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The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Provisional Working Stresses for Steel Columns

Formula for Determining Safe Strength of Pin End Columns—Recommendations of the American Society of Civil Engineers Not to be Taken Too Exclusively—Suggestive Formula Expressive of Strength of Columns as Disclosed by all Tests to Date

By C. R. YOUNG

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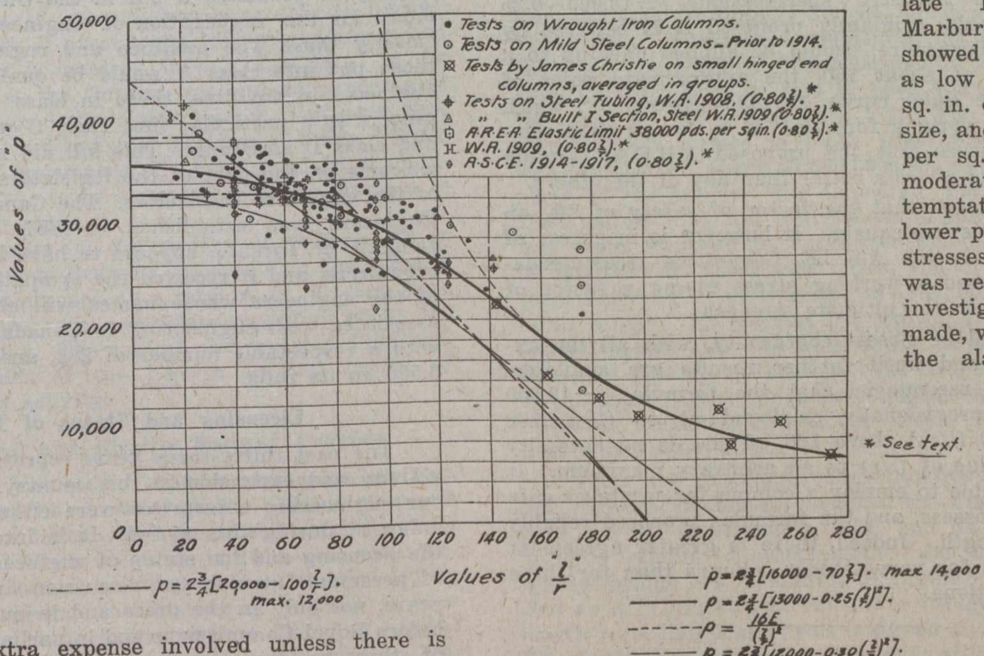
IN the new and revised structural steel specifications that have recently been proposed, a tendency to drastic downward departure from hitherto generally accepted column formulas is disclosed. Thus, in the draft specification for steel railway bridges, prepared by a committee of the Engineering Institute of Canada, the recommended working stress on steel columns for slenderness ratios up to 175 is $p=12{,}000-0.3\ (l/r)^2$. Conformity with this provision would, as compared with the requirements of the Dominion Government specifications, 1908, still in force, necessitate a considerable addition of material in columns of low slenderness ratios. Thus, for columns with medium end conditions, the excess of area required by the proposed Engineering Institute specification would range from 33 per cent., when (l/r) is zero to nothing when (l/r) is 90. It is obvious that the purchasers of structurad steel work should not be saddled with the extra expense involved unless there is good reason for it.



Although for some years a conservative attitude has been adopted with respect to the proportioning of columns of low slenderness ratio, as evidenced by the truncating of working formulas to a maximum of 14,000 or to 13,000 lbs. per sq. in., it was not until the publication in detail of the tests made by the special committee on columns of the American Society of Civil Engineers that the existing state of semi-panic arose amongst structural engineers concerning the low strength of short columns. In its report, as will be recalled, the committee recommended that working stresses on columns of 60,000-lb. steel be limited to 12,000 lbs. per sq. in. and that this stress be used up to a value of $(l/r)=80$. Above 80, the working stress was to be reduced uniformly to 8,000 lbs. per sq. in, when $(l/r)=120$, that is the reduction would be in accordance with the formula $p=20{,}000-100\ (l/r)$.

Although unexpected weakness was disclosed in some of the columns tested by the A.S.C.E. Committee, it does not seem prudent to hastily accept as final the disquieting features of the tests, and without further ado bring specifications down to conform rigidly to them. There are several reasons for more cautious action. Some ten years ago the structural engineering world experienced a rude jolt, analogous to the present one, on the publication of the results of tests on I-beams by the late Professor Edgar Marburg. These tests showed an elastic limit of as low as 10,800 lbs. per sq. in. on beams of large size, and below 20,000 lbs. per sq. in. on some of moderate size. The temptation to at once lower permissible bending stresses on rolled beams was resisted till further investigation could be made, with the result that the alarming conditions were shown to be largely transient, and specifications were generally left as they were. Would it not be well to take a hint from this incident and defer extreme action till more is known concerning the strength of columns? The American Railway Engineering Association is apparently taking this attitude in revising its column formula only moderately and in undertaking a series of tests itself as a basis for further revisions.

Then, too, for many years, engineers employed with a feeling of satisfied conservatism, formulas for the design of steel columns based upon a safe stress of 16,000 lbs. per sq. in. properly reduced, and in recent years truncated as well. Many thousands of bridge and building columns were built upon this basis, and the writer does not know of a single column that has failed through the inherent inadequacy of such a formula as $p=16{,}000-70\ (l/r)$, with maximum of 13,000, to express its safe strength. Where failures have occurred, they appear to have arisen from such causes as the neglect to properly support the column laterally, or from the failure to take account of dangerous eccentricity, or from some faulty body detail.

Undoubtedly, we should take into account the tests and recommendations of the A.S.C.E. Committee, but not to the extent of making them the *exclusive* basis of a new and drastic column formula—one which sweeps aside those that have stood the test of experience and one which carries with it the implication that our last practice has been wholly, if not dangerously, erroneous. Surely it is more reasonable to take into account the experimental knowledge on the strength of columns available before the A.S.C.E. tests were made than to discard it as worthless. Our practice should be based upon the *whole mass* of data available rather than upon a fraction of it. Besides, subsequent investigations may not wholly corroborate the A.S.C.E. tests.

The writer therefore believes that in the light of available knowledge, we should be going far enough if we adopt a formula which expresses as closely as possible the safe strength of columns as disclosed by the *sum total* of tests to date.

In order to discover what formula could best express the safe strength of pin-end columns, the type for which provision must be made in any general formula, the accompanying diagram has been prepared. On it are plotted the ultimate strengths of all columns for which test data are at hand. Flat-and fixed-end column results are plotted for 80 per cent. of their slenderness ratio, thus placing them approximately on the basis of pin-end columns. On this diagram are plotted, using an assumed factor of safety of 2¾, the formula proposed by the A.S.C.E. Committee, $p=20{,}000-100\ (l/r)$, with maximum of 12,000, the formula proposed by the Engineering Institute of Canada Commitee, $p=12{,}000-0.30\ (l/r)^2$, the present A.R.E.A. formula $p=16{,}000-70\ (l/r)$ with maximum of 14,000 and the new formula proposed for the A.R.E.A. specification, $p=13{,}000-0.25\ (l/r)^2$. This formula, originally proposed it is believed by Professor F. E. Turneaure, should be applied only up to a slenderness ratio of about 160, the approximate point of tangency with the Euler curve, $p=169{,}000{,}000/(l/r)^2$, which then becomes the working formula. It is seen from a comparison of the curves that the proposed A.R.E.A. formula fits the *whole mass of tests* better than any of the others.

It may be alleged that the factor of safety of 2¾ on ultimate strength is inadequate. It however is in excess of that provided for in the A.S.C.E. Committee recommendations which proposed a working stress giving a factor of safety of only 2.6 on the ultimate strength.

On the ground of closest conformity, with all the experimental data, and until further results are available, the writer would recommend that the formula, $p=13{,}000-0.25\ (l/r)^2$ be provisionally employed up to $(l/r)=160$ and $p=169{,}000{,}000/(l/r)^2$ above 160. There is no necessity of limiting the value of (l/r) to an arbitrary maximum. It should be permissible to employ a column for whatever safe strength it may possess, and the formulas proposed reliably indicate that strength. Indeed, there is greater agreement in the test results for very slender columns than for those of stockier proportions.

The office and laboratories of the Canadian Inspection and Testing Co. have been moved from Manning Arcade Annex to 100 Jarvis St., Toronto.

In view of the provisions of the agreement between the city of Toronto and the Ontario Hydro-Electric Power Commission, which requires the assent of the commission to the acquisition by the city of any street railways, it was decided by the Toronto board of control to ask the "Hydro" whether they should negotiate for the purchase of the Toronto & Suburban Railway. Works Commissioner Harris informed the board that A. J. Mitchell, vice-president of the Canadian National Railways, had advised him that the C.N.R. would consider the sale of the Toronto & Suburban Railway at a fair price, or subject to arbitration, provided the city would agree to take over the Woodbridge extension and to provide running rights for the C.N.R. on an equitable basis.

A GENERATION OF ENGINEERING IN CANADA*

By R. O. Wynne-Roberts
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DURING the past generation, said the speaker, engineers have accomplished great things for the public, but in the matter of status and emoluments we are practically in the same position as in 1887. This implies our inability to do something for ourselves, and unless we bestir ourselves I fear we shall find the status of our profession suffer. The remuneration of engineers, especially those in the employment of others, is inadequate to enable them to maintain their positions with becoming professional dignity, and the Engineering Institute of Canada, in concert with the other engineering societies, should strive to improve matters. The fees for the services of consulting engineers should also be estabilshed. Our society fundamentally exists to assist each member, and conversely, the members are called upon to do their utmost to promote the interest of their society.

Founding of Canadian Society of Civil Engineers

The history of Canadian engineering during the past generation is suggestive of what is yet to be accomplished. This year is the thirty-third since the establishment of the Canadian Society of Civil Engineers. The Royal Canadian Institute was established in 1851, particularly for the promotion of surveying, engineering, and architecture, and its chief sponsor was Sir Sandford Fleming. An effort was made in 1880 by the late E. W. Plunkett to start an engineering society. He issued a circular letter under the pseudonym of X. Y., but no active results ensued. Some engineers in the same year promoted a bill in the Ontario house of parliament for the registration of engineers which proposed to classify those who qualified and registered. For example, those put into class A would be qualified to become chief engineers in any line, those in class B would be chief engineers in a particular line, class C were simply engineers, and class D assistants. This bill did not receive much of a welcome on the part of the legislators nor by the majority of the engineers themselves. The Canadian Society of Civil Engineers was established in 1887. The late Alan MacDougall, of Toronto, appears to have been one of its active organizers, and it received the sympathetic support of most of the engineers whose names will always be prominently associated with engineering in Canada. The society started with a respectable number of 288, and to-day it has nearly 3,500 on its rolls.

Licensing and Status of Engineers

The past thirty-three years represent a period of great activity and expansion in this country. A large number of our engineering enterprises were either started or greatly enlarged during this period. It is interesting to note that the licensing and the status of engineers have been subjects of perennial interest and discussion during the past forty years, not only in the press and in our meetings, but also before Royal Commissions and in parliaments. Whilst a code of ethics was formulated early in the history of the society, engineers were not the first to adopt one, for it appears that the Undertakers' Association of Ontario, organized in 1884, had already done so. This association asserted in that year before a House of Commons Select Committee on Combinations that there was "no profession after that of the sacred ministry in which a high-toned morality was more imperatively necessary than that of the funeral director; his moral principles are his only safeguard."

At the time of Confederation, in 1867, four provinces only formed the union, and the area was only 377,000 square miles, whereas now there are eleven provinces and the area is ten times as large. The population in 1887 was about four and a half millions; to-day it is over eight millions. When

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*Abstracted from Inaugural address delivered January 22nd.

we consider the engineering achievements in a country with such a relatively small population, it must be acknowledged that they have been on a transcendent scale. Several cities now well known in 1887 were either non-existent or very small. Toronto, for example, in 1793 had one solitary Indian wigwam, but in 1887 it had about 160,000 residents, and now contains about 500,000. The remarkable expansion of many of our cities has imposed great tasks upon engineers in the providing of roads, sewers, water supply, transportation and numerous other modern requirements.

Development of Highway Engineering

In an interesting history of Ontario roads, given in the 1914 report of the Public Roads and Highway Commission, it is stated that a military road system was carried out in Upper Canada by Sir John Simcoe in 1791, when the population was at least 10,000 souls. The first legislation in Upper Canada in connection with roads, was to appoint the justices of peace as highway commissioners to maintain roads by statute labor. Yonge street and Dundas road were laid in 1794, and roads from Kingston to Montreal, Montreal to Quebec, Newark to Fort Erie, were opened. The Queen's Rangers built bridges over the Humber and Credit rivers about 1798. York county has been the home of toll roads since 1833, and in 1889 an Act was passed to purchase them, but I believe some still remain. Good roads date from the passing of the Highway Act of 1901. The earliest reference to permanent roads which I have found is that a James Call constructed macadamized roads in Toronto in 1833. Canadian cities have built paved streets which will compare favorably with those laid elsewhere. A considerable mileage of good roads have been constructed in this province, but with the "enormous area, sparse population and monetary resources which, while not meagre, nevertheless have definite limits," this country has a task of great magnitude to undertake, and as indication of what it involves, it was announced in the press a week ago that the Ontario government proposes to build 1,600 miles of good roads this season. I observe that the Hon. F. C. Biggs, the Provincial Minister of Public Works, lays emphasis on the importance of a high standard of maintenance, which I believe to be a fundamental requirement in connection with good roads.

In 1887 there were 30 waterworks in Ontario, 28 in Quebec, 1 in Alberta, 2 in British Columbia, 7 in Nova Scotia and 5 in New Brunswick, making a total of 73. To-day there are about 540 waterworks in operation, supplying about 450 million gallons per day. The capital cost is about $125,000,-000, which is an index of the growth in that branch of municipal enginering activity.

Sewage Disposal and Electric Railway Progress

The problem of how best to dispose of sewage has been one of the usual difficulties in many places. Canada possesses many large rivers and lakes which are most tempting outlets for its disposal. Mr. Wilils Chipman, in 1912, read an interesting paper at the annual meeting of the Canadian Public Health Association, giving the history of several sewage works, from which I have extracted the following items: "The first practical attempt at sewage purification in Ontario was on the flat bed irrigation system at the London Asylum in 1888. The first municipal sewage works built in this country was at Kitchener in 1892, followed by Waterloo in 1894. Hamilton installed the first chemical precipitation plant with presses in 1896. Stratford and Kitchener were the first to have septic tanks, and in 1912 Vernon, B.C., possessed the first trickling filters. The first electric railways in this country were built in 1890 from Windsor to Walkerville, and from St. Catharines to Thorold, but there may have also been a short stub exhibition line to Toronto at that time. These were followed by four miles each at Victoria and Vancouver, and short lengths at one or two other cities. When these railways were introduced engineers considered it sufficient to allow six H.P. per car. To-day it is customary to allow about 70 H.P. for single cars, 140 for double cars and 300 to 500 for suburban cars. In 1898 it was considered good practice to assume nine miles as the maximum distance for electric street cars to run from the powerhouse. Official annual statistics in this connection were begun in 1901, when there were 674 miles of electric railways in operation in Canada, whereas there are now about 2,300. The capital invested amounts to about $170,000,000 and about 500,000,000 passengers are carried annually.

Hydro-Electric and Steam Railways

When the Canadian Society of Civil Engineers was first established, hydro-electric power schemes were almost unknown in the Dominion, and it is estimated that not more than 200 H.P. were then generated. In 1890 the total was about 4,500 H.P., compared with at least 2,000,000 to-day, so that Canada stands well in the van of hydro-electric developments. The equivalent of this power in coal at 6 pounds per horse-power-hour is about 52,500,000 tons per annum, the value of which can be easily calculated. The standard dynamos in Toronto in 1890 were 40 light, 10 amperes, 48 volts. To-day the Hydro-Electric Commission of Ontario is arranging to instal 50,000 to 60,000 H.P. generators in connection with the Chippawa scheme. One authority in 1893 expressed the opinion "that the practical success of the scheme of supplying hydro-electric power from Niagara to Hamilton was doubtful. The fact remains that hitherto no transmission of electric power for 35 or 40 miles has yet been accomplished on a commercial scale." The Ontario hydro-electric scheme was advocated many years before it materialized, and to-day, with a capital expenditure of over $90,000,000, it supplies 120 municipalities.

The first steam railway in Canada, known as the Champlain and St. Lawrence, was built in 1836, and was 16 miles long, from Laprairie to St. John. No other railway was built in this country for ten years, and the first railway in Ontario was that from Toronto to Simcoe, which was started in 1853. The Federal government commenced the Intercolonial before 1867, and the National Transcontinental in 1905. The Canadian Northern may be said to have started in 1889, though the name did not appear until 1899. The Grand Trunk Railway Co. was formed in 1853: these four railways, with a total capital of about $1,300,000,000, now become the property of the people. The Canadian Pacific was formed in 1880, and by 1885, five years ahead of contract time, the railway from Montreal to Vancouver was laid. The first train to run between these two cities was in June, 1886. There were 12,000 miles of railways in 1887, compared with 39,000 miles to-day. The capital has grown from $519,000,000 to $2,000,000,000, and the number of passengers carried has increased nearly five times, and the freight nearly eight times in the same period. Important engineering construction was involved, including tunnelling, docks, harbors, workshops, depots and other works.

There are, of course, many hundreds of bridges in Canada. Robert Stephenson designed the Victoria tubular bridge over the St. Lawrence in 1854, and its superstructure was recently rebuilt to accommodate the traffic requirements. Quebec bridge is a monument of engineering daring and skill, and as it is the largest cantilever bridge in the world, it is worth recording that it was designed and built by Canadians. The Lethbridge railway bridge may still hold the record for length and height. The Saskatoon reinforced concrete bridge is so far the largest of its kind in Canada, but will be excelled by the Hunter street bridge, which is now being erected at Peterboro.

Irrigation Matters

In matters relating to irrigation I think engineers have some reason to be proud of their achievements. The Canadian Pacific Railway schemes are very large, and other schemes are now being contemplated.

With regard to inland navigation, I suppose the Sault Ste. Marie canal, built by the Hudson Bay Co. in 1797, was one of the first in Canada. One of the locks is fortunately preserved, and its dimensions are 39½ ft. long, 7½ ft. wide, and 9 ft. deep, exceedingly puny when compared to the present-day locks. The present canal at Sault Ste. Marie was begun in 1888, and finished in 1894 at a cost of approximately

$5,000,000. Soulanges canal, 14 miles long, was commenced in 1892, and finished in 1899 at a cost of about $7,000,000. The new Welland canal will be the largest in Canada, and will cost probably $50,000,000. The Trent canal was recently finished at a cost af about $15,000,000. The Georgian Bay canal scheme has been discussed for many years, and it is stimated to cost about $100,000,000. The Federal government control six canal systems, the total length of the waterways being about 1,600 miles, but the actual canals measure 117 miles. The volume of traffic in 1917 was 22,000,000 tons.

Town planning was probably not even thought of in 1887, but is now almost a profession. The enormous extension of railways gave birth to a great number of new villages and towns. Many of these were laid out on almost identical chessboard lines, regardless of local topography, particularly in the west, and were lacking in individual features. Mr. Elliott-Cooper, in his presidential address at the Institution of Civil Engineers in 1912, remarked that "A few of these perhaps would not affect the traveller much, but when 1,000 miles, covering 125 towns of this description are passed, it takes all the sublime diversity of the scenery of the Rocky Mountains to soothe his irirtated nerves." Engineers are now more inclined to consider the æsthetic side of town planning, and some day we hope to see model villages springing up adapted to local conditions and requirements, and possessing pleasant and useful features. Wireless telegraphy was commercially unknown in 1887, and Canada sent its first message by wire to Britain in 1907.

Role of the Engineer

Enough has been stated to indicate the immense progress that has been made during the last thirty-three years. It is manifest that engineers have played an important role in the development of the country, and a profitable hour could be spent in listening to papers on the lives and achievements of eminent Canadian engineers. Significant is the absence of engineers in parliament and municipal councils, and it would be to the benefit of the country if engineers were given an opportunity by these authorities to consider schemes involving the expenditure of public money. Engineers should take a more prominent part in state politics for the reason that a large number of questions that are intimately associated with the welfare of the people are of an engineering character or closely allied to it.

The foregoing observations lead us back again to the status of the engineer. Even if a legal status was granted to us now, I think our position in respect to public recognition will depend largely upon the services we render freely to the community, and the publicity we invite. We may continue to attend to our own particular businesses with cloistered assiduity and subconsciously enjoy the satisfaction that we have done our best for our employers. But this will not be adequate to satisfy the general public that we deserve fuller appreciation; we must bid for it and not wait for it.

One more point, and that is the fraternal relations amongst engineers. Etiquette and ethics are useful as beacons to guide our footsteps, but I firmly believe that a solid brotherhood of professional engineers will do much more. Mutual assistance and respect in all professional matters would be a splendid slogan for our society to adopt.

That the Lethbridge-Northern irrigation project to bring water to 100,000 acres north of Lethbridge is feasible, is the opinion of Geo. Anderson, irrigation engineer, who has been engaged by the provincial government to report on various schemes now contemplated in Southern Alberta. As the irrigation district for this project had already been organized and the trustees elected, it was the first so receive Mr. Anderson's attention. Accompanied by the provincial minister of public works, Mr. Anderson recently inspected the district. Construction will likely be started early this year. Mr. Anderson will later report on the project in the vicinity of MacLeod and others that have been outlined and upon which surveys have been partly completed.

HOW CAN LABORATORY TESTS OF CONCRETE MATERIALS BE MADE OF GREATER VALUE TO THE FIELD ENGINEER AND CONTRACTOR?

By G. M. Williams
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WHY are the results of tests and recommendations of the laboratory given so little consideration and so often disregarded by field engineers and users of concrete? That the field engineer and the contractor do not fully accept the tests and the advice of the laboratory, whether really good or bad, must be admitted by any one who is familiar with conditions in the laboratory and in the field.

Off the job, the practical user of concrete may give respectful attention to the advice from the laboratory, but on the work, he is inclined to forget the procedure outlined for his guidance and return to his usual practice which he feels is satisfactory and has given him good results in the past. Beyond question, the disregard of such advice may in some cases lead to inferior work, but owing to the meagre amount of testing of field concrete which is done, inferior work resulting from such a policy may never properly be impressed upon the responsible party.

Co-operation Necessary

Concreting processes have for the most part been developed through years of practice in the field, rather than by work in the laboratory, and the field engineer is disinclined to make any changes in his methods which will result in any great variation from his usual practice. Without much aid from testing laboratories, good concreting practices have been developed as a result of years of experience, and from the engineer, down to the foreman on the job there is a tendency to avoid any changes in procedure which may disarrange the old established methods, or seem to increase concreting costs.

Such an attitude on the part of the field engineer and contractor is sometimes due to expensive experiences which have resulted from the use of materials and methods which have been recommended by the laboratory. Unworkable mixtures may have been specified which resulted in bad work, delays, and increased costs, or the following out of such advice may have required changes on the job in materials or plant equipment which increased costs with no apparent improvement in the quality of the work. One or two such experiences are certain to cause laboratory advice to be shunned, and case the engineer to fall back on well tried methods derived from experience, which he knows will furnish satisfactory results without unreasonable expense.

That such a disregard for laboratory tests and recommendations is often justified can be made clear by a consideration of the practices, and lack of practices which are employed in laboratory work. While it is not claimed by testing engineers that laboratory methods are complete and entirely satisfactory, this does not obviate the fact that the field engineer's disregard for laboratory tests and conclusions can be blamed to lack of progress in developing laboratory methods of testing, and in applying in laboratory practice a knowledge of the obstacles and adverse conditions which the latter must meet and overcome "on the job."

Uniformity of Tests Desirable

To begin with, testing laboratories are not in accord as to what methods of tests should be employed in determining the value of any given materials for use in concrete.

An inspection of reports of tests indicates the lack of agreement among different laboratories as to what tests should be made, and what methods should be employed. In planning a series of tests, consideration may be given to proportions, method and time of mixing, consistency, size and shape of test specimens as well as special tests, such as colorimetric, hardness of particles, silt, etc. There is little agreement as to whether materials should be proportioned by weight or volume, how weight per cubic foot of aggregate should be determined, what portion of the sand should be classed as silt, or how its quantity should be determined. Often only a few of the above mentioned factors may be given consideration due either to lack of testing equipment, or lack of appreciation of their necessity. As a result, some of the essential and important features which should be determined by test may be disregarded, and erroneous and misleading conclusions may be drawn from the few test data obtained. The most essential test data, which may in some cases explain why improper conclusions have been drawn, are often omitted as of no importance, and the conclusions may be so opposed to the well established results and experience of the field engineer that he is fully justified in his refusal to be governed by the results of the test data. The wide variation in tests results which have sometimes been obtained by groups of laboratories using similar materials in a specified manner by skilled operators, furnishes additional evidence that something is lacking in laboratory practice. A few of the laboratory methods which are sometimes responsible for such a condition of affairs are worthy of more detailed consideration.

Use of Dry Mixtures

Tests have repeatedly shown that the value of a sand for use in concrete cannot be determined by its use in a mortar, but that it should be employed with the same coarse aggregate which is to be used on the work. Sands which may be condemned as a result of tests in a mortar, may be satisfactory for use with a properly graded coarse aggregate. Any specifications for sands which limit the amount passing any given sieve are no doubt in many cases due to results obtained in mortar tests, and good concrete sands have been rejected because of such false conclusions based upon improper methods of test. To base judgment of a sand on tensile mortar tests is a still further step in the wrong direction and cannot be too strongly condemned. In some classes of work where a mortar is used the tension test may be proper, but the mortar test, either in tension or compression, is of little value in evaluating a sand for use in concrete.

The use of dry laboratory mixtures, unworkable under the usual field conditions, is another source of error sometimes encountered. This applies to tests of both mortars and concretes. A consistency which appears to mold well and produces good laboratory test specimens may be entirely impossible in the field, with the result that when the concrete is made on the job more water must be used to obtain a workable mix. A much weaker concrete than the laboratory tests would indicate is certain to result. It should be realized that in molding a laboratory test piece, considerable energy is expended in forming a small compact mass which is free from reinforcing steel and other obstructions, while in the field a small amount of energy is usually expended in placing a large volume of concrete which must flow in around a network of steel rods. Based on laboratory tests proportions of sand and gravel may be recommended which result in such a harsh, unworkable mixture that excessive amounts of mixing water, resulting in subsequent loss in strength, must be used for its proper placing. In case comparative tests are being made on materials from two sources of supply, the aggregate which may be judged inferior, based upon the comparatively dry laboratory consistency, may actually produce the stronger concrete in the field where a workable consistency must be used.

Use of Natural and Ottawa Sand

In laboratory tests the fact is sometimes overlooked that such a consistency as will result in maximum strength, or even approach such a value, will be entirely unworkable in the field. Some strength must be sacrificed to ease in handling and placing. Very often other properties are equally as important as compressive strength, yet most laboratory work is seemingly based upon the assumption that other properties increase proportionally within the increase in compressive strength. Experience in the field has indicated that this assumption is not true, and that concrete which must withstand water pressure, for instance, can well sacrifice strength for water tightness or impermeability.

Natural sands are often tested in comparison with standard Ottawa sand, using the quite dry consistency specified in laboratory tests of cement. Such so-called normal consistency mortars are too dry to be properly workable and should not be employed in tests of sand. The quantity of mixing water is insufficient to furnish a plastic, workable consistency, with the result that unnecessary errors are introduced both in mixing and molding which would otherwise be avoided. The attempt to bring the natural sands and the standard Ottawa sand to the same consistency will be made more nearly successful in case the wetter consistency is employed.

Usable Field Consistencies Should be Used

In construction work it is common practice to specify that a 1:2:4: concrete shall have a strength of 2,000 pounds per sqaure inch at 28 days, and with fairly good materials it is not difficult to obtain that strength in the laboratory, but the same mixture as used in the field has been known to have a strength 30 to 40% less than obtained in the laboratory, generally due to the necessity for using a greater quantity of mixing water. Lack of specification requirement and facilities for testing field concrete are responsible for such conditions not becoming better known. On one particular job, with given materials, the specified combination of 2 parts sand with 4 parts of gravel would not result in a concrete of proper and necessary workability when the quantity of mixing water was reduced sufficiently to result in a strength of 2,000 pounds at 28 days. Here the strict adherence to the specified proportion, together with the necessity for a certain minimum consistency needed for placing under the given conditions resulted in a concrete having considerably lower strength than was predicted from the laboratory results. Such a condition on the work could have been avoided had the laboratory tests given proper consideration to the field conditions.

It cannot be too strongly emphasized that tests of sands in mortars may bear little relation to their true values when used in combination with a coarse aggregate, and that usable field consistencies should be employed in the laboratory. Such practice will almost entirely do away with the use of such consistencies as are commonly associated with the use of normal consistency Ottawa sand mortars.

Consistency Should be Measured

Probably the one greatest cause for the divergence between laboratory results and field practice is the lack of some method for properly measuring and expressing the consistency, workability, or flowability of a mortar or concrete mixture. While the quantity of water used in any concrete or mortar mixture is easily determined in the laboratory, when working with dry materials there is no method in common use for properly measuring the consistencies so obtained. We are familiar with the terms "dry," "plastic," "mushy," "fluid," etc., but these expressions are inexact and do not mean quite the same to any two operators, and from day to day, especially when working with aggregates varying widely in granular composition, are not used in the same way by the same operator. Although it is well understood that change in the water content causes greater change strength than variation of any other single factor, we lack any method of test which will definitely and accurately classify any consistency so that it can be duplicated by other operators, or even by the same operator. In other words, one of the necessary and fundamental methods for the testing of concrete aggregates is lacking, and as a substitute we judge by "eye" and "feel." Throughout the test all materials may have been followed, yet the most important factor, the consistency, has merely been crudely estimated. Although we recognize that concretes must be of the same consistency to be comparable, we compare strength results obtained with materials which require wide differences in the quantity of mixing water to give the same apparent consistency.

A study of the results of comparative tests made in this manner indicates that the judgment of the operator is a very poor substitute for a method of measuring the consistency of a mixture. In a series of carefully made tests in which the consistencies were determined by the "eye" and "feel" of an experienced operator, it was later found that as much as 25% more mixing water should have been used with certain of the aggregates to result in the same consistencies for the whole group. In the case of a group of mortar mixtures which the operator intended to have the same consistency, even greater discrepancies in the quantities of mixing water actually needed were found. These are not extreme or unusual cases but are representative of errors which are certain to occur in laboratory practice until some method is obtained for properly measuring consistency.

At present the only definite figure which has any bearing on consistency is the quantity of mixing water, usually expressed as a percentage based on the total weight of the mix, or upon the cement content alone, but such a figure is of little value in itself because of the wide variations in water requirements due to great variations in surface areas or number of particles in a unit volume of different aggregates.

Occasional Strength Tests Desirable

The cylinder slump test has been proposed as a means of measuring and controlling the consistency. However, tests have shown that while this apparatus has some merit when working with very rich mixtures, or for controlling the consistency of the same proportions of the same aggregates, it often gives very erratic and misleading results when with aggregates of widely varying granular composition which are met with in the laboratory. The range of water content which can be accurately measured under ideal conditions is rather narrow, and when carefully used with the same aggregate has resulted in such absurdities as a 1:2½:5 concrete being stronger than a 1:2:4: proportion.

Lack of means for accurately recording and expressing consistencies of mixtures has made it difficult to make real progress in studies of concrete aggregates. Results show that the same operator cannot duplicate the same consistencies with any degree of accuracy, and the task of comparing the results obtained in two different laboratories, when working with different aggregates, is almost hopeless, since the figures for per cent. of making water mean little under such conditions. Were it possible to assign some accurate and definite values to this most important property, the results obtained in different laboratories would be comparable after taking into account the physical properties of the cements used. Such a scheme would be of very great value to the field engineer, since the laboratory, in testing any aggregate for field use, could state the range of strength values which might be expected for different consistencies of the same proportion. Determination of the consistencies from time to time on the job would then permit of close estimates of the ultimate strengths which might be expected for that particular lot of concrete. Occasional strength tests would permit any slight adjustments to be made in the range of strength values used in case the field concrete values should differ greatly from the laboratory tests, due to curing conditions,

No Common Basis for Comparison

Due to the present lack of means for measuring and controlling consistency, and the apparent failure to recognize its importance in connection with laboratory tests of concrete, the test data obtained in the many different laboratories must in most cases remain as small and isolated groups of tests, none of which bears any definite and known relation to those of another laboratory, since there is no common basis for comparison.

Consideration of the above methods and lack of methods in the laboratory can only lead to the conclusion that the field engineer and contractor is often justified in giving scanty attention to the results of laboratory tests and recommendations. There is no doubt that the causes for such a condition can be eliminated by devoting more attention in the laboratory to the conditions under which the concrete materials must be used in the field. A full appreciation of the limitations and requirements of the process of producing and placing concrete "on the job" will do much to eliminate "laboratory specifications" for concrete, which so often result in confusion and expense before their impracticability can be impressed upon the engineer who is responsible for their enforcement. The assistance which the laboratory should render to the practical user of concrete is great, and should result in bettering the quality of field concrete and the methods which are used in producing it, but such tests and recommendations which will assist in bringing about such improvements must result from the application of proper laboratory methods which take into account the conditions met with in practice.

DEVELOPMENT OF RAILWAYS

D. O. LEWIS, District Engineer, Canadian National Railways, recently read a paper to the members of the Victoria branch of the Engineering Institute of Canada on "The Development of Railways."

The speaker traced the progress of locomotion from the days of the horse-hauled wagons of the collieries of England and Scotland in 1693, to the first steam propelled vehicles of Watts, Coulau, Murdock and Stevenson between 1770 and 1823.

Some of these early models of steam locomotives in use for coal transportation were in use for over fifty years, said Mr. Lewis, and grew out of the horse-hauled cars on rails. The horse-drawn wagons were unique in some respects, the train running on its edge or plate railed track, and when the train came to a down grade it started to move of its own weight, the horses were slipped and jumped on to a low flat car behind, riding in state behind the train until the next level, where the horses got out and worked again.

The growth of steam traction was clearly elaborated by the speaker, who told of the skepticism of the people of the country, and the laughter of the members of Parliament, when the locomotive builders suggested that they would build locomotives to haul many tons at speeds of twelve to fifteen miles per hour. For a long time the railways were restricted by law to eight and nine miles an hour.

The development of the modern rails from wooden affairs with metal tops and flanges was traced, and the gradual adoption of metal wheels with flanges. Sleepers or ties were of stone in those days, he continued.

The paper was followed with interest by all, and admirably illustrated by lantern slides depicting the earlier models of locomotive traction. In 1825 the first official demonstration of a real locomotive hauling a string of wagons with passengers and freight was made, and on this occasion a man on horseback rode ahead with a flag to signal the approach of the train.

Stevenson, who was running the locomotive, got tired of the progress at six miles an hour, and signalled the rider out of the way. It is recorded that the train attained twelve and even fifteen miles an hour in places, and the demonstration was concluded with some 600 people hanging on to all the available space on board.

ACKNOWLEDGMENT OF TEST DATA

IN the article, "Present Status of Reinforced Concrete Design," by F. G. Engholm, which appeared in last week's issue of *The Canadian Engineer*, there were some results of tests made by the Emergency Fleet Corporation and the U.S. Bureau of Standards. We regret that in presenting this article, acknowledgment to W. A. Slater and A. R. Lord was overlooked. These gentlemen, who were the engineers in charge of the tests for the Emergency Fleet Corporation and the U.S. Bureau of Standards, kindly furnished Mr. Engholm with the test data and also with the photographs showing beams after test.

The sixteenth annual meeting of the American Wood Preservers' Association will be held at Hotel Sherman, Chicago, Ill., February 10th, 11th and 12th.

NEW TORONTO INCINERATOR

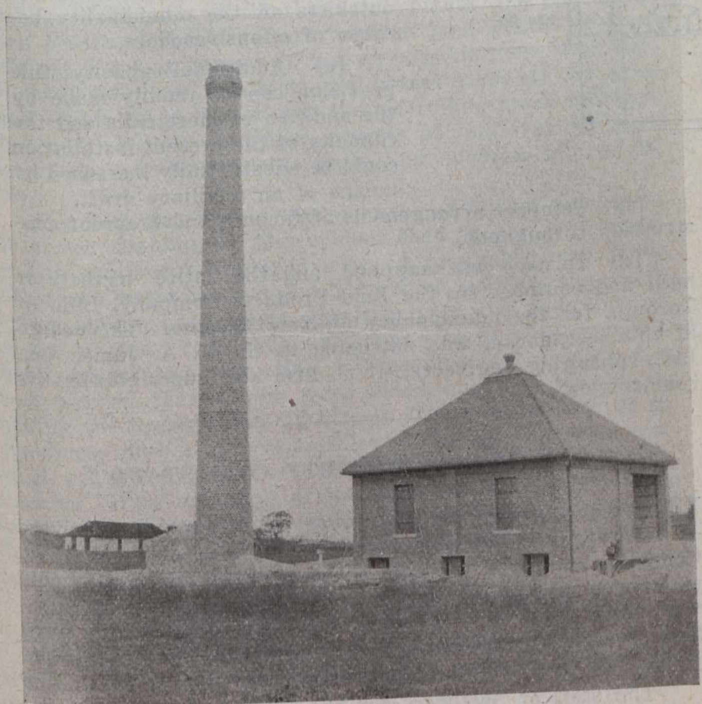
A Design Suitable for Small Towns

By E. A. James*

THE collection and disposal of refuse is one of the urgent problems confronting growing towns. Most large cities are forced to provide adequate disposal of refuse, but from a hygienic standpoint this provision is equally necessary on the part of smaller municipalities. The presence of certain industries, which accumulate objectionable trade wastes, considerably intensifies this problem in certain localities.

There are two general methods in use for the disposal of refuse; namely, reduction and incineration. In the reduction method the grease is extracted leaving an inoffensive pulp, but to accomplish this, the materials composing the refuse must be carefully differentiated with the result that the process is only economical for comparatively large cities. Incineration is, therefore, the most practical method which a small municipality can employ for the effective disposal of its refuse. While the same degree of separation of materials is unnecessary, when incineration is employed, it will be in the interests of efficiency to provide a separate collection of ashes and rubbish; thus leaving the incinerator to deal with the kitchen and trade wastes, commonly spoken of as garbage, the destruction of which is so necessary for hygienic reasons.

Some idea of the classification of refuse and relative quantities of the different components of which it is com-



General View of Incinerator Buildings

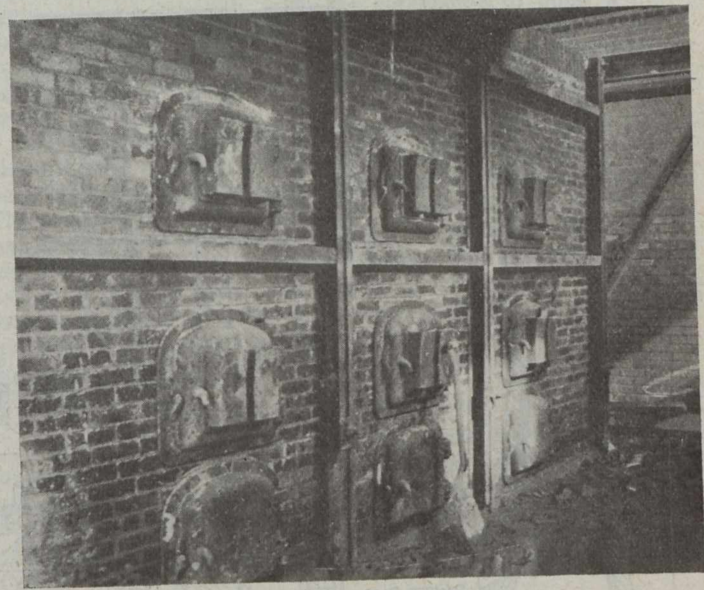
posed can be obtained from the following table; the results of which were compiled from data taken at different American cities:—

	Pounds.	Yards.	By Weight.	By Volume.
Garbage	0.5	0.0005	15.3	12.1
Street sweepings..	0.5	0.0006	14.4	15.5
Ashes	2.3	0.0017	64.3	44.7
Rubbish	0.2	0.0010	6.1	27.7
	3.5	0.0038	100.00	100.0

According to this authority, the individual refuse per day amounts to 3.5 pounds, which includes a garbage item of 0.5 pounds per individual per day.

*The E. A. James Co., Ltd., Consulting Engineers, Toronto.

A municipal incinerator of particularly interesting design was erected by the municipality of New Toronto in 1916 to serve a growing population of five thousand (5,000) people. Since this plant was put in operation in 1917, it has given such satisfactory results that a description of its chief features may prove of interest. Adjoining the municipality of New Toronto is the town of Mimico, and the incinerator is located on the boundary between the two towns, being of sufficient capacity to treat the garbage of both. The location



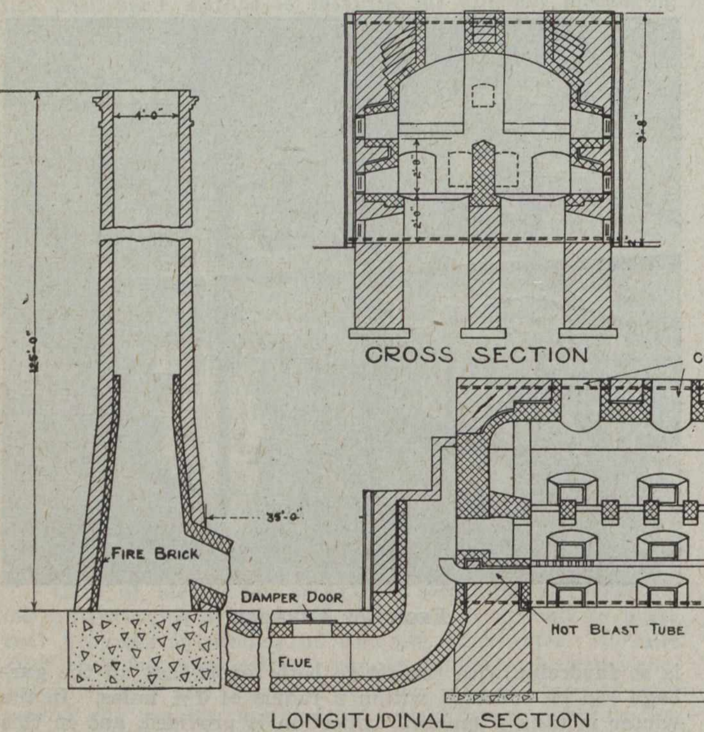
Front of Furnace

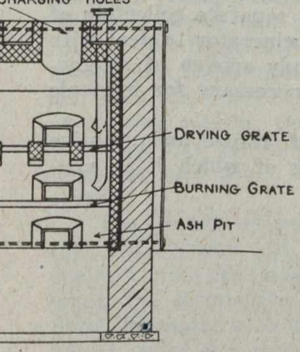
is so favorable with respect to both towns that all the garbage can be collected within a radius of 1½ miles. In the winter months a separate collection is provided, and in this way the garbage is delivered at the incinerator free from ashes and rubbish. The furnaces installed have a rated capacity of 12 tons per 24 hours, and since the area served yields on an average of 15 tons per week it is only necessary to operate the incinerator one or two days per week, unless the weather conditions demand more rapid destruction.

The general layout of the plant is simple and convenient. The building itself, of red brick, with metal roof, is neat and attractive in appearance. Approaches are provided from either end to the dumping floor at grades of 5% and 7%. In the lower story of the building the furnace is compactly built and conveniently situated to receive the charge from the dumping floor. The furnace is equipped with a dust chamber from which the smoke and gases are carried to a brick chimney some 35 ft. north of the building by means of a tunnel. Directly behind the chimney an ash storage bin is provided in order that the ashes may be kept dry by the heat from the chimney. A runway for conveying the ashes leads from the basement to the ash bin.

The incinerator building is of fireproof construction 30′ x 28′ inside dimensions. The basement has a clear height of 8′ 6″, and the dumping room 12′ 3″. The charging room is adequately ventilated by means of windows on either side and a skylight ventilator in the roof. A clause in the specifications respecting the building reads as follows: "The building shall be of reinforced concrete floor, reinforced concrete unloading floor, slabs and beam construction with reinforced concrete column, reinforced concrete runways, metal sash red brick for housing required above the unloading floor. The up runway to have a grade not greater than 5%, and the down runway a grade not greater than 7%. The building shall include a lavatory equipped with wash basin, etc., for the convenience of the operator."

The furnace itself is of fire brick construction, horizontal type consisting of 6 cells charged from the top through corresponding holes in the dumping platform. The incinerator is designed to consume the garbage without the use of auxiliary draft although the same may be added at any time should the garbage to be treated warrant increased capacity. A vertical section through the furnace shows it to consist of three distinct chambers. The upper or refuse chamber receives the garbage, and by means of supporting arches, it is held suspended until the moisture is driven off by the fire underneath. Below this level is the fire chamber having necessary grate area to consume the garbage as it is dried in the refuse chamber. To receive the ashes from the fire chamber a clinker chamber is situated beneath each grate.





LONGITUDINAL SECTION

The cells of the furnace are so arranged that entrance can be had to each cell at each different chamber by means of outer doors. The entire furnace is supported on reinforced concrete footings.

At the back of the furnace a dust chamber is situated through which the smoke and gases pass on their way to the chimney. The decreased velocity in this chamber allows the deposition of the heavier particles and a clean-out door allows the removal of the same. From the dust chamber the smoke and gases are conveyed by means of a tunnel two feet in diameter to the chimney 90 ft. high 35 ft. north of the furnace. Some details regarding the design of the chimney may prove interesting in this connection. A clear inside diameter of 4 ft. is maintained through the entire height. The thickness of the wall varies from 20 ins. at the base to 8¼ ins. at the top, changing at intervals of 16 ft. The entire chimney is supported upon a concrete base 14 ft. square by 4 ft. in depth. The interior of the chimney is lined with fire brick for a distance of 40 ft. from base, and a similar lining is provided for the tunnel leading from the dust chamber to the chimney.

The operation of the entire incinerator is very simple. As the garbage is deposited upon the dumping floor, the operator forks the contents over to remove such materials as dry papers, bottles, rags, iron, and tin cans.

The dry papers are used to fire the furnace, and from the sale of the rags, bottles, etc., a slight revenue may be recovered. The garbage is then fed into the refuse chambers and a good fire kindled on the grates beneath. Under average conditions, ¼ cord of dry wood together with dry papers will fire the six cells of the furnace, and after maintaining this fire for a period of one hour, the furnace will have absorbed sufficient heat to dry the garbage and consume it as it is dumped from the refuse chamber from time to time, and no extra fuel is necessary to accomplish the complete combustion, if operated continuously. Frequently enough lumber and sticks come with the garbage to kindle the fires.

The cost of operating this incinerator is very low. From a combined population of approximately 5,000 people, 15 tons of garbage are secured every week. Besides the operators' wages and the cost of fuel for the initial fire, the cost of collection might be added in determining the cost per ton of collecting and destroying the garbage. Reckoning the operators' wages at $4.00 per day, fuel at $10.00 per cord, teams with driver at $7.00 per day, the cost per ton of garbage amounts to $6.00, of which $4.50 can be charged against collecting. The cost of destruction in this plant would remain unchanged if 60 tons were consumed instead of 15 tons.

In studying the favorable features of this type of incinerator, attention should be directed to the following considerations:—

(a) The entire installation is simple in construction and operation; this means relatively low first cost.

(b) Low operating charges, as little or no fuel is required if furnace is operated continuously, and no auxiliary draft is necessary.

(c) Complete combustion; material is entirely reduced to ashes, and if garbage is plentiful enough to guarantee continuous operation, such materials as tin cans will be so heated as to quickly rust away when piled.

(d) Absence of objectionable odors; this feature is very important, inasmuch as the incinerator may be built at the most efficient location for the collecting of the garbage and not removed to the outskirts of the municipality because of offensive odors.

(e) Additional capacity; this provision can be readily made by the addition of more cells and the capacity of the present installation could be substantially increased by means of an auxiliary draft.

(f) Compact arrangement of furnace and fireproof construction throughout.

The furnace was supplied and the entire incinerator built and equipped by the Reid Products Company, Ltd., of Toronto, for the municipality of New Toronto. The design of this installation was entrusted to the E. A. James Co., Ltd., consulting engineers, which firm also superintended its construction.

LECTURES BY BARRETT CO.'S STAFF

FOR several years, at the request of a number of universities and colleges, the engineering staff of the Barrett Company has given talks to students in engineering schools on various phases of the use of coal tar materials in highway work. This year another series of such lectures have been prepared, covering the field of the talks of previous years, but with added and new data.

The staff of lecturers for the present season includes P. P. Sharples, manager of the General Tarvia Department; J. S. Crandall, consulting engineer of the company; Walter Buehler, consulting engineer on wood preservation; P. K. Sheidler and C. S. Reeve.

There are eight lectures in the series as follows: (1) Chemistry, manufacture and control testing of refined tars; (2) the laboratory tests to which road tars are subjected; (3) the construction of pavements with refined tar; (4) city pavements of the block type; (5) wood preservation; (6) wood-block pavements; (7) maintenance; and (8) maintenance of broken-stone and gravel roads.

While available dates have already been well filled with engagements, many colleges having requested all eight lectures, there are still some open dates, and any engineering societies, clubs or schools which would be interested in obtaining any of these lectures should address J. S. Crandall, of the Barrett Co., 17 Battery Place, New York City.

STREET CLEANING, REFUSE DISPOSAL AND SNOW REMOVAL*

By Geo. H. Norton
City Engineer, Buffalo, N.Y.

In this committee's report of last year it was noted that another society had been formed for these specific subjects, and, therefore, our activities might well be less along these lines. However, as this society is not now active, the subject cannot but be of interest to many members of this society and demand our consideration.

Rather than a general review of the field of action, it has seemed to the writer that a presentation of the concrete problems as met in one city might illustrate a fair example and be of interest. What is here given is a short survey of these activities in Buffalo, N.Y.

Passing of the Horse Broom

In street cleaning, for many years the old horse brooms had been used, preceded by an attempt at sprinkling. A few years ago the condition was reached where the equipment of the contractor was obsolete. A renewal of the contract did not seem desirable. Three appraisers were named by the council, with consent of contractor, to appraise the whole plant, which consisted mainly of horses, mules, broom sweepers, wagons, sleighs, horse equipment and leased barns. After some adjustments the prices of the appraisers were approved and the plant taken over by the city. At the same time similar action was taken on the plant of contractor for garbage collection. With these two plants the city found itself possessed of a large assortment of junk located at seven different barns or yards. As fast as possible these were consolidated into two locations; old horses replaced by good ones, repair shops located and the old rolling stock repaired. This was a slowly continued process of improvement until motorization became commercially and mechanically advisable.

The first step was in the purchase of flusher equipment for street cleaning. It was evident that no half-way measures in equipment would be wise. A beginning was made with three motor tractors, each drawing a 2,000-gallon tank flusher trailer, having two wheels in rear and front carried on the tractor. With these in use it was at once apparent that a proper and economical method of street cleaning had been reached. Three more were added, and then nine more, making the present fleet of fifteen. The results, both as to cleanliness and cost, are excellent. The one improvement which yet seems desirable is a successful scraper and pick-up machine. Hand-brooming or sweeping is not in line with to-day's requirements. It would appear that some device of the squegee kind with pick-up would add materially to satisfactory street cleaning.

Combination Tractor and Flusher Introduced

The effect of flushing material into sewers through inlets seems to be so dependent upon grades and crowns of pavements, width of street and frequency of cleaning, as well as kind and size of sewers, that nothing definite can be said as generally applicable.

The above-mentioned combination of tractor and flusher seems most appropriate in this northern city. Flushing cannot well be done in freezing weather, but upon the advent of the freezing weather the quantity of coal ashes is greatly increased and snow removal becomes necessary. This separable arangement of tractor and flusher is then economcal. The flusher is housed and the tractor augments the hauling equipment when most needed.

In this northern city during a normal snow season the auto traffic is forced on to the car track streets unless regular snow removal is maintained on other streets. A few years ago this was of little moment; to-day it is vital.

With the large fleet of tractors it will now be possible to fight a snowstorm from its beginning and keep all thoroughfares open. The feature of elasticity seems to make this combination the most desirable.

In refuse disposal this city has also been guided by results obtained through step-by-step experience. For many years the public dump was economical. City growth, with less available dumps and longer hauls, made another method desirable. When the collection was made by contract an arrangement was made with the contractor to build a destructor plant for refuse in city property, with right of city to acquire at expiration of contract at 60% of cost, but before expiration of contract the city took it over at an agreed price.

All rubbish is assorted and the saleable reclamation sold. Many figures might be given, but such are so dependent upon market conditions that such would be of little general value. The city fortunately had a good market for its recovered paper, and with such, over a long term of years, this plant has proven just about self-supporting. The quantity of recoverable material has been greatly affected by war conditions and market prices have been variable. The general average of self-support, however, is most satisfactory, as it solves the question of dumps and long hauls.

Garbage and Hog-feeding

Garbage disposal has been the most troublesome and unsatisfactory. Under the old contract system the collection and disposal was done by a fertilizer company, the garbage being taken to their plant for reduction. For some reason this reduction seemed less and less desirable, even after the city made collection and delivery of garbage and a material price demanded to accept delivered garbage.

The increasing success of hog-feeding has been closely followed, and this year bids were requested for both reduction and feeding. The first proposals eliminated reduction, but so complicated the feeding that new bids were received and contract made on basis of top price of hogs in Chicago on monthly averages and amount of garbage delivered:—

Six times for 25,000 tons per year.
Seven times for 30,000 tons per year.
Eight times for 40,000 tons per year.

While this contract is but recent, it promises a reasonable solution of the garbage problem.

Haulage is yet to be settled.

The separable tractors used for flushing assist materially.

Small trucks have been tried, but with small success. Several patterns of trailers are now being tried as to comparative merits.

This brief outline has been given as perhaps typical of a city's experience. Figures in detail from one locality may prove most misleading at another unless the conditions are quite parallel, and this is seldom the case.

Sound judgment, a knowledge of the difficulties of other cities, courage and opportunity for reasonable trial of new methods seem the essentials for reasonable progress in the "housekeeping of cities."

*Report of Committee on Street Cleaning, Refuse Disposal and Snow Removal presented before the American Society of Municipal Improvement.

The following officers have been elected for the ensuing year by the Draughtsmen's Association: President, R. Goodman; vice-president, C. Perkins; recording secretary, C. Borrett; minutes secretary, R. Ames; financial secretary, E. Radcliffe.

The demand for professional engineers in the United States is continuing on an upward movement as viewed by the service department of the American Association of Engineers. Less than one per cent. of the total number of technical engineers in that country are actually out of employment at present. The demand is greater than can be supplied for a long time. Recent university graduates have excellent opportunities, judging from the many requests for them. Practically no demand exists for engineers for foreign work. Some of the largest engineering companies in the United States who have been doing foreign work have but one or two men in the field at present.

CONCRETE PARTS FOR GENERATORS*

By C. M. Hackett
Power and Mining Engineering Department, General Electric Co.

The manufacture of reinforced concrete may now be regarded as having reached the scientific stage. Haphazard methods will doubtless continue to be used in the selection of materials and in the manner of mixing for many kinds of work, but it is possible with our present knowledge of aggregates, cement, water and the methods of combining them, to get not only uniform strength in all parts of a concrete structure of large size and mass, but, also, to produce duplicates of that structure in any quantity desired. This progress, combined with the great strength of the finished product, has led to the adoption of concrete for various classes of work where metal has heretofore been regarded as the only suitable material.

There are two parts of large size, low speed, vertical shaft generators usually made of steel or iron that can with advantage be made of reinforced concrete, namely, the stator frame and thrust bearing support.

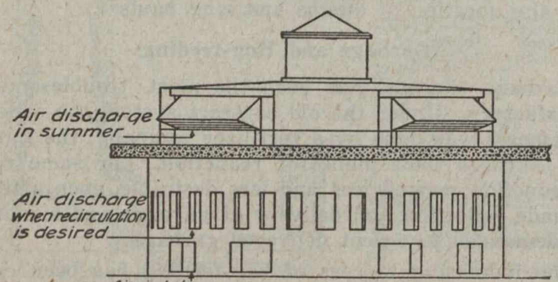


Fig. 1—Elevation of Generating Unit

The use of concrete instead of metal for these parts does not involve any problems of stability or strength that cannot be readily solved by care in design and construction; and, provided technical and practical knowledge of conditions to be met are kept in mind when carrying out the work, the chances of trouble developing are no greater than with all-metal machines.

The concrete stator frame will, in most cases, be combined with the power plant structure.

If a house is to be built over the generators, the stator will likely be nearly, if not completely, below the floor level; but, if the machines are to be of the out-of-door type, then it will generally consist of a cylinder between the operating floor and upper deck or platform, extending somewhat above the latter, and will be an important part of the support for that deck as well as a means of carrying the load imposed by the thrust bearing.

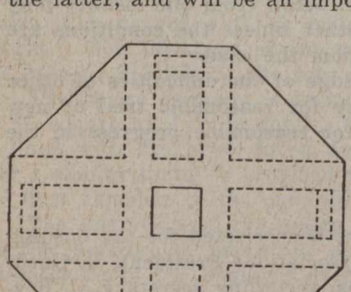


Fig. 2—Plan of Bridge

The main points to be considered in the design of the stator frame are ample cross section for carrying load, and reinforcement so placed as to distribute the stresses produced by short circuits and unbalancing.

The admission of air to the machine, as well as its discharge after having passed through the windings, will also form a feature of the design, and in case generators are of the out-of-door type, and recirculation of air is necessary during a portion of the year, outlet ports and dampers for air control will be required in the stator as well as in thrust bearing supporting structure, so that the discharge of air from the machine can be regulated according to temperature conditions.

*General Electric Review.

The securing of the stator laminations and windings to the concrete can be accomplished either by anchor bolts, spaced and arranged to support and adjust the clamps which hold the laminations, or by the use of a skeleton ring, cast in sections and machined to the proper form and dimensions. If a ring is used it will rest on a shoulder formed in

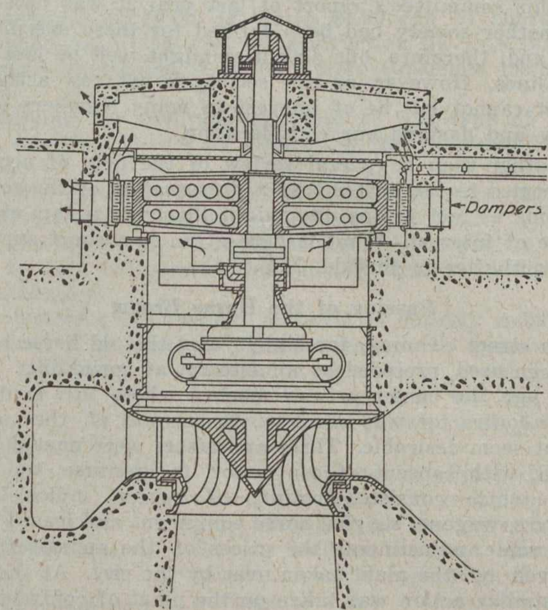


Fig. 3—General Section of Generating Unit

the concrete and will be bolted and grouted in place after the final adjustment of the rotor has been made. When the bolt type of support is adopted, the placing of the stator laminations and windings must be done at the power plant. They may be put in either at the factory or at the plant if the skeleton ring is used.

The taking off of leads, the shrouding to control the direction of air, and the placing of vanes for driving it will be approximately along the same general lines as for an "all metal" machine. Also, the arrangements for braking and lifting the rotor will contain no novel features.

The bracket or bridge for supporting the thrust bearing may consist of a heavy floor or cover with deep girders

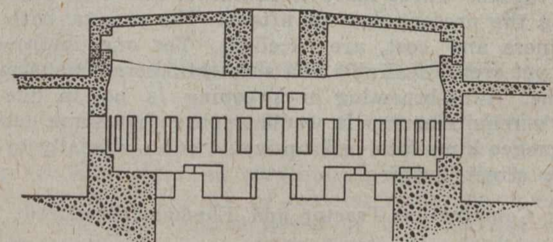


Fig. 4—Section Through Stator and Bridge

rising from it, or the girders may extend below the floor in truss form.

In designing this part, the following points should be carefully considered:—

The reinforcing steel should be of a high grade, viz., equal to the best structural steel.

In placing the steel, the heavy, or primary, bars should be located so that they carry the load to the best advantage while the lighter or secondary reinforcing should be so placed that there is no portion of the concrete that is not effective, not only for supporting the load, but for distributing and absorbing vibration. To meet this latter condition, a massive structure is desirable.

To facilitate handling, eye bolts or tapped sockets, into which eye bolts can be turned, should be so placed that they are well tied into the primary reinforcing, and cause the structure to be held level when being lifted.

The bearing plates may be formed of steel plate if no adjusting of the position of bridge is to be made by them, but in case such adjustment is desired, then flanged castings, strongly anchored to the stator and bridge, with the necessary adjusting screws and allowance for the desired movement, will be required.

The simplest method of adjusting thrust and guide bearing housings will be by wedging and shimming, and to seam them in place after rotor is accurately centred. They should be so designed as to permit the pouring of grout into all open spaces between castings and concrete structure before anchor bolts are tightened. If desired, the guide bearing housing can easily be designed to allow for a small adjustment of that portion which holds the bearing shell and in this way make it possible to correct any inequality in the air gap.

The bolts for holding the bearing plates in position may be moulded directly into the concrete, but if anchor bolts are to be used for holding the bridge to the stator, properly located tubes of sufficient size to allow the bolts some play should be moulded into the structure. It should be possible to remove anchor bolts from both the bridge and stator when the bridge is to be lifted.

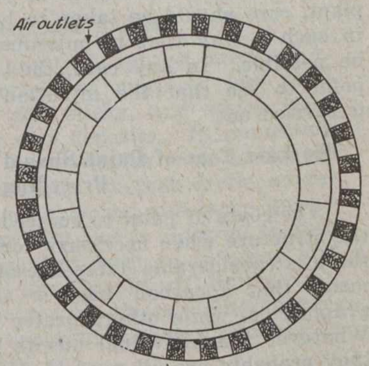


Fig. 5—Plan Section of Stator Showing Openings for Air Discharge

Only the vertical type of machine has been considered in the foregoing, but it is also practical to build stator frames of concrete for large size horizontal shaft machines, using either a solid or split ring as may be desired. The housing or weather protection of such machines, if of the out-of-door type, can also be conveniently made of concrete, and provisions can be made for handling the sections of the housing if at any time it is necessary to do anything in the way of repairs on the windings.

The economies to be found in the substitution of concrete for metal for parts of generators lie chiefly in the lower cost of materials and labor, reduction in shop expenses, and the saving in freight and handling charges. To these may be added a considerable saving in the cost of weather protection, if the generators are to be of the out-of-door type, since the concrete bridge structure can be water-proofed at a small cost, and its general design makes the effective protection of all joints and openings a simple matter.

A study of the advantages of the use of concrete in the construction of generators indicates that its special field lies with machines of large size. Just how far down the scale of sizes it is likely to show a gain over metal, can only be determined by time and experience. The indications are, however, that it will prove practical and economical in a fairly large field.

In New York City on December 17th last a Federal Grand Jury indicted five chimney construction companies and more than a dozen of their officials on the charge of having organized and operated a trust for the construction of radial brick chimneys in violation of the Sherman anti-trust law. The indictment accuses the defendants with having sought to restrict the business of those allied with the defendant corporations, to fix prices, and to prevent competing concerns from using the same materials and methods in chimney building. It is charged that the Chimney Builders' Association was incorporated in 1914, and that the members agreed to send to the secretary of the association written information of every inquiry received from prospective customers, and to state each quotation or bid submitted. The companies indicted are the Alphons Custodis Chimney Construction Co., the M. W. Kellogg Co., H. G. K. Heinicke, Inc., Bergen & Lindeman, Inc., and the Heine Chimney Co.

MUNICIPALLY-OWNED ASPHALT PLANTS

At the request of C. A. Mullen, director of the paving department of Milton Hersey Co., Ltd., Montreal, *The Canadian Engineer* herewith reprints a list of the municipally-owned asphalt paving plants in Canada, the United States and other countries. This list was originally compiled by and published in the "American City." Mr. Mullen states that his firm has received many enquiries from Canadian engineers for this information. The list follows:—Atlanta, Ga.; Bayonne, N.J.; Brooklyn, N.Y.; Buenos Aires; Charlottetown, P.E.I.; Chicago, Ill.; Cincinnati, Ohio; Cleveland, Ohio; Columbus, Ohio; Dayton, Ohio; Denver, Colo.; Detroit, Mich.; Erie, Pa.; Fall River, Mass.; Flint, Mich.; Fort Wayne, Ind.; France; Hamilton, Ont.; Harrisburg, Pa.; Honolulu; Indianapolis, Ind.; Kansas City, Mo.; Kingston, Ont.; Lansing, Mich.; Lima, Peru; Lincoln Park Com., Chicago, Ill.; Little Rock, Ark.; Manchester, N.H.; Manhattan Borough, N.Y.; Milwaukee, Wis.; Montreal, Que. (three plants); Nashville, Tenn.; New Bedford, Mass.; New Orleans, La.; Newark, N.J.; Niagara Falls, N.Y.; Norfolk, Va.; Ottawa, Ont.; Pawtucket, R.I.; Pittsburgh, Pa.; Portland, Oregon; Queens Borough, N.Y.; Saginaw, Mich.; San Francisco, Cal.; Schenectady, N.Y.; Scranton, Pa.; Seattle, Wash.; Sherbrooke, Que.; Shreveport, La.; Spokane, Wash.; Springfield, Mass.; St. Louis, Mo.; St. Paul, Minn.; Syracuse, N.Y.; Toronto, Ont.; U.S. Government (12 plants); Victoria, B.C.; Washington, D.C.; Worcester, Mass.

PROGRAM FOR TORONTO BRANCH OF ENGINEERING INSTITUTE OF CANADA

At the annual meeting of the Engineering Institute (Toronto branch), held last Thursday, the new president, R. O. Wynne-Roberts, whose inaugural address appears in this issue, announced that the following papers had been arranged for this session:—

February 5th, "The Romance of Heat," by E. Metcalfe-Shaw; February 12th, "Siberia," Capt. F. A. Dallyn and Maj. C. S. L. Hertzberg; February 19th, "Bituminous Roads," by Bruce Aldrich; February 26th, "York Township Sewerage Scheme," J. M. M. Greig; March 4th, debate on, "Should Engineers Unionize?" Positive side by W. Snaith, negative side by Prof. P. Gillespie; March 11th, "Toronto Harbor Works," by Geo. T. Clark; March 18th, "Automatic Telephones," F. A. Danks; March 25th, "Concerning Bridges," Frank Barber; April 1st, "Town Planning and the Canadian Engineer," A. V. Hall; April 8th, "Chemistry and Engineering," T. Linsey Crossley; April 15th, "Sarnia Intake," F. W. Thorold, "Reinforced Concrete Pipes," H. W. Heywood; April 22nd, "Application of the Venturi Principles," E. Dean Wilks; April 29th, "Dredging," W. E. M. Bonn; May 6th, "Ontario Highway Policy," W. A. McLean.

The 10th American Good Roads Congress will be held on February 9th to 13th in Louisville, Ky., under the auspices of the American Road Builders' Association.

Upon a report which will be made by officials of the Hydro-Electric Power Commission's railway department depends the proposed purchase by the city of Sarnia, Ont., of the street-car system in that municipality. If the report be favorable to the undertaking, negotiations with the company will be started.

Proposals for a new treaty between the United States and Canada to provide for the withdrawal for power purposes of an additional 60,000 cu. ft. per second from the Niagara River above the Falls have been made to the State Department of the United States by Representative Clarence MacGregor, of New York. Under the present treaty the diversion of water for power purposes is limited to 36,000 cu. ft. per second by Canada and 20,000 cu. ft. by the United States. Under the treaty as proposed by Mr. MacGregor each country will be given 30,000 cu. ft. more than it has at present.

PROTECTION OF METAL STRUCTURES BY PAINTING*

By J. R. Shean
Of the Pacific Electric Railway

As a rule, when steel is new, the rust is only light yellow spots here and there, and can be removed with scrapers made from old files turned over at the end and retempered and sharpened. Stiff scrapers and putty knives are also useful at this time. Steel brushes are not of much real value, except to clean dirt and loose mill scale off. Any heavy seed rust which has formed cups down in the steel should be chipped out with a hammer, and the greatest care should be taken to be sure and get all the rust out of this cup so that the clear steel shows in the bottom. Care should also be taken to avoid cutting the steel unnecessarily with the sharp edges of the hammer. The sand blast is a very thorough way of cleaning steel at this time, but it should be followed at once with the first coat of paint, as the surface starts to rust again very soon after the blast is used.

The tools needed for cleaning the work before repainting are about the same as for new work. Light chipping hammers are indispensable for getting the rust scale off. For cleaning the dirt off, a small bunch of broomcorn wrapped with twine makes a very handy tool. After the dirt has been loosened with the broomcorn, it can be brushed off easily with the duster. This saves considerable scraping with the putty knife.

If a structure is properly treated when it is new, there is hardly any need of using a sand blast for repainting. The rust will only show where it is able to push the paint off and these spots should be chipped out until the cup formed by the rust shows the clear steel. Holding the blast on one of these spots until the cup is clear of rust will cause considerable unnecessary cutting of the steel around it. After the rust is cleaned off, the bare places should be spotted with good red lead and then painted the same as the rest of the bridge. If this work is done thoroughly there is no reason to expect further trouble from these places, but if it is not, it is only a matter of a short time until the rust will be at its work of destruction again.

The First Paint Coat

After the surface has been thoroughly cleaned, the next question is what to use for a first coat of paint to give it the maximum protection against the rust getting another foothold. There are several "inhibitive" pigments, most of which are impractical for general use. The one which is generally accepted by engineers as being the most valuable is red lead. This pigment has had many enemies among engineers and painters on account of its tendency to sag and run on vertical surfaces, and to settle into a hard concrete-like mass in the bottom of the container. These faults are caused by an excessive amount of litharge, which sometimes amounts to 30 per cent. of the cheaper grades.

In the last few years some lead manufacturers, by finer grinding and reroasting, have reduced the litharge until the United States government standard is true red lead 94 per cent. and litharge 6 per cent. More improvement has been made, however, and now it is possible to buy red lead containing only 2 per cent. of litharge and 98 per cent. true red lead Pb_3O_4. This makes an ideal paint for a first coat. Being extremely fine, it fills all pores, and brushes out in a smooth, even film, free from voids. It stays in place on vertical surfaces and does not act ropy under the brush.

Another great advantage in using this high grade material is that it can be bought in paste form, saving the time it used to take to mix up the dry red lead by hand. The vehicle with which the red lead is mixed is fully as important as the pigment itself. The merit of linseed oil is too well known to need comparing with any other for this work, although the paint film is much better if reinforced with Japan oil.

Elaborate tests, made recently, have proven that, without reinforcing, an oil film loses from 18 per cent. to 23 per cent. of its volume in 200 days. This shrinkage of the oil film, which should hold the pigment together, is worthy of serious consideration and Japan oil or anything else which will truly reinforce it, should certainly be used. Japan oil also furnishes sufficient dryers of the right kind, as rosin dryers are a detriment rather than a help to red lead.

The amount of red lead to be used in one gal. of vehicle is a question upon which engineers differ. On the Hell Gate bridge, 37 lbs. of red lead was used to one gal. of vehicle, but this would only be possible with the very finest quality of red lead. The general average for railroad use is about 25 lbs. to the gallon of vehicle, or about 17 lbs. to the gallon of paint mixed and ready for use.

When steel work is to be red leaded at the fabricating plant, care should be taken to have the specification worded in such a way that no misconstruing of its intention will be possible. In any case, the inspector should make it a point to see that the intention of the specification writer is carried out.

The Last Coat of Paint Should be More Elastic Than the Preceding One

The coats of paint to succeed the red lead and to re-paint the structure when necessary form a proposition upon which there is considerable difference of opinion. Some authorities insist that a carbon base is the best, others insist that graphite is, while others prefer mineral red or lamp black. Whatever the individual merits of these pigments are, and they probably are all good if applied right, the fact remains that they are all heat attractors. As heat is a first-class destroyer, it is hard to understand why it has become such a common practice to use these dark colors. Unless the price of material is the main consideration there is no reason why steel work should not be painted in light colors, as their resistance to heat rays would certainly be easier on the oil film which holds the pigment together, than the dark colors which attract and hold the heat rays.

Canary yellow, pearl grey or light olive green will change an unsightly black structure to one that will at least be more in harmony with its surroundings. These light colors will last enough longer than the dark colors to pay for whatever difference there is in the cost of the two. It may be argued that light colors become unsightly in a short time from dirt and smoke. This cannot be noticed to any extent except overhead on through truss bridges and on overhead bridges, but even if painted black the smoke marks show considerably on this part of a bridge.

The theory to follow when applying the coats which follow the red lead, as well as any other time the bridge is painted, is to have the last coat of paint more elastic than the coat preceding it. This will insure against checking and alligatoring. Some authorities advise putting a little non-drying oil in the last coat, to make a better "shedder" of water. This would appear to be a good plan, provided it finally did dry hard by the time the bridge had to be repainted, so that the next coat was more elastic, thus avoiding the danger of checking.

*Abstracted from paper read before the American Railway Bridge and Building Association.

Baldwin's, Limited, of Bristol, Eng., who purchased the large plant of the British Forgings, Ltd., Toronto, from the Imperial Munitions Board, are now preparing to commence operations with 2,000 men on May 1st. The number of employees will be increased to 10,000 when the $1,000,000 addition to the plant, now in course of construction, has been completed, and when more power is available as a result of the Queenston-Chippawa development.

It is expected that the official opening of the new parliament buildings of Manitoba will take place July 15th, as it was on that date fifty years ago that Manitoba entered the Dominion confederation. The next session of the legislature, which will convene in a couple of weeks, will be held in the new buildings, but they will not be fully completed until June 1st, after which work will be started in tearing down the old buildings and clearing the grounds as far as the Assiniboine river.

TERMS USED IN CONNECTION WITH ASPHALT FOR HIGHWAY WORK*

SOME confusion exists in the popular mind, and to some extent among highway engineers, in connection with terms relating to highway work in which asphalt is used. To many, asphalt has always been surrounded with a certain sort of mystery that has been heightened rather than clarified by various scientific or highly technical reports which have been published from time to time. The purpose of this brochure is to set forth in plain language the meaning of certain terms and to explain their relationship to other terms in order to prevent their inadvertent misuse. In general, involved technical definitions will not be discussed, although a number of such have been widely adopted as standard.

The Terms Bitumen and Asphalt

The word *bitumen* was at one time applied only to certain naturally occurring materials of more or less solid consistency which were black and sticky, and which were usually associated with rock or clay deposits. In connection with highway work this term now includes that portion of petroleum asphalt and tar products, whether crude or refined, which is soluble in a liuqid chemical substance known as carbon disulphide. The term *bituminous material* is even broader in its scope and is applied both to bitumen and materials containing bitumen. The amount of bitumen in a bituminous material, as determined by its solubility in carbon disulphide, is frequently reported as *total bitumen* in connection with laboratory tests.

Asphalt is a semi-solid or solid sticky product formed by the partial evaporation or distillation of certain petroleums. If the asphalt has been produced by natural agencies it is called *native asphalt* and often occurs mixed with considerable quantities of water, gas, vegetable matter and earth or clay. If, on the other hand, the asphalt is directly manufactured from petroleum, it is sometimes called *petroleum asphalt* and is practically pure *bitumen.* When asphalt occurs impregnating a porous rock such as sandstone or limestone, it is called *rock asphalt.* This material contains only a limited amount of bitumen and is mostly rock.

Terms Relating to the Preparation of Asphalt

The term *asphalt cement,* ("A. C.") is applied to an asphalt which is of suitable consistency for direct use in highway work. If the *asphalt* is too hard for direct use but is otherwise suitable it is called *refined asphalt* ("R. A."). When an *asphalt* is manufactured from petroleum it is usually made directly into an *A. C.,* although it may, if desired be, turned out a *R. A.* Crude *native asphalt* is almost invariably subjected to a refining process in order to remove the vegetable and mineral impurities as completely as possible. The refined product is then an R. A. which may still contain an appreciable amount of impurities. Before use in highway work all R. A., whether produced from *native asphalt* or directly from petroleum, must be softened to suitable consistency by combining it with a *flux. Flux* or *flux oil* is a non-volatile liquid produced from petroleum by distilling off the lighter and more volatile constituents. It may be mixed with melted R. A. in proper proportions to form an absolutely homogeneous *fluxed asphalt* or *A. C.* of any desired consistency. The fluxing process is usually conducted at a paving plant in the manufacture of paving compositions.

Sometimes an A. C. of suitable consistency for a given purpose is thinned to fluid consistency with a volatile petroleum distillate such as gasoline. The resulting product is then called *cut-back asphalt* and upon exposure will rapidly become an *A. C.* through evaporation of the light solvent. An A. C. may also be thinned to fluid consistency by the addition of water, provided an emulsifying agent such as soap is present in the mixture. When combined with water in this manner the product is called *emulsified asphalt.* The term *liquid asphalt* is sometimes applied to a fluid petroleum product or road oil which is highly asphaltic in character and possesses the property of adhesiveness or stickiness to a marked degree. An *asphaltic petroleum* is one which contains a considerable amount of *asphalt* dissolved in the lighter oils present and from which asphalt may be readily manufactured by evaporation or distillation to remove these light oils. Certain *asphaltic petroleums* are quite similar to cut-back asphalt, in which case they are sometimes called *malthas.*

Terms Relating to the Physical Properties of Asphalt

The *hardness* of an *asphalt* is expressed as penetration, which is a measure of the depth to which a standard needle will penetrate it at a standard temperature during a definite period of time when the needle is loaded with a known weight. Unless otherwise indicated, the temperature, weight and time factors are understood to be 25 degs. Centigrade (77 degs. Fahrenheit), 100 grams, 5 seconds. The depth of penetration is expressed in units. Thus a 50 penetration asphalt is one in which the standard needle penetrates to a depth of 50 units. Asphalt of 100 penetration is a softer grade because under the same conditions of test the needle will penetrate it for a depth of 100 units. Thus the softer the asphalt the higher its penetration, and the harder the asphalt the lower its penetration becomes.

The *ductility* of an *asphalt* is expressed as a measure of the distance which a standard briquet of the asphalt will stretch without breaking, at a standard temperature, when the ends of the briquet are pulled apart at a definite rate of speed. The temperature is usually specified as 25 degs. Centigrade (77 degs. Fahrenheit) and the rate of speed is 5 centimeters per minute. Ductility is then expressed as the maximum number of centimeters which the test specimen will stretch without breaking. Thus a ductility of 40 means that the briquet will not break until pulled apart for a distance of 40 centimeters.

The *melting point* of an *asphalt* is that temperature at which it softens sufficiently to flow as determined by an arbitrary method. Upon being subjected to a rising temperature there is no critical point at which asphalt suddenly changes from a solid to a liquid, as it gradually becomes softer and softer. The metlting point test is ordinarily made by first moulding the asphalt in a circular brass ring which is suspended under water beside a thermometer. A standard steel ball is placed upon the upper surface of the test specimen and the temperature of the water is then raised at a standard rate. The temperature at which the steel ball forces the asphalt one inch below the brass ring is expressed as the melting point. Other methods have also been devised which, for identically the same asphalt, will show a different melting point. It is therefore important that *the exact method of testing be known* in connection with any statement of *the melting point of an asphalt.*

The *flash point* of an asphalt is that temperature at which it evolves vapors which ignite upon contact with a flame. This temperature is and should be higher than any to which the asphalt should be heated during its application in highway work.

The *loss by volatilization* of an asphalt is the per cent. by weight which it loses when a sample is heated and maintained at a temperature of 163 degs. Centigrade (325 degs. Fahrenheit) for a period of five hours under standard conditions of test.

Pavements and Foundations

Highways in which asphalt is used are almost invariably composed of two or more courses. The *upper or wearing course* is called the *pavement* provided it has a substantial thickness, usually of one or more inches. When asphalt is used in the superficial treatment of any pavements to produce, with a subsequent application of stone chips, sand, etc., a thin blanket course, such superficial course is called an *asphalt carpet* or *asphalt seal coat.*

The *bottom course* of a highway which is laid directly upon the sub-grade, is ordinarily called *the foundation* or *base* and if courses are placed between the *foundation* and *pavement* they are called *intermediate courses.* When subgrade conditions are particularly bad a course is sometimes

*From Brochure No. 5 issued by the Asphalt Association.

placed below what would ordinarily be considered the foundation, in which case it is termed a *sub-base*.

Asphalt pavements are laid upon a variety of foundations or intermediate courses which may or may not be of the same type as the *pavement proper*. The most common types of foundation are the broken stone or macadam foundation, the Telford foundation, the cement concrete foundation, and the bituminous concrete foundation. Asphalt pavements are frequently laid upon old pavements such as macadam, cement concrete, brick or stone block, in which case the old highway structure as it exists is usually referred to as foundation.

Classes of Asphalt Pavements

The *asphalt Macadam pavement* is a broken stone pavement laid in a manner similar to ordinary Macadam, except that the broken stone of the wearing course is coated and filled with asphalt applied by the pouring or *penetration* method after the stone has been placed on the road. Such application may be made with hand pouring pots or by mechanical pressure distributors. No Macadam pavement which has merely been surface treated with asphaltic road oil, cut-back asphalt, or asphalt emulsion should be called an asphalt Macadam. Such indiscriminate use of the term is not only misleading but places a relatively high and permanent type of construction in the same class with water-bound Macadam which is temporarily maintained by surface treatment.

An *asphaltic concrete* pavement is one composed of a mixture of asphalt with broken stone, broken slag, or gravel and often with sand and mineral filler as well. The term *concrete* presupposes a mechanical mixture prepared before laying. When the aggregate of asphaltic concrete is composed of a single commercial size of broken stone such as used in the wearing course of Macadam, the resulting pavement has sometimes been erroneously referred to as asphalt Macadam. Such practice should be discouraged as the asphalt Macadam is always constructed by the penetration method. There are a number of patented pavements belonging to the asphaltic concrete class, such as "Bitulithic," "Warrenite," "Bitoslag," "Amiesite," "Filbertine," etc. An unpatented pavement, known as the "Topeka" type, is an *asphaltic concrete* in which the individual particles of the mineral aggregate range in size from one-half inch in diameter to dust.

The *asphalt block* pavement is one constructed of blocks composed of a dense asphaltic concrete which has been subjected to heavy compression during the process of moulding. Such blocks are laid in regular courses as in the case of a brick pavement.

The *sheet-asphalt pavement* is composed of a mechanical mixture of asphalt with a carefully graded sand and a mineral filler such as limestone dust. The mixture is often called *sheet-asphalt topping* or *surface mixture*, and is usually laid on an intermediate course of asphaltic concrete know as the *binder* or *binder course*. In some localities asphalt is mixed with local sand which does not meet the standard grading requirements for sheet asphalt. A pavement construction of such a mixture is greatly inferior to sheet asphalt and is usually called an *asphalt sand pavement*.

A *rock asphalt pavement* is one in which the wearing course is constructed of natural rock asphalt which is usually crushed or pulverized first and in which is sometimes incorporated additional asphalt or flux oil.

An *asphalt-earth* pavement is one composed of a mechanical mixture of asphalt with finely divided earthy material such as clay. The "National Pavement," which is patented, belongs to this class.

The term *asphalt seal coat* is often employed in connection with the use of asphalt in the surface treatment of *asphalt Macadam* and certain *asphaltic concrete pavements*, either during or after construction. In such cases the asphalt serves to fill the surface voids in the pavement and when covered with stone chips, fine gravel or sand, produces an *asphalt carpet* or mat which protects the underlying pavement.

Asphalt Fillers

Asphalt fillers are prepared for filling joints and cracks in brick, stone block and cement concrete pavements. There are three general types of asphalt filler.

The *poured joint filler* is a specially prepared asphalt which may be heated and poured into joints or cracks.

The *asphalt-grout filler* is a mechanical mixture of asphalt and fine sand which, while hot, may be poured over the pavement surface and broomed or squeegeed into the joints.

The *prepared joint filler* may consist either of specially prepared asphalt in the form of premoulded strips, which are inserted in the joints, or they may be premoulded mixtures of asphalt with such substances as limestone dust, silica or shoddy dust. Sometimes the filler strips are reinforced with fabric and sometimes they consist of one or more layers of fabric or felt saturated with asphalt. Premoulded expansion joints reinforced or armored with metal are also manufactured.

WENDIGO LAKE HYDRO-ELECTRIC POWER PROJECT

FOR the purpose of generating and distributing electrical power, and also of taking over certain rights in Ontario, the Wendigo Power Co., Ltd., has recently been incorporated with head office at Guelph. The rights consist of a lease from the Ontario government of the power rights on Wendigo lake, and certain parts of the Blanche river, and also rights of the storage for power purposes on Wendigo, Skeleton, St. Anthony, Larder and other lakes and streams in the Timiskaming district. The drainage covers some 340 square miles. The company is also authorized to cut and remove timber on parts of the grounds adjoining the development of power and to purchase 190 acres of land through part of which the pipe line will pass and upon which the power house is to be erected.

The location of the plant is in the township of Marter, on the east branch of the Blanche river, in the district of Timiskaming, about six and a-half miles from the town of Englehart, and is in the proximity of a large and active mining area. The development of 2,000 h.p. will be proceeded with immediately. It is also the intention of the directors to develop the full capacity of 3,500 to 4,000 h.p. immediately it is required.

The engineers, Messrs. Sutcliffe and Neelands, in their report, estimate the average flow at 270 c.f.s., which, on a 143-ft. head, would give 3,500 h.p. continuous 24-hour load, figuring 80% efficiency on the wheel shaft. They state that they do not believe the spring freshet run-off can be entirely controlled, but that the major portion of the flow can be regulated. Five feet of water on Larder lake, which has an area of thirteen square miles, would hold 65-mile ft.; 10 ft. on Skeleton lake, 14-mile ft.; 15 ft. on Wendigo lake, 25.5-mile ft.; 5 ft. on St. Anthony lake, 12.2-mile ft.; and 5 ft. on Raven lake, 12.2-mile ft., or a total available storage of 129-mile ft. Besides that which would be taken care of by the power plant itself when operated to full capacity, they figure that the spring run-off would be 176-mile ft.

Announcement was made by the Hon. W. F. A. Turgeon on January 20th, in the Saskatchewan Assembly, that the controversy between the Saskatchewan and Federal governments relative to the reimbursement of the former of over $500,000 paid out as interest to bondholders under provincial guarantees of the Grand Trunk Pacific branch lines in the province, has been terminated. The Federal government will take over the branch lines in the province and incorporate them in the National system of railways, will repay to the provincial government the interest payments made as a result of the default of the railway and official receiver, and will relieve the government of all obligations as to future interest payments. The province will also be relieved of a contingent liability under the guarantees of $13,200,000.

CONTRACTS—A COMPARISON OF "COST PLUS" WITH OTHER FORMS*

By Ernest Wilder Clarke

THE use during the past two years of the "cost plus" form of contract on very large and complicated construction work seems to the writer to render the time opportune for a general discussion of the advantages and disadvantages of this type of contract.

In order to bring the matter before the society, the following résumé of some of the more or less self-evident faults and virtues of the usual contract forms are presented, not with the idea of informing the members of the society, but to establish a basis for discussion.

Lump-Sum Contracts

The usual methods of paying for work are by lump-sum, by item charges and by cost plus a percentage. Under the first two methods, the contractor takes the engineers' or architects' specifications and estimates of the quantities, possibly checks the latter by his own computation, guesses at the interpretation which will be placed by the owner's representatives on the terms of the specifications and, from his knowledge of cost of materials and cost of labor, makes up a bid.

In a lump-sum contract the preliminary estimate of quantities is final, as are also the original plans of foundations, details, etc. Any changes must be a matter of settlement between the owner and the contractor. The latter takes all the gamble, and if conditions or quantities turn out more favorably than was anticipated, he wins; otherwise, he loses, or is tempted to decrease the cost to himself by some method which generally means a poorer grade of work than that contemplated in the specifications. If conditions turn out much worse than anticipated by the contractor, he may forfeit whatever bond he put up and leave the owner and bondsman to settle. The owner very often desires to change the plans as the work progresses, either to cheapen the job or to add new features or improvements, and as there is no basis in the contract for payment to the contractor for such changes, a new bargain must be made. Generally, it is almost impossible to let additional work to a new contractor, so the owner is at the mercy of the original one and must submit to whatever terms he offers or forego the changes. The lump-sum contract has all the seeds of misunderstanding, disputes, lawsuits and poor work; and not even the benefit of a pre-knowledge of ultimate cost, as there is almost invariably a long list of "extras."

"Item" Contracts

In "item" contracts, the award is made on the sum of the products of the units in each item multiplied by the bid per unit. In most engineering work, the preliminary estimate of unit quantities is necessarily approximate—often the owner is unwilling on account of cost or unable for various reasons to make the investigations which would afford a basis for an exact determination. This is especially true of sub-surface structures, but quantities even in superstructures cannot always be accurately computed in advance. This is one of the great sources of disappointment to the owner in the ultimate cost of work let under this form of contract —of gambling on the part of the contractor and of loss or unfair cost to both.

The contractor and the owner may disagree on the interpretation of the data for the estimate—the contractor backs his judgment by bidding low on items which he thinks are over-estimated and high on those which are under-estimated. His total bid is lower than he would be willing to take the work for if the preliminary estimate of quantities was known to show also the final estimate, but allows a fair or better profit if the final estimate approximates that made by himself. In other words, the owner thinks he is letting the work to cost one sum, and the contractor expects to receive another and larger sum. Badly unbalanced bids are often thrown out, but a skilful bidder does not make his unbalancing so raw as to justify this action. This kind of bidding is not, per se, unfair or dishonest, and the ability thus to bid safely may be truly a part of the contractor's equipment, but it results in disappointment to the owner when he finds his final estimate largely in excess of that anticipated. If, on the other hand, such bidding is merely a wild guess or due to optimism on the part of the contractor, it is a gamble pure and simple which, if unsuccessful, results in loss to himself and often to the owner.

Definition of Items

Item bids require as a basis a set of definitions. Some items are so self-evident that no confusion can possibly arise as to the meaning of the definition; others shade into other items, and it is hard to define the line of demarcation. Other items are described as containing certain materials in certain proportions, and any variation from these proportions constitutes a new item, more or less expensive. Another item is described as being a certain stock material or machine, and any variation ordered or permitted raises the question of cost to the contractor. The possibility and even probability of argument and variation in cost, due to varied reading of definitions or changes in details of items, could be elaborated almost indefinitely, but enough has been said to illustrate how fruitful of bills for extra cost this part of the specification can be.

The "item" contract is better than the lump-sum in that changes in plan, due to the development of the work or the meeting of unforeseen conditions and variations in unit quantities, can be adjusted under the terms of the original contract, if the items included in that contract can be reasonably construed to apply to the new conditions; but it is still limited by the items which can be so construed and which both the contractor and owner are willing to admit are fair as to cost under these new conditions.

Applying to both these forms are several factors which are taken into account in their bids by all successful contractors and for which all owners pay indirectly. Some of these are the clauses removing responsibility from the owner for the accuracy of the preliminary data; for errors in laying out work; for refusing to accept the action of the owners' inspectors at the time of actual construction and retaining the right of rejection to the final inspection; making the owner's engineer the final interpreter of his own specification and allowing him to supplement his drawings and specification in any way, in order to make the meaning conform to this interpretation. The contractor has to take the gamble that the original data are reasonably accurate, that the work of laying out will be carefully done, or else maintain an engineering organization to check the work—for which duplicate organization the owner will pay—that the engineers will be just, and that the original engineer will remain in charge throughout the life of the work.

Test of Material Requirements

Many specifications require tests of material which, if rigidly enforced, would often cause great delay and expense to the contractor or the carrying of a large stock, entailing interest charges, storage space, rehandling and other expenses. The contractor usually expects that the purchase of material from well-known manufacturers or certificates from them will avoid the enforcement of these clauses, but if he is wise, he considers the possibility that they may be insisted on, and bids accordingly.

In short, the tendency of the entire specifications is to remove responsibility from the owner and his representatives and place it on the contractor; also, all the gamble on weather, foundations, changes in labor and material market, and every other unknown or unknowable factor is carefully unloaded on him.

The contractor accepts all this, but the owner pays. The individual owner may save money, because the gamble went against the contractor on his job, but his neighbor loses, because in the long run the contractor must make money to

*A paper presented before the American Society of Civil Engineers and printed in the Proceedings, Vol. XLV, No. 6, pp. 443-449.

live. The owner may lose by a contractor being too optimistic, getting a job partly done and then being unable to finish on account of high costs; readvertising, reletting and delays follow, or else the bondsmen finish the work at a loss to themselves, which loss is passed on to other owners.

If a contractor makes an unexpectedly large profit, however, on Job A, he does not reduce his bid on Job B, in consequence, so that it is only the losses that are passed on to other owners and never the gains.

"Cost Plus" Contracts

In "cost plus" contracts, the owner accepts all risks, all costs, and receives the benefit of all favorable conditions; each job carries its own load only, without the addition of losses on other jobs and without the percentage added by the contractor to offset possibly unfavorable conditions, ambiguous specifications, or captious owners.

The specifications and plans may be as general or as specific as the owner desires; changes can be made, difficulties met, and advantage taken by the owner of special machines, material and methods.

The contractor furnishes the plant, organization and expert knowledge of construction and buying; the owner supervizes the work and pays the bills.

In the case of "cost plus" contracts, the contract and not the specifications is the crux of the matter from both the owner's and contractor's viewpoint, but the writing of the contract is more simple than the writing of the specifications. It is necessary first to define what expenses are to be borne by the contractor, as not part of any one job. These may be head office expenses, salaries of chief officers whose time is spent only in part on the job, traveling expenses, except as agreed on, the contractor's auditors, timekeepers, or material checkers. Second, to define what expenses are to be borne by the owner and are to form the basis for the fee. Such expenses would include the cost of materials purchased through the contractor, the cost of labor of all grades, and the cost of rental of plant. Third, to define what expenses are to be borne by the owner, but which are not to be included in calculating the fee to the contractor. These might be engineering services, inspection, owner's timekeepers and auditors, and the cost of specified material which the owner elects to purchase and deliver to the contractor.

The approval of the owner would be required for all purchases of material both as to the necessity for the purchase and the price paid. The owner may reserve the right to enter the market with the contractor, purchase any material he can buy cheaper than the contractor, and deduct such cost from the total cost of the work for fee calculation. The owner would have control of the number, grade and wages of all classes of labor, and, of course, would pay all insurance charges.

The sliding percentage with maximum fee, as used on government work, could be applied to any contract, large or small.

Basis of Contracts

Contracts could be let on the basis of fee demanded, both percentage and maximum, on the size, adaptability and condition of the plant controlled by the bidder, and on his experience, reputation and the size and character of his organization.

It is true that the interest of the owner to keep down the cost, and that of the contractor to receive a large fee, would clash, but that is controlled by the sliding percentage which can be arranged to give an actually larger fee for smaller total cost, and by the maximum fee which is based on the owner's estimate of total cost.

Capable, honest, efficient contractors would fare well under this form of contract; the opposite kind would soon find it impossible to secure work. Engineers of the two classes would meet the same fate as the corresponding contractors. The engineer would no longer be supposed to act as an arbiter when he is paid by one of the parties to the contract to supervise the work of the other and to secure work conforming to specifications and plans which he himself has drawn. The engineer is always biased, and no matter how hard he tries to be fair or how cordial the relation between himself and the contractor, in case of argument, the latter bears the burden of the proof. For this state of affairs the owner pays, and the successful contractor is one who has added enough to his bid, in one way or another, to make up for the losses he suffers due, not to the work itself, but to the specifications. The writer believes that, given the same men as owner, engineer and contractor, a cheaper and better job can be secured by the owner, and, in the long run, more profitable business to the contractor by the "cost plus" contract than by either the lump-sum or item bids. The owner will not be confronted by bills for extras, vexatious claims for adjustment due to different interpretation of the specifications, lawsuits with their attendant cost, and the perpetual chance that, in spite of inspection, poor work will be done by the contractor in order to secure a profit on an underbid item. The contractor will be sure of a reasonable return on his investment in plant, he will not have to pay for special plant of use to him only on that one job, or to carry the burden of the gamble on unknown or unknowable factors.

Weakness of "Cost Plus" Contracts

The gamble belongs to the owner who gains or loses by the location of the site, the season of the year in which the work is done, the state of the market for men, materials and money and circumstances other than strictly construction work, which affect the cost of the structure; and when contractors are relieved of this gamble, they can bid closer, they can put their energy and knowledge into efforts to turn out good work, and not be constantly on the watch to cheapen the work for their own benefit—maybe salvation—and the owner's harm.

It will be for the owner and his engineer to say where to cheapen, when to spend, to pay extra prices, if they wish, to speed up work, or secure quick delivery. The job is the owner's; he should handle it and take the profits and the losses.

There can be, of course, great dishonesty under "cost plus" contracts, but, if this occurs, it is the owner's fault in lax supervision of his own forces or from incompetent or dishonest engineers.

It is hoped by this paper to obtain an expression of opinion as to the wisdom of substituting "cost plus" contracts for the other forms. At the present time, municipal work is usually required by law to be let to the lowest bidder, and any violation of the custom, even when the law permits, affords a basis for accusations of graft on the part of the officials responsible, no matter how self-evident the lack of ability of the low bidder may be.

If "cost plus" contracts can wisely be substituted for the other forms, the writer conceives it to be a timely occasion to endeavor to have the laws amended so that municipalities as well as individuals can take advantage of it, and also to draft a standard form of contract sufficiently elastic to be adaptable to all usual work, so that the possible disadvantage may be reduced to a minimum and that dishonest officials may be prevented from discrediting a method which, in the hands of honest men, can certainly produce economical, rapid and good construction.

ALBERTA LAND SURVEYORS' ASSOCIATION

THE annual meeting of the above organization has just been held at Edmonton, and the following officers for 1920 elected: President, Lieut.-Col. G. W. McLeod, of Edmonton; vice-president, F. H. Peters, of Calgary; secretary-treasurer, B. F. Mitchell, Edmonton; councillors, J. H. Smith, J. A. Buchanan and W. H. Waddell, all of Edmonton; auditors, R. H. Cautley and H. E. Pearson.

Ald. Herbert Wilson has been elected president of the Builders and Contractors' Association of Windsor. Other officers for 1920 are: Vice-president, William Walker; recording secretary, A. J. Loosing; secretary-treasurer, Charles E. Padden; directors, L. McGill Allen, J. Reid and A. L. Laing.

The Canadian Engineer

Established 1893

A Weekly Paper for Civil Engineers and Contractors

Terms of Subscription, postpaid to any address:

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

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

President and General Manager JAMES J. SALMOND
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GROWTH OF INTEREST IN TOWN PLANNING

AN interesting announcement was made this week to the effect that the University of Toronto had established a course in town planning, with Mr. Thos. Adams as lecturer. The course is designed particularly for students of the senior years in civil engineering. This is, according to Dean Mitchell, but the commencement of a new series of courses, embracing the broad principles of civics generally, town planning and landscape architecture.

This announcement is significant of the general interest which is being shown all over Canada on the subject of town planning. This interest is not confined to any particular class, but all who are at all public-spirited and have the best interests of the country at heart are becoming more and more seized of the importance of dealing with this problem before our communities have grown to such proportions in a haphazard fashion as to make the task of effecting changes, to say the least, very discouraging.

City planning, in reality, should begin with the inception of the city, and the first step is to so locate the city as to provide the particular physical features which experienced city planners will have decided are necessary.

The locating of a site for a new town raises many questions which must be dealt with in order to effect a well-planned city. The position of railroads already constructed or possible; the highways to and from cities already established and their distance from this embryo city; the natural and artificial waterways, with possible facilties for makng use of them for commerce; the topography of the site, which will affect the economic and healthful distribution of the residents; the cost and utility of improvements; the supply of water, fuel and other necessaries of life are all factors requiring earnest attention.

Following the location of a city comes the laying out of streets and the zoning of the city into districts for residential, business and industrial or manufacturing purposes, and the planning of parks and other public places. Street planning and zoning are interdependent, for traffic and other conditions vary according to the district. Problems relating to parks and public buildings are also intimately related to the street plan. Street planning includes location, width and improvement of the roadway, which features involve considerable study as to how best serve the citizens in providing means of transportation for themselves and the commodities used by them from one part of the city to another. The multiplication of the lines of communication determines the layout of the streets. Intercommunication by telephone and telegraph, and the proper spacing of buildings for santitation and harmony, also enter into this problem. Easy and safe grades are desired, and the widths of streets required are those which will give ample room for traffic purposes, for pavement and public utility accessories, and for a plentitude of light and air to buildings. The general adoption in Canada of a limit of sixty-six feet in least width has undoubtedly been a good thing, for there has thus been secured a street entering the class of a secondary thoroughfare.

Buildings and structures of all kinds demand much detailed design. A small cottage should be so designed as to be of good appearance and comfortable, and so placed on its lot as to obtain the maximum of fresh air and sunlight, consideration being paid to the utility of the remaining space. More important buildings require increased attention to these details and to others peculiar to their class. The height of business buildings may be accurately figured out to provide the greatest degree of economy, utility, beauty and sanitation, and service connections to buildings from sewer, lighting, power, heating, telephone and other public utility systems present important features in the design.

City planning must include the design of transportation systems, yards and docks, and lands segregated for industrial use. Parks and playgrounds must be made to serve their purpose, and innumerable other items have to be planned in laying out and constructing a city, in which work the engineer plays a large part.

The work which the wise town planner can do, and is doing, for some communities should be enough to convince the most rabid anti-town planner of the wisdom of looking well ahead when this all-important subject is under discussion.

SCIENCE AND ENGINEERING

ALTHOUGH there is no distinct line of demarkation, one is often led to believe that the relationship between science and engineering should be more clearly defined. If engineers would more generally recognize that there is a line of demarkation, it is less likely that in many cases they would enter upon schemes of an impracticable and, therefore, wasteful character.

It is true scientists and engineers are both engaged in a study of the forces of nature and of ways and means to properly control these forces, so that they may be rendered more serviceable to mankind. But the work of the scientist precedes that of the engineer. It leads him into unexplored fields and reveals the suitability of these fields for exploitation and development; such is the work of the purely scientific man. Nevertheless, it is perspective in nature, and must eventually pass the muster of a combination of engineering and business ability before it is presented to the world for assimilation and use. In other words, the purely scientific mind must relinquish its conquest to the engineer and the financier in order that it may be judged productive and worthy of development. It is at this point that the engineer takes hold of the problem. If he intrudes earlier than this he is encroaching on the field of the scientist and hazarding his reputation as a reliable engineer.

Some time ago the dangers of a situation such as this were well portrayed in "Engineering," of London. That article went on to say: "It cannot be denied that many engineers are inclined to become too much absorbed in the purely technical aspect of engineering, and to regard their profession a little too much from a standpoint which, though perfectly legitimate in the case of a physicist, is improper in the case of men whose labors are expected to contribute directly and immediately to the wealth of the world.

The engineer who interests himself solely, however, in the scientific aspect of his profession greatly reduces his opportunity to benefit his kind, and often is indirectly responsible for much wasteful expenditure. The complaint, for instance, is often made that funds appear to be easily found for financing engineering schemes of the most impossible and impracticable character, whilst really reasonable schemes go begging. Were those responsible for the latter better acquainted with the ways of business men there would be a fair chance of diverting into productive channels resources which are now just as truly wasted as if they were invested in a timber limit and immediately fired."

MEETING OF THE ONTARIO SECTION OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

On Monday evening, February 2nd, a meeting of the Ontario Section of the American Society of Mechanical Engineers will be held at the Engineers' Club, 96 King St. West, Toronto. Supper will be served at 6.30 p.m., after which an address on "Industrial Relations" will be given by Mr. R. W. Gifford, superintendent of the Massey-Harris works, followed by a discussion. Mr. Calvin W. Rice, New York secretary of the A.S.M.E., will be at the meeting and will also speak. Tickets for the supper may be obtained from the secretary, C. B. Hamilton, Jr., 43 Madison Avenue, Toronto.

NEW ENGINEERING PUBLICITY

One of the means that will be employed by the American Association of Engineers to promote engineering publicity throughout the United States is through a co-operative arrangement with the producer of several moving picture weeklies. Arrangements have been made with the producers of six screen weeklies whereby the association will furnish lists of engineering projects and works, photographs of which will interest the public. After the film people have been notified of some engineering structure or event of sufficient interest, they will communicate with their correspondent living nearest the scene of the work or event, and he will either take stills or film, as the situation merits.

"In order to make this project successful," says the secretary of the association, "we will require the active assistance of every professional engineer. Officials of corporations or construction companies who are doing or having done noteworthy construction work, or who are building or installing unusual or otherwise interesting types of machinery, engineers in charge of construction work who are developing new methods or who know of spectacular or otherwise interesting features in which the public will be interested, can make this service a success by advising us of such projects as will warrant photographing.

"There has never been a time when the general public was so interested in mechanical and other engineering pictures. The time is propitious for developing in the mind of the public a greater appreciation of the part which the engineer plays in society."

At the annual meeting of the Architects' Association of the Province of Quebec, the following officers were elected for the ensuing year: President, D. MacVicar, Montreal; vice-president, E. Payette, Montreal; 2nd vice-president, L. Auger; secretary, Jos. Perreault, Montreal; treasurer, E. Muller, Montreal.

PERSONALS

W. H. Moore is the new chairman of the Peterboro Utilities Commission.

Sir Adam Beck has again been elected chairman of the London and Port Stanley Railway Commission.

J. E. Green, of the firm of C. D. Howe & Co., has been retained as consulting and supervising engineer for the new reinforced concrete Louise bridge to be built at Calgary. The bridge is estimated to cost about $200,000, and tenders are being called on an unit basis.

Thomas Lowes, formerly town engineer of Mimico, and inspector of sewers in New Toronto, left on January 17th, for a three-year stay in England. Mr. Lowes was formerly a partner in the firm of Murray and Lowes, Toronto. Six years ago he was appointed town engineer of Mimico.

Norman S. Cumming has been appointed superintendent of the Canadian National Railway lines, with headquarters at St. Catharines. Mr. Cumming, who, for several years has been an official of the Dominion Power and Transmission Co., will supervise the electric railways running between Niagara Falls, Port Colborne, Welland and St. Catharines.

S. E. Craig, B.A.Sc., has been appointed 2nd vice-president and district manager of the Montreal office of the Canadian Inspection and Testing Co., Ltd., in place of Mr. T. S. Griffiths. Mr. Craig graduated from the University of Toronto in 1904 with honors, and was engaged with various engineering corporations until 1912, when he joined the Canadian Inspection and Testing Co.

TORONTO POWER CO. OBTAIN $800,000 FOR POWER SUPPLIED DOMINION GOVERNMENT

On reducing their claim from $1,200,000 to $800,000, the action of the Toronto Power Co. against the Dominion government for power supplied to the Ontario Power Co. on the order of the Federal power controller, was settled out of Court. The Ontario Power Co. is to pay $510,000 of the claim and the Dominion government will pay the balance.

In regard to the power charge, the government has admitted that there is justification for a claim for power supplied to the Ontario Power Co., but hold that if there was to be any payment, then the Ontario Power Co., which is now the Ontario Hydro-Electric Commission, must re-imburse the government for any moneys paid out in this action.

A second action involved was that of the Niagara Park Commissioners against the Toronto Power Co. for water energy used in the production of the hydraulic power supplied under these orders. Mr. Justice Middleton, in a judgment on this point, had ruled that the Toronto Power Co. was entitled to a maximum of 124,000 h.p., and that any amount over this which was used the park commission should be recompensed for. The park commission therefore claimed if any money was to be paid for this power it should go to themselves. This case will be heard Friday, January 30.

The Dominion government takes the attitude in this action that it was waste water that was utilized. The water, it is claimed, is public property, and if not used for the production of power would not have been utilized for any other purposes until it has flown past the domain of the park commission.

This phase of the action has an international aspect, and it was stated may go before the Privy Council before there is a final pronouncement on it. The question of the water rights between the provinces and the Federal government is involved, as is also the question of using water from a navigable stream and from an international stream.

A copy of *The Canadian Engineer* for January 15th, 1920, is wanted by a subscriber. Will any reader who has no further use for his copy of that date kindly forward it to the office of *The Canadian Engineer*?