represents a mixture in which the material was a very fine sand, 10% of which was dust or silt. Under these conditions it is hardly to be expected that this point would agree with the other and more usual materials, because our means of determining equal mobilities are not such as to function accurately under these conditions.

The results of Fig. 4 cannot be explained by the fact that the surface area and fineness modulus have approximately a linear relation, for in the series represented (see Fig. 3, Series 120), this relation is a slight curve.

Water-Cement Ratio and Strength

Fig. 5, taken from the article by Prof. Abrams which was published in *The Canadian Engineer* for June 6th, 1918, shows the general relation found by Prof. Abrams between compressive strength and water-cement ratio. This curve covers an extremely wide range of mixtures, materials and consistencies. Fig. 6 is platted from the results of Mr. Edwards' mortar tests and show a similar relationship for the range covered by his tests. In these tests the proportions were constant, but the consistency varied. Fig. 7 is platted from data published by the Bureau of Standards from tests in which the consistency was nearly uniform, but in which the proportions varied. Fig. 8 is a similar series, carried out by the writer in the laboratories of the Hydro-Electric Power Commission of Ontario. Similar curves have been obtained in the same laboratory where the proportions were constant and the consistency varied. In all of these curves the mixtures used were plastic. The relationships are practically identical in each of these figures, showing very good agreement on this point.

Prof. Abrams has shown that for given materials and age, approximately equal strength will be obtained even with widely different grading of aggregate and consistency, provided that the mixtures are plastic and that the grading is not too coarse for the quantity of cement used.

Mr. Edwards in his early tests on surface area proved the same things, for he varied both the cement and water according to the surface area and obtained a constant water-cement ratio, and his mortar mixtures were of nearly equal strengths.

It is hard to reconcile the Bureau of Standards' claim that "a wide difference in strength is found with constant water-cement ratio even with the same aggregate and cement," unless it is that these tests were designed to give unusual conditions.

Prof. Abrams, in commenting on the Bureau's tests, has said of the aggregate used: " Over 40% of the aggregates were too coarse for the quantity of cement used; 26% of the mixes were too dry; 21% were both too coarse and too dry; 72% of the aggregates were of freakish grading." The writer agrees with Prof. Abrams' criticism, and considers this to be the explanation of the unusual results obtained.

It is interesting to note that Fig. 7, drawn from data obtained by the Bureau of Standards before the controversy arose, while not bearing upon the disputed question of equal water-cement ratios having equal strengths, shows that a consistent relationship is being obtained in this laboratory for commercial aggregates and plastic consistencies.

Surface Area and Strength

If, for workable mixtures of similar materials, a given strength concides with a fixed water-cement ratio, then it is evident that if the quantity of water required to bring a concrete mixture to a uniform degree of plasticity is a function of the surface area of the aggregate, the quantity of cement required to maintain this fixed water-cement ratio is likewise a function of surface area.

Conversely, if a fixed plasticity is maintained, and the cement content of the mixtures are constant, then the compressive strength varies with the surface area of the aggregate. Both of these points have been brought out nicely in the tests by Mr. Edwards.

Compressive Strength and Cement Content

In the writer's article published in the June 26th, 19 issue of *The Canadian Engineer*, the form of the theoretical relation between compressive strength and the cement content of a mixture was derived. The cement content was given in terms, of "pounds of cement per 100 sq. ft. of surface area," a unit which has been adopted by the Hydro-Electric Power Commission in all of its work. Figs. 9 to 12 show curves of the same form obtained from the experimental data of the investigators referred to, with the exception of Prof. Talbot. In the case of the tests of Figs. 9 and 12, the original results were obtained by other than the surface area method of proportioning. These curves are strikingly similar and are further evidence of the agreement between the data of the different investigators.

It is not within the scope of this article to discuss the relative merits of either the fineness modulus or the surface area methods of proportioning. Enough has been brought out, the writer believes, to show that they are simply different adaptions of essentially the same data.

Shortcoming of "Fineness Modulus"

The fineness modulus method of evaluating an aggregate has one serious shortcoming not present in the surface area method: It is dependent upon the number and sizes of the sieves used in its determination.

The surface area method is not so dependent; the same result can be obtained with any one of the commercial series of sieves in common use, because the surface area of an aggregate is a property of the material and not of both the material and the size and number of the sieves used in the sieve analysis.

A modification of Mr. Edwards' surface area method is being successfully applied by the Hydro-Electric Power Commission in the construction of several of its power developments. It is working satisfactorily and is giving better concrete with less cement than is being obtained on work where it is not in use. It is simple, and has been found easy to introduce into the field. It is not a panacea for all the ills of concrete, and its successful use requires careful inspection, intelligent supervision and a certain amount of laboratory assistance, but these are necessary with any method if good concrete is to be produced. It can be made to do all that is claimed for the "fineness modulus method," and it has certainly been found simpler to "put over" in actual field work.

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*Presented June, 1919, before the American Society for Testing Materials; see *The Canadian Engineer*, November 6th, 1919, issue for summary of this paper.

Letters to the Editor

EFFECT OF RODDING CONCRETE

Sir,—Prof. F. E. Giesecke's tests on rodded concrete, reported in your August 14th issue, are of interest in showing the increased strength due to this treatment, and in illustrating the extent to which fresh concrete may be disturbed without adversely affecting its strength. The author properly attributes the increase in strength to the removal of the excess water by rodding.

The writer believes, however, that Prof. Giesecke is not on safe ground when he compares his tests directly with certain results from this laboratory, and depends on that comparison for a measure of the effect of rodding when using concrete of different consistencies. It is unfortunate that he did not make a parallel group of tests from which the water-ratio strength relation could have been platted for the unrodded concrete. (The water-ratio is the ratio of the volume of water in the batch to the volume of cement, considering cement to weigh 94 lbs. per cu. ft.) The strength of his concrete was probably different from ours, due to many factors which had no relation whatever to the effect of rodding. In other words, in his Fig. 1 the water-ratio strength curve for unrodded concrete may have been entirely different from the curve shown (which is based on certain of our tests), due to differences in the quality of the cement, temperature, curing conditions, time of mixing, or numerous other variations which affected all tests alike. The comparison of his earlier tests with our curve is not very convincing.

In our discussions of the water-ratio strength relation for concrete, we have pointed out that the constants in the formula quoted by Prof. Giesecke ($14,000/7^R$ where R is the water-ratio, an exponent) depend on the quality of the cement, age of concrete and other conditions of the test.

Other tests made in this laboratory give different values of these constants, although the general relation between water-ratio and strength has been found to hold true for different proportions of given materials so long as the concrete has water enough to make it plastic and the aggregate is not too coarse for the quantity of cement used.

Prof. Giesecke's Error

Prof. Giesecke has fallen into an error in plotting his tests in Fig. 1, since no allowance was made for the reduction in the water-ratio of the concrete as a result of rodding, due to one or more of the following factors:—

1. Working water to the surface, which escaped, and consequently did not influence the final water-ratio.
2. Evaporation due to long exposure of the cylinder during rodding.
3. Absorption of water by the aggregate during rodding.

Concrete which was originally mixed with a water-ratio of 1.00, may after rodding have a water-ratio of 0.7, consequently the strength should be platted with reference to the latter figure and not the former. In other words, the curves from Prof. Giesecke's tests should all be moved to the left, the exact position being unknown on account of the uncertain effect of rodding on the final water-ratio. If this were done, we would find a very different relation from that given by the original figure, and at the same time attribute the increase in strength to the proper cause; that is, the artificial reduction in the water-ratio.

The time of setting of the cement used in Prof. Giesecke's tests would have been of interest. Undoubtedly the plastic condition was quite different for the concrete which had been rodded for long periods than at the beginning. This should be borne in mind in considering applications of this method. It seems probable that the strength would have been quite similar had the concrete been permitted to stand for the periods shown, before being placed in the forms, provided that sufficient water were used in the beginning to provide a plastic mix after the absorption and evaporation had occurred.

In a series of tests carried out by the writer several months ago, a study was made of the effect on the strength of the concrete of using different methods of moulding the specimen. We were interested only in methods which could be used in moulding test cylinders in the laboratory. Compression tests were made on 6 by 12-in. cylinders at the age of 28 days, using sand and pebbles graded up to 1½ in. A 1:5 normal consistency mix was used, with a water-ratio of 0.87. For 12 strokes of the ⅝-in. steel bar on each 4-in. layer of concrete, we secured a strength of 2,680 lbs. per sq. in.; for 25 strokes, 2,780; and for 50 strokes 2,810; an increase of about 4% for 25 strokes as compared with 12, and an increase of about 5% for 50 strokes as compared with 12.

The first and third values were the average of 5 tests; the second, the average of 15 tests made on different days. Puddling was done during the moulding of the specimen and the concrete was not subsequently disturbed.

Water-Ratio Determines Strength

These tests showed a comparatively slight effect due to the different number of strokes used on each layer. Twenty-five strokes for each 4-in. layer is the number regularly used in making our test pieces. It will be noted that the water-ratio of this concrete was not changed, consequently we would expect little effect due to the number of strokes, so long as the minimum number of strokes gave compact concrete. Several methods of tamping were also used. The same series covered a study of the effect of vibration, jigging and pressure. These tests brought out clearly that the increase in strength due to pressure on fresh concrete may be measured by the quantity of water which is forced out by the pressure. In other words, *it is the reduction in the water-ratio of the concrete which increases the strength.*

It is the writer's belief that much of the effect due to workmanship in handling and placing concrete can be traced to the influence of any particular practice on the final water-ratio of the mixture.

DUFF A. ABRAMS,
Professor-in-Charge,
Structural Materials Research Laboratory,
Lewis Institute.

Chicago, Ill., November 22nd, 1919.

EFFECT OF WATER UPLIFT ON OVERTURNING OF DAMS

Sir,—Replying to your comments in your issue of November 6th, regarding article on "Effect of Water Uplift on Overturning of Dams," the writer wishes to make a few explanatory remarks.

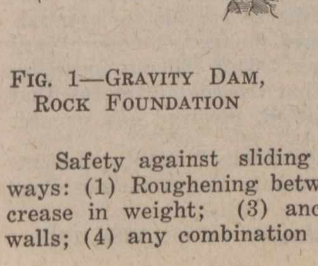

Fig. 1—Gravity Dam, Rock Foundation

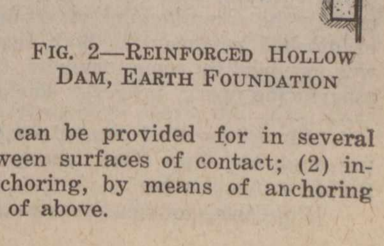

Fig. 2—Reinforced Hollow Dam, Earth Foundation

Safety against sliding can be provided for in several ways: (1) Roughening between surfaces of contact; (2) increase in weight; (3) anchoring, by means of anchoring walls; (4) any combination of above.

Fig. 1 shows gravity dam section with rock surface roughened so that stability against sliding depends on shearing strength of concrete or rock.

Fig. 2 shows hollow reinforced dam section on earth foundation provided with toothing and anchoring wall. This method is comparatively new and has been described fully in the transactions of the American Society of Civil Engineers, December, 1917, in the article on the "Reconstruction of the Stony River Dam."

In both cases, Figs. 1 and 2, no concrete has been added to the amount required for stability against overturning, except in that in the second case a small amount of concrete was added to form toothing and anchoring wall. Inasmuch as this anchoring wall is merely an extension of a cut-off wall, but heavily reinforced and thicker, it serves two purposes—namely, (a) safety against sliding; and (b) increase in percolation distance in conjunction with sheet piling.

E. MAERKER.

Jackson, Mich., November 21st, 1919.

ECONOMIC STATUS OF GUARANTEES FOR PAVEMENTS ON ROADS AND STREETS*

THIS committee has very carefully considered the points brought up in the discussion of its progress report† during the annual convention held in New York, February, 1919, and in the technical press thereafter. It feels that certain of the criticisms of its report were based upon an incomplete understanding of its aim and scope, but realizes the difficulty of discussing a subject of this kind after listening to the reading of a somewhat lengthy and comprehensive report without having had opportunity to study it thoroughly.

It has been suggested that it would be helpful if the committee were to indicate what it considers a proper period of reasonable life without repairs for various kinds of pavement under different conditions. An earnest effort to compile such a table, which would cover all possible conditions, clearly showed however that the wide variation necessary in a general schedule would render the figures worthless and would probably lead to a very heated discussion as to whether the figures cited were to be regarded as a measure of the life of various types of pavement when laid upon different kinds of foundations and subjected to traffic of various densities, and the attempt was therefore abandoned. Each set of conditions must be given individual consideration, and the committee believes that the determination of such reasonable periods in any particular case would not be extremely difficult and that any competent engineer can do this satisfactorily.

The committee's recommendation that the guarantee bond be supplemented by a cash retainer was based largely upon the difficulty sometimes experienced in having necessary repairs made within a reasonable time and was designed to provide a means of enforcing this necessary provision of any paving contract without first having to resort to a lawsuit. As a rule, a municipality has no fund available for this class of work and the cash retainer therefore serves two purposes:—

1. It tends to bring the contractor back to make the repairs, as he knows he will collect some money toward the expense involved.

2. It gives the municipality cash with which to make the repairs and thus avoids the necessity of going through the formalities and oftentimes difficulties of securing an appropriation, with all the attendant delays.

In this connection the committee recommended that a greater percentage be retained on resurfacing work as compared with new construction, in order to provide for approximately the same amount of retained money per square yard of finished pavement in both cases. This did not mean, as was assumed by some members, that the committee felt that resurfacing work, properly conducted, involved any greater guarantee liability than new construction work. On further consideration of the matter, your committee believes that reasonably adequate protection would be assured to the municipality by a reduction of the amount of the retained moneys from 10% to 20%, as at first recommended, to 5% and 8%, respectively. It further feels that such a provision cannot be justly held to be a curtailment of a contractor's working capital.

Fifteen Cents Per Square Yard

In arriving at this conclusion, your committee takes the position that fifteen cents per square yard to cover guarantee liabilities may be assumed as a fair average. On this basis the following figures may be considered as typical and illustrative of the principle involved:—

	Resurfacing.		New work.
Construction cost per sq. yd.	$1.50		$2.50
10% profit	.15		.25
Guarantee	.15		.15
Total	$1.80		$2.90
Retained (8%)	.15	(5%)	.15
Payment on completion	$1.65		$2.75

In both cases the contractor receives a payment equal to his construction cost plus profit, the municipality retaining an amount practically equal to the sum included by the contractor in his bid as necessary to cover the guarantee provisions. This amount per square yard is the same for both types of construction and has not been expended by the contractor in his work and will not be expended by him except where defects in construction have occurred. While held by the municipality, the contractor will be paid interest on it. This amount, while sufficient to cover ordinary defects in workmanship and insure the making within a reasonable time of necessary repairs, is totally insufficient to cover extensive repairs rendered necessary by serious defects or failure of the work, protection against this being assured by the guarantee bond.

Your committee further believes that the criticism that its provision as to forfeiture of all retained moneys in case of failure to make ordered and necessary repairs is too drastic, is well founded and has modified its progress report in that respect by providing that the city may make these repairs at the expense of the contractor and such expense shall be deducted from the retained money. When any part of the retained money is due to the contractor, only such balance as has not been expended by the municipality shall be considered to be due and payable. When the cost to the city of such repairs exceeds the amount of retained money, the balance shall be recoverable from the sureties.

Amendments to Progress Report

It therefore submits as its final report, all of its progress report down to the paragraph commencing: "For new construction involving grading," etc., and adds thereto the following:—

"For new construction involving grading, foundation and wearing surface, we would recommend that an amount equal to 5% of the aggregate cost of these items be retained.

"For surfacing on an old foundation, we would recommend retaining an amount equal to 8% of the cost of surfacing.

"In the case of a two-year guarantee, the whole of the retained money should be payable at its expiration and not before. In the case of a five-year guarantee, one-fourth of the retained moneys should be payable two years after the completion of the pavement and the balance in three equal instalments. The date when payments of retained moneys become due shall be governed by the clause previously recommended for pavements completed and accepted between November 1st and May 15th.

"If the contractor, having received notice from the engineer, fails to make and complete the ordered repairs within a reasonable time (not to exceed thirty days in any case), the city shall have the right to undertake and complete the ordered repairs at the expense of the contractor or his sureties."

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*Final report of committee (Francis P. Smith, consulting engineer, New York, chairman) to the American Road Builders' Association.

†Published in *The Canadian Engineer*, June 12th, 1919.

SIX HUNDRED MANITOBA "GOOD ROADSTERS"

Assembled at Joint Roads and Municipal Associations' Banquet to Consider Province's Future Highways Policy and Welcome President S. L. Squire

WINNIPEG has been definitely chosen as the meeting place for the annual convention of the Canadian Good Roads Association to be held the second week in June, 1920, S. L. Squire, president of the association, announced last week at a joint banquet of the Manitoba Good Roads Association and the Union of Manitoba Municipalities. Over six hundred were present, representing every organized municipality in Manitoba.

The speakers of the evening were Sir James Aikins, Premier T. C. Norris, Mayor Charles F. Gray (Winnipeg), S. L. Squire and several others. Sir James Aikins said:—

"At this gathering are representatives of all organized Manitoba, who show their spirit by action as well as words in the upbuilding of our system of roads. Roads are now recognized as one of our greatest necessities."

Most Successful Year in History

S. R. Henderson, president of the Manitoba Good Roads Association, acted as chairman. "Ten years ago the Good Roads Association of Manitoba was inaugurated," he said, "and since the drafting of the Good Roads Act great strides have been made in the development of our roads. This has been the most successful year in our history."

Premier T. C. Norris declared that "the Good Roads Association and the Union of Municipalities are among our two most useful organizations. We have representative men here—men who carry on the good government of our municipalities. Co-ordination and co-operation is shown in this gathering. The question of good roads is one of the great problems of the day. The time has arrived when we must have a 365-day road in Manitoba. It will be some time yet before we reach such a standard, but we are gradually working there. The main trunk roads of the province should be dealt with first, and then the market roads should be built up. It is the intention of the province to have trunk roads extending across the province within a short time. Large sums will necessarily have to be expended and they must be spent well. In order to maintain our position as one of Canada's foremost provinces, we must have good roads. Good roads will have a good effect on community life. It will result in more of our young people staying on farms and will continue farming as our basic industry. The people of Winnipeg are taking a great interest in the building of roads, and if Winnipeg progresses other parts of the province will progress also."

No Particular Types Recommended

Mr. Squire outlined the work of the association during the past few years. Winnipeg was chosen for the next convention, he said, because of the great interest taken by that city and the west in the development of the roads. "We do not say what kind of roads should be built," said Mr. Squire, "as long as they are good roads. Every dollar spent on roads is an investment for the country. We are past the experimenting stage.

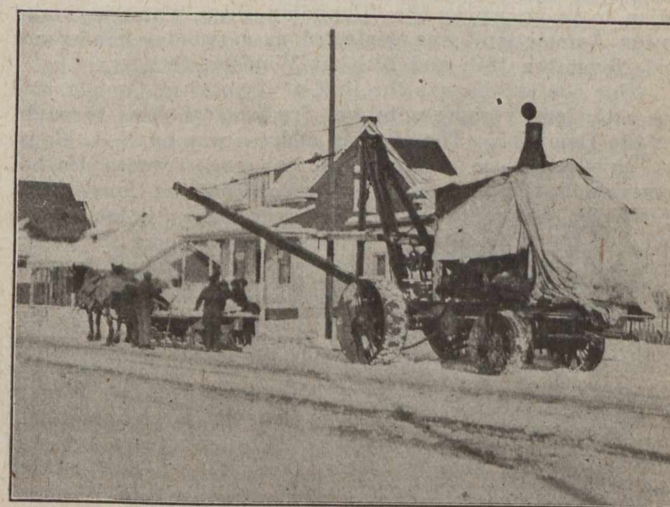
"There is no such a thing as a permanent road. The only thing that is permanent is the location. Roads must continually be repaired. Roads must be built to take care of the traffic to which they are subjected. Expensive roads should not be built where there is little traffic, and cheap roads should not be built where there is a great deal of traffic. We have come to the time when the government must take over the initiative and lay plans for the building of roads. It is purely the work of the government.

"In the past roads have followed colonization, but we have reached the period when colonization must follow the roads, just as immigration follows transportation. The building of roads will fill up the vacant lands of the west and result in greatly increased production. It will be a good investment and will mean the upbuilding of the country. The people will support the government which lays a good system of roads throughout the province."

FROST HEAVES STREET RAILWAY PAVING SLABS IN EDMONTON

By C. L. De Vall
General Contractor, Edmonton, Alta.

CONSIDERABLE inconvenience, and some delays to Edmonton's street railway system were caused recently by the early "freeze-up." The triangular-mesh-reinforced concrete pavement between the rails was heaved for several m..es by the action of the frost—enough to interfere with the gear casings of the street car motors, causing suspension of traffic until the heaved slabs were removed.



Tractor Derrick Loading the Slabs

This condition, arising quickly, required prompt action by the city's officials. The slabs varied in length from 6 to 16 ft., the larger ones weighing about 1½ tons each, presenting a rather awkward bundle to handle on account of their shape and weight.

The first operation was to remove the slabs from their location between the rails and skid them to the curb; this was done to open the lines quickly and to find temporary storage for the obstructions, although in a measure they were still more or less obstructions for vehicular traffic. Special equipment was necessary to remove these slabs from the curb advantageously. A tractor hoist and derrick was secured from a local contractor, and with its aid the slabs were loaded on flat cars, special hooks being used for grappling the slab.

Unloading and Piling Slabs at Pool

This work was necessarily carried on in the early hours of the morning and was suspended when the cars started running. The time available each night proved too short to make sufficient headway with the work, so teams and sleighs were secured and the work carried on in daylight, this proving to be the more satisfactory method.

The problem of salvage and disposal was partially solved by deciding to line the children's swimming pool at the park with the slabs, which work will use up a large quantity of the slabs. For the unloading, a small stiff leg derrick was used to pile the slabs in accessible locations convenient for rehandling when the time arrives to line the pool.

INLAND WATERWAYS CONFERENCE

WITH the object of obtaining an inland waterway suitable for ocean-going freighters and extending from the Atlantic Ocean to the head of the great lakes, an organization to be known as the "Canadian Deep Waterways and Power Association" was perfected at a two-day conference held November 18th and 19th at Windsor, Ont.

This conference was the first of its kind in Canada, and was attended by representatives from many cities throughout the Dominion. The opening address was by E. L. Cousins, chief engineer and general manager, Toronto Harbor Commission, who took as his subject, "What the Canalization of the St. Lawrence Means to Great Lakes Points." He spoke of the work Toronto is doing in developing its waterfront and stated that approximately $25,000,000 will be spent in deepening the bay and reclaiming marshland.

Already $19,000,000 has been expended by the city, several millions by the government, and several millions remain to be spent. The returns on the money invested for the past year were still less than the expenditure, but Toronto is not disappointed, and believes that the large investment has been well made. On land which a few years ago was only marsh and shallow water, factories are now located which employ upwards of 6,000 men, and Toronto estimates that an additional population of 20,000—a small city in itself—has been attracted to the city by the harbor improvements and the new industrial sites built up from waste land to attract manufacturers.

Until Canada extends her export trade, said Mr. Cousins, she cannot expect to get a full dollar's worth for a Canadian dollar, and her citizens would have the experience which he had had in Detroit of having to pay five cents to get a Canadian dollar changed.

Toronto had undertaken great harbor improvements because Toronto is the logical importing and distributing point for the province of Ontario, and because she needed deep draft vessels to call at her port to carry her manufactures chiefly to distributing points. Last year the imports of Toronto were $17,000,000 in excess of Montreal.

A British investor who recently opened a factory in Toronto had said he would not have located there had he not anticipated that in a very near day he would be able to load his own boat with raw materials at Swansea, and unload it at his own wharf at the door of his Toronto factory.

Toronto now controls 99 per cent. of its water front, an advantage which no other city in America possesses. Out of the total appropriation Toronto has spent $2,000,000 in parks and boulevards, preserving a part of its water front for the recreation of its citizens. The newspapers supported the project strongly, and even the railroads gave it encouragement.

Dwelling upon the wonderful natural resources of Canada still untouched, Mr. Cousins mentioned a new discovery of what he believes to be the greatest iron deposits in the world, near James Bay.

Since Toronto improved her harbor, private capital has invested over $5,000,000 in land that was formerly marsh and water. A New York amusement firm had offered millions for amusement privileges on one point of the reclaimed land which has been kept for park purposes.

The possibilities of the development of ocean commerce on the Great Lakes were discussed by C. P. Craig, of Duluth, secretary of the Great Lakes-St. Lawrence Tidewater Association; Hon. Frank H. Keefer, Port Arthur, under secretary of state for Canada; and R. J. McLean, Detroit, ex-director of the Atlantic Deeper Waterways' Association.

Mr. Craig pointed out that the Canadian Northwest must have a market, which could only be obtained when greater transportation facilities are provided for ever-increasing production. He urged co-operation between Canada and the United States in furthering the project of canalizing the St. Lawrence. He asserted that the deepening of the St. Lawrence would reduce the cost of carrying a bushel of wheat from Duluth to Liverpool from 15 cents to 9 cents.

Mr. Keefer thought that the time is not far off when waters of the Long Sault will be harnessed to supply light and power for the homes and factories of Michigan cities. He said that the governments of the United States and Canada have been so interested in railways, and the railways themselves have been so selfish, that development of the Great Lakes as highways for deep-water vessels has been overlooked. The problem of carrying the increased production of the local northwest, which, he said, the railways had wholly failed to meet, can only be solved by deepening the St. Lawrence.

With more than a million horsepower available by proper development of the St. Lawrence, there is no reason why the whole of Ontario and a great portion of the State of New York should not be using "white coal," thereby releasing many million tons of coal for use in other sections of the two countries.

At the afternoon conference November 19th, Sir Adam Beck spoke on power development. He stated that by means of deepening the Welland Canal to from 25 to 30 ft., and deepening the St. Lawrence at one or two points, 90 per cent. of all ocean-going vessels in the world would be able to traverse the Great Lakes freely.

The power possibilities of the St. Lawrence were unexceeded anywhere. For four years the Hydro Power Commission had had a skilled staff of engineers and investigators, in constant research and investigation, collecting information and data regarding the possibilities of this development.

For the whole Great Lakes-St. Lawrence development scheme, not much more than $100,000,000 would be required. To carry the coal used in this territory 285,000 cars were required. By building one dam and deepening a waterway to 30 ft., half a million carloads of coal would be saved by the power developed for Ontario and New York.

Ninety per cent. of all ocean-going vessels could traverse a passageway 24 ft. deep.

The building of the Morrisburg dam would make possible the control of the levels of Lake Ontario, with a regulation of from two to four feet. It would also increase the depth of Montreal harbor from two to three feet, while now at certain times of the year vessels cannot dock at Montreal for lack of six additional inches of water.

Remedial works would also increase the levels of Lake Erie from two to three feet and 50,000 second feet wo[illegible] be gained without impairing the scenic beauty of Niagara Falls. On the American side 20,000 second feet would be gained.

W. M. German, K.C., the newly elected honorary president of the Canadian Deep Waterways and Power Association, said that before the St. Lawrence river could be navigable for ships 600 ft. long and requiring a 30-ft. draft, the expenditure would amount to about $200,000,000.

A resolution calling for the joint undertaking of the deepening of the Great Lakes waterways for ocean-going shipping by the governments of the United States and Canada was moved by O. E. Fleming, of Windsor, and seconded by Clarence R. May, of London, Ont. The resolution follows:—

"That this association is of the opinion that the work to be undertaken in the deepening of the natural watercourses for ocean-going shipping should be undertaken by the governments of the United States and Canada jointly, and that it should be operated as a joint undertaking, so far as the watercourses may be international, and that the water powers of the St. Lawrence should be developed to their fullest extent for the purpose of producing a revenue, such revenue to be used to provide a sinking fund for the retirement of t[illegible] capital expenditure, payment of interest and maintenance and operation of the canal system and hydro-electric operation; and that in this way, in our opinion, the project should be made self-supporting."

Recovery of Valuable Constituents of Garbage

Summary of the Various Methods of Disposal of Municipal Wastes, Including Hog-Feeding, Incineration, Sorting, Reduction, Alcohol Production, Etc.—Paper Read Two Weeks Ago at Annual Convention of American Society for Municipal Improvements

By SAMUEL A. GREELEY
Consulting Engineer, Chicago, Ill.

THE subject-matter of this paper covers a large and important field of municipal activity. It is not within its scope to reach many of the details of the processes required for the economic recovery of valuable materials from municipal refuse; the paper deals very largely with general principles and the limitations attending their application.

The term "valuable" is, furthermore, difficult to use with any degree of certainty under present market conditions. Only the most careful consideration of local conditions, with projects tempered by a measure of flexibility, can justify definite conclusions.

Particular attention is directed to the importance of local conditions in developing methods of garbage disposal. Apparently satisfactory garbage disposal is obtained in one place by incineration, in another by hog feeding, another by reduction, etc. Matters of administration, stage of city development, past experience and training in garbage disposal, location, climate, character of population, topography, soil and many other factors are pertinent.

Fundamental Considerations

Broadly speaking, a method of final disposal of municipal refuse should serve three functions as follows: (a) It should render satisfactory service to householders; (b) it should be measurably clean and sanitary; (c) it should be reasonably economical.

In accomplishing these three ends, there are four parts, or phases, of the problem to be developed, as follows: (1) The house treatment; (2) the collection; (3) the transportation; (4) the final disposal.

The problem of garbage disposal is the proper development and adjustment of these parts of the problem to local conditions. The house treatment more directly affects the people; the collection is generally the more costly part of the work; transportation other than in collection wagons is needed only in the larger communities; while final disposal involves more engineering work and in general stimulates more discussion than the others. In the author's opinion, each of the four phases is equally important, and a limitation of what follows primarily to disposal is not intended to eliminate or discard the influence of "house treatment" and "collection" upon the disposal.

Two other fundamental considerations are important, viz.: (a) The so-called relative values in sanitation; and (b) the fact that a successful handling of the refuse problem revolves primarily about operation.

By relative values is meant such items as, for instance, the stage of other municipal improvements possibly more directly affecting the public health, as well as the question of the proper cost of measures for eliminating odors not constituting a general nuisance. It is also obvious that "operation" looms large in refuse disposal work and must be given first consideration during the development of new works.

Valuable Constituents

Refuse is the term for the solid waste resulting from community activities as distinguished from sewage. Refuse is made up of garbage, ashes, rubbish, manure and many other materials. The valuable constituents contained in them are as many as the varied activities of the community. These constituents may, however, be roughly classified by the disposal methods used to recover them, thus:—

1. Dumping, or land fill, makes the fullest use of the inert constituents of refuse not otherwise generally useful. Sometimes valuable land can thus be made.

2. Burial, or ploughing into the soil, makes possible the recovery of those constituents of refuse which are valuable for fertilizing the soil. Manure is quite generally disposed of in this way and some cities have developed its collection and transportation to farming districts very advantageously to the public comfort and the municipal pocket book. At Columbus, Ohio, a gross revenue of about $4,000 per annum is derived from the sale of manure. Street sweepings are also used in this way; sometimes, for instance, to cover dumps of mixed refuse for park purposes.

3. Mixed refuse can be burned at high temperature, producing steam suitable for power development, thus recovering or using the carbon and hydrogen contained in the refuse. With the increased demand for power, the higher price of coal and oil, and the gradual reduction in available close-by dumping areas, the value of refuse for steam production is increasing.

4. Garbage contains grease and tankage, both valuable constituents which are being economically recovered on a large scale by the reduction process.

5. From rubbish many marketable materials can be recovered, such as paper, rags, leather, old metals and the like. The process is commonly termed "rubbish sorting."

6. An old and universal method of recovering the valuable food constituents from garbage, is by feeding to hogs. This is one of the most interesting and useful methods of garbage disposal which has recently been given much prominence by war shortage of food.

7. There are many other processes for the recovery of valuable constituents from garbage which have been more recently studied, such as the production of alcohol and the preparation of a stock and chicken food.

Hog Feeding

For garbage alone, feeding to hogs is a method of disposal which undoubtedly has a wide field. By this method the food constituents of garbage are recovered in part. Some tests during an investigation of the refuse disposal problem made by the writer in Louisville, Ky., showed that 32.4 pounds of city garbage were required to add one pound to the weight of the hogs. The tests lasted seven weeks and covered observations on the feeding and growth of 25 to 40 hogs. The garbage was taken from several collection districts, but contained a somewhat smaller amount of other refuse materials than does much city garbage. With pork on the hoof at 15 cents a pound, the garbage would have a gross value of $9.26 per ton. It was actually sold by the city at that time (September, 1918), at $3 to $3.50 per ton for feeding to hogs.

At Worcester, Mass., where the separation of garbage is very good, it takes 37.5 pounds of garbage per pound gained by the hogs.

Hotel garbage has a higher food value. Mr. Gaumnitz, who feeds such hotel garbage in St. Louis, states that it takes only 25 pounds of such garbage to make one pound of gain on a hog; and this data is confirmed by tests at the Iowa Agricultural Experiment Station. At 15 cts. per pound of pork, hotel garbage should thus have a gross value for feeding purposes of $12 per ton.

From the gross indicated value of garbage for hog feeding, it is, of course, necessary to deduct plant operation, risk, overhead, fixed charges, etc. These vary with the location of the hog farm, the value of the land, the climate, the length of the contract and the care with which the operation of the farm is conducted. In 1916, in connection with a study of garbage disposal in Worcester, Mass., the writer estimated the total annual cost at $2.30 per ton, which was considered rather liberal at that time, but was predicted on an ample plant and good operation. As a matter of fact, contractors seem willing to pay not much over $1 per ton for city garbage, and in some cases less, some contract prices being as follows:—

Town.	Year.	Price paid by contractor to city per ton of delivered garbage.
Minneapolis, Minn.	1918	$1.26
Grand Rapids, Mich.	1917	0.45
Portland, Ore.	1918	3.90
Newark, N.J.	1919	1.20*
St. Paul, Minn.	1917	0.80
South Bend, Ind.	....	....
Anderson, Ind.	1917	1.00

*Figured at 8 times the pound price of live pork in Chicago.

The operation of hog farms is not an easy matter and varies considerably in different places, which may possibly explain the abandonment of hog feeding as a method of disposal in some cities. Of first importance is a superintendent who knows the feeding and care of hogs. But sanitary considerations are likewise important and must supplement the experience of the hog feeder. The more important items are:—

(a) Methods of feeding, (b) area required, (c) pens and runways, (d) vaccination, (e) disposal of unconsumed garbage, and (f) suppression of rats and flies.

The design will depend somewhat upon the location of the hog farm. For instance, in a report on hog feeding of garbage at Rockford, Ill., the writer recommended that "no garbage be fed to hogs in buildings closer than 300 ft. from a traveled roadway, and that garbage fed out of doors on platforms should be at least 600 ft. away."

Of paramount importance, however ,are matters of house treatment, frequency and adequacy of collection, and other items affecting the public comfort and the quality of the garbage.

Incineration

The carbon contained in refuse is a valuable constituent. The carbon content of garbage is low, generally less than 5%, and is not sufficient to warrant economical recovery. However, the carbon content of ashes and rubbish is higher, and so-called "mixed refuse" (garbage, ashes, and rubbish as collected from houses) contains as much as 20% of carbon. This gives it a value of about one-fourth that of coal (80% carbon), and as many municipalities are now paying upwards of $5 per ton for coal for pumping stations and lighting plants, the indicated gross value of a ton of mixed refuse is $1.25. Assuming an average evaporation of one pound of steam from and at 212 deg. F. per pound of refuse, this is equivalent to 6¼ cts. cost per 100 lbs. of steam, as compared with 4 cts. per 100 lbs. of steam used in the Milwaukee incineration tests in 1910.

A plant to burn mixed refuse should be especially designed for that purpose. The details of design cannot be taken up in this paper, but there are a number of plants which have been giving good service for periods up to 12 years as at Westmount, Savannah, Altanta, Milwaukee, West New Brighton and elsewhere. A record of power production at the Milwaukee refuse incinerator is shown in Table 2, and a record of operation of the refuse incinerator at Westmount, P.Q., in Table 1.

In projects for mixed refuse incineration, the effect (of collecting the refuse mixed) on the house treatment and cost of collection are important factors.

Rubbish Sorting

Rubbish contains much material which can be sorted out and sold, such as paper, rags, metals, rubber, shoes, and the like. During the war, the government urged that this should be done as a conservation measure, and there appears to be no reason why the practice is not good.

The gross value of rubbish varies with the market over a wide range. From 35% to 50% of the rubbish by weight can usually be recovered under normal city conditions. These materials bring in a gross revenue of about $2 per ton of rubbish on pre-war prices. The figures from the Columbus municipal rubbish sorting plant are given in Table 3. The selling price of rubbish materials in the Chicago market from quotations dated November 7th, 1919, are as follows:—

Metals—		
Copper	$ 0.16	per pound
Light copper	.15	" "
Brass—red	.16	" "
" —heavy yellow	.10½	" "
" —lighter yellow	.09	" "
" —yellow boring	.09	" "
" —red boring	.14	" "
Lead	.05¼	" "
Zinc	.05	" "
Mixed iron	12.00	per ton
Rags—		
Mixed rags	.03	per pound
Bagging	.02	" "
Paper—		
Newspaper	.70	per 100 lbs.
Mixed paper	.60	" " "

MILWAUKEE, WIS.

TABLE 2— POWER PRODUCTION AT REFUSE INCINERATOR.

Month, 1917.	Total k.w. hrs.	Month, 1917.	Total k.w. hrs.
January	3,466	July	86,404
February	.....	August	118,249
March	.....	September	107,057
April	59,160	October	59,607
May	32,985	November	16,884
June	32,072	December	.....
Year's total			515,794

Average percentage of refuse incinerated:—Garbage, 68.84; ashes, 26.49; rubbish, 4.49; manure, 0.17. Average evaporation per pound of mixed refuse, 1.626 lbs.

TABLE 1— FIXED CHARGES, OPERATING COST AND REVENUE OF WESTMOUNT, P.Q., REFUSE INCINERATOR

	1907*	1908	1909	1910	1911	1912	1913	1914	1915	1916
No. of tons of refuse	10,704	13,641	14,331	15,280	17,008	20,878	18,731	23,800	20,800	19,500
Fixed charges:—					*COST PER TON*					
Interest	$0.19	$0.17	$0.19	$0.25	$0.25	$0.21	$0.23	$0.18	$0.20	$0.22
Sinking fund	0.04	0.08	0.06	0.08	0.07	0.05	0.05	0.04	0.05	0.05
Depreciation	0.13	0.12	0.15	0.21	0.21	0.17	0.17	0.15	0.15	0.17
Operating charges	0.55	0.52	0.46	0.48	0.59	0.48	0.65	0.55	0.65	0.71
Total cost	$0.91	$0.89	$0.86	$1.02	$1.12	$0.91	$1.10	$0.92	$1.05	$1.15
Revenue	0.36	0.31	0.40	0.40	0.46	0.40	0.45	0.48	0.48	0.46
Net cost	$0.55	$0.58	$0.46	$0.62	$0.66	$0.51	$0.65	$0.44	$0.57	$0.69

*Ten Months.

Rubber—		
Automobile tires	.03	per pound
Tubes	.09	" "
Mixed boots and shoes	.07	" "
Arctic shoes (cloth covered)	.04	" "

A rubbish sorting plant comprises a receiving room and a wide belt conveyor travelling slowly up between two platforms on which the sorters stand. Along the outside of each platform are bins for storing the sorted materials. Below the bins are baling presses and other apparatus used to prepare the materials for shipment. An incinerator, usually with a boiler, is required to burn the unsorted rubbish. Such plants are in operation at Buffalo, Rochester, Pittsburgh, Columbus and elsewhere; and in many places rubbish materials are sorted on the dump and sold. The revenue from the sale of the sorted materials does not usually much more than pay for the cost of operation.

TABLE 3—REVENUE FROM COLUMBUS, OHIO, MUNICIPAL RUBBISH SORTING PLANT

	1917.	1918.
Bottles	$ 365.21	$ 116.33
Paper	1,859.06	1,876.06
Iron	145.53	58.19
Rags	579.94	239.45
Cans	452.59	1,600.31
Metal	114.39	5.50
Miscellaneous	5.03	28.26
	$3,521.75	$3,924.10

Reduction of Garbage

Reduction of garbage is a chemical and mechanical process whereby the garbage is separated into four parts, viz.: Volatile matter driven off as gas; water; grease; and dry material which is somewhat stable, mostly fibrous, and of vegetable and animal origin, and called "tankage." The grease and tankage have market values.

TABLE 4—VALUE OF PRODUCTS FROM GARBAGE

Market price of grease, per pound.

Year.	Chicago. Cts.	Cleveland. Cts.	Columbus. Cts.
1913	....	4.26	3.73
1914	....	4.17	4.32
1915	....	4.41	3.76
1916	7.29	6.50	5.17
1917	7.34	8.00	7.50
1918	11.57	13.50	11.76
1919	....	5.0 to 7.6	.....

Market price of tankage, per ton.

Year.	Chicago.	Cleveland.	Columbus.
1913	....	$6.00	$6.79
1914	....	6.75	7.41
1915	....	8.75	7.00
1916	$4.16	7.75	8.50
1917	4.16*	9.58	10.84
1917	10.27**	....	.....
1918	10.27*	18.50	20.50
1918	16.85**	....	.....
1919	.....	10.00	.....

*To August 1st. **Balance of year.

The amount of these materials which can be recovered depends upon the character of the garbage and the process used for recovery; 2½% of grease and 11% of tankage by weight of raw garbage may be recovered. The gross value of these constituents depends upon the market price, which varies greatly, as shown in Table 4. The present market price of grease is about 6 cts., and of tankage about $10 per ton, which would indicate a gross value of garbage for the reduction process of $4.10 per ton. During the war these prices were doubled.

Many processes have been devised for reducing garbage, cost of which fall into one of three groups designated as follows:—Drying method, cooking method, and Cobwell process.

The Cobwell process is the most recent and may be described as the "dehydration, or drying, of the garbage by cooking at low temperature while immersed in a solvent, the extraction of grease from the dried garbage by the same solvent, the recovery of the solvent for further use, and the production of grease and dry tankage for the market." Almost all of the action takes place in closed reducers and the connections. At New Bedford, Mass., the recovery by the process is stated to be 4% of grease and 15% of tankage, and at Los Angeles, Cal., 15.5% of grease and 3.1% of tankage.

TABLE 5—MATERIALS RECOVERED AT CLEVELAND AND COLUMBUS REDUCTION PLANTS

Cleveland

Year.	Total tons of garbage reduced.	Percentage of total garbage recovered. Grease.	Tankage.
1905	30,382	2.63	....
1906	34,891	3.07	....
1907	37,606	3.14	....
1908	41,242	3.46	9.2
1909	44,525	3.70	11.3
1910*	44,747	3.75	13.2
1911	46,562	3.53	12.8
1912	43,555	3.38	11.5
1913	52,384	3.13	9.7
1914	55,730	2.95	10.5
1915	66,271	2.81	10.4
1916	63,450	3.06	11.2
1917	56,121	2.73	11.3
1918	57,254	2.36	11.0

Columbus

Year.	Total tons of garbage reduced.	Percentage of total garbage recovered. Grease.	Tankage.
1911	17,534	1.85	12.9
1912	18,789	2.72	11.6
1913	20,711	2.72	10.5
1914	21,629	2.73	9.7
1915	22,909	2.21	10.0
1916	21,862	3.08	10.3
1917	17,127	2.26	10.21
1918	15,630	2.16	10.26

*At Columbus operation was begun in July, 1910, and there was no percolation until January, 1912.

In the drying method, the garbage is first dried and then degreased in naphtha percolators. The grease recovery is comparatively low and the tankage recovery somewhat higher than in other processes. At the Chicago reduction plant, which uses the drying method, the percentage of grease recovered is 2.0, and of tankage 22.7, for the year 1918.

The cooking method comprises a first cooking of the garbage with live steam under pressure, then pressing out the free water and grease, then drying the pressed material, and finally recovering additional grease by percolation with a solvent. This process is used at Cleveland, Columbus and elsewhere. The percentage of grease and tankage recovered is shown in Table 5. Garbage reduction plants are usually located at some distance from built-up districts, which requires a transportation of the garbage. This and other local factors, such as size of city, should be considered in connection with this method of disposal.

There are, in addition to the more generally used methods mentioned above, several comparatively new methods not yet tried out on a very large scale. The Union Poultry Food Co., of Los Angeles, have a process which consists in placing the garbage, as collected, in a direct heat steam dryer. The dried product, which amounts to about 18% by weight of the garbage, is sold for poultry food, bringing as high as $40 per ton. This would indicate a gross value of the garbage of $7.20 per ton. The process has been considered at Kansas City, Mo.

A process for the production of alcohol from garbage, under patents held by Dr. S. J. Morgan, has been tested (1916) on an experimental basis at Columbus, Ohio. These tests showed a possible yield of 4.8 gals. of alcohol per ton of garbage, which, at 40 cts. per gallon, indicates a gross value of $1.92 per ton of garbage. It appeared from the tests that the recovery of grease and tankage was not materially affected by the alcohol recovery process.

There are, of course, other processes, such as that of Dr. Marsh, recently considered at St. Louis, which the inventor guarantees will yield "at ordinary market prices" not less than $3.60 per ton of garbage; the "Nufuel" or "Oakoal" process for making fuel briquettes; and others.

Summary

The writer does not feel justified in offering any conclusions in this paper except that garbage disposal should be considered with a view, where possible, to an economic recovery of valuable constituents. The lure of profit, however, should not overshadow the development of operation for the convenience and comfort of the householder and for the economy of collection.

It is a mistake to arouse public opinion on the matter of disposal where other parts of the problem are of equal importance and sometimes more costly. Nevertheless, economy of operation, elimination of waste, the salvage of useful and essential materials, are matters of vital importance in the present development of society, and the skill and efficiency with which they are done will reflect the general progress of the community.

This means that the economic value of valuable constituents of garbage and other refuse materials must be considered with the house treatment and collection, first cost of plant, overhead and fixed charges, and costs of operation. When and where the problem is approached in this broad, sound way, the writer believes that methods of disposal involving the recovery of valuable constituents will endure and will permit of operation without the interruptions and changes of method which now occasionally occur.

The Mechanical Engineering Department of the University of Manitoba, Winnipeg, Man., requests all firms manufacturing mechanical machinery and apparatus of all kinds to place the department on their mailing lists for catalogues, bulletins, etc.

Boynton & Williams, dealers in contractors' supplies, have moved to new and larger offices and warerooms at 42 Lombard St., Toronto. George P. Beswick, secretary of the Purchasing Agents' Association, and for twenty years with the Polson Iron Works, Toronto, has been appointed office manager and purchasing agent of the Boynton & Williams organization. At the new warehouse a large stock of pipe, valves and fittings is being carried. The firm also acts as representatives for a number of American manufacturers, and deals in new and used machinery.

In a circular letter sent to water companies and departments by the American Water Works Association, the formation of the American Committee on Electrolysis is announced, with representatives from water, electrical and railway engineers' and gas associations, etc., the purpose of this committee being to gather and classify information regarding electrolysis and to study and report on methods of construction and means of mitigation. The committee will co-operate with the Bureau of Standards in carrying out experiments and investigations and it is proposed that Prof. Lewis Allen Hazeltine, of Stevens Institute, should serve as a technical expert on the consulting board, on behalf of the interests of the water companies and departments. Subscriptions towards a fund of $3,000 to finance this work are now being solicited.

NO ROOM FOR TRADE UNIONISM IN ENGINEERING PROFESSION, SAY DIRECTORS OF AMERICAN ASSOCIATION OF ENGINEERS

FOLLOWING is a statement that has been issued by the executive committee of the American Association of Engineers, setting forth the position of that association in regard to trade unionism in the engineering profession:—

Reason for Statement.—In the present state of industrial unrest, the Board of Directors of the American Association of Engineers considers it desirable to make a statement defining the position of the association.

Responsibility.—The American Association of Engineers is an incorporated organization responsible for its acts.

Economic Position of the Engineer.—The engineer is the medium through which both capital and labor are used in production and in industrial development. The aim of the profession is to advance civilization and render the highest service to society. Except when their acts further this aim, it is an advocate of neither capital nor labor.

Increased Production.—Production should be increased—not limited. The profession cannot support strikes or lockouts or any other methods that may benefit any class at the expense of the nation as a whole. They are unsound and must inevitably lead to economic disaster. The law of supply and demand for men or material must ultimately prevail. Attempts may be made to limit the supply of either, but looking toward the upbuilding of civilization, we believe rather in increasing the demand through the promotion of legitimate enterprises.

Reward According to Merit.—Rewards should be according to ability, initiative and constructive effort. Men are not equal in these respects. Each man should be encouraged to do his utmost and be given compensation according to ability and will to increase production and to achieve large results.

Methods.—The engineer, as an educated professional man, believes in basing his claims for proper and just reward for his services upon the justice of the facts presented, upon enlightenment of public opinion, upon loyalty between employer and employee, and upon the underlying fundamental desire of the great majority to do what is fair and right when the merits of the case in question are clearly presented and demonstrated. We believe in organized representation for the correction of wrong, the advancement of the profession and service to the public, but are opposed to methods inconsistent with the dignity of the profession and which would lessen public confidence.

Conclusion.—The American Association of Engineers, through its Board of Directors, who have signed this statement, recognizing the many fundamental differences between the principles and objectives of the trade union and of an organization of professional men, expresses the opinion that an engineer cannot subscribe to the tenets of both.

Signed by Dr. F. H. Newell, head of department of civil engineering, University of Illinois; W. W. DeBerard, western editor, Engineering News-Record, Chicago; T. A. Evans, assistant engineer, Jacobson & Schraeder, Chicago; R. Burnham, consulting engineer, Chicago; W. W. K. Sparrow, chief engineer C. M. & St. P. Ry., Chicago; Harold Almert, consulting engineer, Chicago; J. N. Hatch, consulting engineer, Chicago; F. K. Bennett, principal assistant engineer, M. & St. L. Ry., Minneapolis; H. W. Clausen, general office manager, C. D. Osborne Co., Chicago; C. A. Soans, patent attorney, Chicago; W. D. Wilcox, past president, American Association of Engineers; L. K. Sherman, U. S. Housing Corporation, Washington, D.C.; Isham Randolph, consulting engineer, Chicago; Alexander Potter, civil engineer, New York; E. F. Collins, valuation engineer, St. L.S.F. Ry., St. Louis; C. H. Crawford, manager, Baldwin Locomotive Works, Philadelphia; John Ericson, consulting engineer, Department of Public Works, Chicago; and C. E. Drayer, secretary, American Association of Engineers.

(NOTE.—Since the above statement was received, we have been advised by C. E. Drayer, secretary of the American Association of Engineers, that all of the other directors of the association have added their signatures to the statement, making it unanimous.—EDITOR.)

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Western Canada Office: 1206 McArthur Bldg., Winnipeg. G. W. Goodall, Mgr.

PRINCIPAL CONTENTS

AWARD HIGHWAY CONTRACTS EARLY!

IN a letter addressed to the heads of the State Highway Departments, Thomas H. MacDonald, chief of the Bureau of Public Roads, United States Department of Agriculture, urges the state departments to place under contract during December and January as great a mileage of roads as possible.

Mr. MacDonald estimates the amount of money available for road work in the United States during 1920 to be $633,000,000, or more than four times as much as has been expended during any previous year for like purposes. He calls attention to the lack of open top cars for transporting road materials, and says that this deficiency must be made good by using these cars more efficiently and by awarding contracts sufficiently early to permit contractors to obtain their materials during the season when the open top cars are not in the greatest demand.

Last spring the number of open top cars that were idle in the United States was estimated at over 250 000, but as the season advanced and road contracts were actually under way, acute car shortage manifested itself generally throughout the country.

Should the movement of coal demand the cars, or should there be any railroad labor trouble, highway work would be sadly interfered with in case the contracts are awarded too late, inasmuch as road materials are not perishable and are among the last things that would be moved on the rails.

What Mr. MacDonald says in regard to conditions in the United States applies with equal or greater force to Canada. The placing of materials in storage piles involves some expense, but this cost is small in comparison to the loss occasioned by the lack of materials when the contractor's organization is waiting. Contracts which are not awarded during the winter months may have little opportunity of being supplied with materials which require railway transportation.

Another good feature of the early award of highway contracts is that the contractors are encouraged to place their orders early, and material producers are given an opportunity to operate their plants during all seasonable weather. Not only does this help the car shortage, but it generally results in lower prices.

THE ASPHALT ASSOCIATION

THOSE who are interested in the movement for better roads and streets in Canada will note with pleasure the strong engineering staff which is being built up by the Asphalt Association. As is now undoubtedly well known by the readers of our paper, this association was formed a few months ago by a number of competing asphalt producers for the purpose of ensuring not only the widest possible use of their product, but also the most efficient use. In forming an association of this kind for general promotion and research work, the asphalt producers are merely getting into line with the service policy that is now rapidly being adopted by all industries that are conducted upon the best business principles.

Highway engineering in Canada will undoubtedly benefit by the formation of the Asphalt Association. The service which its engineers and laboratories can render will not be any the less appreciated for the fact that these engineers are at the same time promoting the sale and use of asphalt. All service has a *raison d'être,* and good service, whether in engineering or other fields, is always entitled to recognition and reward. The service which the Asphalt Association will render will undoubtedly be met with a marked increase in the use of that material.

The officers of the Asphalt Association indicate its high standing in point of responsibility for data published, and also its independence from a competitive standpoint. They are as follows:—

President, J. R. Draney, of the United States Asphalt Refining Co.; vice-president, W. W. McFarland, of the Warner-Quinlan Asphalt Co.; treasurer, N. G. M. Lykx, of the Freeport Mexican Fuel Oil Co.; secretary, J. E. Pennybacker, formerly secretary of the U. S. Highways Council and formerly of the U. S. Bureau of Public Roads; chief of research department, Prevost Hubbard, former chief of tests and research of the U. S. Office of Public Roads.

The intimate relation which both Mr. Pennybacker and Mr. Hubbard have had with the good roads movement on this continent for the past fifteen or twenty years is too well known for them to need any introduction to Canadian engineers. Bruce Aldrich, the engineer who will be in charge of the affairs of the association in Canada, is not so well known in this country, but among engineers in the United States, particularly in the south, his experience and ability have long been recognized. His work in connection with street improvement and maintenance in Baltimore has well trained him for his new duties. Mr. Aldrich will not endeavor alone to solve the many paving and other problems which may be placed before him, but will merely serve to a certain extent as a link between the Canadian territory and the authoritative laboratory and engineering facilities which the Asphalt Association is rapidly establishing.

AMERICAN ASSOCIATION OF ENGINEERS

REMARKABLY rapid has been the growth of the American Association of Engineers. Founded in 1915, this association had a membership of approximately 250 at the beginning of 1916, 750 at the beginning of 1917, 1,500 at the beginning of 1918 and 2,500 at the beginning of this year. The membership of the association last Thursday was 8,866, and the officers have arranged a membership drive, to be carried out the first two weeks of December, which will undoubtedly boost the number to five figures.

Compared with the growth of the four main engineering societies in the United States, the American Association of Engineers has had a record-breaking career. It now has about

1,500 more members than has the American Institute of Mining and Metallurgical Engineers, and it has practically the same number as the American Society of Civil Engineers; moreover, it is only about 1,000 short of equalling the membership of either the American Institute of Electrical Engineers or the American Society of Mechanical Engineers. All four of these societies were, of course, founded many years ago, and have a tried and established membership which is immune from any fluctuations such as may or may not occur in the membership of the American Association before that organization is as old as is any of the other four societies.

During the past 10½ months the American Association of Engineers has grown almost as much as has the average membership of the other four societies during the last 17 or 18 years. The executive committee of the association express confidence that their organization will be the largest engineering society in the United States before the end of this year.

PERSONALS

Paul Emile Mercier, consulting engineer to the Administrative Commission of the city of Montreal, who was recently appointed as a professor on the staff of L'Ecole Polytechnique, Montreal, and who will hereafter devote a considerable portion of his time to educational work, was born March 15th, 1877, at St. Hyacinthe, P.Q. He was educated at St. Mary's College, Montreal, and received his technical training at L'Ecole Polytechnique. He became chainman on the Montreal Park & Island Railway in 1895. Entering the service of the C.P.R. in 1896, as a rodman on the Quebec division, he became a leveller in 1897. In 1898, he joined the staff of the Public Works Department of Canada, as an assistant engineer, and from 1899 to 1904 was a district engineer in that department. In 1905 his services were requested by the National Transcontinental Railway, and for the following two years he was engineer in charge of that project. In 1908 Mr. Mercier engaged in private practice in Montreal, under the firm name of Baulne & Mercier, which connection was retained until 1914, when he was appointed deputy chief engineer of the city of Montreal. When George Janin, chief engineer of the city, was given leave of absence to go overseas in December, 1914, Mr. Mercier became acting chief engineer, and upon Mr. Janin's death in 1915, Mr. Mercier was appointed chief engineer. In May, 1918, he became the city's Director of Public Works, from which position he retired in November, 1918, to act as consulting engineer to the newly-appointed Administrative Commission. Mr. Mercier is a member of the Engineering Institute of Canada, the American Railway Engineering Association, the American Society of Civil Engineers and the Society of Civil Engineers of France.

A. P. Miller, of Glenmiller, Ont., has been appointed assistant engineer on the Trent Canal staff, Department of Railways and Canals.

B. H. Prack, industrial architect and engineer, has moved his Toronto office from the Lumsden Building to the Otis-Fenson Building, where he is now occupying the entire top floor.

Profs. Norman Bowen and Cecil Greenland, of the Faculty of Science, Queen's University, have resigned. The former is going to Washington, D.C., while Prof. Greenland is leaving for South America.

W. G. H. Cam has been appointed power engineer for the Canada Cement Co., Ltd., Montreal. He was formerly engaged in the design and construction of lighting and power systems in Montreal and vicinity.

Arthur Sande, consulting engineer, has established an office in the Lister Building, Hamilton, Ont. Mr. Sande will specialize in buildings and equipments for industrial plants, hydro-electric developments, pulp and paper mills, steel mills, foundries, etc.

Lt.-Col. Chas. G. Du Cane, O.B.E., who was engaged all last summer on work connected with the Madras docks and harbors, and who has just sailed for London, Eng., to complete his report, will return to Vancouver in January to resume business with his former firm, Du Cane, Dutcher & Co., consulting engineers, who have in hand a number of new and important projects.

Guy Morton, formerly Alberta manager for the Canadian Westinghouse Co., Ltd., has organized "Electrical Engineers, Ltd." at Calgary, Alta. Mr. Morton's new firm will deal in electrical and mechanical engineering equipment. He is a graduate of the University of Toronto in mechanical and electrical engineering, class of 1909, and served overseas as a lieutenant, returning to Canada only four weeks ago.

J. A. Owens, who graduated in civil engineering at the University of Toronto, class of 1914, has joined the staff of J. B. Nicholson, Ltd., of Toronto and Hamilton, as resident engineer on reinforced concrete construction in Toronto. Mr. Owens was formerly with Wheelock & Christie, consulting engineers and surveyors of Orangeville, Ont., and for the past few months has been in the employ of James, Loudon & Hertzberg, Ltd., consulting engineers, Toronto.

Prof. L. W. Gill, of Queen's University, Kingston, Ont., has been appointed Director of Technical Education, Department of Labor, Ottawa. This directorate is a new office the creation of which was made necessary by the action of parliament in voting $10,000,000 to be spent on the encouragement of technical education throughout Canada. The money for the most part is to be spent by the provinces on the basis of agreements to be reached with the provincial governments, in much the same manner as federal votes in aid of agriculture have been distributed. Prof. Gill served with the Canadian forces overseas, in command of the 46th Battery. He has been head of the electrical engineering department of Queen's University for the past fifteen years.

ONTARIO PROVINCIAL DIVISION, E. I. C.

Twenty-six engineers, representing the various branches of the Engineering Institute of Canada throughout Ontario, met last Friday afternoon and evening at the Engineers' Club, Toronto, as delegates to the first formal conference of the institute's Ontario Provincial Division. J. B. Challies, of Ottawa, chairman of the division, presided.

The most important decision reached was that a joint committee of twelve men be formed to consider legislation for Ontario, the division to name two of the twelve and two to be named by the Ontario branches of each of the following five organizations: The Canadian Mining Institute, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Canadian Institute of Chemistry and the Ontario Association of Architects.

The other matters discussed were solely internal affairs of the institute, chief of which was a recommendation to the council of the institute that Ontario be divided into three districts instead of two, so as to give Western Ontario larger representation on the council.