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The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Construction of Water-Bound Macadam Roads

How To Prevent Their Destruction By Modern Automobile Traffic Proves a Serious Problem for the Highway Officials of Quebec Province—Translation of Paper Read in French Before the Canadian Good Roads Association

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SINCE the inception of the good roads movement in Canada, macadam has been the type of pavement most generally adopted. The paving methods of Macadam and Tresseillet had acquired great popularity in Europe, and, like a good many other progressive ideas, soon drew the attention of the American nations.

It did not take long for the provincial governments (at least for the Quebec government) to grasp the opportunity offered by this type of pavement for the betterment of rural roads in Canada. In this province the proposition was rapidly thought out, and was developed at a rate of approximately 400 miles per annum, since 1913. The Province of Quebec owns, at the present time, approximately 2,500 miles of macadamized and gravel roads. The pace does not seem to diminish, but a new problem, somewhat difficult and full of unknown factors, presents itself. It is that of up-keep of water-bound macadam.

The extraordinary development of commerce, industry and agriculture in the last twenty-five years have naturally revolutionized the transportation methods considered sufficient up to that time. It was considered sufficient up to that time to maintain the exchange of merchandise and of movement of traffic. At present, however, industry is becoming decentralized, spreading out around the cities and reaching even the small country villages. The distributor wishes to cover with his goods the largest possible area in the minimum length of time. Intensive and up-to-date farming necessitates the immediate distribution of farm products to the cities. The railways, excellent as they are for transportation in large quantities, do not provide a sufficiently detailed distribution.

The whole of commercial life has seized the advantage offered by the development of the automobile and auto truck industry to enlarge the radius of its businesses, and to add to pleasure trips. This entails boundless competition. As soon as good roads are developed and multiplied, truck traffic increases in density, and speed craze appears. Passenger automobiles ply between Montreal and Quebec, and are now reducing the time necessary for the same trip by railway.

Cannot Carry Heavy Traffic

The strength of water-bound macadam is not sufficient to bear the heavy loads, which seem to increase endlessly. The blows of auto tires running at 35 or 40 miles an hour, tear out the surface stones and leave voids which promptly grow larger. Against these multiplied factors of disintegration, it seems as though macadam will have to be given up on most highways. A good many efforts have been made to solve the practical problem of the up-keep. None of the proposed solutions have been entirely satisfactory. This is so much the case that, in engineering circles, one no longer hears anything but concrete, bituminous macadam, bithulithic and Warren pavements, etc. All these pavements have deserved the somewhat pompous title of "Superior Pavements." They are indicated from every point of view on main highways, and in the vicinity of cities, but on account of their very high first cost they are not suitable for roads of purely local importance. All the roads which serve as tributories of the main highways, towards farms and villages, come in this latter class, and as the provincial government, which controls paving programs, is much interested in the welfare of the farmers, it is practically certain that at least 50% of the mileage that will be constructed will be water-bound macadam.

Estimate of Annual Cost

Even if one leaves out all the factors of preference and if one considers good roads as a purely economical problem, the kind of construction that will be adopted under certain given conditions will depend on the annual expense for up-keep for the different kinds of pavement proposed. That is to say, the yearly interest on the capital to be expended, the yearly cost of up-keep and sinking fund. Taking for example a concrete pavement costing $20,000 a mile, with probable up-keep expenditure of $75 per mile per year, and a sinking fund period of, say, thirty years, interest being figured at 5%, and comparing this with a water-bound macadam whose first cost would be $7,000 a mile, and up-keep cost of $300 per mile per year, with a sinking fund period of ten years, interest rates being the same in both cases, a little calculation shows us that the yearly cost of delivery of the concrete road will be $1,376 a mile and that of water-bound macadam $1,206 a mile, showing a difference of $170 per mile per year in favor of water-bound macadam.

Under such conditions as outlined above, macadam should in every case receive favorable consideration as against concrete. This logic cannot be side-tracked, but a difficult problem is to arrive at the proper factors which vary widely both as to yearly up-keep and as to sinking fund period. Figures which statistics and experience seem to favor to-day as a rational basis for estimates will in a few years be replaced by others widely different because at that time the traffic conditions will have changed and construction methods will be much improved. However, the proposition remains the same, and although certain factors of the problem may change, the theory will remain the same. We can foresee the capitalization as based on the present data will favor water-bound macadam for roads of local importance, and that a good many milions will yet be expended to extend and complete the system of macadam roads in the Province of Quebec.

We know, also, that considerable sums will have to be put aside for the up-keep of these macadam roads. Under these circumstances we may be sure that the provincial and municipal authorities will give a good deal of attention to this type of construction, and the engineers of the Department of Roads of Quebec are working towards a more perfect solution of the problem of construction and up-keep of water-bound macadam. Our climatic conditions and the nature of the available materials differ so widely from those of Europe that although European countries are ahead of

us in road building, we cannot follow here the methods currently used in France and England. Even among American and Canadian engineers we find quite a diversity of opinion on this subject. This is quite natural, as we cannot suppose that speaking from personal experience the New York engineer will have the same ideas as the man who has been building roads around Lake St. John. This is due, of course, to sub-soil conditions. The autumn rains and the intense colds following thereafter, place the Province of Quebec in an unique position which cannot even be compared with that of the states of Vermont and New York close by.

Quebec Problems Different

Quebec roads must be studied, free from all theories obtaining in other countries. We know that the provincial department of roads has always given its full support to the experiments of their engineers. The special conditions found in our province are: Firstly, the heavy winter frosts which penetrate several feet into the earth and cause heaving. Secondly, the nature of the materials to be found locally and which must be used to the best advantage. We cannot here go extensively into these two subjects. Let us remark, however, that water-bound macadam, having relatively little elasticity and small resistance to shearing stresses, suffers considerably from the disturbances caused by frosts. The only way to obviate, to a certain extent, this disintegration is to keep away from the roads the water resulting from the autumn rains.

Drainage, therefore, plays a very important part in this work and neglect of ditches and curbs will entail much more serious consequences than is generally known. However, in a good many cases the drainage is not sufficient to prevent infiltration, and in these cases means must be taken to catch the water before it penetrates under the road.

Water penetrates through the shoulders from ditches when their grade is poor, and even sometimes from the surrounding land, especially in cuts.

The construction of a longitudinal drain below the foundation will intercept the water and maintain the road in a sufficiently dry state, and so nullify the action of frost. The cost of these drains put down after the method adopted by the Department of Roads of Quebec is approximately 25c. per lineal foot, and increases the cost of construction of macadam roads approximately 10 or 15% for a drain on one side only. This relatively high cost is probably the reason that drainage has not been more extensively adopted in municipal road work. It is, however, recognized that under the very unfavorable circumstances, drainage must be used to avoid the necessity of reconstructing the macadam surface every spring.

Field Stone and Limestone

Field stone is most usually employed in the construction of water-bound macadam in Quebec. Quarries are not usually sufficiently scattered, and the cost of transportation is, as a result, too high to permit the use of quarry stone on road construction in all parts of the province. Besides, nearly all our quarries produce limestone, for example, the quarries of Montreal, Quebec, Deschambault and Joliette. These limestones are homogeneous and free from defects and mesh very well, but experience seems to show that they are not sufficiently hard for the necessary resistance to wear for heavy traffic. However, for roads of purely local importance, which are exactly the ones that should be built with water-bound macadam, these limestones should be used wherever their cost is comparable to that of field stone.

Despite the advantage of limestone, it can be foreseen that field stone will be mostly used in macadam roads. It can be found anywhere, and the use of it for road work enables the farmers to get rid of the rock heaps often to be found in their fields, which interfere with ploughing and harvesting. Field stone, as a result, is a mixture of different crystalized blocks, with granite and gneiss predominating. It is usually hard but somewhat brittle, and almost entirely lacking in the mesh qualities which characterize limestone and schist.

It would be difficult to make a careful choice of the various kinds of field stones scattered in small heaps in various farms, and in order to lower the cost of transportation, the best procedure is to use stone close to the road. Stone which is evidently of an inferior quality can be discarded before crushing. The discard will usually be small and comprise only stone too soft to be used for the wearing surface.

It is to be hoped that the installation in the various municipalities of permanent up-keep gangs and foremen will enable this selection of stone to be made in the winter.

Macadam, as invented and practiced by the originators of this system of road building, was meant to have a smooth, hard surface, and the union of the stone should be sufficiently effective to render the wearing surface almost as hard as concrete. European nations have come close to this idea, and the French people especially find it quite natural that a water-bound macadam road should give them 15 or 20 years of hard service without the necessity of resurfacing.

European Methods Not Applicable

Let it be well understood, however, that the European procedure cannot in every case be applied to Canadian roads. In France the abundance and low cost of labor enable the crushing to be done by hand, at least for the surface course. They attain in this manner carefully selected stone, practically cubical in shape, and varying in size only from 1½ ins. to 2½ ins. This is quite different from the product of crushers which often give flattened stone with sharp angles easily broken up under the roller, which enlarges the proportion of small pieces. It must not be said, however, that these defects of jaw crushers necessitate a revolution in our system of road building. This country is young, labor is scarce and consequently to be spared whenever possible. We must therefore substitute machines. Even with the high salaries latterly paid, the cost of crushing has hardly exceeded 50c. per cubic yard.

We must calculate therefore on the principle that we must make the best of the situation as we find it, as the aim is to better the crushing and so to grade and crush stone as to introduce here, as much as they may be applicable under our conditions, the processes which experience has proven to be most efficient in other countries.

The three principal points to be carefully watched in crushing are the speed of the machines, the renewing of worn-out jaws, and a proper arrangement of screens for grading. It is easily seen that speeding up the crushers means that stone crushed to the proper size in the upper end of the jaw will be crushed once again before getting out of the bottom, and this will result in too many small fragments. It is therefore necessary to choose a crushing speed which will prevent this, and will at the same time be sufficiently fast to give an economical output. The high price of jaw blades, which has become exhorbitant in the last year, has resulted in the use of worn jaws (by some contractors and foremen) until the jaws are perfectly smooth. Flat stones can therefore pass through the crusher and make their way to the screen in sizes which cannot be used.

It is therefore essential that jaw blades be carefully inspected, and a good foreman will not await orders of the engineers to replace these when they are worn out.

Small Stones Undesirable

Careful attention to the first two points will practically eliminate the third. It can easily be seen that by diminishing the proportion of small pieces, narrower limits as to size can be set down, and we would thus use for the wearing surface nothing but stones from 1½ to 2½ ins. This can only be done provided that there is not too much reject and that the small stones from ¾ to 1½ ins. will prevail only in sufficient quantity to be used up as filling material in the foundation courses.

The undesirability of small stones is very apparent when one knows how difficult it is to maintain a good bond on roads macadamized with field stone. It is easily seen that the force exerted on macadam surfaces by passing vehicles is the resultant of two forces, one (vertical) being the weight of the load, the second (horizontal) being the tractive effort of the vehicle. These two forces are very variable. In the case of an automobile travelling at high

speed, the horizontal force becomes very high and tears out the stone and destroys the bond of the surface. In the case of a steam roller, the vertical force is much more apparent and therefore the roller is employed to rebuild the surface which the horizontal force destroys.

It is out of the question to restrict the speed of automobile to a point where they will not be harmful. The only solution is to offer to the pneumatic tire the solid surface with not only the necessary hardness but also the necessary weight and tensile strength.

The larger the stones composing the surface, the better the contact with adjoining stones and the more the macadam will be compact and massive. The means mentioned above for reducing the proportion of small stones, will help considerably towards the desired result. The limit as to the size of stone which will permit a sufficiently smooth surface for present vehicles is approximately 2½ ins.

Use of Limestone Dust

Another method of lengthening the life of macadam and at the same time diminishing the up-keep cost of field stone macadam, is to use limestone dust as a binder.

There is in the Parish of St. Jean-Chrysostome, in Chateauguay County, a road built in 1913 with field stone and a limestone dust binder. This road has carried continually very heavy traffic, and in addition carries the transportation of stone for the construction of surrounding roads. In 1918, after five years of continuous service, there were no apparent ruts and no loose stones, although the crown of the road has almost entirely disappeared through wear.

The value of a limestone binder in connection with field stone is pretty generally recognized, but fear is often expressed that the advantage to be obtained will not be proportional to the extra expense due to the purchase and transportation, often for long distances by rail, of this limestone dust, which cannot be obtained outside of quarries. If we take it that the quantity necessary for good results is equivalent to a layer ¾ in. thick, the necessary quantity for one mile of 12 ft. road would be 146.6 cubic yards, and as we may reasonably suppose an average cost of $3 a yard, the cost of the road would be enhanced by $440 a mile, which is an increase of 6.3% in the cost of a road costing $7,000 per mile.

If we now take it that by the use of this process we succeed in lengthening by 20% the life of the macadam, it will be economical to use this dust. We see in this way that the reduction in up-keep cost would more than cover the interest on the additional capital used up in the construction.

Limestone quarries are unable to furnish in large quantities this binder, which consists of particles varying from ½-in. to the finest dust. In some parts of the province this dust may be obtained in its natural state. The binder which was used on the above-mentioned road in St. Jean-Chrysostome, was found right in the parish and so close to the road itself as to be quite economical.

Common Errors in Construction

It is often found in practice that a number of mistakes and omissions occur in the detail of construction as written in various specifications generally used at the present time. We must recognize that specifications, however elaborate, offer always sufficient leeway that the contractor may use his personal views and methods. I think it advisable to enumerate here certain methods frequently found which seem really bad, and the suppression of which would bring us nearer to the methods in use in European countries, which possess at the present time the finest roads in the world.

Certain foremen and contractors have the habit of considering in every case crusher dust as a binder. This error is due to a false idea of what takes place in the interior of the macadam during rolling. Under the pressure of the roller, the stones mesh themselves as to produce strong friction between the surfaces in contact. This friction produces a very fine dust which is the best possible binder when the stone possesses binding qualities. This binder will be very efficient if sprinkling takes place at the same time.

Stone which will not bind without previously filling the voids will not bind any better with its own dust. In filling the voids with dust before rolling, one may obtain a macadam with an opparently compact and even surface but which will disintegrate in a few dry days. However small the proportion of binder in the stone, the macadam must be watered and rolled, but never rolled dry until the macadam is very compact and the voids reduced to a minimum. This is the time to spread crusher dust to fill what voids may remain, and thus render the surface still more compact and sufficiently impervious to water.

Must Apply Small Quantities

We must, however, make one exception. This is when limestone dust is used as a binder. Limestone must be applied in successive very small amounts as soon as the rolling begins in order to enable the limestone dust to penetrate gradually between the stones. This operation must be watched in order to prevent the application of an excessive dust at the beginning of the rolling.

We witnessed some years ago a typical case showing the undesirability of an excessive dust in the macadam. A contractor in perfectly good faith had gotten the habit of placing all the crusher dust, including the small fragments up to ¾-in., in the last layer of stone. In order better to obtain this result, the dust was spread before any rolling over the stone, which was entirely covered. Be it noted that the stone was of good quality and contained sufficient binder to give results. Nevertheless, it was only after prolonged rolling, renewed at intervals after several weeks, that he was able to obtain a satisfactory bond. One could, however, see at the same place a piece of macadam built the previous year in the same fashion, which showed a rough and uneven structure which could not be charged to wear, age or heavy traffic.

One might claim to upset this principle by showing a new macadam built after this style and sufficiently bonded. This would merely show that the stone employed was very easily bonded, and in any case the argument would only last for the time necessary for traffic and wind to destroy the layer of dust with which the surface of the macadam is camouflaged.

Cannot Interrupt Sprinkling

Another very common error in construction consists of carrying sprinkling water a considerable distance in the sprinkler itself. This means that sprinkling is interrupted for considerable intervals, during which the rolling continues under unfavorable conditions. We must not forget that the water is one of the principal materials in the construction of macadam, and although it may be true that certain limestones bind fairly well when dry, it is also true that this bond will be much more effective if treated with water at the proper time and in sufficient quantities.

It has often been noticed that in clay regions the surface of a macadam road is deteriorated for 200 or 300 ft. at each end by the clay which the wheels of vehicles spread on it. This defect which everybody sees and which is considered almost inevitable, could be much diminished by proper precautions and principally by ending the macadam with special care. Last year there was to be seen in the Parish of St. Malachie, in Dorchester County, a macadam two years old which had kept its shape and surface without any deterioration up to the point where it joined a clay road. The contractor who built this road was an artist in road construction. Would that he might have many disciples!

The up-keep of macadam roads in Quebec began two years ago, when the first signs of deterioration and of wear appeared in the roads constructed in 1912 and 1913. Two years are very short to study a problem which can only be solved through experience. It is not easy to obtain at the present time a general rule which will apply to the special conditions in our province. There are, however, certain causes of deterioration of macadam which leave no doubt as to the best measures to retard and nullify their effects.

Frost, for example, disintegrates more or less all macadam roads. This is not surprising, since the effect of frost can be seen even on solid roads. We can, therefore, adopt the practice of rolling anew every road each spring as soon as the frost has disappeared. We must not forget that this rolling must be preceded by the ordinary sprinkling. Sometimes the sprinkling may be avoided if the weather is rainy at the beginning of the summer, but it is not advisable to delay this work too long awaiting rain. The cost of rolling and sprinkling might reach approximately $100 a mile per year.

The heaving of the soil produces blisters which are a cause of rapid deterioration. These can be eliminated by drainage. If the system of drainage employed during the construction of the road has been insufficient to keep the road from infiltration, some means will have to be devised to eliminate water from the affected spots. Tile drains are usually advisable in these cases.

The cleaning out of the ditches and curbs is imperative each year and should be done in the first days of spring, before vegetation gets a chance to take root. In flat country, such as the land to the south of Montreal, at Laprairie, Chateauguay and Huntingdon, it often happens that

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MUNICIPAL ENGINEERS AND TOWN PLANNING

By Thomas Adams

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THERE was a time in Britain when the engineer looked somewhat askance at town planning and regarded it as sort of a fanciful idea promoted by impracticable idealists. The period of this attitude ended about 1911 when the town planning act became really operative and engineers began to take up the subject as a part of their daily practice. Ever since then the annual meeting of the Institution of Municipal and County Engineers has included one or more papers on town planning in its program and on two or three occasions has dealt almost exclusively with town planning as the subject for discussion at their annual meeting. Such eminent municipal engineers as John Brodie, of Liverpool, and H. E. Stilgoe, of Birmingham, are prominent members of the council of the Town Planning Institute, and have promoted, in their own cities, town planning schemes for most of the undeveloped building land.

The last annual meeting of the institution was held June 26th to 28th, in Birmingham, under the presidency of Mr. Stilgoe. This is the last occasion when Mr. Stilgoe may preside as a city engineer, since he has been appointed as chief engineer of the Metropolitan Water Board of the County of London.

At the Birmingham meeting, a town planning paper was presented by James Thomson, the city engineer of Dundee. Its subject was "Housing in Relation to Town Development." Mr. Thomson indicated the connection between housing and town planning from the standpoint of the engineer, and how the fact that they were inseparable parts of well considered schemes of expansion made them pre-eminently engineering questions. He pointed out how the absence of any comprehensive plan has produced disastrous effects to amenity and housing conditions. Plans of development, he suggested, should sufficiently meet not only the present-day requirements but also the needs of every locality for a period of not less than 50 years.

Mr. Thomson indicated the following main proposals which local authorities should consider in relation to housing and land development:—

(1) Absolute change from the present method of town growth as one mass without intervening spaces.

(2) Acquisition at every opportunity of undeveloped land at as near its agricultural value as possible.

(3) Design of the frame work or skeleton of all existing and proposed main roads, excluding subsidiary roads, within a well-considered probable extended boundary.

(4) Limitation in the size of all new combined industrial and housing areas to a maximum to be fixed by the local authority.

(5) Separation of all new combined industrial and housing areas from each other, and from existing areas by open spaces and wooded belts.

(6) Complete revisal of former methods of lay-out of land for working-class dwellings.

(7) Drastic change in the design, type, size, equipment and environment of houses for the working classes.

(8) Reduction of housing density.

(9) Sufficiency in all housing schemes for gardens and allotments and facilities for culture.

(10) Certainty that in all new works areas, housing shall be carried out on town planning lines.

(11) Allocation to each new housing and industrial area of sites for buildings necessary for culture and recreation facilities.

(12) Facilities in every new housing unit for out-door recreation for adults and children.

(13) Increase in the number of small parks corresponding with the increase in number of housing areas.

(14) Transit facilities to outlying districts and to all new industrial and housing areas.

(15) Abolition, step by step, of all slum areas.

(16) Improvement by degrees of central area and of all congested districts.

(17) Gradual widening of central main streets and the early widening of portions of arterial roads in the outskirts.

(18) Preparation of town planning schemes for all areas proposed or brought within boundaries in conjunction with town planning of areas within the existing town.

(19) Extension of railways and provision of railway sidings into land to be used for industrial purposes.

(20) Appropriation of sites for landing grounds in anticipation of the introduction of aerial transport in conjunction with the fixing of housing and industrial areas.

Mr. Thomson pointed out that as expansion of cities took place, the necessity of a combined scheme of housing and development became more and more necessary.

Cities would continue to grow as formerly and would consist of an aggregation of houses, industrial buildings and streets massed and expanding without method. He claimed that there was a large responsibility resting upon municipal engineers to prevent the laying out of roads "insufficiently wide and illogically placed, public buildings erected without regard to suitability of site, traffic and transport convenience neglected, and, generally, a haphazard accumulation of all that goes to make a town unattractive and depressing."

We have still some progress to make in Canada in getting the municipal engineers to take such an active part in promoting town planning as they seem to be doing in Great Britain. Now that we are gradually getting the needed legislation, it is certain that engineers will give more attention to the subject.

One of the directions in which we need to make progress in Canada is in providing more education in our universities to engineers and architects on town development, and it is hoped and expected that this defect will be made good in the near future.

In connection with housing there is a tendency in Canada to promote schemes of building houses on vacant lots in parts of the cities that are already in course of development. This does not give the engineer who has ideas, any opportunity of assisting in securing an efficient and economical system of building houses and laying out local improvements—matters which go together.

One of our tendencies is to have stereotyped rules fixing width of streets and other things in connection with land development, leaving no initiative to the engineer. The time has surely come when the members of the engineering profession who specialize in municipal work should get together and co-operate, with a view to giving more influential direction to some of the problems of town development. We have just as great problems as they have in Britain and, being a new country, we have better opportunity to solve them.

STUDIES IN THE BACTERIOLOGY OF WATER*

By Denis B. Wood

IT is well known that bacteriological examinations of water supplies are directed to the detection and enumeration of what are known as "indicator organisms"—that is to say, organisms which are always to be found in large numbers in the excreta of man and animals. The presence of such organisms in water indicates potential danger to the health of consumers, for individuals suffering, or having suffered, even at some remote time, from typhoid fever and kindred diseases may void the specific organisms in large numbers in their excreta.

Contamination of water with excretal matter derived from animals is of less potential danger, for the lower animals are not to anything like the same extent subject to these diseases. They are known, however, to be subject to infection with the Gäertner group and paratyphoid bacilli, and with animal parasites, though such infections are rare, and contamination with animal excretal matter must be regarded as undesirable. Moreover, as we have as yet no means of distinguishing between contamination with human and animal excretal matter, so similar are their bacterial flora, we are obliged to take a safe course and regard all waters showing definite evidence of excretal contamination as more or less unsatisfactory.

There are three groups of "indicator organisms": (1) The B. Coli group, (2) the Streptococcus group, and (3) the Enteritidis Sporogenes group. The average numbers in which they are present in one gramme of human fæces are:—

B. coli.	Streptococci.	Spores of B. Enteritidis Sporogenes.
100-1,000 million.	100-1,000 million.	1-10 million.

It is evident, therefore, that tests based on the enumeration of B. coli and Streptococci will be the most sensitive. In this paper only these two groups will be considered.

The B. Coli Group

Members of the B. coli group have one characteristic in common—viz., the fermentation of lactose with production of acid and gas. The study of this group reveals the fact that it can be divided and subdivided into a number of types.

From MacConkey's result it appears that 87% of the lactose-fermenting organisms present in human fæces all produce indole, acid and clot in milk, do not liquefy gelatine nor give the Voges and Proskauer reaction. In other words, they possess, practically speaking, the cultural characters of Houston's "typical B. Coli." Houston found that about 85% of the lactose fermenters present in human fæces, and 65 to 85% of those present in sewage, possessed these characteristics.† The results of his investigations on the viability of members of the B. coli group in soil and water show that the atypical varieties persist for longer periods than the typical, and are therefore less characteristic of recent contamination. Houston's definition of typical B. coli is admirably suited to routine bacteriological examination, and has been very generally adopted as a basis for bacteriological reports.

The Streptococcus Group

It sometimes happens that in a water examination only lactose fermenters having the characteristics of Houston's "typical B. coli" are to be found. It is then a great advantage to have recourse to another test, and the most satisfactory corroborative test is based on the enumeration of streptococci. Savage and Read have shown that the majority of waters showing evidence of contamination on the B. coli basis contain streptococci.

In calculating percentages nothing is to be gained by working out the percentage of water-samples which contain streptococci or B. coli respectively in the different amounts. The percentage results are worked out in two ways. In one way each group of B. coli prevalence is taken separately and the percentage prevalence of each group of waters on a streptococcus basis is calculated. In the other way each group of streptococci prevalence is taken separately, and the percentage prevalence of the waters on a B. coli basis is recorded.

An example will make this clear. Take, for instance, 118 samples from deep-water supplies containing B. coli in 10 or 30 cm.; 58 or 49.2% contained no streptococci. Or take the 198 samples from deep-water supplies containing no streptococci; 64 or 32.3% contained B. coli. The mean of these two numbers (49.2 and 32.3) is 40%, and gives a fair average of the number of samples in which B. coli may be present in only moderate numbers and streptococci absent. In other words, the chances are rather more than even that streptococci will be found, and if not found in one sample they probably will be in the next, or at any rate in subsequent examinations. This correlation between B. coli and streptococci is a point the author particularly wishes to emphasise. Apparently the value of this test as carried out by Savage has not been fully appreciated.

The streptococcus group can also be differentiated into a variety of types by fermentation reactions; those producing acid in lactose are particularly typical of excretal contamination. Differentiation of this group, however, is seldom practised.

Index of Recent Contamination

The streptococcus enumeration is particularly valuable as an index of recent contamination. This was shown by the results of an investigation carried out by the present author in conjunction with Dr. W. G. Savage on the relative viability of B. coli and streptococci in water under conditions closely resembling those of a well. In this investigation an earthenware pipe cemented at the bottom and holding about 40 litres of water was used as the model well. The water was contaminated with excretal matter emulsified with water, or with sewage, and examinations were made at regular intervals to ascertain how rapidly the organisms diminished in numbers and finally disappeared.

These experiments with excreta or sewage added to a large bulk of water yield minor differences in the individual experiments, but in general they show a rapid diminution and elimination of the streptococci and a continuous, yet not quite so rapid, diminution in the number of B. coli.. With the latter it was more common to find persistence in small numbers for a period extending to many weeks. The elimination of the streptococci was particularly uniform and rapid. At the end of three weeks in only two experiments were they present in more than insignificant numbers.

The decline curves of both organisms agree very closely, as could be seen most readily when the figures were plotted out as graphs.

Comparison with Typhoid Bacillus

Comparison with the viability of the typhoid bacillus is of special interest. Sir A. C. Houston's investigations in the viability of uncultivated typhoid bacilli in river water showed that they died out within three weeks, even when as many as 38,000 were present per c.c. of the infected water.

Several lactose-fermenting organisms isolated from various sources gave the Voges and Proskauer reaction, very few of which—only 6.3%—were represented in human fæces. These types have recently attracted the attention of American bacteriologists, and have been shown by them to be rare in the excreta of man and animals, more common in sewage and surface water, and the predominant types in soil and grains. They can be distinguished in the laboratory by two tests—(1) the methyl-red test, and (2) the Voges-Proskauer reaction, alluded to above. These two tests are very closely correlated, and by them the lactose-fermenting organisms can be divided into two main types, which are known as—

*From a paper read at the annual summer meeting of the Institution of Water Engineers, England.

†Since the large majority of organisms fermenting lactose and producing indole fulfil the other tests also, according to Houston's later definition, the other tests are dispensed with in routine examinations.

(1) The methyl-red positive type ("M.R.+"), or the Voges-Proskauer negative type ("V.P.—"), and

(2) The methyl-red negative type ("M.R.—"), or the Voges-Proskauer positive type ("V.P.+").

The first is characteristic of excretal contamination, and is sometimes called the "Coli type," while the second is not characteristic, at any rate, of recent excretal contamination, and is sometimes called the "Aërogenes type," after its type organism, B. lactis aërogenes.

These tests commend themselves to the bacteriologist as suitable for routine work in the same way as the tests of Houston, by their simplicity, and are particularly to be welcomed by those in whose experience particular water supplies have yielded only atypical varieties of lactose fermenters according to Houston's definition.

Results show how small a proportion of the lactose-fermenters of excreta belong to the "M.R.—" type, and how large a proportion are present in soil and grains. Occasionally a specimen of fæces contains a fairly large proportion, the high figure of 26% obtained by Rogers, Clark and Lubs was due to a single abnormal specimen, and to the employment of a method specially selected to favor the growth of this type, and does not represent the average numbers in which they were actually present.

Methyl-Red Negative Organisms Survive

Records of various observers strongly suggest that organisms of the "M.R.—" type are the more resistant, the more capable of surviving outside the animal body, and of finding a favorable environment in soil.

Winslow and Cohen carried out experiments on the relative viability of these two main types in water, and their results show that there is distinct evidence that the viability of the "M.R.—" type is greater than that of the "M.R.+" type.

Experiments show a decrease in the "M.R.+" type from 50 to 5%, and from 56 to 0% respectively (in sixty days). On the average, however, the reduction in the percentage was from 54 to 29.

As the methods employed by American bacteriologists differ in some respects from those usually employed in this country, it was thought advisable to investigate how frequently organisms of the "M.R.—" type were likely to be encountered in the routine examination of waters by English methods, and, by noting the association or absence of association with streptococci, to ascertain whether the presence of lactose-fermenting organisms of this type affords evidence of recent excretal contamination or not.

Observations were therefore made by the author of a large number of samples of water from various sources. Out of 200 samples in which lactose fermenters were present, organisms of the "M.R.—" type were encountered in 66, or 33%.

Lactose fermenters of the "M.R.+" type and streptococci were absent from practically every sample, strongly suggesting that in general no recent excretal contamination had occurred, for if it had streptococci would have been found in about 50% of these samples. [These samples were of water of good repute.]

Other samples from shallow wells, etc., were as follows:—

Samples from Shallow Wells

(1) Those containing no streptococci and no lactose fermenters of the "M.R.+" type, suggesting no recent contamination.

(2) Those containing streptococci and probably lactose fermenters of the "M.R.+" type also, though, since contamination was sufficiently proven, further search for this type was not made.

(3) Those containing streptococci and lactose fermenters of the "M.R.+" type, further search having been made for this type for the purpose of this investigation.

It may be asked, How is it that the "M.R.—" type are found in samples of groups 2 and 3 in which recent excretal contamination is proved? The explanation obviously is that a certain amount of self-purification has already taken place, but the contamination is sufficiently recent for organisms of the "M.R.+" type and streptococci to be present also in larger quantities of the sample.

Of special interest was the occurrence of lactose fermenters of the "M.R.—" type in the deep wells in limestone. This supply consists of seven or eight wells, several miles apart, varying in depth from 250-450 ft. These wells yield a very pure supply, lactose-fermenting organisms being absent from 100 c.c. in 85% of all samples examined. In the spring of 1918 lactose fermenters were found in a much larger proportion, and all (with one exception) were found to belong to the "M.R.—" type. Streptococci were invariably absent. The inference is that the most resistant types only of the lactose fermenters reached the underground water, though why they were present in abnormal numbers at this particular time could not be discovered. The only exceptionally heavy rainfall occurred five months previously.

Viability of Capsulated Organisms

The large majority of lactose fermenters of the "M.R.—" type (about 85%) show capsule formation. Experiments by the present author show that some capsulated organisms display remarkable viability in boiled (or steamed) hard water. In one experiment the organism added to such water, containing no measurable trace of saline or organic ammonia, was isolated after a period of three and a-half years. It should be noted that it is only in boiled (or steamed) hard water that such remarkable viability is observed, though in unboiled water some of the capsulated types live longer than the non-capsulated (in one experiment fourteen weeks as compared with seven weeks). The phenomenon seems to be dependent upon the slow deposition of supersaturated carbonate of calcium or hydrate of magnesium, which takes place in the boiled water after filtration. Whether the necessary conditions for prolonged viability occur in limestone silt is a matter worthy of investigation.

Other experiments confirming this remarkable behaviour, one of which was carried out independently by Dr. W. G. Savage, are recorded in the *Journal of Hygiene* Vol. XVI., No. 3, January, 1918. In periods varying from five to eleven weeks, multiplication from fifty to one hundred fold was recorded.

Both strain T. and strain N.D. gave the Voges--Proskauer reaction, and belong to the "M.R.—" type. Strain N.D. produced indole and acid and clot in milk, and was therefore indistinguishable from Houston's "typical B. coli," except by the methyl-red and Voges-Proskauer tests.

Summary

(1) Although attempts to distinguish between human and animal excretal matter by the characters of lactose-fermenting bacilli present have so far been unsuccessful, some measure of success has attended attempts to distinguish between recent and less recent contamination by the identification of the less resistent and more resistant types.

(2) Clemesha based his differentiation on MacConkey's classification; Houston on the more simple indole test. Savage retains the milk-clot test, and notes marked weakness of lactose fermentation, having shown that these attributes tend to diminish with soil environment. American investigators have recently based their differentiation on the methyl-red and Voges-Proskauer tests.

(3) The more resistant the types, obviously, the less evidence there is of recent contamination in waters in which they are found.

(4) Most valuable information as to recency of contamination is afforded by the enumeration of streptococci by the simple method of Savage.

(5) Association or absence of association of lactose fermenters with streptococci can therefore be used as a control in judging the merits or demerits of any of the above methods of differentiation.

(6) Relative absence of association of the lactose fermenters of the "M.R.—" type with streptococci strongly supports the view that they are the more resistant types.

(7) Experiments show that, under certain conditions, the viability of capsulated organisms of the "M.R.—" type may be very considerable. Whether similar conditions occur in nature is a matter requiring further investigation.

METERING AND WATER CONSUMPTION.*

By H. P. T. Mattice,
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In considering the effect of the installation of water meters upon the consumption of water, and in comparing the usage in various cities, three elements, which may have an important bearing upon the results, are seldom taken into account. These are:—

1. Pressure upon the water system.
2. Extent of house connections with sanitary sewers, especially the use of bathtubs and water-closets.
3. Effective size of mains and services.

Pressure of Water System

When per capita rates of consumption are published or mentioned, how often is the average pressure at which the water is supplied included? It is a mistake to omit that item, as it is an important one. A city with a higher pressure than another will find that its leakage rate, both through fixtures and underground piping, will be greater than that of another one which maintains a lower average pressure.

In Oak Park the per capita rate of consumption is easily varied between one and two gallons per pound change in pressure within the entire range of rates of consumption. That is to say, 10 pounds' variation either way will make a difference of 10 to 20 gallons per capita daily. Thus the Oak Park rate of 65 gallons per capita at 45 pounds' pressure can be reduced to 45 gallons at 25 pounds. In Niagara Falls, where the per capita rate of consumption was 300 gallons per diem, exclusive of the industrial usage, the writer determined this rate to be from 3 to 5 gallons per capita per pound change in pressure, or 30 to 50 gallons per capita for each 10 pounds. The Niagara Falls consumption was about 6¼ times that of Oak Park, and the average pressure was about 60 pounds, which accounts for the different limits; but the principle is the same and its importance is clearly seen. The pumping units were designed for a maximum rate of consumption owing to the heavy drafts, and, as there were no small units provided, the effect of reducing the fixture leakage by the installation of meters and the house-to-house inspection was to boost the pressure at night some 30 pounds greater, or to 90 pounds; and the effect of reducing the leakage was not evident owing to the greater discharge of water through the remaining defective fixtures.

The following table shows one of the uses of water affected by pressure:—

A ¾-inch hose 50 feet long with nozzle at 60 lbs. consumes 5,000 gallons per day if in form of jet; at 30 lbs consumes 3,600 gallons per day if in form of jet; at 55 lbs. consumes 10,000 gallons per day if in form of spray; at 30 lbs. consumes 7,200 gallons per day if in form of spray.

These figures have been obtained from tables prepared by Manager Sullivan, of the Nashua, N.H., Water Co.

Connections with Sanitary Sewers

Another element which is noteworthy in its effect on water consumption is the use of water-closets and bath tubs, although the number of consumers on the line of pipes are often considered in computing per capita consumption. It is seldom that the number of consumers which have the use of faucets only are separated from those which have all the sanitary conveniences.

In Oak Park, from numerous experiments, we determined that the average number of gallons per capita consumed by water-closets where no leaks or waste existed was 20; while under the same conditions the average family consumed 15 gallons per capita through bath tubs. An interesting fact connected with the use of bath tubs is that a person who takes cold baths every morning is very likely to consume 40 gallons per day in this item alone. A psychological effect of the lack of pressure, consequently an increase in length of time required to fill bath tubs, oftentimes reduces the quantity of water used for baths.

The records from the following cities show the effect of the installation of sewers upon the general water consumption:—

City.	Before Installation of Sewers.	After Installation of Sewers.
Marlboro, Mass. .	21 g.p.d. per capita	38 g.p.d. per capita
Newton, Mass. ..	31 g.p.d. per capita	63 g.p.d. per capita
Waltham, Mass. .	32 g.p.d. per capita	70 g.p.d. per capita

In Madison, Wisconsin, the per capita daily consumption in residences with sewer conections was 68, while in residences without sewer connections it was 14.

In Rochester, N.Y., services with water-closets consumed 22 g.p.d. per capita; services with water-closets and no baths, 18 g.p.d. per capita; services with water-closets or baths, 14 g.p.d. per capita.

The limited extent of services and sewer connections in foreign cities, thus cutting down the number of outlets for consumption and fixture leakage, is responsible for the low per capita consumption in those cities. From figures obtained three or four years ago, it was noted that the large European cities of over 2,000,000 population had about as many service connections as the average city of 300,000 in this country, while the number of services in foreign cities of about 350,000 population equalled that of our cities of 40,000 population.

Effective Size of Services and Mains

The data on this subject is limited, but difficulty is experienced through loss of pressure by friction from the reduced area of corroded lime-coated service pipes and water pipes filled with algae, crenothrix and tubercles, indicate the importance of the effective size of service pipes and mains on leakage and waste. Water bills on metered premises in which leakage and waste exist often double in size after the renewal of service pipes, both in the ground and in the interior of the house especially when iron pipe has been replaced.

The following table compiled from some experiments conducted by the New York Department of Water Supply, Gas and Electricity, throws more light upon the subject:—

Pressure in street mains required to give the tabulated discharge through a corporation cock and 30 ft. of lead service pipe.

Gals. per Min.	1-in. Service.	¾-in. Service.	⅝-in. Service.
5	.....	2 lbs. sq. in.	3 lbs. sq. in.
10	.....	5 lbs. sq. in.	10 lbs. sq. in.
15	3 lbs. sq. in.	11 lbs. sq. in.	23 lbs. sq. in.
20	5 lbs. sq. in.	18 lbs. sq. in.	38 lbs. sq. in.
25	8 lbs. sq. in.	28 lbs. sq. in.	54 lbs. sq. in.

This table also gives the difference between the pressure at the main and the house side of the service under pressure.

Use of Water Meters

Having considered the items which affect domestic water consumption as governed by local conditions irrespective of industrial and other usually recognized conditions, we may now discuss the meter question.

Can one imagine a gas company or an electric utility selling its commodity without measuring it? Doubtless though, it is easier to tolerate the waste of water because it is not seen or appreciated. Gas leakage is offensive and dangerous. Wasted electrcity is mainfested by motion, light or heat; but water disappears unnoticed into the sewers. Yet the speaker knows that in an Eastern city where electric-light current was sold under the flat rate system, electric-light bulbs on numerous porches remained turned on all day long. Queries brought the answer that it did not matter as there was no meter. What can the effect be on the water consumer of this type when the water consumption is not metered? In fact, in this same city, which

*Excerpts from a paper read before the annual convention of the Western Society of Engineers.

was only 28% metered, the fixture leakage per capita, as determined by an extended survey, was 205 gallons daily.

Any student of water consumption and waste knows that underground leaks contribute little to the waste included in high per capita statistics. From his experience in Oak Park and elsewhere the writer affirms that the periodical inspection of fixtures in lieu of complete metering is entirely unsatisfactory. When avoidable leakage will occur through meters, what can be expected when there is no automatic check on the consumption?

In Oak Park it has been observed during the past four years that the annual number of high bills complained of, including those places at which the same conditions obtained two or three times a year, dropped from 33 to 10% of the total number of services, due to education of the consumer. Without meters there would have been few complaints and much increase in waste and leakage.

Meters vs. Inspection

It is most difficult to control fixture leakage by inspection on account of the recurring of the waste as soon as the inspection has been made. In order to do the work that the meter does, it would be necessary to make inspections every month, at least, and in the case of an ordinary residence, it takes about four times as long to make an efficient inspection as it does to read a meter. In apartment buildings an inspection is a thankless job because all the occupants are seldom at home at the same time. The work, therefore, is usually slighted.

It has been found also that efficient fixture inspection is more objectionable to tenants than meter reading because the inspector has to pry into the privacy of the home. The landlords who dislike to pay plumbers' bills for the repair of poor plumbing are the ones who object to meters. In New York it was noted that after six months' work the inspector was stopping leaks at about the same rate as the leakage previously stopped was reappearing.

Unmetered water in completely sewered cities with universal sanitary facilities is usually sold at less than cost per thousand gallons.

In Boston with the gradual introduction of meters up to 60%, the capita consumption dropped from 130 gallons to 90 gallons and in this city vigorous house-to-house inspection was previously practiced. The same may be said of most cities which are metered, although in a few, owing to lowered water rates, with too great a minimum allowance, industrial use, and the other factors which are mentioned above, the curve is more erratic.

Methods of Control

For the past five years the water department of Oak Park has made an intensive study of water consumption with a view of reducing to a minimum the waste, and consequently the quantity of water purchased from Chicago. The city is, and always has been 100% metered, and it has been found that without meters a further material reduction in needless waste would have been an impossibility. In 1913, according to the accepted standards, the Oak Park per capita consumption of 75 gallons was very low, indeed. The night rate of consumption for the total system, however, was 58% of the average daily consumption, while 20% seemed to be a fair ratio for a city composed principally of high-class residences with few industries.

As a result of the waste campaign the daily per capita consumption of Oak Park has decreased from 75 gallons in 1913 to 65 gallons in 1918. Yet who can say that Oak Park is not one of the most sanitary cities in the state of Illinois, if not in the whole country?

There are no privies in this city, every house being connected with the sewers. All the consumers have the benefit of water-closets, 95% have bath tubs; and the bathroom consumed about three-fifths of the water used for domestic purposes. Moreover, every building has a lawn, every street has a grassed parkway on each side of the roadway. From inspection of records of sanitary surveys in various cities with lower and even greater per capita consumption than Oak Park, it was found that the number of premises not connected with the sewers varied between 20% and 80% of the total. Every home in Oak Park is connected with the water supply and there are no active wells except two deep wells used by a gas company as a supplement to the city water, and consuming one gallon per capita. In other cities of which we have record, the wells number 5% to 81% of the total number of buildings.

From the foregoing it follows that Oak Park should use more water than the average city, regardless of relatively small industrial use, because in many cities with industrial plants the big users have access to river, lake or well supply and use the city water only for emergency use or for drinking water.

The Waste Problem

It will be noted that the night rate of pumpage will often be from 80 to 90% of the average daily consumption. This is indicative of much waste. Too much consumption is generally assumed for industrial and other night uses. Such should be determined, not estimated. In Oak Park the night rate, which is considered the waste barometer, was reduced from 56% to 21% of the average daily consumption in the four years between 1914 and 1918, inclusive.

The waste problem was attacked along various lines, some of which are not commonly associated with water consumption. The elements substantially affecting waste elimination as developed in the four years between 1914 and 1918, being these:—

1st. 100% meterage.
2nd. Efficient maintenance of meters.
3rd. Efficient complaint bureau, including education of consumers in cause and remedy of needless waste.
4th. Strict collection of high bills due to leakage or waste.
5th. Periodical waste surveys.
6th. Comprehensive and workable water ordinance, or rules and regulations, with their strict observance.
7th. Centralized control of the water department.

Meterage

With regard to the first item, 100% meterage, this means that all water pumped or otherwise delivered into the system is measured at the distributing point no matter where located. Included among the services metered are all municipal buildings, watering troughs, drinking fountains, street sprinkling, water used in parks, water used in the construction of houses and all dwellings regardless of size or character; together with fire hydrants when used for other than fire purposes. It is admitted that in the construction of buildings and in the case of fire hydrants that sometimes more water is wasted than is measured, but it was found that the moral effect of the meter had a great weight in minimizing the unlawful use of water. It is, in fact, a visible permit. Selective metering has been proposed and widely adopted in many large cities in order to reduce expense, but under that basis it would be necessary to meter only 10% of the Oak Park services, for Oak Park would be considered one of the good controllable districts adapted to periodical inspection, in a city like Chicago, for instance. Under this method, too, the wastage must have taken place before the necessity for stopping it will have become apparent.

Maintenance of Meters

The second item, the efficient maintenance of meters, is more important than appears at first glance. Meters should be repaired as soon as possible after being reported stopped or otherwise defective. This condition of the meter is usually detected by the readings, supplemented by observations of the meter reader. All suspicious variations in the readings, both high and low, should be investigated promptly. It has been found that frequent readings taken not less than four times a year, preferably more, gives satisfaction to the consumer in measuring accurately all the water that is used and in giving ample warning of unavoidable excess consumption. The periodical testing of meters, such as once every five years, has disclosed many unsuspected defects caused by undue wearing of parts, or the detection of tampering by the consumer. In Oak Park

the test of meters which were used by the private company preceding municipal management disclosed under-registration varying between 10% and 50%, with an average of 20% for the entire system. It was also found that in several cases where the bills were not high in spite of very small leakage that the meters did not register leakage as small as 30 gallons per day.

Complaint Bureau

The efficient complaint bureau, and the education of the water consumers, are important both for the satisfaction of the water-taker who tends to regard the meter with suspicion and for the peace of mind of the water department executive who realizes that it does not pay to antagonize citizens. The systematic handling of complaints is infinitely more satisfactory than adverse arbitrary decisions, or spineless methods of leniency caused by fear of political pressure or favoritism. Every high bill can and ought to be explained. The problem is really one of education. In Oak Park the campaign was begun by utilizing the backs of the water bills for admonitions to the consumer referring to the waste of water. This was supplemented by letters to each complainant with follow-ups in order to test the reduction in consumption after the repair of leaks. The meter readers report all suspicious sounds of running water, although not attempting to trace the cause to save time, and the rest is handled in the office by the complaint clerk. If the consumption is abnormal, a special call is made by a complaint inspector before the waste is brought to the attention of the consumer. It was noted that if notices were sent to the consumer before the investigation, he often repaired the fault and then insisted there must be a mistake or that the meter was incorrect, because there could be no leaks. Hence the adoption of a policy of locating serious trouble before reporting it.

No one in Oak Park has ever been obliged to stint in the use of water in order to receive reasonable bills. In fact the leaks consumed 3 to 10 times more water than the consumers themselves can actually use for all purposes. Our investigators proved that, in every case of that kind, there were toilets leaking at the rate of ⅛ to ½ gallon per minute. Sometimes the waste was so small that the watching of the meter did not readily indicate the quantity. Sound is really the best indicator of leaks. This is explained to the consumer who thereafter manages to use all the water he needs, although keeping down the bills. Often a warm meter advocate is thus obtained. It is always a good policy to give the consumer the benefit of the doubt and let it be known that the department is glad to correct errors. In many cases diplomatic cross examinations will uncover sources of waste which the consumers do not realize. It is dangerous to try to prove that the complainant is wrong until you can show him where. Rectify errors promptly. Service is the important element in popularizing the use of meters.

Aside from the waste through fixtures, high bills are caused by leaks in toilets, broken underground pipes in basements, defective toilet valves or ball-cocks, dripping faucets, thermostats, water motors, pumps operated by water power, defective stop-and-waste cocks, leaking valves, breaks in pipes under cement floors and between walls, water used for cooling food, water wasted to obtain a cool drink or to procure hot water from defective heaters, children leaving faucets open, lawn sprinkling with hose without nozzles, the flushings of water-closets uselessly after use for purposes for which they are not designed such as garbage receptacle, leakage through tanks in attics and by allowing water to run continuously in order to prevent freezing or into wash tubs or lavatories for washing purposes instead of filling the bowls or tubs before using.

Domestic Waste Detector

For cases where the department was unable to determine the cause of high bills owing to the fact that there was no leaking and that the consumer was sure he was not wasting water, a recording detector was designed, which when substituted for the meter gives a graphic record of the consumption for 24 hours or a week. This device consists of a piece of brass pipe ½ in. or ¾ in. in diameter and 7 ins. long, into which are inserted two brass tubes 1/16 in. in diameter, one pointed upstream and the other perpendicular to the axis of the pipe. For convenience these orifices or pitot tubes are soldered into ⅛ in. brass nipples. Two needle valves and strong rubber tubing complete the meter. A special type of recorder with a rapidly revolving chart so that drafts lasting only one-half minute could be detected, was constructed, which indicated at what time and how long faucets were left open for baths, for washing dishes or clothes, or for lawn sprinkling; how often toilets were flushed, together with a record of all leakage of 1½ gallons a minute or more. In fact, it was found easy to determine at what time the consumers arose and retired and whether they got up during the night or not.

First Apparatus Was Limited

The pipe, in reality a brass meter nipple into which are soldered permanently two pitot tubes, is inserted in the house service either in place of the meter or connected in tandem with it. In all, only two tubes were necessary for the range of consumption which exists between a four-room bungalow and 24-apartment building. In the first experiments the pitot tubes were connected to a mercury U-tube, by means of which rates ranging from less than ½ gallon per minute to 30 gallons per minute were measured by using the ½ in. and ¾ in. nipples. A camera provided with a revolving sheet of bromide paper, 3 ins. wide, was designed and adjusted so that the lens magnified the deflections through a slot about eight-thousandths of an inch wide. A pocket flashlight supplied the illumination, through a condenser, and the power was furnished by a single-cell storage battery constructed for the purpose. The only drawback to the device was that the high deflections were beyond the range of the slot, although small leakage was detected which the disc meter failed to record.

Will Detect All Flows

The next step, after fruitless attempts to alter the quantitative measuring device of the displacement so that it would register in gallons per minute, was to design a recorder which could take care of all flows. This new recorder will detect rates as low as 1½ gallons per minute, and there is no limit to the maximum recording capacity if larger meter tubes with lower centre velocities are used. The diaphragm is constructed of ⅛ in. mechanical rubber, and it is surprising to note the power transmitted through the stuffing box. The recovery after a short draft is rapid, even at maximum velocities. The recorder is not extremely accurate but frequent rating by means of the regular meter-testing outfit indicates that it is amply dependable. It has been used successfully in connection with a 2-in. Venturi meter, in making waste surveys by means of the hydrant and hose method, and gives much assistance in determining the varying consumption in the district tested, so that the leakage can be ascertained.

Plumbers invariably mislead the consumer by failing to appreciate small leaks and by discrediting the meter. But Oak Park water-takers are rapidly becoming educated in spite of this. After being shown repeatedly the waste which plumbers failed to locate, and seeing the effect of the stoppage of leaks which, according to the plumbers, could not amount to more than 10 gallons a month—they refuse to be sidetracked.

High Bills Caused by Leakage

Regarding rebates on high bills which were caused by leakage, we find that to reduce these indiscriminately is to defeat the purpose of the meters. As stated before, reliance should be placed upon educating the consumer rather than in the practice of allowing reductions in order to avoid adverse criticism or to satisfy some influential citizen. Water-takers easily fall into the habit of depending upon leniency if such is known to be a possible way out of their difficulties. The average consumer can bring the plea of first offense and a promise to be careful in the future. The way it works out though is this: If a rebate is allowed in one case, the tendency of the authorities will be known throughout the community in a short time, and it will be

very difficult to enforce payment of other similar bills. If a complainant feels that the water department is lax, he will not exert himself to keep his fixtures in repair. If, on the other hand, the water officials are known to be severe and exacting, and absolutely impartial, the majority of the consumers will be satisfied that there is an advantage in being on the alert. The minority, it is true, will complain and accuse the manager or other executive of unfairness, but the fact that everyone has been treated alike and that there are no favorites will permit a very successful operation of the "no reduction on account of leakage" policy. Oak Park speaks from experience. Better to allow a lower rate on the water, approaching the cost per thousand gallons in the case of unavoidable leakage; or else adopt a partial-payment plan or both. But charge for every gallon wasted. The lesson will strike home and be appreciated throughout the community.

Waste Surveys in Oak Park

In making waste surveys the most convenient method is to make, first, a rough survey of the entire city by means of the Pitometer. This is done by isolating certain districts by closing gate valves and measuring the supply through one of the mains left open to serve as a feeder. It is possible on small systems to make the preliminary test by shutting down those districts entirely for a few minutes, especially in the residential sections, and note the drop in the rate of consumption as indicated by the recording chart at the pumping station or reservoir or wherever the master meter may be located, providing it is on the distributing system.

It is often found, however, in districts which are completely metered that the velocity of the smallest feed main is so low that it is impossible to obtain an accurate record of the consumption if there are no large leaks. It is then necessary to by-pass the flow of water through a small pipe, 2 ins. or smaller in diameter, in order to increase the velocity. This is commonly called the hydrant-and-hose method because the most practical way of doing it is to feed from a fire hydrant, without the district, through a fire hose to a hydrant within the district. Oftentimes a regular displacement meter is used and the rate is obtained by noting the readings of the meter at regular intervals. This method is not a very useful one owing to the fact that several drafts may occur during the test. In Oak Park two other methods have been used: One consisting of a 2-in. Venturi meter with a ⅝-in. throat which can accurately record rates from 3 gallons to 50 gallons a minute. The other is by means of Pitometers inserted into short pieces of pipe 2 ins. or smaller. Thus a quantity as low as ¼ of a gallon per minute can be measured.

Tests Made During Day

Contrary to the usual method of making waste surveys, all tests are made during the daytime, after determining the best hours in which the flow is somewhat steady, for inspection of the Venturi meter at the pumping station. The districts tested varied between ¼ of a mile and 2 miles in length. By being able to watch the rate of consumption, it is rarely found necessary to be on the job for more than half an hour at a time in order to determine the minimum rate of consumption.

The exact population of the district tested is obtained as well as the average daily consumption through the domestic meters—the former from the prevailing school census and the latter from the water accounts. Thus an estimate of the legitimate rate exclusive of the underground leakage is determined. In all cases where there is not much leakage the normal pressure is maintained through 600 ft. of fire hose. In order to bring the reading within the limits of the manometer where the flow is abnormal the valve on the meter is throttled. In one case a rate of 60,000 gallons per day at 10 pounds' pressure in a stretch of pipe only one-half mile long was observed, the normal pressure in the mains being 45 pounds per sq. in. Subsequent investigation by means of the aquaphone disclosed six service leaks which wasted water into the sewer at the rate of 200,000 gallons a day. This meant a leakage per capita rate of 305 gallons per day, while the service meters indicated only a total per capita consumption of 45 gallons, but after the repairs were made the leakage rate per capita dropped to 10 gallons a day.

Water Ordinance

In order to be able to operate the water department efficiently it is necessary that a comprehensive and workable water ordinance be adopted and followed to the letter. All the employees and officials should be able to follow a definite, unswerving policy with a minimum number of loopholes to be detected by skilfull lawyers. The water ordinance is either legal or it isn't. If there be a number of rules which have become a dead letter or are so ambiguous that the executive does not attempt to enforce them because he feels that they would not hold in case of a lawsuit, they had better be tried out immediately or else repealed. The efficiency of a water department is greatly impaired if there is a conflict with other city laws, as in the case of many municipal plants.

Centralized Management

Just a word on the final factor in the control of the water system. It follows from the foregoing paragraphs that all the divisions connected with the operation of large water departments must be under centralized management. It would be better if many municipal plants were made an independent branch of the municipal government. There would then be fewer failures in the operation of municipally owned utilities; failures which are concealed by taxes. There is a little incentive for efficiency in operation if the superintendent or manager makes a decision and is obliged to back down because the complainant is able to obtain a concession from another city official higher up, who is not vitally interested in the operation of the department. It is discouraging if the manager has outlined policies which resulted in a saving to the department and finds that the gains made are taken advantage of by some other municipal division which is not operated efficiently; or used because other funds have been exhausted. It is impossible to prevent needless waste of water against the advice of the manager, or if the manager is continually compelled to yield to pressure from some political adherent of the city fathers.

In the case of complaints on account of high bills, it is disconcerting to attempt adjustments and give satisfaction if the money is collected in one department, "shut-offs" for non-payment of bills handled in another and the meters read and accounts rendered in either of the foregoing or yet in a third one, all these different divisions being independent and under different executives. Unless all policies originate in the same department, there will be neither co-operation nor co-ordination.

The Canadian National Exhibition will open its gates August 23rd, but the formal opening will not take place until Monday, when H.R.H. the Prince of Wales will preside over the inaugural ceremonies.

The Jos. Dixon Crucible Co., of Jersey City, N.J., announces that for the past two years it has invested in Canadian government, provincial and municipal bonds all of its cash returns from sales of its products in Canada. This is an example which, if followed by all of the other American firms doing business in Canada, would be of benefit to Canadian finance. A. R. MacDougall & Co., Ltd., of Toronto, are the Canadian representatives for the Dixon pencils. The Canadian Asbestos Co., Montreal, are the representatives for the Dixon paints and lubricants.

The enforcement of regulations governing the practice of surveying and civil engineering in Idaho now comes under the Commissioner of Law Enforcement, R. O. Jones, Boise, Idaho. There is now a law regulating the practice of civil engineering in Idaho which appears to include all branches except mining and metallurgy. Examination for civil engineers will be held the second Tuesday in September; for surveyors, the first Tuesday in September. No survey of land or plat of same has been legal since June 1st, 1903, unless made by a licensed surveyor.

THE RELATION OF THE ENGINEERING PROFESSION TO ENGINEERING EDUCATION*

By Frederic Bass
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ENGINEERING education must meet the demands of the engineering profession, not only those demands which have been given definite form, but also those which now inarticulate, are struggling for expression. Professions come into being in response to great human needs; and are endowed with vitality and life in proportion as they minister to those needs. The engineering profession is youthful, it has lavished the service of its constructive genius upon a waiting world, and a new order of civilization has evolved with a rapidity unknown in other ages. Men have been given suddenly, within a few score of years, new wealth and power which has brought their minds into contacts a thousandfold multiplied beyond previous experience. In the last four fateful years, new groupings have been formed in unforeseen environments with still further acceleration. The world is now confronted with the problem of quickly adjusting itself to the conditions which are inexorably imposed upon it.

No Clear, Determined Declaration

The question in the minds of men is: Can we meet the situation and master it? The questions in the minds of engineers are: What part is it that the engineering profession must play? Are we going to meet our problems and master them as we have in the past? Are we going to realize this supreme opportunity and marshall our strength to grasp it? If we are, how is it to be done? Were the answers to come from any one of the great number of engineers whose hearts beat for their country and whose minds have grasped its peril, there could be no doubt as to its nature. But how about the answer from the group, from the profession as a whole? What do we hear? One voice loud, emphatic and clear? A babel of sounds from an eager multitude? Or only faint murmurings from the ranks here and there?

We can all agree that no clear, virile, determined declaration has come in unison from the profession, for it is relatively young and does not yet know its place in the world; it has not had the experiences and grapplings with life that alone can teach its true place, its duties, its privileges, its limitations and its power. Time and trial will bring it to a realization of these, a realization that will be splendid and magnificent.

Secondary Positions at Best?

The voices that are heard here and there expressing the hope, and even the confident expectation of the future, are becoming more numerous. They come from the local societies, from the state societies, from the older national societies. As their volume swells, the time for action nears, and in action, clear-headed leadership must be had.

The question might be asked: "What has this history and this concern for the destiny of the profession to do with education?" It has everything to do with it. The students of the engineering schools of to-day will constitute the fibre of the engineering profession of to-morrow. When the choice of a vocation presents itself to a young man, he asks: "Whither does it lead? What tasks await me there? In what company shall I find myself? Am I to be a slave or a servant, or am I to be a master? Am I to be in a position where my constructive genius, whatever it may be, shall lead me to a position where my works shall demand and receive their just recognition, or shall I forever hand the fruits of my labor to others who knowingly or unknowingly shall profligately waste them or throw them aside?"

What is the teacher to answer the boy? Can he point to a life of magnificent service, full of experience, rich with all the associations that the highest type of human being desires, a life in contact with the really great human developments? Or must he answer that engineering organization is weak, that, if he takes up engineering as a life work, he will always be the servant of others, at most, in a secondary position; or, if he finally wins a high place, he will have to fight alone?

The replies to these questionings are to be found in the places where practicing engineers are found, in the character of the profession and its relations with other groups and the general public. As a spring of water rises no higher than its source, so no body of men can rise to greater heights than the individuals which compose it, and if the profession of engineering is to be what its best friends hope it shall be, then it must make such answer to the questionings of youth that shall attract to it the young men of high ideals, of clear mind and vision, of determined purpose; the men who shall be neither servants nor slaves,—but masters of their work. These questionings of youth constitute a direct challenge to each one of this body.

Let the Engineers Lead!

The first requirement in teaching or in any other form of directing men's minds and hands is to give to them a clear, definitive objective, and so it is that the greatest factor in intelligent, fruitful and efficient teaching lies in supplying the motive force a reward for accomplishment. Given that, the problem of teaching is one of direction, and not one in which the teacher must use his energy in forcing unwilling minds to grasp ideas, theories, applications of theories and facts which seem to be devoid of interest. A foreman or superintendent who must continually, with his own hands, do the work of his gang or his force is not the man to produce results. He must keep his attention on all his men and their tasks, encouraging, checking, taking advantage of occurrences and co-ordinating the efforts of all. So must the teacher work, and his students, like the men under the foreman, must receive the inspiration of a clear objective and definite progress toward it, even though the objectives be unlike in character and in degree of remoteness. The engineers of America hold in the hollow of their hands the future of their profession. Let them set the mark, let them demand results from the schools, let them lead and they shall not be disappointed in their followers who themselves, some still better day, shall be the leaders.

New Ideals Affect Curricula

The formulation of ideals and aims and the definition of the fields of activity of the profession would also prove a valuable standard by which engineering curricula might be judged, and according to which all of the separate courses of instruction might be correlated. Such co-ordination both within the schools and without would seem to be a fair primary requirement in education, yet only rarely is such an ideal approached. In many institutions there are inconsistencies in the curriculum, frequent, unnecessary duplications in instruction, omissions of important fundamentals, inclusion of irrelevant subjects, caused on the one hand by slavery to precedent, and on the other by undue susceptibility to fads, both of which exercise influence in the absence of a comprehensive understanding and vital faith in the future of engineering.

This question of curriculum is important; upon it depends to a large extent the equipment with which the student must tackle his job when he graduates. It is fairly uniform throughout the engineering schools of North America, although many variations do exist. All engineering schools require practically the same courses in mathematics, rhetoric or English, mechanics, physics, chemistry, drawing, shop surveying and the various applications of theory to practice, such as machine shop design, steam engines, electrical machinery, structural design, hydraulic and sanitary engineering, railroad engineering and the like. The general assumption among engineering educators is that engineering is almost entirely a technical pursuit, that its foundation lies in an understanding of the forces of nature and their mathematical expression. Observation of engineers' *work* indicates that in the great majority of cases this assumption fits the facts, and that it will continue to do so to some extent, but the conception of the engineering profession which is taking form in the minds of thousands of engineers to-day is a much greater and higher one, and the curriculum must conform to it and will when engineers definitely demand that it be done and see to it that it is done.

*Address to the American Association of Engineers.

It is the engineer's duty in design to plan not only for the present, but for the future; he is coming to see that the structure of his professional organization, while adequate for the past, is being overloaded, and must be reconstructed to take care of future loads; he is about to design a new structure. Engineering college faculties must recognize this and so plan their curricula that the foundations shall include not only the principles of physics and chemistry and methods of mathematics, but those of the basic nature of the human institutions by whose agency and through whose processes the service which the engineer has to offer may be made to bear fruit. The student of engineering must realize this; he must know that his task is to be a more serious one than that which his predecessors faced.

Teachers Should Work "Outside"

The engineers of this country are now beginning to realize their lack of unity. A number of experiences have brought it home. It is perfectly apparent that when a desirable public improvement, either in political method or in application of method to any particular object is to be made, that the advocates of it will have a greater chance of success when their case is well studied and prepared, and when their forces are marshalled so that at the opportune time the final blow can be given with the concentrated power of all. So in the administration and conduct of an educational institution it is important that the members of the faculty agree as to their aim and methods, and can concentrate their force upon their common object. This involves the question of teachers, their organization, and the spirit which drives them on. Some colleges, often for very good reasons, take their own graduates in as instructors, thus losing the advantage of minds with a new viewpoint. Other colleges discourage professional practice among the faculty and thereby tend to divorce the college from the world of action. The most vital requirement of a technical college is that the members of its faculty have at least a sympathetic appreciation of the character of the practising engineers' problems even if it is not possible for them to personally engage in practice themselves. Certain teachers of applied science should be *required* to do some professional engineering work. It is often forgotten that a large percentage of the teachers of engineering students, in language, rhetoric, physics, mathematics and mechanics and drawing, have little or no connection with or knowledge of engineering methods or engineering organization. A still larger percentage are entirely beyond the reach of the renaissance of spirit now manifest among engineers. This problem of keeping the teacher in close connection with the developments of engineering, not only technically, but socially, is fundamental. Every teacher of engineers should be affiliated with at least one national engineering association, the ideals and activities of which are not bounded by too narrow an outlook.

Students Benefited by Discipline

In spite of all that may be done to lead the student to self-help aroused by interest, there must still be some work done because the teacher orders that it shall be done. There must still be some things taken on faith. For this there must be discipline. No system of education can be devised which can rely wholly upon the student's own initiative to maintain order and progress. The statements already made should not be construed to mean that the standard of work, both in quantity and quality should be determined and maintained by the student's interest and not by the teacher; that is the teacher's first duty. A brief period of experience with the Students' Army Training Corps, in which the writer had 900 students in surveying, convinced him of the desirability of a stricter system of discipline among students. The average college student will *not* map out his time so that it may be usefully employed; the army discipline did that for him. He will not generally show the regard for property and persons that is required of students at West Point. There was a noticeable improvement in this respect during and immediately after the recent military training period. While the writer is not willing to see military training in such a concentrated dose again administered to the colleges, he does heartily believe that the average college student would be immensely benefited personally by a strict discipline, not only while under it in college, but afterward. There would be taught the value of courtesy and perhaps of the deeper meaning of courtesy, which is understanding and tolerance of and respect for other people as well as himself. We all recognize the results of it in the splendid officers of the United States army and the navy.

There has been considerable discussion lately in regard to marking systems. Psychological tests for various reactions have been suggested as a substitute for numerical grading of scholastic work. While the writer has only a reading acquaintance with such tests, he believes that after a teacher has come to know the individuals in his class, he unconsciously treats them according to their mental constitution, and as long as his final grades do not entirely depend upon answers to formal questions, they will represent a fair rating. It is not to be doubted, however, that an analysis of the men in a class according to a correct psychological score card, would assist any teacher in a mere accurate estimate of each student's personality and the rate at which he is developing his powers.

A Threatening Development

To summarize here the points which have been mentioned: First, the engineering student must have an ideal which offers an opportunity of realization and which is worthy of the effort of the highest type of man; this ideal must be set for him by the engineers in practice. Second, the engineering curriculum must provide the student with a thorough grounding both in the fundamental principles of natural law and of human institutions. Third, the school must have a faculty in sympathy with the great body of practising engineers, organized themselves with a common purpose to develop every student so far as possible, and to make of him a master of what little he can compass in his college course. Fourth, a certain discipline which shall demand a high standard of personal conduct. With a high ideal, an adequate curriculum, a well organized faculty in touch with the profession and sufficient discipline, the school can perform its duties.

There is one development which threatens the engineering school. Colleges of arts and sciences and of commerce are beginning to recognize the need of the business man and the man of general education for a more definite purpose in his courses of study, a need for those departments of knowledge of which the world is going to demand much; among these, the fundamentals of engineering. If engineering colleges do *not* meet the demand for a broader fundamental training, we may expect to see men choose the courses in the colleges of arts and sciences in which engineering principles are taught, and the engineering colleges continue to hold only the men who wish to confine their interest to strict technical details. If such a development attains any considerable volume and momentum, there will be many college graduates wth insufficient engineering training, attempting to enter engineering practice, men whose teachers have still less sympathy with and knowledge of conditions of practice than those of engineering colleges, and who can be reached and influenced by engineering organizations only with the greatest difficulty.

Committee on Engineering Education

The whole future of engineering education lies with the profession. When engineers have formed an inclusive national organization that can speak as the voice and authority of a great profession, whose mission is to create and conserve wealth and to demand a higher type of human accomplishment and civilization, the public will listen; financiers, farmers, skilled and unskilled labor will give ear, and order and justice will more and more prevail in the affairs of men. Engineers must first set their own house in order. Only by intense and prolonged study and planning can they do that first task and only by ceaseless vigilance can they maintain it. The labor involved is great and must be divided; it must be done by well chosen committees fully cognizant of the portent of their work. Among these the writer would wish to see a committee on engineering education, well provided with funds to diligently prosecute its labors.

The Carnegie Foundation for the Advancement of Teaching has enabled a notable investigation and report to be made upon the subject of engineering education. This report, admirable as it is, is but a beginning. Such investigation and inquiry should be continuous and more general. The advancement of teaching of engineers means the introduction into the engineering profession of a higher type of man, and this strengthening of the engineering profession means an indefinitely better service to all men.

On the other hand, this same agency has devoted enormously greater funds and efforts to pensioning aged professors. Pensioning means decreased salaries. It is merely a system of enforced saving. It is in this case gratuitous and insiduously undermines independence and self-respect, and is hence essentially a hindrance to the advancement of science. If an agency instituted for promoting education can be found to donate millions for a mistaken method, can one not be found to promote a true method, to promote an inquiry into the problem of attracting to engineering the most promising youths, who shall devote themselves to all the finest and greatest things that engineering includes?

DETECTION OF WATER WASTE*

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

THE absolute necessity and great value of taking means to detect and control water waste in a water supply system are being more and more clearly demonstrated. The special means now available for this purpose, when applied to a system operated as was customary in the past, invariably reveal and locate numerous wastages and losses, allowing these to be easily checked and curtailed.

A striking example of what conditions may exist in other systems is given by a municipality of some 30,000 population in the state of Ohio. A recent survey by professional water savers resulted in the curtailment of the total water pumped by more than one-half. This may at first seem an exaggerated statement but an analysis of the various losses revealed and stopped shows that it is quite within reason.

As is usually the case, the losses were principally due to leakage and illegal consumption. The illegal use detected was very large and practically confined to one consumer, a bottle works, the water being taken through a covered connection to the fire line for the property. The company disclaimed any knowledge of the connection although it was being used by them regularly for cooling purposes.

The following shows how the daily consumption was reduced:—

Consumption before survey	3,932,000 gals.
Consumption after survey	1,845,000 gals.
Decrease	2,087,000 gals.

The decrease was made up as follows:—

Leakage detected and stopped	692,000 gals.
Illegal use stopped	895,000 gals.
Unaccounted for	500,000 gals.

The "unaccounted for" decrease of 500,000 gallons was attributed by the experts to the voluntary action of an illegal user who feared detection. That is, it was assumed that another large consumer became aware of the investigations and discontinued the illegal use of water before detection.

The costs in connection with the above-mentioned survey are also interesting to note. The contract price for the entire work by the experts was $2,600, while the extra expense incurred by the municipality in connection with the survey is estimated at $2,600 more. On the other hand, the company caught using water illegally offered to settle for $6,700 in payment of the water used, but the municipality is suing them for $49,000.

*From "Conservation."

REGIONAL PLANNING OF THE NIAGARA DISTRICT*

By Thomas Adams
Town Planning Adviser to the Housing Committee of the Dominion Cabinet, Ottawa

IN order to plan our cities and towns properly we must investigate and analyze many problems which have a bearing on life and growth within and surrounding them. What is true of the individual is still more true of the city. It cannot and does not live to itself alone. Recent events throughout the world have shown the extent to which the town and the country are inter-dependent. Recent tendencies in industrial decentralization have also shown the importance of one of the modern aspects of town planning, namely, the direction and control of the growth taking place within the rural and semi-rural districts where new industries are being established. The artificial boundaries of cities are becoming more and more meaningless. The real controlling factors which determine and encourage industrial growth are physical and natural to a greater extent than they are administrative and artificial.

Regional Survey and Plan

One of the difficulties in dealing with this subject is that we have not yet adopted a clear and unambiguous terminology. The same words have different meanings to many of us. I must, therefore, begin by explaining what I mean by regional planning and regional survey, and I will take them in the logical order:—

1. The regional survey has to do with the investigation and mapping of the existing physical, industrial and residential features of a region that has interests and problems in common, which needs comprehensive and co-ordinated treatment without regard to arbitrary administrative boundaries.

2. The regional plan is concerned with the general planning of the area included in a regional survey. It is a skeleton and tentative plan of a region within which there is comprised a series of municipal units, in juxtaposition to one another, and having overlapping and inter-related problems. The width, direction and classification of our main and secondary highways should be governed by the needs of such a region and not by the needs of one municipality within it. This principle is fully recognized in Ontario highway legislation, in regard to the principle on which the cost of construction is apportioned. The planning of our system of communications in the regional plan should also have regard to the classification of land for different purposes of industry or residence. Land should be classified in a general way for industries, for residences, and perhaps for agriculture, for park areas or for special reserves or as unsuitable for building purposes. We would also consider within the region how far it is desirable to prescribe a code of housing and town planning regulations to deal with building conditions that need to be dealt with in common over large areas of different character. Sewerage and water supply may have to be dealt with in large regions to obtain efficient and economical schemes in cases where it is not practical to get an efficient system of either in separate units of administration. These and other problems that can be dealt with in a preliminary and general way need regional rather than municipal treatment.

The Town Plan

3. The town plan is the definite plan, accompanying a definite piece of legislation, for fixing within the city or the county areas first those parts of a regional plan which are locally approved, and secondly, the civic design and regulations dealing more intimately and precisely with the problems connected with the growth of the town, its means of communication, its industrial development, its residential areas, its character and density of building, etc.

We thus have three distinct processes, each connected with one another, and logically leading up to one another, which are the regional survey, the regional plan and the

*Address at the National City Planning Conference, Niagara Falls, N.Y.

civic plan. It is unnecessary for me to argue with town planners how hopeless the task is to attempt to prepare a plan without having obtained accurate data regarding existing physical and industrial conditions.

The Niagara District's Problems

The Niagara district seems to me to be one which needs the making of a regional survey and a regional plan as a preliminary to a series of civic plans for its city, town and county areas. Neither Buffalo, nor the Tonawandas, nor Niagara Falls, are strategic centres; they are parts of a strategic centre of 1,000 square miles in extent on both sides of the Niagara River. The problems of this region are international, and give us proof that the power of natural conditions is so great that even the boundaries of nations do not form intelligent and appropriate boundaries to regional and town planning schemes. Indeed, may we not hope, that in the process of planning them we shall help to knit these two nations, their industries and people, closer together; and also that the bridge which we propose to erect as a symbol of peace will be more than that—will be a symbol of co-operation and mutual respect? Personally, I should like to see something more than a physical bond, such a bond as could be provided by a Regional Planning Commission representative of the State of New York and the Province of Ontario to deal with the planning problems of the Niagara district. That need not be an idle dream any more than the creation of an International Waterways Commission.

Superficial study of the problems which need to be dealt with within the Niagara region has convinced me that the whole district, for at least 20 miles on either side of the Niagara River, needed to be made the subject of a regional survey. The Niagara district is one with enormous potentialities for future commercial development. It has a strategic position of great importance to both our countries, and it has certain advantages as a tourist centre which are sufficiently in conflict with the aims of those who are interested in its industrial expansion to make it important that a survey be made before any definite plans are adopted by any municipality within the district.

Area and Population

What I call the Niagara District comprises approximately 20 miles on either side of the Niagara River for a length of 28 miles between Lakes Erie and Ontario. Further west in Canadian territory another regional area has the city of Hamilton for its centre. In the United States the area covers all the county of Niagara with the exception of the towns of Somerset, Hartland and Royalton, and in county of Erie includes the towns of Tonawanda, Amherst, Clarence, Cheektowaga, Lancaster, West Seneca and Grand Island. The total area is over 700,000 acres, of which about 317,000 acres are in Canada and 418,000 acres are in the United States. The present population is estimated at about 751,600, made up of 86,700 on the Canadian side and 604,900 in the United States. Buffalo is not the geographical centre of the region, although it is the predominant partner among the local units by reason of its size. Further consideration might lead me to include more of the southern environs of Buffalo to a distance of 10 miles from its centre.

Including all towns of less than 7,000 population, the rural population on either side of the border is about directly proportionate to the rural area, being about one person for a little less than seven acres on the Canadian side, and one person for a little over six acres in the United States. The densities of Lockport and the Tonawandas are very low, being only about 4.5 persons and 2.7 persons respectively per acre. An estimate of the population gives 1,170,000 for the Niagara frontier regional area in 1950. It has been considered that the rural population would remain unchanged, and the estimate has been based on future growth curves of the combined total of three Canadian cities in the region and six of the regional cities in the United States.

Consolidation Desirable

A study of conditions shows that cities are growing along the Niagara frontier and the Welland Canal, so that their boundaries are being forced out to meet the smaller towns. For example, Lasalle is now really a residential part of Niagara Falls, N.Y., but Niagara Falls has no control over its development, although the boundaries of these two places are now adjacent. Consolidation is considered desirable in these places as well as in St. Catharines, Merriton and Thorold; Lancaster and Depew, partly industrial and partly residential, have similar problems; Bridgeburg and Fort Erie, Port Colborne and Humberstone are other cases in point. Then there is the larger question of what areas will soon be incorporated in the city of Buffalo. Evidently there is great need for some definite control over suburban areas, or looking further into the future, areas that are to become suburban areas, and eventually urban areas.

Purposes and Problems

For what purposes do we require more accurate information, and what are the usual problems that have to be dealt with in planning a large region? We may summarize these purposes and problems as follows:—

1. Industrial development—including the arrangement and classification of all lands and the location and distribution of manufacturing plants.
2. Economic use and regulation of the sub-division of land and the character and density of structures in rural and urban areas.
3. Housing—sanitation, convenience and amenity.
4. Transportation—railways, highways and waterways.
5. Sources and distribution of power.
6. Water supplies and sewerage.
7. General amenities—including parks and boulevards and development of tourist facilities.

I will now proceed to consider some of those principles in relation to the problems of the Niagara district.

Industrial Development

In the Niagara district the varied character of the soil and its great fertility in the rich valleys, make it of special importance that the system of distribution should be of the best kind to encourage the maximum of agricultural production. Being an old settled region it is probably impracticable to carry out any schemes of re-planning or re-classification of the lands. It is in connection with the growth of manufacturing industries that the chief problems occur. The combination of cheap power, adequate transportation facilities, and reasonably priced land are having their effect in promoting rapid manufacturing development in the region. As an example the town of Welland had only five factories five years ago and now has thirty. In the cities and towns on the Canadian side there are 145 manufacturing establishments; and on the United States side, 183 outside of Buffalo. The manufacture of cereal foods and the canning and preservation of fruits and vegetables are carried on side by side with the manufacture of aluminum, calcium carbide, etc. Too little regard has been paid even in recent years to regulating the location of objectionable industries, and great and perhaps unnecessary injury has been caused to the great asset of scenic beauty possessed by Niagara Falls. The need for zoning is evident to the casual observer; the methods of carrying it out require prolonged study so as to avoid injury to industrial development.

The low-lying land to the north of the escarpment and also including the area for a few miles south of the escarpment on the higher land is excellent soil and well suited for fruit farming. The balance of the region is only at Lake Erie level, and presents some drainage problems, especially in the clay strip that runs through the centre of the region. On the Canadian side, near Lake Erie, shallow soil is also encountered, with limestone outcropping near the surface, and peat bogs are also encountered. Generally speaking, the level area which is given up to dairying and general farming, has not been developed up to the possibilities of the soil.

Housing Situation

Generally speaking, no protection is afforded to residential areas in the region, and sanitary conditions are defective in districts occupied by workingmen's families. There is an estimated shortage in the cities, not including Buffalo,

in the region of about 2,350 houses. Taking the figure of 2,350 as the shortage in houses and an estimated population of 168,000 it will be found that for every seventy people there is another house needed.

A survey of housing conditions is needed not only to ascertain facts with regard to the shortage, but also to find out the best means of raising the standards of existing dwellings and improving sanitary conditions.

Railway Situation

The numerous railways that serve this area make it a great railway centre, and perhaps unrivalled for rail transportation faciilties. At Gardenville gravity freight yards, near Depew, some $25,000,000 is to be spent, and the yards completed in the next ten years; $6,000,000 has already been appropriated.

At the Lake Erie end of the region there is only one railway bridge, and that single tracked. Trains are said to cross at the rate of one about every seven minutes, and there are 15,000 cars of merchandise passing through every month. The C.P.R. may consider it desirable to build bridges at Goat Island to cross the Niagara River and give them their own bridge entrance into Buffalo.

As far as the cities and towns are concerned, the greatest problem is that of grade separation. In this matter the railways have had the upper hand in the past, and it is time that the general interests of the public were safe-guarded in connection with railway enterprises to a greater extent than hitherto. But it is not the railway corporations that are to blame; the fault lies with the local authorities in not taking action in time. Portions of Niagara Falls, Ontario, and Niagara Falls, New York, are practically devoted to switching, and this right on some of the busy streets. For example, in Niagara Falls, Ontario, there are 14 level crossings. It would be an advantage to have the tracks of the electric radial railways moved from the central streets of cities and towns in certain cases. In other cases, streets are too narrow for double tracking.

Highways and Waterways

Even a preliminary survey of conditions on the Canadian side, across from Buffalo, would seem to indicate that that area is being hampered in its development by the lack of a highway bridge. A "peace bridge" has been proposed as a memorial, and it is stated that bills are now before the governor of the State of New York, one for a bridge at Buffalo, and one for a bridge at Niagara Falls. Apart from the question of the peace bridge, there is no doubt as to the need for a bridge at Buffalo across the Niagara River, but the means of communication on both sides of the river need to be studied before the site of the bridge is settled.

The Niagara River, as a waterway between Lakes Erie and Ontario is, of course, impossible for navigation. On the Canadian side the Welland Canal provides a waterway between the lakes.

The great improvement which is taking place in regard to the waterways which feed the district will be certain to greatly increase the population and industries of the region in the near future, and they will also tend to create changes in regard to local conditions of development and settlement of land. A regional survey and plan is needed to deal with expected growth and change of conditions, even if no other development of transportation facilities were taking place. It is also important, as we shall see later, to consider the park system of the region, and perhaps the drainage system also, in connection with the abandonment of old waterways.

Power Situation

The rapidity with which the demand for electrical energy has grown is indicated by the fact that the first modern power development at Niagara Falls took place in 1890, with an initial installation providing for the production of 100,000 h.p. At the present time the total production is 650,000 h.p. At Power Glen, adjacent to St. Catharines, there is also a development of some 52,000 h.p. There is also under construction a plant to produce an additional 400,000 h.p. The principal development is that of the Hydro-Electric Power Commission of Ontario, which is constructing a canal 8½ miles long to divert the flow of 10,000 second ft. of water and provide for the ultimate development of 300,000 h.p. at Queenston. This enterprise will cost $25,000,000, and will not be completed until 1921.

There has been some criticism of the construction of the open cut, which is having an injurious effect on adjacent property, and will make the city of Niagara Falls, Ont., an island. Whether this criticism is justified or not, and whether part of the canal should have been in tunnel, as apparently would have been practical, does not concern us, but the fact that it is made shows that no such scheme should be carried out without careful study of all the factors, including those outside the purview of the hydro-electric engineers, before this kind of enterprise is begun. The day should be past when great corporations, whether railway or power companies, should be permitted to ignore the effects of their enterprise on the industries, property and lives of the community as a whole.

Water Supply and Sewage Disposal

Lake Erie is the source of water supply for the urban population in this region, water being obtained either via the Welland Canal or the Niagara River. There is pollution of the Niagara River, practically none of the cities or towns treating their sewage. This pollution will be increased with the completion of the Welland Ship Canal and the entrance of the water from the Welland River into the system. It has been decided to have a pipe line extending from Lake Erie to Lake Ontario to supply the cities and towns along the canal.

The Tonawanda Chamber of Commerce is considering a scheme of sewage disposal for their whole area. F. W. Barrally, city engineer for Tonawanda, has done some preliminary work on this scheme which, it is claimed, provides for sewage disposal and drainage of the outlying area along the Niagara River, and incidentally for the development of power. It would avoid the very serious pollution of the Niagara River, and would use the old Erie Canal as a drainage canal for sewage from Buffalo to Tonawanda. There is urgent need for study of the sewage disposal problem of the whole district so as to get an economical and efficient system.

Parks and Tourists

Both the rural and urban areas seem to be deficient in parks. It might almost be stated that the cities and towns have no parks. An estimate had been made that from 1885 to 1907, 15,000,000 visitors have viewed Niagara Falls. In spite of all that has been done, it cannot be said that sufficient care and vigilance has been taken to preserve the remarkable scenic beauties of this region, or to regulate industrial development so as to prevent injury to the amenities of the district, with loss of convenience or efficiency. The commercial value alone of the great combination of natural and historic features is such as to justify the expenditure of more money and effort in conserving them. At old Niagara, with its large "Commons," there are points of historic interest, and the ruins at Fort Erie at the southerly end of a possible park system should also be preserved.

But it is a regional and not a local problem. The district has been endowed by nature with exceptional gifts, extensively as well as intensively. People should be attracted here to spend days instead of hours. All these matters I have referred to, create one big problem that requires big men to solve it and raise it above the level of the politics of the village pump. The whole question of the development of this region in all of its ramifications is big enough to be dealt with internationally. As an immediate practical measure I suggest that a permanent conference or a joint town planning commission of representatives of all the municipalities in the region, be created to prepare a regional survey and a general plan for the area; that federal, state and provincial aid be invited towards the preparation and carrying out of a comprehensive scheme. This need not be done in any way that is unconstitutional, or so as to interfere with local autonomy. It need not involve that any municipality now engaged in preparing its own scheme suspend its operations, but merely that it recognizes that it is only part of a greater whole, and that whatever it does should be made to fit a regional plan.

COST AND SERVICE OF NEW YORK STATE HIGHWAYS*

By George C. Diehl
County Engineer of Erie County, New York

ESSENTIAL elements in the costs of highway transportation are the cost of road construction and maintenance, and the cost of vehicle construction, maintenance and operation.

The first two costs are primarily the concern of the highway engineer. In these days of million and billion dollar expenditures, there is a tendency to expend fabulous sums for permanent highways, so-called.

Of course, every highway engineer is well aware that no road surface is permanent, and the time is sure to come when a new surface must be constructed.

The actual annual cost of a highway includes the yearly interest and sinking fund charges, the yearly cost of maintenance and the yearly allowance to provide a resurfacing fund.

Interest and sinking fund requirements cease when the bonds mature, but this is often from 30 to 50 years, and for that period, at least, should be included; and at maturity it is difficult to foretell road requirements and problems.

Large sums of money have been squandered in the construction of too expensive highways, as well as in the failure to provide sufficient funds.

Accurate Statistics Needed

Sooner or later, every wasted dollar must be made good —generally by the consumer, who staggers under high living costs, and is apprehensive lest there be no check in rapidly mounting prices. The only sure remedy is to practise economy, particularly in the disbursement of public appropriations, knowing that every dollar saved helps lift the burden. Accurate statistics, comparing tonnage, construction, maintenance and financing costs, would help to determine sound highway policies and proper types of construction, including widths, cross-sections and materials.

Unfortunately, such statistics have not been gathered, but a systematic record of costs and travel should be outlined and comparative figures collected which would be of great value in a year or two, and absolutely indispensable after a term of years.

New York State has expended more money than any other commonwealth in highway construction and has the greatest mileage of connected improved roads, so that her experience is of value in considering the highway problem.

There cannot be much doubt that an expenditure of $50,000 to $60,000 a mile is required, and would be justified on the main highway from Buffalo to New York, and possibly on a few other important trunk lines. It is equally certain that expenditures of upwards of $30,000 per mile would be grossly extravagant on a great part of the state and county highway system, and that $15,000 per mile would be far too much to spend on the preponderating majority of lateral roads.

A prominent highway official recently stated that every mile of road in the state should be of a type costing at least $30,000 per mile. There are 80,000 miles, and this plan would require $2,400,000,000—so impossible that discussion is unnecessary.

All Macadam at Start

Starting in 1898 with an appropriation of but $50,000, which was supplemented by an equal amount by the localities, the state engineer improved about 12 miles of highways with water-bound macadam at an average cost of $8,000 per mile. This type of pavement was specified almost exclusively until 1909, and 2,000 miles were constructed during this period at an average cost of about $9,000 per mile.

In 1909, the State Highway Commission was created, and about the same time motor vehicle traffic began to increase very rapidly, and other types, such as the asphalt macadam, both penetration and mixed methods, and brick block, became quite common. In 1915, about 61%, and in 1916, about 46% of the state projects provided for the water-bound macadam type of pavement, and a total of about 3,560 miles of this class of pavement was constructed.

Many of the older water-bound macadam pavements which had been constructed on the main routes have been resurfaced, and in some instances reconstructed with more substantial pavements. By reference to the State Highway Bulletin, just published, it can be noted that about 1,040 miles of these pavements have been resurfaced, about 205 with the same type, 810 miles with asphalt macadam, penetration method, and 25 miles with asphalt macadam, mixed method; and about 125 miles have been reconstructed, 67 miles with new concrete pavement and 58 miles with new brick pavement, leaving about 2,600 miles of water-bound pavement still in the state system.

Resurfacing and Reconstruction

New York State, in building water-bound macadam pavements continuously for 20 years, to the extent of 3,560 miles, has found it necessary to reconstruct with a pavement of a radically different type 3½% of the total, and resurface with a new top course of macadam, using the old pavement as a foundation, about 30%.

During the first ten years of state highway improvement, 1899 to 1908, no maintenance was provided by the state, but the law provided that the maintenance should be performed by the towns. In 1909, state maintenance work and supervision were instituted. The water-bound macadam pavements have accordingly been separated into two groups. Of the 2,000 miles of water-bound macadam constructed from 1899 to 1908, and upon which maintenance had been neglected, about 860 miles, or 42%, have been resurfaced and reconstructed. Of the 1,560 miles constructed between 1908 and 1918, about 180 miles, or 12%, have been resurfaced or reconstructed.

With modern conditions of traffic, where motor vehicles predominate, water-bound macadam can only be maintained by surface treatment of asphalt or tar. With the light, cold materials and heavy traffic, the surface treatments are required every year, while with average traffic the treatment may be omitted about every third year.

When the surface treatment is delayed beyond the proper time, surface holes develop rapidly and constant patching is required.

In 1909, the state first undertook the construction of the asphalt macadam, penetration method, and this pavement soon became the prevailing type for the main through and market routes.

The state system now includes about 3,000 miles of this type, of which about 850 miles are old, water-bound macadam, gravel and second-class concrete pavements which have been resurfaced with a new asphalt macadam top course, laid over the old pavement as a foundation.

Maintenance of Asphaltic Macadam

It is significant to note in the bulletin that of the 3,000 miles that have been so constructed, it has been found necessary to reconstruct but about 10 miles, or ⅓ of 1%, with a pavement of different type. About 8 miles have been reconstructed with concrete pavement and about 2 miles with brick pavement. One hundred and ten miles, or about 3⅔%, have been resurfaced with a new top course of the same type. Many of these pavements have been subjected to nine years of traffic and are in perfect condition to-day, resembling sheet asphalt.

Little maintenance is required for asphalt macadam pavements for the first three or four years after construction.

About four years after improvement the pavements are given a surface treatment of light asphaltic oil, which acts as a flux to the asphalt in the macadam, which works to the surface and is distributed by traffic, to the extent that

*From "Good Roads," New York.

the seal coat is renewed, and under ordinary conditions another treatment will not be required for at least five years after the first treatment.

Little or no trouble is experienced by pitting or raveling, and the pavement will stand considerable neglect without serious deterioration. The cost of maintenance for the first three years of ten asphalt macadam pavements, selected at random, aggregating 54 miles, is found to be $180 per mile per year.

Bituminous Veneer on Concrete

During the period from 1912 to 1914 there were constructed about 300 miles of second-class concrete and Hassam concrete, with a light, bituminous surface, generally of tar.

These types have not given satisfaction, as the concrete does not sustain traffic without disintegration unless protected by a bituminous mat. This light veneer surface of bituminous material is with difficulty maintained, and constant patching of the surface is required. These pavements have been covered with a course of asphalt macadam as fast as funds would permit, and about 40 miles, or 13%, of the total have been so treated, about 24 miles having been surfaced with the penetration type and 16 miles with the mixed method of asphalt macadam. These types were discarded in 1914, when the first concrete pavements of the present-day type were constructed.

There are now 360 miles of standard concrete pavements in the state highway system, all constructed within the past five years.

Commencing in 1909, and continuing to date, the State Highway Department has constructed a limited amount of brick pavement each year. There are now 350 miles of this pavement in the state system.

The state system contains about 122 miles of asphalt macadam (mixed method) pavements of various specifications, laid both on macadam and concrete base, which have been constructed over a period of ten years. Less than ½ mile has been reconstructed or given a general resurfacing.

In order to determine the relative cost of maintaining the various types of pavement, the State Highway Commission in the year 1915, decided to segregate the expenditures for maintenance and repair, charging to the various types of pavements all expenditures obligated to the roads of such types, and in the annual report for the year 1917 is found a tabulated statement of the average cost per mile, combined for the years 1915, 1916 and 1917, for the types having a material mileage in the state system.

Resurfacing Costs Omitted

This table should be qualified by a statement giving the average age of the pavements, as the relative cost of maintenance bears some considerable relation to the average age of the pavements maintained.

The ages of the pavements in the New York system in 1917 ranged about as follows: Water-bound macadam, 1 to 18 years; asphalt macadam, penetration method, 1 to 8 years; concrete pavement, 1 to 4 years; brick pavement, 1 to 8 years.

The maintenance cost data published by the New York Commission does not include resurfacing costs of brick and concrete pavements—as such work—as these pavements are not yet old enough to require resurfacing.

As the old macadam type of pavements shown in the table carries the resulting resurfacing charge, it will be necessary to eliminate this expense or to add an estimated charge for resurfacing of the concrete and brick pavements, and the first method would appear more consistent.

By reference to the annual reports and the latest bulletins, it is determined that during the years 1915-1916-1917, some 635 miles of resurfacing was performed, and that the average cost of the new top course, generally of asphalt macadam, was $6,260 per mile.

Five hundred and five miles, or 21%, of the water-bound macadam was resurfaced, representing an average charge of $437 per mile per year when distributed over the average number of miles of this type maintained; 57 miles, or 2%, of the asphalt macadam, penetration method, was resurfaced in this period of three years, the cost of which, distributed over the entire mileage of the type, represents an annual charge of $45 per mile. The records of the bulletin indicate that of the 80 miles of this type constructed in 1909, only 7.2 miles, or 9%, have been resurfaced in a period of nine years, or 1% per year.

Thirty miles of gravel and 43 miles of second-class concrete were also given a new asphalt macadam top course during this period, but as the types are obsolete they will not be considered in the table of comparative costs.

Complete Data Not Available

In the accompanying table an effort is made to illustrate the economic features pertaining to the selection of a pavement suited to the average highway having average traffic conditions. The cost of improvement is based on estimates prepared and proposals received by the New York State Commission and the fixed charge of interest is computed at 4% (sinking fund charges being omitted).

Type.	Average cost of improvement.	Interest on first cost at 4%.	Average cost of maintenance.	Total cost per mile per year, exclusive of renewal.
Asphalt macadam (penetration method)	$22,000	$ 880	$419	$1,299
Water-bound macadam	20,000	800	539	1,339
Concrete	35,000	1,400	124	1,524
Brick	50,000	2,000	196	2,196

The cost of upkeep and maintenance is taken from the published data in the report of the New York Commission for the year 1917, which has been amended by subtracting the cost of resurfacing of the macadam types as enumerated above in order that a consistent comparison may be made of maintenance costs only.

Complete data are not available with which costs of ultimate renewals by resurfacing can be determined.

While the periods between resurfacing of the more costly types are of longer duration than are those of the macadam types, the cost of such resurfacing is more expensive.

This table appears to demonstrate conclusively that the majority of the mileage should be constructed of the two macadam types.

The New York statistics are not sufficiently complete to determine what is the character and amount of traffic which will require the more expensive types.

Complete statistics should be collected; a traffic census should be taken frequently, and interest, sinking fund, resurfacing, renewal and maintenance cost per ton-mile ascertained, also the annual tonnage per foot width of road metal.

Wider Roads and Control

The demand for wider roads and more rigid control of traffic is even more pressing than of more durable types.

Until more detailed reports and statistics are available it will not be possible to estimate accurately probable traffic increase or to select in doubtful cases the most economical types of highway construction.

It is certain that the most heavily travelled highways should be wider, and that increase of width will add greatly to the life of all types of pavement.

At present 10% of the New York State improved highways are of brick or concrete construction—90% of bituminous and macadam types.

A careful study of New York State statistics and highways would indicate that there should be in the state aid system a gradual increase in the percentage of brick and concrete, with a corresponding decrease in percentage but not in mileage of other types, but it is unlikely that for many years the proportion of the more expensive types should exceed 20%, and at least 80%, or four-fifths, of the mileage will be of the various bituminous macadam types.

EFFECT OF VIBRATION, JIGGING AND PRESSURE ON FRESH CONCRETE*

By Duff A. Abrams
Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago

EXPERIMENTAL study of the effect of vibration and pressure on fresh concrete on its strength and other properties is of interest in view of the frequent use of such devices as hand-hammering of forms, or air-hammering, jigging or vibration as an aid in placing concrete. Such methods are particularly applicable to the construction of reinforced-concrete ships and houses, where thin sections and a multiplicity of reinforcing members are of common occurrence. Jigging or vibrating machines are frequently used in concrete products plants. The effect of pressure on fresh concrete is of interest in certain problems of concrete design.

Little attention has heretofore been given to the experimental study of the effects produced by vibration and jigging fresh concrete. A few tests were made in a study of the effect of pressure on fresh cement paste in a confined space by James E. Howard, at Watertown Arsenal. The effect of pressure on the compressive strength and bond was studied by the writer at the University of Illinois in 1913. Since the tests now reported were completed, Prof. F. P. McKibben has published a report on compression tests of concrete columns which set under pressure.

The tests covered by this report were made as a part of the experimental studies of concrete and concrete materials being carried out through the co-operation of Lewis Institute and the Portland Cement Association, and include the following topics:—

1. Different methods of hand-molding of test cylinders.
   - (*a*) Puddling with ⅝-in. round steel bar (varying number of strokes).
   - (*b*) Tamping (tampers of different size).
   - (*c*) Tapping metal forms after puddling.
2. Effect of vibrating fresh concrete (small electric motor).
   - (*a*) Time of vibration varied up to 1 min.
3. Effect of jigging fresh concrete.
   - (*a*) Concrete of different mixes (1:7 to 1:3).
   - (*b*) Concrete of different consistencies (0.70 to 1.25).
   - (*c*) Using aggregate of different grading (fineness modulus 4.00 to 6.50).
   - (*d*) Using aggregate of different sizes (0-28 sand to 0-1½-in. concrete aggregate).
   - (*e*) Using coarse aggregate of different shape (pebbles and crushed stone).
   - (*f*) Effect of rate of jigging (0 to 150 r.p.m.).
   - (*g*) Effect of height of drop (0 to 0.50 in.).
   - (*h*) Effect of length of time jigged (up to 3 mins.).
   - (*i*) Effect of age of concrete before jigging (up to 6 hrs.).
   - (*j*) Jigged with 30-lbs. weight on top of fresh concrete.
   - (*k*) Hand puddling on jigging machine while in operation.
4. Effect of pressure on fresh concrete.
   - (*a*) Using different pressure (0 to 500 lbs. per sq. in.).
   - (*b*) Effect of duration of pressure (15 mins. to 16 hrs.).
   - (*c*) Effect of removal of water by pressure.

This series included 900 compression tests of 6 by 12-in. concrete cylinders at the age of 28 days. All specimens were made from the same materials at the same time, consequently direct comparisons may be made between any two sets of tests.

*Excerpts from paper presented to the American Concrete Institute.

The tests gave conclusive results on many phases of the effect of vibration, jigging and pressure. In some instances the effect is entirely different from what accepted opinion would suggest. Following is a brief summary of the tests:—

Puddling and Tamping

1. Varying the number of strokes from 12 to 50 on each 4-in. layer in the standard method of hand-puddling with a ⅝-in. bar had little influence on the compressive strength of ordinary plastic concrete.
2. In general, the tamping methods used gave lower strengths than hand-puddling.
3. A tamper of large diameter for a given weight was less effective than one of small diameter.
4. Increasing the thickness of the layer from 4 to 6 ins. caused a falling off in strength of about 12% for tamped concrete.
5. Tamping or puddling the first 4-in. layer only caused a falling off in strength of 10 to 13%.
6. Striking the metal form with a steel bar after the completion of moulding by standard method had no effect on the strength of concrete.
7. The "standard" method of hand-puddling, using 25 strokes with a ⅝-in. steel bar for each 4-in. layer of concrete in a 6 by 12-in. cylinder is recommended for laboratory tests of concrete.

Vibration with Electric Hammer

8. Vibration of the specimen after moulding by means of an electric hammer running at 1,000 r.p.m. had little influence on the strength of the puddled concrete up to a period of about 30 seconds. If continued, there was a steady falling off in strength; after 45 to 60 seconds the strength was only 90% of that produced by the standard method of puddling.
9. In general, jigging in any manner with the apparatus used reduced the compressive strength of the concrete, regardless of the height of drop, rate or duration of treatment. Exceptions were found in the dry mixes and those made of aggregates of the smaller sizes.
10. There was little difference in the effect of jigging due to the quantity of cement used.
11. In the very dry mixes the strength, due to jigging for 20 seconds, was increased about 25%.
12. The wetter mixes (relative consistency, 1.10 to 1.25) were reduced in strength 3 to 6% by jigging.
13. Pebbles and crushed limestone as coarse aggregate gave essentially the same results in the jigging tests.
14. The concretes for finer aggregates showed a material increase in strength with jigging in both 1:5 and 1:3 mixes.
15. For aggregate coarser than about ⅜ in., jigging reduced the strength from 3 to 10%.
16. The grading of the aggregates (for a given maximum size) had little influence on the effect of jigging.
17. The greater the drop, the greater the reduction in strength for 1:5 concrete. For a drop of ½ in. the strength was reduced 12%.
18. The faster the rate of jigging, the lower the strength of 1:5 concrete. Using 1½-in. aggregate at 150 r.p.m., the strength was reduced about 13%.
19. The strength of 1:5 concrete fell off rapidly with the duration of jigging. After 2 to 3 minutes' jigging the strength was reduced about 20% as compared with standard method of hand-puddling.
20. Allowing the concrete to stand for a period of time before jigging increased the strength to a slight extent. The maximum increase was found at 2 to 4 hrs.
21. The application of a pressure of 1 lb. per sq. in. during the jigging process (equivalent to a head of 1 ft. of fresh concrete) gave the same strength as standard hand-puddling.
22. Moulding the cylinders by the standard method on the jigging table while it was in motion gave the same strength as standard hand-puddling without jigging.

(Concluded on page 194)

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PRINCIPAL CONTENTS

FORESTS OF BRITISH COLUMBIA

AT no time in the history of Canada has an accurate knowledge of our natural resources been of more vital importance than at present. In view of the keen commercial competition that will surely accompany "reconstruction," and because of the much larger national debt which Canada must now carry, all the efforts of this country must be devoted to the intelligent utilization and conservation of our natural resources.

To this end, accurate knowledge of the extent and character of our resources is of the greatest possible value. Very timely, therefore, is the splendid report on the forests of British Columbia which has just been published by the Commission of Conservation, Ottawa. This report has been prepared by H. N. Whitford and Roland D. Craig under the direction of Clyde Leavitt, chief forester of the Commission. It comprises 390 pages of type matter and tables, 6¾ by 9¾ ins., in addition to a 19-page index, numerous inserts bearing half-tone illustrations, and several folded maps.

Part 1 covers geographical, physiographic, climatic and soil relations; land tenure; forest administration on provincial and Dominion lands; forest policy and exploitation; trees and insect injuries.

Part 2 describes the forest resources of the interior of British Columbia, of the coastal belt of the province, and of the province as a whole. Appendices are the timber sale contract form, volume tables compiled by the British Columbia Forest Branch, and a condensed British Columbia log scale.

As the authors point out in the introduction to their report, it is poor economy to attempt to develop any industry for which the basic materials are not available in sufficient quantities to ensure successful operation. In order that industry may be intelligently applied, a knowledge of the natural resources upon which it depends is fundamental. Through lack of knowledge, the forest resources of Canada have often been described as "illimitable." While the forest resources of British Columbia are vast, constituting one of Canada's most important resources, they are not illimitable, and the report just issued by the Commission of Conservation will aid greatly in their proper conservation. Incidentally, it may be pointed out that the definition of the word "conservation" that has been accepted by the Commission, includes efficient utilization.

Letter to the Editor

METRIC SYSTEM REVISED

Sir,—Referring to my letter re international measures, published in last week's issue of your paper, would you be kind enough to add the following tables:—

PROPOSED TABLES

Length

1,000 mils = 1 inch (131% present inch).
10 inches = 1 metric foot.
3 metric feet = 1 meter (exact).
100 metric feet = 1 chain.
4,800 metric feet = 1 mile (99.4% present mile).

Area

100 square inches = 1 square foot.
9 square feet = 1 square meter (exact).
36,300 square feet = 1 acre (99.7% present acre).

Content

1 cubic inch = 1 ounce.
100 ounces = 1 gallon (82% Imp. and 102% American gal.).
1,000 ounces = 10 gallons = 1 bushel = 1 cubic foot.
27 cubic feet = 1 cubic meter.

Weight

1 cubic inch = 1 ounce.
12 ounces = 1 lb. (98% present pound).
2,000 lbs. = 1 ton.

C. R. COUTLEE,
Department of Public Works.

Ottawa, Ont., July 28th, 1919.

CONSTRUCTION OF WATER-BOUND MACADAM ROADS

(Continued from page 178)

macadam surfaces are damaged by the melting of the snows. It is impossible to hasten drainage in this territory, where the land has practically no slope.

It has been suggested that in the most exposed places, the surface should be rebuilt with a bituminous binder. Where the water crosses the road with a strong current, a local concrete pavement is usually recommended. There are, however, a number of places where the erosion is purely accidental, and in these places it is sufficient to repair the macadam surface in the ordinary way.

We must carefully distinguish between disintergration of macadam and wear. The wear is natural and unavoidable, otherwise we would have roads with permanent surfaces, which is an impossibility. It is therefore not always wise to undertake repairs at the first sign of wear on macadam. At other times, on the other hand, wear can be retarded and life lengthened by the application of certain materials such as bituminous binders, asphaltic oils or even a thin layer of fine, hard gravel. This last proposition especially provides an economical cure for rough surfaces.

Many things can be said regarding the construction and up-keep of water-bound macadam, and an article entering into all the details would involve a regular course in construction work. The writer has treated the subject briefly and only from the point of view of the Province of Quebec.

PERSONALS

FRANK BARBER, consulting engineer, Toronto, whose design for the $300,000 Hunter Street bridge, Peterborough, Ont., which will be the longest concrete arch bridge in Canada, was formally accepted by the city of Peterborough last week by the mayor's signing the constract for its construction, was born December 27th, 1875, at Milton, Ont., and was educated at the Dunnville high school, Mount Allison University and the University of Toronto, where he graduated in 1906 in the civil engineering course, specializing in mathematics. After graduation Mr. Barber entered the office of the late James MacDougall, who was then engineer of York County, Ont., and later became Mr. MacDougall's chief assistant. Upon Mr. MacDougall's death in 1908, Mr. Barber entered private practice and was also appointed York County engineer. Mr. Barber was in partnership with C. R. Young, who is now an associate professor at the University of Toronto, under the firm name of Barber & Young, until 1911, when Mr. Young joined the staff of the University as a lecturer. From 1908 until the outbreak of war, Mr. Barber and his staff designed and planned an average of about thirty bridges a year in various parts of Canada, including the longest concrete arches and some of the longest steel highway bridges in Ontario, also including the first open spandrel arches in Canada and fifteen out of the first twenty concrete truss bridges in the Dominion. At the outbreak of war, when bridge work partially stopped, Mr. Barber became managing-director of the Thor Iron Works, Ltd., Toronto. This plant was soon converted into a shipbuilding yard, and in 1917 launched its first ocean-going steel freighter. Under Mr. Barber's management the business is said to have increased from $200,000 to over $1,000,000 a year. In October, 1917, he sold his interests in the firm to New York shipbuilders who reorganized the business as the Dominion Shipbuilding Co., and Mr. Barber decided once more to devote his entire time to consulting work. He is at present corporation engineer or consulting bridge engineer for the counties of York, Simcoe and Haldimand, and the townships of York, Vaughan, Etobicoke, King and various other townships and towns. During the past two years he has acted in association with R. O. Wynne-Roberts for various water works, sewerage and other municipal improvements, including water works extensions costing about $1,000,000 for York Township. The firm is now reporting on a sewerage scheme for York Township which will also cost about $1,000,000.

WILLIS CHIPMAN, of the firm of Chipman & Power, consulting engineers, Toronto, is in British Columbia (Vancouver Island) on an engineering mission for the Dominion Government.

CHARLES R. MURDOCK, who for the past nine years has been on the staff of Chipman & Power, consulting engineers, Toronto, has resigned to accept an appointment as town engineer of Dundas, Ont. Mr. Murdock graduated in 1906 at the University of Toronto, with the degree of B.A.Sc. He was formerly resident engineer for Chipman & Power at that firm's Winnipeg office.

NORMAN MALTMAN, formerly purchasing agent of the Russell Motor Car Co., Toronto, has joined the staff of A. R. Roberts, Toronto, who recently severed his connection with the firm of Burns & Roberts, Ltd., and opened a new office as manufacturers' agent and dealer in new and used machinery.

OBITUARY

A. C. MACKENZIE, who was for many years an outstanding figure in the construction world of Western Canada, died suddenly last Friday at the power plant which is under construction on the Winnipeg River. Mr. MacKenzie was 56 years of age. He was president of the Northern Construction Co., who are the contractors for the Winnipeg River power plant. For over 20 years he was one of the best known railway contractors in Western Canada, having been actively identified with the C.N.R. interests. Interment took place last Monday at Beaverton, Ont.

EFFECT OF VIBRATION, JIGGING AND PRESSURE ON FRESH CONCRETE

(Continued from page 192)

23. The compressive strength of concrete was increased by pressure applied immediately after moulding. For pressure of 200 to 500 lbs. per sq. in. the increase was 20 to 35%.

24. The duration of pressure as between 15 mins. and 16 hrs. produced no difference in strength.

25. There was a steady reduction in the water-ratio of the concrete with the application of pressure.

26. The application of pressure increased the strength of concrete in accordance with the quantity of mixing water expelled.

27. The tests of concrete subjected to pressure showed the usual relation between compressive strength and water-ratio. The strength is increased *because the water is expelled.* In other words, pressure produces a drier concrete, and, consequently, gives higher strength. This makes it clear why the duration of pressure has no influence on the result.

The indications of the vibrations and jigging tests should not be misinterpreted. The tests show that *after the concrete is properly placed* these methods of treatment do no good, and may be harmful if too severe or too long continued. However, there can be no doubt of the value of such methods *for getting concrete into place* in intricate forms and around reinforcing bars. The tests are of value in showing that this is the only desirable function of such treatments. One series of tests shows the ill effects of lack of compactness in the concrete, the strength being reduced 13% due to failure to tamp or puddle the top 9 ins. of the cylinder. It is impracticable to duplicate in a compression test piece the performance of air hammers and other similar methods of vibrating when used on reinforced concrete work.

The tests show that with jigging high strength may be secured with drier mixes than would be feasible otherwise. It is a matter of common experience that concrete of drier consistency (and, consequently, higher strength) can be placed by means of jigging or vibration than would be possible by the usual methods.

There are already thirty-two surrendered German aeroplanes assembled at Toronto, and all will be displayed or flown at the Canadian National Exhibition, August 23rd to September 6th. Canada owns nearly 100 German or allied planes, and they will eventually become part of the official museum display or be distributed among the various cities by the Dominion government.