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MISSING

The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Comprehensive Topographical Surveys Required

Planning of Land and Water-Power Developments, Roads, Canals, Etc., Would Be Facilitated by Standard Maps Showing Important Topographical Details—Faults of Present System and Suggestions for Improvements—Plane Table in Peace and War

By P. J. BARRY

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MUCH has been said and little of a tangible nature has so far been accomplished in organizing a better system of topographical maps for the use of the public in Canada. At this time of industrial and agricultural development, efficiency is a positive necessity. Engineers confronted with problems of land and water-power development, roads, canals, town-planning, etc., are at a loss for skilled topographers to give them the information necessary for accurate estimates.

There are numerous maps and innumerable surveyors engaged in making them, but they are in most cases merely skeletons; the important topographical details are missing. It is to be regretted that co-operation rather than controversy is not made the ground for solving this difficulty. Differences of opinion between surveyors and legal arguments are, unfortunately, too common to convince the public that they are getting the best service for the money expended on surveys in this country.

Everybody will admit that there is much survey work being done which is not directly required, and the requests which are being made to the Dominion government for resurveys of land where boundaries and corner posts have disappeared, tend to show that a lot of this work has been premature. Some of the time and money could have been expended to advantage in making a permanent detail survey of more important territory. The absence of detail maps of our cities and towns has been discussed frequently at meetings of engineers and town-planners, but no practical solution is apparent.

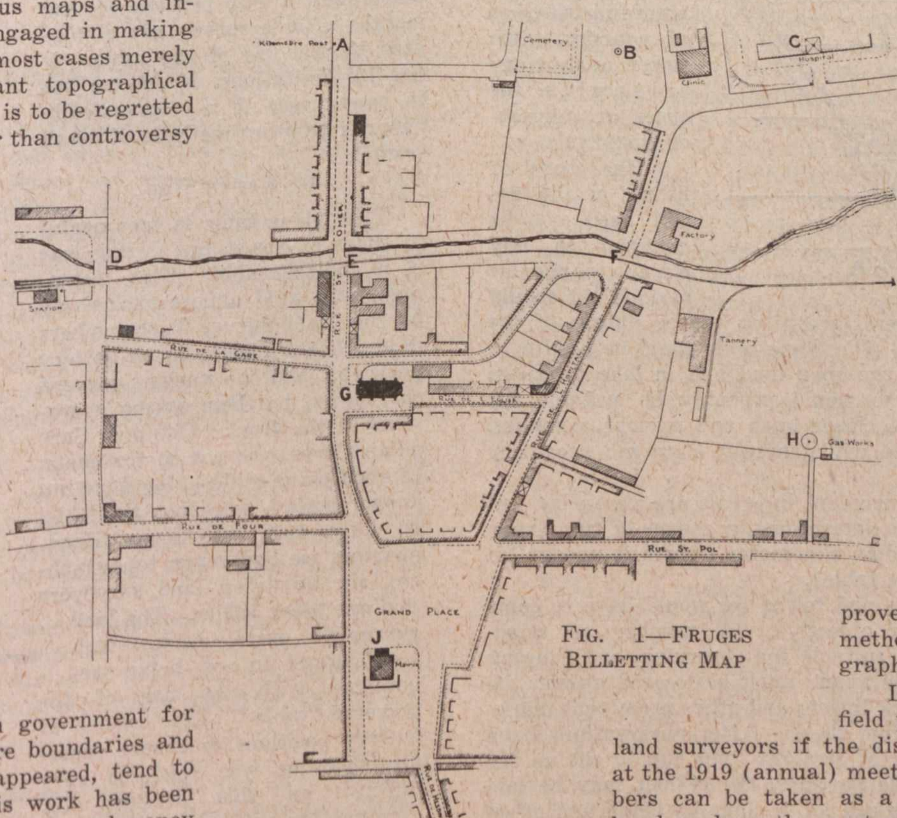

FIG. 1—FRUGES BILLETTING MAP

Faults of Present System

To a person who has spent many years in the field of standard surveys, some of the present methods of procedure appear incomprehensible. In the preparation of maps, there seems to be confusion as to the actual meaning of the word "topography." One government issue carries the impress "Standard Topographical Sheet," although a close inspection does not reveal anything of a topographical nature except the water outline; the land divisions shown in firm lines are in most cases undefined by fence or ditch on the ground, and therefore not topographical features at all.

It is also noticeable that the cost of surveys is very high for the results obtained. There are too many men employed and a tremendous amount of energy expended and time wasted in cutting wide avenues through woods for traverse and cross section lines. Abundant opportunities for triangulation in open country and across lakes and wide rivers are seldom taken advantage of. The use of stadia "shots" for supplying detail is a very complicated arrangement to feature on plan, as the draughtsman knows to his sorrow. And so on. The more we study the maps at our disposal, the more we are impressed with the need for drastic changes. There is room for much improvement in our "one-method" system of topographical surveying.

Little can be expected in field practice from provincial land surveyors if the discussion on this subject at the 1919 (annual) meeting of the Ontario members can be taken as a criterion. On the one hand we have the most minute accuracy:—

Chairman of the Committee on Topography—"But with reference to the tower of the City Hall (Toronto), we have found that as a permanent point it is of no value whatever. It moves a number of *inches* throughout the day. When there is no wind there is a movement due to the sun."

Comment on this would be superfluous. On the other hand we hear:—

Mr. D.—"On the last map which has been issued by the Department of Lands, Forests and Mines, this line is also projected and apparently would cross the Albany River about *50 miles* east of the point shown on the other map."

There are several other instances discussed of maps failing to agree by many miles. One of the members concludes a statement with the remark that "we have a great deal to learn in the way of map making." In the face of such a statement the ordinary engineer will be curious to know what the qualifications are for provincial land surveyors. But probably it is better to take a more optimistic view of the situation and seek for a remedy.

Combined Methods Needed

In considering the possibilities of a general topographic survey, the really important point to be emphasized is the employment of men who are proficiently trained for such an undertaking. No amount of effort spent in fitting the right men for this work could possibly be wasted, for the reliability of our maps depends on the quality of the information collected in the field. The next consideration should be the system of control points and lines. The most satisfactory basis on which to build a mass of detail is, undoubtedly, trigonometrically fixed points. Secondary triangulation could then be used according to class of country, with closer or tertiary triangles for cities or congested districts. The work of filling in the detail need not be confined to any one particular method, but should be a combination of several according to the nature of the country to be dealt with. The plane table could be used with advantage over most of the open land and in lake districts; transit and chain-traverse would probably be suitable for woods and rivers; in the closer bush and ravines, compass, stadia and sketching case will generally map the necessary detail.

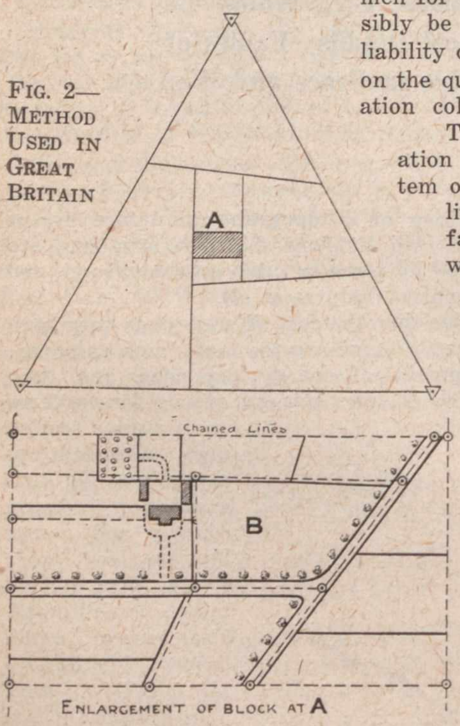

Fig. 2—Method Used in Great Britain

Lines of levels at convenient intervals are necessary, but approximate levels can be determined by means of the Abney aneroid hand level or Indian clinometer (which is unequalled when used with the plane table).

In dealing with cities and towns we would have to come to closer grips with our objective. A number of trigonometrically fixed points suitable for observing, and ranging from one-half to one mile apart, must be located around the towns; church spires, clock towers and other prominent marks inside can be resected from these. After observations have been made and a number of straight lines run to cut up the triangles into manageable portions, the transit may be laid aside, for the detail work can all be done by chain and offset staff. The surveying lines should be run through to an established line—that is, secured at both ends—and they will check themselves when put down on plot.

The method employed in the British Isles and also in the colonies is shown in outline in Fig. 2. The small shaded portion at "A" is enlarged at "B" to show the way in which the chained lines are secured. Fig. 3 is a trig. station used on tertiary triangulation and centred on a square tile; the pole is merely resting on the tile, so that if the former is pulled out the latter remains to mark the position.

The need for skilled topographers has already been mentioned. The name is often applied to persons who take cross sections or interpolate contours on small detail surveys, but in its real significance it means much more. The training of topographers for detail work is not very difficult if instructors with considerable field experience are available.

The text-books, as a rule, throw too many obstacles in the way of the aspiring plane table operator. Graphical solutions on the ground are what he should be concerned with, and no amount of literature can make him proficient without long practice in the field. Under experienced guidance the so-called "three-point problem" will cease to have any terrors for him; the old topographical hand has only a nodding acquaintance with this *pons asinorum* of theoretical scribes.

The student can also learn that resection from fixed points is the basis of good plane tabling; not interpolating positions at a distance outside fixed points, a method of locating given too much prominence by many writers on the subject. The curving lines of land and shore features as they appear to the observer in perspective will assume different shapes when adjusted to plan, but this difficulty will disappear with practice. In fact, there are a lot of useful things which can only be learned in the field and even the best books cannot attempt to explain some of the interesting developments which arise from a close study of nature's profile.

The Plane Table

The amount and variety of work that can be accomplished by the use of the ordinary traverse plane table in the hands of an experienced operator, is surprising. Some persons object that it is only serviceable on small-scale work, but almost any scale can be worked satisfactorily on it. The accumulation of field notes, tedious days spent in plotting, mapping features from memory and all the drawbacks to assembling a map perhaps several months after a survey, are eliminated by the use of the table. It has its limitations, of course, but in most cases it is economically superior to other methods of detail work.

Its Use in War

The plane table is very useful in times of peace, but during war it is indispensable. This instrument was used almost exclusively by the Field Survey Topographers of the Royal Engineers on battery positions, and the various surveys carried out by them during operations at the front. Our own Canadian Corps was not so fortunate, as good plane tablers, for some unknown reason, were not available. In July, 1918, at Corps Headquarters we had seven topographers, six Dominion land surveyors and one plane tabler. The land surveyors were very much handicapped in not being acquainted with the use of the traverse "table." The location of battery positions to ensure accurate shooting was rendered very difficult on this account, for although the men employed on this work did their best, the methods used were too slow and complicated for military operations. They were compelled to resort to angular measurements with the box sextant or transit, and as this system necessitated lengthy calculations, battery commanders were usually obliged to wait until the next day for their positions. The plane table was more prompt, the positions being resected on the spot, and the batteries had the necessary information before the topographer left the ground.

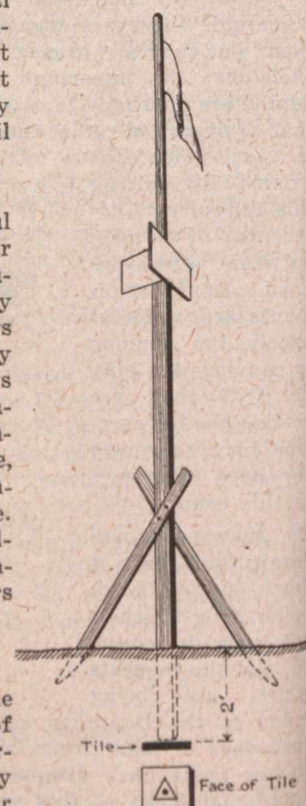

Fig. 3—Trig. Station Used on Tertiary Triangulation

Fig. 1 shows an example of plane table projection which was used to make a billetting map. It is not an accurate survey, but is much better than a sketch, and has no distortions. There were no angles read and no lines measured, the points of control having been resected by graphic triangulation. Incidentally it may be remarked that those points were more secure than if fixed by ordinary transit and tape method; because, being closely resected in horizontal, the liability to error in chaining over uneven ground was eliminated. The point A was a kilometre post, and the second tenth (every tenth of a kilometre—328 ft.—is marked on the main roads in France) or 656 ft. north of A, supplied the base line, from the extremities of which B and C were located. From A and B the points D, E, F, G, H, and J were in turn resected, and the control was established. The detail was supplied by "productions," "cross shots" and pacing, and the whole completed in four hours' field work. The military information has been left out of Fig. 1 in order to make it clearer.

Government Control

A complete and comprehensive topographic survey of the Dominion would necessarily have to come under the supervision of the government. The organization of a staff could be effected without much difficulty. A system of primary triangulation could be entrusted to surveyors from the astronomical and geological branches; secondary triangulation could be linked up by men selected from the topographical surveys branch; and the topographic detail supplied by topographers working under the supervision of the Director of Military Surveys, Department of Militia and Defence. The latter department is probably the only one in the government which has had the experience of using trained topographers, for the production of the one-inch military map.

ONTARIO MUNICIPALITIES FAVOR HYDRO RADIALS

At a meeting of the Ontario Municipal Hydro-Electric Association held last week in Toronto, representatives of the various cities, towns and townships affected, unanimously expressed the opinion that the construction of hydro radials should be started without delay. During the war the provincial government prohibited any work on hydro radials, but the municipal representatives now desire that this prohibition should be withdrawn. One delegate inquired regarding possible increased cost of construction, and was informed by the secretary that the Hydro-Electric Power Commission is of the opinion that construction can be successfully completed without exceeding the money previously voted by more than 10%.

The delegates were granted an interview by members of the provincial cabinet and requested that the government should guarantee the bonds of the Bowmanville, Oshawa & Eastern section of the proposed radial railway. The bonds of the western section have already been guaranteed by the province.

The meeting also passed a resolution requesting the provincial government to empower the Hydro-Electric Power Commission to make a survey of the province to inquire into the possibility of a provincially owned telephone system.

At the third annual meeting of the Canadian Geodetic Society, held last week in Ottawa, the following officers were elected: President, W. M. Tobey; vice-president, J. D. Craig; secretary-treasurer, H. G. Rhoades; members of council, A. M. Grant, J. B. Cameron and H. P. Moulton.

The new $7,000,000 structural steel mill now being built in Sault Ste. Marie—the first one in Canada—will be 1,650 ft. long, will give employment to 700 men in addition to the force now employed, and will turn out $20,000,000 worth of steel each year. Pig iron, open hearth steel rails, billets slabs, merchant bars, light rails, angle bars, splice plates, tie plates and structural shapes, chrome vanadium and nickel, coke, tar and sulphate of ammonia are to be among its products. The new plant will require 1,250,000 tons of coal and 1,000,000 tons of ore annually.

AN ENGINEER'S LETTERS*

By P. B. McDonald
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The letters of an engineer should differ somewhat from the letters written by the average business-man. Although there are, of course, many exceptions to the rule, the engineer is more likely to be a college man than is the business-man. The professional man is supposed to show in his letters the marks of his education, and generally to indicate a dignified "professional" bearing and a temperament influenced as much by a desire to add to the world's knowledge as by the pursuit of gain.

The professional man does more or less work in research and "pure science" for the good of his profession. He is, of course, not averse to making a profit, but he does not bend everything to that end as does the business-man. Incidentally, this is one of the reasons why the professional man has been relatively losing ground in the matter of compensation for his services during the last several years. It is the reason why teachers, editors, pharmacists, etc., are underpaid and overworked. It is the reason why college students have been parading in different parts of the country carrying such signs as "Feed the Prof." and "A Professor Works on his Stomach."

Cannot Be Too Commercial

Yet it would be a calamity indeed if professional men went too far in commercializing their efforts. It would lessen the discoveries in science, lower the confidence we like to feel in an engineer, and spoil the human element in the teacher and minister. There is something to be said for the ethics and traditions of the professions,—for the impracticableness of the researches and student. Imagine a physician who advertised in vivid colors on bill-boards, or an engineer who built a flimsy bridge to skimp a profit, or a minister always thinking of his remuneration for a funeral. It is obvious that a professional man should be swayed by a point of view somewhat different from that of the business-man "on the make," to whose activities Adam Smith's dictum of supply and demand and the itching palm still hold good.

Business-men have some of the finest qualities imaginable, are often unsung heroes, and deserve praise and appreciation that they do not always get. Yet the gingery, "get-there" attitude which the more extreme types assume is sometimes over-done. The "New York Times" recently printed the protest of a South American writer named Albuquerque against the more superficial and "slapdash" variety of North American advertising, which gives offense to the dignity and traditions of high-class Latins.

A European criticism of American business style complained that a letter from New York or Chicago is too likely to run in this vein:—

"You are a business-man; your time means money. You cannot afford to waste it by fooling around after low-grade stuff. It is up to you to get the best. You can get it, and get it quick, from Jones & Co. Why? Because Jones & Co. specialize in mind-saving. Jones & Co. have studied this thing out. They know that you need your brains for live work, not for worrying over back numbers."

The "Art" of Salesmanship

This style of letter is, of course, familiar to everyone; most of us have received waste-paper baskets of such "live-wire" exhortations and commands, frequently re-enforced by a picture of a vigorous man pointing his finger straight at the reader!

Another European stricture on American business methods bewailed the adavnce of the "art of salesmanship," because, with "the system in the saddle," complained this conservative, one eats imitation jam in which even the seeds have been made by machinery to give an appearance of naturalness to the product.

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*From the Compressed Air Magazine.

Such protests as these apply only to the more frothy businesses, but they serve to illustrate why a business style of correspondence is not exactly the proper one for professional men to imitate. What then should be the style of a professional man's letters? Sweeping aside temporarily all political prejudices, it can be said that the most extreme example of a professional-letter writer (some sarcastic people might say professional letter-writer, a significant shift of the hyphen) well known to the public is Woodrow Wilson.

Making due allowance for Mr. Wilson's diplomatic vagueness and political oratory (what one senator called "souffleé of soap-bubbles"), his letters have the dignity, moderation and flowing smoothness that should characterize—though perhaps in a less degree—the letters of the typical professional man. The following note of the president, consisting of only two sentences, is in the best professional style:—

A Letter from President Wilson

"My dear Senator:

"Matters of so grave a consequence are now under consideration that I would very much appreciate an opportunity to have a talk with you about the treaty and all that it involves. I wonder if it would be possible for you to see me at the White House at 2.15 o'clock to-morrow, Thursday afternoon.

"Cordially and sincerely yours,

"Woodrow Wilson."

Or it is pertinent to take as illustration the president's 200-word message on prohibition:—

"I am convinced that the attorney-general is right in advising me that I have no legal power at this time in the matter of the ban on liquor. Under the act of November, 1918, my power to take action is restricted. The act provides that after June 30th, 1919, 'until the conclusion of the present war and thereafter until the termination of demobilization, the date of which shall be determined and proclaimed by the president, it shall be unlawful,' etc. This law does not specify that the ban shall be lifted with the signing of peace, but with the termination of the demobilization of the troops, and I cannot say that this has been accomplished. My information from the War Department is that there are still a million men in the army, under the emergency call. It is clear, therefore, that the failure of congress to act upon the suggestion contained in my message of the twentieth of May, 1919, asking for a repeal of the act of November 21st, 1918, so far as it applies to wines and beer, makes it impossible to act in this matter at this time. When demobilization is terminated, my power to act without congressional action will be exercised.

Leisureness of Thought

Like these letters of President Wilson, the correspondence of an engineer should convey a certain leisureness of thought, such as the design of a machine should receive. The style ought to suggest long views, a careful judgment, a thoughtful manner, while still containing underlying strength and forcefulness. No one need use such long sentences as President Wilson favors, unless he wishes to, of course. Such excellent writers as Abraham Lincoln and Georges Clemenceau prefer short, logical and pithy sentences. The French incline to mathematically short and precise sentences, based on their prevalent philosophy of rationalism. The British naturally adopt long sentences, and are not averse to wandering from the main thought if the side-paths seem interesting. Many British writers cultivate a certain sonorousness of phrase, and it must be admitted that their journalists, for instance, construct more impressive sentences than the somewhat careless prose common to American newspapers.

In striving for a dignified, thoughtful style suggestive of an educated man not entirely preoccupied with dollar-chasing, the professional man by all means should avoid the pompous manner of the many verbose writers who evidently have never heard of that sterling rule, "Eliminate the superfluous word." As a case in point, the following sentence from an engineer's letter, can be reduced to the better form shown:—

"The reason why I desire a change of position is due to the fact that in a larger concern my chances for advancement undoubtedly would be better."

Reducing this 27-word sentence to 16 words gives the simpler and better sentence:—

"I wish a change because with a larger company my chance for advancement would be better."

Reduction in Verbiage

This is a 40% reduction and saves that much effort for the reader. It gives point to the remark of Charles A. Dana that he had time to write a long letter but not time to write a short one. While it is not true that a 40% reduction in words can be made often, it is probably true that a 20% reduction would improve most letters, making them simpler, more moderate, and truer. The wording, however, should not be so reduced as to give an aspect of telegraphic abruptness. Equally as important as the omission of superfluous words is the desirability of making a letter smooth and flowing in diction, as illustrated in President Wilson's style.

The engineer should be even more careful than the business-man in the matter of using words in their exact meanings and in not using certain over-worked words too much. He should choose such words as "quite," "line," "concern," "desire," "due," etc., only for their proper and limited meaning. He should avoid the undue use of such words as "so," "as," "advise," and the participles and superlatives.

Everything considered, the engineer has reason to be particularly careful in his employment of language. As an intellectual leader, and a man of judgment and taste, he has high traditions to maintain. His choice of words and literary style are often taken as criterion of his professional skill and character.

The city of Calgary has decided to sell the old steel bridge over the Bow River at Hillhurst, which was originally built by the Alberta government, but which is now owned by the city. This bridge is popularly known as the Louise Bridge. It has been replaced by a reinforced concrete structure.

The Automobile Club of Canada, Montreal, is in receipt of an official letter from Hon. J. A. Tessier, Minister of Roads in the Quebec cabinet, stating that in view of the recent arguments put forth by the club showing the pressing need for improving the Laprairie dyke, instructions have been given to proceed with the work of placing a smooth surface along the dyke for a length of 8,000 ft..

Prof. J. W. Dorsey, of the University of Manitoba, who recently announced that he had discovered a new and inexpensive method of transmitting electrical power, states that as a result of this invention it will be possible to serve farms for a distance of 50 miles on both sides of a main power line with electricity at very low cost for transmission. He advocates that crops be energized electrically at night when other power demands are negligible and when power can be secured at low cost. He declares that two crops can thus be grown where only one would otherwise be possible.

That the 8-hour day is not only more efficient than the 10-hour day in industrial plants, but also more economical, is the conclusion reached by the Uinted States Public Health Service after three years' study of conditions and production in factories. Following is a summary of the Service's report: "The outstanding feature of the 8-hour day is steady maintenance of output; the outstanding feature of the 10-hour system is the decline of output. Under the 8-hour system work with almost full power begins and ends approximately on schedule, and lost time is reduced to a minimum; under the 10-hour system, work ceases regularly before the end of the spell and lost time is frequent. Under the 10-hour system the laborers seem to artificially restrict their efforts and to keep pace with the less efficient workers; under the 8-hour day the output varies more nearly according to the individual capacity of the laborer. The full report is contained in Public Health Bulletin No. 106, which is the first of a series to be published by the U.S. Public Health Service on the problems of industrial working capacity."

NEW METHOD OF SNOW REMOVAL

Christie Four-Wheel-Drive Truck Equipped with Bucket-Type Conveyor Driven by Sterling Engine Makes Remarkable Record in Removing Snow and Ice

SNOW removal is always an expensive item in the estimates of all city engineers in Canada; therefore, the following description of the Friedman "snow tank," which was recently tried in New York City with splendid results, will be found of interest. Each "tank," it is claimed, will load approximately 1,300 trucks (8 cu. yds. capacity) in 24 hours (allowing 2 hours daily for filling with gas, oiling, changing shifts, etc.,) and in the New York demonstration four 5-ton trucks were loaded with ice in less than three minutes.

The "tank" consists of a Christie four-wheel-drive truck with a special frame, the truck being operated in the usual manner. Over the rear wheels of the truck is mounted a 6-cylinder, 5½-in. bore, 6¾-in. stroke, 150 h.p. Sterling marine-type engine, which receives its cooling water from the radiator. The fuel tank is located on each side of the motor. Two operators are required, namely, the driver of the truck and the mechanic who stands on the rear platform and operates the motor underneath. and the levers for the operation of the loading slide. The Sterling engine is started electrically from the rear platform.

The machine is 26 ft. long, 9½ ft. wide, 12½ ft. high, and weighs 22 tons. Its speed is from 2 to 10 miles per hour, and it has four speeds ahead and one reverse. It clears a path by depositing the snow to one side in a ridge or in piles of 10 cu. yds. each. The speed of operation depends upon the depth of the snow fall and varies from 2 miles per hour when handling a 24-in. fall, to 8 miles per hour when handling a 6-in. fall. For 18 ins., the speed is 3 mi. per hour; 12 ins., 5 mi.; 8 ins., 7 mi. It is claimed that the machine will actually handle ice that is frozen solid to the pavement.

A flat car or any similarly shaped vehicle travelling parallel to the machine can be loaded at the rate of 50 cu. yds. of snow per minute, or at the rate of 10 to 25 cu. yds. of solidly packed snow or ice per minute. It is stated that the machine can load a truck of 8 cu. yds. capacity in from 60 to 90 seconds, depending upon the condition of the snow or ice.

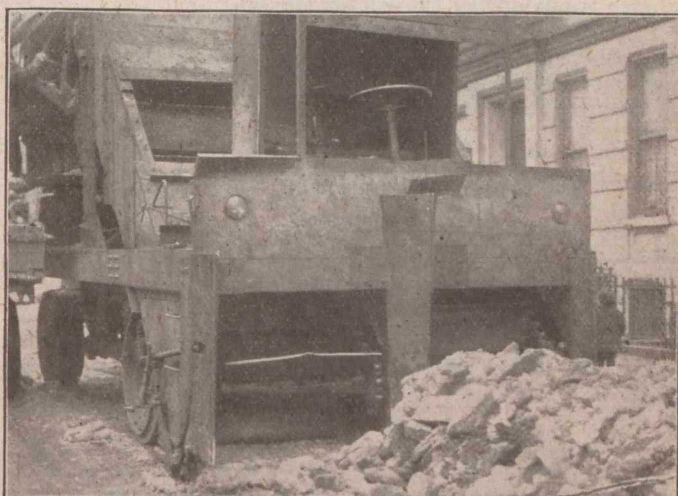
COST OF REMOVING SNOW BY HAND

Loading, 8 men, 20 minutes, at 50c. per hour	$1.33
Auto truck at $4 per hour, waiting 20 minutes while being loaded,	1.33
Auto truck carting snow and returning, average 15 mins.,	1.00
	$3.66
Cost to city, 8 cu. yds., at 54c. per cu. yd.,	$4.32
Expansion 25%, 6 yds. on ground expand to 8 yds. in the truck,	1.08
Actual cost to city,	$5.40
Piling, 8 cu. yds. at 9c. per cu. yd.,	.72
Total cost to city of loading, carting, and piling 8 cu. yds.,	$6.12

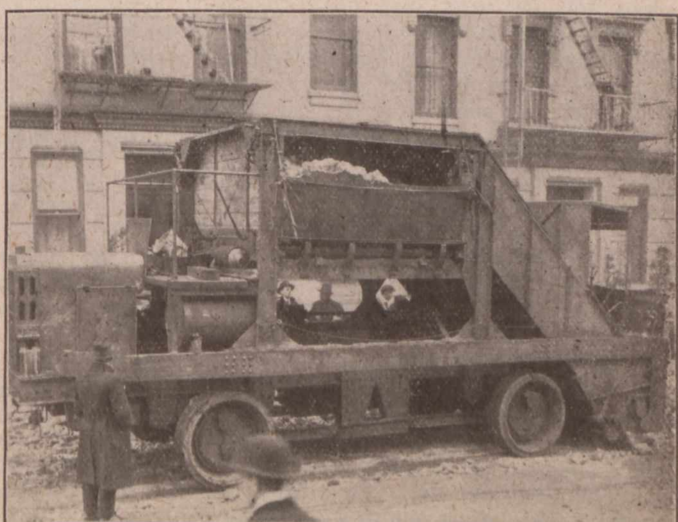
COST OF REMOVING SNOW BY "TANK"

Loading, 3 men ($60 per 24 hours) filling truck in one minute,	$0.04
Gas and oil (5 gals. per hr.),	.03
Wear and tear ($25 per 24 hrs.),	.02
Overhead ($50 per 24 hrs.),	.04
Auto truck, waiting one minute while being loaded,	.07
Cost of loading,	$0.20
Auto truck carting snow and returning, average 15 mins.,	1.00
Cost of loading and carting,	$1.20
Less compression, 50%, 16 yds. on ground compressed by force of conveyors to 8 cu. yds.,	.60
Actual cost of loading and carting,	$0.60
Piling,	.04
Total cost of loading, carting and piling 8 cu. yds.,	$0.64

SNOW TANK DISCHARGING TO TRUCK



FRONT VIEW OF "SNOW TANK"



SIDE VIEW, FRIEDMAN "SNOW TANK"

The snow removal is effected in two operations, as follows:—

1. A bucket-type conveyor cuts into the snow or ice as the machine advances, and carries the snow or ice up to a bin.

2. When the bin is full, a door at the side is lowered, a lever thrown and the snow and ice are ejected into the truck. When simply clearing a path, the door is left down and the snow is discharged continuously in a ridge at the side of the roadway; or the door can be lowered at intervals when the bin is full, thus piling the snow in heaps of 10 cu. yds. each.

Percy Braman, deputy commissioner of public works, Milwaukee, Wis., wrote as follows on April 1st, 1920, to Dr. Samuel Friedman, of New York, who is the inventor of the "snow tank":—

"Since returning home from your city where I witnessed the demonstration of your snow pick-up machine, I have become more and more enthusiastic over its performance. The way it handled the 4 to 6 ft. high by about 8 ft. wide pile of ice frozen solid to the pavement, elevating it into a hopper and loading into auto trucks faster than they could take it away, was a revelation to me.

"In my opinion you have solved the snow removal problem not only from city streets, but also from the main arterial highways throughout the country, which will make possible the successful operation of motor trucks, tractor and trailer trains during the winter months."

The accompanying comparison of the cost of loading an auto truck with 8 cu. yds. of snow and ice, first by hand, and secondly by machine, shows a saving of $5.48 in favor of the machine.

SASKATCHEWAN'S BRIDGE PROGRAM

SASKATCHEWAN'S bridge-building program for the current year will involve a total expenditure of approximately $200,000, announces G. A. Palmer, chief clerk of the provincial highways department.

Structural steel and piling for the large bridges have been ordered and the department has been assured of shipments, so that most of the large bridges can be completed by fall.

The department anticipates building 15 capital account bridges during the season, with other possible additions. Some of these will be reinforced concrete bridges from 40 to 80 ft. in length. The remainder will be steel spans from 84 to 150 ft. with reinforced concrete abutments. The supply of cement and reinforcing steel for these bridges has already been secured. Tenders have already been secured on three concrete bridges.

Last year's program has been completed, with the exception of one bridge, which the contractor will soon complete.

Owing to the exceptionally early advent of winter, timber bridge construction was discontinued earlier than expected last year, but the department kept the crews in the field all winter completing the erection of the steel bridges. These crews are now working and will be immediately available for the new program of timber bridge work which is now being organized.

The Bloor Street Progressive Association of Toronto has decided to organize a campaign in favor of the construction of a high level bridge across the Humber River at Bloor Street.

In a report to the London, Ont., city council, City Engineer Brazier states that the change from the contract system to day labor in the London works department has saved that city $150,000 within the past few years. Motorizing the department is the next step planned, he says. A municipally owned rock crusher will soon be installed and he predicts that before many years have elapsed the Thames River will be bridged at a number of points with concrete structures.

BRITISH EMPIRE STEEL CORPORATION

DEFINITE details have been given out by Col. Grant Morden as to the terms of incorporation of the British Empire Steel Corporation. Division of the share capital of the giant merger, the largest in the British Empire according to Col. Morden, is as follows:—

	Authorized.	To be issued.
7% cumulative pfd.	$ 50,000,000	$ 37,000,000
8% do. (participating) ..	100,000,000	25,000,000
7% non-cumulative pfd. .	150,000,000	68,000,000
Common	200,000,000	77,000,000
Total	$500,000,000	$207,000,000

Component Companies

The companies which have been taken into the amalgamation are the following:—

The Dominion Steel Corporation and its subsidiaries.
Nova Scotia Steel & Coal Co., Ltd., and its subsidiaries.
Canada Steamship Lines, Ltd., and its subsidiaries.
Canada Foundries & Forgings, Ltd., and its subsidiaries.
Maritime Nail Co., and its subsidiaries.
Collingwood Shipbuilding Co., Ltd.
Port Arthur Shipbuilding Co., Ltd.
Halifax Shipyards, Ltd.
Davie Shipbuilding & Repairing Co., Ltd.

Negotiations are also being carried on with several other companies with a view to their incorporation in the merger.

Basis of Exchange

Authoritative details as to the terms on which the three principal component parts of the British Empire Steel Corporation, Ltd., are to enter the new consolidation, subject to shareholders' approval, are as follows:—

Dominion Steel Corporation, $95 in 7% non-cumulative preferred stock of the new corporation, plus $40 in common stock, to each holder of $100 of the security known in financial circles as "Iron, common."

Canada Steamship Lines, Ltd., $100 in 7% non-cumulative preferred stock, plus $45 in common, to each holder of $100 in stock of the steamship company.

Nova Scotia Steel & Coal Co., Ltd., $90 in 7% non-cumulative stock, plus $40 in common, to each holder of $100 in "Scotia" stock.

Details as to the terms upon which the enterprises of lesser importance are included are as yet unavailable, but will be communicated to the shareholders of each company within the next few days.

The 7% cumulative preferred which figures in the division of the share capital of the corporation will, according to Col. Morden, be issued in exchange for the securities of a preference category now outstanding in the obligations of the various companies to be embraced in the consolidations. The 7% non-cumulative stock, in addition to the common, is to be exchangeable for the existing common shares of the enterprises affected, while the $25,000,000 of 8% cumulative and participating securities are to be issued to provide the corporation with the additional funds needed to carry out its ambitious program of expansion and improvement.

London Directorate

The London advisory board of the corporation is to include Sir William Beardmore, chairman of William Beardmore & Co., Glasgow; Henry Steel, chairman of the United Steel Companies of Great Britain and the Bengal Iron & Steel Co. of India; Right Hon. Viscount Furness, chairman of the Furness group of English steel industrials; Benjamin Talbot, managing director of the Furness companies; Major-Gen. Sir Newton Moore, formerly prime minister of Western Australia, director of the General Electric Co. of England, and closely associated with the Australian steel industry; and Sir Trevor Dawson, deputy chairman and managing director of Vickers, Ltd.

TYPHOID FEVER OUTBREAK AT TONAWANDA*

By Theodore Horton
Chief Engineer, State Department of Health, Albany, N.Y.

On December 30th, 1919, the writer submitted a report to the State Commissioner of Health of New York, Dr. Hermann M. Biggs, on an epidemic of typhoid fever at Tonawanda which had been long predicted and, when it came, was checked by means which would have prevented it had they been provided when the local authorities were urged to give the matter consideration. The facts in the case, as developed from the official records and examinations made at Tonawanda by Dr. Senftner, epidemiologist of the State Department of Health, and E. S. Chase and Earl Devendorf, assistant engineers, are as follows:—

The water supply for the city has been drawn from an intake crib in the Niagara River about 1,800 ft. from the American shore in about 30 ft. of water. The crib or pier is at a point in the river where the water is ordinarily less polluted than it is nearer the American shore. The typhoid rate in the city has always been high, although there is no record of any epidemic reaching the proportions of that in the autumn of 1919. For years this supply had been used without any purification whatever despite the urgent recommendations of the state health officials that some form of treatment was greatly needed. To show how slow local officials sometimes are to heed the warnings of specialists that water supplies are in danger of serious pollution, the record of the notices sent to the Tonawanda officials is given here:—

Notices to Municipal Officials

In 1912 a report was submitted recommending the immediate purification of the existing supply or the introduction of a satisfactory new supply. In 1916, a report was made recommending filtration and sterilization, and the immediate installation of duplicate chlorination apparatus. In 1918, the principal assistant engineer of the State Department of Health appeared before the common council and board of health and urged the installation of a chlorination apparatus; later a letter was sent to the superintendent of the water works giving the names of manufacturers of chlorination apparatus and general advice concerning chlorination. On January 25th, 1919, a letter was sent to the mayor explaining the need of chlorination. No acknowledgment was received; so on April 4th, 1919, another letter was sent to him covering the same points. No acknowledgment was received, so a third letter was sent to him on June 5th, 1919, which was acknowledged on June 18th by the city clerk, who stated that nothing had been done about chlorination. Before that answer was received an inquiry was sent to the superintendent of water works asking what steps had been taken to treat the water, and the superintendent replied promptly that nothing had been done. On July 19th, 1919, the secretary of the Chamber of Commerce was urged to press the need of immediate chlorination of the water supply upon the city authorities.

Old Intake Broken

As a result of orders issued by the federal government the intake main had to be lowered to permit dredging a deeper ship channel in the river. The work was begun in the spring of 1919 and involved laying a 48-in. wood-stave intake main at the required depth, which entailed crossing and breaking through the old intake line 350 ft. or more nearer the American shore than the intake crib. At the point where the old intake was broken the water is more polluted than at the crib. The break was made some time between June 19th and July 4th. Following it there were many cases of severe intestinal illness in the city and somewhat later, a few cases of typhoid fever. On July 8th advertisements were printed in the newspapers advising all persons to boil water used for drinking purposes and circulars were distributed from house to house warning everybody of the danger of drinking water which had not been boiled.

On July 19th a letter was received from the secretary of the Chamber of Commerce advising the State Department of Health of the breaking of the old intake line and asking for analyses of the supply. Authorization to collect the samples was given at once, and attention was again called to the importance of the purification of the supply. Nothing was said about the prevalence of typhoid fever in the letter from the Chamber of Commerce, and it was not until August 7th that the state department was informed of the fact. Its emergency chlorination apparatus was at once shipped to Tonawanda and an engineer was sent to the city. He found that the city officials had ordered a liquid chlorine apparatus which was then on its way by express.

Chlorination Stopped Typhoid Outbreak

The city's chlorination apparatus was installed and started on August 11th, 1919, and has been in use since then. There are two manual control solution feed chlorinators installed in the suction well and the chlorine solution is applied to the raw water in the well before it enters the suctions of the pumps. Every time the installation has been visited by the engineers of the state department it has been found to be carefully and properly operated.

There were 236 cases of typhoid fever having onsets between July 5th and October 4th, 1919. Of these 202 were residents of Tonawanda and the remaining 34 cases were residents of neighboring municipalities and suspected of being infected at Tonawanda. The majority of the cases in Tonawanda occurred between July 4th and September 15th, beginning soon after the break in the old intake and continuing for about four weeks after the installation of the chlorination plant, the latter plainly checking the outbreak. Considering the character of the raw water during this period, of which more will be said later, it is noteworthy that chlorination alone was effective. Since October but 5 cases have been reported. The investigations of the department's representatives showed that local wells and an industrial water supply occasionally used for drinking water may have had some influence on the typhoid case rate, but the evidence is clear that the city water was the principal source of infection.

Garbage in the Water

The character of the river water as pumped between September 15th and October 3rd was so bad that the water works superintendent was confident that something was wrong with the new intake line. On October 3rd an examination was made by a diver employed by the contractors and he found a leak near the American shore, where the pipe was 4 ins. off centre, leaving a large opening for water to enter the intake. This was repaired by placing a sleeve around the joint. A few days later the diver found another leak about 300 ft. from the intake crib, where one end of a length of pipe was in such bad condition that it had to be replaced, which work was completed October 14th. So far as known to the author, this is the last work done on the line. The trench in which the pipe was laid has been backfilled to a depth of about 4 ft.

During the period from September 15th to October 4th, while the intake was leaking, it is reported that water of very objectionable character was delivered to the city. In fact, it is reported that particles of garbage and offal were removed from the pumps and suction well during the latter part of September.

The Alberta government has appropriated $600,000 to assist in the financing of the Lethbridge Northern Irrigation District, which includes approximately 200,000 acres.

Within the past few months the Saskatchewan Department of Highways has tested more than 449 samples of gravel from various parts of that province. These samples were submitted by 200 municipalities and about 75% of them were satisfactory for use as road material, and about 60% were found to be suitable for concrete.

*Presented to the American Water Works Association.

CONCRETE AGGREGATES*

THIS committee, working in close co-operation with Committee C-9 on Concrete and Concrete Aggregates of the American Society for Testing Materials, has had the progress of its work seriously interfered with by the active participation of many of its members in government work, and more recently by urgently pressing business demands and lack of assistants in laboratories. The committee has, through its sub-committees, continued some of its investigations along lines previously laid out and has considered a large mass of data, made available by various investigators in the field covered by this committee. Some of this data relates to the concrete and mortar making qualities of aggregates, both fine and coarse, as indicated by their "Fineness Modulus" proposed by Prof. Abrams, their "Surface Area" proposed by Mr. Edwards, and their "Surface Modulus" proposed by Prof. Talbot, and also to the effect on the strength of concrete or mortar of the "Water-Cement Ratio" proposed by Prof. Abrams.

TABLE 1—AVERAGE WEIGHTS OBTAINED BY ALL OPERATORS WITH ALL SIZES OF MEASURES

	Sand	Rod Method Lbs.
1.	Coarse dry	107.5
2.	Coarse wet	93.4
3.	Difference	14.1
4.	Fine dry	99.5
5.	Fine wet	82.9
6.	Difference	16.6
7.	Dry	103.5
8.	Wet	88.7
9.	Difference	15.3
10.	Average of all	95.8

To get a better idea of the relative value and importance of these functions, a special sub-committee is now engaged in the conduct of a series of tests, which it is hoped will be carried out by a considerable number of co-operating laboratories, designed to duplicate some of the work already done by one or two laboratories in their own investigations, and so to furnish a basis for some general comparisons of the functions mentioned in the last paragraph above. This sub-committee met in Chicago on November 17 and 18 last, and spent the two days considering data placed before it and at the end of the session drew up an outline of a series of tests designed to touch the high spots of the work previously done at enough points to indicate the relative value of the functions under investigation. These tests are now progressing.

TABLE 2—AVERAGE OF DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL OPERATORS WITH ALL SIZES OF MEASURES

Sand	Rod Method Lbs.
Coarse dry	3.8
Coarse wet	7.5
Fine dry	4.4
Fine wet	6.1
Dry (coarse and fine)	4.1
Wet (coarse and fine)	6.8
Difference	2.7
Average of all	5.4

Cloyd M. Chapman, chairman, made an extended report in 1917 of the work done and results obtained in investigating some eight methods of determining the unit weight of sand. At that time it was suggested that another method which had been in use at Lewis Institute might prove of value, and consequently the committee undertook an additional series of tests to compare this newly proposed method with those previously investigated.

This new method has been called, for the want of a better name, the "rod method," and is operated as follows:—

Fill the measure one-third full of the aggregate, then, with a pointed iron rod of a prescribed size, jab or puddle the aggregate twenty-five times, distributing the strokes over the surface of the aggregate and avoiding penetrating through the layer of aggregate so as to hit the bottom of the measure. Then add another one-third to the contents of the measure and again jab with the iron rod twenty-five times, penetrating only the last layer of aggregate placed in the measure. Next, fill the measure to overflowing and repeat the jabbing, then strike off the surplus sand with the iron rod and weigh.

This method appears equally applicable to fine or coarse aggregate, or mixtures thereof, and its simplicity and convenience recommend it to consideration, since the results obtained are of a degree of concordance equal to that obtained with the best of the other methods considered in the 1917 report.

To investigate this method, it was desirable that the same aggregates be used that were used in the previous tests, so that results would be directly comparable without repetition of the earlier tests. Inquiry, however, developed the fact that only two of the laboratories co-operating in the 1917 series had retained their samples, so it was decided to have the new method investigated in only one laboratory, using the same old samples, but having five different operators make five tests each with the same measures used in the previous tests, with the two grades of fine aggregate, each of them used in a dry and in a damp condition. These tests were, therefore, conducted in the laboratory of Westinghouse, Church, Kerr & Co., under the direction of the chairman of the sub-committee.

TABLE 3—AVERAGE FOR ALL OPERATORS FOR ALL SIZES OF MEASURES, OF THE VARIATION FROM THE MEAN WEIGHT OF ALL OPERATORS

Sand	Rod Method Lbs.
Coarse dry	.8
Coarse wet	1.6
Fine dry	.8
Fine wet	.9
Dry (coarse and fine)	.8
Wet (coarse and fine)	1.3
Difference	.5
Average of all	1.0

The six measures, described and illustrated in the 1917 Proceedings, were used. They were a 100 cc. cylindrical measure, a 1,000 cc. cylindrical, a ¼ cu. ft. cylindrical, a ¼ cu. ft. cubical, a 1 cu. ft. cylindrical, and a 1 cu. ft. cubical measure. The rods used were ¼ in. diameter by 18 ins. long for the 100 cc. and 1,000 cc. measure, ½ in. by 18 ins. (long for the quarter) for cubic foot measures, and ¾ in. by 18 ins. for the cubic measures. The aggregates were a coarse siliceous Long Island sand and a fine siliceous New Jersey sand. These aggregates were used "room dry" and moistened to the extent of 3% for the coarse sand and 5% for the fine sand.

In order to make a comparison between the results obtained by this rod method and those reported on in 1917, a set of tables similar to those previously published are given herewith for the rod method.

By comparing this table with Table 1 on page 319 of the 1917 Proceedings, it will be noted that the rod method gives average weights about equal to those given by Methods B and E, or about midway between the light weights given by Methods A, F, and G, and the heavy weights given by Methods D and the cone method.

*Report of Committee on Concrete Aggregates, American Concrete Institute.

In Table 2 is shown the average difference between the highest and lowest weights obtained by all operators with all sizes of measures.

A comparison of this table with Table 3 on page 323 of the 1917 Proceedings shows that the rod method gives as little average difference between highest and lowest results as does Method D, and not appreciably more than the cone method. The rod method gives a small maximum difference as compared with other methods.

Taking up next the average variation from the mean, there is shown in Table 3 this average for all operators with all sizes of measures.

This table indicates, as will be shown by comparison with Table 5 of the previous reports, that the rod method gives more concordant results than any method used except the cone method, which is slightly better in this particular.

Coming now to a summary of the results obtained with all of the nine methods employed, there is shown in Table 4 data which gives a very concise idea of the relative values of these methods.

From this data it is apparent that the rod method gives medium weights per unit volume, that it gives a low maximum variation, and a very low average variation. The only method offering lower maximum and average variations is the cone method, but as stated in the previous report, the unit weights obtained by the cone method are so high as to be of litle value in practice and, therefore, not considered a desirable standard method for use in determining unit weights.

This committee has, in view of all the data available, voted in favor of the adoption of the rod method as the standard method for the determination of the unit weight of concrete aggregate, and proposes to prepare, during the coming year, standard specifications for the manipulation of the method for presentation at the next convention.

TABLE 4—EFFECT OF METHOD ON AVERAGE WEIGHT, DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL OPERATORS FOR ALL RESULTS, AND AVERAGE VARIATION FROM MEAN WEIGHT

Method	A	B	C	D	E	F	G	Cone	Rod
Average weight	88.4	98.8	103.2	104.3	98.0	83.9	87.2	11.64	95.8
Average maximum variation . .	7.0	7.0	7.9	5.3	6.5	6.3	5.8	4.1	5.4
Average variation	1.9	2.1	2.2	1.4	1.7	1.7	1.6	0.8	1.0

SASKATCHEWAN ENGINEERS WILL INCORPORATE

At last month's meeting of the Saskatchewan branch of the Engineering Institute of Canada, which was held in Regina, L. A. Thornton presiding, the main topic was the possibility of securing legislation incorporating a provincial association of professional engineers similar to the associations that have been incorporated in British Columbia, Alberta, Manitoba, Quebec, New Brunswick and Nova Scotia. An organized effort will be made to show the people of Saskatchewan that legislation closing the engineering profession will be of more benefit to the general public than to the engineers themselves. An article describing the public benefit to be derived from such legislation will be prepared by a committee of the branch and will be published generally throughout the province shortly before the next session of the provincial parliament, which will probably be about November, and it is hoped that members will be able to complete sufficient educational work between now and next winter to ensure favorable consideration of the bill at the next session of the legislature.

Sir George Foster, acting prime minister of Canada, stated last Monday in the House of Commons that the Dominion government does not intend to construct or aid in the construction of grain elevators in Toronto or any other city in Ontario at present.

INTERRELATIONSHIP OF HIGHWAY, RAILWAY AND WATERWAY TRANSPORT*

BY PROF. HENRY E. RIGGS
University of Michigan

WHILE the motor truck is a very recent invention, its place among the permanent transportation agencies is assured. There is a dearth of exact information as to cost of operation, effect of motor truck traffic upon road surfaces of different kinds, effect upon the machines themselves of different kinds of road surfaces, the tractive power of the machines on different grades and surfaces, and many other matters on which definite information must be gained through experience.

The history of civilization is very closely linked with the history of transportation. The development of water transportation has always come first with every nation. The ease with which large cargoes could be transported, the cheapness of water carriage and the absence of capital costs and maintenance charges except to terminals and equipment account for the development of navigation through all of the stages from canoe and catamaran, the galley of the ancients and the sailing vessel of the old Norsemen, down to the modern steamship.

It must be remembered that in the United States, up to a considerable time after the Revolution, all of the principal cities were on navigable waterways.

The need of transportation facilities for the interior of the country resulted in the building of several thousand miles of canals, a development which was only checked by the invention of the locomotive. It is to be regretted that the United States did not adopt a wiser policy relative to her waterways. With her long coast line, with many navigable rivers affording lines of transportation for many thousands of miles, and with the Great Lakes, she had the opportunity to maintain a system of waterways for the handling of low-grade, bulky (and necessarily slow) freight along with a system of railways. Unfortunately, the railway influence was all exerted to check and destroy water transport with the result that the railways are now compelled to spend vast sums in building facilities for handling unprofitable freight. There is a distinct tendency once more to encourage the development of water transportation on the inland rivers in the west and south.

Transportation on land was slow in developing. The opposition to a policy of spending public money for building a system of good roads seems to have been general and to have continued from the first settlements on the Atlantic seaboard, down to within the last few years. It was, undoubtedly, this neglect of the roads, and the terrible condition of the roads over large areas of the country that hastened railroad development.

The railroad has always been dependent upon the general character of highway traffic and condition of highways for its tributory population. Ordinarily a strip of territory from four to ten miles on each side of the line, unless cut off by a river or hills, will furnish the directly tributary business. Impassable roads for long periods will check development. Good roads and favorable grades to the railroad will permit the settlement of districts at considerable distances back from the main line.

We have made serious errors in the development of transportation systems in the past. The neglect of waterways, the lack of good judgment in building many lines of railroad, and the failure to recognize the value of the highways and to improve them, constitute blunders which have resulted in retarded development of large areas, great financial losses and the building of much useless railroad.

*Excerpts from committee report presented to the National Highway Traffic Association.

With the present phenomenal development of our highways, coincident with the great expansion of the automobile and motor-truck business, we have an opportunity to retrieve past mistakes and to avoid new ones. We may state the general transportation situation as follows:—

1. Water transportation, not only along the coast and great lakes, but on such rivers as the Mississippi, Missouri, Ohio and many of the southern rivers has, undoubtedly, a great future and should be developed far more than has been done in the past.

2. Railway transportation for long distance business and for all carload business where there is direct track connection to the factory or warehouse of the shipper, is and always will be more economical than any form of highway traffic.

3. Highway transportation should be built up and encouraged as supplementary to railway and water transportation.

Solves Railway Terminal Problem

The motor truck is the inevitable solution of the railways terminal problem. The most serious expense connected with rail transportation is the terminal expense. From warehouse or factory to cars, and from cars to consumer, involving in the case of a large volume of the business two extra handlings of all goods and two short hauls, forms an expense item equal to the cost of hauling hundreds of miles by rail. We have no definite statistics on this subject. The railroad keeps no record of it. Too often shipper and consumer kept none. The latter make no report.

The motor truck and the automobile extend the zone of territory tributary to the railroads. With the improvement of roads radiating out from railway stations, the use of motors, either on regular routes or privately owned by farmers and shippers, will place the man who is twenty miles away in as good position as was the man who under old conditions lived four or five miles away.

In metropolitan districts the motor truck has a great advantage over the railroad in quickness of delivery and probable economy on hauls of packages and less than carload freight for distances of twenty to seventy or eighty miles. Here the cost of motor transport has to compete with the cost of transfer at each end of the line, the extra handling and the cheaper per ton mile cost of the railroad.

The question of the establishment of lines of motor trucks in competition with railways is one calling for study. Just what weight should be given to certain conditions? It must be clear that local business on a great through railroad from such cities as New York, Chicago, Philadelphia, Detroit or Cleveland to towns twenty to forty miles away may get through occasionally in one to two days, but is more likely to be from four to six days between shipper and buyer, while with motor trucks it can be delivered the day it is shipped.

The problems here are what density of traffic will justify the service, and what is a fair rate. It is equally clear that between two small cities on one direct line of railroad, where the delivery depends wholly on the schedules of the local freight trains, delay in the railroad is reduced to a minimum, and costs are smaller, so unless there is an absolute guarantee of sufficient tonnage, competition should be avoided.

Matters Requiring Further Investigation

Further investigation should be made in regard to:—

1. The cost per ton mile of railway traffic.
2. The cost per ton of transfer and handling from shipper to railroad.
3. The cost per ton of loading and transfer from railroad to consumer.
4. The cost per ton mile of motor truck hauls.
5. The difference in character and cost of packing for shipment by rail and by motor truck.
6. The effect of different grades upon cost of motor transportation.
7. The effect upon cost of motor transportation and loss of time due to differences in character of roads.
8. The effect of the introduction ot the motor truck upon railroad shipments in country districts.
9. In so far as possible to secure it, the effect of the increasing use of the motor truck upon the cost of maintenance of highways.

That the mileage of improved highways is to be vastly increased within the next five years is very certain. It is equally certain that motor trucks are not only here to stay but that their use will increase many fold, and we must, therefore, build all of our trunk highways to handle this traffic. We engineers have argued to the farmer that good roads are an asset to him as they reduce the cost of hauling his crops to market. We cannot now fail to recognize that the motor truck as well as the road makes for the same result. Nor, must the maker of the truck, nor its owner, lose sight of the fact that the cost of building and maintaining the road is a part of the cost of transportation, and that the motor truck should bear its share of the burden.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

FOR the first time in the history of the American Institute of Chemical Engineers, its annual summer meeting will be held in Canada during the week of June 28th to July 4th. The formal and business sessions of the institute will be held in Montreal, after which the members will proceed to Ottawa by special train, where they will be shown several of the large chemical works located there and the various government bureaus.

Wednesday, June 30th, the party will travel by special train to Belleville, Ont., and on the following day will be entertained by the city of Belleville. There will be a motor trip to several of the chemical works situated in Hastings county. A complimentary luncheon will be tendered the institute by the Deloro Smelting and Refining Co., Ltd. The large plant of the Industrial Alcohol Co., Ltd., at Corbyville, will also be visited. In the evening a dinner will be tendered by the city and county, at which several of the leading men in the chemical industries in the United States and Canada will be present. From Belleville the party will go to Shawinigan Falls, Que., where the large electrolytic industries will be inspected. Saturday, July 3rd, will be spent in La Tuque, inspecting the large sulphate pulp mill of the Brown Co. The party will return to New York by special train.

As Canada has abundant resources for the development on a large scale of some of the most important chemical products required in commerce, it is hoped by the Canadian members of the institute that the meeting will result in renewed activity along chemical industrial lines in this country. The Canadian members are putting forth every effort to make this meeting an outstanding event in the chemical history of Canada.

QUEBEC BOARD OF HEALTH vs. HULL

IN the case of the Quebec Board of Health vs. the City of Hull, argued last week before Judge Chauvin in the Superior Court at Hull, Que., the counsel for the defence claimed that, while the Board of Health has the right to say whether a certain system of water purification is satisfactory, it has no right to dictate what particular system should be introduced. He dwelt upon the fact that samples of water taken by the board for analysis had not been taken from the source of supply, but from taps throughout the city, which he declared to be an improper practice. He stated that the city of Ottawa is using practically the same water; that there chlorination had been found satisfactory in every respect, so far as the Ontario Board of Health is concerned, but that the Quebec board insists upon filtration before chlorination. The Board of Health has the right of insisting upon a pure supply, he admitted, but he argued that it has no right to dictate the means to be employed in securing the desired degree of purification. The judge reserved his decision.

HYDRAULIC-FILL DAMS*

By Allen Hazen
Consulting Engineer, New York City

THE hydraulic-fill method of dam construction grew out of hydraulic mining. It was natural that a process conspicuously successful in mining on an enormous scale, and that moved material at very low unit costs, should find other applications.

The late James D. Schuyler and J. M. Howells were pioneers in the application of hydraulic methods to dam construction. Mr. Schuyler presented a paper to the American Society of Civil Engineers in 1906 setting forth in a most admirable way the peculiarities of the method and its application to actual dams.

The method is certain to have an important place in future dam construction. It has two fundamental advantages: First, in sorting out the fine particles and placing them in the centre of the dam, thus insuring complete watertightness; and second, in the use of power in place of muscle to the greatest extent, so that the labor cost and the animal cost of construction are reduced to a minimum.

It is sometimes possible to place material by the hydraulic process at much smaller cost than by any other method. On the other hand, several hydraulic dams have not proved to be stable. Failures, usually during construction, have caused great losses, and their occurrence has been discouraging.

There may have been more than one cause of failure, but one cause has certainly predominated. In the interior of the dams there have been masses of clay and other fine-grained material, that have not consolidated to the point of stability. Instead of forming an integral part of a solid dam, these have remained in almost liquid form, dividing the dams and tending to disrupt them. In this respect, hydraulic-fill dams are on a different basis from other earth dams. If the hydraulic method of dam construction is to be successfully used, this element of weakness must be eliminated.

There seem to be two promising ways of eliminating it. The first and most natural one is to increase the size of the dam until the solid parts forming the toes are amply strong to resist the full fluid pressure of the unstable core. The second consists in selecting material and handling it in a way to secure drainage and consolidation of the core, so that the whole dam will act as one solid mass.

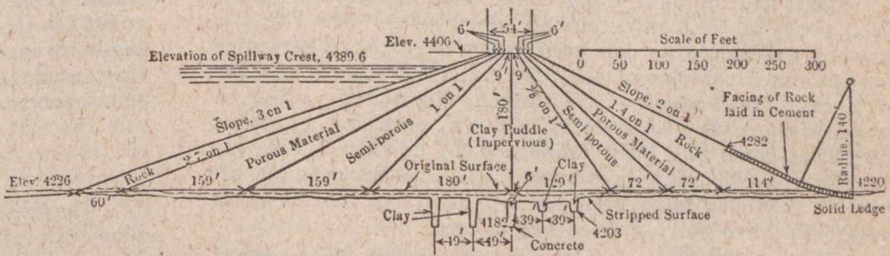
If core material can be fully drained and consolidated, there is no reason why a dam built by the hydraulic method on a section that is suitable for an earth dam built dry should not be safe. If drainage and consolidation of the core is not secured, however, safety can only be reached by making each toe large enough to stand the full pressure of the liquid core, and in that case, in order to be safe, a dam built by the hydraulic method must have flatter slopes and a larger section than is otherwise needed for an earth dam.

It is interesting to note that Clemens Herschel, in discussing Mr. Schuyler's paper in 1906, made the point that a larger section would be required for stability; Mr. Schuyler took exception to this, and stated that in his experience there was no reason for building a dam of greater dimensions because the material was placed in it by the hydraulic method.

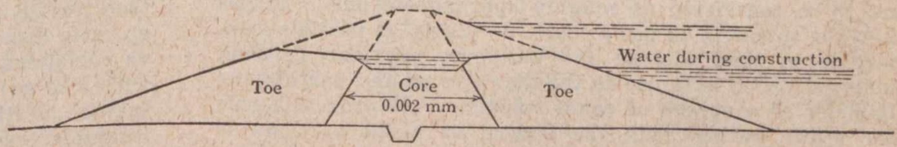
The advantages and economies of the hydraulic method are such that it will often be good business to use it, even though the required volume of the dam should be greater. If work can be built at half the cost per cubic yard, twice as many cubic yards can be placed for the same money.

The number of failures with the hydraulic-fill dams growing out of this fundamental condition of fluid cores and inadequate toes has been such as to make it clear that this condition of instability has not been recognized in the designs. Mr. Schuyler's excellent paper contains no discussion of this point. Looking at it from the standpoint of thirteen years afterward, it is easy to see how this condition could have been overlooked and to see, also, how some of the early failures were attributed to other causes.

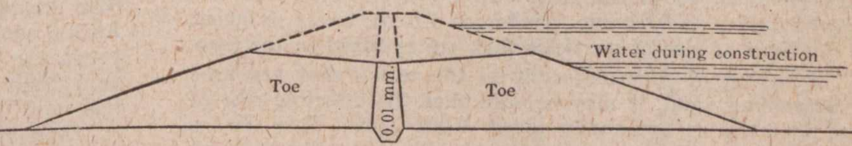
Now, however, enough experience has been gained so that a better analysis may be made. To insure success with future hydraulic dams, this analysis must be thorough. It is the writer's thought that it will be possible to make it in a way to secure as high a degree of safety in hydraulic-fill dams as is required, and is customary, in other engineering structures. It may be that we do not yet have all the necessary data; but, if not, the best way to find what is lacking is by using what we have.



CROSS-SECTION OF DAM NO. 2 AT NECAXA, MEXICO.
SHOWING
DIMENSIONS, CUT-OFF TRENCHES AND THEORETICAL DISTRIBUTION OF MATERIALS.
FIG. 1



TYPICAL SECTION OF HYDRAULIC FILL
DAM DURING CONSTRUCTION.
FIG. 2



ILLUSTRATING PROPOSED SECTION WITH
NARROW COARSE-GRAINED CORE.
FIG. 3

Character of Core Material

The first point to be considered is that, in many or perhaps, most hydraulic-fill dams, the core material is so fine in grain size that it is incapable of drainage. By that is meant that it is incapable of drainage within a reasonable length of time. The lower parts of the core do not become stable before the upper parts are placed upon them.

In general, all the material placed in hydraulic-fill dams may be divided into two classes, namely, toe material and core material. Mr. Schuyler presented a picture of materials divided into several classes, the coarsest being found at the outside and the finest in the middle (see Fig. 1). Practical experience does not show that the material is graded in quite that way. There is some grading in the toes and the average size of particles near points of delivery of material near the outer slopes is greater than away from those points and near the core; but, practically speaking, this gradation is not very important. Ordinarily, all the toe material is of coarse particles when first placed. Afterward, passage of silt-laden water from the operation

*Presented to the American Society of Civil Engineers.

of hydraulicking partly fills the voids with fine material, but the process stops itself before they are all filled. The toes readily drain and all the stability naturally inherent in the stock is obtained.

The core may be defined as that part of the dam deposited from water in the central pool. In the writer's experience, core material is homogeneous. At any level there is no appreciable difference in grain size between the middle of the core and its farthest extremities.

Similar to Sedimentation Basin

The principles determining the size of particles deposited in the core, or not deposited, are the same as the ones that apply in a sedimentation basin of a water works plant. The larger the area of the pool in proportion to the quantity of water that goes through it, the more complete will be the subsidence, and the smaller will be the limit of size of particles retained.

Most hydraulic-fill dams have been built with good-sized pools in the centre during construction (see Fig. 2), in which sedimentation has been fairly complete. The writer has examined samples of the core materials from a number of dams. The samples are rather surprisingly alike in grain size. They ordinarily contain particles in large quantities down to a limit between 0.001 and 0.002 mm. (or sometimes 0.003 mm.) in diameter. Generally speaking, all smaller particles have been carried away by the escaping water and have not remained in the core.

It should be said that the determination of the exact size of these small particles is by no means as precise as the determination of the size of grains of filter sand. The results are reached by the microscope with a micrometer and are to be considered as roughly approximate only. It has been the intention to use a basis as nearly as possible comparable to that adopted for the large particles in sand analysis, which is to use as the diameter of any particle the diameter of a sphere of equal volume. Following this rule the width, rather than the length, of small particles is measured.

Core material then, as a matter of observation, consists of particles from this size up to the size of the smallest particles retained in the toes. In a general way, this size may be taken as 0.03 mm., or ten to fifteen times as great as the limit of size of particles that are retained in the core.

Speaking of core materials in the terms that are used in describing sand, it may be said that the effective size of core material is ordinarily about 0.002 mm. This size is so small that one who is not accustomed to microscopic work has little conception of it. For comparison, it may be stated that ordinary filter sand has an effective size of from 0.3 to 0.4 mm., while dune sand, being the finest material usually spoken of as sand, has effective sizes ranging from 0.15 to 0.20 mm.

Drainage of Core Material

Without attempting precision, and using round figures, the core material is one-hundredth of the size of dune sand. This means (assuming that the laws of flow and the laws of capillarity applying to the finest sands apply also to these still finer materials) that, other things being equal, the drainage of core material will take ten thousand times as long as corresponding drainage of fine sand. Fine dune sand would drain as much in an hour as core material in a year. It means, further, that the height to which water can be held by capillarity is ten thousand times as great as the height at which it is held by fine sand. If fine sand will hold water by capillarity to a height of an inch, as it will, then core material like that shown by the samples will hold water by capillarity to much more than the full height of any dam.

The reason why this core material does not drain is, therefore, clear. It seals itself up and becomes practically water-tight.

With the dimensions existing in dams that have been built, assuming that the laws of flow known to apply to the finest sands apply also to the still finer materials, it will take years for the excess of moisture to drain out, as it must do before the solidification of the material is possible.

As a practical proposition, drainage is not possible with such fine materials. By that is meant such prompt and complete drainage as will result in solidification during the construction of the dam.

Construction records and samples show approximately what happens. Core material of the fineness already described goes down first in the form of soft mud in which the voids filled with water are at least 70% of the total volume. Such mud is very soft.

The percentage of voids furnishes, on the whole, the best index of consolidation and stability. In itself, it is not an adequate basis of comparison, because different kinds of core material may have different degrees of stiffness with the same percentage of voids; but, notwithstanding this difference, the percentage of voids is the best index of consolidation so far available.

The material when it goes down contains 70% of voids. Under these conditions, the minute solid particles are held apart by the water contained between them, and the passages through which water can pass are much larger than they would be with a more compact arrangement of the same material. Water drains from this material gradually, and the material consolidates.

Water Moves to Top

The drainage may be horizontal, in which case the surplus water finds its way through the core material to the toes and escapes. There is, however, a shorter way out, and it appears probable that most of the drainage takes place vertically. That is to say, the solid particles settle down and consolidate while the water moves upward between them to the top. This consolidation takes place gradually at rates depending on the dimensions of the dam and also on variations in the effective size of the core material; for while the writer considers all this material broadly as having an effective size of 0.002 mm., there are no doubt considerable variations in size and permeability.

Experience shows that consolidation goes on so that after a period of from a few months to two or three years in the ordinary course of dam construction, it will have been consolidated to a point where the voids are about 50%. As the consolidation increases, the sizes of the passages between the grains become smaller, and the flow becomes less rapid and the process of consolidation goes forward more and more slowly.

Material with 50% of voids when taken out of a boring is described as material having the consistency of stiff putty. It is capable of standing up in a boring driven beyond the casing for several feet, and it offers great resistance to penetration.

One of the best field methods of testing the consolidation of core material has been to find the depth to which a 1½-in. pipe could be forced into it by two men. This method of testing has been used in several dams. It has been possible to co-ordinate the penetration so found with records of the percentage of voids. In a general way, penetration by 1½-in. pipe pushed down by two strong men extends to the point where the voids are about 50%. In other words, the 50% material is so stiff that it can no longer be penetrated to any considerable depth by this method.

Tests of material by letting down cannon balls, etc., are less searching. The penetration does not go as far.

Void Percentage for Stability

Material with 50% of voids in a considerable depth acts essentially as a liquid. It exerts the full lateral pressure corresponding to its height and weight per cubic foot, and when the resistance of the toe is overcome, this material moves forward and flows. Precise limits cannot be set, but this is the general result of observation at Calaveras as a result of determinations of voids in many samples of material that did flow and in other samples of material that did not flow. This refers to the Calaveras Dam near San Francisco, Cal., which slipped as it was approaching completion on

March 24th, 1918, investigation of which afterward gave an unusual opportunity for studying some of the conditions that grew out of the methods of placing material that had been used.

Core material becomes solid when it is dried. Core material dried in the summer sun at Calaveras was consolidated until only 35% of voids remained. In this condition, it was only a little less strong and stable than the natural sandstone in the neighboring hills.

Core material consolidated to 35% of voids would form the strongest and most stable kind of an earth dam. No large toes would be required to contain it, for on any reasonable slope it would be stable by itself. Such consolidation, however, as far as is known, is reached only by complete drying. Unfortunately, drying cannot be applied to the core of a large dam.

Without attempting precision of statement, it is the writer's judgment that if core material like that at Calaveras could be consolidated to 40% of voids, it would be sufficiently stable to do its share toward resisting the pressures that come upon the dam without tending to disruption. Perhaps this degree of stability would be reached before consolidation had proceeded as far as 40% of voids. There is a middle ground of uncertainty. Material with 50% of voids is still unstable; and between this limit and 40%, one cannot be certain just where to draw the line.

It is interesting to note that the 1½-in. pipe used in the penetration tests only reaches to points where the material is still unstable. It follows that tests of this kind do not and cannot demonstrate stable material. Tests made by cannon balls or other less searching means are equally defective. It cannot be considered, in the light of the Calaveras experience, that tests made by such methods throw much light on conditions of stability. They may at times serve a purpose in showing lack of stability, but that is as far as use can be made of them.

It is the writer's thought that the best method of investigating consolidation and stability is by making borings. There are difficulties, for boring usually involves stopping the sluicing of material while the holes are being put down; but it does lead to more definite results. Borings can be driven and samples taken from the bottom of the borings for physical inspection and for determination of the percentage of voids.

Determining Percentage of Voids

This is a very simple matter, but experience shows that it is easy to go wrong, and for that reason a brief statement of methods that have been found suitable will be given.

The samples taken from the bottom of test borings are saturated with water. A determination of water content, therefore, can be made a measure of voids. This procedure is sound so far and only so far as the voids are completely filled with water. A useful check can be obtained from the specific gravity of the moist material.

The specific gravity of the solid particles of core material may be taken as 2.65. It may be that in some locations other specific gravities will be found, but in the writer's experience, actual values differ little from this mean value.

In determining the specific gravity of these exceedingly small particles, the most careful manipulation is required to get all the air out of the dry material. Methods similar to those used for determining the specific gravity of Portland cement are appropriate, but water can be used.

A table can be made showing the weight of the solid particles, the weight of water, the percentage of water by weight, and the specific gravity of core material containing various percentages of voids. Table 1, in convenient and somewhat condensed form, gives these values for saturated clay.

When a sample is taken from a test boring, a portion is put in a dish and weighed. The weighed material is dried at or above the boiling point to constant weight, and the percentage of moisture computed. As even a little drying before the first weight affects the result, the samples should be weighed on the spot when first brought to the surface; to do this, portable equipment must be used. After the first weighing, samples may be taken to the office or laboratory for the completion of the process. When the percentage of moisture by weight is found, the corresponding percentage of voids is obtained from Table 1.

As a check, the specific gravity of another part of the sample is determined. This is obtained by putting a weighed portion of the moist mass into a graduated cylinder partly filled with water and noting the increase in water level. The specific gravity is the ratio between the weight of material added and the weight of the water that corresponds to the increase in level, and so to the volume of material placed in the cylinder. With this specific gravity determined, Table 1 indicates the percentage of voids.

The percentage of voids determined by the two methods with good manipulation should check within 1 or 2%. If it does not, there is something wrong and the error must be found and eliminated.

TABLE 1—SATURATED CLAY*

(Specific Gravity of Solid Particles, 2.65)

Percentage of Voids	Percentage of Water by Weight	Specific Gravity Wet	Weight —Per Cubic Foot— Wet	Dry
40	20.1	1.990	124.2	99.2
41	20.8	1.974	123.1	97.5
42	21.5	1.957	122.1	95.9
43	22.2	1.940	121.1	94.2
44	22.9	1.924	120.0	92.6
45	23.6	1.908	119.0	91.0
46	24.3	1.891	118.0	89.3
47	25.0	1.874	117.0	87.6
48	25.8	1.858	116.0	86.0
49	26.6	1.841	115.0	84.3
50	27.4	1.825	114.0	82.7
51	28.2	1.808	112.9	81.0
52	29.0	1.791	111.9	79.3
53	29.8	1.775	110.8	77.7
54	30.6	1.759	109.8	76.0
55	31.5	1.743	108.7	74.4
56	32.4	1.726	107.6	72.8
57	33.3	1.709	106.6	71.1
58	34.2	1.692	105.6	69.5
59	35.1	1.676	104.5	67.8
60	36.1	1.660	103.5	66.1
61	37.1	1.643	102.5	64.5
62	38.1	1.626	101.5	62.8
63	39.1	1.609	100.5	61.2
64	40.1	1.593	99.5	59.5
65	41.2	1.577	98.5	57.8
66	42.3	1.560	97.4	56.2
67	43.4	1.543	96.4	53.5
68	44.5	1.527	95.4	52.9
69	45.6	1.511	94.4	51.2
70	46.8	1.495	93.4	49.6

*This table is not to be used for any material that has lost water by evaporation so that the voids are not completely filled with water.

To determine the weight of the coarse and hard toe material, no better method has been found than to make an excavation accurately to a dimension of 1 cu. yd., or other convenient size, and to weigh the excavated material on platform scales. Percentages of moisture vary, and the weight of dry material affords the best basis of comparison. An average sample of material on the scales is taken for determining the percentage of moisture, and the results are reduced to weight of dry material per cubic foot.

Draining Fine Material

The writer is fully satisfied that there is no practical way of rapidly draining core material as fine in grain size as that described previously. He has considered it from a theoretical standpoint and also from the standpoint of practical experience.

After the material reaches a condition of 50% of voids, 6 cu. yds. must be compressed into 5 cu. yds. of 40% material by the exclusion of 1 cu. yd. of water before full stability can be counted on. This water, amounting to one-sixth of the whole volume of core material, must be expelled. The computed rate of flow through material with an effective size of 0.002 mm. is very slow. The rate depends on, and is proportional to, the hydraulic slope. With a slope of 10% (which is as steep as is usually found) the computed rate of flow as a solid column of the full area of the section is 0.32 mm. daily. At this rate, 80 days are required for the water to move 1 in. and 2.6 years for it to move 1 ft. This calculation cannot be used with assurance as establishing the exact rate of flow, but it is the writer's judgment that the actual rate is as likely to be below as above the result given. It is clear that, for a large dam, complete drainage and consolidation may be a matter of many years.

From a practical standpoint, it may be recorded that a 6-in. well driven 60 ft. in saturated core material having voids averaging 50%, with the casing perforated freely to admit water, stood empty for weeks. Not enough water drained from this material to raise the water in the well. This may represent the effect of capillarity. With such a degree of tightness, it is clearly useless to attempt to secure consolidation by any method depending on additional drainage outlets.

Measuring Core Pressures

An interesting method of measuring the pressures actually existing in core materials has been suggested by A. T. Goldbeck. By this method, small test cells are built into the core material. Some are placed with horizontal and some with vertical faces, arranged to indicate pressures on the faces during construction and afterward. Such devices are reported to have been placed in hydraulic-fill dams now building by the Miami Conservancy District. The results of observation through a certain period have already been recorded. These observations indicate, as would be expected, that the horizontal and vertical pressures are the same at first and until the material has become somewhat consolidated. Afterward, horizontal pressure increases less rapidly than vertical pressure, and the inference may be drawn that this represents solidification of the material in which the cells are placed to a point where the full horizontal pressure is no longer produced.

This is certainly an interesting method of test and one that may throw light on the conditions of core material.

It reminds the writer of one of his early experiences, which related to different circumstances, but possibly the same underlying principles are involved. It was proposed to build large and heavy structures in which the weight would be well distributed on a foundation of stiff silt. The question was presented as to whether the foundation was sufficient to carry the weight. An apparatus was provided by which test areas of 1 sq. ft. at the level of the proposed foundation were loaded. The results of the tests were most satisfactory. The material carried more than the expected loads with only insignificant settlements. When the actual structure was built, however, there was considerable settlement. The actual settlement was many times greater than had been indicated by the tests.

Pyramid Effect

The explanation is simple enough. The single square foot that was loaded distributed the weight applied to it to a much larger area a short distance below. What was loaded was in effect a pyramid with a flat top of 1 sq. ft. The full applied weight per square foot was carried only at the top, and the unit stress rapidly became less going downward as the area of the pyramid increased. A thin layer of material just below the footing actually got the pressure and was compressed accordingly, and in this way the slight observed settlement was produced. Lower down, however, the unit pressure was lower and there was no appreciable compression.

When the structure was built there was no chance for a corresponding distribution of pressure. The whole area underneath was loaded, and the weight had to be carried through the full depth of silt and the silt was compressed. A corresponding settlement would no doubt have taken place in the test apparatus if the material loaded had been a column 1 ft. square all the way down to rock. The writer thinks that because of this dispersion of load it is generally true that a small test area will carry more per unit than a larger one, and it may be that the same conditions will be found to apply to the test cells built into the core of a dam.

In view of all the information now available, the only safe course to follow, so long as the core material is like that here described, is to assume that it will produce the full horizontal pressure corresponding to its weight and height; and the toes must be made large enough to resist that pressure with ample safety.

Resisting Core Material Pressure

The first point to be considered is the coefficient of friction of the material in the toe, sliding either upon the foundation or upon itself. With hard, clean gravel a coefficient of 0.7 or 0.8 might reasonably be expected, although the data for establishing this coefficient are not as convincing as could be desired. No such coefficient was found, however, in accounting for the Calaveras slip. Instead, it was estimated that the weight of the material pushed forward in the upstream toe was five times as great as the pressure of core material against it. In estimating that pressure the whole height and weight of core material was included, assuming that it acted as a heavy liquid. This indicated a coefficient of friction of only 0.20. This is to be taken as an average for the whole area on which the slip occurred. It may be recorded, however, that a similar calculation for the lower toe which did not slip indicated a coefficient of 0.22. No one can tell how much more it would have held.

The Calaveras material is softer and perhaps more slippery than the hard particles of glacial drift of the eastern states; and it would not be reasonable to expect as high a coefficient of friction. It may be, also, that the coefficient of friction under such heavy pressures as are found in the lower part of a high dam will be less than under the small pressures of moderate depths.

San Pablo Dam Experiments

Some experiments were authorized by George Wilhelm, and made by G. W. Hawley, resident engineer at the San Pablo Dam, near Berkeley, Cal., following suggestions of the writer. A 14-in. cast-iron pipe was cut into two short parts, one of which was fixed and the other attached securely to a steel frame which swung freely on an axis about 8 ft. above. Another steel frame securely connected the ends of this axis with the fixed part of the 14-in. pipe and with other parts of the apparatus. Two hydraulic jacks were used and the pressures were computed from the measured pressures on the pistons.

The two pieces of 14-in. pipe were placed in line and the frames held them so that the ends would just clear.

A sample of the material to be tested was placed in the pipe, filling the lower or fixed part and extending some distance into the movable part. Oak planks, cut to fit as a loose piston, were then placed above. One of the hydraulic jacks was placed above it. Pressure was then applied to compress the material in the pipe to any desired extent. Experiments were made with various pressures, the greatest corresponding to a depth of fill of 200 ft. While the material was held under this pressure, the other jack was placed horizontally against the side of the 14-in. pipe with suitable blocking, and pressure applied until there was movement. The ratio of pressures on the two jacks then gave the coefficient of friction.

The steel frame and the pivot at the top was built so that there was no appreciable friction in the apparatus. A slight correction was necessary because the lever arm to the slipping plane was longer than the lever arm to the point on the 14-in. pipe where there pressure was applied.

The form of the experimental apparatus was suggested to the writer by a paper by A. L. Bell on clay pressures. The apparatus as worked out was more like that used by E. P. Goodrich in his experiments on soil pressures.

The apparatus used differed from both of its predecessors in that tests were made at very much higher pressures. The results may be compared, but it must be remembered that the local material had peculiarities of its own, and that it was no doubt quite different physically from the material tested by Bell and Goodrich.

The writer will not attempt to discuss this matter further, but suggests it as a fruitful topic for further experiment.

Experiments were made by Mr. Hawley with various local materials at various pressures. These showed that, with low pressures, the coefficient of friction was distinctly larger than it was with higher ones. The explanation for this may be that the higher pressures broke down and crushed the particles, and so reduced the relative resistance. After a certain pressure was reached there was less rapid change in the coefficients, and for the higher pressures the coefficients for any material were practically constant.

For material from the local soft sandstone rocks at San Pablo, coefficients of friction of approximately 0.5 were found.

There was one kind of material more slippery than the others for which an average coefficient of 0.45 was found. Other harder materials gave coefficients of 0.55 and more. Sand and gravel from the creek representing the remnants of much harder rocks in the hills (and so corresponding more nearly to the glacial drift of the eastern states) gave coefficients of about 0.7.

The materials at San Pablo are similar to the materials at Calaveras; and there is reason to think that the coefficients found at San Pablo would apply approximately to the Calaveras materials.

What then is the explanation of the fact that the Calaveras Dam slip indicated a coefficient of 0.2 while similar materials in the test apparatus show a coefficient of 0.5—two and one-half times as much?

The answer seems to lie in the fact that in the course of construction at Calaveras, before the dam was very high, the construction pool in the centre of the dam was sometimes quite wide; so that at some levels the greater part of the width of the dam was composed of fine-grained core material. Afterward the proportion of solid fill was increased and the width of core reduced, but the effects of the wide pool may have been permanently left in layers of core material extending far out under the more solid parts of the toes.

It seems probable that unstable core material placed in this way furnished the lubricant that facilitated and made possible the slip in the dam.

Section of Dam Required

Regarding the section of dam required with the core material considered as a fluid: At Calaveras, the toe material was slightly heavier per cubic foot than the core material. At San Pablo, with fragments of porous sandstone rock predominating in the toes, there was scarcely any difference. With harder material like the glacial drift of the Eastern States, the toe material would be considerably heavier.

For the purpose of a first rough calculation, assume that the weights per cubic foot of toe and core material are equal, as they are at San Pablo. If a coefficient of friction of 0.5 is assumed, each toe must weigh twice as much as the pressure exerted by the core. The pressure exerted by the core is $\frac{1}{2}\,wh^2$ and the weight of the toe to balance it must be wh^2. To produce this weight, a uniform outer slope of 2 to 1 will suffice. In addition, a top width equal to the maximum width of core must be used. If a factor of safety of 2 is required, the outside slope must be made 4 to 1, but in view of the records of slips in actual dams, it may well take a higher factor of safety. A slope of 5 to 1 will give a factor of safety of 2.5 and a slope of 6 to 1 will give a factor of 3. Where toe material is considerably heavier than the core, as would be the case with harder and heavier rocks, the slopes could be reduced in proportion to the increased specific gravity without reducing the factor of safety. Thus, with toe material 20% heavier than core material, a slope of 1 to 5 would allow a factor of safety of 3. Very few hydraulic dams have been built with sections as large as this line of thought suggests. The Gatun Dam at Panama heads the list, and is even larger.

TABLE 2—DIMENSIONS OF A NUMBER OF EARTH DAMS THAT HAVE STOOD SUCCESSFULLY

Dam	Height to Flow Line, H	Area of Section in Sq. Ft., A	Ratio, $\frac{A}{H^2}$	Free-board	Width in Feet: Top	At Flow Line	50 Feet Below Flow Line	100 Feet Below Flow Line	Bottom, W	Ratio, $\frac{W}{H}$
*Gatun	78	99,200	16.30	30	100	397	1,469	...	1,990	25.5
*Big Meadows	64	24,300	5.93	20	30	160	460	...	548	8.56
*Coquitlam ..	83	38,700	5.61	15	40	145	521	...	702	8.48
*Cambria	82	31,200	4.65	13	20	98	429	...	685	8.34
Ashokan	90	35,400	4.37	20	34	112	400	...	650	7.23
Druid Lake ..	82	27,900	4.15	5	60	90	390	...	582	7.10
San Andreas ..	80	26,200	4.10	5	30	58	387	...	606	7.58
*Paddy Creek .	120	58,200	4.05	25	23	161	414	664	757	6.30
*Somerset ...	92	33,200	3.94	13	25	78	375	...	616	6.67
San Leandro .	65	16,350	3.88	5	30	56	335	...	457	7.04
*Haiwee	75	21,600	3.85	14	20	90	340	...	465	6.20
Croton	96	33,400	3.62	24	30	126	336	...	528	5.50
Tabeaud	86	26,400	3.57	8	20	60	345	...	553	6.44
*Necaxa	164	90,800	3.36	16	54	136	386	636	954	5.81
Cold Spring ..	88.5	26,200	3.34	10	20	70	320	...	512	5.79
Belle Fourche	100	33,100	3.31	15	20	65	284	656	656	6.56
Lahontan	112	40,900	3.25	12	20	80	330	580	640	5.72
Santa Maria ..	85	23,500	3.25	8	20	60	310	...	485	5.71
Pilarcitos	74	17,600	3.22	5	30	56	288	...	415	5.61
Morris	90	25,700	3.18	9	20	60	309	...	502	5.58
Borden Brook	64	12,700	3.10	7	24	49	280	...	337	5.27
Honey Lake ..	90	25,000	3.08	6	20	50	300	...	500	5.56
Goose Creek ..	137.5	54,900	2.90	7	16	54	304	554	741	5.39

*Hydraulic fill, wholly or in large part.

A great many cubic yards are involved in such a large section, but if the work is done cheaply enough per cubic yard, it may be economical to use the extra volume. Safety can be secured in this way; and it may be that this procedure is the best one to follow.

Dimensions of Several Dams

To see what these slopes would call for in the way of section in comparison with earth dams that have been actually built either by the hydraulic method or as dry fill, the following comparison is made. Assuming a freeboard of one-tenth the greatest depth of water, H, and a top width of 0.25 H and uniform slopes, the cross-sections of dams in terms of the greatest depth of water would be as follows:—

Slope.	Volume.
3 to 1	$3.9\,H^2$
4 to 1	$5.1\,H^2$
5 to 1	$6.3\,H^2$
6 to 1	$7.5\,H^2$

The actual dimensions of a number of dams are given in Table 2.

Rock-fill dams are not included, but rock fill forms some part of a number of dams in the list. No dams holding less than 64 ft. of water are included.

The Necaxa Dam slipped, but was afterwards rebuilt on the original section. The Big Meadows Dam is being raised with an enlarged section.

Increasing the Grain Size

The second way of increasing stability is to use core material that will consolidate more rapidly and thoroughly. There is only one way to insure this; that is to increase the grain size of the material allowed to remain in the core. With pools and water quantities actually used in the dams known to the writer, particles smaller than 0.001 mm. and perhaps up to 0.002 mm. have been wasted. Everything larger has gone into the dam.

In some cases, an effort has been made to secure completeness of deposition of these fine particles to avoid waste and to increase the yardage accounted for in the dam.

To increase the effective size of core material, it is necessary to increase the limit of size of particles to be wasted. This can be done by narrowing the pool or by increasing the quantity of water passing it. (See Fig. 3.) On one occasion at San Pablo, to test this out, the toes were allowed to increase in height for a time without raising the pool. This was continued until the pool almost disappeared. Hardly more than a muddy creek remained in the middle of the dam. The core became comparatively narrow and much coarser in grain size. The effective size was increased to approximately 0.01 mm. Finer particles were all wasted. In other words, the core material was, say, five times as great in grain size. It had, therefore, twenty-five times as great draining capacity, and only one twenty-fifth of the capacity to hold water by capillarity.

Material placed in this way had a much better chance of drainage; first, because the core was narrower and there was less water to be removed; second, because the water had a shorter distance to go; and third, because, other things being equal, the water would get away twenty-five times as fast. After a few weeks of operation in this manner, the work was stopped temporarily, which gave an opportunity to examine the deposited core material. After only a few days it became hard enough to walk on, many times more solid than ordinary core material.

In one other respect this coarse-grained puddle differed from ordinary puddle. There was a small relative range in its grain sizes. The fine particles were eliminated, and the volume of puddle produced was reduced, but there was no very great change in the quantity and character of the coarser particles. These coarser particles constituted the whole mass of the coarse-grained puddle. With ordinary puddle, they were mixed with a large additional volume of fine-grained stock. The grains in the coarse-grained puddle were thus more nearly of the same size, and it followed that, other things being equal, the percentage of voids was greater. This was found to be the case in the test at San Pablo, and after the material had become hard and stable, it had a percentage of voids that would have indicated lack of stability in ordinary stock. This is an illustration of the fact that voids used as an index of stability can only be properly compared for the same kind of stock.

Waste of Fine Material

If this method of increasing the grain size of core material were to be followed throughout the construction of a dam, obviously there would be two results. First, a great deal of fine material would be wasted. The quantity would depend upon the quantity of such material in the stock used. In the natural course of events most of this would be reposited harmlessly upon the bottom of the reservoir. Second, a dam built in this way would be much more stable but theoretically not quite water-tight. There would be an appreciable amount of seepage through core material of this grain size.

The amount of seepage loss may be estimated approximately. Assuming that the laws of flow are the same as they are in the finest sand to which experiments have extended, it was estimated that at the San Pablo Dam if the whole core material could be made 0.01 mm. and if the rest of the dam had contributed nothing to tightness, the theoretical rate of seepage would be 280,000 gals. per day. The loss of this quantity of water would not be a serious drain upon the supply, if it adds to stability. Practically, as is known from filter experience, considering the core material as a filter, it would soon silt up and become water-tight.

As a practical proposition in dam construction, core material having a grain size of 0.01 mm. is to be accepted as sufficiently fine from the standpoint of water-tightness. This size of 0.01 mm. is not given as a precise limit. It may be that still coarser material would give sufficient tightness or that finer material would drain sufficiently. The size is mentioned because it is the size of material that was actually found possible to produce at the San Pablo Dam by reducing the size of the pool to a minimum, and because other considerations suggest that it may be suitable.

The question remains as to whether a dam in which the pool and water quantities were so adjusted as to hold the effective size of core material at 0.01 mm., or at some other selected limit, and in which the core material was never permitted to become very wide, would consolidate itself as the dam increased in height to an extent that would eliminate lateral pressure of core material.

It is the writer's idea, that a dam built in this way would certainly be more stable and safer than one in which the core material contained an additional quantity of finer particles.

This thought is similar to an idea expressed by D. C. Henny, who stated:—

"Probably the nearest approach to a perfect core of great thickness which can be hydraulicked, is one composed of fine sandy silt, such as is generally found in the arid West, having little cohesiveness, good self-drainage qualities, becoming hard and solid after a short time, and yet being, if not perfectly, at least practically water-tight."

Mr. Henny's description may be taken as an accurate description of the writer's idea of 0.01-mm. material. It certainly does not apply to 0.002-mm. material. Mr. Henny's other propositions in regard to fine core material such as is ordinarily used, are believed to be well founded.

Use of Rock Fill

In building hydraulic-fill dams, the débris above the solid rock has been most easily worked and extensively used. Such débris is frequently fine in grain size, and its use may result in an excess of core material and a deficiency of toe material. To correct this tendency, rock fill has been added to the toes of a number of dams.

The rock fill has usually been placed as dry fill; that is to say, by blasting, steam shovel, and cars or carts. The cars or carts run on the toes of the dam and deposit material at the same time that the hydraulic process is being used to fill the interior.

At the San Pablo Dam, a similar result has been reached by handling the rock after blasting by the hydraulic method. Open flumes were used with a flow of from 15 to 20 cu. ft. per sec. A 6% slope was necessary as long as wooden flume bottoms were used. With steel flumes, equally favorable results were obtained with a 4% slope. About 3,000 cu. yd. per day were placed, on an average. Pieces of broken rock up to 1 cu. ft. in size were handled under these conditions. By blasting the hardest rock available, it was possible to get material for fill that contained relatively few fine particles, and all of the small quantity of very fine material was wasted. Large additions to the toes of the dam were made in this way.

Working a quarry with a high face, it was possible to throw down great quantities of material in one large blast, and to wash many thousands of yards into the dam from a single position of monitors and flumes. The economy resulting from operating so long in one place, as compared with moving the equipment all over the hillside to pick up scattered and relatively thin deposits of débris above the rock, turned out to be fully equal to the additional cost of rock excavation; and rock fills, built in this way, cost no more per cubic yard than fill made from débris.

On the other hand, the fill made in this way is believed to be heavier, and to have a higher coefficient of friction which gives it additional value as toe material. The practical methods of handling rock fill were worked out by Mr. Hawley and D. W. Albert.

Quicksand Conditions in Dams

When a granular material has its pores completely filled with water and is under pressure, two conditions may be recognized. In the first or normal case, the whole of the pressure is communicated through the material from particle to particle by the bearings of the edges and points of the particles on each other. The water in the pores is under no pressure that interferes with this bearing. Under such conditions, the frictional resistance of the material against sliding on itself may be assumed to be the same, or nearly the same, as it would be if the pores were not filled with water. In the second case, the water in the pores of the material is under pressure. The pressure of the water on the particles tends to hold them apart; and part of the pressure is transmitted through the water. To whatever extent this happens the pressure transmitted by the edges and points of the particles is reduced. As water pressure is increased, the pressure on the edges is reduced and the friction resistance of the material becomes less. If the pressure of the water in the pores is great enough to carry all the load, it will have the effect of holding the particles apart and of producing a condition that is practically equivalent to that of quicksand.

An extra pressure in the water in the pores of such a material may be produced by a sudden blow or shock which tends to compress the solid material by crushing the edges and points where they bear, or by causing a rearrangement of particles with smaller voids. An illustration of this can be seen in the sand on the seashore. Such sand, comparable to dune sand in size, is usually found to be saturated with water for a certain distance above the water level. This condition is maintained by capillarity. If a weight is slowly placed on this saturated sand, there is a slight settlement, the grains of sand coming to firmer bearings and the weight is carried. A sharp blow, as with the foot, however, liquefies a certain volume and makes quicksand. The condition of quicksand lasts for only a few seconds until the surplus water can find its way out. When this happens the grains again come to solid bearings and stability is restored. During a few seconds after the sand is struck, however, it is almost liquid, and is capable of moving or flowing or of transmitting pressure in the same measure as a liquid.

Fine-grained sand in which this condition exists is called quicksand. The properties of quicksand are well known. Fine-grained sand saturated with water and then mixed with an additional 5% of water acts practically as a liquid. It will flow through small orifices or in a pipe at a 5% slope. The sand in a mechanical filter in process of washing is a typical case. When the sand is drained, in the filter, it forms a bed as hard as any sand bed. When subjected to a reverse current of water strong enough to slightly lift it, however, the volume is increased by perhaps 5%, and it becomes liquid. An object can then be pushed through it with scarcely more resistance than would be offered by a liquid of high specific gravity.

The conditions that control the stability or lack of stability in quicksand may also control the stability or lack of stability of materials in dams.

Hazard With Soft Rock

The puddle clay core of an hydraulic-fill dam is physically like quicksand, but with particles one hundred times smaller in diameter and a million times smaller in weight. It has the instability of quicksand in full measure and it retains it for a long time, or perhaps indefinitely.

With the coarse-grained part of an hydraulic-fill dam, that is to say, with rock toes, there may be also, at times, a similar condition. Generally speaking, it would be expected that such coarse-grained materials would have sufficient drainage to let out surplus water and prevent the possibility of an excess sufficient to destroy its stability. With hard-grained materials from glacial drift of New England and the Northern States, it is hard to conceive of a lack of drainage in gravel that would permit the accumulation of an excess of water. With the softer materials of the Pacific Coast, however, the conditions may be different. In the first place, these soft rocks by partial crushing under pressure produce fine material which tends to fill the remaining spaces and to reduce the drainage capacity.

On the other hand, each increment of loading applied to soft-grained material produces a certain compression and settlement; and with it a reduction in voids. This may happen to a toe of soft rock on the upstream side of a dam against which water is being stored during construction. There is first an open condition with ample voids and ample drainage. As the dam is built higher, pressure increases; there is compression and reduction in porosity. Each additional increment of loading and compression means that a certain quantity of water representing the difference between the old voids and the new voids must be expelled. As long as the material remains sufficiently pervious to carry off this excluded water, the process of compression is harmless. The surplus water is pushed back into the reservoir and stability is retained. There may come a time, however, when the compression goes forward so rapidly that the surplus water cannot be carried off fast enough. When that point is reached (if it is reached), there will tend to be an excess of water in the interstices and that excess will transmit some of the pressure that was before carried only by the bearings of solid particles, and the frictional resistance of the material will be less, and perhaps much less, than it was before.

The thought has occurred to the writer, in looking at the material that slid in the Calaveras Dam, that something of this kind may have happened on a large scale—800,000 cu. yds. of fill flowed for a brief space, and then became solid. It was, in fact, so solid that in examining it afterwards, by samples and by borings, it was difficult to see how the material could have flowed—as it certainly did flow.

It may be that after the first movement there was some readjustment of the material in the toe that resulted in producing temporarily this condition of quicksand, and that destroyed for a moment the stability of the material and facilitated the movement that took place.

This will not account for the initial movement; but the initial movement of some part of the material might result in accumulating pressure, first on one point, and then on another, successively, as the early points of concentration were liquefied and in that way a condition comparable to quicksand in a large mass of material may have been produced.

Summary

To summarize briefly the points that the writer has attempted to make and to apply them practically to dam construction:—

1.—It is not well to build an hydraulic-fill dam of material of which any large percentage consists of clay or of particles less than 0.01 mm. in diameter; and in general all such smaller particles may well be wasted and excluded from the dam.

2.—By reducing the construction pool to a minimum, and by controlling it and the quantities of water used for sluicing, the core material may be held to a certain degree of coarseness by wasting all smaller particles. An effective size of 0.01 mm. may reasonably be sought.

3.—To study by borings the actual consolidation of the material, and to adjust the construction of the upper parts of the dam to the demonstrated condition of that which lies below.

4.—To make the toes large enough to resist with an ample factor of safety the whole pressure of the core material as a liquid until there is demonstration of the solidification of the core to a point where horizontal pressure is eliminated.

5.—To increase the weight and solidity of toes by the use of rock fill, placed hydraulically or otherwise.

6.—Stability is increased by compactness. It is worth while to watch voids closely, and to make every effort to hold them at a minimum. The extra weight is advantageous, but security against compression and re-arrangement with resulting temporary quicksand conditions, can be best reached in this way.

A strict application of these principles may reduce the number of hydraulic-fill dams that are built by eliminating that method of construction from consideration where the available material contains too many very small particles. It may also increase considerably the volume and cost of those that are built. It would seem, however, that following them to a logical conclusion, with such testing as can reasonably be done, will result in eliminating present uncertainties and in putting a most useful method of dam construction on a definite and safe basis.

"CEMENT-GUN" REPAIRS CONCRETE SHIP

FOLLOWING is a letter written April 21st, 1920, to the Cement-Gun Co., Inc., Allentown, Pa., by Godfrey L. Smith, head of the civil engineering department of the Newport News Shipbuilding and Dry Dock Co., Newport News, Va.:—

"We had occasion a short time ago to repair one of the Shipping Board ships, the 'Cape Fear,' and this work was done with a cement-gun. It appears that this ship, which was built at Wilmington, N.C., was sent to New York for a cargo. While in that port, she suffered some damage by collision, either with a pier or with some watercraft, the net result being that there were three holes punched in her port side, one just aft of the collision bulkhead, one in the fore hold and one abreast the boiler room in way of a bunker.

Attempted Repairs With Concrete

"An attempt was made to make repairs in New York harbor, but not very successfully. Apparently, the method of procedure pursued was to chip out a large hole, approximately 4 ft. square, clear through the shell, in way of the bunker and in way of the second hole referred to as being in the fore hold. No attempt was made to repair the hole just aft of the collision bulkhead.

"The last-named hole was not much larger than a man's hat on the outside of the hull and about the size of a dishpan on the inside of the hull. The concrete was shattered, but was still held in place by the reinforcement. The other two holes had been repaired by placing forms inside and outside of the hull and pouring wet concrete between the forms. There was considerable shrinkage, particularly at the top of these patches, but also on the forward and after edges.

"The vessel then came to Newport News to receive a cargo of coal. After a portion of her cargo was loaded, the captain decided that the patches were leaking too much for comfort and insisted on having repairs made. Inasmuch as this work is in my line, and inasmuch as we had on hand what I considered the proper apparatus for making the repair, the job was turned over to my department. We proceeded by cutting out all of the concrete that had been placed in New York and cleaning out the shattered material in the hole in the after collision bulkhead, after which we placed a form on the inside of the ship, about 3 ins. clear of the inside of the shell, and proceeded to build up the patch with gunite.

"Our reason for adding this thickness on the inside was that the captain very much desired an added thickness shell in way of these holes, although I assured him that we could make a prefectly satisfactory patch on the original thickness of the hull, which was a little over 3 ins. thick for the forward holes and slightly more for the after ones.

Reinforcement Closely Spaced

"The reinforcement of the shell, which consisted of two networks of small rods, one near the outside of the thickness and one near the inside of the thickness, was so closely spaced that it was necessary for us to stop gunning twice and cut the gunite off the reinforcement with trowels in order to get the necessary amount inboard of the reinforcement. We finally completely filled the hole and built it up about ½ in. outside of the hull, after which we trimmed it down to a fair line by means of sharp steel trowels and rubbed it to surface by means of a wooden float.

"Inasmuch as the captain was in a great hurry to get away, I then decided to hurry up the hardening process, which was done by dropping a canvas screen over the side of the ship, well over the patches, holding it in close against the ship around the edges and turning live steam into the space between the canvas and the hull. This steam was kept on all one night. The following morning the steam was shut off, the canvas screen raised and the surface rubbed down smooth with a carborundum brick and water. The canvas screen was then replaced and steam was left on all of that day and night. The following morning, it was evident that the job was an entirely satisfactory one, as there were no cracks anywhere in or around the patch. We then painted the patch with 'Granolith,' a special concrete paint, which we use for such purposes, and after this was dry, with a coat of black asphaltum varnish.

Tested Under 150 Lbs. Pressure

"For our satisfaction, as well as to demonstrate to the captain that he need have no further fears from leakage, we arranged a hose test on all of the patches, using a 1⅛-in. nozzle with 150 lbs. pressure at the nozzle and holding the nozzle within 12 or 15 ft. of the patch. We applied this stream all over the patches, particularly around the edges. The stream was strong enough to blow all loose concrete from the surface adjacent to the patch and to strip off a considerable portion of the paint, which had not had time to harden properly. Not a drop of water leaked through any of the patches; in fact, anyone on the inside of the ship would not have known that any water pressure was being applied to the outside. We then repainted the patches, and the ship left the following day to be loaded with coal at the Newport News coal-piers. I have not heard from the ship since leaving here, and I understand that no trouble of any kind has been experienced.

Salt Water for Mixing

"We had some litle trouble in getting the cement-gun to work just right. This was not the fault of the gun, but was due to the water holes in the nozzle being partially stopped up, to an insufficient water pressure and to an excess air pressure. When these troubles were corrected the gun worked perfectly. It may be of interest to you to know that we used salt water, instead of fresh, for moistening the sand and cement. This may safely be done when the cement possesses certain chemical characteristics, although I would not advise its use with all cements. The cement used was Old Dominion and the sand was a moderately coarse, well-graded quartz sand, carefully screened and free from dirt."

The head office of Westinghouse-Church-Kerr & Co., Inc., has been moved from 37 Wall St., New York City, to 125 East 46th St. Pending the completion of the merger with Dwight P. Robinson & Co., Inc., which was announced in the April 8th issue of *The Canadian Engineer*, the W.C.K. firm will be continued under the present name.

Addressing the Toronto branch of the Engineering Institute of Canada last Thursday evening, W. E. Bonn, of the Canadian Stewart Co., Ltd., stated that 192 acres would be reclaimed in Toronto Harbor between the Humber River and the western ship channel by the material which his company is placing back of 20,000 ft. of breakwater; that 200 acres would be reclaimed in the harbor proper and 700 acres in the Ashbridge Bay district, which is now known as the Eastern Harbor Terminal District. This reclamation will require the placing of approximately 30,000,000 cu. yds. of material, about half of which has already been dredged. It will require another six years to complete the work, said Mr. Bonn.

MONOLITHIC CONCRETE HOUSES*

NEARLY fifty years ago the first monolithic concrete house was constructed. This house is in use to-day and shows every evidence that the end of the next fifty years will find it in the same condition as it is to-day. A permanent asset to the wealth of the nation was contributed when this house was built. We do not know what this house cost at the time it was built, but whatever the cost may have been, it is insignificant when spread over the half-century of useful service it has already rendered and will doubtless continue to render for years to come. No doubt this house cost more to build than a frame house would have cost, but *ultimate* economy, which includes the cost of maintenance, repairs and depreciation, tells a story quite different from a comparison of first cost. The cheapest thing to buy is usually not the cheapest in the end.

A very pertinent question, then, is why have we not built more concrete houses? The answer lies largely in the fact that general knowledge in regard to the real worth of concrete houses is slight, and that knowledge in regard to the technique of constructing them is confined to a few. The objects of this report will be, therefore, not only to state the case of the real worth of concrete houses, but to point out the lines along which future practical development of the monolithic concrete house must take.

A house must be habitable and therefore comfortable. It must protect its inhabitants against the heat and cold, and be sanitary. Its appearance, while secondary from a purely utilitarian standpoint, must not violate the principles of architecture and harmony with surroundings and proportion. But, "A thing of beauty is a joy forever" is true only if the thing lasts forever. This means that the structure must be permanent.

Utility is obtained by proper planning for the use of enclosed space. The concrete house allows this without interfering with architectural treatment. By employing a "dead" air space in the walls, insulation against heat and cold is obtained. The concrete house is easily cleansed and furnishes no harbor for vermin or disease-breeding germs. Concrete is strong and permanent. It does not rust, rot or decay. Admitting then, that concrete as a house-building material meets the fundamental requirements, the question remains as to how it may be utilized in a practical way in the construction of homes. The report of this committee will attempt to answer this question only in so far as the monolithic house employing forms in its construction is concerned.

There are but two fundamental problems to be solved in practical monolithic concrete house construction. These are (1) forms and design, and (2) field practice.

Forms and Design

A monolithic house of any architectural design, form or size can be built, but in order that the cost of construction be held within reasonable limits, the forms must be used over and over again. This requires either that the same set of forms should allow wide variation as to length, height and relation of surfaces, or that the design itself be limited to the flexibility allowed by the particular system of forms employed.

There is no system of concrete house molds available but that require a certain degree of standardization in design to make their use economical. Gables, bay-windows, curved surfaces or other than right-angle corners add to the cost of form-work. For a large group of houses, which is essentially the industrial housing problem to-day, much emphasis has been placed on appearance. Rows of houses of identical design are often condemned, and rightly so if each individual house is ugly, whether built of wood, brick or concrete. There is little choice, however, between a group of houses all different, but each of which is ugly, and a group of ugly houses all alike, excepting that the ensemble of all different ugly houses is more offensive than the group of all alike ugly houses.

*Report of committee presented at the recent Chicago conference on concrete house construction.

The real objection seems to lie in the design of the house itself. It does not appear that a group of houses each of which is pleasing will present an unpleasing ensemble even though they all have the same general dimensions. Thus the problem is at once solved by producing a correct architectural design as to general style and proportion, which can readily be altered in minor details, such as the entrance, porch and roof, without at all affecting the pleasing architectural proportion. This is the work of the architect and offers a challenge to his talent and genius.

Design for a large project must above all other things be practical and must, therefore, meet all the real needs of the occupants. Large groups of industrial houses will, in large measure, be occupied by a fairly uniform class of families. Different grades of workmen or different nationalities usually require separate groups, with corresponding differences in size or design of house. Within each of these sub-groups there is little reason for much variation in the main dimensions or floor plans of the houses, and the objection of sameness is at once removed by a skilful arrangement of houses, with variations in roofs and porches, surface treatment, location of entrances and the facing directions of their fronts. This has been amply demonstrated in a number of recent industrial housing developments, and the fact that the monolithic house has practical limitations as to variety, because of the use of forms, should not hinder the adoption of this type.

Too often the monolithic house is discarded as soon as the half truth is suggested that they must all be alike, when, as a matter of fact, a little skill will completely dispel all appearance of monotony, and if the general design is good, the group will be attractive.

The molds that have been developed and used may be classified as to material: Wood and steel. The most widely known concrete house molds are those invented by C. H. Ingersoll and used to construct the concrete houses at Phillipsburg and Union, N.J. These molds do not permit of much variation in design, and a complete separate set is required for each type of house. The houses at Phillipsburg are all of the same general design, but the visitor will be struck more by the apparent variety than the actual similarity. The molds produce a solid wall, which is furred, lathed and plastered to furnish the insulation required to prevent condensation of moisture on the interior surface.

Another system of wooden forms utilizing grooved 2 by 4's which support and hold in place sectional wooden forms, is known as the Felligren system, and is said to have been successfully used in and around Chicago.

The best known systems of steel molds are the Hydraulic Steelcraft, Morrill, Lambie, Metaform, Blaw-Knox, Schub and the Van Guilder. The Steelcraft, Morrill, Metaform, Blaw-Knox and Schub molds are made up of relatively small plates from 2 to 3 ft. square. The Lambie forms are composed of steel channels set vertically, clipped together at the flanges and lined with horizontal liners composed of steel angles. The Van Guilder molds represent a different type, consisting of a combination of plates about 9 to 18 ins. high, held together by yokes and released from the wall by levers. When the chambers of the machine are tamped full of concrete, the plates are released and the machine moved ahead, travelling around the wall and forming a course from 9 to 18 ins. high. This method produces a double wall and obviates the need of furring, and does not impose restrictions on design.

Field Practice

The total amount of concrete required for a concrete house is relatively small and does not justify heavy and elaborate equipment. Large capacity mixers and spouting from a high tower have not proven successful. A small one-bag batch mixer will mix the concrete in sufficient quantity and with sufficient rapidity, and where construction is on a large scale, with many houses going up at once, several small mixers are needed rather than one or a few large ones. For the construction of two-story houses, some separate means of elevating the concrete is necessary unless elevating machinery is a part of the mixer outfit, such as the Humphrey conveyor equipment.

George E. Lewis, of the Marion Double Wall Co., Marion, Ohio, who has had a great deal of experience in constructing Van Guilder houses, has solved the elevating problem as required by the Van Guilder wall machines by using a small lift which carries a flat platform wheelbarrow loaded with pails full of concrete. This is the quickest, easiest and most economical way of handling the materials. A pail full is just the right amount to be tamped into place at a time, and a good operator can tamp as fast as an assistant can throw it into the forms. The pails are easily wheeled to place, and by using a system of inexpensive, collapsible scaffold horses to carry the plank runways, they can be kept within easy reach of the forms with but very little effort.

They use a small portable lift which consists only of two guides built up in interchangeable sections and bolted together. These are held in position by staying to the different floors as the work progresses. Where it is impossible to put the lift inside of the building, they have used it outside by means of just a few extra stays. The platform of the lift itself is about 2 ft. 6 ins. by 3 ft. 6 ins.,—just large enough to carry a wheelbarrow but not so large that it will be too heavy for the power plant. They use a mixer with 3½ or 5½ h.p. engine, either of which is sufficiently strong to operate the lift and mix a batch at the same time.

The mixer should have a hoisting drum attached to operate the lift, and should be sufficiently open to be easily cleansed. The hoisting attachment is usually added to standard mixers as a special appliance.

Construction of the one hundred concrete houses at Donora, Pa., was started with a high tower, but the tower was dispensed with later and small mixers and hoists substituted with better results. A small mixer was placed alongside each house during concreting. The concrete was handled in buggies, lifted by swing derricks.

Houses consisting of reinforced concrete foundations and walls with a brick veneer were constructed in groups of ten by Daniel Crawford, Jr., at Long Island City, N.Y. The equipment used consisted of a one-bag capacity side loader mixer, a 7-h.p. kerosene hoist, and a mast-hoist bucket plant, this equipment being placed on the street in the centre of a group of ten houses, so that five houses were poured without moving any chutes. After five houses were poured, the chutes would be swung around to pour the remaining five, so that from one set up of the plant the entire ten were sufficiently covered.

A 50-ft. mast was used, this being framed by carpenters on the job, the mast being hollow and framed out of 2-in. stuff. In erecting this mast a light gin-pole about 35-ft. long and 6 ins. in diameter was first put up, then the mast for the bucket was rigged up to the gin-pole and set up, and the four supporting guys made fast. The cable for the bucket hoist line was reeved up before the mast was set in place, and the lifting was done by the hoist that was afterward to be used to elevate the bucket and in dismantling. The frame supporting the chutes was then clamped fast near the top of the mast and the plant was ready for operation as soon as the chutes were hung in place.

The plant handled about 70 yds. per day with a crew which consisted of one foreman, three men wheeling aggregate, one man handling cement and water, one hoisting engineer, and the men tamping and handling chutes.

In constructing the Van Guilder houses at Youngstown, Ohio, a ¼-yd. mixer was used, and the material conveyed in buckets on platform wheelbarrows operated on runways up to the second floor level. The buckets were passed up by hand for second-story walls. The crew consisted of 8 men up to the second floor, and 9 men for the second story.

Surface Finish

It is usually assumed that the exterior walls of monolithic concrete houses cast in forms require some treatment to make them attractive. It is not within the province of this committee to say what color, combination of color, or light and shadow is best suited to the exterior of houses. A wide variety of colors, lights, and shadows, however, are obtainable with concrete, and final decision as to finish must be made to conform to local conditions, and especially to the grade or class of the houses.

There are two general ways of obtaining surface finish: (a) Application of coloring to the concrete surface after the forms are removed; (b) treatment of the surface itself either before or after the forms are removed. Color may be applied directly to the concrete surface either as stucco or paint. Stucco may be had in any conceivable shade of color, and a considerable range of choice is also afforded by special paints suitable to concrete surfaces. A machine for applying stucco, known as Hodges stucco machine, has lately gained considerable attention. Saving the expense of painting has been given as one of the advantages of concrete houses. Stucco, applied directly to the concrete surface without the use of lath or fabric of any sort, will be absolutely permanent if the work is properly done, and freshening of the surface to restore the color may be effected by the simple process of washing with a hose and scrubbing.

Surface finish obtained by depositing colored aggregate or coloring material in the forms next to the surface or by mechanical means, such as tooling, sand blasting, etc., or a combination of these, will usually cost less than stuccoing and will produce an absolutely permanent finish. The variety of color effect is, however, much more limited than is obtainable with stucco.

Interior Construction and Finish

The truth is outstanding and should not be lost sight of that the monolithic concrete house in which concrete has been consistently used in walls, floors, partitions and roof *does* represent the highest type of firesafe, permanent, maintenance-free house.

It is universally admitted that concrete floors are fireproof and sanitary. There is, however, a marked difference of opinion as to the desirability of a concrete floor surface from the standpoint of comfort and coziness.

Wooden floor surfaces are applied either by embedding nailing strips in the concrete or by covering the structural concrete floor with "Nailcrete" or a mixture of cement mortar and sawdust or cinders. The best solution of the concrete floor problem is the use of easily removable floor coverings of carpets, rugs, linoleums or patented floor coverings. Inserts for buttoning down floor covering may be embedded in the concrete. The covering is easily removed and the floors may be flushed and scrubbed.

Solid monolithic concrete walls are no exception to other masonry walls in regard to the requirement for insulation to prevent condensation of moisture on their interior surface. Furring, lath and plaster should be used, producing an air space between the concrete wall and the surface of the interior finish. For this purpose wooden nailing strips or plugs to which the furring may be attached should be embedded in the concrete wall, or wires or "hairpins" allowed to protrude from the concrete, for the attachment of ribbed metal fabric or wire mesh. Whatever detail is adopted, the fundamental requirement of insulation must be provided, and either a "dead" air space must be obtained or some insulating material such as linofelt, cabot's quilt, cork-board, etc., used between the concrete and the inside finish.

Partitions in a thoroughly fireproof house should also be fireproof. In monolithic houses of the bearing-wall type with concrete floors, it is usually economical to make some of the partitions heavy enough to carry the floor loads, thus cutting down the floor spans and obviating the use of columns or deep beams. These partitions are then similar in construction to the exterior walls and are fireproof. Furring is omitted and the finish applied directly to the concrete surface. Partitions that do not carry floor loads may be constructed by plastering and back-plastering on ribbed expanded metal or mesh. Openings in such partitions may be secured by using pressed steel or concrete studs at each side of opening. Plastered partitions may be made to form a dead air space by constructing two walls a few inches apart, both plastered on expanded metal or mesh reinforcement.

In order to carry out the idea of firesafeness completely, the roof must be incombustible. If the ceiling of the top floor is concrete and the roof covering is tile, slate or asbestos shingles, the roof framing may be of wood without appreciable increase of fire hazard. If there is no means of communication between the upper rooms and garret, a wooden frame roof, and the top floor concrete ceiling constitute in reality two roofs, and the extra expense can be justified only because of architectural effect and some additional protection from heat and cold. The concrete ceiling may serve at the same time as a roof. This brings us to the question of the flat roof and its appearance. Much difference of opinion exists in regard to this matter. It is certainly true that many high-class residences have flat roofs. Both flat and pitched roofed houses were constructed in the Cranwood development, and the flat-roof houses were the first choice of the purchasers. A concrete pitched roof built with forms is more difficult to construct than a flat one. A concrete pitched roof can, however, be constructed by plastering or shooting with a cement-gun on expanded metal or mesh reinforcement.

Conclusions

1.—Concrete being a different material than other materials used in home building, presents new problems and new limitations in design. These must be studied in order to produce artistic effects economically.

2.—When houses are built in groups having the same overall dimensions, good architectural design can be given sufficient variety to remove appearance of sameness by using colors, by methods of surface finish and by skilful arrangement of roofs, balustrades, cornices, porches, etc. Irregularity of design, bay windows, curved surfaces, cornices or oblique angles are not necessary to good appearance of a large group of houses.

3.—The thickness of walls of monolithic houses is governed by considerations of field practice rather than by the requirement for strength. Building regulations should recognize the greater strength of concrete, and therefore the thickness of walls should be governed by the requirements of standard engineering practice. The exterior bearing walls built solid, the thickness in the basement need not exceed 8 ins., and in first and second stories, 6 ins. Where hollow wall construction is used, the same total thickness of concrete is sufficient. For exterior partitions, 4 ins. is recommended.

4.—Well constructed 6-in. concrete walls require little reinforcement for structural reasons, but do not need more than ¼ of 1% to provide for temperature stresses. A proper mix for these walls is about 1: 2½: 4, with maximum size aggregate about 1-in. Broken stone, pebbles or a good grade of slag or cinders may be used as coarse aggregate.

5.—In climates subject to sudden and great changes of temperature, a dead air space throughout the exterior walls must be included within the wall proper, or an air space must be formed by furring and plaster, or some insulating medium used between the solid wall and the interior finish.

6.—Complete firesafeness requires concrete floors and partitions and an incombustible roof.

7.—A concrete floor should preferably be covered by rugs, carpets, linoleum or special floor coverings that are easily removed.

8.—A thin stucco coat has been found a satisfactory method of finishing exterior surfaces. Finishes have also been obtained by exposing colored aggregates and by tooling, sand blasting or rubbing, in some cases with success. Trowelled finishes are not recommended.

9.—Small one-bag batch mixers and simple elevating equipment of the mast and bucket or two-legged tower and skip type are best adapted to monolithic house construction.

10.—Window and door frames can be set in the forms and the concrete cast around them. Wooden frames should be well primed as a protection from moisture in the concrete. Frames should be anchored to the concrete by means of long spikes or bolts. They should be braced against distortion from the pressure of the wet concrete.

11.—Forms should be light enough or in sufficiently small sections to allow handling by the form setters without producing undue fatigue. They should be capable of positive alignment both vertically and horizontally.

12.—The monolithic house offers an unlimited field for development. Encouragement should be given to the development of all systems of forms for the construction of monolithic houses.

13.—The monolithic house offers advantages in speed of construction that makes it especially suitable for large housing developments.

SAYS EASTERN ONTARIO FAIRLY TREATED

REPLYING to complaints from Eastern Ontario regarding the number of roads in the eastern part of that province which were recently taken over by the provincial government as parts of the provincial highway, Hon. F. C. Biggs, Minister of Highways and Public Works in the Ontario cabinet, has issued a statement in which he declares that the eastern part of the province has been more than fairly treated. He says that whereas the assessment of the central district of the province is 55% of the total assessment of the province, and the assessed population is 49% of the total, only 35% of the provincial highway system is in the central district. In the western district there is 25% of the total assessment of the province and 26% of the population, with 31% of the provincial highway system. On the other hand, although 34% of the provincial highway system is in the eastern district, the assessment of that district is only 20% of the total and the population 25%, says Mr. Biggs. He refers to the western district as comprising all of Ontario west of a line drawn southerly from the Georgian Bay to Lake Erie, the central district as the remaining portion of the province as far east as Lindsay, and the eastern district as the portion east of Lindsay.

E. A. Cleveland, of Victoria, and Donald Cameron, of Northern Vancouver, well-known consulting engineers, are suing the Pemberton Drainage Commission to recover money which they claim to be due for their services as consulting engineers.

By a majority of only two votes, the railway committee of the House of Commons refused last week to grant a charter to the Pabos & Edmundston Railway Co. to construct a 240-mile railway in the Gaspe peninsula. The Minister of Railways stated that the day of federal subsidies for railways had gone.

According to a newspaper despatch from Quebec City, more bridges will be built by the Department of Public Works of that province this season than were built in any previous year. Among the larger bridges under construction are the Batiscan and the Metabetchouan. In the Gaspe region a considerable number of new bridges will be built to encourage colonization.

Scientific research in government laboratories has considerable advantage over similar research conducted privately for competitive purposes, declared Dr. G. K. Burgess, chief of the Division of Metallurgy, Bureau of Standards, Washington, D.C., in lecturing last week before the Royal Canadian Institute, Toronto. Dr. Burgess claimed that the conditions under which research is conducted in the Bureau of Standards is admirably suited to the requirements of investigators.

A. Brooks, representing Sir John Jackson Co., Ltd., of London, Eng., visited Edmonton recently en route to Victoria, where his company has a contract for the construction of docks. While in Edmonton Mr. Brooks stated that his company fully intends to proceed with the construction of a railway from Edmonton to their hydro-electric power development on the Saskatchewan River, and to spend $400,000 on additional power development. Mr. Brooks expressed regret that conditions due to the war had interfered with this work, and said that he did not know precisely when the construction would be started, but he assured Edmonton interests that the work would be completed as soon as financial circumstances permit.

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PRINCIPAL CONTENTS

ST. MARY'S AND MILK RIVERS CASE

THE International Joint Commission met in Ottawa last Monday to discuss the St. Mary's and Milk Rivers case, which seriously affects irrigation projects in Alberta and Montana. The headwaters of both of these rivers are in Montana, but they both flow across the border to Alberta. The St. Mary's River empties into the Saskatchewan, but the Milk River returns to Montana. The case to be settled is whether either Alberta or Montana has the right to divert the waters of either of these rivers, and if so to what extent. This case differs from others previously argued before the International Joint Commission in that it deals with rivers crossing the international boundary rather than with rivers forming a part of the boundary. All previous cases before the commission have dealt with rivers such as the Niagara, St. Clair, etc., which flow along the boundary, but the commission has decided that it is equally within its province to deal with the distribution of water from streams crossing the boundary.

MR. MAGRATH AS POSSIBLE AMBASSADOR

AMONG the names suggested for the post of Canadian ambassador to the United States, the daily newspapers have prominently mentioned C. A. Magrath, chairman of the Canadian section of the International Joint Commission. The Dominion government could, undoubtedly, seek far without discovering many men as well qualified for such a position as is Mr. Magrath. His experience in the highly diplomatic post which he now holds, and as the country's fuel controller, well qualifies him for the new post. His work on the International Joint Commission has been characterized by ability of the very highest order. He has been faced with many extremely difficult situations, all of which have been handled in the best possible interests of the country and with an extraordnary degree of tact.

Mr. Magrath knows Canada. He has had experience in provincial and Dominion politics, and as a surveyor and civil engineer he has acquired an intimate knowledge of every part of the Dominion, including not only the more populous districts but also those undeveloped portions of the country which are best known by surveyors.

Mr. Magrath has a dominating personality, an impressive physique and an education considerably superior to that of most men in public life. His choice would be a fortunate one for the Dominion and would certainly meet with the approval of all engineers throughout Canada who know the many pitfalls around which Mr. Magrath has so ably guided the International Joint Commission.

A SELF-CONSTITUTED WATERWAYS ASSOCIATION

BUSINESS firms in Toronto have been circularized by J. H. Duthie, secretary of the "National Waterways Association of Canada," and urged to join his association—at five dollars per annum. Mr. Duthie's letter claims that "for the past ten years a systematic publicity campaign has been carried on in Canada and in the United States by *members of* his association, urging the construction of a deep waterway from the great lakes to the sea by way of the St. Lawrence River, and, *as a result thereof*, the question has now become one of international concern." The reader should note that Mr. Duthie does not claim that his association has been at work for ten years,—in fact, he has admitted to *The Canadian Engineer* that it was very recently organized—but he states that *members* of it have been at work, and makes the modest claim that the international attention now being given to the canalization of the St. Lawrence is the result of his efforts and those of his fellow-members in this new association.

Enclosed with Mr. Duthie's letter is a suggestively convenient membership blank which begins with the words, "Enclosed find cheque for five dollars," and he intimates in his letter that the time has arrived when those who will benefit from the completion of the deep waterway to the sea should do their part by getting out their cheque-books and obeying his injunction to "Make all cheques payable to the National Waterways Association."

The names of no officials excepting Mr. Duthie, as secretary, and Dr. E. Herbert Adams, as chairman of the organization committee, are given on Mr. Duthie's literature now being circulated. When asked for names of other officials, Mr. Duthie replied that they had not been elected. He admitted that his association has not received the official endorsation of any municipality, nor that of the Hydro-Electric Power Commission.

To both Dr. Adams and Mr. Duthie, *The Canadian Engineer* pointed out that there is already in existence an officially organized Canadian Deep Waterways and Power Association, and that the formation of another association would seem unnecessary and inadvisable. Strenuous objection to this viewpoint was expressed by both gentlemen. Mr. Duthie claimed that the Canadian Deep Waterways and Power Association is self-constituted just as much as is his own association, and that it is not an official organization.

That our readers and the general public may judge of the relative standing and prestige of the two organizations, it should be stated that Sir Adam Beck and Mayor Church, of Toronto, are the honorary vice-presidents of the Canadian Deep Waterways and Power Association, and the active vice-presidents are: E. L. Cousins, manager Toronto Harbor Commission; Geo. J. Guy, chairman Hamilton Harbor Commission; Geo. A. Graham, of the Fort William Board of Trade; and T. R. Deacon, formerly mayor of Winnipeg. The president of the Canadian Deep Waterways and Power Association is O. E. Fleming, K.C., former mayor of Windsor, and the honorary president is W. M. German, K.C., formerly a member of the Ontario legislature, and now president of the Welland Board of Trade. The honorary secretary-treasurer is F. Maclure Sclanders, commissioner of the Border Cities Chamber of Commerce, and the secretary is Major Alex. Lewis, formerly secretary of the Toronto Harbor Commission. The Canadian Deep Waterways and Power Association was not formed by a few private individuals, but was organized at a meeting called by the Border Cities Chamber of Commerce, which invited the municipalities interested in the proposed canalization and power project to send representatives. The representatives attending the organization meeting were appointed by the municipal officials or boards of trade of the various towns and cities.

The Canadian Deep Waterways and Power Association has solicited no private contributions. It is supported by the municipalities, and the municipalities—not individuals—constitute the membership. On the executive committee are the appointed representatives of a number of cities. The Canadian Deep Waterways and Power Association is endorsed by the Hydro-Electric Power Commission and by scores of municipalities. Its organization meeting was attended by representatives of the Dominion government and the Dominion Power Board. The International Joint Commission conducts all of its correspondence with the municipalities, in regard to this project, through Major Lewis, the secretary of the Canadian Deep Waterways and Power Association.

In view of these facts, anyone who may be asked to contribute to the "National Waterways Association of Canada" is fully warranted in investigating the operations and organization of that association before giving it any support. It should also be borne in mind that such contributions have not been asked, and will not be asked, by the Canadian Deep Waterways and Power Association.

PERSONALS

PHILIP EARNSHAW, of Kingston, has been appointed instructor of civil engineering at the Royal Military College.

JAS. STEVENSON, of Calgary, has been appointed resident engineer at Calgary for the Department of Public Works of Canada.

A. P. MILLER, of Glen Miller, Ont., has been appointed assistant chief engineer, Trent Canal, Department of Public Works of Canada.

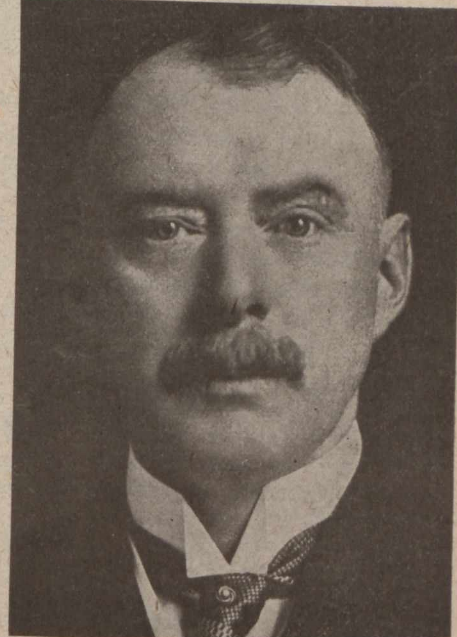
EDW. T. MCLAREN, assistant city engineer of Brantford, Ont., has been appointed acting head of the department, succeeding the late city engineer, T. Harry Jones, pending action by the city council in regard to a permanent appointment.

C. M. ARNOLD, water administration engineer of the Reclamation Service, Department of the Interior, Calgary, Alta., has resigned in order to accept a position on Maj. Muckleston's staff on the construction of the Lethbridge Northern irrigation project.

R. D. WAUGH, formerly chairman of the Greater Winnipeg Water District, who was recently appointed a member of the Saar Valley Commission, is not chairman of that commission, as was previously announced in the House of Commons. In a letter to a friend in Winnipeg, Mr. Waugh states there was a misunderstanding in this regard, as M. Roualt, the French commissioner, was appointed chairman a week before Mr. Waugh received his appointment as commissioner.

SAM G. PORTER, engineer in charge of the Lethbridge project for the C.P.R. Irrigation Department, has been elected president of the Rotary Club of Lethbridge. Mr. Porter was born on a farm in Texas and lived there for 20 years. He graduated at the Massachusetts Institute of Technology in civil engineering, having previously obtained the degree of M.A. at Baylor University, Waco, Tex. His engineering career includes three years with the United States Reclamation Service; six years as chief engineer of the Arkansas Valley Sugar Beet & Irrigation Land Co., Colorado; and five years with the Irrigation Branch of the Dominion government as special inspecting engineer and assistant chief engineer, during which time he was in charge of many of the surveys upon which irrigation districts in Southern Alberta are now being based. He went to Lethbridge about a year ago to assume his present duties.

GORDON GRANT, of Ottawa, who was recently appointed chief engineer of the Dominion Highways Commission, was born January 2nd, 1865, in Dufftown, Banffshire, Scotland, and was brought to Canada when seven years of age. He was educated at the Ottawa Business College and at Ottawa University. At the early age of seventeen he went to Argentina and was engaged in railway construction for the following five years. In 1887 he returned to Canada and was employed for three years on the Cape Breton extension of the Intercolonial Railway. In 1890 he joined the engineering staff of the C.P.R., but three years later resigned to accept an offer from the Florida East Coast Line. In 1895 he returned to the C.P.R. Construction Department, where he remained for ten years, resigning in 1905 to become assistant district engineer of the National Transcontinental Railway. Two years later he was promoted to be inspecting engineer, and in 1909 became chief engineer, which position he held until 1918, when he was appointed consulting engineer, Department of Railways and Canals, Ottawa. Mr. Grant is a member of the Engineering Institute of Canada and of the American Railway Engineering Association. He is a brother of A. J. Grant, engineer in charge of the construction of the new Welland Ship Canal.



ROBERT DICKEY, a civil engineer on the staff of the Sewer Section, Department of Works, city of Toronto, was seriously injured last week by a dynamite explosion. While he was inspecting the tunnel for the new storm overflow sewer at College St. and Manning Ave., workmen fired an explosive charge almost immediately above him for the purpose of removing rock for the construction of a manhole. Mr. Dickey sustained serious injuries about the face and head, and was unconscious when removed from the tunnel.

The contract for fifteen 15,000 k.v.a. transformers recently awarded to the Canadian Westinghouse Co., Ltd., Hamilton, Ont., by the Hydro-Electric Power Commission of Ontario, is said to be the largest single order for transformers that has ever been placed. These transformers are to be used in the new Queenston powerhouse to step up the power from the generating voltage of 12,000 volts to the transmission voltage of 110,000 volts.

Within a fortnight the new plant near Grenville, Que., which was built by the newly incorporated Scottish-Canadian Magnesite Co. at a cost of nearly $500,000, will begin operations to supply the steel industry with magnesite, which before the war came almost exclusively from Austria. T. L. Dates, manager of the company, states that the plant is located near the only magnesite deposit in the Dominion, and will have a capacity of 100 tons daily. J. M. Kilbourn, vice-president of the Canada Cement Co., Ltd., and one of the pioneers in malleable iron in Canada, owns controlling interest in the new company.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand or proposed, contracts awarded, changes in staffs, etc.

BRIDGES, ROADS AND STREETS

Birtle, Man.—As no tenders were received for the draining and grading of 52 miles of road, the work will be advertised again later on. Secretary-treasurer, W. B. Chapman.

Brockville, Ont.—Council of Leeds and Grenville counties voted $350,000 for road construction and improvement.

Bruce Mines, Ont.—The town council and Citizens' Committee are agitating for the construction of a trunk road from Chapleau to Bruce Mines.

East Selkirk, Man.—Ratepayers passed a by-law to grade and gravel the main road through the village.

East Whitby Tp., Ont.—Tenders will be received by W. A. McLean, Deputy Minister of Provincial Highways, Toronto, until 12 o'clock noon on Saturday, May 22nd, 1920, for earthwork, etc., on Provincial Highway. (See official advertisement in this issue.)

Englehart, Ont.—Property owners in the Skead township district will appeal to the Ontario government for assistance in building a bridge over the Blanche River and road construction.

Fredericton, N.B.—Plans have been prepared for the construction of a railway bridge across the St. John River, the new location of the C.N.R. tracks. Work will probably start some time this year, and, while various figures have been mentioned, it is said that the lowest figure calls for an expenditure of more than $2,000,000.

Fredericton, N.B.—Contract for the Burnt Church River mouth bridge, Parish of Alnwick, Northumberland, has been awarded by the provincial public works department to J. E. and D. P. Connolly, Bathurst, N.B., their tender being approximately $49,000. Contract for the Porter Brook concrete arch culvert and approach, Parish of St. Mary's, York, was awarded to W. D. Steeves, and F. E. Barryman, of Woodstock, N.B., the contract price being approximately $9,000.

Hamilton, Ont.—Works Committee decided to proceed with the construction of permanent roadways on parts of the following streets: Kensington, Belview, Grosvenor, Rosslyn, Mars and Homewood Ave., and London, Stirton and Catharine Sts. City engineer, E. R. Gray.

Hamilton, Ont.—City council considering repairs on Kensington Ave., from Maple to Cumberland; Belleview Ave., from Cannon St. to the T., H. and B. tracks; Grosvenor Ave., from Cumberland to Sherbrooke; Rosslyn Ave., from King to Maple; London Ave., from Dunsmore to Cannon; Belleview Ave., from King to Cannon; Sturton Ave., from Barton to Cannon; Mars Ave., from Wentworth to Emerald; Catharine St., from Main to Hunter; Homewood Ave., from Dundurn to McDonald. City engineer, E. R. Gray.

Hamilton, Ont.—Wentworth county council decided to call for tenders on the macadamizing of the stone roads on Queensdale and Yale Aves. Tenders will also be called for the building of cement sidewalks in Barton township. Road Superintendent, Thos. R. Allison, Court House, Hamilton.

Hamilton, Ont.—Board of Control opened tenders as follows for the grading or Scott Park: Sheridan and Morrison, $53,000, or $1.56 per cu. yd.; A. Cope and Son, $1 per cu. yd.; W. C. Brennan and Co., $46,000, or $2 per cu. yd. These tenders were referred to the city engineer. Tenders for the motor flusher were also received as follows: F. H. Hopkins and Co., Toronto, $11,045; the Watson-Jack Co., Montreal, $10,400; John C. Russell Co., Wabash, Indiana, $8,288, f.o.b. Wabash, and Leather and Smye, $12,750, f.o.b. Hamilton. Only one tender was received for the construction of storage bins, and was from J. B. Nicholson, Hamilton, at $19,500.

Hawkesbury, Ont.—Council let contract to the Barry Construction Co. for repairing John St.

Kenora, Ont.—J. F. Whitson, Road Commissioner for Ontario, together with Engineer Stewart, is working on the survey of the road to the boundary. He will explore both the north and south routes before deciding definitely as to location.

Kingston, Ont.—City council passed a by-law for the paving of Bagot St., from Princess to Charles, and of Charles, from Bagot to Montreal.

Ottawa, Ont.—Tenders will be received until 3 p.m., Tuesday, May 18th, 1920, for reinforced concrete arch bridge over Rideau River. A. F. Macallum, Commissioner of Works. (See official advertisement in this issue.)

Swan River, Man.—Time for receiving tenders for grading roads in municipality of Swan River has been extended to 12 o'colck noon, May 22nd, 1920. Jos. Armstrong, Secretary-treasurer.