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The Canadian Engineer

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Bulking Effect of Moisture in Sands

Varying Percentages of Moisture in Sand Aggregate an Important Factor in Concrete Making—Wet Sands Weigh Less than Dry—Suggested Methods of Overcoming Irregularities due to Moisture.

By CAPT. LLEWELLYN N. EDWARDS

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A DEFINITE knowledge of all the conditions which tend to produce widely varying results affecting the strength and durability of concrete, is necessary to a thorough understanding of the full range of its usefulness. "The methods and operations used in the making of concrete are vital factors in the production of conditions affecting the density, strength and permanance of the concrete mass. The materials are too frequently a means to an end without consideration of the end itself."

Before making a laboratory investigation of the mortar or the concrete making qualities of a given sand, the sand particles are very commonly surface dried and the test batch, whether proportioned by the Heath-Edwards "surface area" method, by the Abrams "fineness modulus" method, or by the time-honored but nevertheless irrational and unscientific "arbitrary volume" method, is based upon the use of a weighed quantity of the dry sand. The stone aggregate for a concrete mix is also very commonly dried before being used. The results of the investigation are, therefore, to be interpreted only on the basis of using dry aggregate. It is well nigh axiomatic that if results consistent with those secured from laboratory tests are to be obtained upon the construction work, the conditions under which the sand con-

"NORMAL" CONSISTENCY "WET" CONSISTENCY

FIG. 1—TEXTURE OF CEMENT MATRIX IN CONCRETE OF DIFFERENT CONSISTENCY (x 60)

tent of the mix is measured, must be such as to assure a reasonable uniformity in the net volume of sand entering into each batch.

Notwithstanding the important improvements made in recent years in the manufacture of Portland cement and in the power driven machinery and other accessions used in the field, the method commonly used for measuring the ingredient materials of the mix is by loose volume. This century old practice is, to say the least, haphazard, and when applied to the measuring of the sand aggregate is productive of widely varying results.

Upon the average construction, job so called "barrow measurement" of the sand is the rule; measurement by "struck" box, or better still, by weight, are the exception.

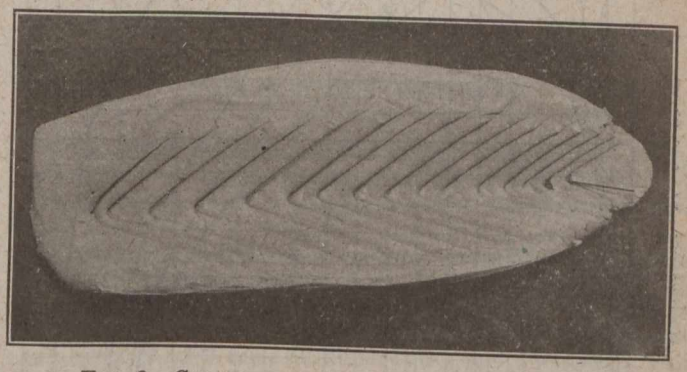


FIG. 2—CONSISTENCY TEST FOR NEAT CEMENT

Assuming that the engineer, or his inspector, has gauged the barrows and has indicated by plainly visible marks the height to which each barrow is to be filled, the careful filling of the barrows will then depend mainly upon the personal equation of the laborers, the personality and vigor of the inspector and the co-operation of the foreman. The volume of sand placed in each barrow will rarely be less than that indicated by the gauge mark. Very commonly, the laborer shows his goodwill toward his employer by the addition of one or more shovelfuls for luck and good measure. The shape of the barrows commonly used tends to minimize rather than exaggerate the appearance of the variations in "barrow-measured" quantities, and, in consequence, these variations are frequently greater than is commonly supposed. Obviously, the strength of the mortar, or of the concrete produced by the use of a given sand, will vary with the irregularities in the measured volume of the sand content of the individual batches.

Bulking Effect of Moisture in Sands

The paucity of published data relating to the effect of varying percentages of water contained in sand aggregate used in mortars and concretes is evidence that this feature has not been given sufficient attention by engineers, architects and construction men. It is not the intention to indulge in a lengthy discussion of all the principles involved, but rather to point out the fallacy of the commonly used method of mortar and concrete making in so far as resulting

strengths are affected by the moisture contained in the sand aggregate.

No less important than the barrow measurement variations heretofore described are the variations in the strengths of mortars and concretes produced by the moisture contained in the sand aggregate. Unlike the above, however, these variations very commonly tend to decrease the net volume of sand material in the mix. The common effect is, therefore, to increase rather than to decrease the strengths of mortars and concretes. However, there is no evidence that the "bulking" effect of the moisture in the sand has

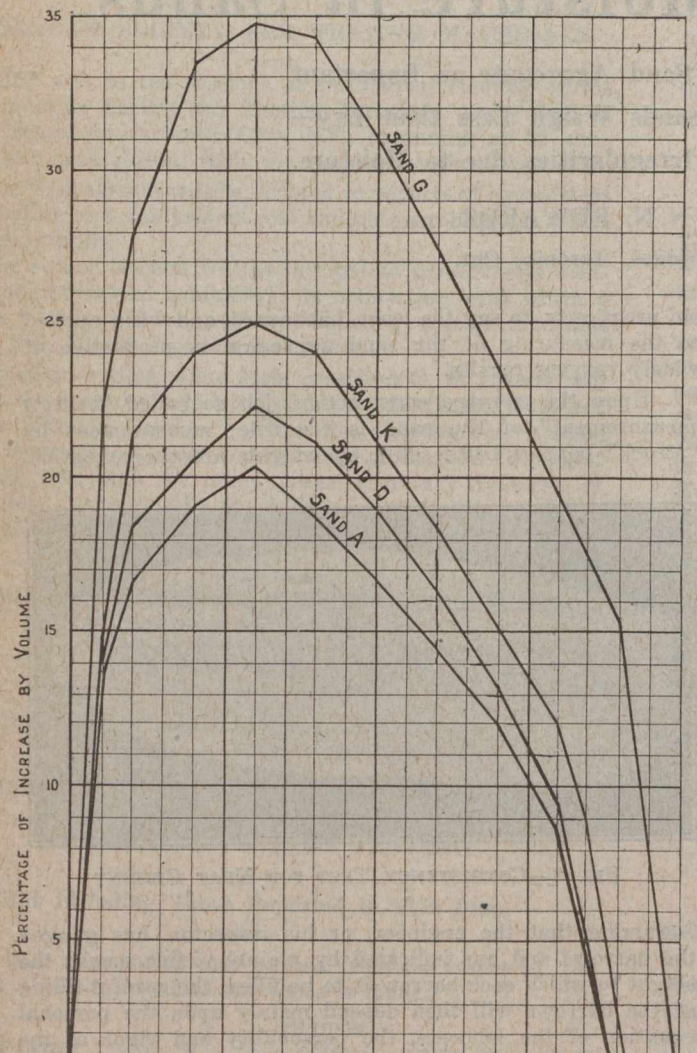


FIG. 3—CURVES SHOWING THE RELATION OF MOISTURE TO VOLUMES OF SAND

been given consideration either in written specifications or in the field operations incident to mortar and concrete making.

Paradoxical as it may seem, the addition of a quantity of water, equal to one per cent. of the weight of a given quantity of dry sand, will serve to throughly coat the surfaces of the sand particles, a uniform distribution of the water being secured by working the sand with a trowel or other tool. This moisture has the rather remarkable effect of increasing the volume of sand by holding the sand particles somewhat rigidly in positions different from those they would readily assume when dry.

A series of tests made for the purpose of securing definite information relative to the "bulking" effect of moisture in sands differing in their granulometric analyses, shows that the surface area of the sand particles is a direct function of the volume increases, produced by varying the quantities of water. In a portion of these tests the water content was varied in relation to the weight of the sand. Fig. 3 shows the volume increase curves derived from tests of three different sands. These curves are typical of those secured from the entire series of tests. In this connection it is of interest to note that when the water content has reached the "flooding" stage, the volume of the sand is the same as that originally occupied by it when thoroughly surface dried. Incidentally, Fig. 3 gives unquestionable proof of the reliability of the common practice of compacting sandy or other earths of rock origin by flooding them with water.

Occasionally, a carload of sand is delivered at the work site in a practically dry—sometimes a thoroughly dry, condition. Doubtless, in such cases the sand was taken from a portion of the pit in which, due to several hot days without rain, a considerable quantity of dry sand had fallen from the pit face and had accumulated at its bottom. This accumulation of dry sand when loaded would, no doubt, contain sufficient heat to render thoroughly dry any moist sand that might be loaded with it. On the contrary, carloads of sand may contain, by reason of continued rainy weather, comparatively large quantities of water. Under such conditions fine sands will retain a larger volume of water per cubic yard than will coarse sands.

Having discussed, at least to a limited degree, the possible range of moisture contained in sands, it will not be amiss to examine its effect mathematically, no allowance being made for the "bulking" effect of moisture contained in the sand.

Assume that a desired strength of concrete can be produced by the use of sand, thoroughly surface dry and mixed with cement and stone aggregate by volume measurement, one part cement, two parts sand, and four parts stone, 100 lbs. of cement being considered as producing 1 cu. ft. of cement paste. Assume now that the sand, as used on the job, contains 6% of moisture, and when shoveled into barrows will bulk up 23%. From simple calculations it is found that the batch as used on the job will contain the following: 100 lbs. cement, 1.54 cu. ft. sand, 4 cu. ft. stone.

Lest the question may arise as to why deficiencies in the quantity of sand are not more commonly noticeable in the field, it may be well to call attention to the fact that a lack of mobility in the mix, due to a lessening of the net volume of sand, is very commonly supplemented by an increase in the volume of water. This increase in the volume of water dilutes the cement paste and ultimately produces a marked change in its physical structure. When examined under the microscope a cement matrix, produced by the use of a quantity of water sufficient for the development of its natural functions in the mix, appears gray in color and adheres closely to the surfaces of the aggregates in amorphous masses containing myriads of minute voids, but nevertheless giving the impression of possessing strength, hardness and rigidity. In comparison, the cement matrix produced by the use of an excessive quantity of water is milky white in color, presenting a loose, skeleton-like, flaky structure lacking cohesiveness and other attributes of physical strength.

Fig. 1 shows photomicrographs (x 60) of "normal" and "wet" specimens. The latter specimen was produced from the concrete of the former by the addition of sufficient water to render it a soft, mushy mixture.

Another condition may be mentioned here which indicates very clearly the "bulking" effect of moisture in sands. While the weights of sands vary with the character of the rock material from which they take their origin and also with their granulometric composition, yet, for any given sand, its weight per cubic foot when dry is greater than its weight when wet, provided, of course, that in each case the sand is shoveled into the measuring receptacle. This condition holds true, even when the wet sand is subjected to a moderate amount of compacting.

From a consideration of the sources of irregularities in the field operation of measuring the sand content of batches of concrete two conclusions may readily be drawn. They are: That, with the present practice of volume measurement of aggregates, the most consistent results can be secured by maintaining the moisture in the sand as nearly uniform as possible, allowance being made for the "bulking" effect of this moisture; That the adoption of appliances whereby the sand content of the batches will be measured by weight rather than by loose volume will unquestionably result in an important increase in both the uniformity and the reliability of the concrete produced.

Concerning the former conclusion, it may be said that, since the maximum "bulking" effect for all sands adapted to concrete making is produced by a moisture content of 6% to 8% by weight, a simple test involving the measuring, drying and remeasuring of, say four cubic feet of sand, will determine a visual appearance indicating very closely this range of moisture content.

Concerning the latter conclusion, it will readily be seen that its application to field operations involves the construction of a comparatively simple weighing device into which the sand is shoveled and from which it is dumped by overturning into the barrows. The adoption of such a device would, under certain conditions, result in an economy of labor, since the operation of shoveling up the sand from the stock heap would be practically continuous.

Consistency of Concrete

In a recent issue of *The Canadian Engineer* (May 1, 1919), Mr. H. M. Thomson, laboratory engineer, Greater Winnipeg Water District, in an article "Physical Properties of Mortars and Concretes," has called attention to the fact that water is thrown off from concrete mixtures, even when the water content is only slightly in excess of that required to produce a saturated, semi-plastic mortar, adhering freely to the particles of stone aggregate or, in other words, a concrete of a consistency that, although saturated, shows no free water when taken from the mixer. The quantity of water required to produce concretes of this consistency is dependent upon the quantity required to wet the cement and the quantity required to wet the surface of the sand and stone aggregates. Concerning the former, tests made by the author have shown that water will be thrown off from neat cement paste containing quantities of water approximately 4% in excess of those required to produce pastes of standard normal consistency.

Fig. 2 shows the method used to ascertain the consistencies of neat cement pastes at which the water content will not be entirely retained. The water stain left by the slight accumulations of water at the apexes of the trowel indentations are plainly visible in the photograph. This method was also used in similar investigations of mortars. However, it is not well adapted to the examination of lean-mix mortars which permit the water content to sink below the surface.

In a series of mortar tests made with the object of developing the surface area (Heath-Edwards) method of proportioning (see *The Canadian Engineer*, Vol. 35, page 5), it was found that the surface area of the sand bore a direct relation to the quantity of water required to produce "normal" uniform consistency mixes. Doubtless, the quantity of water required for uniform consistency concrete mixes, bears a somewhat similar relation to the total surface area of the sand and stone aggregates.

Laboratory Testing of Concretes

For a proposed concrete structure the consideration of possible sources of supply of aggregates frequently involves the laboratory examination of the concrete making qualities of two or more different aggregates varying in their sieve analyses and other physical properties. The field conditions attending the mixing, handling, placing and finishing of the concrete, as well as the ultimate strength, toughness, etc., of the concrete producible from them require that the relative merits of these aggregates be determined under conditions eliminating variations in the relative plasticity and final strength of the cement matrix.

The surface-area method of designing concrete mixtures bears no direct relation to other methods which have been proposed from time to time. It is believed that this method more nearly fulfils the requirements of the complicated conditions attending both laboratory investigation and field construction work than does other methods. In this connection a comparison of the general characteristics of the "surface area" method with those of Abram's "fineness modulus" method, is of interest. The latter is fully described in a paper by Prof. Duff A. Abrams, published as Bulletin No. 1, Lewis Institute, Chicago, Ill.

Materials and physical properties.	Fineness modulus method.	Surface area method.
Area of aggregates	Variable	Variable
Cement	Uniform	"
Water	"	"
Consistency (plasticity) .	Variable	Uniform
Strength	Uniform	"
Toughness	Variable	"

It is obvious from the above comparison that these two methods approach the problem of concrete design from quite different angles. It is believed that on account of simplicity of application to both laboratory and field operations, the surface area method is the more practical and tends toward greater economy, efficiency and excellence of results.

PUBLICATIONS RECEIVED

EXAMPLES IN MAGNETISM.—Third edition, 1919; published by Prof. F. E. Austin, Hanover, N.H.; price, $1.10. Ninety pages and cover, 4¾ by 7½ ins., illustrated; flexible binding.

ANALYSIS AND TESTS OF RIGIDLY CONNECTED REINFORCED CONCRETE FRAMES.—Published as Bulletin No. 107 of the Engineering Experiment Station, University of Illinois, Urbana, Ill. By Dr. Mikishi Abe; price, 50c; 106 pages and cover; 6 by 9 ins.; 59 illustrations and 16 tables. This bulletin presents a résumé of the analytical treatment of rigidly connected reinforced concrete frames and the principal results of the experimental work on reinforced concrete frames which were given in the thesis of Mikishi Abe as presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Engineering in the Graduate School of the University of Illinois, June, 1914. The work of condensation and reformulation necessary to bring the text within the space available for the bulletin was done by members of the department of Theoretical and Applied Mechanics, University of Illinois.

MIAMI CONSERVANCY DISTRICT.—Part VI. of the technical reports of the district has been issued, accompanied by an atlas containing 139 selected contract and information drawings, illustrating the principal features of the flood-protection system. Part VI. contains the district's standard contract forms and specifications for building the dams and channel improvements. It also contains the information originally printed for the use of bidders and lists of principal quantities involved in each section of the work. To date six volumes, or "parts," of the technical reports of the district have been published and others are in preparation. The problems attending the design and construction of the $27,000,000 flood-control works for the Miami valley required study and research work of an exhaustive character and some of the data published in these reports are entirely new and in other respects of a kind not available in convenient form elsewhere. A pamphlet describing these six volumes has been issued by the district (head office, Dayton, Ohio) and the volumes are being sold to the engineering profession at from 50c. to 75c. each and $1.50 for the atlas.

TOWN PLANNING INSTITUTE OF CANADA

THE following is the provisional constitution and by-laws of the Town Planning Institute of Canada, the inaugural meeting of which is to be held at an early date.

The advent of this new organization, coming as it does at a time when Canada is confronted with pressing housing and town planning problems, makes it particularly opportune. This new organization will doubtless find great scope for beneficial and effective work. Foresight in town planning is very, very essential, and it would be unfortunate, indeed, if the evils that have arisen in older countries as a result of lack of foresight should be allowed to grow up in the Dominion. The Town Planning Institute of Canada will be able to do much toward the prevention of the repetition of such conditions in the Dominion. The possibilities of town planning, and all that term implies in a country like Canada, are illimitable.

1. The objects of the Institute are:—

(a) To advance the study of town planning, civic design and kindred subjects, and of the arts and sciences applying to these subjects.

(b) To promote the scientific and artistic development of land in urban and rural districts.

(c) To secure the association of and promote the general interests of those interested in the study of town planning.

2. The membership of the Institute will comprise residents in Canada who are architects, engineers, surveyors, landscape architects and barristers in good standing in their professional institutes or societies who shall be prepared to qualify themselves to engage in the practice of some aspect of town planning.

The various classes of membership are defined in the by-laws as follows:—

Members

3. Every candidate for election as a member shall be at least twenty-five years of age, and a member of the Royal Architectural Institute of Canada, or of a recognized Provincial Association of Architects; a corporate member of the Engineering Institute of Canada; a Dominion land surveyor or a provincial land surveyor; a member of a recognized association of landscape architects, or a member of the Town Planning Institute of Great Birtain. Or he shall be an architect, a civil engineer, landscape architect, municipal engineer or surveyor who is in actual practice or in charge of a department, and who, while not being a member of any of the institutions above referred to, has, at the date of his application for membership, attained a degree of experience in matters relating to town planning satisfactory to the council.

After the 31st of March, 1920, every candidate prior to his election shall, in addition, have passed the qualifying examination for members imposed by the Institute, or been exempted therefrom by the council under the powers conferred upon them on that behalf.

Associate Members

4. Every candidate for election as an associate member shall be at least twenty-one years of age, and a member in actual practice of one or other of the above-named professions. After the 31st of March, 1920, every candidate shall, prior to his election, have passed the examination imposed by the Institute, or been exempted therefrom by the council.

Legal Members

5. Every candidate for election as a legal member shall be at least thirty years of age, a duly qualified barrister, and a member of a recognized law society. After the 31st of March, 1920, every candidate, prior to his election, shall in addition have passed the examination imposed by the Institute, or been exempted therefrom by the council.

Legal Associate Members

6. Every candidate for election as legal associate member shall be at least twenty-one years of age, and either a duly qualified barrister or a chief assistant to a legal member of the Institute. After the 31st of March, 1920, he shall in addition, prior to his election, have passed the law examination of the Institute, or been exempted therefrom by the council.

Students

7. Students shall be persons not less than nineteen years of age who either have been pupils or assistants of architects, civil engineers, surveyors, town planners or barristers, or who are studying with a view to entering one of these professions at such places of professional instruction as the council may approve; but no person shall be deemed eligible for admission as a student unless, prior to his election, he shall have passed such examinations as may, from time to time, be prescribed or approved by the council.

Associates

8. An associate of the Institute shall signify any person who, while not eligible as a professional member, shall be an active member of a body associated with town planning, or of a town planning commission, a medical officer, or a member of some municipal council, who shall in some manner have acquired knowledge of, or practical experience in, some one or more of the aspects of town planning.

Honorary Members

9. Honorary members of the Institute shall comprise distinguished persons who may be elected from time to time as honorary members because of special interest in town planning, and who, by reason either of their position or experience in matters relating to town planning, appear to the council to be able to render assistance in promoting the objects of the Institute.

Period of Probation

10. Prior to the 31st of May, 1920, no members or legal members will be elected. During that period the membership will consist of associate members, legal associate members, students, associates and honorary members.

11. Associate members and legal associate members must comply with the requirements of candidates for election as set out in By-laws Nos. 4 and 6, and will be elected on probation only for one year.

12. As a condition of their election, such associate members or legal associate members must agree to undertake a course of study in town planning, and either pass a qualifying examination or submit a thesis dealing with an aspect of town planning prior to the above-named date satisfactory to boards of examiners to be hereafter appointed.

13. The said boards of examiners when elected shall submit a report prior to the 31st of May, 1920, to the Provisional Council of the Institute as then constituted, setting out the results of their examination, and making recommendations as to the classification of those associate members and legal associate members who have submitted to the necessary tests into four groups, namely: Members, associate members, legal members and legal associate members. The Provisional Council will then proceed to elect these four groups of qualified members, and those so elected will, together with the members of the board of examiners, be the foundation members of the Institute.

On completion of their duties the above members of the board of examiners shall be eligible for membership in the class for which they are professionally qualified.

Subscriptions

14. Every associate member, legal associate member and associate shall pay a preliminary subscription of five ($5) dollars and each student a subscription of two ($2.50) dollars and fifty cents. The subscription shall be due and payable on the date of application for membership, and shall represent the liability of each associate member, associate or student, respectively, up to the 31st of May, 1920. Honorary members shall not be required to subscribe to the ordi-

nary funds of the Institute, but the council may invite from them donations for special purposes.

Provisional Council

17. The following Provisional Council has been elected for the purpose of carrying on the work of the Institute during the probationary period and for framing the by-laws under which the Institute will be constituted on May 31st, 1920:—

Chairman, Thomas Adams, housing and town planning adviser for Canada; vice-chairmen, E. Deville, surveyor-general of Dominion lands; R H. Millson, president Ottawa Chapter of Architects; members, J. B. Challies, superintendent of Dominion Water Power Branch, Department of the Interior, Ottawa; H. B. Dunnington-Grubb, landscape architect, Toronto; J. P. Hynes, architect, Toronto; O. Klotz, chief astronomer for Canada; R. S. Lea, Montreal; T. McQuesten, barrister, Hamilton (legal); honorary librarian, W. D. Cromarty, architect, Ottawa; honorary secretary and treasurer, F. D. Henderson, Ottawa.

The Provisional Council will draft the by-laws of the Institute, assist in organizing local branches, promote educational courses in town planning in the universities, arrange lecture courses and other meetings for the benefit of probationary members and students, and perform such other duties as may be considered necessary or desirable to promote the interests of the Institute. The council will remain in office until the date of the first annual business meeting of the Institute called under By-law 18. Vacancies occurring in the membership of the Provisional Council may be filled by the council.

Meetings During Probationary Period

18. The inauguration meeting of the Institute will be held in Ottawa during May, 1919, and the first annual business meeting will be held on the first convenient date following the 31st of May, 1920, for the purposes of approving the constitution and electing members and officers.

Voting

19. Associate members and legal associate members only shall be entitled to vote on matters pertaining to the business of the Institute, but associates and honorary members shall be entitled to representation on the Provisional Council.

Local Branches

20. Local branches may be formed in the different provinces and cities, the membership of which shall be subject to the same by-laws as the membership of the Institute.

Applications are invited from those eligible as associate or legal associate members, students or associates. Application forms can be had on application being made to the secretary, F. D. Henderson, office of the Surveyor-General, Ottawa, Canada.

NATIONAL WATER MAIN CLEANING COMPANY IN CANADA

THE General Supply Co. of Canada, Ltd., have completed arrangements whereby they will represent the National Water Main Cleaning Co., of New York, for the whole of Canada, with the exception of the province of Nova Scotia.

In view of the very urgent demands for the greatest possible efficiency in all fields of endeavor, it is very important, indeed, that in the distribution of municipal water supply the most efficient methods be employed. The regular cleaning of water mains ensures delivery of full capacity, the importance of which will be apparent to all those concerned with the operation of water distribution systems.

The proposed bridge over the Batiscan River to replace the old ferry is estimated to cost $40,000.

THE ROAD TO KIRKLAND LAKE*

INTERESTS representing some of the leading mines of the Kirkland Lake district are presenting evidence to the Ontario Government, showing the advantages and disadvantages of a steam railway, the disadvantages of an electric railway, as well as the advantages and disadvantages of a first class motor road. It will perhaps be a surprise to many to learn that these leading interests are not in favor of a steam railway, but appear to believe a first class motor road would best fill the requirements of the district.

A summary of the situation, viewed from various angles, is given herewith. It represents the opinion of a leading operator in the Kirkland Lake field, and is being submitted to those most vitally interested, asking for expressions of opinion. The summary follows:—

As you are probably aware, the government has authorized the construction of a branch line of the T. & N. O. Railway from Swastika to Kirkland Lake at an estimated cost of $155,000, the route selected being that through the Elliott-Kirkland, across the narrows of Kirkland Lake to a point near the Wright-Hargreaves office and thence across the Sylvanite towards the Tough-Oakes mill.

As you are no doubt much interested in this important question of transportation and after consultation with a number of men who have considered the question in all its bearings, I venture to submit some facts, figures and estimates which I have collected, as the result of enquiries on the spot, and from data supplied by Mr. Clement, the chief engineer, and Mr. A. A. Cole of the T & N. O. Railway, with a view to asking you to give an immediate expression of your opinion upon the question as to how the needs of the community can best be met in this matter of transportation.

There were originally three obvious solutions for consideration, viz:—

1 A trolley road, which would appear to meet practically all requirements and give a fairly frequent and flexible service.

This has been ruled out on the score of cost, the estimated capital outlay involved being approximately $266,000, with the necessary transformer sub-station and equipment.

2 A steam railroad as outlined above, which has now been authorized.

3 A first class motor road capable of withstanding heavy motor trucks, and costing about $72,000, which does not appear to have received much consideration.

You are now asked to consider the relative merits and disadvantages of the steam railroad and motor road.

Steam Road Advantages

1 Enable freight, including heavy machinery, and passengers to be brought to the mines cheaply, irrespective of weather conditions.

2 Provide for unlimited expansion of traffic in the future.

3 Cut freight rates from Swastika to any point up to Tough-Oakes in all probability to .40c. per ton on coal, with proportionately higher rates on other stores and supplies, with an average all round rate of about 60c. per ton.

4 Cut passenger fares probably to .25c. each way.

Disadvantages

1 Not enable freight to be delivered direct to the stores or bunkers on more than perhaps one or two properties, and therefore in most cases roads will be required from the railway stations, of which there will be but two (one near the Elliott and one on the Wright-Hargreaves at the east end of the lake) to each mine and the townsite and practically all freight will have to be loaded on to wagons and teamed over these roads which have yet to be made, in order to reach its destination, at an average estimated cost of 40c. per ton at least, thus making the actual average cost of freight $1.00 per ton.

*From "The Canadian Mining Journal."

2 Passengers will in nearly all cases have to walk or obtain other means of transportation from the stations to their destinations—distance varying from a few hundred yards to three-quarters of a mile or more.

3 The present wagon road will fall into almost complete disuse excepting isolated sections which will still be required, and it is unlikely that anyone will be inclined to make and keep in repair.

4 The service will be limited to one train per day each way, probably giving very little time for people to come in, transact business, or look for work, and get out on the same day.

5. The train service will necessarily be slow, with the stops for picking up freight, etc.

6 Consignees will require to have representatives present on the arrival of trains to take delivery or pay for their freight just as they do now at Swastika.

7 The estimated cost of operating and maintaining the branch, aside from interest on capital, amortisation or depreciation, is $100 per day, which would require say 130 tons at 60c. and 88 passengers at 25c. per day to break even. The average freight handled at present is 36 tons and the average number of passengers about 40 per day, so that it is clear the railway would operate at a heavy loss amounting to over $20,000 per annum, which must ultimately come out of taxes.

8 The right-of-way covers a considerable area of the claim over which it passes and tends to cut such claims in two with its bank or cutting and fences.

Motor Road Advantages

1 Enable existing road freights to be reduced by means of motor trucks to about $1.00 per ton for the full distance to the Tough-Oakes with proportionately lower rates for the shorter hauls, this being as low as the total cost of delivery with the steam road.

2 Enable passengers to be handled for about 5c. per mile in motor 'busses or less than the steam road could charge.

3 Provide a flexible system of transportation at all necessary hours, delivering freight and passengers to or from their destinations on the various mines or the townsite.

4 Enable individuals to walk, 'bus or cycle to any point along the field at all times of the day or night, thus permitting men to have fixed homes while moving their place of employment as they require.

5 Permit branch roads to start off at any point to outlying properties instead of only from the two stations on the steam road.

6 Save more than half the first cost of the steam road while providing ample facilities for the present time and the immediate future.

Disadvantages

1 In winter snow would have to be ploughed off or the vehicles run on the snow as in most cities in winter.

2 Heavy cost (12,000 per mile) in order to make a thoroughly permanent water-laid or tar-macadam road.

3 Difficulty in getting a railway built in addition to the road later on unless a further great expansion takes place.

There is every probability that the matter will soon be settled definitely by the government, and meanwhile if it is considered by those interested in the Kirkland Lake field that a motor road would serve the purpose best, *provided*,

(a) That the government authorized the work immediately under proper supervision and if possible agreed to maintain the road for say ten years—at a cost not exceeding the estimated cost of maintaining a railway road bed, and

(b) That the mines would allow all available waste rock on their dumps to be taken for the work free of cost there is good reason to believe that the government would readily adopt the latter plan.

Will you, therefore, please answer the following questions:—

1 Are you in favor of a steam railway?

2 Are you in favor of a first class motor road, more or less on the line of the old road with modified and improved gradients?

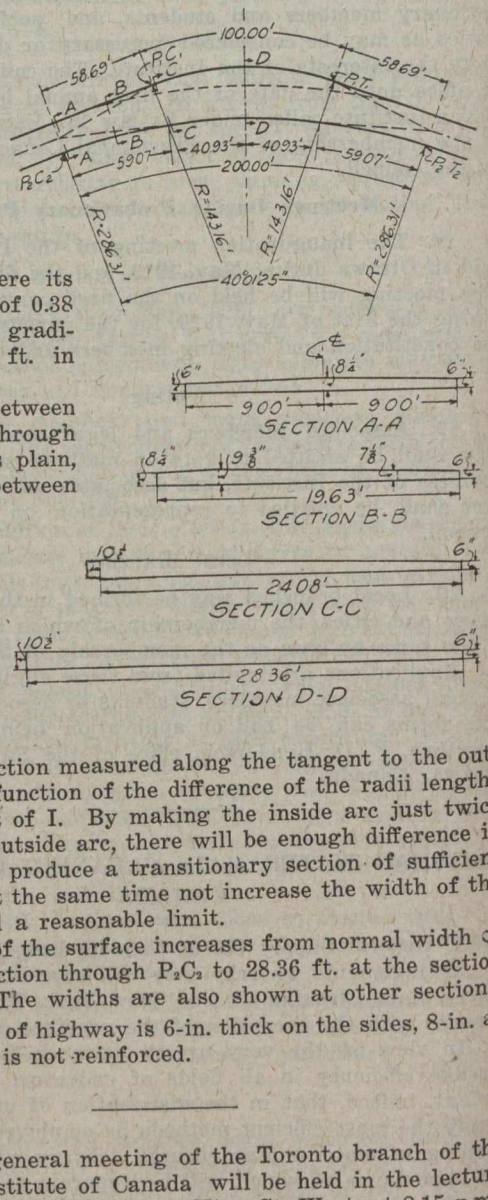
3 If you have any waste rock dumped are you willing to allow it to be used for the road free of charge?

SUPER-ELEVATION AND WIDENING OF HIGHWAY CURVES

By F. N. Huddleson
Consulting Engineer, Salt Lake City, Utah

THE necessity of super-elevating and widening curves of appreciable degrees of curvature was never given much consideration in Utah until the construction of the Beck Street section of the Salt Lake-Ogden Highway, immediately north of Salt Lake City, in September, 1917. This particular highway was built under the jurisdiction of both the State Highway and Salt Lake City Engineering departments.

The method outlined in the sketch proved very simple of construction and gives excellent results for relatively high speed traffic. The super-elevation of the outside edge of the roadway starts on the section through P_2C_2 and increases uniformly to the P.C. of the outer curve, where its maximum value of 0.38 is attained, the gradient being 0.12 ft. in 58.69 ft.



The surface between the sections through P_1C_1 and P_1T_1 is plain, while that between those through P_2C_2 and P_1C_1 is warped and serves as a transition from the normal road surfaces to the plain surfaces. The length of the transitionary section measured along the tangent to the outside curve is a function of the difference of the radii lengths and the tangent of I. By making the inside arc just twice as long as the outside arc, there will be enough difference in radii lengths to produce a transitionary section of sufficient easement and at the same time not increase the width of the roadway beyond a reasonable limit.

The width of the surface increases from normal width of 18 ft. at the section through P_2C_2 to 28.36 ft. at the section through D-D. The widths are also shown at other sections.

The stretch of highway is 6-in. thick on the sides, 8-in. at the middle, and is not reinforced.

A special general meeting of the Toronto branch of the Engineering Institute of Canada will be held in the lecture room of the Engineers' Club, 96 King St. West, at 8.15 p.m., on Monday next, May 19th, for the purpose of considering and discussing the draft bill of the proposed legislation. It is desired to obtain an expression of opinion of the Toronto branch on this important question.

Disposal of Sewage by Treatment With Acid

Miles Process Is Worthy of Consideration for Cities Where Large Volume of Strong Sewage Is Discharged—Causes No Local Nuisance—Paper Read Before the Boston Society of Civil Engineers—Removes 99 Per Cent. of the Bacteria

By EDGAR S. DORR† and ROBERT SPURR WESTON‡
Boston, Mass.

IN the sewage disposal realm, several ideas struggle for mastery: first, that of the economist, now many years old, that the enormous loss of fats and fertilizer caused by the discharge of human wastes into our rivers and oceans should be prevented; second, that of the sanitarian, that human excrement should not endanger human life; third, that of the lover of beauty, that nuisance and unpleasantness should be avoided; fourth, that of the engineer, that the ends of health and beauty should be obtained efficiently and economically; and fifth, that of the citizen, that he should not pay an excessive price for benefits received.

The enormous values of the products wasted with sewage have allured many engineers to attempt to recover them, as the hundreds of descriptions of patents, processes and plants, in the scientific literature of the past twenty-five years, testify.

Quite recently Dr. Samuel Rideal¶ has estimated that, from the camps in England, 40,000 lbs. of fat might be recovered daily, and from the rest of the population, 400,000 lbs. daily. Dr. Rideal also states that the pressed and dried sludge from the Dresden sewage contained 13.4 per cent. of fat, which was extracted by ethylene chloride. It has been reported that during the war many other German cities have used sewage as a source for fats; also that the city of Stockholm, Sweden, has done the same. Although these were war-time measures, the possibility of recovering the 7,300 tons of fats and the 27,000 tons of fertilizer discharged annually with the Moon Island sewage is alluring as a peace-time practice.

What has been the result in normal times of the many attempts to recover valuable products from sewage? The Chinese and others have made use of human excrement for fertilizer, and evidences of the practice are carried away in the nostrils of travellers from the Far East; but so far there are only two methods of disposal for water-borne wastes which have shown a real profit in practice, namely, farming with sewage irrigation in arid districts, and the acid process when applied to wool-scouring waste or to sewage consisting largely of wool-scouring waste, as at Bradford, England. During the war the profits of the Bradford plant were very large.

Sludge Treatment

While so far the efforts to recover fat and fertilizer from ordinary aqueous sewage have not proved profitable, several note-worthy attempts have been made to recover valuable by-products from the sludge from plain subsiding basins. At Cassel, Germany, sludge so produced was heated to boiling, acidified, filter-pressed, dried, and the grease then extracted from the dried mass with benzine. The extracted grease was then distilled with superheated steam. This plant failed to pay the cost of operation, notwithstanding the fact that the dried sludge contained 18% of grease, and the wet sludge produced 10% of cake, having a fertilizer value of 32.5 cents per 100 lbs. in addition to its grease value. (The distilled grease sold for $4.87, and the tarry residue left behind in the still for 41 cents per hundred pounds. The yield of the refined grease was 60% of the crude.§)

Experiments were conducted at the city of Frankfurt‖ to determine the feasibility of recovering the values contained in sludge. They are of chief interest in connection with this article in showing that the sludge when acidified with sulphuric acid yielded three times as much grease as the unacidified sludge.

In Wolverhampton, England, a process has been adopted based upon experiments of Dr. J. Grossman, of Oldham, England. The process was patented in 1908.* The sludge is partially dehydrated by adding 0.3% by weight of sulphuric acid to the sludge precipitated in the subsiding basins. After treatment with acid, the clear liquid is drawn off from beneath the scum, leaving a concentrated sludge, said to contain 75% moisture. This acidified and concentrated sludge is distilled with superheated steam in an externally fired, cylindrical still containing a hollow agitator with perforated radial arms through which superheated steam is passed. The process is reported profitable.

In addition to the above, many attempts have been made to utilize the sludge from chemical precipitation plants, using lime and ferrous sulphate as precipitants, but so far they have been unprofitable.

Biological Process.

In recent years engineers have turned very generally to the biological process of sewerage purification, chiefly to the method of disposal by bacteriological oxidation. In doing so, they have planned their works to oxidize the organic matter contained in sewage and to reduce the sludge by digestion. The plan has been considered most successful which produced most economically the highest degree of oxidation, or, as often expressed, the highest degree of nitrification, also the least and the least offensive sludge. The plant which best embodies these ideas comprises an Imhoff tank and a bacterial filter bed.

With one exception, no by-products of any considerable value can be recovered to offset the cost of treatment by oxidation. The one exception is the activated sludge process. This is a combination of a physical and a biological process, in which part of the organic matter is destroyed and a very complete separation of the suspended and liquid portions of the sewage is brought about. The process has the further advantage of producing an effluent of good appearance and low bacterial content, which can be discharged into many bodies of water with impunity. This feature and that of easy sludge separation have stimulated engineers to recover the fat and fertilizer values which exist in the bulky activated sludge. It is claimed by many that products of enough value can be recovered to gain a small profit over and above the cost of handling the sludge, but this value will not entirely offset the cost of the whole process. However, it will probably outweigh the cost of sludge disposal. The whole process marks a notable advance. It may be regarded as the climax of the biological processes, and if the net cost, including the cost of aëration and recovery of valuable products, may be brought within reasonable limits, the process may be applied in many cases where the conditions are favorable. It is not applicable to sewages containing those manufacturing wastes which retard bacteriological action.

The activated sludge process, and one other process to be described shortly, have served to re-stimulate interest in the possibility of recovering enough valuable products to

† Engineer of Sewer Service, Public Works Dept., Boston.
‡ Of Weston & Sampson, consulting engineers, Boston.
¶ Rideal, S., 1916. Recovery of Fats and Nitrogen from Sewage. Proceedings, Association of Managers of Sewage Disposal Works, 59, 571.
§ Hopfner and Paulmann, 1902. Die Verarbeitung der Ruckstande aus der Schmutzwasser Reiningungsanlage der Stadt Cassel. Mit, a. d. Konig. Prufungsanstalt f. Wasser, und Abwasser, 1, 146.
‖ Bechold, 1899. Untersuchungen an dem Klarbeckenschlamm zu Frankfurt a. M. Zeitschrift fur angewandte Chemie, 12, 849.
* English Pat., 16, 397, August 4, 1908.

make their values important factors in the economy of sewage disposal processes. That other is a new chemical precipitation process known as the Miles acid process, and to describe it and to indicate its possibilities is the object of this paper.

Further Information Necessary

While all of the large-scale trials of the Miles process have been giving promising results, it is true that the drying and degreasing of sludge has never been practised on a large scale. All of the estimates are based upon small-scale trials and the opinions of engineers and of manufacturers who have handled similar materials. There is great need, therefore, for a large-scale experiment with normal sewage to determine the actual possibilities in practice. This experiment should be made on a scale large enough to determined beyond all doubt the cost of drying and degreasing and the possibility of marketing the products. It might cost $50,000.

Adaptability of Miles Process

In the words of Winslow and Mohlman,—"For communities where clarification and disinfection are desirable, —where screening would be insufficient and nitrification unnecessary,—the process of acid treatment comes fairly into competition with other forms of tank treatment; and that it is particularly suited to dealing with sewages which contain industrial wastes and for use in localities where local nuisances must be avoided at all costs and where sludge disposal could be provided for only with difficulty." This means that in 90% of the cases where a large volume of strong sewage is discharged, the Miles process is worthy of consideration.

Conclusions

We conclude the following from the results of the various experiments and studies:—

(1) The Miles process will produce a well disinfected effluent from which 90% of the settleable solids have been removed.

(2) Whereas it requires for its accomplishment devices for the chemical treatment of the sewage and for drying and degreasing the sludge, competent supervision is necessary.

(3) On account of the nature of the plant and the relatively high cost of operation for small installations, it is not well adapted for the purification of small volumes of sewage.

(4) Its operation should cause no local nuisances.

(5) It causes the removal of over 99% of the bacteria.

(6) The effluent remains stable long enough for the neutralization of the excess acid, and the oxidization of the sulphites and the sulphates by dilution.

(7) As compared with the activated sludge process, the volume of sludge is very small.

(8) Compared with the cost of the oxidation processes, the cost of installation is low; it is somewhat higher than that for Imhoff tanks with chlorination.

(9) The products recovered are valuable, and their recovery would effect a conservation of natural resources.

(10) Apparently it is the most economical process for producing so well clarified and so stable an effluent, and under present conditions it seems as if it could be installed and operated at a profit in those larger cities where the conditions are favorable.

(11) To determine the costs of sludge drying and degreasing more accurately than is possible from the available data, a large-scale experiment is urgently needed.

History of Miles Process

Beginning about the year 1900, Mr. George W. Miles, a well-known Boston chemist, with the co-operation of the officers of the Boston Sewer Department, suggested the use of acid to accelerate the precipitation and separation of sludge, and proposed to recover fats and fertilizer from the sludge so produced. The most important factor in the new process consists in the application of the acid to the sewage itself, rather than to the sludge precipitated therefrom; and it lays emphasis upon the decomposition of the soluble soaps and the liberation of the fatty acids,* which latter do not appear as fats when unacidified sewage is tested by standard methods, and are only partially precipitated with the sludge in plain subsiding basins. Furthermore, Miles has suggested the use of sulphur-dioxide gas rather than the sulphuric acid† made from it, thereby avoiding several expensive steps in its manufacture and greatly reducing the cost, besides bringing into play the disinfecting action of the sulphur-dioxide gas upon the sewage itself. If desired, a combination of sulphuric and sulphurous acids may be used.

Sodium acid sulphate (niter cake) is the waste product from the nitric-acid plants, and, as a result of the war, there are enormous quantities of this material piled near nitric-acid plants, for which there is now little use. At the present time this is the cheapest source of sulphuric acid. Before the war, the cheapest source was either sulphur or pyrite (ferrous sulphide).

Experiments

Experiments conducted by one of us (E.S.D.), and by other officers of the Sewer Division of the city of Boston, were made at different times between June 20, 1911, and June 29, 1914. In all, eleven runs were made at different times during the four years, and 25,986 gals. of sewage were treated. The quantities of products recovered per million gallons of Boston sewage, during these experiments, were, as averaged, 1,738 lbs. of dry sludge, containing 21.7% or 436 lbs. of grease, and 1,361 lbs. of fertilizer base, having an ammonia content of 4.5%.

Early in 1915, one of us (E.S.D.) delivered a lecture before the students in the Public Health Department of the Massachusetts Institute of Technology, on the possibilities of the Miles process. The subject, as presented, greatly interested Prof. William T. Sedgwick, who later arranged with Mayor Curley for a large-scale experiment at the joint expense of the city of Boston and the Sanitary Research Laboratory of the Institute.

In the Technology experiments two continuous runs were made, one of seven days in July, and one of three days in November, 1915; and the volume of sewage treated averaged 8,241 gals. daily. The experiments are described elsewhere,‡ but the results obtained during the city's experiments were almost duplicated, as the following table shows:

During the summer of 1914, Mr. Langdon Pearse, division engineer of the sanitary district of Chicago, made experiments¶ to learn whether acidification could increase the yield of fat from the Centre Avenue sewage. Tests in barrels and in a tank holding about 1,500 gallons were made under his direction. A three-hour period of subsidence was used, and the alkaline sewage required about 3,200 lbs. of 100% H_2SO_4 per million gallons. Sulphur dioxide was not tried.

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*Most fats are combinations of glycerine with fatty acids. Soaps are combinations of fatty acids with sodium or potassium. Soaps are soluble, and if a sewage containing them be evaporated, and the residue extracted with ether (the ordinary method of obtaining the fats), the fatty acids in the soaps are not dissolved. On the other hand, if acids be added, they decompose the soaps, set free the fatty acids, and then, if the sewage be evaporated or extracted with ether or another solvent, the fatty acid is dissolved with the true fats. The fatty acids recovered by the extraction of the sludge from acid-treated sewage, may be remade into soaps by treatment with soda or potash.

†Theoretically, sulphuric acid is oxidized sulphur plus water, that is:

$S + O = SO_2$ (Sulphur Dioxide).

$SO_2 + H_2O = H_2SO_3$ (Sulphurous Acid).

$H_2SO_3 + O = H_2SO_4$ (Sulphuric Acid).

Sulphurous acid is more effective than sulphuric acid for treating sewage. Furthermore, its use avoids the cost of oxidizing the sulphur dioxide. This is ordinarily accomplished by the use of nitric acid and the oxides of nitrogen in what is called a "lead chamber," into which nitrogen trioxide (N_2O_3), steam and air are introduced with the sulphur dioxide. The more modern way is to produce oxidization by direct contact of sulphur dioxide, oxygen and water with spongy platinum or some other catalytic agent, activated by electricity. From either the old or the new process dilute sulphuric acid results, and the cost of concentration as well as the cost of transporting the water, which is a necessary part of the finished product, ordinarily enter into the cost of sulphuric acid. It must, therefore, be added to the cost of sewage treated when sulphuric rather than sulphurous acid is used.

‡Weston, R. S., 1916. Tests of a New Process of Sewage Purification, with Grease Recovery and Apparent Profit. American Journal of Public Health, 6, 334. Reprinted in Boston City Record, March 3, 1917.

¶Sanitary District of Chicago, Report on Industrial Wastes, 1914, pp. 191-194.

Pearse's results showed that acid treatment produced a higher recovery of fat, namely 69% of that in the sewage as compared with 47% obtained by plain subsidence for three hours. The sludge, which amounted to 2,275 lbs. per million gallons, contained, on an average, 93% of moisture and 25% of fats. The results also showed a great reduction in oxygen demand,—170% of that obtained by an Emscher tank. They also showed a removal of 71% of the suspended matter.

TABLE 1—COMPARISON OF AVERAGE RESULTS OF TREATING SEWAGE WITH SULPHUROUS ACID, AS SHOWN IN EXPERIMENTS BY E. S. DORR AND M. I. T. SANITARY RESEARCH LABORATORY, 1912-1914 AND 1915, RESPECTIVELY

	Experiments by E. S. Dorr.	Experiments by M. I. T. Sanitary Research Laboratory.
Average daily flow of sewage during experiments, gallons	92,514,647	103,498,049
Average amount of dry sludge, pounds per million gallons of sewage	1,738	1,909
Average percentage of grease in dry sludge	21.7	22.66
Average amount of grease precipitated from sewage, pounds per million gallons	436	430.1
Average amount of sulphur dioxide used, in pounds per million gallons	*2,300	1,963

Much more extensive experiments have been conducted by Prof. C.-E. A. Winslow of the Yale University Medical School, and Dr. F. W. Mohlman, now chemist of the Connecticut State Department of Health. The results of these experiments have been embodied in a paper read in September, 1918, before the American Society for Municipal Improvements at its meeting in Buffalo and abstracted elsewhere.†

The experiments were conducted at New Haven under the auspices of a special committee, and consisted of four long-time runs with the sewage from the East Street sewer, and one run with that from the Boulevard sewer, the former runs varying from twenty-four to seventy days, the latter being twenty-nine days' duration. Alongside the experiments with the Miles acid process, there were conducted experiments with screens, with the activated sludge process, and with Imhoff tanks and with plain subsiding basins, with and without chlorine disinfection.

In the experiments with the Miles process, the sewage was acidified with sulphur-dioxide gas, and a four-hour period of subsidence was provided. The alkalinity of the

TABLE 2—CHARACTER OF MILES ACID SLUDGE AT NEW HAVEN

	East Street Sewer.				Boulevard Sewer.
Length of run	25 days	24 days	44 days	70 days	29 days
Total gallons sewage treated.	260,000	239,400	407,820	602,220	145,500
Pounds of wet sludge per mil. gals. sewage	3,750	4,025	3,200	2,600	5,375
Specific gravity	1,067	1,048	1,054	1,061	.....
Per cent. moisture	86.6	88	86.3	85.7	92.5
Pounds dry sludge per mil. gals. sewage	503	483	439	368	403
Ether extract, per cent. dry sludge	23.7	24.0	29	32.6	30.9
Ether extract, pounds per mil. gals.	119	116	127	120	124
Volatile matter, per cent. dry sludge	47.2	51.2	57.3	63.8	78.5
Nitrogen, per cent. dry sludge	1.6	1.6	2.4	2.0	3.0

East Street sewage was very low, so that it was necessary, to secure an excess acidity of 50 p.p.m., to add only 700 lbs. of gas per million gallons of sewage treated. With the Boulevard sewage, 1,130 lbs. of acid per million gallons of sewage were required to secure the same excess acidity (computed in terms of calcium carbonate).

The treatment removed from 61% to 66% of the total suspended, and 90% of the settleable solids. The removal of bacteria was all that could be desired, the two last experiments, with the East Street and Boulevard sewages respectively, indicating removals of over 99% of the total bacteria, and of the gas-forming organisms.

The use of acid accelerated the precipitation of the suspended solids by about 50%, only 40% being removed from the untreated sewage by plain subsidence as compared with 60% when the Miles process was used. The data regarding the production of sludge are as follows:—

Opposed to these very favorable results is the presence in the grease extracted from the sludge of a large proportion of unsaponifiable material (waxes, mineral oils and similar substances). Substances of this kind are practically worthless, and their removal is attended with a great deal of expense. The sludge from the East Street sewers contained 24% of grease, 46% of tankage and 28% of water. The grease had the following composition:—

	Per Cent.
Moisture and volatile matter	11.0
Unsaponifiable material	21.1
Free fatty acids	40.2
Neutral grease	22.3
Insoluble soaps	3.3
Per cent. of resin in free fatty acids	14.4

The degreased sludge had the following composition:—

Ammonia	3.91%
Phosphoric acid, P_2O_5	0.96%

Winslow and Mohlman are advised by experienced users of grease that it would be necessary to distill the crude extracted product in order to produce a salable grease. This fact has been recognized, and, on the basis of distillation experiments, they estimate that the grease in the East Street sewage would be worth $5.00, and the fertilizer $2.09 per million gallons,—a total of $7.09 net,—while the grease value of the Boulevard sewage would be $8.50, and the fertilizer value $2.88 per million gallons,—a total of $11.38, net.

Conditions at New Haven are such that the effluent must be clarified and disinfected, but not necessarily nitrified. These conditions are favorable to the Miles process, to Imhoff tanks combined with chlorination, and to fine screening combined with chlorination, respectively. The activited sludge process would not work because of the presence of copper salts in the sewage.

The operation costs of the disposal plant are estimated in the following tables:—

TABLE 3—ESTIMATED COST OF TREATMENT OF EAST STREET SEWAGE—DOLLARS PER MILLION GALLONS

	Miles Acid Process.	Imhoff Tanks and Chlorination.	Fine Screens and Chlorination.
Tanks and Buildings (interest and depreciation)	$ 2.47	$ 5.28	$ 4.60
Acid treatment	6.93		
Drying sludge	2.09		
Degreasing sludge	1.78		
Redrying sludge	.17		
Superintendence	1.06	.46	.46
Labor on tanks and screens	1.00	1.20	1.42
Disposal of sludge or screenings		1.00	.50
Chlorination		4.05	4.05
Gross cost	15.50	11.99	11.03
Revenue	6.57		
Net cost	8.93	11.99	11.03

The results of these experiments have warranted the New Haven Committee in recommending the Miles process for adoption by the city of New Haven, and that a plant be built first at the East Street sewer, which discharges 16,000,000 gals. daily, and, if this plant be successful, the sewage from the other outfalls should be treated.

*Approximate.
†Engineering News-Record, 81, 1034-1036. Also 82, 32-36.

TABLE 4—ESTIMATED COST OF TREATMENT OF BOULEVARD SEWAGE—DOLLARS PER MILLION GALLONS

	Miles Acid Process.	Imhoff Tanks and Chlorination.	Fine Screening and Chlorination.
Tanks and Buildings (interest and depreciation)	$ 2.47	$ 4.44	$ 4.60
Acid treatment	10.74		
Drying sludge	2.04		
Degreasing sludge	1.91		
Redrying tankage	.17		
Superintendence	2.65	1.15	1.15
Labor on tanks and screens	1.00	1.50	2.05
Disposal of sludge or screenings		1.00	.50
Chlorination		4.05	4.05
Gross cost	20.98	12.14	12.35
Revenue	10.66		
Net cost	10.32	12.14	12.35

Winslow and Mohlman's paper is an eminently fair report of the results of a thorough investigation. They have given this new proposition just the treatment it should receive, namely, an unbiased discussion to bring out all important points, both favorable and unfavorable. In so doing they have made two criticisms, both of which are unfavorable and call for comment and explanation. F. W. Mohlman* states that the effluent, containing as it does bisulphites and free dioxide, has the power of deoxygenating several volumes of diluting water, and apprehends that a zone of deoxygenated water will be formed about the point of discharge of the acid effluent. Although not so stated, the implication is that such a zone might cause a nuisance or be injurious to fish life. Otherwise there would be no need for considering it a danger. The question raised is whether or not effects would be produced which would call for the aëration of the effluent. Mohlman's laboratory experiments show the effect upon the dissolved oxygen and sulphur dioxide contents of diluting the Miles process effluent with varying volumes of New Haven harbor water. The results are given in the following table:—

TABLE 5—MIXTURE OF HARBOR WATER AND MILES EFFLUENT

	Effluent.	Harbor Water.	1 Eff. to 2 Water.	1 Eff. to 4 Water.	1 Eff. to 9 Water.	1 Eff. to 19 Water.
Dissolved oxygen	0.8	12.0	1.0	5.0	8.8	11.0
Sulphur dioxide	118	0	8	0	0	0

This table shows that in a dilution of 2 of harbor water to 1 of effluent, the oxygen is reduced from 12 parts to 1 part per million, and the sulphur dioxide from 118 to 8 parts. At a dilution of 4 to 1, the oxygen is decreased five times, and the sulphur dioxide has disappeared. At a dilution of 9 to 1, the oxygen is 73%, and at a dilution of 19 to 1, 92% restored.

Polluted waters produce nuisances when they putrefy and give off tne products of the decomposition of organic matter containing sulphur. They putrefy if the oxygen is exhausted before the organic matter is oxidized. In other words, the bacteria will oxidize the organic matter to the limit of the oxygen, and if any organic matter remains, the bacteria of putrefaction will attack it and produce the well-known conditions.

TABLE 6—CONTINUOUS AERATION OF MILES EFFLUENT

Date.	Sulphur Dioxide, Influent.	P.P.M. Effluent.	Reduction, Per Cent.	Air per Gal. Cu. Ft.
March 6, 1918	99.1	44.9	54	0.10
March 7, 1918	70.4	14.4	79	0.10
March 8, 1918	72.3	14.4	80	0.11
March 9, 1918	69.1	5.2	92	0.10
March 10, 1918	81.3	46.4	43	0.10
March 11, 1918	80.9	36.1	55	0.06
March 31, 1918	53.8	10.2	81	0.10
April 1, 1918	108.5	37.4	65	0.10
April 2, 1918	90.9	26.5	71	0.10
April 3, 1918	71.0	19.8	72	0.10
April 4, 1918	92.2	4.5	95	0.10
Average	78.1	23.6	70	0.097

*F. W. Mohlman. Miles Acid Process May Require Aeration of Effluent. "Engineering-News Record," 81, 285, August 1, 1918.

The Miles acid effluent does not represent the same conditions as those which exist in a deoxygenated, polluted water, because, in the case of the effluent, the deoxygenation has been produced chemically, not biologically, and the organic matter present has been practically sterilized. Furthermore, the settleable solids which might form sludge banks near the point of discharge have been largely removed. Before a nuisance can occur, bacteria must be introduced and be given a chance to multiply. Meanwhile dispersion and dilution are doing their work, and reaëration is taking place. Then there exists the condition of a warm, practically sterile effluent, free from sludge-forming suspended matter, being discharged into a considerable body of water, to the surface of which it will tend to rise and spread in a thin layer, thereby becoming subject to the reaërating effect of the wind, currents, passing craft, etc.*

Removal of Sulphur Dioxide

Mohlman showed that the sulphur dioxide may be removed by aëration before dilution with harbor water, and after aëration the effluent will not deoxygenate large volumes of diluting water. The average results of various aëration experiments using compressed air admitted through a "Filtros" plate into a shallow aërating tank providing a detention period of thirty-one minutes are as follows:—

From the results of these experiments, Mohlman concludes that 70% of the free sulphur dioxide may be removed by blowing the effluent in a shallow tank with 97,000 cu. ft. of free air per million gallons of sewage. This degree of aëration is about one twentieth of the 2 cu. ft. per gallon commonly used in connection with the activated sludge process.

Oesten, also G. C. and M. C. Whipple, and others, have shown that the aëration of water, which is in this case the interchange of oxygen and sulphur dioxide, may be accomplished more economically by the use of riffles, sprays or cascades, than by aëration with compressed air. The latter method is rarely if ever used in water-works practice. In the case of the Miles effluent we believe that a sufficient degree of reaëration could be secured by discharging the effluent over a series of riffles, or, if that plan were impracticable, by pumping the effluent through a suitable aërator, in the latter case at a cost of less than $1.00 per million gallons.

Fish life could hardly be affected, for the only place where fish could get into any considerable depth of deoxygenated water would be close to the outlet. Elsewhere they would not be affected unless they swam on the surface, which fish would not do ordinarily.

Recovery of Grease

Pearse's statement in connection with experiments at Chicago†—namely, that the acid effluent has a lower oxygen requirement than ordinary tank effluent—is evidence that, while the effluent contains no oxygen, less is required for the oxidation of the remaining organic matter than in the case of settled sewage.

It is therefore our opinion that under ordinary conditions of discharge into rivers or harbors, the dispersion, dilution and reaëration of the acid effluent would be much more rapid than the development of putrefaction and consequent nuisance; and in rare cases where aëration might be necessary it could be accomplished at a cost which would not militate against the usefulness of the process.

The second point,—namely the presence of unsaponifiable matter in the recovered grease has already been referred to above, and it is one of great importance, as it makes necessary the distillation of the grease.

The value of the grease from the Boulevard sewage is estimated at 8.5c. per lb. to the producer. This is the

*Mohlman, loc. cit.
†Report on Industrial Wastes, loc. cit.

judgment of the Falk Company of Pittsburgh, who distilled a sample of considerable size. This is about one-half the current price of good, saponifiable grease, containing less than 4% of unsaponifiable matter. Evidently the value which has been assigned to the recovered grease in previous statements regarding the economy of the Miles process should be correspondingly reduced.

Massachusetts State Experiments

The New Haven authors have referred to the report on the Miles process made by Messrs. Goodnough and Clark of the Massachusetts State Department of Health to a commission appointed by the legislature, and presented by that commission to the legislature early in 1918, and have stated that "these Massachusetts experiments (by X. H. Goodnough and Harry W. Clark) were made on a small scale in bottles, and an eighteen-hour sedimentation period was used, which seems somewhat unfair to the acid process which accomplishes the same results in four hours. The disinfection of the effluent, and the freedom of the process from nuisances, is, of course, ignored in such a comparison." As this report is made by a Massachusetts commission, and because its conclusions are contrary to the New Haven results, we believe it warrants discussion.

The experiments of Goodnough and Clark were made with three 2-gal. samples made up of aliquot hourly portions collected one day each week for several weeks. The sampling was apparently fair, but on account of the infrequency of the samples could not have been as truly representative as the portions of sewage used during the tests made by the Massachusetts Institute of Technology, amounting to a hundred thousand gallons of sewage. The small samples of sewage were acidulated with sulphur dioxide gas, settled, and the sludge collected and analyzed. While it is true that the sewage was treated with acid, enough departures were made from the Miles process so that it can hardly be called a test of that process.

The results compared with the Technology experiments show that 61% as much acid was used and 75% as much sludge; and 79% as much grease was recovered. These lower results may have been due either to a weaker sewage, or to insufficient acidification. But the most radical departure from the Miles process was in the use of an eighteen-hour period of subsidence in place of the four-hour period used in the Miles process. Using the longer period of subsidence, the state authorities came to the conclusion that there was not enough difference (25%) between the amounts of sludge obtained to pay for the acid used. In this conclusion no attention was paid to one of the cardinal points of the Miles process, namely that acid is used to accelerate precipitation; therefore it was hardly fair to compare it with an eighteen-hour period of subsidence, particularly so because no engineer would ever consider the use of so long a period of plain subsidence for the treatment of sewage.* The plan would be prohibited by the initial costs of the work, the local nuisances produced, and the small amount of purification effected by the treatment. Conditions at Moon Island—Where sewage is stored about four hours, on an average—which are bad enough, only approach those which would exist were sewage stored eighteen hours before discharge, and it is abhorrent to contemplate what the conditions would be if the sludge from these tanks could not be discharged with the sewage, but had to be otherwise disposed of. These were the conditions which in a great measure prevented the success of the plant at Cassel, Germany.

Absence of Local Nuisance

Apparently the report of the Massachusetts commission attaches little importance to the sterilizing effect of the sulphur dioxide and the absence of local nuisance, although that point was brought out in the report of the experiments conducted by the Massachusetts Institute of Technology. Furthermore, Winslow and Mohlman state that "it is particularly important from the point of view of the practical sewage-works operator to note that both effluent and sludge were so affected by the acid present as to be stable for considerable periods, so that with a plant of this type no local nuisances need be anticipated. During the whole period of our experience, there were only one or two occasions on which slight signs of septic action were noticed in the tank, and the sludge was stored in barrels for weeks without the production of offensive odors." They also state that "above all, however, the thing that counts most heavily in favor of the Miles process under the conditions obtaining at New Haven is its freedom from nuisance."

In view of the local nuisance produced by many a bacterial tank and filter, we believe the stability and freedom from nuisance of the Miles process effluent and sludge are worthy of all the consideration which previous experimenters, with the exception of Messrs. Goodnough and Clark, have given it.

The Practicability of the Process for Boston Sewage

It is interesting to apply the New Haven estimates of cost to the results of the experiments with Boston sewage which have been made under our direction. These experiments showed that Boston sewage yielded about 1,500 lbs. of degreased tankage, containing 4.53% of ammonia; also about 400 lbs. of recoverable grease per million gallons. With fertilizer ammonia at $4.00 per unit, the tankage is worth $18.12 per ton, or $13.59 per million gallons of sewage. Using 8.5c. as the price per pound for the recovered grease, which seems fair because this was the estimated value of the New Haven Boulevard sewage which contains about the same percentage of unsaponifiable matter as the Boston sewage), the grease would be worth $34 per million gallons.

Modifying the New Haven costs to correspond with the stronger Boston sewage, we have determined the costs as given in the following table, which also shows the costs of treatment of the Boulevard sewage of New Haven. We have not used the East Street sewage for comparison because it is not representative; it contains an unusual amount of machine oils and wastes from the metal industries.

TABLE 7—COST PER MILLION GALLONS OF TREATING 100,000,000 GALLONS OF CALF PASTURE SEWAGE DAILY, APPLYING THE UNIT COSTS ESTIMATED BY WINSLOW AND MOHLMAN FOR 16,000,000 GALLONS OF NEW HAVEN SEWAGE DAILY

	Calf Pasture Sewage.	Boulevard Sewage.
Tanks and buildings	$ 2.47	$ 2.47
Acid treatment	18.65	10.74
Drying sludge	10.35	2.04
Degreasing sludge	9.12	1.91
Redrying tankage	.10	.17
Superintendence	1.06	2.65
Labor on tanks and screens	1.00	1.00
Total cost per million gals	$42.75	$20.98

In applying the New Haven unit costs, we have made no subtraction on acount of the larger plant or the available tanks at Moon Island. Unit costs for all items except superintendence and labor are those used for Boulevard sewage; the unit costs for the superintendence and labor are those used for East Street sewage.

The estimated net financial result of operation is given in the following table.

In the above we have estimated the price of ammonia at $4 per unit. This is low at present. When ammonia is worth $4.50 a unit, the gross revenue would be $49.29, and the profit $6.54 per million gallons, and at $4.75 per unit, the gross revenue would be $50.14 and the profit $7.39 per million gallons. While the above estimate shows a profit under present conditions, it is probably true that under pre-war conditions the process would not produce a revenue; and in their conclusion, Winslow and Mohlman state that "our experience with New Haven sewage lends no color to

*It is obvious that if sewage be held for a period of days, all of the settleable solids would subside, and there would be little or no difference in favor of acid treatment, assuming, of course, that fermentation would not interfere with plain subsidence, as might be expected.

the hope that a net financial profit can be obtained by the use of the Miles acid process, unless with sewage of exceptionally high grease content and low alkalinity."

One may rightly question the values of any conclusions based on pre-war prices, because the present evidences indicate that the prevailing prices will not be lowered immdiately, and they may never reach their pre-war level.

TABLE 8—ESTIMATED FINANCIAL RESULTS OF OPERATING THE MILES ACID PROCESS AT THE CALF PASTURE

	Per Million Gallons.
Revenue:	
From tankage	$ 13.59
From grease	34.00
Total gross revenue	$ 47.59
Expenses:	
Estimated cost of treatment	42.75
Profit on above basis	$ 4.84

This is particularly true of labor which is the principal factor in the costs of materials. At present high prices it seems as if the Miles process would be profitable at Boston, and this favorable condition would gradually disappear as the rate of fall in prices exceeding the rate of fall in cost of operation comes into effect.

The materials produced are fertilizer and grease, and it does not seem likely that the demand will decrease rapidly. The materials used for purification are sulphur, pyrite, nitre cake and the sulphur acids. The war has stimulated the production of all these materials, and now that the abnormal demand has ceased they should be cheap.

Therefore we feel that in many cases it is likely that the Miles process might be operated at a slight profit for some time to come, and, in any event, operated at a cost lower than that for any other process producing the same grade of clarification and disinfection.

Other Advantages of the Miles Process

In addition to the advantage due to the freedom from nuisance, the stability of effluent and sludge, and those due to the compensating value of the recovered products, there are still other advantages which should be reckoned with.

Sanitary Efficiency a Necessary Concomitant

All are aware that modern sanitary engineers are designing sewage disposal works to purify sewage to the degree to which the body of water into which the effluent is to be discharged demands and as the financial conditions will allow. In so doing they often sacrifice a desirable degree of clarification, as when only subsiding basins or screens are used; or a high degree of nitrification, as when high rates of filtration through coarse material are employed; but with the Miles process it is a fundamental necessity, in order to recover the valuable products upon which the cheapness of the process depends, to at the same time disinfect the effluent and attain a much higher degree of clarification than can be obtained by screening or plain subsidence. Therefore there is little temptation to sacrifice safety for cheapness.

The sludge from the Miles process contains much less moisture than activated sludge, and about the same as the subsiding basin sludge and the Imhoff tank sludge, as the following table shows.

TABLE 9

Kind of Sludge.	Average Percentage of Moisture in Sludge.	Relative Volumes of Sludges Containing the Same Amounts of Dry Matter.
Activated sludge	98.5	100
Subsiding basin sludge	91.5	18
Miles process sludge	90.0	15
Imhoff tank sludge	89.0	13.6

As compared with activated sludge, the advantage of handling less than one seventh of the volume of activated sludge is obvious.

Installation Cost

The devices required for the operation of the Miles process are the following:—

Devices for producing sulphur-dioxide gas, and for feeding niter cake or other forms of acid.
Subsiding basins.
Sludge-handling apparatus.
Sludge driers.
Grease extractors.
Grease stills.
Tankage driers and grinders.

While the list is formidable and is enough to rule out the process for small plants, in the case of a city like Boston, however, the cost should not exceed $15,000 per million gallons, daily capacity.

MAINTAINING WATER SUPPLIES IN YARD MAINS*

BY GEO. H. GREENFIELD

IT is frequently found, when making changes or repairs on the fire main systems of large industrial plants, that the amount of protection removed while the water remains shut off is excessive and creates a considerable hazard. This condition can often be improved by installing sufficient sectional control valves, but even then, in large plants, outlying portions of the fire mains are frequently rendered useless when section control valves are shut to allow of repairs, etc.

A system that has recently been adopted by a corporation owning several large plants is as follows:—

Double female hose couplings have been provided at the different works, and, before any section is shut off, the fire main plan is carefully examined by the fire chief. In a great many cases it is found possible to bridge a section of water main that is out of service, or to join up an outlying section by running lines of hose from hydrant to hydrant, using the double female couplings.

In summer the water is turned on, but in cold weather the lines of hose are run and all made ready, but water is not turned on.

During a recent shut-off one Sunday to allow of some extensions on the fire loop at one of the works, the adoption of the above system made it possible for water to be maintained on the lumber yard section, which included five hydrants and three large sprinklered lumber storage buildings. Under normal conditions the protection would have been entirely removed whilst the changes were being made.

A few six, eight and ten-inch soft taper wooden plugs, about two feet long, are kept in the fire station, so that when mains are being cut they can be plugged in a hurry should occasion arise.

The double female hose couplings also serve the additional purpose of allowing municipal fire departments steamers to couple up to the yard hydrants and boost the pressure, should this be necessary through failure of the plant fire pumps, or through excessive demand for water. In the latter event, the system serves a purpose similar to that of the reverse hydrant mentioned by Mr. Charles E. Worthington in the July, 1918, issue of the *Quarterly* ("Planning Factory Water Supplies for Emergencies," page 76).

*From the National Fire Protection Association.

The Ontario Department of Highways will have an exhibition at the coming Good Roads Congress in Quebec, of thirty miniature models of roads in all conditions of construction. Moving pictures of provincial activities in road making will also be shown.

THE IMPORTANCE OF ADEQUATE DRAINAGE AND FOUNDATIONS FOR ROAD AND STREET SURFACES*

By Clifford Richardson,
The Barber Asphalt Paving Co., New York

THE satisfactory nature of any type of pavement or road surface is primarily dependent on the rigidity of the foundation which supports it. Inadequacy in this respect reduces all forms of construction to a common level of inferiority. Rigidity in a road surface cannot be obtained without suitable under-drainage and, for this reason, drainage is a feature of primary importance in the construction of roads and pavements.

Historical

This fact has been recognized for at least a century, but it has seldom been carried out effectively. The ideas of the older engineers, McAdam, Telford and others, in regard to road construction and the importance of the relation of drainage thereto, are widely scattered through the earlier literature of the subject. They were recognized and summarized in an interesting book by S. DeWitt Bloodgood, published at Albany, N.Y., in 1838, entitled, "A Treatise on Roads," in which it is found that sound principles had been established in the United States at that early date, by engineers who had an adequate comprehension of the subject, at least as far as the requirements of their day were concerned.

That this was a fact can be realized from some of Mr. Bloodgood's statements:—

"The strength of a road depends on the nature of the material of which it is formed, and of the basis on which it is placed."

"McAdam's theory of road-making may be comprised in the following quotation from his Report to the Board of Agriculture, (vol. vi. p. 46):—'Roads can never be rendered perfectly secure until the following principles be fully understood, admitted and acted upon, namely, that it is the native soil which really supports the weight of traffic; that while it is preserved in a dry state it will carry any weight without sinking, and that it does, in fact, carry the road and the carriages also; that this native soil must previously be made quite dry, and a covering impenetrable to rain must then be placed over it, to preserve it in a dry state.'"

"The erroneous opinion so long acted upon, and so tenaciously adhered to that, by placing a large quantity of stone under the roads, a remedy will be found for the sinking into wet clay or other soft soils; or, in other words, that a road may be sufficiently strong, artificially, to carry heavy carriages, though the sub-soil be in a wet state, and by such means to avert the inconveniences of the natural soil receiving water from rain or other causes has produced most of the defects of the roads of Great Britain. At one time, McAdam had formed the opinion that this practice was only a useless expense; but experience has convinced him that it is likewise positively injurious."

"Drainage: In proper construction in this part of the business of road making, great care is necessary. The utmost judgment of the skillful surveyor will be called into action to enable him to make the best use of the natural facilities of the country, and to overcome the obstruction that he will sometimes meet with. In passing over flat land, open main drains, cut on the field side of the fences, must communicate with the natural water-course of the country; they should be 3 feet deep below the level of the bed of the road, 1 ft. wide at bottom, and 5 ft. wide at top."

With the building of railroads, however, the construction of highways of the better type was gradually neglected, and but little attention was paid to the subject of drainage and foundations, with perhaps some exceptions.

In the seventies of the last century the condition of our roads was such that W. M. Gillespie, in a volume, published in 1872, entitled "A Manual of the Principles and Practice of Road Making," stated in the preface:—

"The common roads of the United States are inferior to those of any other civilized country. Their faults are those of direction, of slopes, of shape, of surface, and generally of deficiency in all the attributes of good roads. Some of these defects are indeed the unavoidable results of the scantiness of capital and of labor in a new country, but most of them arise from an ignorance either of the true principles of road making, or of the advantages of putting these principles into practice."

From this quotation it appears that road construction and maintenance were at a very low ebb at that period. They remained so until the bicycle came into common use. For the comfort of the riders good roads were demanded and a considerable effort was made to provide them. The difficulties of the present period, however, are to be attributed to the fact that motor vehicles and, particularly, motor trucks have become important features in the transportation of passengers and freight over our highways and streets. It is a form of traffic and travel which has made much more serious demands upon them and on the methods of their construction, especially as regards drainage and foundations. As a result the problems relating thereto demand, and are receiving, more attention to-day than they have ever had, although their consideration is, even now, too often neglected.†

Drainage at the Present Time

It is evident that the demands made by the traffic which is carried at the present time by our main arteries of communication are such that the greatest stability is necessary for the support of their surfaces, and this can only be accomplished on a soil which is firm or made so by suitable drainage. In arriving at such an end the following points must be given consideration:—

The travel and traffic to be carried.
Character of subsoil.
Drainage, natural or artificial.
Climate.
Location.
Material available for construction.

The relative importance of these features will vary with different local conditions. There is no general rule which applies. In one case the character of the subsoil and the necessary drainage may be the ruling conditions, in another a severe climate, and in a third the material available for construction. Attention must be paid in a certain degree to all of them, however, in any case.

Location

As the solution of the problem of drainage and of the character of the foundation necessary for any particular road is dependent to a very large degree upon its location, the latter is, in this connection, an important consideration. It involves the application of both good judgment and experience, and due regard to the economic principles involved, that is to say, to the relation of the money expended and the results obtained. Like so many other problems which arise in building highways adapted to the use to which they are to be put, it is entirely a local one both financially and structurally.

Soil

As the support of a road surface is the soil upon which it, or its foundation, rests, the stability of the latter, or the imparting of stability to it, is a matter of primary importance.

Soil, as distinguished from sand, which is an aggregation of much coarser particles of mineral matter, is the fine residual of the weathering and decay of rock, associated with more or less organic matter of vegetable origin. Soils are of importance in road building since they form the initial foundation upon which the road is placed. Upon their character is dependent that of the drainage and artificial found-

*From "Municipal and County Engineering," Indianapolis, Ind.

†"Drainage Increasingly Vital with Growth in Heavy Traffic," by E. W. James—"Public Roads," Vol. 1, No. 3, July, 1918.

ation upon which a road surface or pavement is supported. They may be classified in a general way as sandy, loamy and argillaceous, between which all degrees of gradations exist. Marl and peat are particular forms of soil identified by components which characterize them, in one case shells and in the other a large amount of residual matter of vegetable origin being important components. Any soil may be modified in character by the presence of sand or gravel.

Some Moisture Desirable

A soil is of interest to the highway engineer chiefly as regards its stability, when properly drained, either naturally or artificially, that is to say, when any excess of water is prevented from accumulation therein in an amount sufficient or more than sufficient to fill the voids between the soil particles, thus involving in stability which arises from such a condition. The presence of an amount of moisture only sufficient to be absorbed by the surface of the particles of soil, but less than sufficient to fill the voids between the particles, will add to its stability and increase it beyond that of a perfectly dry soil. Sufficient water to form a film on the surface of the soil particles and thus develop a surface energy which will bring about cohesion of these particles may be an advantage as compared to a bone dry condition and undoubtedly exists very generally, but an amount to any degree beyond this would result in instability and also in disturbance by freezing, thawing and refreezing.* This condition is well illustrated by a sandy sea beach where as the tide recedes that portion in which the particles of sand are drained of excess of water, as the tide falls, still contains sufficient for the absorbed film on the surface of the individual grains to develop a surface energy which will bind the particles together in perfectly stable state, and one which will not be displaced under travel, whereas the same sand when perfectly dry, possesses no stability, the same condition existing at the other extreme, at that part of the beach nearer the sea and containing an excess of water. Attention need be called here only to the bearing of this relation on the stability of subsoils and the necessity for drainage. The solution of the problem of under-drainage in road construction is, therefore, largely dependent upon the character of the soil which is to be dealt with, that is to say, the state of subdivision of the particles of which it is composed. It is important that the surface of a road be impervious to water so that the bottom may be dry and stable. If these provisions are lacking every road surface or pavement, of no matter what type, will prove unsatisfactory and give no adequate return for the cost of construction, even with careful maintenance. This is, fortunately, beginning to be recognized.

The drainage demanded by any particular piece of road construction will depend primarily on the character, stability and dryness of the subsoil on which the road rests, its location, relative to its environment, and the climatic conditions which it is called upon to meet. It relates to the removal both of surface and of soil water. The character of the provision for the former will depend upon the surface area and the run-off to be taken care of; for the latter, on the nature of the subsoil upon which the surface is to be placed, the climatic conditions which are to be met, the lay of the surface of the road to that of the adjoining land and the traffic which it is to be called upon to carry.

Location of Drainage

Drainage is hardly necessary on sandy subsoils, for instance, such as some of those found on Long Island, New York, which in themselves will take care of water, except at low points, but it must be given serious consideration on heavier and especially clay sub-soils, in cuts and fills, particularly the former, and where seepage from slopes or hillsides may destroy the stability of the subsoil and reduce its capacity for carrying a load. In such cases an intercepting gutter for surface water and drain for ground water should be provided between the slope and the road. The necessity for the location of drainage for the removal of ground water should be determined in the spring, when frost is coming out of the ground, and for surface water during storms and periods of high water.

*"Engineering and Contracting," 49, 238, 1918.

Roads on Fills Should be Drained as Well as in Cuts

The location of a road on a fill does not always insure good drainage if the supporting soil is clay, especially if there is a steep grade on an adjacent portion of the road. An example of a difficulty of this description has been cited by Mr. J. P. Arnold,* of Delaware, who states that:—

"In one location water came from a spring in a cut at the top of a hill, ran down the hill and half way up a fill over a railroad track—a total distance of 1,000 ft. Breaks were found all the way across this fill and when the stone was picked up and a ditch cut through the shoulder at the break furthest from the cut, a 2 in. stream of water ran for nearly a day."

He adds: "A stone-filled V-shaped trench, pointing up the hill and placed at the end of every clay cut, will eliminate such breaks in these locations. Furthermore, weeps should be constructed about every 50 ft. to let the water out through the hard shoulder."

This is an excellent example of the fact that a fill should be maintained in as dry a condition as a cut.

The necessity for careful drainage is also emphasized where the soil has no inherent stability in itself, especially when wet, and offers little resistance to displacement.

Drainage may, perhaps, be of less importance, in cases where a Portland cement concrete foundation is provided, but in general, as evidenced by the behavior of concrete roads, under the action of frost, which develop cracks and defects extending longitudinally, it cannot be disregarded.

Proper drainage of a road is much more essential in climates where frost and low temperatures are encountered than in a moderate or warm one, for reasons which are evident.

In the treatment of subsoils and in the character of the foundation placed upon them, local conditions must be given consideration. The most serious situation exists with clay subsoils which are exposed to extremely low temperatures in winter and which are thrown as the frost comes out of the ground in the spring. Examples which demonstrate this are illustrated by instances where insufficient drainage has been provided for bituminous and waterbound macadam surfaces in northern New York.* The only satisfactory way to meet such a condition is by removing the clay, which is encountered, to the depth that frost reaches, and replacing it with stone or gravel, with proper drainage, which will not be displaced or not as much so, by freezing and thawing.

Drainage Too Often Neglected

In considering under ten heads the main problems connected with highway construction, Mr. H. E. Breed,† of the New York Highway Commission, classes the matter of drainage as second only to that of bond issues, calling attention to the fact that, although it is an elementary topic, it is too often neglected like many other self-evident truths. He adds:—

"Drainage problems are considered so easy to solve that any one may adequately handle them. True, there is but little theory involved in the application of the principles that make for perfect drainage, but that rare quality known as judgment comes in largely here, as it does in all successful engineering work. Greater care and judgment in respect to drainage are needed now more than ever before in order to incrase the bearing power of our soils for the heavier loads that the traffic of to-day brings upon them.

"This topic may seem more worthy of attention when I tell you that in 1916, 84 miles of improved highways in New York, out of a total of 1,939 miles, broke up in the spring of the year. Of this, 43% was directly attributable to inade-

*"Engineering News-Record," 80, 933, Nov. 15, 1917.

*See illustrations in Trans. Am.Soc.C.E., 1912, Discussion: Road Construction and Maintenance.

†"Engineering News-Record," 80, 610, March 28, 1918.

quate drainage. During 1916 about 75% of these weaker areas was repaired and 238 miles of thin pavement was resurfaced. It may have still more force when I tell you that in New York State in 1917, 48 miles of improved highways, out of a total of 2,090 miles, broke up in the spring of the year, of which 18% was attributable to inadequate drainage.

"The percentages given as attributable to inadequate drainage were reported by the men having charge of each section and the personal equation enters largely into the cause to which each break-up was made attributable. They are, however, the most accurate percentages that could be obtained of the inadequacies of our drainage systems. These roads were not built by guess but under careful calculation by some of the best road engineers in the country. They installed upon them drainage systems such as they thought ample, but they had not taken into account the large increase in traffic and wheel loading that we have to-day. The roads failed because they disregarded the pumping action caused by the excessive pounding of that traffic, which draws the water and fine material up to and through the crust of the pavement until the crust is broken and the road shattered.

"I shall not attempt to suggest any scheme for the solution of the drainage problem, because each condition requires different treatment. Broadly speaking, however, drainage can be divided into two classes; surface drainage, and subsurface drainage. Surface drainage is cared for by the crown of the road and side ditches with proper run-off to carry the water away from the road at frequent intervals, so that it will not trouble us again as subsurface drainage. Every roadway should have ditches."

No better evidence of the importance of drainage, at least in climates like that of New York State, with severe winters, is needed.

It is unnecessary to go into detail here in regard to systems of drainage for ordinary conditions, since these are described in all their various forms and for different types of pavements and of road construction in text-books, in discussions of the subject before societies, in publications of the United States Office of Public Roads and State Highway Departments and in the engineering press. It is, however, necessary to insist upon the fact that in clay or heavy subsoils, especially in northern climates, if drainage is inadequate no amount of thoroughness in the construction of the foundations and surface of both pavements and roads will result in a satisfactory return for the money expended, even where the traffic is of the most moderate description. Adequate drainage for heavy clay subsoils, in the coldest climates, can rarely be satisfactorily accomplished, and the only method of meeting such conditions is the excavation of the clay to a considerable depth and its replacement with material which can be drained, or which is not as liable to displacement by frost. In general, it may be said that drainage is a local problem and its satisfactory solution is more dependent on a study of local and individual conditions than upon fixed standards.

Foundations

The first essential in the construction of pavements and road surfaces of durable character having been shown to be a dry, that is to say a well-drained and firm, sub-soil, as the result of either natural or artificial provision therefor, upon which to build and maintain a durable surface, another and equally essential factor in the successful construction of both pavements and highways is a suitable foundation. Its character will depend upon the conditions to be met. Practice, which might be excellent in one locality, may fail in another. A concrete foundation will, of course, be more costly than one of broken stone, but a foundation of this type 4 ins. in thickness will be stronger than a loose one of 2½ ins. broken stone of 6 ins., and the difference in cost will not be a serious consideration since the much smaller amount of stone used in the 4-in. foundation will largely make up for the cost of the cement and sand in the concrete. In a concrete foundation, when once laid, we have an asset which can be counted upon for all time, while a broken stone foundation is necessarily of a more or less temporary nature, owing to its displacement under travel, and disappearance, in some cases, into the soil which should support it.

Concrete Foundations

There seems to be every reason why, in the building of our highways, an effort should be made, at least in the case of those which are to carry heavy travel, to construct them with a concrete foundation, which will last for all time, and on which a wearing surface can be constructed, at such intervals as may be necessary, something which can be easily and economically done, and the life of which depends on the rigidity of the support afforded it. It is evident that as we are now constructing surfaces for many of our main arteries of heavy travel, we are throwing away large quantities of money by lack of adequate support of them. The result is much the same as if expensive buildings were erected without suitable foundations. This question of adequate foundations is one which should receive the careful attention to-day, and one which, if neglected, will do more than anything else to hamper the development of good roads, since great disappointment must arise when, within the course of a few years, it is discovered that the wearing surfaces which are now being constructed are so inadequately supported that they have given no reasonable return for the cost incurred in building them.

An adequate return, therefore, for the money expended on any type of pavement or road surface is dependent, after the provision of a dry support, on the rigidity of its foundation. The necessity for strong foundations is emphasized at the present time by the fact that our street pavements and main arteries of communication are called upon to carry a heavy burden and a very large traffic, owing to the advent of the motor vehicle, more especially the motor 'bus and motor truck, the latter rapidly increasing in capacity to such an extent that it is recognized that means for regulating it must be considered.

Foundations may be differentiated, primarily, as those depending on the soil alone as a support, known as natural or subsoil foundations, and those provided artificially which are of many types.

Foundations, like drainage, are a local problem. To meet it satisfactorily involves a careful consideration of the environment of the road and the uses to which it is to be put. A foundation of a thickness of only 4½ ins., which appears to be satisfactory in the climate of southern California, would be useless in northern New York. A different thickness may be called for on a hillside and on a level and in low as compared to high ground. The nature of the subsoil or manner in which the road is supported from below will also have a decided influence, a weak support calling for a heavier foundation. Again, if the drainage is not entirely adequate, a heavier foundation will be demanded. Its character will also be influenced by the materials which are available for its construction. If these are of the best, the thickness may be less than would be desirable with inferior materials. Last of all, the character of the travel to be carried must be given due consideration. If heavy motor trucks form part of it, proper provision, greater thickness and stability must be made for their support.

Thickness of Foundations

In any case the foundation must be perfectly rigid and free from vibration, that is to say, it must have complete stability under the conditions it is called upon to meet and the loads which it will carry. No rule can be laid down for a thickness suitable for all conditions. In some instances, as on city streets, from 8 to 12 ins. or more of concrete may be necessary under the heaviest travel, while, as has been said, in California, 4½ ins. in that climate seem satisfactory for the main country highways.

According to the London "Times" of Feb. 13, 1913, the following depths of foundations have been used in London and in the neighborhood:—

"In Bermondsey, for instance, while concrete 6 in. deep was formerly sufficient, the depth is now being made 9 ins. or even 12 ins. In Hackney, foundations which were sufficient a few years ago, are now found quite inadequate, and in new

work the concrete is being made 50 per cent. thicker. The Hampstead surveyor considers that the life of wood paving has undoubtedly been reduced by one or two years, and it has become necessary to increase the thickness of the concrete foundations from 6 ins. to 9 ins. In Holborn, cement foundations, 12 ins. thick, are being laid in places where a thickness of 6 ins. was sufficient ten years ago. In Paddington, concrete from 10 ins. to 13 ins. thick, is being used on wood-paved carriage ways, where the thickness was originally about 7 ins., and in Westminster the specifications now used when new foundations have to be laid provides for 1 in. of floating and 8 ins. of concrete foundation instead of 6 ins."

The necessary thickness of foundations under the surfaces of our country highways will vary with local conditions, as will the determination of its character, whether it should be concrete, a Telford support or broken stone or gravel placed on the soil. With the increased construction of durable surfaces, provision for proper drainage and adequate foundations must receive greater attention than they have had up to the present time, and many of the failures on our country highways are due to deficiencies in these directions. To these deficiences must be added the carelessness of contractors in carrying out work and lack of inspection on the part of state and local authorities. The best materials cannot give results commensurate with the increased expenditure incurred in using them unless the surfaces constructed are properly supported and drained, which is too often not the case.

There are but a few types of foundations which have been recognized as the result of service tests, as being satisfactory for road surfaces subjected to heavy travel, and some of these only under favorable conditions.

Portland cement concrete of sufficient thickness, properly proportioned and supported on a well-drained subsoil, is probably the most satisfactory foundation for pavements and road surfaces. Old waterbound macadam, which has been thoroughly compacted under travel, has also demonstrated its suitability, or a course of broken stone 2½ ins. or larger in size, put in place for the purpose, on a dry, firm subsoil, has given satisfactory results as a support for asphalt surfaces under particular conditions. Gravel surfaces, new or old, when in good condition, have also served.

AMERICAN WATER WORKS ASSOCIATION

Thirty-Ninth Annual Convention to be Held in Buffalo, June 9-13th—Detail of Programme

THE executive committee of this association will meet on Monday, June 9th, at 2 p.m. Any business to come before this committee should be in the hands of the secretary by noon. Other standing and special committees will hold meetings during the day, announcements of which will be posted in the secretary's office. Committee chairmen should arrange for meetings as much in advance as possible. In the evening the Water Works Manufacturers' Association will hold a reception and dance at the Iroquois Hotel, for members and their guests.

Tuesday, June 10th.—Following the address of welcome and response, Messrs. John E. Teeple and John A. Kienle will read a paper on "The Relation of the Chemical Industry of Niagara Falls to the Water Works." Following which there will be a round table meeting for the discussion of problems relating to operation and maintenance of water works. Among the topics to be discussed will be: Damage to fire hydrants by motor vehicles and remedies therefor: (a) Moving hydrants from the curb back to the building line; (b) substituting flush hydrants for the post style hydrant; (c) placing post fenders around hydrants; (d) making no change in previous practice as to location of hydrants, but repairing broken hydrants at minimum cost by welding stand pipes.

Afternoon Session: Report of Private Fire Protection Service Committee by Mr. Nicholas S. Hill, chairman of the committee. This will be a final report of this important committee and a very complete one. Great care has been taken by the committee to make the report a very full one, and members are requested to come prepared to discuss it, present their views and take final action. The question box will be opened after the committee report is disposed of.

Evening Session: The following named papers on the Buffalo water supply will be presented, illustrated by lantern slides: "Buffalo Water Supply with Special Reference to the Filtration Problem"; "Reduction of Water Consumption by Means of Survey and Constant Inspection." Also a paper by Mr. D. A. Decrow, "The Uniflow Pumping Engine."

Wednesday, June 11th.—Forenoon Session: A series of papers by United States government officials and manufacturers on the trend of prices.

General Business: President's address, reports of treasurer, secretary and committees. Selection of place for holding the 1920 convention, and nomination of candidates for the nomination committee. Each district is to nominate one or two candidates at the convention, such nominations to be later confirmed by letter ballot.

Afternoon Session: The meeting will be called promptly at 1.30 p.m., and papers read as follows: "Purification of Water for the Army and Field Purification Plants," by Willam J. Orchard. "Air Lift and Water Purification," by Mr. Oliphant. At 3 o'clock automobiles will be provided for a trip to the Buffalo water works pumping station.

Thursday, June 12th.—At the morning session Mr. Leonard Metcalf will read a paper on "The Effect of the War Period, 1914-1918, and Public Control upon Water Works of the United States." Other papers elaborating and discussing this live topic will be presented by members of the association, showing the effect of the war on the cost of water works operation.

Thursday afternoon: The Water Works Manufacturers' Association will provide tickets for a trolley trip to Niagara Falls.

Friday, June 13th.—Informal talks on personal war experiences by members of the association, and unfinished business. A golf tournament will be held during the convention. Arrangements are being made for visits by interested members to Buffalo manufactories of water works appliances. Facilities will be arranged in the secretary's office for registration for such trips, and full information can be obtained there.

The Manufacturers' Association have an unusually large number of applications for exhibit space and the exhibits will include a number of novelties well worth examining.

Charters as applied for by the Canadian Pacific Railway include the following lines to be constructed: From a point at or near Duchess on the Bassano Easterly Branch in the province of Alberta, in a general northerly direction. From a point at or near Archive on the Moose Jaw South Westerly Branch in the province of Saskatchewan, thence southwesterly and westerly to a point at or near Wymark on the Swift Current Southeastern Branch. From a point on the Moose Jaw Northwesterly Branch at or near Fortune or Rosetown, in the province of Saskatchewan, thence in a general southerly direction for a distance of about fifty miles, then in an easterly direction for a distance of about thirty miles. From a point on the Weyburn Stirling Branch in Saskatchewan, thence in a southerly direction and then west. From a point at or near Lanigan, on the Pheasant Hills Branch, in Saskatchewan, and thence in a northeasterly direction to a point between the Carrot and Saskatchewan Rivers, and then in a general southeasterly direction to a point at or near Cumberland House. From a point at or near Leader, on the Swift Current Northwesterly Branch in Saskatchewan, and then in a general southwest direction a distance of about fifty miles, then east to a point on or near Big Stick Lake. From a point on the Manitou Lake Branch in Saskatchewan, then in a general northwest direction to a point on or near Whitford Lake.

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PRINCIPAL CONTENTS

"BULKING" EFFECT OF SAND

IT is an encouraging fact that the importance of the selection of materials and the improvement of the field conditions attending the proportioning, mixing, placing, seasoning, etc., of concrete are receiving greater attention than formerly. Broadly speaking, it may truly be said that the progress made within the past few years is mainly due to the untiring efforts of comparatively few investigators. Nevertheless, a knowledge of the physical properties of the materials entering into concrete mixtures is of vital importance to all engineers and superintendents who have to do with the construction and the maintenance of structures composed entirely, or in part, of concrete, since the economy, efficiency and permanence of these structures depend to a marked degree upon a practical application of this knowledge.

Attention is called to an article in this issue in which the "bulking" effect of the moisture in sand is discussed and its relation to the quantities of sand aggregate entering into concrete mixtures is pointed out. In view of the dearth of information in engineering literature relating to this physical effect of the moisture contained in sands and the fact that this source of irregularity in the strength and other physical properties of concrete has not been recognized in engineering specifications, it seems reasonable to assume that Capt. Edwards' investigations are more complete than any hitherto made.

The photomicrographs reproduced in this article show the remarkable change effected in the physical structure of the cement matrix by the inclusion of excessive quantities of water in the concrete mixture. Doubtless this change of structure is the primary cause contributing to low strength, friability, shortness and other undesirable properties in concrete to which failures are due.

PRESERVING TECHNICAL PUBLICATIONS

MOST engineers have been at sometime or other impressed with the advisability of having technical information on hand and ready for any emergency. Accurate information is as essential to the success of the engineer as a compass to the navigator. The value to an engineer of a library of technical information will be apparent to all, and there is much to be said in favor of the establishing of such a library by the individual or the organization of which he forms a part.

Through the medium of printer's ink, one is put in possession of knowledge of what others are doing and how. No one knows it all. Engineers, like men engaged in other professions, must depend to some extent upon the knowledge which can be brought to them through the medium of the printed word.

With the close of the half year or the year, as the case may be, technical publications complete their volumes and it is a wise practice for engineers to bind them for preservation and facility of reference when occasion requires. This practice of preserving copies for the purpose of having them bound at the end of the half year or year, as the case may be, is one which should be encouraged and its importance emphasized.

This office very frequently receives requests for back copies to complete volumes and it is a matter of great regret that occasionally these requests cannot be complied with owing to the particular issue desired being out of print. The result is that the volume is either left unbound or bound in an incomplete state. The wisdom of having a place for each copy of the paper and of keeping it in its place is therefore evident.

A word as to the practice of clipping articles from journals for purposes of filing. While this plan may save space on the book shelf and articles on like subjects may be kept in a single file, it often means waste of time besides destroying the value of the copy itself. One cannot foretell what articles are thereby destroyed as a result of this mutilation or whether they will be of equal or greater value at some time than those that have been actually preserved. One's range of interest is apt to expand or change very materially as time goes on.

Taking it for granted, however, that engineering journals are not to be read like a newspaper and then carelessly thrown aside, there are several points to be kept in mind:—When each copy arrives, look it over carefully; examine the index page; then place the copy with the previous issues, returning it whenever taken from its place. When July first or January first comes round call in the bookbinder.

GOVERNMENT FINANCING OF INDUSTRY

THE British Columbia government, in addition to establishing a provincial department of industry, plans also to furnish funds through that department. The "department of Industries Act," recently drawn up, provides that the minister may, upon the recommendation of an advisory council, give financial assistance to any person, partnership, association or company, by way of loan, guarantee, or guarantee of securities, for the purpose of aiding and developing industries and manufacturies, or to establish, maintain and operate such industries. Before granting any loan or guarantee, however, the minister of industries and the advisory council have to be satisfied as to the following points:—

1 The value of the security offered, estimated on the basis of productiveness.

2 The desirability of the proposed loan or guarantee for any of the purposes of the act.

3 The ability of the applicant to make a fair profit from his enterprise.

4 The solvency and the capacity and moral hazard of the applicant, and his earning powers.

5 That the granting of the proposed loan will be of economic benefit to the province.

Among the powers and functions of the department of industries the following may be mentioned:—

1 To carry out an economic survey of the natural resources of the province, and to furnish advice in regard to the best methods of utilizing such resources.

2 To aid by loan, guarantee, or guarantee of securities on approved plans any enterprise calculated to encourage the economic and commercial manufacture of the natural resources or products of the province.

3 To consider and deal with plans submitted by representative bodies of returned soldiers of British Columbia for promoting and providing for employment through the establishment of new industries and the development of existing industries.

The maximu[illegible]ch the government will be empowered to borrow fo[illegible] purpose, will be $2,000,000, according to the present draft. While this sum is not great in view of the already extensive debt of British Columbia, there is an important principle involved which should be carefully considered before action is taken. It is one thing to create a department to assist industry by education, publicity and other means to which public action is peculiarly adapted; but it is quite unnecessary and unwise for a Canadian province to risk money raised on the credit of the taxpayers as a whole, to such borrowers as the public officers see fit to favor, when adequate banking machinery exists for such purposes. It is distinctly an injustice to holders of the provi[illegible]ce's bonds that new securities, ranking equally with those [illegible]ady outstanding, should be issued except for necessary [illegible]eful works. We suspect that this measure is in some [illegible] the result of agitation on the part of would-be industrial leaders whose credit is not sufficiently good to satisfy the careful examination of a bank; its adoption will appreciably affect the credit of the province. Investors and bond dealers in Canada, Great Britain, and the United States, will hesitate before loaning money to a province which has embarked on such an uncertain enterprise.

It may be said that this money will be used productively in private industry, whereas if expended on roads or other public works it would to some extent be wasted. The latter can, it has been found by experience, be provided only by public enterprise, and a certain amount of extravagance is inevitable; in the case of the former, however, it is not necessary for the government to intervene at all. The saving attained by pledging the credit of the province as a whole may, and probably will, be more than offset by actual losses, and by the degree to which the standing of British Columbia is affected in the investment world. Government loans on farm property, while not commendable, are at least secured by tangible assets. Loans on personal credit require a careful estimation and a personal relation which a government is peculiarly unfitted to give.

PERSONALS

DR. JOHN L. BATES, superintendent of the Forest Products Laboratories, Montreal, has resigned, to join the staff of Price Bros. & Co., Quebec.

JOHN FLOOD, JR., a civil engineer of St. John, N.B., has been admitted to partnership in the general contracting firm of John Flood & Son, and the name of the firm has been changed to John Flood & Sons.

W. A. MCLEAN, deputy minister of Highways, Ontario, has recovered from his recent illness sufficiently to return to his home. He still hopes to be able to attend the Good Roads Congress in the Parliament Building, Quebec City, on May 21st, when he will address the meeting on "Shall We Restrict the Load or Build the Road."

DR. FREDERICK HAYNES NEWELL has been elected president of the American Association of Engineers. He graduated in 1885, at the Massachusetts Institute of Technology, and after field experience in Colorado and other states, was appointed as assistant hydraulic engineer of the U. S. Geological Survey. He is the head of the civil engineering department of the University of Illinois and is widely known as a public spirited engineer. He was the first chief engineer, 1902 to 1907, and director, 1907-1914, of the U. S. Reclamation Service.

CHARLES W. TARR, vice-president and general manager, Morris Knowles Ltd., engineers, located at Windsor, Ont., was born at Lawrence, Mass., at which place the first slow sand filter was built to treat the water from the Merrimac River, before it was supplied to the city. In 1896, he was employed by the Metropolitan Water Board at Clinton, Mass., where the Wachusett Reservoir was under construction. He has superintended construction of many public utilities, including water supply and purification plants, distribution systems, sewage collecting and purification works, pavements, bridges, etc. Mr. Tarr is a member of Engineering Institute of Canada, American Society of Civil Engineers, Detroit Engineers Society. Is now vice-president and general manager, Morris Knowles, Limited, at Windsor, which firm has reported on the water supply and sewage problem for the Essex Border District, consisting of Ford, Walkerville, Windsor, Sandwich, Ojibway and Townships of Sandwich East and Sandwich West. A portion of the intercepting sewage system is under construction, aggregating five miles in length. Water purification plants were designed for Ojibway and Amherstburg, the latter having been built and now operating. A report of the various possible sewage systems for Ford City was made, together with the plans and estimates of cost.

A. K. GRIMMER, C.E., who superintended the installation of the filtration plant at Woodstock, N.B., has been appointed town engineer for the development of the town of Temiskaming for the Kipawa Co., Ltd. Mr. Grimmer was formerly city engineer of Medicine Hat, Alta. Later he went to take up consulting work in the Maritime Provinces and located at St. Andrews, N.B. Just previous to accepting his present position he was connected with the Bate-McMahon Maritime Co., at Halifax.

OBITUARY

DUNCAN MCDONALD. inventor of the paye-as-you-enter street car, died on May 8th, at St. Agathe, of tuberculosis. He was, at one time general manager of the Street Railway Company, and later, was a controller of the city of Montreal.

Construction of the new race track and exhibition buildings in Connell Park, Woodstock, N.B., is now under way. P. Corbett is the engineer in charge.

The city of Moose Jaw, Sask., is considering an extension to their present waterworks system with an alternative plan to obtain 4,000,000 gallons per day from the Saskatchewan River. The alternative plan would mean a conduit approximately 60 miles in length and an expenditure of about $1,630,000.