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IMPACT FORMULAS FOR HIGHWAY BRIDGE DESIGN

Part I.

A BRIEF HISTORY OF TWO RAILWAY BRIDGE IMPACT FORMULAS, SHOWING THAT THEY ARE UNSUITED FOR HIGHWAY BRIDGE DESIGN.

By **E. H. DARLING**, M.E., A.M.Can.Soc.C.E.

OVER a hundred years ago, in 1807, Thomas Young first announced the general principle of the properties of bodies "to resist impulse." This property, to which he gave the name "Resilience," is the capacity of a body to endure, absorb, or store up the work which may be done on it and give it out again under proper conditions.

As a simple example of this, when a tensile force is applied to a bar of steel, the bar is extended and work is done by the force. The work is absorbed by the bar and by the law of conservation of energy the internal work in the bar must equal the applied external work. When the external force is removed the bar assumes its original length, giving out as it does so the stored-up work which is, by definition, the resilience. Wherever in engineering structures there is compression, extension or deflection (provided the elastic limit of the material has not been exceeded) we have examples of resilience.

This property is of the utmost practical importance in engineering. Were it not for it a structure, no matter how strong under static loads, would be liable to be shattered by a light blow. Glass is an example of a material with low resilience and we are quite familiar with its "brittleness" and its inability to withstand a shock. But even a bar of iron or steel can be broken with a surprisingly small amount of work. A bar of steel having one square inch section area and a modulus of elasticity of 29,000,000 will require only 17.6 foot-pounds of work to stretch it to its elastic limit of 32,000 lbs.

If the bar were 10 feet long or 10 square inches in section it would take ten times as much work to stress it to the same point. So that the resilience of a bar or a bridge member varies as its section and length, or, which is the same thing, as its volume.

But the absorption of work is not quite instantaneous, although very rapid. Stress is said to travel in steel at the rate of about 17,000 feet per second—the same rate as sound. Rapid as it is, it is still slow enough to make it an important consideration. If the force be applied to the bar instantaneously by striking it a blow it is possible to stress the metal at the point of contact beyond the elastic limit or even the breaking point before the rest of the bar can absorb the work.

After Young, there was considerable investigation and discussion of the subject, but it was first put into practical form, as far as the engineering profession is concerned, in 1849, when an extensive series of tests was made in England by a "commission appointed to inquire into the application of iron to railway structures." The result of their report was that the British Board of Trade established the rule that for cast iron the factor of safety for live loads should be double that for dead loads. This rule was largely used for many years and became accepted as a general principle to be applied to live loads of any kind or however applied. It is based on the fact that a suddenly applied load, *i.e.*, one which reaches its maximum value the instant it is applied, does produce twice the stress in a structure that it would if it were applied gradually.

If a tensile force p be applied suddenly to a bar and extend it a length λ the work performed on the bar will be $p\lambda$. But in absorbing this work the stress in the bar increases from zero to p_b so that the work absorbed equals $\frac{p_b \lambda}{2}$.

As the internal work equals the applied work

$$p\lambda = \frac{p_b \lambda}{2} \text{ or } p_b = 2p$$

If the force were applied gradually p_b would equal p.

All the experiments of the above-mentioned commission were performed on cast iron and the experimenters failed to detect the elastic limit of the metal, as in this material it is so near the breaking strength. Besides, testing machines did not reach a sufficient degree of refinement to permit an accurate study of materials under stress until thirty years later. The commission, however, detected a phenomenon in materials subjected to repeated stresses which was called "fatigue." This subject was carefully investigated by Woehler between the years 1859-1870, and he established the principle that when a bar iron was subjected to a varying stress a number of times (sometimes it took an enormous number) it broke at a stress less than its maximum strength, as shown by a static test. This stress he expressed as a function of the ratio of the maximum and minimum stresses.

His principle was at once adopted in the design of iron bridges and was made applicable by suitable formulas by Launhardt and Weyranch. These formulas replaced the simple method of doubling the live load stress and they persist to this day in one form or another.

The fallacy of this method lies in the fact that Woehler's principle applies only to materials stressed beyond the elastic limit and it does not apply, and has no meaning, if the stress is below this point. As some one has said: "If we were designing a structure so that it would *fail*, then Woehler's formulas would be the correct ones to use.'' However, the early designers were consistent to this extent, that they worked with the ultimate strength of their materials but took care to apply a sufficiently large factor of safety to bring their working stresses within the elastic limit.

Another fault of this method is that it confuses ''fatigue of material'' with stresses due to sudden loading. Fatigue is the evidence of ''permanent work'' done on the material while the impact formula in bridge design is an attempt to express the stresses caused by ''temporary work.'' Impact is a property of the applied force depending on the way the load is applied, and it is only when resilience of the material is destroyed that fatigue appears.

But to return to our history. It was Bauschinger who proved that Woehler's rule did not hold good below the elastic limit, and in 1877 Prof. Winkler, of Berlin, first suggested that the dynamic effect of the live load should be considered in addition to its static effect. (Trans. Am.Soc.C.E., Vol. 41, p. 172-174.) In other words, his suggestion was that the effect of impact should be treated as an increase in the live load rather than a mechanical effect on the material of the structure.

The effect of simple impact on a bridge may be roughly analyzed if the word is used in its correct sense, meaning the effects due to the stopping of a moving body. When such a moving body strikes a bridge the kinetic energy or work stored in it must be dissipated in one way or another. There are three stages in the process. First, the motion of the moving body will be imparted to the particles of the structure and set them in motion. If the structure were free to move and perfectly rigid in itself all the energy would be thus transferred according to the laws of motion. Only such stresses would be developed as would be necessary to transfer the motion to the distant particles of the structure. However, as bridge structures are not rigid and are anchored to their abutments the particles move as far as they can and the total effect is what we recognize as deflection. This is the second stage. Some parts will be compressed and others stretched. Even the abutments are never absolutely rigid and will therefore also be affected. By this action the structure absorbs work and the process goes on until the sum of the internal work equals the work imparted by the moving body. But this is not a state of equilibrium, so a series of oscillations or vibrations begins which lasts until all the surplus energy has been converted into molecular work or heat. If at any instant the stresses in any part of the structure exceed the elastic limit, permanent work will be done and the structure will not regain its original shape. Its capacity to absorb work—its resilience—has been exceeded and it cannot give back all it received.

When a train moving at a high rate of speed passes over a railway bridge there is doubtless increased stresses due to sudden loading as defined above. There are also innumerable blows, shocks, jars, etc., too complicated for analysis. The result is that stresses are produced above those that the train would cause if at rest on the bridge. This difference in stress between what would be the static stresses from the live load at rest and the actual stresses, however produced, is what is covered by the ''impact increment'' of modern specifications.

Joseph M. Wilson in 1885 first introduced in America the method suggested by Prof. Winkler, but the most widely used formula was first brought into systematic use by the late C. C. Schneider and published in the specifications of the Pencoyd Iron Works in 1887. (Trans. Am. Soc. C.E., Vol. 34, 1895, p. 331-2.) Mr. Schneider had collected some data of experiments on existing bridges to ascertain the effect of passing trains and from this he developed the formula

$$I = L\left(\frac{300}{s + 300}\right)$$

In which I = impact increment to be added to the static live load stress L; s = loaded length of span producing the stress L.

It is an interesting fact that since then the American Railway Engineering Association, after making thousands of measurements on existing bridges, recommended this formula, and it is now widely used in railway work.

It will be noted that in this formula the value of I, the impact increment, depends only on s, the span length, or that part of the span which, when loaded, produces the maximum static stress. For a train moving at a uniform rate of speed the length s will determine the time required for the live load to reach its maximum, so that the value of I really varies inversely as the time required to apply the load and thus takes care of sudden loading. Also, as the longer spans will usually have the longer members this formula may be considered to insure that short members have a larger impact increment than the long ones. No account is taken of the inertia of the structure nor the relative mass of train and bridge since it is used for all types of spans and for this reason many engineers were not satisfied with it but favored a formula developed by Henry S. Prichard.

Mr. Prichard derived his formula by ''starting with Launhardt's and modifying it to accord with the results of a study of all data bearing on the subject which was available,'' and in 1895 published it in the revised specifications of the New Jersey Steel and Iron Company. (Trans. Am. Soc. C.E., Vol. 41, p. 503.) This formula is

$$I = L\frac{L}{L + D}$$

I = impact increment;
L = live load stress;
D = dead load stress.

The impact increment in this formula depends only on the relative magnitudes of the dead and live load or, in other words, the relative mass of the bridge and the train. No account is taken of the speed at which the train is moving, or the length of span. In later specifications which use this formula, such as the Dominion Government, 1908, in order to correct this defect, the live load stress is first multiplied by a factor varying with the length of span and the product is used as L in the above formula. The factor is

$$\left(1.40 - \frac{s}{200}\right)$$

This is only used for spans under 80 feet.

It will be interesting to compare the relative values of the impact increment as obtained from these two formulas. In order to do this the values of I, as given by them, have been plotted as curves in Diagram 1. The ordinates give the values of the impact increment in percentage of the live load for spans up to 200 feet. As the Prichard formula depends only on the ratio of the dead and live load, two curves are shown—for dead load equal to zero, and for dead load equal to live load.

It will be noted that the Schneider formula gives values about an average between the other two curves. In actual design the relation between the dead and live loads is such that the results are about the same whichever formula is used, except for very short spans and heavy loading, under which conditions the Prichard formula gives higher values. The Dominion Government formula gives much higher values for spans under 80 feet.

After all, this similarity of the two formulas is what one would expect when it is remembered that they are both empirical formulas based on measurements and experiments made on railway bridges. This is the point that the writer wishes to emphasize. It at present seems utterly impossible to express by means of a rational mathematical formula the effects of shocks, blows, jars, etc., which will be generally true for all structures and all manner of moving loads. Given a certain uniform type of structure and method of loading, it is quite possible to obtain a factor or formula which will give more or less accurately the equivalent static stress for moving loads but it would be rather a strange coincidence if the formula thus obtained for railway bridges should be found to be in any way suitable for any other structures, such as highway bridges not carrying street cars. Until it has been shown conclusively that railway bridge formulas or some modifications of them are generally true for all bridges they should not be so used, for the conditions of loading are very different, as may be seen from the following detail comparison.

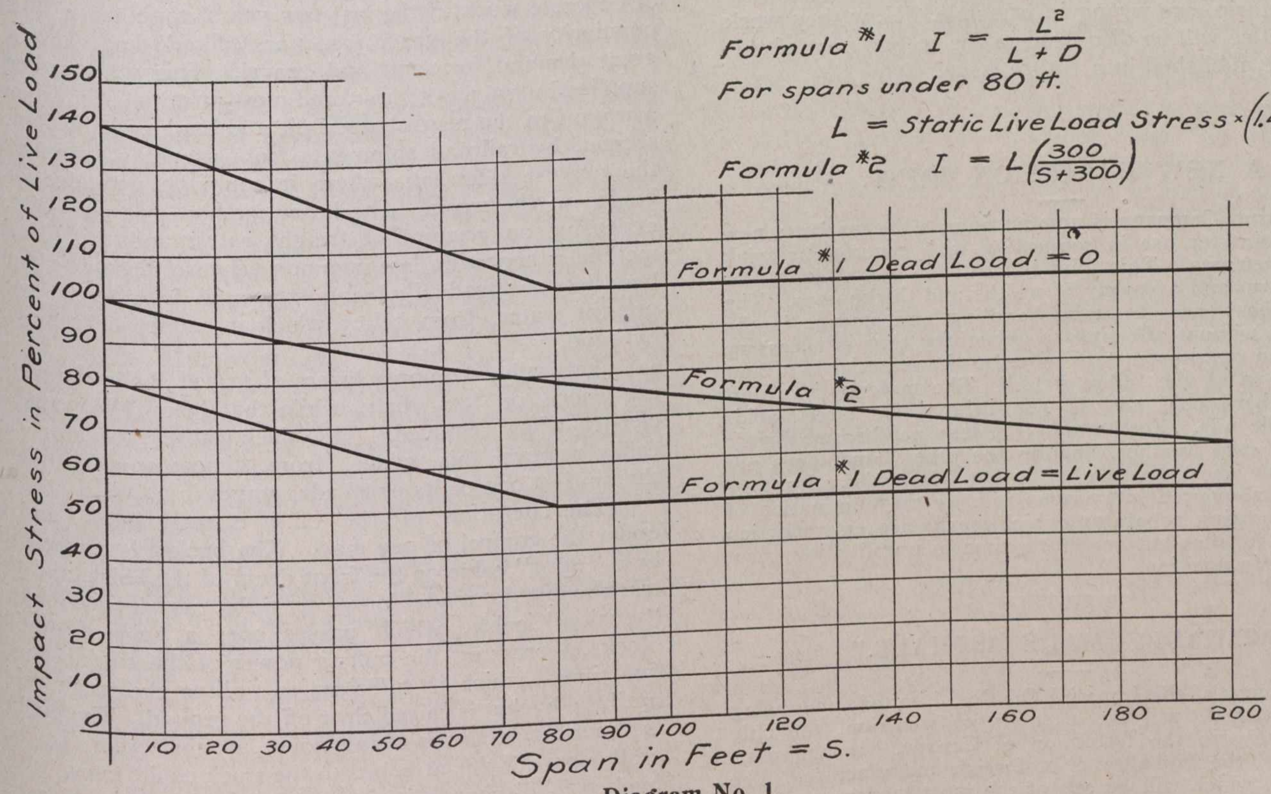

Diagram No. 1.

The impact increment in the design of railway bridges is supposed to cover the stresses produced by the following conditions:

(1) True impact due to sudden loading caused by the maximum engine and train loads travelling at a high speed.

(2) Pounding of unbalanced parts of the drive wheels, etc.

(3) Pounding of wheels at open joints and of flat wheels.

(4) Swaying of engine and top-heavy tender and other loads.

(5) Vibration and jarring of machinery in motion; the "noseing" of the engine and jolting of cars.

(6) Rhythmic motion set up in the structure due to the synchronism of the blows from the train with the period of vibration of the bridge.

(7) Every other uncertainty in the magnitude of the loads and their application, including possible derailment and future increase.

Effects somewhat similar to these will doubtless be produced in highway bridges by their loads, but the conditions are so entirely different that the results are quite modified. We have the heavy concentrated load producing maximum stresses in the floor beams, stringers and short spans; and the uniform or distributed live load of a much smaller order of magnitude which develops the maximum stresses in the trusses of spans above a certain length. But their liability to cause impact stresses is not the same as a train passing over a railway bridge, as a comparison with the above items will show.

(1) It is not necessary to consider such a thing as true impact due to high speed for a highway bridge. The experiments of the committee of the American Railway Engineering Association, mentioned above, found that impact stresses were inappreciable for speeds below 30 miles an hour. In highway traffic the only live load that exceeds this speed is the motor car. But the heaviest motor car is so much lighter than the road roller for which provision must be made that there is, in a properly designed bridge, an ample factor of safety for the high-speed car. It is true that the 20-ton motor truck is in sight, but its speed is about 10 or 12 miles an hour, and it is far from likely that they will be permitted to travel on highways at the rate of 30 miles.

(2) There is no analogy in highway bridge loads to the pounding of unbalanced drive wheels of locomotives. This is a very important consideration in railway bridges.

(3) The bumping of heavy loads over rough floors, stones, etc., may be compared to the pounding of wheels at open rail joints, but the conditions of highway bridge floors are often such as to aggravate this effect relatively beyond anything that occurs in a railway bridge.

(4) There is the same analogy in swaying of top-heavy loads, but this effect is also associated with the

concentrated load and cannot affect the truss of any but short spans.

(5) Vibration, jarring, jolting, etc., apart from that covered by item 2, need not be considered in highway bridges.

(6) Rhythmic motion set up by the uniform live load on long spans is a possible contingency. In spans which are relatively long for their width there is likely to be a swaying effect in a high wind. Stresses caused by these conditions are probably the only kind of impact stresses that need to be considered in the trusses of highway bridges.

(7) Much uncertainty exists as to actual stresses in highway bridges as well as in railway bridges, but it will be generally admitted that the uncertainties in the former are within much narrower limits than in the latter.

In consideration of all the above facts, it seems to the writer to be quite evident that the question of impact in highway bridges should be considered by itself and that the present methods and formula (at least those commonly used in Ontario) are wrong in principle. How they work out in practice will be discussed in the second part of this paper to be published in a future issue.

A NEW EXPANSION JOINT.

The Barrett Company is now putting on the market a new expansion joint for use in connection with concrete or brick or block pavements. This joint is mastic in character, comes in ribbon form and a variety of widths and thicknesses. The requisite cohesiveness to stand handling and storage in the ribbon form without affecting the elasticity that is necessary for expansion requirements, is given to the material by a new process known as the "fibre weld." The material is waterproof, weather-proof, and is not injured by street acids or automobile oils. Furthermore, it does not become brittle with age or cold weather, and on the other hand, does not soften or run when the weather is hot. Its chief advantage over the usual poured bituminous joint is the elimination of pouring or heating apparatus, which means a great reduction in labor, as it takes but very little time to unroll a joint, cut it and put it in position.

"CANADIAN-MADE ASPHALT."

The refinery of the Imperial Oil Co., Limited, now being built in Montreal, will be, after its construction, the only asphalt refinery in the Dominion of Canada. In the past, practically all the asphalt was of foreign manufacture. The new refinery, which will be one of the most modern and best equipped ever constructed, is for the refining of crude asphaltic oils of the highest grade exclusively, producing thereby the best material possible for the making of asphaltic roads. The equipments of the plant consist of 14 large crude oil stills, many special reductors, and pressure distillators and agitators, and a special factory for the manufacture of metal containers in which, with the aid of tank cars, the material will be shipped. The plant will have a capacity for crude and manufactured products of over 600,000 barrels.

The refinery is located at Montreal East, on a piece of ground containing more than 55 acres, fronting the St. Lawrence River. The property runs over one mile north, crossing Notre Dame Street to above the Canadian Northern Railway Co.'s tracks. The company has on the river front its own wharf, the depth of water being sufficient to permit ocean-going tank vessels, transporting crude oil, to dock at the wharf. The shipping facilities by waterway, either in bulk or in packages, are of a great advantage.

As to the shipping by rail, the Imperial Company has the Canadian Northern Railway and the Montreal Tramways Co. at its disposal, and later will have the Harbor Commissioners' Railway.

This modern installation represents an expense of more than $1,250,000, and when in full operation should employ at least 3,000 men.

TYPES AND COSTS OF SLACK CABLE EXCAVATOR PLANTS.

A FEW years ago the slack cable method of excavation was not well known, and was used only in a few isolated places. Lately, there have appeared on the market, however, a number of excavators employing this principle, and the idea is becoming more popular. This type of excavator, which has been described by A. A. Smock in The Contractor, consists of four essential parts: (1) the bucket; (2) the cable upon which the bucket is hung; (3) the mast, to the top of which the slack cable leads; (4) the engine that controls the operation of the outfit. There are numerous buckets for this use, each designed under some special patent and possessing features that distinguish it from others.

The excavators may be used for soil stripping, handling of coal, ore, rock, or other loose material, and especially for gravel excavation. The increased amount of concrete work in the last few years, together with the popularity of the gravel road or "pike," has caused a great demand for sand and gravel. This was formerly supplied in two ways; first, and most primitive, by driving a wagon to the nearest open pit and loading it by hand; second, by railroad shipments from source of supply to the nearest sidetrack, where it could be unloaded and hauled to the work. The latter method was and still is expensive on account of freight rates, and the former method is becoming less common because these neighborhood pits are gradually being excavated down to the ever-present water, from below which it cannot be removed by hand.

Naturally, the upper layers of gravel above the water are more or less dirty, while that below the water is cleaner when removed. The slack cable excavator can easily remove this gravel from almost any depth and therein lies one of its chief advantages.

The operation of the outfit is very simple, and is under the control of one man. The bucket is brought in by a "drag" cable on the front drum of the hoist, and the track cable is made loose or tight, as desired, by a "tension" cable, which passes over a pair of double blocks, increasing the pulling power of the engine about five times, which is sufficient to tighten the track cable until the bucket is raised clear off the ground. The bucket is drawn in to the dumping point, at which there is generally some device attached to the track cable, causing the bucket to discharge its load, after which it is released, rolling down the tight cable by gravity. The cable is then loosened, allowing the bucket to rest on the ground in its natural digging position ready to repeat the operation.

The power must come from some kind of a double drum hoist, either steam or electric. The most popular size is the one-yard bucket, which is generally operated by an ordinary contractor's double-cylinder, double-drum hoist, sixe 8 x 10, although smaller engines will suffice in easy digging. If electric power is used, the best hoist is a direct-connected one with a system of gears enabling the bucket to be drawn in slowly with great power while loading, and then to be drawn up to the dumping point more rapidly with less lower. In this case, a 50-horse-power, variable-speed motor is sufficient. In occasional plants where electricity is low in cost, the bucket is sometimes operated by means of a hoist which is belt-connected to a 60 to 70-horse-power motor, the larger size being required on account of the loss due to belt slippage, and also on account of the motor running at a constant speed.

The average time required to make a complete trip with the bucket is found to vary a great deal, on account of the difference in the material, the speed of the engine, and the skill of the operator. The average outfit uses the ordinary hoist engine, which has a speed of about 200 feet per minute. Thus on a 400-foot span, 2 minutes are required to haul in the bucket and about 1 minute to dump it and return it ready for another load—3 minutes per trip. This will be found to be a very conservative figure, for many plants run as high as 40 trips per hour. Much time can be saved by using a two-speed hoist, arranged to run at about 150 feet per minute under a heavy pull, and at about 450 feet per minute under a lighter pull, thus bringing in the bucket in 1 minute instead of 2, and enabling the operator to get out 30 buckets per hour under similar conditions.

The commonest form of gravel plant is the "bar run" outfit. This consists merely of the bucket, cables, mast and engine, digging the gravel from a pit or creek-bed and depositing it on the ground in a pile. Many such outfits are in use in various locations, and are generally called "gravel dippers," the owners, as a rule, making a business of "dipping" gravel for townships, road supervisors, contractors or private individuals.

In or near cities where strict specifications are enforced regarding the gravel used, it is customary to erect screening plants to wash the sand and gravel thoroughly and grade it into sizes. These plants present an interesting study, but it is not our purpose to enter here into a discussion of their details of design and construction. There are many kinds of screening outfits, the simplest kind having an elevated table upon which the gravel is dumped, and from which it is washed by a stream of water through an inclined trough, in its course passing over inclined screens that give the required separation. The most complex plants with the greatest output and most efficient operation are more expensive, being equipped with revolving screens, washing tanks, crushers, overhead bins, etc. Between these two limits there are endless varieties of screening outfits.

Cost.—The following estimates of the cost of plants are based upon new material throughout, although in actual practice much second-hand but serviceable material is used, such as old lumber, second-hand cables, and engines. The "bar run" outfit, with a one-yard bucket, costs, complete, including a reasonable allowance for freight, erection, etc., about $2,250, while a screening plant of the more simple type, including a water pump and the screen towers, will be about $3,000, which is subject to increase on account of bins, crushers, etc., to sometimes as high as $10,000.

Operating Cost.—The average bar run outfit, with a one-yard bucket, can easily excavate, with the ordinary engine and engineer of average ability, 250 yards per 10-hour day, often running much higher or lower according to conditions. Many plants hire only one man, who tends his own boiler, as well as making all minor repairs. It is economy, however, where results are desired, to employ an engineer, fireman and a laborer. The daily costs will be as follows: Engineer, $4; fireman, $2.50; laborer, $2; coal, $3; oil and miscellaneous, $1.50. Total, $13.

The yearly fixed or overhead charges are ordinarily not computed, but should be for an accurate notion of the business. They are as follows:

Interest on $2,250 at 6 per cent.	$135.00
Renewal of cables, blocks and sheaves	400.00
Depreciation of engine	200.00
Depreciation of bucket	150.00
Total	$885.00

The depreciation items are as a rule replaced by the actual money spent on repairing the outfit.

Counting out Sundays and days when no work is done on account of weather, it is safe to figure a year at 200 days.

200 x $13 daily pay roll, etc.	$2,600.00
Annual charge as above	885.00
Total	$3,485.00
200 x 250 yards	50,000 cu. yds.
Total cost per yard	7 cents

As an actual matter of fact, the cost at most plants is much more than this. Sometimes the men are paid yearly, whether they work or not. Frequently there is not enough business available, so that, instead of operating steadily and excavating 50,000 yards, 20,000 or 30,000 yards will be the year's business, costing 12 to 17 cents per yard.

Screening Plants.—These plants require more careful operation, and as they are generally dependent upon the retail trade near cities and towns, the output is determined not so much by the capacity of the plant as by the amount of sales made. The daily expense is greater, on account of the attention necessary to keep the screens clean, operate the pump, dispose of boulders, etc., as well as the necessity of maintaining some sort of an office and a set of accounts. In view of these facts, the above figures will be modified as follows:

200 x $15	$3,000.00
Annual charge	1,000.00
Accounts and collections	1,000.00
Total	$5,000.00
Annual sales, average	30,000 yards
Cost per yard, screened gravel	16⅔ cents

This figure is very conservative and can be attained by proper management of a plant. At the customary retail prices of 35 cents per yard, a profit of $5,500 per year results. As most plants are managed by the owner, this sum represents his salary and profits for the year.

A large plant, with a capacity and a demand for 400 yards per day, running at full capacity, will put out screened gravel for as low as 10 cents per yard, and is a very profitable business.

RAILWAY EARNINGS.

The following are the railway earnings for the first three weeks of March:—

Canadian Pacific Railway.

	1916.	1915.	
March 7	$2,198,000	$1,667,000	+ $531,000
March 14	2,258,000	1,731,000	+ 527,000
March 21	2,281,000	1,738,000	+ 543,000

Grand Trunk Railway.

March 7	$ 992,026	$ 852,151	+ $139,875
March 14	957,542	857,147	+ 100,395
March 21	967,233	857,937	+ 109,296

Canadian Northern Railway.

March 7	$ 540,200	$ 428,700	+ $111,500
March 14	538,000	412,000	+ 126,000
March 21	549,000	421,700	+ 127,300

A decrease of 44 per cent. in the operating costs for the Schenectady, N.Y., garbage plant is expected this year. The difference is accountable to reduction of working staff and efficient management.

MOVING A SAND BIN.

By E. P. Muntz.

THE accompanying four illustrations show the various stages in the moving of a large stone and sand bin at Lock No. 2 on the Welland Ship Canal. The bin is 50 feet long by 30 feet wide, 30 feet high, and is capable of holding 250 cubic yards of sand and a similar amount of stone. It supplied the aggregates for concreting operations at Lock No. 2 during the latter half of last summer. A relocation of the concrete plant has since been decided on to mix the remaining 200,000 cubic yards required. This necessitated the removal of the bin from its position alongside the construction railway, opposite the south end of the lock, to a point about 1,000 feet further north and at a 30-foot lower elevation.

The construction railway parallels the canal centre line at Lock No. 2. On the west slope of the lock pit a track lies between the construction railway and the top of the slope. This track was used by the contractors to haul the dry material from the bin to the mixer; the mixer being situated towards the north end of the lock on the top of the slope and about 800 feet from the bin.

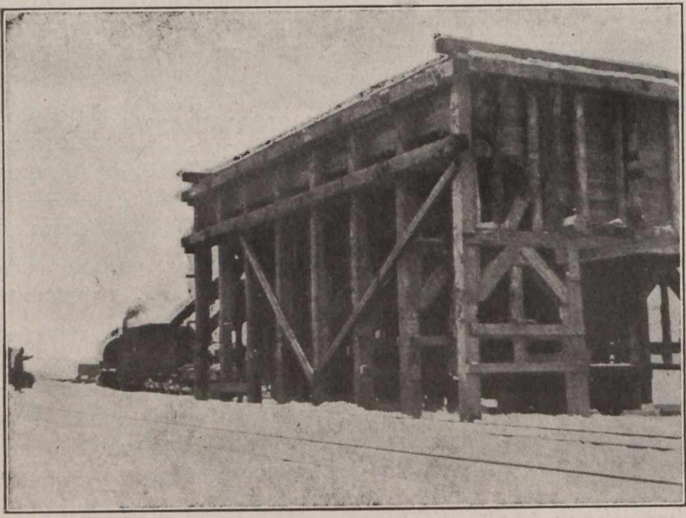

Fig. 1.—Hauling on the Level. The Double-track Railway is in the Foreground.

The moving was accomplished by jacking the bin up about two feet to permit a 60-ton steel gondola car to be run under it, on the loading track mentioned above. The weight of the bin was estimated at about 60 tons. Beams were laid across the top of the car to carry the bin and cables were used to tie the bin down to prevent swaying. The steepness of the incline (shown in Fig. 4) onto the trestle, which is the final location of the bin, necessitated the placing of a racking cable and inclined struts in the car to prevent the bin sliding.

The car carrying the bin was moved quite readily by the 45-ton Kingston locomotive, shown in Fig. 1. The track was far from being in good condition and in one place, where it lay directly on the top of the slope of the lock pit, a flat car loaded with "plums," set on the construction railway, was used as an anchor to prevent the bin overturning. Elsewhere, any tendency to upset was taken up at once by the legs bearing on the ground, the clearance being but a few inches.

The bin was lowered down the incline onto the trestle by means of two sets of blocks and tackle; the two together capable of lifting 80 tons. The free ends were secured to two locomotives, one south and one north, on the construction railway. Two heavy "dead men" held the blocks at the top of the incline. The bin was lowered by signalling the engines to come together. The rigging of the lowering tackle and the moving and lowering of the bin took about a day and a half.

Fig. 2.—Starting Down the Incline. The Track Shown is a Siding from the Construction Railway.

The whole operation was performed without a hitch. The bin was run out from the bottom of the incline to the end of the trestle and jacked up again and the car then hauled back.

The top of the bin is now at about the same elevation as the top of the slope on which runs the construction railway. The trestle is to be built to the same level between the bin and the slope, so that cars can be brought out from the construction railway and dumped directly into the bin.

Two 2-yard Ransome mixers are to be installed under the bin. They will be fed direct from the bin and will feed direct into buckets on the concrete trains. The concrete trains will run through the trestle at a point directly below the position of the boom of the McMyler crane shown in Fig. 4. The trestle itself and the sub-

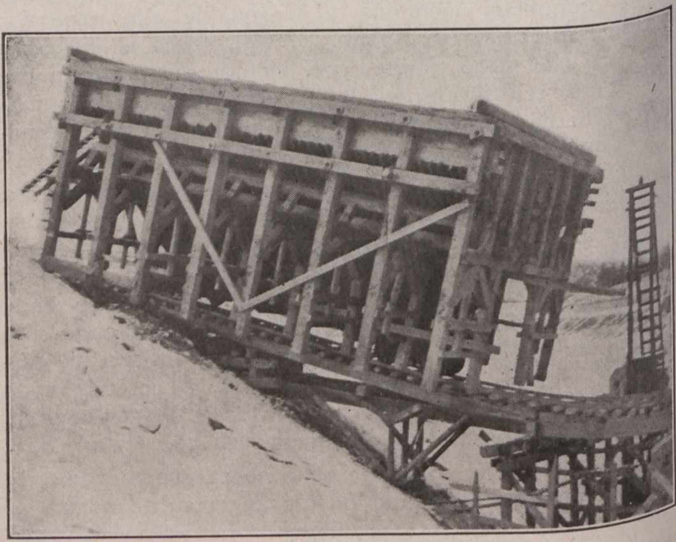

Fig. 3.—Hauling Bin Over Uneven Ground.

structure carrying the bin is built of piles driven about 10 feet to refusal. The trestle is built on the bottom of the canal below Lock No. 2.

The work being carried on at Lock No. 2 is part of section 2, of which Messrs. Baldry, Yerburgh and Hutchinson are the contractors and Mr. H. M. Balfour the resident engineer under Mr. J. L. Weller, C.E., engineer-in-charge for the Department of Railways and Canals.

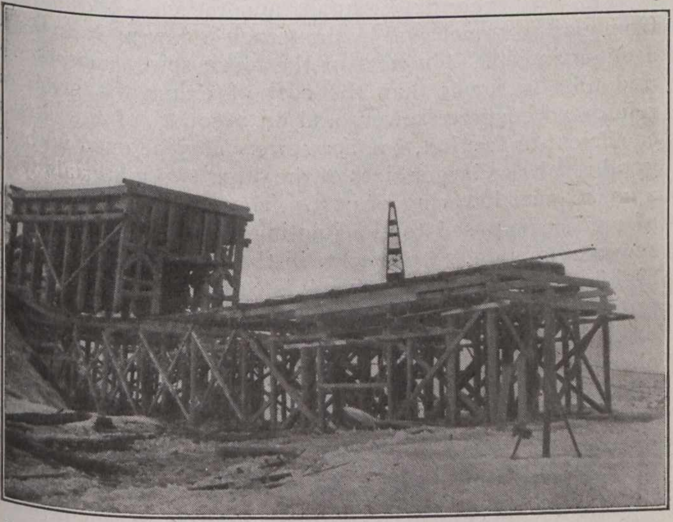

Fig. 4.—Showing Steepness of Incline onto Trestle, which is the Final Location of the Bin.

THE USE OF DREDGES IN EXCAVATING OPEN DRAINAGE DITCHES.

SOME practical notes from a paper read before the Iowa State Drainage Association by A. L. Goldenstar, of Mankato, Minn., will be of interest to engineers in this country inasmuch as the employment of dredges for the work has received very little attention here. The use of dredges has influenced the design of the ditch to some extent. Engineers have specified a cross-section which can be efficiently handled by the machine. It usually has been a section with rather wide bottom and steep side slopes. Side slopes of ½ to 1 have been very common and some have been even steeper. The arguments in favor of such a section have been that the sides were expected to cave down and the ditch would finally assume a section of its own that would stand, and second, that there would be little trouble in getting a contractor to dig the required section, because it is the easiest and most natural one to cut with a dipper dredge. But instead of the channel becoming an ideal one the sides are always rough and ragged, never cease caving in and the ditch fills up above grade clogging up the tile outlets that may be in it. The argument that nature will form the proper form of channel seldom holds good.

For the ordinary soils of northern Iowa and southern Minnesota, 1 to 1 should be the minimum slope and 1½ to 1 is often better. For loose, sandy soils even flatter slopes than these should be used. In order to avoid excessive top widths with these flatter slopes the bottom may be kept comparatively narrow. This will aid in making the ditch self-cleaning. In standard railroad and highway construction the slopes for excavation in cuts are never less than 1 to 1 and 1½ to 1 is now commonly specified. The slopes of railroad and highway cuts are exposed to even less erosive forces than the sides of open ditches.

But the proper construction of an open drainage ditch does not begin and end in specifying the right cross-section. Means must be taken to create absolutely the form that is desired. Where teams and scrapers can be used it is comparatively easy to secure smooth sides and bottoms without much hand labor. But teams and scrapers can be used in very few places so we must reckon with the dipper dredge or the dragline machine. Dipper dredges cannot cut a smooth enough or true enough side slope or bottom without the help of hand labor. Then, also, these machines are usually started at the upper end of a ditch and proceed down stream. There are only two arguments in favor of this method of procedure. The first is that it insures a good supply of water that will lubricate the dipper and make dumping easy, and the other is that it provides the necessary amount of water to float a floating type of machine. From all other points of view this method is detrimental to the job. The machine is always digging under water so that the operator can never see what kind of slope he is digging. When the dipper full of material is raised up through the water all the loose particles will wash off to remain suspended in the agitated water until the machine has moved on. Then this matter settles to the bottom in the form of silt. The author has seen from 2 to 4 ft. of this silt in a semi-liquid condition behind a dredge. It is usually assumed that this will all wash out with first flood, but it never does. Keeping the ditch full of water makes trimming of the sides by hand or any other means impossible. The wet plastic material dropped on the spoil banks settles so firm and tough as to make subsequent spreading very difficult.

The dragline machine seems to be coming into more general use now for wide open channels. Greater care can be taken with this type of machine in cutting the true cross-section channel. The sides can be left smoother since a wide flat bucket is used. Also, the spoil can be dumped over a wider area which reduces the amount of spreading.

Other types of excavator are being used, but only in a few cases. The so-called "template" excavators are made but experience with them is very limited in this territory. They still seem best adapted to dry land work.

In the light of the experience we have had with the various dredging machines, we can say that there is room for much improvement. The dredging machine is still to be invented that will by its own work, without assistance, make a first-class open drainage ditch. The kind of ditch needed is the common sized channel with from 4 to 16-ft. bottom. For the larger channels the present machines may suffice, but for the smaller ones they are not satisfactory.

The first logical step to be taken in handling this problem is to specify exactly the section that is desired and then insist that it be built that way. This will foster the designing of machinery that will build this section. Whether the dipper dredge and dragline machine can be improved to do this or whether some sort of a template excavator must be invented that will move cheaply all kinds of earth remains to be seen. At any rate, a change must be made or we will continue making open ditches that are a continual expense to maintain and never permanent. Instead of designing ditches that the present machinery can build we should try to develop machinery that can build the ditch that will stand.

HINTS ON THE CONSTRUCTION OF VITRIFIED CLAY SEGMENT BLOCK SEWERS.*

At the present time, there are on the market two vitrified sewer blocks of different design, one being a single-ring block and the other a two-ring block. The single block has a ship-lap joint on the ends and a tongue and groove joint on the sides, while in the double block, the laps and joints are made in the construction of the sewer and the blocks are placed one on top of the other as in a two-ring brick sewer. The blocks are hollow longitudinally with web braces. They are made for sewers varying in size from 30 to 108 ins. in diameter, and according to size, weigh from 40 up to 120 lbs., are 18 and 24 ins. long, are from 9 to 15 ins. wide, and are from 5 to 10 ins. thick. Short lengths are also made for convenience in construction and for use on sharp curves. Special blocks are also made for connections and junctions and consequently this type of sewer is as flexible as any pipe, brick, or concrete sewer. The blocks are also made for use in egg-shaped sewers, in which case, an extra heavy base block is furnished.

In constructing the sewer with the blocks, the method of excavating the trench does not vary from methods used in constructing sewers of other types. If the soil excavated is stiff enough to permit, the bottom of the trench should be shaped to conform to the outside of the sewer, thus forming a good foundation and eliminating excessive tamping. A template may be used to procure this shape as well as a means of guidance for laying the blocks. The first block is laid in the centre of the trench to line and grade and the blocks comprising the invert are laid to it. As the blocks of the invert are laid up, care in back-filling behind the blocks must be practised. The joints, both end and side, must be mortared about ¼ in. thick, and the blocks must be laid broken or staggered. The joints of the invert may be pointed up as they are laid. Careful tamping on each side of the spring line behind the blocks will give much added strength to the sewer and this tamping should continue to the second course above the spring line. Wooden forms are used for the arch and are usually placed a little bit higher than the required diameter in order to allow a little wider space for the key block. The blocks are then laid up on either side of the form, the key block finally inserted, the form immediately removed, and the arch will then settle into place and form the correct diameter. Backfilling can then be started at once. In laying these blocks, experienced bricklayers are not needed, as the ordinary pipelayer can soon pick up the art of laying the blocks. If wet and quicksandy conditions prevail in the trench and sheeting is necessary, it must be driven low and cut off and left in the trench below the spring line. In cases where steel sheeting would be used, very careful backfilling must be resorted to and as the sheeting is slowly pulled, water flushing must be carried on as it is very necessary that a good bearing be given the invert. In cases where the soil conditions in the trench bottom are very bad, planks may be laid under the first block or a cradle may be used for holding the first few blocks. However, there are no disadvantages in using the block in bad trench work not encountered in using other materials, and it is claimed by some of the engineers that have used them in bad trench conditions, that they are to be preferred to any other type of material.

The cost of laying the blocks, of course, varies with the efficiency of the contractor and his organization, and with the varying labor conditions. It should not exceed 1 cent per inch in diameter of the sewer per lineal foot; this to include labor of laying, cost of mortar, and backfilling up to the spring line. The cost of the block is moderate and has the advantage over the large sewer pipe in that it takes a smaller freight rate, the breakage in transit is exceedingly small, and the cost of handling from cars to trench and in the trench is low as it is easily a one-man job. The cost of the block sewer complete is undoubtedly lower than the cost of either the brick or reinforced concrete sewer, and on account of its lower coefficient of friction, smaller sewers may be used with as good results as larger sizes of the other two materials with a consequent lowering of cost. There is only 7 per cent. of surface exposed to the jointing material in the block sewer as against 28 per cent. in the brick sewer, and the highly glazed impervious block is certainly superior to the ordinary sewer brick. Good speed in construction can be made and it is not necessary to have much trench open ahead of the block-laying and, as mentioned before, backfilling can be done as soon as forms are lowered and the work cleaned up generally as it progresses. All of these points tend to lower the cost of this type of sewer with the advantage of giving a more efficient structure.

Good connections can be made between segment block sewers of different size as well as between segment block sewers and pipe lines. The segment block sewer can also be adjusted to fit sharp curves with very little loss of efficiency. Special blocks are made for the small connections with the pipe molded to the block and in the large sizes, four or six adjacent blocks are so molded in the manufacture to permit of the entrance of the large pipe and thus saves any cutting or chipping of the block on the construction work. The matter of sub-drainage is eliminated, as the ducts in the hollow block form a subdrain and the ground water is readily carried off.

These blocks, while being particularly adapted for use in constructing storm and sanitary sewers, are also coming into use as outlet drains for large farm drainage projects instead of small open ditches. They can also be used for service tunnels as well as for highway culverts. Sewers of vitrified clay segment blocks have been constructed during the past few years in many cities in this country and Canada.

Both internal hydrostatic pressure and loading tests have been carried on in connection with this type of sewer and the results of these tests may be obtained from the manufacturers and testing laboratories, it being enough to state here that the strength of the blocks have proven ample and sufficient for the use for which they are made. Examinations of segment block sewers have been made after they have been in use for some time and the reports are that they are in good shape and answering their purpose in every respect. Perhaps one of the most critical tests in actual practice was made at Louisville, Kentucky, where a 72-in. diameter block sewer was examined after it had been in service for two years, being located in a trench 28 ft. deep. The examination showed that the sewer was in perfect condition with absolutely no defects either from abrasion or the weight of the fill above the same.

The asphalt deposits found at Trinidad and the Red Sea are practically pure bitumen.

Owing to the scarcity of box cars for shipping automobiles, an American manufacturer is using flat cars and gondolas. After loading the cars on board, a heavy tarpaulin is used to cover them, something similar to the English method.

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*From a paper read before the annual meeting of Illinois Society of Engineers and Surveyors, by J. M. Egan, Jr.

WATER SUPPLY OF THE CITY OF ST. JOHN, N.B.

By **R. FRASER ARMSTRONG**, A.M.Can.Soc.C.E.,
Engineer and Superintendent Water and Sewage Department.

THE city of St. John, owing to geographical conditions, is provided with two separate water supply systems. The city is situated on the Bay of Fundy at the mouth of the St. John River, which divides it into two parts, the city proper being on the eastern and the other part being on the western peninsula.

The eastern side was supplied with water by a company which was organized in 1836.

On the advice of a noted American engineer, Colonel Baldwin, a small body of water called Lily Lake, in the northeastern part of the city, was chosen as a source of supply. The area is 27 acres and elevation above city high-water datum is 80 feet. Construction commenced in 1837 and the supply was available to the city in October, 1838.

The works, as then constructed, consisted of a small wooden-box conduit which conveyed the water by gravity from the outlet of Lily Lake to a steam pump, which forced the water through 10 and 12-inch cast iron pipes to the distribution reservoir. The supply was of an intermittent character, the water being pumped to the reservoir three or four times a week, and doled out daily to the consumers between the hours of 6 and 8 a.m. and a sufficient supply had to be drawn during the two hours that the water was on to last the balance of the day. When a fire occurred no water was available at any hydrant until the water was let on from the reservoir and the mains filled.

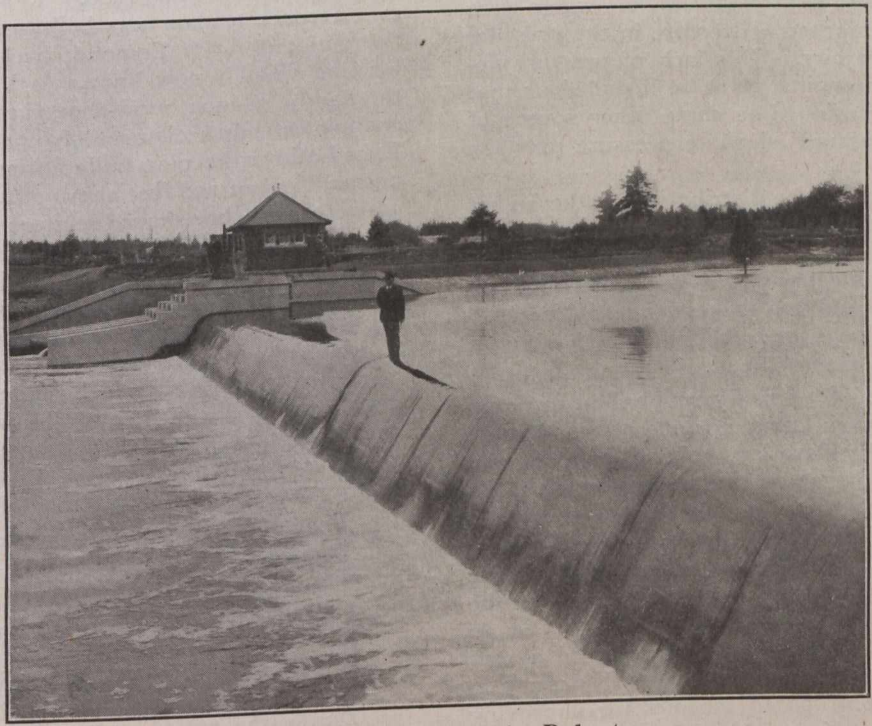

Fig. 1.—Concrete Dam at Lake Robertson.

The system was not long in operation, however, until it was discovered that, aside from the unsatisfactory service, the water was not well suited for domestic or steam purposes; and the obtainable supply altogether inadequate for the future requirements of the city. These most undesirable conditions led to an investigation being carried on to obtain not only a more potable and copious supply but also a more satisfactory service. The first survey made with a view to a change was conducted by R. C. Minnette, Esq., C.E., then city surveyor. It was found that good water could be obtained at Little River at a point about 4½ miles from the city in an easterly direction, at what was then considered sufficient elevation to supply the greater part of the city by gravity for some years to come. Chas. W. Fairbanks, civil engineer, of Halifax, was then employed to investigate and report upon the proposed works. Mr. Fairbanks chose a site for a reservoir on Little River, recommended the erection of a dam and the placing of a 12-inch cast iron pipe from this point to the city. Construction work was undertaken by the company in October, 1850, and in September, 1851, the water was formally turned on to the city from this new source.

The bed of the river at the point selected for the reservoir is 140 ft. above city high-water datum, the reservoir, as at first constructed, having a surface area of about 37 acres, with a drainage area of about 9,500 acres.

The distribution reservoir was now fed by gravity, but it was found in cold weather, when the consumption on the lower levels was high, that the consequent increase of friction in mains caused pressure to drop to such an extent that water would not flow up the Carmarthen St. hill. This very evident lack of pressure and the cholera epidemic of 1854 aroused the citizens to the necessity of a more abundant and potable supply of water which would be, in a measure, under the control of the city.

The outcome of this was that under an Act of Assembly, commissioners of water and sewerage for the city of St. John (East) and a part of the parish of Portland, were appointed.

The duties of the commissioners were to take over, construct and maintain the sewers and all works for the supply of water to that part of the city of St. John lying on the eastern side of the harbor and the water supply works of the urban portion of the adjoining parish of Portland.

Several improvements in the inside distribution were immediately undertaken, but the commissioners soon realized that their system was inadequate for future requirements, so, on the recommendation of the superintendent, which was confirmed by James Slade, Esq., then city engineer of Boston, it was decided to place a 24-inch cast iron pipe main from Marsh Bridge to Little River, the idea being that eventually this pipe would be extended to Lake Douglas or to some source capable of adequately supplying the city's requirements. The 24-inch supply main was completed in 1857 and in the same year observations were taken to determine the capacity of Lake Latimer, where an additional head of about 150 ft. could be obtained. These observations satisfied the commissioners that this lake could only be used for compensation purposes or in conjunction with some larger supply scheme.

The city was now supplied from Little River by the two cast iron mains, the 24-inch and the old 12-inch.

By the placing of the new supply main the service was much improved, but as the inside distribution was extended and consumption gradually increased, it was not long before the friction losses demanded that additional supply mains be considered.

With a view to increasing pressure and also to duplicating the large pipe running into the city, so that in case of accident to one pipe the city would not be wholly without water, it was decided to place another 24-inch supply main, which work was completed in 1874.

The Little River reservoir, assisted at times by Lake Latimer, while apparently being capable of furnishing an abundant supply, was not at a sufficiently high elevation to supply water to the summits of the city. The inconveniences arising from this low elevation of supply head were aggravated during the winter by water being too freely used in the lower levels, to keep services from freezing. The number of consumers kept increasing from year to year and such unwarranted quantities of water were wasted that each year marked a decrease in the pressure head through the entire city. This lack of pressure demanded that either a pumping plant be installed or that the supply mains be continued to some other source of sufficient elevation to assure adequate pressure over the entire city.

For a time a portion of the distribution on the higher levels was isolated and a water turbine-driven pump installed at Silver Falls. Within certain limits this pump was satisfactory, but its capacity was too small to allow for fire or any large demand and at these times it "raced." This condition might have been relieved by having it always pump against a definite head.

When the question of a gravity supply first came up it was recognized that Loch Lomond would be the ultimate source of supply, as the elevation, volume, softness and purities of the waters presented strong arguments in its favor and when the scheme of supply from Little River was adopted, it was realized that this was only a unit of a future larger scheme. The drainage area of the Little River basin is about 9,500 acres or about one-third the drainage of Loch Lomond.

In the year 1882 Gilbert Murdoch presented a very comprehensive report to the commissioners, discussing at considerable length the proposed schemes for improving the water supply at that time. Mr. Murdoch practically accepted Loch Lomond as the ultimate source, his report being a consideration of the several routes of reaching this lake. The routes considered were: (1) By way of Lake Douglas; (2) by way of Lake Donaldson; (3) by way of Lake Latimer. In summing up, Mr. Murdoch expressed the opinion that the Lake Latimer route was the superior one and this route was ultimately adopted.

Loch Lomond is situated about 10½ miles from the city in approximately the same direction as Little River reservoir. Surface elevation about 300 feet above city high-water datum, and area of Lower, Middle and Upper Loch Lomonds, which are all connected, about 2,480 acres. This may be further increased by converting the principal feeders (Lakes Otter, Terrio, Godsoe and Chambers) into storage reservoirs, as could easily be done were such required.

The drainage area comprises about 27,700 acres. The water is soft and of a very superior quality.

Lake Latimer is situated about 7⅓ miles from the city in a line with the Little River supply, has a surface area of about 210 acres, great depth, and an elevation about 300 feet above city high-water datum. The drainage area is only about 550 acres, much of its water originating from springs and the capacity of the lake is not sufficient to supply the requirements of the city.

Lake Douglas is between Little River reservoir and Loch Lomond, being almost directly north of Lake Latimer.

Lake Donaldson is between Lake Latimer and Loch Lomond, being northwest of the present concrete dam across the Mispec River, the outlet of Loch Lomond.

As the demand for a better service on the higher levels became more insistent, Snow and Barbour, consulting engineers of Boston, were called in to make a report. In general, their report was a confirmation of reports that William Murdoch had made in previous years. The recommendations as given by Snow and Barbour were adopted and they were authorized to prepare plans and specifications for a water supply extension.

In 1905 these plans and specifications were accepted, tenders for construction awarded and water has been used from this source since 1906.

A concrete dam was built across the Mispec River, the outlet of Loch Lomond, backing the water up and forming what is now known as Lake Robertson. From the dam a 48-inch horse-shoe shaped reinforced concrete conduit extends a distance of 6,916 feet and empties into Lake Latimer, keeping Lake Latimer at approximately the normal level of 298 feet above city high-water datum. A 39-inch horse-shoe shaped reinforced concrete conduit conveys the water from Lake Latimer to an open chamber at Finney's Hill, a distance of 7,480 feet. The level of water in this chamber is the head from which computations for pressures in the city are made. From this point the elevation of the ground drops rather abruptly and the water is carried through a 33-inch diameter wood-stave pipe, a distance of 9,880 feet, and the wood-stave pipe is connected at the Little River gate-house through 400 feet of 36-inch cast iron pipe with the three cast iron supply mains leading into the city, a distance of 23,000 feet.

The total value of waterworks of the city is nearly two and a half million dollars. This includes the two supplies.

THE CREOSOTE INDUSTRY.

During the past year, according to the Victoria, B.C., Daily Colonist, a shipment of 160,000 creosoted railway ties was made by the Dominion Creosote Company of Vancouver, to India, for the Bengal and Northwestern Railway Company. The Indian railways use annually large quantities of sleepers which have been supplied from Australia, but as Australian timber is becoming scarcer and prices are advancing, it is expected that the British Columbia product will come into more demand.

Although the preservative treatment of wood industry in British Columbia was established only five years ago, it has had a steady growth, particularly in export markets. At present only one plant is in operation, that of the Dominion Creosote Co., but a second is about to be established. The former covers twenty-two acres on the north arm of the Fraser River with river frontage of 1,300 feet. The company operates a sawmill with daily production of 55,000 to 60,000 feet per ten hours; a paving block mill with capacity of 1,600 yards of block paving a day and a creosoting plant with two retorts one hundred feet long.

The projected plant is that of the Vancouver Creosoting Co. This company has secured a site with five hundred feet of waterfront at North Vancouver, and expects to build a plant at a cost of $150,000 by April next.

Including the Dominion Creosote Co., there are four producing plants in Canada, the others being the Dominion Tar and Chemical Co., of Sydney and Winnipeg; the Canada Creosoting Co., Trenton, and Alex. Bruce & Co., Fort Frances.

THE ENGINEER AND THE WAR.*

By Walter J. Francis, C.E.,
Consulting Engineer, Montreal.

IT is the engineer who harnesses the Niagaras of the world to transform the night of our cities into noonday and to turn the wheels of commerce.

It is the engineer who develops the mining and furnishes the metal with which he builds machines that, by their ingenuity, compel us to stand in awe and admiration.

It is the engineer who produces the steel to form a network of highways over our continents, and that makes possible the myriads of floating palaces on our oceans.

It is the engineer who has abolished famine and pestilence.

It is the engineer who has annihilated distance with his telegraph and his telephone.

It is the engineer who has made possible the conquest of the air.

It is the engineer who furnishes the worker in the golden west with the machines whereby millions of bushels of wheat are each year made ready to enter the hopper that the engineer has constructed.

It is the engineer who has made the Canada of to-day what she is.

Imagine, if you can, the cessation of all engineering activities, the obliteration of the living engineers and the death of engineering instinct, and our much-vaunted present-day civilization is immediately plunged into the darkness of the middle ages. In a century, engineering spans the chasm between the messenger on horseback or the beacon lights on the elevated places and the wireless telegraph service, the chasm between the ox-cart or the caravan and the palatial Pullman trains, the chasm between the wooden sailing vessel and the luxurious floating palaces, the chasm between the powder-horn and flintlock and the modern machine gun, the chasm between the most primitive manual labor and the most highly organized mechanical processes. The steel industry, the flying machine and the under-water boat are all engineering creations, and so modern in their conception that it seems impossible to name any connecting link with the past—they are new.

Who was the first engineer? I have a notion that the first engineer was probably that simian who discovered that the use of a stick enabled him to more readily knock down the cocoanuts than by laboriously climbing the tree. His object was to knock down cocoanuts. The simians that gathered them up were doubtless the first financiers. Of course, they encouraged the engineer, and the engineer developed his apparatus for the purpose of increasing the output. We have kept on in the development—and the others have kept on with the gathering in. The development has become so natural and so universal that we have grown as unmindful of it as of fine weather and good health and all the other blessings of heaven.

From time immemorial, engineers have come forward in times of war and have rendered signal service. Xerxes sent his armies across the Dardanelles into Europe over a bridge of boats. Darius cut a canal at the site of the present Suez Canal to prevent the passage of the enemy horde. The military roads of the Romans are still wonders of the constructive art. The stone cannon balls and the "frightful noise" of the guns of the middle ages are well worth reading about. The fortresses over Europe have withstood every attack until the advent of present-day artillery. Naval supremacy has been obtained by engineering development.

Doubtless the earliest application of modern engineering to the problems of warfare is to be found in the case of Khartum, where the foremost of Royal Engineers raised the Union Jack in 1898. Kitchener, of Khartum, combined all the qualities of the soldier, the organizer and the engineer. Appreciating the futility of hurling his soldiers into the desert melting-pot, he decided to build the world-famous military instrument—the Sudan Military Railway, whereby he was able to transport not only the troops, but also everything for their needs. In this he was ably assisted by Bimbashi Girouard—a Canadian, a graduate of the Royal Military College, and one of the engineers on the construction of the C.P.R., of whom Steevens had said: "Girouard goes on building and running his railways—over five hundred miles of rails laid in a savage desert, a record to make the reputation of any engineer in the world."

In the next war engineering played no less a part. To South Africa went Kitchener, and with Kitchener the solution of all the difficulties of transportation problems. Here the crafty guerilla warfare of those "peaceful, pastoral people," the Boers, made serious havoc with the railways. Embankments were destroyed, culverts blown up and bridges torn down. A most complete military organization was built up to cover the territory by the Royal Engineers. The Imperial Military Railway became a great institution with Girouard again at the head. Included on the staff, in positions of great importance, were Colonel H. S. Greenwood and Mr. A. F. Stewart, both of the C.N.R., and well known to many Canadians. The Royal Engineers did the whole work thoroughly, without overlapping or loss of time. To mention just one incident recounted in the official report, "on one occasion (January 1st, 1901), information of a break near Wolvehock reached Major Lindsay at Kroonstad at 2.30 a.m. The distance to the break was 63 miles. Nevertheless, this distance had been traversed and the break repaired by 8 a.m." In order to get a proper estimate of the work of the field engineers it is essential to remember that they are armed soldiers, frequently carrying on their work under enemy fire.

The Right Honorable David Lloyd George, the Minister of Munitions, in a speech delivered last summer, is reported to have said that the present war is a terrific contest between the engineers of the warring nations. The object lesson so tragically taught by Germany has aroused the other nations of the world to a keen appreciation of the result of the application of engineering energy to military purposes. While Germany was, as we all think, so misapplying a great part of her engineering talent, the other nations had been devoting their efforts to the development of the arts of peace. We have been forced to meet the exigencies of the situation, and to our military engineers and to the engineers in civil life has fallen the task of overtaking Germany's forty years of preparation, not only on the fields of battle, but in the workshops at home. Two of the most eminent military engineers of the world are in foremost places—Lord Kitchener and General Joffre.

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*Abstract of an address before the Ottawa Branch of the Canadian Society of Civil Engineers.

The war is an immense work of cold, calculated programme. Let us draw an analogy. A building contractor, let us say, determines to carry out a piece of work in a certain time. He calls his superintendent and explains what is to be done and when it is to be finished. The superintendent, in turn, calls his foreman and the various interests to whom he looks for co-operation and assistance. The materials are ordered. The laborers and artisans start their work—and the work is completed according to the wishes of the master mind. It is all a matter of mature forethought and cold calculation. There is nothing of accident or haphazard trust-to-luck haste. It is all carefully thought out ahead. The proceedings in the war are quite analagous, only on a stupendous scale. Nothing happens by chance. The constant care is to be in readiness at the necessary or appointed time. I would not modify my analogy, but would point out that Germany stands in the position of a contractor with an organization complete and ready, while the Allies have to be likened to one who may be without an organization and have to build it up. King Albert, the Belgian engineers, the engineers of France, and the British Navy were partly prepared, or we should not have the privilege of discussing the subject this evening.

There was one at least of the Canadian engineers who specially prepared himself in his spare hours for the service of his country in time of need. The reference is to Lt.-Colonel Charles H. Mitchell, General Staff Officer in charge of the Intelligence Department of the Canadian Army Corps in France. In a card recently received from him, he says:—

"The nice feature about my work is that after all it's pretty much the same in its type as consulting engineering—in fact, is the same if you substitute the Huns for the forces of nature." And in a letter just received, he says:—

"It is strange, and yet very fortunate, what an analogy there is between this work and my own professional work at home. The general character of the work, life and thought is similar, the assistants similar and one's activities are quite the same—office work, reports, analysis, correspondence, direction of investigations, deductions, maps, outside tours of inspection, constant telephone activity—all the same if you substitute the enemy for the forces of nature. There is a difference, though. It is seven days a week from 9 a.m. until 11 p.m. Our headquarters are in the Hotel De Ville of this little city (about 12,000 people normally), and it is really quiet and peaceful if one gets used to the passing to and fro of thousands of men and hundreds of motor lorries, motor cars, wagons, and so on, in the day, and the recent aeroplane activity by the enemy, in which he has been dropping bombs on various parts of the town, railway station, flying aerodrome locality, and not forgetting the cemetery. I had the misfortune last Sunday to lose one of my best draftsmen, killed on the street on his way to a noonday meal."

Canada is to be congratulated on the special services required of her soldiers. Like Sir Percival Girouard, Colonel Ramsay, of the C.P.R., has been called to the front with a corps of railway constructors, every man a specialist in a particular branch of railway construction. He has since been followed by a second corps, and now other engineering parties are being called for to render special services at the front. One of the most unique of these parties is one armed with broadaxes, and recently inspected by His Royal Highness in this city. In Flanders we can see them performing their task fearlessly and faithfully. Under the fire of the enemy they unflinchingly construct their bridges and prepare their highways. With tireless energy they minister to the needs and convenience of the men in the trenches. Anywhere, everywhere, their services are required, and the special skill stands them in good stead, for it must be remembered that in these bodies of men are artisans of all classes. Among the classes required by an engineer corps are bricklayers, carpenters, draftsmen, mechanics, masons, wheelwrights, shoemakers, clerks, drivers, chauffeurs, saddlers, plumbers and tailors.

The Canadian Society of Civil Engineers has nearly five hundred of its members on the field of honor, and some have made the supreme sacrifice. The whole of the struggle is not on the battle-fields, nor, indeed, in Europe. Soldiers must not be without ammunition. At the outbreak of the war nobody in Canada knew how to make ammunition on a commercial scale. Metal manufacturing industries were paralyzed by the interruption of normal conditions. The Allies needed shells. The Canadian manufacturers in a body rose to the occasion and transformed the shops of the Dominion into shell factories. The speed with which this transformation was accomplished probably stands without a parallel in the history of manufacturing. The Government appointed as the head of a commission an engineer whose knowledge of the machine shops of Canada had been gained from a lifetime in the work, following his father, and in a few months the shops of Canada had learned their lesson and were exporting shells to the Allies. In recognition of his services Alexander Bertram was knighted by His Majesty King George at the New Year.

The celerity with which new methods, new processes and accurate measurements were put into practice is a standing monument to the skill of Canadian manufacturing engineers. To illustrate, by a few figures, the transformation which has taken place in one shop alone. Prior to the war this engineering firm employed about twelve hundred men and had a daily output valued at about $30,000. To-day, the employees number five thousand men and the value of the daily output is $200,000. It is a significant fact that the president of the Canadian Society of Civil Engineers, as well as two of the immediate past-presidents, are all, directly or indirectly, engaged in the manufacture of ammunition.

Naturally, from the present conditions in Canada we pass to the thought of the future. When the war is over and when German militarism will have been crushed, what of Canada? Already a new word has been coined in the United States, "preparedness." President Wilson recently said: "There may come a time when I cannot preserve both the honor and the peace of the United States," and the outcome of this movement has been the appointment of a consulting board of specially chosen engineers, composed principally of the representatives from the five foremost engineering institutions of the United States, the American Society of Civil Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers and the American Chemical Society. Its immediate work will be to make an inventory of the facts necessary to be known to the army and navy relating to the resources of the nation for the supply of munitions of war in case of need. The French Republic has organized a similar civilian board, and has raised it to the dignity of a ministry, "Le Ministere des Inventions.'' Great Britain has also enlisted the services of civilian scientists and technologists with a view to the development to the utmost of the nation's industries for the prosecution of the war.

Meanwhile the world struggle is becoming fiercer. The engineers in civil life must attend to the production and the transportation. The mines must be kept producing the raw materials and the factories the finished products. The railways and the steamships and the motor cars must take them to the front, where the military engineers, amidst the inferno of shell and machine gun fire, are doing their part under the old motto of the Royal Engineers, ''Everywhere,'' and continuing the fight, led by the stirring war-cry, ''Where right and glory lead.''

CIVIL SERVICE COMMISSION OF CANADA.

The Civil Service Commission of Canada announces that applications will be received for the following position in the Inside Division of the Civil Service Commission of Canada:—

A technical clerk in the Railway Land Branch of the Division of the Interior, Sub-Division B of the Second Division. The salary is $1,300 a year. Candidates must be able to compile and check plans, be experienced in preparing descriptions of lands, and able to conduct technical correspondence relating to these subjects. Candidates should have had at least five years' experience in work of this or similar nature or be graduates in science of a recognized University, Applications are to be in by the 17th of April next, and application forms may be obtained from Wm. Foran, Secretary of the Commission, Ottawa.

STRENGTH OF SLAG CONCRETE.

A series of very interesting and important tests has recently been made at Columbia University, in New York, in which concrete made from blast furnace slag showed over 18 per cent. greater resistance to compression than concrete made of trap rock from the Palisades. The slag used was recovered from the large slag dumps of the Bethlehem Steel Company at South Bethlehem, Pa., and marketed by the National Slag Company, Newark, N.J., which has a reclaiming and crushing plant at South Bethlehem. The tests were conducted for the building departments of New York and Newark, the Public Service Commission of the First District of New York, the Public Utility Commission of New Jersey and the Erie Railroad. Four tests were made in each case of 8 x 16-in. cylinders of concrete of 28 days, 3 months, 6 months and 12 months' age, the concrete made of sand from the same source and in the same way. A 1:2:4 mixture was used. The National slag concrete of the 28-day period averaged 2,465 lb. per square inch compressive strength, which was 24.8 per cent. higher than the trap-rock concrete. The slag concrete of 3 months showed 3,496 lb. compressive strength, or 18 per cent. better than the rock concrete; for 6 months the strength was 3,567 lb., and 16.9 per cent. better than the rock concrete, and for 12 months, the strength was 4,187 lb., against 3,547 lb. for the rock concrete, or 18.4 per cent. better. National slag weighs 80 lb. per cubic foot and Palisade trap rock 100 lb.; the concrete with the slag weighs 140 lb. per cubic foot, and that with the rock weighs 151 lb. per cubic foot.

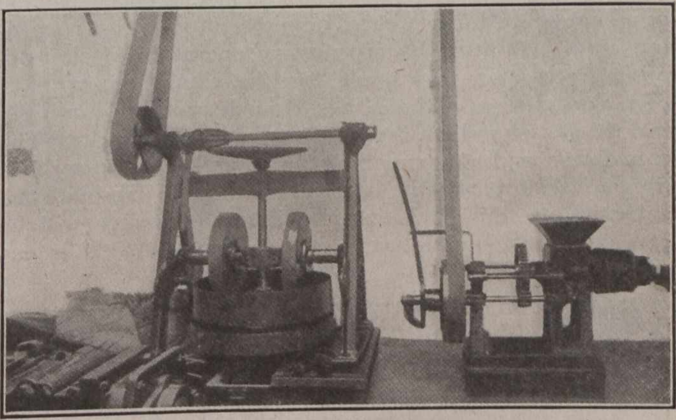
NEW LABORATORIES AT OTTAWA.

TWO new laboratories of special interest to engineers have been installed by the Mines Branch at Ottawa, descriptions of which have been given in recent reports of the Mines Branch. One of these, the ceramics laboratory, owes its existence to the great development of commercial activities prior to the war, which necessitated its establishment to investigate Canada's resources in this line.

The commercial value of clay products in Canada may be estimated from the following figures, collected through the statistical division of the Mines Branch. The clay products mentioned were manufactured in Canada during the years 1912 to 1914.

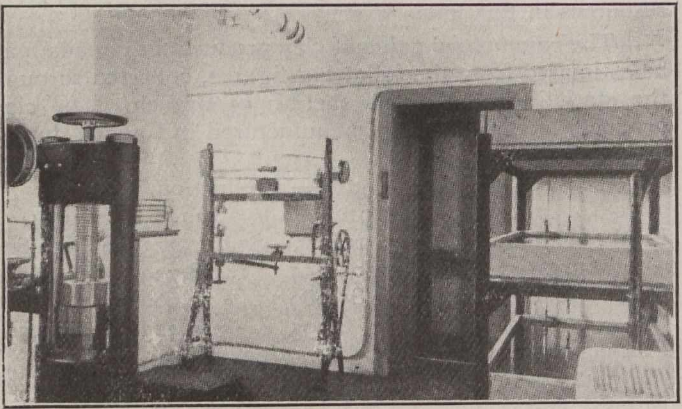
	— Production in —		
	1912.	1913.	1914.
Brick, common	$ 7,010,375	$5,917,373	$3,653,861
" pressed	1,609,854	1,458,733	1,115,556
" paving	85,989	75,669	49,627
" ornamental..	8,595	15,423	23,592
Fire-clay and fire-clay products	125,585	142,738	107,568
Fireproofing	448,853	461,387	405,543
Pottery	43,955	53,533	35,371
Sewer pipe	884,641	1,035,906	1,104,499
Tiles	357,862	338,552	366,340
Kaolin	160	5,000	10,000
Total value	$10,575,869	$9,504,314	$6,871,957

During the year 1905 the importation of clay products amounted in value to $2,501,206, and it increased to $6,760,762 for the year 1913, but dropped in 1914 to $4,467,140, due to the war. In the year 1914, we utilized clay products valued at $11,291,024, yet the returns show that we imported over 39 per cent. of these products. This simple statement shows that in 1914 we sent out of Canada for these products alone, $4,419,067 which if it had been held in our own country, would have meant the investment of a large amount of capital, and would have given employment to a large number of men.

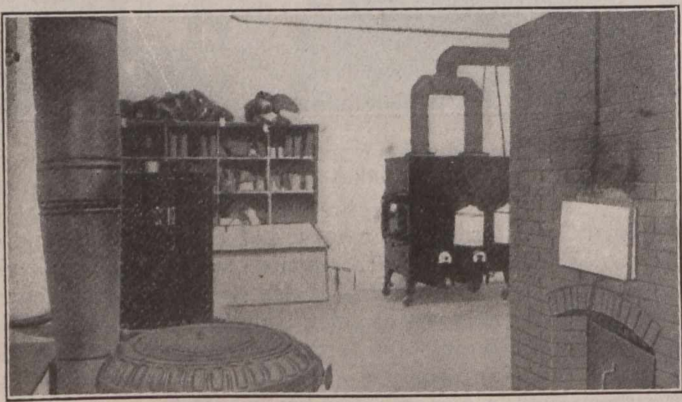


Ceramic Laboratory—Dry Grinding Pan and Experimental Auger Machine.

It must not be concluded from this statement that this very large importation is due to lack of raw materials at home. Reports on the location and character of the clay deposits of Manitoba, Saskatchewan, Alberta, Quebec, and the Maritime Provinces, issued by the Geological Survey, show that Canada is rich in materials for an important ceramic industry. New deposits are constantly being discovered and specimens sent to the laboratories, with the request that they state what use can be made of the material. To merely send the owner of the deposit a chemical analysis of his clay does not meet the case, since chemical analysis is only a preliminary step in ascertaining the fitness or unfitness of a clay for the manufacture of any special product. Before a sound opinion can be arrived at, as to whether a particular specimen of clay is suitable for the manufacture of tiles, brick, terra cotta, sewer pipe, or other clay products, the specimen must be submitted to a physical examination to ascertain the character of the product as it comes from the kiln. It is during this investigation that the problem, in many cases, admits of solution, namely, how a clay, otherwise unfit, may, by special treatment, be rendered suitable for the manufacture of a commercial product. To enable the government to furnish this complete information regarding clays submitted by prospective operators of clay deposits, provision was made for the establishment of a ceramic division in the Mines Branch, with a properly trained and experienced ceramic specialist in charge. The completion and equipment of the ceramic laboratory was accomplished during the latter part of 1915. Through the activities of this Division, intelligent assistance will be given to the manufacturers of clay products. It is expected that this course will lead, on the one hand, to a decrease in the large imports of clay products, and on the other hand, tend to the further development and increasing importance of the ceramic industry in the Dominion.



Structural Materials Laboratory, Showing Compression and Tension Machines.



Ceramic Laboratory—Kiln Room, Showing Cement and Brick Kilns.

Another laboratory, that for testing structural materials, was equipped with apparatus which would make a more thorough study of materials possible than had been heretofore, as a physical test had been the only means of examination.

In equipping this laboratory, adequate provision was made for conducting complete tests on all kinds of building supplies, etc., such as sands, brick, stones, cement, concrete, and like materials. The laboratory equipment includes machines for making all the physical tests necessary for the determination of the transverse, tensile, and compression strength of all structural materials. The installation of the machines for testing iron and steel is complete.

The increasing use of bituminous materials in the surfacing of city streets and interurban highways, has emphasized the necessity for apparatus suitable for the testing of such materials; but in connection with the installation of apparatus for the examination of bituminous road materials—including bituminous sand—there has been a regrettable absence of generally accepted standard methods of testing. The apparatus available in the Mines Branch Structural Materials Testing Laboratory, however, is well suited for classifying, and for determining the value of bituminous road materials.

THE ERIE RAILROAD LIBRARY.

The Erie Railroad has opened at its general office in New York City a free circulating and reference library for the use of the 1,300 persons employed in the offices of the company in that building and nearby. On the day that the library was opened, March 14th, the shelves were almost swept clear of the several hundred volumes which had been provided, and a "rush order" was sent out for more books. The demand was keen from all classes of employees, from girls who count tickets in the auditing department up to the higher officers.

The library, which is described in Railway Age Gazette, consists of standard text books and reference works, engineering and technical books of interest to railroad men, and also the latest popular fiction, together with current periodicals and newspapers. Employees in all departments will here find facilities to educate themselves in their own work, and also to inform themselves concerning other departments of the railway service. The library contains about 1,000 books.

The demand for steel from domestic consumers is increasing instead of falling off and Europe is in the market for almost unheard of tonnages for shell purposes and for railway steel. There is no doubt in the minds of manufacturers that prices will go higher than ever seen before.

The busiest street intersection in the world is in New York City at Fifth Ave. and 42nd St., according to a recent count by the Traffic Committee of the Fifth Avenue Association. According to this investigation, between 3.30 and 4.30 p.m. on the day of the test, 1,149 vehicles were counted proceeding south. J. Bernstein, who made the count for the committee, stated that the top figure for the Strand, London, is 900 vehicles per hour, and in Paris the record is 600 in an hour on the Boulevard des Capucines. The count revealed other interesting statistics: Of the vehicles on Fifth Ave. at 42nd St. 92 per cent. are now motor-driven. Between 8.30 a.m. and 6.30 p.m., under unfavorable weather conditions, 7,762 passenger vehicles were counted northbound, of which 300 were commercial (of these 60 per cent. were horse-drawn), while 600 busses passed in the 10 hours. The grand total was 8,862. The traffic peak was between 2.30 and 3.30 p.m. Southbound in the avenue the total for the day was 7,190, consisting of 6,388 passenger vehicles, 198 commercial and 604 busses. On 42nd St. the total from east to west was 4,716; and from west to east, 3,909.

BITUMINOUS ROADS.*

By Robt. C. Muir, A.M.Can.Soc.C.E.

BITUMINOUS roads constitute a modern development to meet both the actual needs under modern traffic and the desires of modern civilization for greater efficiency, comfort, satisfaction and better sanitary conditions.

The introduction of the motor vehicle has greatly changed the conditions under which a road exists. The suction action of yielding tires is to remove the binder in a macadam surface and thus expose the stone to the action of traffic and the weather. There is then no longer a solid mass to meet conditions and disintegration occurs. Therefore, it is necessary to protect the macadam surface against this action of high-speed vehicles. Of the various materials which have been used in several types of roads, there is none equal to bitumen in its ability to withstand water, abrasion, and temperature changes.

There are three ways in which a road may be treated with bitumen, namely: (1) Penetration method, known as bituminous macadam; (2) mixing method, known as bituminous concrete; (3) bituminous surface, known as carpet coat.

A choice of these methods depends upon conditions, traffic conditions being the chief factor in deciding which of the three methods should be adopted.

Foundation and Drainage.—The necessity for stronger foundations and to this end for the best possible subdrainage, seems to be generally accepted, especially by those whose vision into the future is keen enough to permit them to recognize the probable increase in demands on the foundations, to be brought about by better surfaces and by the consequent growth in both the bulk and weight of traffic as well as in its severity. A firm foundation is an essential factor for permanent bituminous surfaces.

Again, in bituminous macadam the binding action of the bitumen tends to make the top course "spring" after each passing of the roller and in that way the road never can become firm with a yielding bottom course or foundation.

Bituminous Macadam (penetration method of construction).—On the prepared foundation, a layer of clean stone, varying in size from 1½ ins. to 2 ins. or 2 ins. to 3 ins., should be spread to an uniform depth, usually 4 ins., loose measurement. This is then rolled only until the stones have keyed together. On this surface prepared bituminous material heated to about 375° F., is applied at the rate of 1¾ gallons per square yard. Following this application stone chips are spread on the surface to fill the voids, and in sufficient quantity to cover the surface and permit the passing of the roller without adhesion of the bitumen to the wheels. This is then thoroughly rolled until the surface is uniform and hard. The squeegee or seal coat of bituminous material is then applied at the rate of ⅓ gallon per square yard, followed with an application of stone screenings from ⅛ in. to ½ in. in size, clean, dry and free from dust, sufficient to take up all excess bituminous material. The whole is then rolled, and by the aid of brooms and the adding of more screenings if necessary, a uniform hard and smooth surface results.

With this method of construction the question of size and shape of stone is supposed to be an important point. It is not so much the size as a practical uniformity in size that is essential. That is to say, if the smaller stone run about 1¼ ins. to 1½ ins., then the larger stone should not be greater than 2½ ins. On the other hand, if the smaller stone is 2 ins. in size, then the larger stone may run 3 ins. The point is that a wide variation in size of the stone causes an irregular delivery; one load may run all fine and the next load all coarse stone. This condition is detrimental to the surface of road. The best results have been obtained by the use of stone passing a 2½-in. screen and retained by a 1½-in. screen, with stones breaking cubically with fairly rough surfaces and with sharp angles.

Still another important factor affecting a bituminous road is the sufficiency of the rolling given, as also in the case of a waterbound macadam road. It is fully recognized that with waterbound macadam roads, the utmost possible compaction and interlocking of the stone by rolling is necessary for first-class results. Hence, let us all remember the saying, "Rolling is the life of the road."

The proper selection of the bituminous material for use under this method, or under any method, is a serious one and is influenced by many conditions other than method of use, such as price, soil, weather and traffic conditions, conditions likely to prevail regarding after-maintenance and cleaning.

The use of unrefined tars has been found unsatisfactory and has been practically abandoned. It is generally agreed that the presence in the tar of more than a minimum of water or ammoniacal liquor renders it undesirable for this method of use; that certain amounts of "light oils" are necessary for giving the desired fluidity in handling; that a good proportion of "heavy oil" is necessary in order that the tar may retain the longest possible life in elasticity after use, and under the effects of weather and traffic as well as for giving the body to the tar asked by this method; and that a limited amount of "free carbon" may be advisable in order to help to give body to the tar and to assist in reducing its susceptibility to changes in temperature. This "free carbon" may be either the natural fraction of the tar or it may be added foreign material, such as Portland cement or finely powdered limestone.

Some surfaces built by this method with a low carbon tar have improved as fine material was supplied by traffic.

It is acknowledged that uniformity of penetration is desirable. To this end, as well as for the sake of economy, efforts have been made to supplant the early system of hand-pouring by some mechanical distribution of the bituminous material. Some very successful machines have been devised for the purpose and it seems generally agreed that the best results under this method are secured by the use of such appliances distributing the tar under pressure.

An excess of bituminous material will give a surface which will become wavy under travel, and a similar effect is produced by material containing dirt, which does not permit enough penetration. In cases of unequal distribution, which is more likely under the hose application than in the method described, lean spots break up and go to pieces, while fat spots bunch up and form bumps. If the lower course is not filled, the hot bituminous material penetrates too far, with consequent loss of material in the surface.

Cost.—The usual variations in cost, resulting from different local conditions, have been present with penetration as with any other method.

However, it may be stated that with labor and material at average prices and work within reasonable distance from railway station, the cost for constructing a bituminous macadam road, in manner described, would be about 35 cents per square yard over and above the cost of building a waterbound macadam road. A decrease in

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*Read before the Conference on Road Construction, Department of Highways, Ontario, 1916.

this cost may be looked for as proficiency in practice and as mechanical appliances for the work are developed.

Bituminous Concrete (mixing method).—This type of construction has caused a great many disputes owing to the fact that there is a certain patent covering the use of stone and bitumen mixtures under certain specification. However, it has been pretty well established that if the maximum size of stone is not any greater than ½-in., and furthermore, if less than 10 per cent. is retained at ¼-in. screen, regardless of the method of grading of mineral aggregate which will give the densest mixture there is no infringement of the above-mentioned patents.

This method of construction is well adapted to the improvement of an old macadam road where it is desired to introduce a better pavement at a minimum expense under moderately heavy traffic conditions. It is more expensive than the penetration method, but is more certain in its results, and more suitable for heavy traffic. This method involves a considerable expense for machinery, namely, heating and mixing plant, and with its first cost, as before stated, has led to the development of the penetration method.

Construction.—The mineral material composing the wearing surface is mixed with a sufficient quantity of bituminous material, approximately 15 gallons of tar to 1 cubic yard of material (stone). This mixing is usually done at a plant off the roadway itself and even some distance from the road, though it is preferred that mixing be done on the work.

One of the most common mixing and heating outfits is the Link-Belt portable plant. This machine is 27 ft. long and weighs about 17 tons. Practically all of the mechanism is housed in. This plant consists of melting kettles, a dryer, a dust blower and a mixer. The material is shovelled into one end of the machine, passes through the dryer and thence into the mixer, where it is mixed with the bitumen. The power for operating the machine is obtained by belting it to a tractor or road roller. The heat for the dryer, the melting kettles, etc., is obtained by means of fire boxes underneath the machine, in which coal is burned as fuel; the hot air passing around the various parts of the machine.

The mixture should be put on the road at a temperature of not less than 220° F. The prepared foundation should receive a slight sprinkling of the bituminous material as a binder coat. On this foundation the bituminous concrete is laid and raked into place and then thoroughly rolled with a 10-ton steam roller, until no further impressions occur, to desired thickness, usually 2¼ ins. Sometimes a lighter roller is used. This surface is then given a seal or flush coat of hot bituminous material, about ¼ gallon per square yard, and covered with fine stone screenings and again rolled. In places of this flush coat the surface is sometimes dusted with a coat of Portland cement to fill any surface pores.

With this method a maximum density is sought, using stone carefully graded from fine to large. The requirements of engineers vary to a considerable extent, due to different kinds of aggregate employed; in some cases, one size crusher-run stone is used; again, combinations of broken stone and sand are used. The following specification is adopted in many places in the United States:

Passing 10-mesh sieve....	1.0 per cent.
Passing ¼-inch sieve....	5.5 per cent.
Passing ½-inch sieve....	30.8 per cent.
Passing ¾-inch sieve....	34.2 per cent.
Passing 1-inch sieve....	23.4 per cent.
Passing 1½-inch sieve....	8.1 per cent.

Cost.—The average cost per square yard for this method is about 60 cents over and above waterbound macadam.

The advantages claimed for this method (mixing) are uniformity of surface and of composition of same, maximum value of surface for materials used, economy in use of materials, maximum life of surface and economy of results.

Carpet Coat (bituminous surface).—Surface treatments may be divided into two principal classes, based upon the material used, namely, (1) Those in which tar is used; and (2) treatment with oil.

The method of surface treatment is only applicable to road surfaces already finished by other methods—usually to old or new waterbound macadam.

Two classes of tar are commonly used, one a refined coal tar with a comparatively low melting point, but not fluid at ordinary summer temperatures; the other a refined coal tar which is fluid at ordinary temperatures.

The tar surfaces have the advantage of being much cleaner than oil surfaces in wet weather. The oil surface being softer and more adhesive, holds the dirt and dust upon the surface, while the tar hardens and nothing adheres to it.

The tar road for this reason maintains a better average condition throughout the year than an oiled road. On the other hand, a tar surface is more slippery than the oil, and will, in cold weather, harden and crumble to an extent depending on the season and the kind of traffic.

The use of the first class of tar is more suited to roads of fairly heavy traffic than the second class of tar. Two coats of the latter class give about the same service as one of the first class, and at about the same cost.

The method carried out in this treatment is to clean the old surface of road to be treated free from all dirt and fine material. After such cleaning and when surface is dry, the tar is applied at a temperature of about 180° F. from a tank wagon drawn by steam roller, in a manner described in penetration method. A steam pressure of about 10 lbs. per square inch is applied to the bituminous material. This also keeps the tar hot. This surface is immediately covered with stone screenings, or preferably pea gravel, and rolled. This forms a hard crust, is firmly bound to the surface, and resists all abrasion from motor cars. Where heavily loaded, iron-tired wagons use this type of surfacing, the crust has a tendency to break up, especially in cold weather, and an annual treatment is necessary and will maintain the road in excellent condition.

The amount of tar used is usually ½ gallon per square yard.

The cost of this treatment varies from 8 cents to 14 cents per square yard; even as low as 6 cents per square yard has been recorded, including material and labor.

The advantages claimed for this method are simplicity of work, economy of first cost, and in many cases, economy in the long run, lack of serious interruption to use of road, ease of repairs and renewal.

Satisfactory results have been obtained under this method, and it is believed that it offers an easy and economical way of revivifying a macadam or gravel road otherwise about to need resurfacing at a far greater cost.

Snow removal this winter in New York City has cost $1,150,000. The regular contractors' outfit engaged on the work totalled 2,500 men and 1,200 carts. The emergency gang was composed of 9,000 men, besides the 3,000 regular street cleaners. Motor snow plows to the number of 120 aided in the work. Wherever possible the snow was disposed of in sewers.

Letters to the Editor

Placing Concrete in Frosty Weather.

Sir,—In your issue of February 24th there appears an article entitled "Concrete Pipe Tunnel, N.T.R., Quebec," by Mr. C. V. Johnson, A.M.Can.Soc.C.E.

This article is exceedingly interesting in that it deals with the question of depositing concrete during frosty weather—a subject which, in this country with its long and intensely cold winters, is one of supreme importance. That concrete in large masses, such as heavy dock walls or bridge abutments, may be safely deposited during periods of considerable frost, provided that precautionary measures are taken, is fairly well established; but a special interest centres in Mr. Johnson's article because the work described was a pipe tunnel having side walls only 12 inches thick, and floor and covering of slabs only 6 inches thick; and the article is rendered really valuable because the author gives the lowest temperature during which concrete was deposited, describes fully the precautions taken to insure the safety of the work, and is able to give assurance that no bad results followed.

It is just this point—the completeness of the information given—which has led me to trespass upon your columns in order to direct attention to the necessity for this completeness on the part of engineers who describe, in your columns or elsewhere, works which they have carried out, if these descriptions are to be fully and lastingly valuable.

The question of depositing concrete during frosty weather is one which at present appears to be in a somewhat unsatisfactory condition. Different engineers have varying opinions as to the limit of temperature, and the precautions necessary, and in practice this frequently works out as little better than "rule of thumb," or the precarious judgment of the moment. As stated above, it is fairly well established that concrete in large masses may be safely deposited during frosty weather under certain precautionary conditions, but it would be highly desirable if this could be narrowed down so as to establish a lowest permissible temperature, and to define the precautions necessary during the mixing and after placing the concrete, so that some approach to uniformity in practice might be attained and the conditions, the result of sure and certain knowledge, laid down in the specifications when tenders for work are invited.

Similarly there could be established the lowest temperature at which it is safely permissible to build in brick or stone, in which, of course, the mortar is applied in thin layers.

At one time, the present writer was engaged for some 12 years in the construction of dock, harbor and pier works on the northwest coast of England. These works were almost entirely carried out in concrete and stonework. The setting of stone masonry was stopped as soon as the temperature reached the freezing point; and no concrete was allowed to be deposited, even in large masses, after the temperature had reached 4° below freezing point, or 28° Fahr., and only then when the newly deposited concrete would be immediately covered by the rising tide, and remain submerged for several hours. Of course, no precautionary measures, such as heating the materials, were taken, though occasionally the sea-water was used in mixing the concrete. It need scarcely be added that under such conditions none of the concrete ever showed any signs of deterioration from the effects of frost; but it is quite clear that such extreme caution is unnecessary, and would be well-nigh impossible or impracticable in this country. By heating the materials and protecting the new work concrete may safely be deposited at a much lower temperature than 28° Fahr., and it only remains to establish the lowest temperature and the protective measures necessary under the extreme conditions.

There must be many engineers in the country who have had large experience in this matter, and who, doubtless, have much valuable and detailed information in their possession. If such engineers would publish more freely the results of their experience in full detail, and if these details of various conditions and results were collected and made readily accessible, something approaching the lowest permissible temperature and the necessary protective measures might be reached.

The thought suggests itself that the preliminary step —that of collecting exact information—might very properly be taken by the various branches of the Canadian Society of Civil Engineers, each branch working amongst its own members. After this, the results might appear in the transactions of the parent Society, and the information would thus be placed in the hands of the great majority of engineers throughout the country.

JOHN B. HARVEY, M.I.C.E., M.Can.Soc.C.E.

Ottawa, Ont., March 28th, 1916.

Stresses in Lattice Bars of Channel Columns.

Sir,—We may distinguish between the loads that lattice bars normally carry and the loads for which they should be designed, in order to make the design of a column consistent as a whole. It is the latter problem that Mr. Pearse has sought to solve.

It may be well to review briefly what we know regarding the actual stresses in the lattice bars of columns that have been tested and what bearing these results have upon design.

In Bulletin 44, Talbot and Moore give results of three tests of the lattice bars on each of two columns. Column No. 1 was of steel built for the tests and designed slender to show the phenomena expected. It had two plates 20" x 3/8", four angles 2" x 2" x 1/4", and two rows of single lacing. Column No. 2a was of wrought iron and had seen service in a railway bridge. It had two channels 10" 30lbs., and two rows of double lacing. The strain gauges were attached to the lattice bars in such a way that they gave the average strain over the entire section of each bar in the gauge length used. For the five bars that showed the highest stress in each test the authors of this bulletin estimate the equivalent ratio of the transverse shear to central column load as follows:

— Column 1 —			— Column 2a. —		
Test 5.	Test 14.	Test 15.	Test 11.	Test 12.	Test 13.
0.020	0.016	0.009	0.029	0.027	0.021
0.009	0.010	0.009	0.024	0.019	0.016
0.008	0.010	0.007	0.023	0.018	0.014
0.008	0.009	0.006	0.010	0.018	0.014
0.007	0.009	0.006	0.008	0.018	0.011

In the early use of Column 1, it failed unexpectedly under a slightly oblique load; the alternate lattice bars buckled in one half of the column; the lattice bar loads were not determined by tests upon them, but compression tests had been made on similar bars and the lattice bar load was estimated from these compression tests and it is given in the bulletin as "Probable Maximum Load on Lattice Bar in Pounds, 2,100." It is this result that Pearse has used to confirm his results.

Column 1 was tested in cross-bending also; the "under" lattice bars that were in compression were found to have a maximum stress in each from 39% to 72% greater than the average stress in the bar, while in the "over" bars that were in compression the maximum stress was from 131% to 450% greater than the average stress.

Tests of large columns by Howard, given in Trans. Am. Soc. C.E. for 1911, show insignificant stresses in the lattice bars observed.

Vol. 16 of the Proceedings of the American Railway Engineering Association gives results of tests upon seventeen lattice bar columns conducted at the Bureau of Standards. One was a large plate and angle column, the others were channel columns. The lattice bar strains were erratic, generally small, and compressive in most cases. While the columns did not show much transverse shear, we may express the results in terms of the transverse shear that would be expected to give the same strains and we may express this transverse shear as a fraction of the column load. With a load increase of 28,000 lbs. per sq. in. on the heavy column, the maximum shear indicated was about 0.8% of the column load. The smaller columns under different load variations from 14,000 to 29,000 lbs. per sq. in. showed different maximum values of shear, the average of which is about 0.9% of the column load and the largest value that appears to be normal was abourt 1.6% of the column load. The per cent. of shear seems to increase with increase of slenderness ratio, and for columns of the same slenderness ratio it is smaller for heavy columns than for light columns. Column No. 17 showed an abnormal lattice bar strain with a load increase of 14,000 lbs. per sq. in., but this lattice bar showed little strain for subsequent heavier loading.

It is believed that the results of these recent tests do *not* warrant the conclusion that lattice bar loads should be materially decreased in the design of ordinary columns. The most of these columns were made under stricter specifications regarding workmanship than are common. They were carefully adjusted to their bearings by highly intelligent men. They were loaded by means of a testing machine of unusual accuracy and rigidity. They were all tested with flat ends. It is apparent that the strain gauge lines were on the exposed side of the various lattice bars; Talbot and Moore found that the strain on one side only of a lattice bar may differ very widely from the average strain over the section of the bar, and we should naturally expect the strain on the exposed face to be smaller than the average strain. Perhaps these tests may be looked upon as indicating the lower limit of what may be expected in the way of lattice bar loads *that result from column loads*.

It may be admitted that the present method of assigning loads to lattice bars, such as by Pearse's Equation (d), is not logical. We have not learned that it has given unsafe results. The chief difficulty in trying to get up a consistent method for the design of a column is that different people do not agree upon the meaning of column formulas. I do not think the stress that Pearse designates by S_0 should be considered constant for columns of different slenderness ratios or for columns of some different types of cross-section.

Admitting that Pearse may be right in this respect, he has erroneously introduced a factor 2, that makes all of his results twice too large on this score. Then his equation 7, as applied to the actual length of the column, can hardly be admitted for his purpose. Many people have assumed this equation for the column curve and for certain purposes it matters very little; but that is not true in this case. If a column deflects with no part overstressed and at a load less than that given by Euler's formula, it is because its load is not central. Its axis takes the form of a portion of the sinusoid curve; the whole sine curve extends to the greater length that a column of the same section would have in order to be about to fail by buckling under the same load, the Eule length for this stress. For the columns and average stresses given below the lattice bar loads given by Pearse's formula should be multiplied by the factors indicated.

Slenderness ratio L/r	Average stress S_1	Correcting factor
20	13.325	0.01
40	12.825	0.05
60	12.050	0.10
80	10.835	0.16
100	9.200	0.21

The resulting lattice bar loads would be so small that in many cases we might expect the lattice bars to receive larger loads in transportation and erection. I suspect that Talbot and Moore were not far from right when they concluded in Bulletin 44: "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available."

This futility should not lead us to close our eyes to the possibility of certain loads that can be roughly approximated. A column must be transported and erected; it may be at the bottom of a pile of bridge or building material and should be capable of carrying a good load in addition to its own weight. Some of the lattice bars may be so badly bent that they can carry little load; the adjacent bars should be amply strong.

A channel may not be initially straight; if it is straight before punching holes in its flanges it will not be so thereafter. Riveting tends to bend members more than punching does. It is safe to say that very few channels of latticed columns would remain straight if the lattice bars were sawed in two so that each channel could take its natural form without restraint. In columns, these channels are held to straightness, insofar as they are straight, by the lattice bars, arranged with the channels in triangular truss elements. Some of the lattice bars must carry load due to this service which they perform. If the channels would bend into circular arcs on being released from the lattice bars, we can see that the lattice bars that are near the ends of the column would carry loads due to this bending of the channels, but the intermediate lattice bars would be comparatively free from such load. In general, we should expect the channels to be bent rather irregularly.

It may be worth while to point out approximate relations between these loads and the channel deflections. Let us take the channels given in Pearse's table, same distance between channels, with two rows of single lattice bars inclined 60 degrees with the column axis. Take the channels initially straight and let one of the channels be deflected 0.001 inch by the lattice bars attached to one point of one channel flange, this deflection being forcibly caused by the lattice bars. If we consider the channel as acting like a simple beam of two panels length loaded in the middle, we find the force in each lattice bar to be rather more than 100 lbs. for this small deflection. If we consider the channel as a continuous beam extending over several panels, it is evident that the lattice bar load will be considerably increased; in making an approximate solution by means of characteristic points I found the load for each lattice bar to be about 250 lbs.

One can estimate the maximum deflection that these channels can take before they reach the yield stress; using a yield stress of 30,000 lbs. per sq. in., my estimate for this is approximately 0.001 inch for each inch of depth of the channel. After these values have been checked, they can be used to estimate the maximum possible fabrication loads of the lattice bars of channel columns.

It will be noticed that these fabrication loads cannot be determined by strain gauge measurements upon columns under test loads; they may be estimated by means of such measurements made at the time of fabrication; I do not know if such tests have been tried.

If a single lattice bar is too long or too short by 0.001 inch it will tend to throw the channels out of line, and in the above set of channel columns, this bar will carry a load of about 125 lbs., the channels being regarded as continuous beams. Since this sort of an error throws the channels out of line, this bar will have to carry a portion of the column load. If the error in the bar is 1% of its length, the load in this single bar due to column load is about ⅝% of the column load.

It is to be hoped that fabrication stresses will receive much more attention in the future than they have heretofore received. It is believed that their investigation will reveal many of the reasons why we must use large factors of safety; they may show that our factors of safety as now used are not appropriate to the several structural members.

By way of summary of the views presented above, we may say that it seems improbable that any one formula can now be written for lattice bar loads that will give appropriate results for all conditions; that in assigning lattice bar loads to be used in the design of some particular set of columns it may be appropriate to express the lattice bar load by three terms: (1) the first term may depend upon the carelessness of fabrication and upon the stiffness of the main members of the column; (2) the second term may depend upon the carelessness of fabrication and upon the column loads; and (3) the third term may depend upon the general proportions of the columns; while the sum of the second and third terms should not be smaller than another term which may depend upon the general proportions of the columns and upon the rough handling to which they may be exposed in transportation, erection, and use.

O. H. BASQUIN,
Professor of Applied Mechanics,
Northwestern University,
Evanston, Ill.

March 27th, 1916.

EFFECT OF ALKALI ON CONCRETE.

The engineers of the United States Reclamation Service are investigating the effect of alkali waters and soils on concrete. In the Reclamation Record for February some preliminary conclusions are presented. Sulphates, especially of magnesium and sodium, were found to be the most active in producing disintegration.

Two extreme cases may be cited in the Sunnyside and Belle Fourche projects. Of a number of test specimens exposed on the former no disintegration was observed at the end of about eleven months, with the exception of a specimen containing a soap and alum solution in the mix. The specimens were all of a 1:3:5 gravel mixture. Furthermore, none of the concrete structures on this project have been affected. On the other hand, various mixtures exposed on the Belle Fourche project were all found to be disintegrated at the end of eight months, with the exception of a 1:2 mortar specimen, which was not affected. Concrete structures in this project have also been disintegrated by alkali.

Analyses of samples from the Belle Fourche project show magnesium and sodium sulphates present in strong solution, with the former predominating, and samples from the Sunnyside project show sodium sulphate only, and in much lighter solution. As a general proposition, it must for the present be concluded that in locations where alkali containing these salts is present, special precautions must be taken to prevent its possible action, unless experience with structures previously built has shown no deleterious effect.

Lean mixtures of concrete are more susceptible to disintegration than rich mixtures, and those which are scientifically proportioned as regards cement and aggregate give the best results. This is to be expected, as with scientific proportioning the percentage of voids is reduced to a minimum, thereby preventing seepage of the alkali-laden water into the body of the concrete.

Experiments have shown that the more nearly impervious the concrete the less it is disintegrated by alkali. It is a natural deduction, therefore, that waterproof concrete will resist alkali action. Such concrete, under certain conditions, may be difficult to produce. Laboratory experiments have shown that it is possible to produce concrete that is practically impervious to water up to 50 to 75 lb. per square inch pressure, and satisfactory results have been obtained in the production of an impervious concrete in the field on structures where special care was taken toward that end.

There are numerous patented waterproofing compounds on the market; there are also being manufactured several so-called alkali-proof cements. A number of these have been tested, but the results have not been any better than those obtained with straight Portland cement. Sand cements also have so far shown no superior alkali-resisting qualities. J. Y. Jewett, cement expert, gives his tentative opinion "that with good cement, with care in the selection of suitable aggregates, with proportioning to produce a rich, dense mixture, and with proper methods of mixing and placing, it is possible to produce a dense, impervious concrete that will withstand the alkali action under ordinary conditions without the use of any special materials for waterproofing purposes." With fairly rich concrete an impervious skin of neat cement or rich mortar, such as is produced by working a flat spade between the concrete and steel or surfaced wood forms, will no doubt also have a decided effect in resisting the action of alkali.

COAST TO COAST

Orillia, Ont.—The new filtration plant which has been under construction for the last year and a half, has been put in operation.

Quebec, Que.—The new Transcontinental shops are nearly completed. The machinery for the power plant only remains to be installed.

Vancouver, B.C.—A movement is on foot to establish an inter-provincial road to link up the coast with the Okanagan and Kootenay valleys.

Belleville, Ont.—In the annual financial statement of the waterworks department a net profit of $74,000 is shown for fifteen years' operation.

Fredericton, N.B.—A bill is before the legislature whose purpose is to compel the Street Railway Company to extend their lines in the parish of Simonds.

Hamilton, Ont.—The city council has definitely put itself on record as being favorable to an overhead bridge as an entrance for the Toronto-Hamilton highway.

Sarnia, Ont.—Leakage in services and mains of the waterworks is costing the city $25,000 per year. It is proposed to have a pitometer survey made to locate the leaks.

London, Ont.—New machinery installed at Springbank dam is capable of pumping 3,000,000 gallons of water per day and can be used as a power generator when needed, developing 200 horse-power.

Ottawa, Ont.—The plans for the future layout of Ottawa and Hull, which have been prepared by the Federal Town Planning Commission, are on exhibition under the auspices of the Ottawa Chapter of Architects.

Quebec, Que.—It is expected that the new Bickell bridge will be opened to traffic by May 15th. The structure is of the bascule type and weighs 200 tons. Provision is made for electric railway, horse and foot traffic.

Guelph, Ont.—Spring floods endangered the big concrete bridge over the Speed River, when a portion of the dam immediately above the bridge was washed out, throwing an immense amount of water against the roadway at the end of the bridge and undermining it.

Ottawa, Ont.—The government has passed an order-in-council prohibiting the export of nickel to any but British countries. The order applies to nickel, nickel ore and nickel matte. It is likely that the International Nickel Company will establish a plant in Nova Scotia for refining purposes.

Montreal, Que.—A petition was presented to the Superior Court by the Mountain Sites, Limited, asking that the city be compelled to fulfil its obligation made when Cote de Neiges was annexed to the city in 1910 by which the city was to open a street from Snowden Junction to Liesse Road.

Halifax, N.S.—At a luncheon meeting of the Rotary Club held recently H. R. Mallison, of the Nova Scotia Tramways and Power Company, Limited, described the plans of his company as regards their power development at Gaspereaux. The turbines will have an effective head of 440 feet behind them and will develop 16,000 h.p.

Toronto, Ont.—The proposed new agreement to be entered into by the York Township Council and the Ontario Hydro-Electric Power Commission relative to the operation of the system in York Township has been discussed by the council with representatives of the commission. The agreement has been practically closed and it is expected that its passage will greatly facilitate the installation of extensions, etc., in the township. Under the old method power extensions for either domestic or street lighting purposes were made by the city following the approval of the Ontario Commission.

ELECTIONS TO MEMBERSHIP IN CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a meeting of the Council of the Canadian Society of Civil Engineers, held March 21st, the following were elected to membership:—

Members.—Binnie, Alex. Thos., Victoria, B.C.; Brace, Jas. H., New York City; Hamilton, James, Edmonton, Alta.; Ogilvie, Noel John, Ottawa; Teele, Fred Warren, Hudson, Mass.

Associate Members.—Augustine, Alpheus P., Penticton, B.C.; Barnes, Harry F., London, Ont.; Blackwell, R. H. Holden, Toronto; Burfield, Francis Robt., Calgary, Alta.; Chapman, Alfred Saunders, Calgary, Alta.; Craig, John C., Vancouver, B.C.; Daubney, Chas. Bruce, Port Nelson, Man.; Douglas, Ralph H., Edmonton, Alta.; Edwards, Chas. Peter, Ottawa; Gorrie, David F., Winnipeg; Hodgson, Jos. Pollard, Vancouver, B.C.; Stamford, Wm. Leonard, Victoria, B.C.; Worthington, Wm. R., Toronto; Wright, Clifton M., Barbados, B.W.I.

Juniors.—Cox, O. S., Halifax, N.S.; Dodge, Clinton Lowell, Strathmore, Alta.; Hughes, Hamilton Cleaver, Vancouver, B.C.; Keefer, Jos. Alex., Victoria, B.C.; McColl, Samuel E., Winnipeg; Weeks, Stephen F., Vancouver, B.C.

The following transfers also took place:—

Transferred from the class of associate member to that of member—Young, Frank Moses, Fort Steele, B.C.

Transferred from the class of junior to that of associate member—Crawley, Edmund A., Winnipeg.

Transferred from the class of student to that of associate member—Saint, John B., Vancouver, B.C.

Transferred from the class of student to that of junior—Plummer, Alex. Alfred, Vancouver, B.C.; Taylor, W. Harold, Winnipeg.

SLIDE RULE FOR SPECIFIC SPEED OF HYDRAULIC TURBINES.

A new calculating device in the form of a slide rule has been issued by the Wm. Hamilton Company, Limited, of Peterborough, Ont., manufacturers of hydraulic turbines. The slide rule is used for determining the specific speed or type characteristic of a hydraulic turbine runner. The specific speed is the revolutions per minute which would be attained by the runner if it were reduced in all dimensions to such an extent as to develop 1 h.p. when working under a head equal to 1 foot.

The slide rule is well made of white celluloid with black figures and is contained in a handy pocket case of imitation leather.

Water softening by electricity, especially as regards boiler feed water, is attracting the close attention of American engineers. After the softening compound has been added to the water it is circulated past parallel electrodes which are placed close together in order that as much of the water as possible may be brought in contact with the surface of the plates. The ionising properties of electricity separate the compounds into their components, thereby hastening the recombination to form percipitates, which are easily removed. Ten million gallons of water per day, it is stated, may be treated with only 480 watts per million gallons.

Editorial

MAKING GOOD-WILL A REAL ASSET.

Good-will is an item that often means little or nothing in a firm's balance sheet. A century ago, when but few firms were in each line of business in any town or city, good-will was a real and tangible asset in nearly every well-established store and factory. Changes in methods of competition; the growth overnight of huge concerns, with great resources; amalgamations; price agreements; the large number of sellers in every line,—these and other influences have reduced good-will to a mere figure of speech in many cases.

However, occasionally one happens upon a firm that has, by painstaking processes, built up real good-will. Uniform courtesy in all transactions is generally found to be a strong factor in such cases. A representative of *The Canadian Engineer* recently called at one factory in the United States where "good-will" will certainly some day be a valuable asset, if, indeed, it is not so already. The call was upon the A. P. Smith Manufacturing Co., of East Orange, N.J. The object was to secure an advertisement of their water-tapping machines. The advertisement was not forthcoming at the time; yet, because of the great courtesy with which he was received, the paper's representative, when leaving the factory, was nearly as happy as if a full page weekly contract had been signed.

Immediately upon entering the reception room, he was greeted by the following sign, giving most specific information, and radiating hospitality and good-cheer:—

> INFORMATION
>
> Our correct name is THE A. P. SMITH MANUFACTURING COMPANY.
>
> Our mail address is Norman and Lawrence Streets, EAST ORANGE, N. J.
>
> Our shipping address is in all cases to be taken from our purchase order form.
>
> Our telephone number is ORANGE SIX THOUSAND.
>
> We make valves, hydrants, tapping machines, valve inserting machines, lead melting furnaces, corporation and curb cocks, repair sleeves, pipe cutters, calking machines, meter testers, removable plugs, pipe indicators, etc. A broad description of our line is GENERAL SUPPLIES AND SPECIAL TOOLS FOR WATER WORKS. In addition to the above, we do general machine work, make patterns, and castings in iron, semi-steel, brass, bronze, aluminum, etc.
>
> The officers are as follows:
> D. F. O'BRIEN, - - *President* M. G. PERKINS, - *Vice-President*
> T. F. HALPIN, - - *Secretary* P. A. SMITH, - - *Treasurer*
> All of the above, except Mr. Perkins, are located at this plant.
>
> MR. O'BRIEN can be seen, if an interview has been arranged, any day, except Saturday, between ten o'clock and four o'clock.
>
> MR. HALPIN has charge of sales, advertising, office employment, prices on supplies and specialties in our water works line, etc. He can usually be seen on Tuesdays, Wednesdays, Thursdays and Fridays, from one thirty o'clock to four thirty o'clock.
>
> MR. SMITH has charge of buying, charity and other donations, prices on brass and iron castings and machine work, factory privileges, etc. He can usually be seen on Mondays, Tuesdays, Thursdays and Fridays, from ten o'clock to twelve thirty o'clock and from two o'clock to four thirty o'clock.
>
> In order TO SAVE YOUR TIME and ours, it is best, in all cases, to arrange an interview in advance. Please give the boy at the window full information; you will save time by it, as he has orders that he must obey. He will furnish you with a card marked APPLICATION FOR AN INTERVIEW, if you desire it.
>
> VISITORS will be required to have a pass, properly signed by an officer, before admission to the factory will be granted.
>
> APPLICANTS FOR EMPLOYMENT must fill out an application card. Ask the boy for one.
>
> We will appreciate it if you report to us any discourtesy on the part of any of our clerks toward you. Their instructions are to help you as much as possible. We have street directories, maps, etc., and will be pleased to loan them to you on request. We have many trade papers. If you must wait, as unfortunately you will have to, at times, ask for one, so that your time will not be wasted.
>
> We thank the SALESMEN who visit us for the information and many new and good things they have brought to us. We have salesmen on the road and understand.

"Welcome" surely seemed to be written large upon the door-mat. But the courtesy wasn't confined to the sign. It permeated the whole office and factory. It was evident that politeness was the rule, not the exception, from the president to the office-boy. At the close of his visit, the salesman was even taken to the depot in the firm's automobile, which seemed to be kept handy for such purposes!

DEVELOPMENT OF THE TELEPHONE.

The discovery of the principle of the telephone is brought to our notice just now owing to the unveiling of a tablet in Boston. The tablet has been erected by the Bostonian Society and the New England Telephone and Telegraph Company to commemorate the event which took place some forty years ago. A noteworthy fact in connection with the unveiling is that both the inventor, Alexander Graham Bell, and his assistant, Thomas A. Watson, were present.

Mr. Watson relates the story of the discovery, which was accidental, but, as he says, the incident could only have been taken advantage of by a man with clear conception, such as the great inventor had. The discovery was made on the afternoon of June 2, 1876, during experiments in connection with Bell's theory that a current of electricity should vary in intensity as the air varies in density during the production of a sound. Dr. Bell was testing a spring in one of the receivers to ascertain if the pitch was correct. He had pressed the receiver close to his ear and was listening to the faint sound of the intermittent current passing through the magnet, when the transmitter in Mr. Watson's room stopped vibrating. Mr. Watson snapped it with his finger to start it vibrating again. It was this action that was responsible for the discovery. Dr. Bell heard the pitch due to the length of the spring and also the peculiar soft twang, and recognized instantly that the current carrying such a sound was realizing his long-cherished idea.

What had actually happened was that the spring which Watson had snapped had become permanently magnetized and was in condition by its vibration to generate the sought-for undulating electric current, and when the current passed through the magnet of the receiver, which was pressed against Dr. Bell's ear, it set into vibration the spring of that instrument, which spring, being confined against his ear, was in a condition to vibrate as a diaphragm and not merely as a freed reed.

The invention of the speaking telephone, however, was no accident—it was a development of the undulatory electric current.

From this time on, Dr. Bell devoted his whole time to the study of the speaking telephone, resigning his teaching position at Boston University.

Finally, on March 10, 1876, the telephone actually transmitted intelligible words. The sentence was, "Mr. Watson, come here; I want you." Probably if the inventor had thought of the great invention he was making he would have chosen a sentence not so commonplace as the one he used. From the time of this first use of the telephone as a transmitter of the voice the improvement was more rapid. By early summer in 1876 it was possible to converse fluently between two rooms. On the evening of October 9, 1876, the first long-distance test was undertaken, when messages were carried over a wire two miles long. The commercial success of the telephone was then assured.

Dr. Bell and his assistant possibly have seen the greatest scientific development along any one line that has been the satisfaction of any inventor to see. From the little imperfect room-to-room telephone line they have seen the wonderful lines over which it is possible to converse from Montreal to San Francisco. They have seen the great commercial development due to no small extent to the great inventor by which commercial enterprises have been connected in one great network of wires. It has seldom been the experience of an inventor to see his invention so developed, more especially by himself. It is to be lamented that inventors very often, who make an invention, find it enlarged upon by some other inventor who gets the greater amount of credit and profit. It is to be hoped that Dr. Bell has seen his ideas fully developed and has received all the satisfaction and benefit which he deserves for his great invention.

The blessings which have followed in the wake of Dr. Bell's discovery it would be well near impossible to describe. The world has been made smaller and more neighborly—business has been facilitated to an enormous extent. It is doubtful if any one single invention has contributed so generally to the enjoyment of the people as has the telephone. One can only realize the value and convenience of the telephone when, after having used one for years, he is placed in a position where he cannot have access to it. It is like an insurance policy, " 'Tis better to have it and not need it than to need it and not have it."

PERSONAL.

G. L. PEARSONS has been appointed secretary and general manager of the Goderich Elevator & Transit Company, Goderich, Ont.

H. G. GIRVIN, chief chemist of the Steel Company of Canada, delivered an address to the Hamilton Technical School a few days ago. His subject was "Iron and Steel."

Capt. F. C. KILBURN, of the Signal Corps, Royal Canadian Engineers, who is now in France, has been promoted to the rank of major. Capt. Kilburn was recently recommended for the D.S.M.

W. J. CURLE, of Toronto, has been appointed general manager of the C., W. & L. E. Railway, to succeed the late William Norris. Mr. Curle was formerly connected with the C.P.R. and C.N.R., the latter road having control of the C., W. & L. E. Railway.

MARK WORKMAN, president of the Dominion Steel Corporation, has left Montreal on a trip of inspection to the company's coal and steel properties in the east. He will be away for some time, his intention being to make a thorough survey of the properties, particularly the recent extensions.

Recent changes among the superintendents of the Canadian Pacific Railway are as follows: A. Halkett, superintendent, Kenora, transferred to Moose Jaw; H. H. Boyd, transferred from Moose Jaw to Vancouver; C. A. Cotterell, transferred from Vancouver to Lethbridge; J. M. MacArthur, at present acting superintendent at Lethbridge, is appointed superintendent at Kenora. The officials took charge of their new districts on April 1st.

OBITUARY.

JOHN FLOOK, a well-known contractor of Chatham, Ont., died at his home there last week.

ROBERT DAVIES, proprietor of the Don Valley Brick Works, Toronto, Ont., died on March 22, aged 67.

WILLIAM R. WAGHORNE, manager of the Hydro-Electric System at Wallaceburg, Ont., died on March 23.

GEORGE SMITH, town engineer of Lindsay, Ont., died of heart failure last week while visiting friends in Toronto.

RICHARD FOX, for many years superintendent of the electric light system in Port Arthur, died recently at his home there.

VICTORIA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the regular meeting of the branch last month an interesting lecture on "The Bridges of the Canadian Northern Pacific Railway" was given by J. L. Harrington, M.Can.Soc.C.E., of the firm of Waddell & Harrington, consulting engineers. He described in detail many of the bridges he had designed, making special mention of lift bridges, where the span lifts up vertically, allowing the ship to pass underneath, instead of having the turntable. The lecture was illustrated by a number of excellent lantern slides, showing the completed bridges, the work in course of construction, and details of the work.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The "Panama Pacific Exposition" was the subject of an illustrated lecture before the Edmonton Branch, Canadian Society of Civil Engineers at their regular meeting on March 24. The lantern slides used were loaned to the branch through the kindness of the National Electric Light Association of New York, and showed the wonderful lighting effects secured at the Exposition.

Dr. J. A. Allan, of the University of Alberta, who spent some weeks at the Exposition, explained very clearly the various slides as they were shown.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers will be held in the Chemistry and Mining Building of the University of Toronto, on Thursday, April 13th, 1916.

Professor A. P. Coleman, Ph.D., will give an illustrated address on "A Visit to the Mountains of Northern Labrador."

A large attendance is requested to hear this very excellent address.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.