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The Canadian Engineer

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Physical Properties of Mortars and Concretes

Review of Work Done by Other Investigators and Description of Experiments Performed for the Greater Winnipeg Water District—Use of Chemicals to Resist Alkali Action Abandoned After Trial in One of the District's Structures

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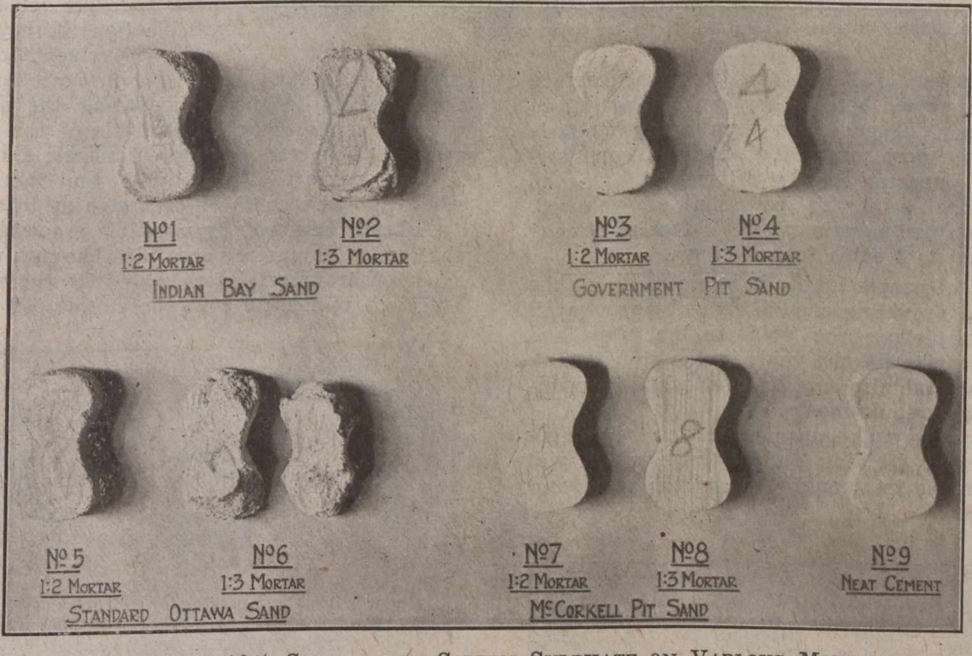
AN enormous amount of work has been done on the investigation of the physical properties of cement mortars and concretes by various workers in all parts of the world. Outstanding among these are investigations made by Mr. Feret of Boulogne-sur-Mer, France, in 1892; those made by Messrs. Fuller and Thompson for the aqueduct commission of the city of New York, 1903 to 1905; those made by various workers at the Bureau of Standards and issued from time to time, which investigations are still being extended at the present time. Much information has been accumulated from these sources, a considerable amount of which is available in various textbooks on concrete. The most recent work published in connection with these studies has been made in the structural materials research laboratory of the Lewis Institute, Chicago, in cooperation with Portland Cement Association. A large staff of men are employed at the institute under the supervision of Prof. Abrams, who has already published in engineering journals in 1918, a large amount of interesting and apparently revolutionary information. His work so far has mostly dealt with the function of the water in concrete mixtures.

Working from a different point of view, Captain Lewellyn Edwards, supervisor of bridges of the city of Toronto, has reached certain conclusions regarding the influence of the surface area of aggregate on mortar and concrete mixtures.

In this paper it will only be possible to outline some of this work and point out some of the characteristics of various concrete mixtures.



ACTION OF A 10% SOLUTION OF SODIUM SULPHATE ON VARIOUS MORTARS

Air briquettes cured 24 hrs. in moist closet and 48 hrs. in steam at 150 degs. F. kept in alkali solution for 3½ months.
No. 1 shows slight action at edges; No. 2, disintegration at ends; Nos. 3, 4 and 5, no apparent action; No. 6, disintegrated; Nos. 7, 8 and 9, no apparent action.

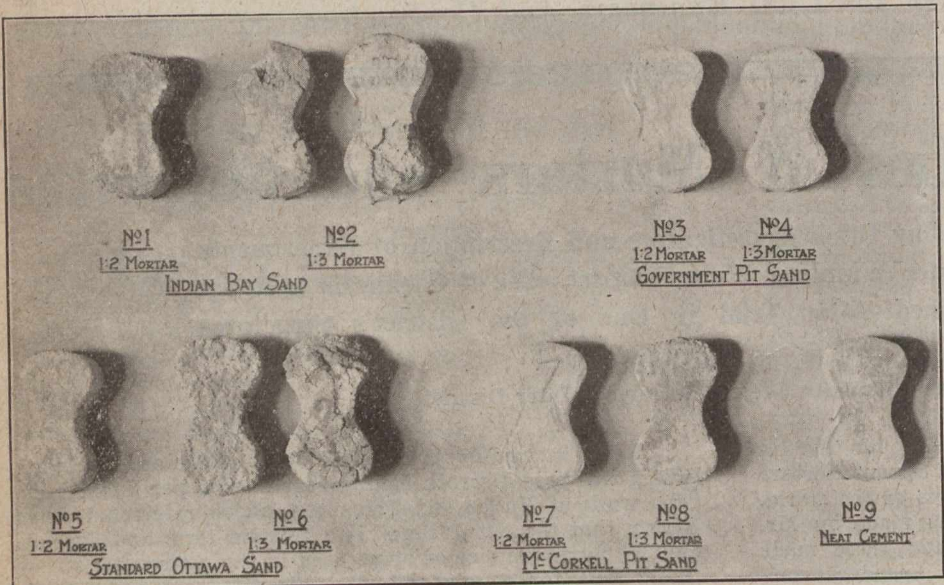
Sand is usually considered to be the fine aggregate which will pass a screen having four meshes per linear inch. The work of Fuller and Thompson, above referred to, has shown that the term "sand" is a relative term and depends on the maximum size of stone used in the aggregate. They show that for a mixture of maximum density the stone portion of the aggregate should be graded according to a straight line and that the sand and cement portion of the mix corresponds to an elliptical curve. The junction between the straight line and the ellipse occurring at a point one tenth diameter of the maximum size of stone in the aggregate (Figure 1). The meaning of the term "sand" will therefore vary according to maximum size stone used in the aggregate.

In our work, in connection with the water district aqueduct, we have considered our maximum size of stone 1½ ins.; one tenth of this is .150. The nearest screen to this dimension is ⅛ in. In subsequent remarks, it will be understood that the term "sand" means material passing ⅛-in. screen.

The first procedure in testing a sand is to make a mechanical analysis of the sand. The sieves used in the water district's laboratory in the grading of a sand are the No. 10, No. 20, No. 40, No. 75, No. 100 and No. 200; the numbers referring to the number of meshes per linear inch. From such an analysis one familiar with sands can form an opinion as to its suitability or otherwise for concrete work and also make a close prediction as to the possible strength obtainable from mortars made from such sand.

The grading of a sand has a very marked effect on all its characteristics. Referring to Figure 2 (copied from

Taylor & Thompson's treatise on concrete, page 140) it will be seen that coarse sands require less water than fine sand to guage them to any given consistency. This is readily understood when one bears in mind the relatively large amount of surface area per unit weight of the fine as



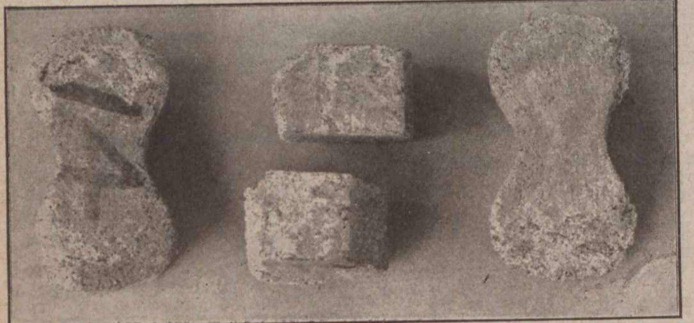
Action of a 10% Solution of Magnesium Sulphate on Various Mortars

Air briquettes cured 24 hrs. in moist closet and 48 hrs. in steam at 150 degs. F., and kept in alkali solution 3½ months.
No. 1 shows slight bulging at one corner; No. 2, distorted and disintegrated; Nos. 3 and 4, slight surface action; No. 5, no apparent action; No. 6, distorted and disintegrated; No. 7, slight surface action; No. 8, slight bulging at one corner; No. 9, no apparent action.

compared with the coarse material, and that the surface of the sands must be wetted before they can be brought to the desired consistency. There have been many methods suggested whereby the best mixture of cement, sand and stone for any given purposes can be determined. One of these methods is the arbitrary selection of volumes. For example 1:2:4 mixture meaning, 1 cubic foot of cement to 2 cubic feet of sand to 4 cubic feet of stone.

A second method of proportioning is by determining the voids in the sand and providing enough cement paste to fill these voids, then calculating the voids in the stone and allowing enough mortar to fill the voids in the stone, using a little excess cement and also mortar over what is exactly required to fill these requirements.

A third method is to make up compression specimens with various mixes and deciding on that mix which will meet the specifications as to strength and at the same time be a workable concrete.



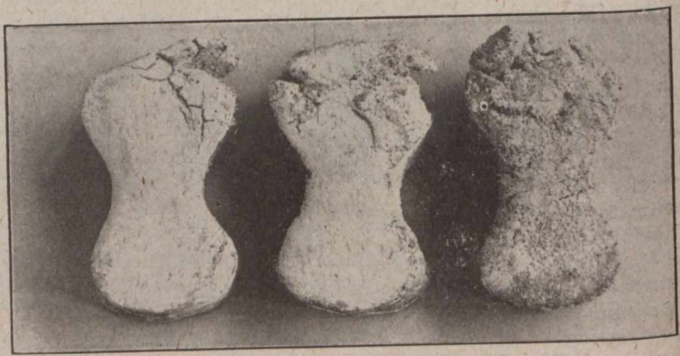
Action of a 10% Solution of Magnesium Sulphate on No. 10 Mortar

1:3 mortar, no chemicals. Cured 24 hours in moist closet and 48 hours in steam at 150 degs. F.

Yet another method has recently been suggested by Capt. Edwards, of Toronto, namely, proportioning a definite weight of cement to a given surface area of aggregate. Charts have been published by him in *The Canadian Engineer* from which the area of surface of the aggregate used can be calculated from its mechanical analysis.

As has been pointed out by many writers on the subject, the method of proportioning concrete by arbitrary selection of volumes may produce good results in practice if care is taken that the exact proportion of the materials specified are actually obtained in the final mix. But the method leaves open many opportunities for error. For example, it is very necessary to specify exactly what is meant by sand and stone. The so-called sand as delivered may contain quantities of material which should be classed as stone, and the material delivered as stone may in the same way contain fine material which should be classed as sand. However, if the percentage sand and stone in these materials is determined they can be so mixed as to give the specified volumes. Instead of considering the one part of cement as a cubic foot it is better to adhere to same unit which is not liable to change, such as a sack of cement which in Canada weighs 87½ lbs. and in United States 94 lbs., including the sack. In this way a definite weight of cement to the sand and stone is always ensured. In many cases contractors have assumed that in the case of a 1:2:4 concrete they were working close enough to the specifications if they used a mixture of one sack cement to six parts of aggregate, and have used as aggregate materials excavated from the pit without separating the sand and stone or making any mechanical analysis of the materials, and the resulting concrete may more resemble a 1:4:2 concrete than a 1:2:4 mixture. It is obvious that there is no comparison whatever between these concretes as to quality.

Capt. Edward's system of proportioning concrete on the cement to surface area idea has met with some criticism from other investigators who take the view that it is not sufficient to merely coat the surface of an aggregate with



Action of a 10% Solution of Magnesium Sulphate on No. 11 Mortar

1:2 mortar treated with 1 per cent. Al_2SO_4 and 1 per cent. soap. Cured 24 hours in moist closet.

cementing materials but in addition the voids in the mixture must be filled and a high density secured. Capt. Edwards does not think that the securing of a high density or the filling of voids is greatly to be desired and points out that nature seems to have totally disregarded this refinement in the construction of the hardest, toughest, strongest and most reliable sandstones (mortars) and conglomerates (concretes). He points out that nature has secured the maximum strength for a given amount of cementing material by concentrating that material at the place it will have most effect, namely, at the points of contact of the particles.

It is evident therefore that there are many differences of opinion on the proper proportioning of concrete, and a method has yet to be found whereby we can tell just how far we can cut the cement in a mixture with safety, since so many factors enter into the problem of making good concrete, such as the amount of cement used, the nature of the aggregate, the sand content of the aggregate, the amount of water, time of mixing and the placing of the concrete.

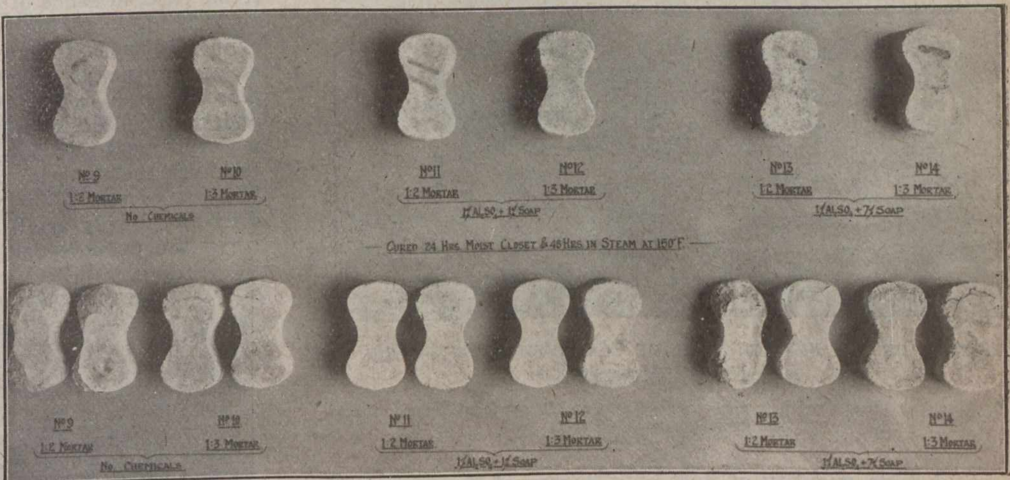
I have heard a great deal on concrete construction work about filling the voids in a concrete mixture and the idea seems prevalent amongst many engineers that this system of proportioning concrete is a good one. Below is an extract from circular No. 8 on the action of alkalies on hydraulic cements published by the Montana Agricultural College in 1911:—

"Much can be done towards the protection of concrete structures by the selection of good material and by proper care in proportioning the cement, sand and gravel. It is the work of the engineer and should not depend altogether on rules, but he should actually determine the amount of cement to fill the voids in the sand to be used."

In his chapter on proportioning concrete in Taylor and Thompson's treatise on concrete, p. 181, Mr. Fuller goes into the system of proportioning in some detail. He points out that the actual volume of voids in a given volume of stone may not, and usually does not, correspond to the quantity of sand required to fill those voids. The use of this method therefore leads to false conclusions, the reasons for this inaccuracy being chiefly because with most aggregates a portion of the particles of sand or fine screenings are too coarse to enter the voids of the coarsest material. The individual voids in a mass of broken stone or gravel are many of them so small that a large number of the particles of bank-run sand will not enter them but will get between the stones and increase the bulk of the mass.

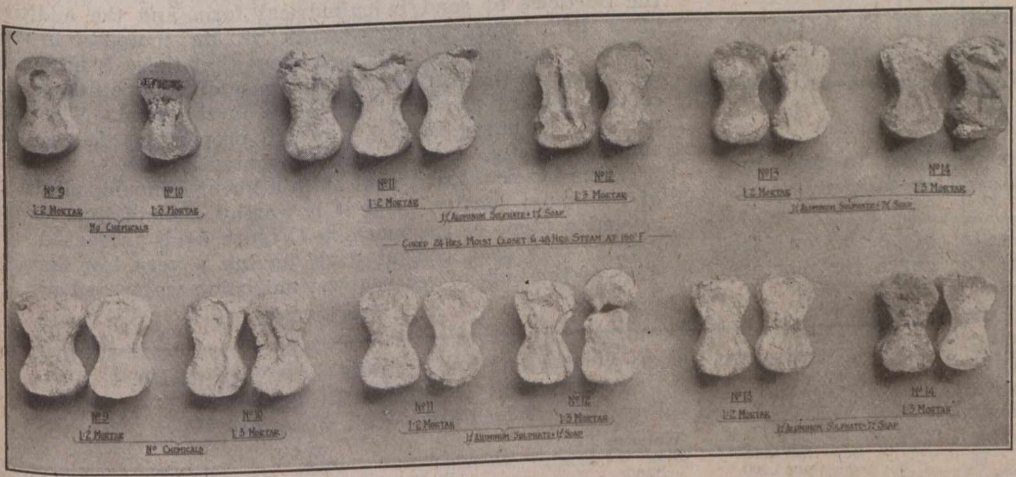
The determination of the proportion of cement to sand by void measurement is still more misleading and so inaccurate that he gives no consideration to it.

To further illustrate the absurdity of basing the amount of cement on the void filling theory, some density tests were made in our district laboratory, using sands of different grading and varying the cement content. The method of determining the absolute density of a mortar is shown in Figure 3, which is self-explanatory, and the usual method of determining the voids in a sand by mixing the sand with water and allowing it to settle is shown in Figure 4. The curve for theoretical density of mortar is obtained on the supposition that the space occupied by the water filling the voids in the sand can be replaced by cement paste without increasing the bulk of the sand. This supposition is of course erroneous, as will be evident from further tests, but it is to clearly illustrate this matter that this curve is drawn. According to this theory there is an exact and definite proportion of cement to sand at which the voids are filled with paste and the mortar will have its maximum density at this proportion. The addition of more cement paste above this proportion will only result in a reduction in density since cement paste itself has a low density. The addition of any less cement paste than this amount will also result in a reduction in density, as is shown in the curve, Figure 4. With the sand here used the voids should be exactly filled at a proportion of cement to sand 1:3.76. But if one attempts to mix cement paste with dry sand it will be found that the sand abstracts water from the paste and renders the mixture unworkable until sufficient water is added to wet



Action of Sulphate Solutions on Mortars Treated with Soap and Aluminum Sulphate

Briquettes immersed in solution for 8 months. Solution used, 10 per cent. sodium sulphate. Top row cured 24 hrs. in moist closet. Bottom row cured 24 hrs. in moist closet and 48 hrs. in steam at 150 degs. F. Top row shows no apparent action. Bottom row: No 9, disintegration at ends; Nos. 10 and 11, cracking at ends; No. 12, no apparent action; Nos. 13 and 14, cracking and disintegration at ends.



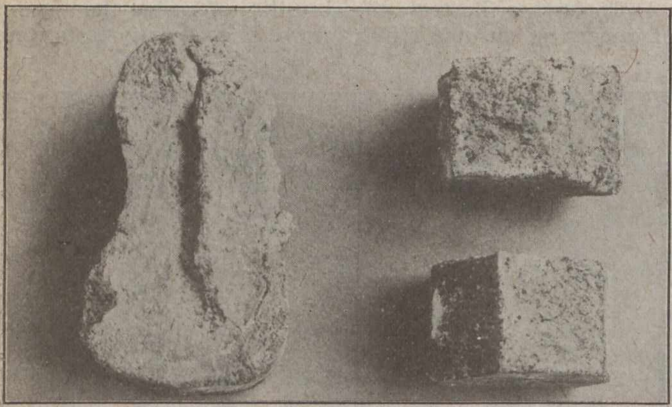
Action of Sulphate Solutions on Mortars Treated with Soap and Aluminum Sulphate

Briquettes immersed in solution for 8 months. Solution used, 10 per cent. magnesium sulphate. Top row cured 24 hrs. in moist closet. Bottom row cured 24 hrs. in moist closet and 48 hrs. in steam at 150 degs. F.

Top row: No. 9, no apparent action; No. 10, no apparent action on exterior, but section shows penetration of alkali; No. 11, distorted and disintegrated at ends and swollen; No. 12, swollen, distorted and cracked, one briquette disintegrated; No. 13, disintegrated at ends and swollen; No. 14, distorted and disintegrated at ends and swollen.

Bottom row: No. 9, cracked and disintegrated at ends and swollen; No. 10, swollen and badly cracked, distorted and disintegrated; No. 11, disintegrated at ends and swollen; No. 12, swollen, cracked, distorted and disintegrated; No. 13, swollen, cracked and distorted; No. 14, cracking and disintegrated at ends and swollen.

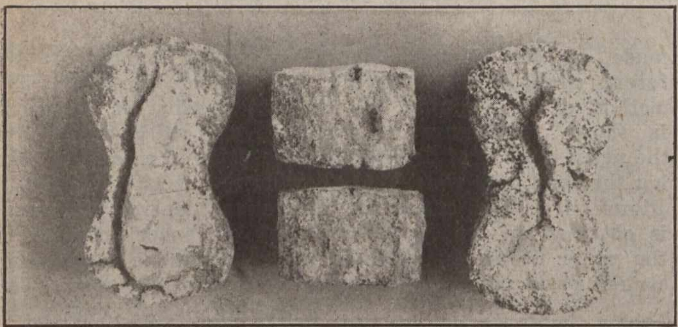
the sand. This water must necessarily occupy space in the set mortar. It is obvious therefore that the amount of cement paste which can be added to a sand without increasing the volume of the sand is very small, and in a case where we have present in the sand a



ACTION OF A 10% SOLUTION OF MAGNESIUM SULPHATE ON No. 12 MORTAR

1:3 mortar treated with 1 per cent. Al_2SO_4 and 1 per cent. soap. Cured 24 hours in moist closet.

considerable quantity of dust of a degree of fineness equal to that of cement, it is impossible to add any paste at all without increasing the volume of the sand. That there is no sharp and definite point at which the voids are just filled with cement paste would seem to be shown by actual



ACTION OF A 10% SOLUTION OF MAGNESIUM SULPHATE ON No. 14 MORTAR

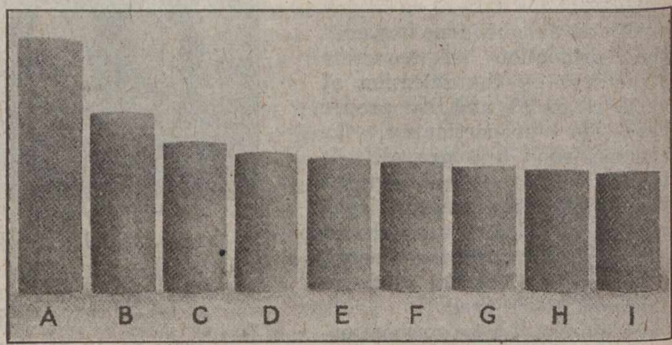
1:3 mortar treated with 1 per cent. Al_2SO_4 and 7 per cent. soap. Cured 24 hours in moist closet.

test; or if there is one, it is extremely hard to find, and even if found its position would depend on so many variables that it is not worth finding.

Figure 5 shows actual results of tests on the densities of mortars. Referring to the curve for mortars with the sand considered in Figure 1, that is McCorkell Pit sand, it will be seen that instead of the voids being filled at proportions 1:3.76 the density is approximately 71%, or the voids are 29%, so that by the addition of cement paste we have succeeded in reducing the voids by only one per cent. It is therefore impossible to do much void filling with this sand. On this same sketch the curves for sands of several other granulometric compositions are shown. The voids by water settlement in these sands were as below:—

Indian Bay sand	36%
Ottawa sand	36%
McCorkell Pit sand	30%
Lake Francis sand	32%

If we were to base the amount of cement used on the percentage voids in these sands, we would expect to be able to add more paste to the Indian Bay sand than to the Lake Francis material. But that exactly the opposite is the case is shown by the curves. The latter material is a very coarse sand and the former is a medium sand or plaster sand. Whether voids can be filled or not will therefore depend more on the actual size of the individual voids than on the total percentage voids in a sand. Taking an extreme case, in sands of extreme fineness the total percentage voids is high, but the voids are so minute that cement paste cannot be made to enter them. The result of the addition of cement paste to relatively fine sands is merely to replace a given bulk of the sand by the same bulk of paste and no void-filling results. The particles of void-filling material must also be smaller than the individual voids, but the finer the material the more water required to gauge it. The use of void-filling materials as such is very limited indeed and a very small amount of these void fillers actually serve the purpose for which they are intended. The fact



THE BULKING EFFECT OF MORTARS—EXPERIMENT BY CAPT. L. N. EDWARDS

Grams cement to sq. in. sand area:

(a) 1:5	(d) 1:20	(g) 1:35
(b) 1:10	(e) 1:25	(h) 1:40
(c) 1:15	(f) 1:30	(i) original sand

that these fine powders cannot be forced into the minute voids, but must be floated into space, greatly reduces their effectiveness. "The Bulking Effect of Mortars," republished from a paper by Capt. Edwards, of Toronto, bears out the density curves in Figures 5. As he points out in his Specimen (i) he has used only enough cement to hold the particles of sand in cylindrical form and the addition of a little more cement results in an increase in the volume of the mortar. He points out that there is no marked change in the increment of increase of volume due to the cement content exceeding the voids in the sand. The flatness of the curve from 1:2 to 1:6 proportions for all the sands in Figure 5, bears out his contention.

One hears a great deal of talk about securing mixtures of maximum density. But it is worthy of note that as the cement content of the mortars (Figure 5) is increased, the density decreases, cement itself having a very low density. 47% of the bulk of set neat cement being water and air.

STRENGTH TESTS: COMPOSITION OF MORTARS—TEST SERIES No. 1
CEMENT, 1 G.: 13 SQUARE INCHES
(From article by Capt. L. N. Edwards)

Sand Letter	Surface per 1,000 gms. sq. in.=S	Water to Gauge the Sand $=\frac{S}{210}$	Cement By Wt. gms.	Cement By Vol. ccs. C	Water for Mortar ccs. =M	Ratio of Cement to Aggreg. by Wt.	$\frac{\text{Water}}{\text{Cement}}$ Ratio $=\frac{M}{C}$
A	5,857	28.0 ccs.	450.5	299	128	1: 2: 22	.428
B	5,106	24.4 "	392.0	260	111.5	1: 2: 55	.429
C	7,864	36.6 "	591.0	392	168.0	1: 1: 69	.429
D	6,758	32.2 "	520.0	345	148.0	1: 1: 92	.429
E	12,816	61.2 "	986.0	654	280.5	1: 1: 12	.429
F	6,769	32.3 "	521.0	345	148.0	1: 1: 92	.429
G	4,182	19.9 "	321.5	213	91.5	1: 3: 11	.430
H	6,565	31.3 "	505.0	335	143.5	1: 1: 98	.428
I	6,565	31.3 "	505.0	335	143.5	1: 1: 98	.428

The securing of a mortar of maximum absolute density is not greatly to be desired since we can secure a higher density in many cases from sand alone, or aggregate alone than we obtain when cement is mixed with these materials. In comparing densities of mixtures it is essential that they be compared for the same cement content.

The difficulty of securing reliable results in density tests can be realized from the fact that for any given

APPROXIMATE QUANTITIES OF CEMENT FOR EQUAL STRENGTHS

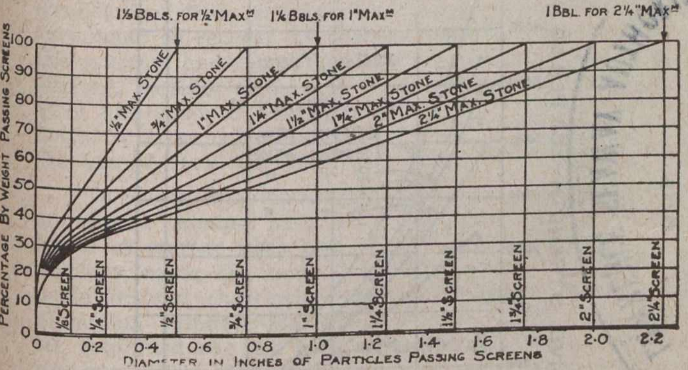


FIG. 1—FULLER'S CURVES FOR MAXIMUM DENSITY

mortars the amount of water used and the method of placing will greatly affect the position of the points on the density curve, the wetter mixes having a lower density. Cement will take up different percentages of water. The amount of water taken up by the sand also varies. If one attempts to make mixtures all of the same consistency, extreme difficulty is experienced in comparing the rich mixes with the very lean mixes. The absence of paste in a lean mix necessitates the addition of considerable water to make the mix workable, resulting in oversaturating both the cement and the sand, and when the mix settles a large quantity of

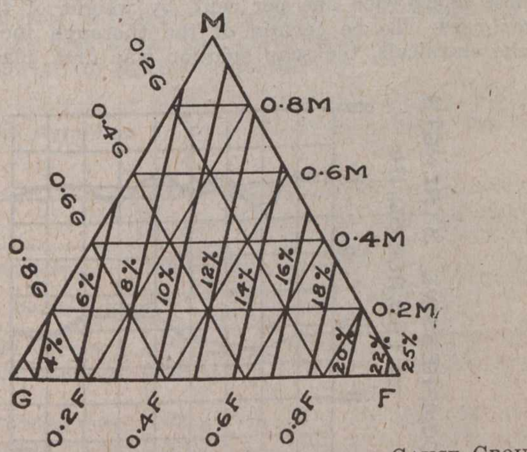


FIG. 2—PERCENTAGE OF WATER REQUIRED TO GAUGE GROUND QUARTZ SAND OF ALL GRANULOMETRIC COMPOSITIONS—FERET'S TRIANGLE

Large grains	G	passing	screen	of	5	meshes	per	linear	inch.
"	"	" retained on	"	"	15	"	"	"	"
Medium	"	M passing	"	"	15	"	"	"	"
"	"	" retained on	"	"	46	"	"	"	"
Fine	"	F passing	"	"	46				

water is thrown off, but also a considerable quantity of water is held in the mix over what is actually needed to gauge the cement and sand, resulting in a reduction in the density of the mixture.

Figure 6 shows the mechanical analysis of sands used in Series I. of tests made in the water district's laboratory on concrete disintegration in alkali waters.

This series was made up with the object of finding what effect concentrated alkali solutions had on freshly made mortar and also after same mortar was steam treated.

A series of briquettes was made from sands of different grading and chemical nature in the form of 1:2 and 1:3 mortars. One set of these mortars was cured 24 hours in a moist closet and a second set was steamed 48 hours at 150°F. in a boiler for testing cement pats. After curing in the above manner, briquettes were placed in the following solutions: (1) Distilled water; (2) tap water; (3) 10% $MgSO_4$; (4) 10% Na_2SO_4. These briquettes were removed

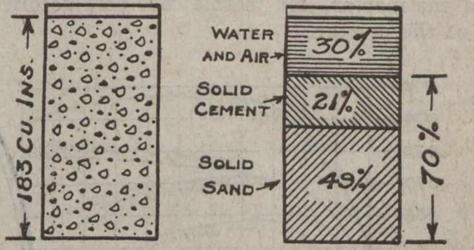


FIG. 3—TYPICAL CALCULATION FOR ABSOLUTE DENSITY OF A MORTAR (MORTAR 1:2)

Cement	4,500 lbs.	Wt. of mould =	0 lbs. 7¾ oz.
Sand	9,000 "	Mould + mortar =	14 lbs. 15 oz.
Water to gage mix	1,665 "	Mortar =	14 lbs. 7¼ oz. = 14.454 lbs.
Total	15,165 lbs.		

MATERIAL IN THE MOULD

Cement	4.29 lbs.
Sand	8.57 "
Water	1.59 "
Total	14.45 lbs.

Specific gravity of sand = 2.65, 1 cu. ft. of solid sand = $62.4 \times 2.65 =$ 165 lbs.

Specific gravity of cement = 3.10, 1 cu. ft. of solid cement = $62.4 \times 3.10 =$ 193 lbs.

$$\text{Absolute vol. of sand} = \frac{8.57 \times 1728}{165} = 89.7 \text{ cu. ins.}$$

$$\text{Absolute vol. of cement} = \frac{4.29 \times 1728}{193} = \frac{38.4}{128} \text{ cu. ins.}$$

Actual vol. of set mortar = 183 cu. ins.

$$\text{Absolute density} = \frac{128}{183} = .700.$$

Absolute voids = 100—70 = 30 per cent. water + air.

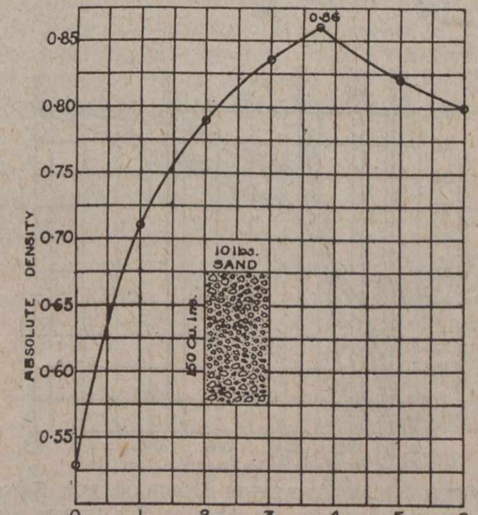


FIG. 4—THEORETICAL DENSITY OF MCCORKEL PIT SAND MORTARS

Voids by water settlement = 30 per cent.; 1 cu. ft. cement paste assumed to require 102 lbs. dry cement. This impossible curve is drawn only to illustrate the absurdity of proportioning a mortar by the "void-filling" theory.

VOID DETERMINATION

Weight of sand = 10 lbs.
Volume of sand after settlement = 150 cu. ins.

$$\text{Absolute volume of the sand} = \frac{10 \times 1728}{165} = 105 \text{ cu. ins.}$$

Absolute density 105/150 = 70 per cent.
Voids 100—70 = 30 per cent.
102 lbs. cement give 1,728 cu. ins. of paste.

$$\text{Cement to fill voids} = \frac{45 \times 102}{1728} = 2.66 \text{ lbs.}$$

Therefore voids should be filled at proportion of cement to sand 266 lbs. : 10 lbs., or 1:3.76.

and examined after three and a half months immersion in the solutions. The actions of the alkali solution is shown in the accompanying photographs of the steamed series; this set being more disintegrated than the set cured in the moist closet. Referring to the density curves in Figure 5, note the order of densities of the mortars, disintegration taking place in general, according to the density of the mortar, and in this case also according to the strength of the mortar.

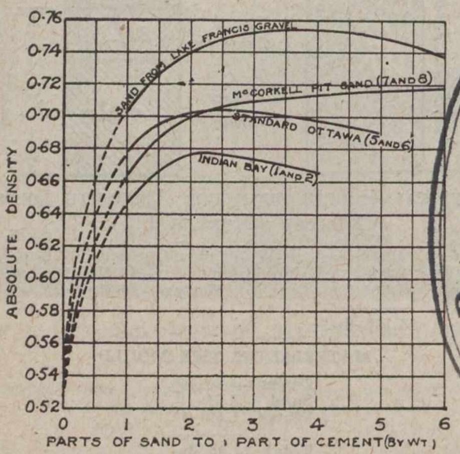


FIG. 5—COMPARISON OF ABSOLUTE DENSITIES OF MORTARS FROM SANDS OF DIFFERENT GRADING

All sands screened through ⅛-in. screen.

Lake Francis Sand. Sieve No.	Per Cent. Ret'd.	McCorkel Pit Sand. Sieve No.	Per Cent. Ret'd.	Standard Ottawa. Sieve No.	Per Cent. Ret'd.	Indian Bay Sand. Sieve No.	Per Cent. Ret'd.
10	24	10	15	20	0	10	4
20	40	20	18	30	100	20	18
40	25	40	26			40	46
75	9	75	27			75	30
100	1	100	3			100	1½
Passg 100	1	pas'g 100	11			passing 100	½
	100		100				100

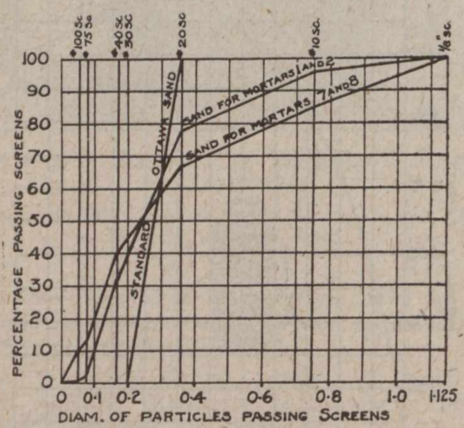


FIG. 6—MECHANICAL ANALYSIS DIAGRAM FOR SANDS USED IN TESTING AFFECTS OF ALKALI SOLUTIONS UPON VARIOUS MORTARS

To prevent the alkali water from coming into contact with the lime of the cement it was suggested by the Montana Agricultural College in circular No. 8, published in 1911, that soap and aluminum sulphate be added to the concrete mixture with the idea of coating the cement grains with a non-absorbent film.

The theory of the action of these chemicals is as follows: When Al_2SO_4 comes in contact with calcium hydroxide of the cement, calcium sulphate and aluminum hydroxide are formed. The aluminum sulphate, which is a gelatinous precipitate, not acted upon by alkali, coats the remaining calcium hydroxide and protects it from further action of the alkali. Soap, when added to cement, reacts with the lime liberated during the process of setting, forming an insoluble calcium soap. The soap will not be acted upon by alkali and will coat the remaining lime or calcium hydroxide.

On the recommendation of the work described in this pamphlet it was thought advisable to use soap and aluminum sulphate in a portion of a concrete structure being built by the Greater Winnipeg Water District, the attack of alkali waters being feared on this portion of the work. Aluminum

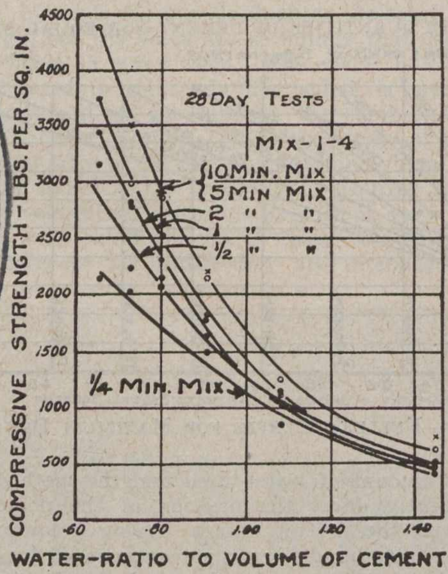


FIG. 7—INFLUENCE OF WATER ON THE STRENGTH OF CONCRETE

Water-strength curves for each time of mixing. Each value is the average of 4 tests from the same batch. Water content calculated as a ratio of the volume of cement. From paper by Prof. D. A. Abrams previously published in The Canadian Engineer.

sulphate and soap were added to the concrete mixers in equal proportions, the weight of these chemical substances being each one per cent. by weight of the mixing water used. To be certain of the thorough incorporation of the chemicals, the soap solution was first placed in the

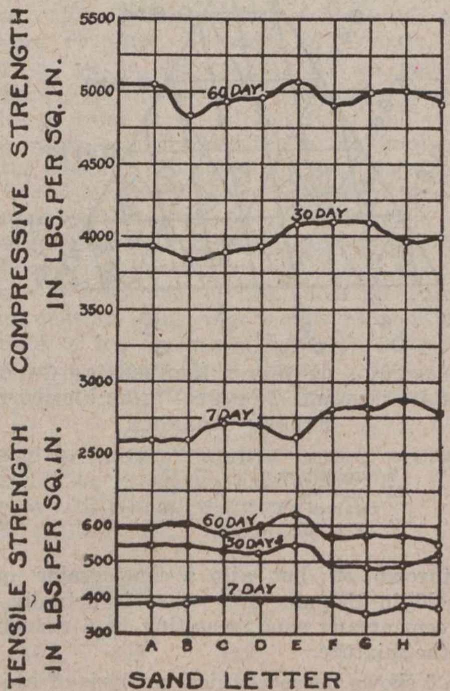


FIG. 8—STRENGTH TEST OF MORTARS OF SAME CEMENT-SURFACE AREA RATIO BUT DIFFERENT VOLUMETRIC PROPORTIONS—FROM PAPER BY CAPT. L. N. EDWARDS

mixer and the cement and aggregate then added and the whole thoroughly mixed. The aluminum sulphate solution was then added and the mixer given a few more turns before the mass was released for placing. In all concrete work poured for the district special attention was given to the securing of a concrete as free from airholes and stone pockets as possible by working and spading the mass continuously during the pouring of any particular section. In concrete in which soap and aluminum sulphate were used it was found that, after setting, the top of the concrete was covered for a considerable depth with a powdery material which had no cohesion, being readily crushed in the hand. This layer of material had to be removed and the concrete cleaned free from such material before a good bonding surface could be secured for further pouring. The spading of the concrete had caused the fine precipitates to come to the surface, possibly along with some laitance and some of the very fine sand of the aggregate. As it was considered better to leave out the chemicals than sacrifice the spading, the use of soap and aluminum sulphate was discontinued.

To obtain some data as to the effect of alkali solutions on mortar treated with soap and aluminum sulphate, a series of mortar tests was made. We made 1:2 and 1:3 mortars, using the same sand throughout. One set was made without chemicals; one set contained one per cent. aluminum sulphate and one per cent. soap; and another set contained one per cent. aluminum sulphate and seven per cent. soap. The chemicals were added as a percentage of the mixing water used. One complete series was cured 24 hours in the moist closet, and one set cured 48 hours in steam at 150 degs. F. These briquettes were placed in 10% $MgSO_4$ solution and in 10% Na_2SO_4 solution and in distilled water.

Briefly the results of tests were as below:—

The only mortar which resisted the attack by the alkali solutions was the 1:2 mortar without addition of chemicals and cured in a moist closet. The steam curing caused even this mortar to disintegrate. Action on the steamed briquettes was greater than on those not steamed. The addition of the soap and aluminum sulphate decreases the strength of the mortars and renders them more liable to disintegration. The sand used was similar in grading to the Indian Bay sand used in the first series, previously referred to. It is a sand giving mortars of relatively low density.

The addition of bulky chemical precipitates due to the soap and aluminum sulphate reactions greatly disturb the density of mortars from this sand. It must not, however, be assumed that a reduction in density means a more porous mortar, since the addition of cement to a mortar usually reduces its density but greatly decreases its porosity. The bulking effect of the precipitates, however, is worthy of note. The photographs illustrate the effect of the solutions on the briquettes.

Before concluding this paper I would refer to some of the most recent work of Prof. Abrams, regarding the effect of excess water on concrete mixtures. See Figure 7. You will note that a rich mix does not necessarily insure good concrete, since everything depends on the amount of water used. Professor Abrams argues that the grading of an aggregate is a secondary consideration and is only a means to an end. For instance, he says the reason why a rich mix gives a higher strength than a lean one is that a workable concrete can be produced by a quantity of water which gives a lower ratio of water to cement. If an excess of water is used we are simply wasting cement. Rich mixes and coarse, well graded aggregate are as necessary as ever but we now know how these factors affect the strength of the concrete. It

Effect of Sand Content on the Strength and Absolute Density of Concrete from McCorkel Pit Materials

Sand—Passing 1/8" Sieve Stone—Held on 1/8" Screen and Passing 2½" Diam. Holes

Mix by Wt.	Per Cent. Sand	Density	Strength	Wt. per Cu. Ft.
1 Part Cement to 6 Pts. Aggreg., or 14.3 Per Cent. of Cement				
1:1:5	16.7	.838	3640	152 lbs.
1:2:4	33.4	.824	3160	150 "
1:3:3	50.0	.809	2920	147 "
1:4:2	66.7	.786	2520	144 "
1:6 mortar	100.0	.711	1140	133 "
1:7 Aggregate or 12.5 Per Cent. Cement				
1:2:5	28.6%	.838	2850	150½ "
1:3:4	43.0	.818	2570	148 "
1:4:3	57.2	.787	2040	144 "
1:8 Aggreg. or 11.1 Per Cent. Cement				
1:2:6	25.0%	.851	3030	153 "
1:3:5	37.5	.830	2540	160 "
1:4:4	50.0	.816	2180	147½ "
1:5:3	62.5	.780	1274	144 "
1:9 Aggreg or 10 Per Cent. Cement				
1:3:6	33.4%	.842	2490	151 "
1:4:5	44.5	.825	1965	149 "
1:3½:5½	39.0	.833	2250	149 "

Action of Sulphate Solutions on Mortars treated with Soap & Aluminum Sulphate — Briquettes immersed in Solutions 8 Months

No	Composition of Mortar	Absolute Density	Tensile Strength: 24 Hrs. Moist Closet & 48 Hrs. Steam @ 150°F. Age 3 Days	Tensile Strength: 8 Months in Distilled Water	10% Sodium Sulphate Solution: Strength of Individual Briquettes				Average Lbs/□"	External Condition of Briquettes	Condition of Centre Section	10% Magnesium Sulphate Solution: Strength of Individual Briquettes				External Condition of Briquettes	Condition at Central Section
	Cured 24 Hours in Moist Closet																
9	1:2 No Chemicals	0.685	—	512	540	520	530	595	546	No apparent action	No apparent action	605	430	365	655	No apparent action	No apparent action
10	1:3 No Chemicals	0.687	—	306	265	295	270	300	282	No apparent action	No apparent action	145	285	190	—	No apparent action	Completely penetrated with Alkali
11	1:2–1% Al_2SO_4 + 1% Soap	0.652	—	527	420	295	405	395	379	No apparent Action	No apparent action	145	—	—	—	Swollen Distorted and Disintegrated	Penetration of Alkali greater at ends than centre section
12	1:3–1% Al_2SO_4 + 1% Soap	0.643	—	323	300	340	360	315	329	No apparent Action	No apparent Action	—	—	—	—	Swollen Distorted & Cracked One briquette Disintegrated	Complete penetration of Alkali & Internal Cracks
13	1:2–1% Al_2SO_4 + 7% Soap	0.612	—	445	235	290	260	220	251	No apparent Action	No apparent Action	105	90	398	—	Swollen and Disintegrated at ends	Completely penetrated with Alkali
14	1:3–1% Al_2SO_4 + 7% Soap	0.620	—	297	230	235	240	220	231	No apparent Action	No apparent Action	—	—	—	—	Swollen – Distorted and Disintegrated at ends	Completely penetrated with Alkali
	Cured 24 Hours in Moist Closet and 48 Hrs. in Steam at 150°F.																
9	1:2 No Chemicals	0.685	360	514	500	510	385	440	459	Cracking at Ends	No apparent Action	170	290	—	—	Swollen (cracked and disintegrated at ends	Completely penetrated with Alkali
10	1:3 No Chemicals	0.687	240	340	0	220	260	190	223	Cracking at Ends	Penetrated with Alkali	—	—	—	—	Swollen – Badly cracked distorted & disintegrated	Completely penetrated with Alkali
11	1:2–1% Al_2SO_4 + 1% Soap	0.652	320	444	340	395	275	415	356	Two Briquettes only Cracked at Ends	No apparent action	—	—	—	—	Swollen – Disintegrated at ends	Penetrated with Alkali but Hard
12	1:3–1% Al_2SO_4 + 1% Soap	0.643	225	401	376	300	285	335	324	Small Crack on One Briquette Only	No apparent Action	—	—	—	—	Swollen – Cracked Distorted & Disintegrated	Completely penetrated with Alkali
13	1:2–1% Al_2SO_4 + 7% Soap	0.612	226	433	250	300	275	275	275	Cracking and Disintegration at ends of 4 Briquettes	No apparent Action	75	—	—	—	Swollen – Cracked & Distorted	Completely penetrated with Alkali
14	1:3–1% Al_2SO_4 + 7% Soap	0.620	213	339	285	260	355	240	285	Cracking and Disintegration at ends of 4 Briquettes	One briquette penetrated with Alkali others partially penetrated	170	95	—	—	Swollen – Cracking and Disintegration at Ends	Completely penetrated with Alkali
			Tested immediately after steaming														

Notes:- Grading of Sand used – Percentage Retained on Sieves #10-2%, #20-17%, #40-67%, #75-12%, #100-1% Thro. #100-1% Total 100% Carbonates in Sand = 35%

Quantities of Al_2SO_4 and Soap are expressed as a percentage of the Mixing Water used. Mortar proportions are by Weight.

For 1:2 Mortar 125 ccs. Water, 1.25 gms. Al_2SO_4 and 1.25 Gms. of Soap were added to 2¼ lbs. Dry Sand and Cement } for 1% Al_2SO_4 & 1% Soap
For 1:3 Mortar 93 ccs. Water, 0.93 Gms. Al_2SO_4 and 0.93 Gms. of Soap " " " 2 lbs. " " " Cement }

Expressed as a Percentage of the Dry Sand + Cement No 11 contains 0.122% Al_2SO_4 and 0.122% Soap — No 12 Contains 0.102% Al_2SO_4 and 0.102% Soap
No 13 " 0.122% " " 0.857% Soap — No 14 " 0.102% " " 0.717% Soap

Most of Briquettes acted on by Magnesium Sulphate Solution were Swollen and could not be tested for Tensile Strength will be observed that the mixture used in these tests was a rich one, corresponding roughly to a 1: 2: 3 mix by volume proportioning. Yet, with such a mixture, strength as low as 700 lbs. per square inch, and as high as 4400 lbs. per square inch are obtained by simply varying the quantity of the mixing water. Other workers, as well as Prof. Abrams, have shown the detrimental effects of the use of too much water in concrete mixtures, but Prof. Abrams has gone into the matter very fully indeed. The writer is at a loss to understand how it is possible to make the mixtures up in all this water. If cement were a material like glue which could be thinned down to an extreme degree and hold all the water added, a continuous reduction in strength would be expected, as the amount of cement in a given volume of mix was gradually decreased, due to its replacement by water; but since water is rejected from concrete mixtures, even when plastic consistencies are used, the limit at which any additional water is thrown off surely must be reached at a percentage of water only slightly more than is present when the mix is in a plastic state.

On making up neat cement paste with different percentages of water and allowing the paste to set, the writer has observed that water is rejected by the paste before a very wet consistency is reached, and it would not seem possible to make the cement hold more than a very limited amount of water unless the cement were prevented from setting by being beaten up into a collodial state, in which form it would of course take up large quantities of water. But for ordinary method of mixing by hand, the writer has been able to obtain only a slight variation in the amount of the cement required to make a cubic foot of paste. It is hard to see how Prof. Abrams gets cement paste into the condition he speaks of in which the cement particles are so far thrust apart by the water that there is no cohesion between the particles, and the mass offers no resistance to stress. This is a matter which I am sure has not been clear to many readers of his work.

About the same time some work was published by Capt. Edwards, of Toronto, who had been working on a "cement to surface area idea. See Figure 8. In these tests Capt. Edwards endeavored to always have the cement at normal consistency and used an amount of water to guage the sand which was always a certain proportion of the surface area of the sand. In this way he was able to eliminate to a degree variations due to the consistency factor. He found that when he kept the ratio cement to surface area constant, he obtained practically the same strength for all sands tested. On examination of the figures in the table originally published, it is evident that another reason why his strengths were all the same is that the water to cement ratio of the mortars is constant.

So that it would appear that his work is in complete accord with that of Prof. Abrams.

It seems to me that a considerable amount of the poor concrete work poured in this country has been due to the use of pit run gravel. Most samples of pit run material which have come to my notice have contained at least 55% fine aggregate which will pass a ⅛-in. screen. The effect of the sand content on the strength and density of concrete is shown in the table on p. 421. Note increase in density and strength when sand content is reduced. One class of material was used throughout these tests. The strength is proportional to the density only when the materials are the same for the mixes compared. It is obvious that the bond of cement to a rough surface aggregate would be greater than in the case of a smooth, polished material.

The limit in the reduction of a sand content is dependent on the workability of the mix. The mix must not be too stony or it will be hard to place, and will cause the production of stone pockets devoid of mortar; but as much stone should be added as possible consistent with the production of a workable mixture. The amount of cement to be used depends on the class of work. If strength is the primary consideration, sufficient cement should be used to give the desired strength as determined by making up compression specimens with various percentages of cement; bearing in mind also that the mixture must contain sufficient fine material to make it smooth working. If strength is a secondary consideration, some of the cement can be substituted with a fine sand or dust to supply the necessary amount of fine fattening material, thus giving workability to the mix and economizing cement. Although such fine dust cannot be considered in any degree as a substitute for cement, its presence in a concrete mixture provides the necessary effect of richness in the mix, minimises the risk of the formation of stone pockets, helps to hold the cement evenly distributed throughout the mix and makes it possible to make workable mixes with a less ratio of water to total dust cement. If lean mixes are poured without the addition of such fine dust, the amount of cement paste or lubricating medium in the mix is small. To make such mixes flow into corners, excess water is usually added. The excess water tends to wash the sand grains free of cement and the result is a mass of concrete full of porous areas.

It has been pointed out by Mr. Feret that for a 1:3 mortar the highest density and strength was obtained when the granulometric composition of the sand was about 80% coarse grains and 20% fine grains. It is obvious that in a richer mortar, such as a 1:2, for the same density the amount of fine material in the sand must be reduced or the coarse increased. In fact it is generally agreed that in practical concrete mixtures, when mortars as rich at 1:2 are used, no fine sand or dust is necessary either from the point of view of strength, density, or workability.

It has been pointed out by Wm. B. Fuller, in his chapter on concrete proportioning, that a finer sand is permissible in the case of a concrete than in a mortar. Dividing a sand into three grades (by Mr. Feret's plan) coarse, medium and fine grains, for maximum strength and density, we require a high percentage coarse grain and in the case of a rich mortar very little fine grains, and preferably no medium grains. In the same way, grading a concrete on three corresponding screens, the stone portion now corresponds to the coarse part of the division. The coarse grains of sand become the medium grains in the concrete. It would therefore appear that a finer sand would be used for a concrete than would be indicated by making tests on mortars. It is pointed out that by using a mortar with a relatively fine sand the small voids in the stone portion of the mix are more readily filled with mortar than in the case of a similar mortar with coarse sand; the coarser particles of the latter getting between the stones and thrusting them apart, and decreasing the density.

But the following facts must also be borne in mind: the mortar with the finer sand is less dense than that made with the coarse sand, thus offsetting to a certain degree any benefits to be gained by the use of the finer material. Also that in practical concrete an excess of mortar is usually used, so that the condition where the use of a coarse sand will thrust apart the stone portion of a mix to a greater degree than the same bulk of finer sand is not usually met with. The influence of the grading of the fine aggregate or sand on the volume of mortar produced from the same proportion of cement to sand using sands of different grading, is well illustrated by the curves in Figure 5.

It is obvious that the sand marked "Indian Bay Sand" will produce concrete of greater bulk or less density than, for example, will the coarse sand marked "Sand from Lake Francis gravel." This is especially the case when excess mortar is used in the concrete.

As far as is known at present, the best way to secure concrete which will resist alkali attack is to use a mixture relatively rich in cement, with a carefully selected aggregate. In the case of a rich mix the aggregate should contain as little sand (and that preferably of a coarse nature) and as much stone as possible consistent with the production of a workable concrete. In this way we have a rich mortar produced. The ratio cement to surface area of aggregate is high with such coarse material, thus producing a very strong and impermeable concrete. As little water as possible should be used in the mixing and the concrete should be thoroughly spaded and worked to enable entrapped air to escape and to work the mortar into all pockets in the

(Concluded on page 429)

THEORETICAL TRAINING FOR APPRENTICES—OUTLINE OF THE EDUCATIONAL FACILITIES PROVIDED AT THE BRITISH GOVERNMENT ARSENAL

By E. G. Timbrell
Department of the Interior, Ottawa; Recently in Charge of the School of Instruction, Toronto, for British Ministry of Munitions

BY the needs of the returned soldier, our attention has been focussed on vocational training. The re-education of soldiers unable to follow their pre-war occupations has given an impetus to the subject, but the teaching of the theory and practice of trades side by side has previously been recognized only to a limited extent.

This does not mean to say that a system of teaching trades in schools and not in factories is advocated, but a great deal of useful ground work may be obtained in a school. The bill that Dr. Cody has before the Ontario legislature makes provision for adolescent vocational training. This article will show what has already been accomplished in Britain and may be useful as a suggestion for the syllabus to be adopted by the Ontario Department of Education.

The need of the ordinary shop apprentice, particularly in mechanical or electrical engineering, for theoretical training which shall proceed along with his practical experience, has had little attention. In this article will be described a system of apprenticeship followed by the British Government for many years in its dockyards and arsenals. It is the system in the Royal Arsenal, Woolwich, with which the writer shall deal, but this differs only slightly from that at the two government establishments near London, the gunpowder factory at Waltham Abbey, and the small arms factory at Enfield.

Distinction in Nomenclature

The admission of engineering apprentices to the Royal Arsenal is governed to a certain extent by social considerations, in that there are two classes of apprentices, those whose parents can afford a university education and those whose parents cannot. It must be understood that something like this system applies also to apprenticeship in private firms, but the question of ability to get a university course does not enter, its place being taken by the payment by the parents of a premium to the firm. Premiums are also the rule in civil and municipal engineers' offices.

A distinction of nomenclature is made. The premium apprentice in a private firm is called a "pupil," and the non-premium an "apprentice;" also, in the government factories, the university man is a "student" and the non-university a "trade lad." It must be understood that it is much more difficult for a person without means to get a university training in England than in North America; for one thing the sessions are usually for nine months, leaving only three months for working at a paying business, and the students do not make use of the idea of taking on outside work during session; nor is there the opportunity for highly paid summer labor as there is in America.

In theory the difference in training is supposed to be that the "pupil" keeps his eyes and thoughts on principles of management, and not so much on ability to use tools, whilst the apprentice concerns himself solely with the idea of being a skilled mechanic.

The entry for a student into the Royal Arsenal is by one of two ways. If he is an engineering graduate of one of the universities and applies for admission and is accepted, he is given a three-year course in the shops, with sufficient pay to keep him in board and lodging (if his ideas are modest). His course may be withdrawn at any time if the student does not show application, is irregular in attendance or his conduct is not satisfactory.

If, however, he has only matriculated and guarantees that he will take a university course, he is given one year's practical training at the same rate of pay as an apprentice, then proceeds to the university, and after graduation returns to the shops for two years to complete his course.

The training consists of a very general experience in mechanical engineering, the pupil being transferred from shop to shop until he has a ground work of fitting, turning, smithing, millwright's work, pattern making, moulding (brass, iron and steel casting), draughting and testing materials. In each shop his work is supervised by one particular mechanic, who receives one cent an hour additional to his pay for his trouble.

The writer does not know of any place in the world where the opportunities for obtaining practical knowledge are greater. If the pupil has a particular bias in any direction, say explosive engineering, an opportunity for training would be given him in the "Danger Buildings," i.e., explosive factory. A similar remark applies to central station powerhouse work.

Trade Lads

The ordinary apprentice, who probably enters with the sole outlook of becoming a skilful artisan, must be between 14 and 16 years of age, and pass a competitive examination, of which the following is the syllabus:—

Elementary Mathematics

Arithmetic.—The application of the principles to whole numbers, decimals and fractions. Contracted methods of multiplication and division. Ratios, proportions, percentages, averages. The metric system.

Algebra.—The application of the simple algebraical laws. Simple factors, easy equations of the first and second degree, and problems involving such equations. Simple graphs.

Geometry.—The subject matter of Euclid, Books I. and II., with simple deductions. Euclid's proofs or sequences will not be insisted upon.

Elementary Physical Measurements and Applications

Written Paper.—Determination of lengths, areas and volumes. Determination of mass and weight. Determination of density and specific gravity. Comparison of English and French system of weights and measures. Applications of the laws established. The questions set will be such as to test whether the candidate has himself performed simple experiments in measurements.

Practical Work.—Candidates who pass satisfactorily in the written paper will be examined in the laboratory, and will be required to make one or more of the simple measurements mentioned above.

English

A short essay on one of three given subjects.

Writing a passage from dictation.

Questions to test knowledge of the correct usage of words, etc.

Drawing

Candidates will be required to make a sketch of a simple piece of machinery from a copy, or to make a sketch of a group of common objects.

Candidates will also be examined to test their knowledge of, and their facility in the use of, the rule, compass, and protractor in simple problems in plane geometry.

This examination is however not so simple as the syllabus would make it appear. The number of boys taken varies from year to year, but on an average less than 20% of those writing the examination are successful. Those who head the list are usually made fitters and turners, those next smiths, then pattern-makers and wheelwrights. Such, we suppose, is the opinion of authority of the relative value of the trades, but the boys are asked on a special form to state any preference for trade or department.

The trade lad is given a longer time in the shops than is the student. The first three years are strictly his apprenticeship, as after that period he is considered an improver, and can work on piecework if there are vacancies in that sort of shop. At the age of twenty-one it was customary to discharge him, but, of course, the war altered that for the time being. A few lads, not more than 10%, were kept on and gradually raised in pay, but it took ten or twelve years before they reached the union rate.

The student is automatically transferred from shop to shop in order to get a comprehensive idea of the whole of the business. The apprentice, if unusually successful in the concurrent classes in the theory of engineering, gets transfers to different shops and may, in this way, get a fairly broad insight into mechanical engineering, but he never gets the full opportunities of the student.

Commencing almost as soon as he enters the shops, compulsory attendance at evening classes is demanded for forty weeks in the year, three evenings per week, with the addition of one-half day, making in all from ten to eleven hours a week. Three annual competitive term examinations, at Christmas, Easter and end of the school year, are held in each of the first three years. Valuable prizes are given for the first four or five boys on the list.

The syllabus of theoretical instruction for these three years is as follows:—

First Year

MATHEMATICS: Fractions, vulgar and decimal. Square and cube roots. Proportion. Percentages. Contracted methods. Use of logarithms and slide rule. Elementary laws of algebra, use of formulæ, factors, easy equations. Lengths, areas and volumes. Densities and weights. Use of squared paper. Plotting. Rates of increases. Correction of errors of observation. Solution of equations. Geometry as covered by Euclid's Books I. and II. and outline of Book III. Trigonometrical functions of an angle. Simple heights and distances.

PLANE GEOMETRY: Construction of triangles. Measurement of areas. Properties of circles.

SOLID GEOMETRY: Projections of geometrical solids with sections and development of surfaces.

MACHINE DRAWING: Simple fastenings. Simple details of machines and engines.

ELEMENTARY EXPERIMENTAL MECHANICS (two terms): Composition of forces. Equilibrium of parallel forces. Parallelogram triangle and polygon of forces. Inclined plane. Friction. Simple machines. Centre of gravity. Hydrostatics. Pressure in a fluid. Pressure varies with depth. Loss of weight of a body immersed in a fluid. Floating bodies. Hydrometers. Specific gravities.

CHEMISTRY (one term): Properties of matter. Elements and compounds. Physical and chemical change. Equivalents. Laws of definite and multiple proportions. Symbols. Formulæ. Combustion. Properties of gases. Composition of air. Water, composition and properties. Preparation and properties of hydrogen. Hard and soft waters. Purification of water. Solution and crystallisation.

ENGINEERING DRAWING: Geometry. Scales. Functions of angles. Properties of triangles, polygons and circles. Loci and graphics. Orthographic and isometric projection. Machine drawing. Construction of various machine details and engine details of simple character. Tracing and photo-printing.

Second Year

MATHEMATICS: Contracted methods of calculation. Logarithms. Factors. Solution of equations. Ratio. Indices. Series. Expansions. Areas and volumes of solids. Squared paper. Partial fractions. Trigonometrical functions and formulæ. Solution of triangles. Rates of increases. Easy differential calculus.

ELEMENTARY APPLIED MECHANICS: Triangle of forces. Moments. Levers. Work. Power. Mechanical efficiency of machines. Velocity. Acceleration. Force. Momentum. Hydraulic pressure. Simple hydraulic machines. Flow of water through orifices.

CHEMISTRY (one term): Occurrence, extraction and chemical relations of the commoner metals. The properties and uses of these metals and some of their alloys. Elements of qualitative analysis.

ENGINEERING DRAWING: Plane geometry. Similar figures. Loci. Simple cams. Simple properties of conic sections. Solid geometry. More difficult examples in projection of solids. Descriptive geometry of point and line. Machine drawing. Continuation of the work of the first year.

HEAT, LIGHT AND GENERAL PHYSICS: Heat and temperature. Expansion. Thermometers. Specific heat. Calorimeters. Fusion. Solidification. Latent heat. Boiling points. Convection. Conduction. Radiation. Mechanical equivalent of heat. Elementary principles of thermodynamics. Production and transmission of light. Intensity. Photometry. Reflection. Refraction. Dispersion. Spectrum. Vibrations. Wave motions. Amplitude. Wavelength. Frequency.

Third Year

MATHEMATICS: Binomial theorem. Expansions. Trigonometrical formulæ. Vector sums and differences. Differential coefficients. Maxima and minima. Taylor's and Maclaurin's theorems. Integration by substitution, by parts and by partial fractions. Areas, centres of gravity and moments of inertia. Applications to problems in engineering, mechanics and physics.

ENGINEERING DRAWING: Plane geometry. Properties of conic sections. Solid geometry. Descriptive geometry of line and plane. Interpenetration of simple solids. Graphics. Forces in simple structures. Machine drawing. Continuation of second year work, with calculations of strength of machine details.

MAGNETISM AND ELECTRICITY: Properties of magnets. Simple phenomena of magnetism. Magnetic moments. Magnetic field. Lines of force. Law of force. The earth as a magnet. Electrostatics. Conduction and insulation. Quantity of electricity. Distribution on a conductor. Simple cells. Electromotive force. Resistance. Ohm's law. Electrolysis. Action of current on a magnet. Galvanometers. Voltameters. Electromagnetic induction. Secondary batteries. Applications to lighting, power, telegraphy and telephony.

APPLIED MECHANICS AND ENGINEERING SCIENCE: Strength and elasticity of materials. Stresses in rivetted joints. Elementary graphic statics. Bending moments and shearing force. Friction. Efficiency of machines. Angular velocity and acceleration. Kinetic energy. Flow of water in pipes. Pumps and turbines. The elementary theory of heat engines.

Fourth Year

In the fourth year the same evening attendance is demanded, but one whole day per week is given to selected lads who showed merit in their third year course and did well at the examinations.

The syllabus for the evening work is left within a certain range to the special taste of the individual, but the choice is usually limited by the authorities to study along the following lines:—

Practical plane and solid geometry; engineering drawing and design; mechanical engineering; electrical engineering; mathematics; mechanics (theoretical and applied); experimental physics (sound, heat, optics, electricity, magnetism); chemistry; metallurgy; and building-trade subjects.

Syllabus for Special Day Classes

MATHEMATICS: Algebra. Summation of simple finite series. Determinants of the second and third order. The binomial, exponential, logarithmic, sine and cosine series. Hyperbolic functions and their series. Simple tests of the convergency of infinite series. Theory of equations. Complex numbers, with their representation in a plane. Definitions by aid of series of exponential and trigonometrical functions for imaginary arguments. De Moivre's theorem and applications. Analytical conics as far as the equation of the second degree. Differential calculus. Differentiation, undetermined forms, maxima and minima, successive differentiation. Expansions. Tangents and normals, asymptotes, tracing of curves, curvature. Integral calculus. Integration of a single variable, reduction formulæ, rectification and quadrature. Moments of inertia. Centre of gravity. Differential equations of first order and degree and linear equations with constant coefficients.

ENGINEERING: Theory of machines and heat engines, Linear and angular acceleration. Centrifugal force. Energy of rotating bodies. Flywheels. Governors. Simple harmonic vibrations. Steam engine mechanism. Turning moments. Simple epicyclic gears. Generation of steam. Combustion. Efficiency of boilers. Isothermal and adiabatic expansions. Carnot cycle Entropy. Efficiency of internal combustion engines. Turbines. Materials and hydraulics. Testing of materials. Theory of bending. Deflection of beams. Torsion. Helical springs. Short columns. Centre of pressure. Bernouilli's law. Flow through pipes. Pressure and reaction of jets. Impulse turbines. Centrifugal pumps.

HEAT: Scale of temperature. Thermometers.. Pyrometers. Method of finding the coefficients of thermal expansion of solids, liquids and gases. Relation between pressure volume and temperature. Properties of gases and vapor. Isothermal and adiabatic expansion. Change of state. Fusion. Evaporation. Boiling. Liquefaction of gas. Measurement of quantity of heat. Latent heat. Formation of cloud, fog and dew. Dew-point. Hygrometry. Law of transmission of heat by conduction and radiation. Convection. Heat as a form of energy. Conservation of energy. Mechanical equivalent of heat and simple methods of approximately determining it.

ELECTRICITY AND MAGNETISM: Properties of magnets. Simple phenomena of magnetism and of magnetic induction (influence). The magnetic field. Lines of force. The law of magnetic force. Magnetic moment. Intensity of magnetization and magnetic induction. The earth as a magnet. The magnetic properties of iron and the elementary laws of the magnetic circuit. The simpler phenomena of electrified bodies. Conduction and insulation. Electrification by friction and by induction. Distribution of electrification on conductors. Electric field. Strength of field. The law of electric force. Potential. Capacity. Energy of charge. Electrometers. Electric current. Production of continuous currents by primary cells. Electrolysis. Faraday's laws. Voltmeters. Secondary cells. Magnetic field of current. Magnetic measurement of current. Galvanometers. Amperemeters and voltmeters. Work done by electric current. Electromotive force. Ohm's law. Resistance. Measurement of resistance and potential difference. Wheatstone's bridge. Potentiometers. Heating effects of current. Thermo-electric couple. Action of magnetic field on circuits conveying currents. Electro-magnetic induction. Faraday's law. Lenz's law. Elementary principles of the dynamo and transformer.

The compulsory evening attendance will probably cease when the new Education Act comes into force and all instruction will be given during the working day (at the expense, as regards time lost, of the employer).

The Institute

The idea of teaching boys whilst at work is very old in the arsenal and goes back to the days when boys were sent to work at an age of eleven or thereabouts, and ordinary public school instruction was given them. The theoretical education of apprentices is more recent and was first carried out at an institute in connection with the arsenal.

Each department—the royal carriage department, royal gun factory and royal laboratory (the first two explain their uses but the latter comprehends shells and explosives)—until about 1904 ran a separate examination for entrance as apprentices, but the examination is now general and successful candidates are allotted where most needed.

The institute became unable to give the proper training and the local polytechnic at Woolwich was enlarged and given additional instructors to take care of the work, where it continues at present, being manned by a well-paid and exceedingly efficient staff.

The course of study is obviously strenuous when it is considered that it is taken on top of a day of 8⅔ hours, and the boys tend to divide into two sections, those who neglect their work for the classes and look ahead to taking a draughting job upon leaving their apprenticeship, and those who are content to be in the latter half of the list at the term examinations and who make sure of a good trade.

Those who neglect their tools pick up, however, sufficient of the practice for most purposes, and have been known to resort to peculiar dodges in order to gain more time for study. There is a functionary in the arsenal called the warder who sees to it that no loafing, reading papers, etc., is indulged in during working hours, therefore the trade lad cannot use his working time for study even if the noise would allow, so he tries to transfer to the testing laboratory or drawing office where the warder is not permitted to enter, and there, with the connivance of his chief (if he is a "good head"), he can study all day long to his heart's content.

Well-Trained Young Engineers

So far as observation goes, the results of this intensive training are to produce remarkably well-trained young engineers, but the aforesaid peculiar social organization does not give them the same opportunity as they would have in Canada. Their openings for improved pay and conditions are mostly in technical teaching or draughting. One enterprising American firm near London, whilst building up its European organization, availed itself of a great number of these apprentices. The idea, as stated by one of the departmental managers to the writer, was as follows: "The British government pays thousands of dollars to educate and train these boys and mostly makes no use of the training at all, but we allowed it to get around that we had openings for a bunch, and paid them good money, and believe me, we skimmed the cream pretty well." The remark about making no use of them refers to the aforementioned fact that the lads were discharged at twenty-one.

This company gave the trade lads an insight into their special line of work and then kept some in England and sent the others to various European countries and to the British colonies.

Following is a partial list of Canadian patents recently issued through Ridout & Maybee, Toronto:—J. Stone & Co., Ltd., valves for fluid pressure systems for operating bulkhead and like doors; Edward P. Leach, concrete mixer.

It is the intention of the municipalities served by the Sandwich, Windsor and Amherstburg Railway system, to purchase it. Recommendations to this effect have already been made to the municipalities by the Ontario Hydro-Electric Commission.

Among the recent orders secured by the English Electric Co.—in which are now consolidated the interests of the Coventry Ordnance, Dick Kerr, Phœnix Dynamo, United Electric Car and Willans and Robinson companies—is one from the Huddersfield Corporation for a 5,000 k.w. turbo-alternator set, speed 3,000 r.p.m., and another from the Nottingham Corporation for a similar turbo-alternator set of 3,000 k.w., together with surface condensing plant and cooling tower.

At a recent meeting of the board of directors of the Association of Montreal Building and Construction Industries, the secretary submitted a communication from A. R. Decary, chairman of the Montreal Administrative Commission, inviting the association to appoint a committee of three members familiar with building construction and building by-laws, to co-operate with other organizations and with a group representing the city, in compiling new building by-laws for Montreal. In accepting the invitation, it was agreed to forward the following names: J. P. Anglin, K. D. Church and E. B. Evans. As Mr. Anglin was not present, it was arranged that should he be unable or unwilling to act, John Quinlan should take his place.

Premier Stewart, of Alberta, recently intimated in the provincial house that unless some means could be found to finance the necessary construction expenditures of the Edmonton, Dunvegan and British Columbia Railway, whose bonds the province has guaranteed, the railway would have to be taken over. He said that as the situation now stands the government would have to draw from the trust account created by the sale of the bonds in order to meet these construction charges and also the interest. This source, however, would not last more than a year. The provincial guarantee is to the amount of $20,000 per mile. It is understood that the Dominion government has been approached for assistance, but no definite announcement is as yet forthcoming from this source.

THE MEASUREMENT OF SNOW*

By Robert E. Horton
Consulting Engineer, Albany, N.Y.

MEASUREMENT of precipitation falling as snow involves so much more difficulty than the measurement of rain as to deserve some special consideration. While an ordinary overflow can of the ordinary Weather Bureau rain gauge is commonly used to catch snow, the amount of which is determined in terms of equivalent water depth, this procedure is far from satisfactory.

The deficiency in catch of a rain gauge is much greater for snow than for rain. The effect of a combination of wind and snow on the catch of an ordinary rain-gauge overflow can is shown by Fig. 2. In the storm in which this sketch was made, and which occurred December 26, 1913, at Albany, N.Y., the amount of precipitation as determined from the snow caught in the gauge can was 0.43 in., whereas the actual precipitation as determined from a sample of the undrifted snow on level ground was 1.41 in.

To avoid errors of this kind, the United States Weather Bureau recommended that, in case of snowfall or windy days, "the true quantity must be found if possible by measuring a section of the freshly fallen snow cut out by forcing the overflow mouth downward through the layer, and then slipping a thin board or sheet of metal underneath so as to separate and lift up the section of snow thus cut out." Needless to say, the sample should be taken in a protected place where drifting does not occcur. (Measurement of Precipitation, Instrument Division, U. S. Weather Bureau, Bulletin No. 13, p. 9.)

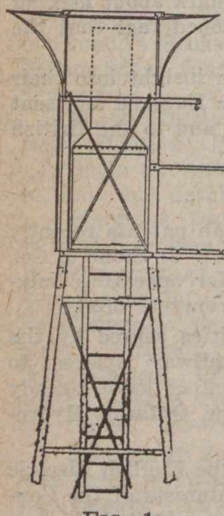


Fig. 1
Shielded Seasonal Snow Gauge

Modified methods and a special form of overflow can, for use in taking samples of snow on the ground, have been devised by the writer. The snow sampler is illustrated by Fig. 3.

The edge of the galvanized rain-gauge can is not sharp or stiff enough to retain its circular form with certainty when thrust down through deep snow. A special can with a reinforced cutting edge chamfered on the outside and inserted in the mouth of the can will reduce the friction and facilitate obtaining an accurate sample. This can should have a brass drain cock at the closed end, this cock to be opened when taking a sample so as to permit air to escape and prevent the snow being forced out while taking a deep sample by the compression of air in the can. Another advantage of a can with a drain cock is that when the sample is melted with hot water it can be drained out, thus avoiding the difficulty of pouring water from the large can into the brass tube without spilling. The closed end should preferably be made funnel-shaped, with a large, straightway water cock similar to the bottom of the Friez tipping rain gauge. A tight-fitting cover for the open end is also desirable. This may be placed on the can immediately after the hot water is added, and the can set in a warm place, if necessary, to complete the melting of the snow. Cover will prevent appreciable evaporation loss.

This snow sampler can be used either for freshly fallen or accumulated snow. It is also intended to replace the ordinary overflow can of the rain gauge, but when so used the bottom ring of the gauge funnel must be enlarged to fit over the brass cutting edge of the sampler. When used as an overflow, the drain cock prevents loss by spilling, and is a great convenience. The conical base reduces danger of breakage by freezing.

Select a level space surrounded by shrubs or sparse trees. The open space or clearing should be 50 to 100 ft. or more in diameter, depending on the height of the shrubs or trees. As a rule, snow will not drift nor be blown away near the middle of such a park or open space. In selecting the spot for snow measurement it is preferable to observe the conditions for a year in advance of its use. When snow falls at an angle, as it commonly does, a tree shadows the ground for some distance to the leeward and prevents the full depth of snow from reaching the ground. The spot chosen for making measurements must be sufficiently remote from all trees to avoid an error from this source.

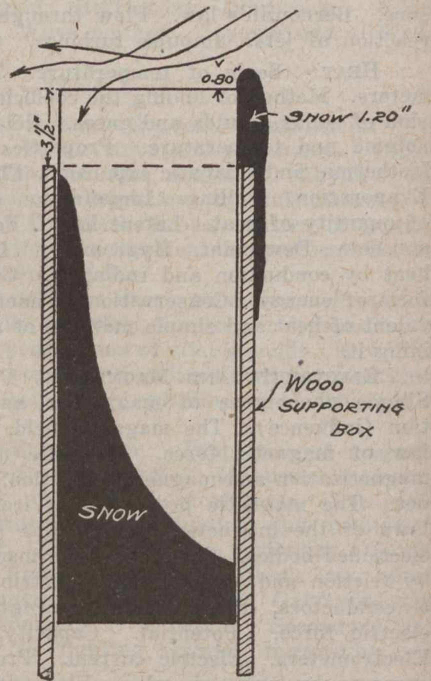


Fig. 2
Action of Snow Gauge, Arrows Showing Path of Snowflakes

Before the first snowfall, place on the ground a sheet of very thin board—plaster board or beaver board answers well. On the upper surface there should be secured by thumb tacks at the corners a sheet of white cloth with a rough surface—white flannel is good. The position of the board may be marked by two or three stiff wires stuck into the ground at a little distance from the board. When the first snowfall comes, a special snow can, described above, may be inverted over the cloth and pressed down firmly, rotating it slowly as it is pressed down. Then the remaining snow should be brushed off from the cloth, the board lifted, at the same time lifting and inverting the can with the board over its mouth. Having shaken the snow down into the galvanized can, the sample may be reduced to slush or water by adding a measured volume of hot water and then measuring in the brass rain-gauge tube in the usual manner used for rainfall and deducting the equivalent of the hot water added.

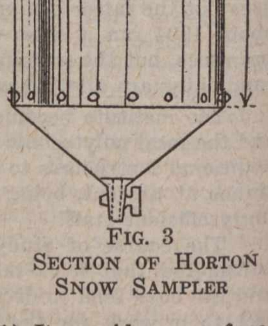


Fig. 3
Section of Horton Snow Sampler

After a measurement, the flannel cloth is, if necessary, dried, retacked on the snow board, and the snow board placed on the surface of the newly fallen snow where the snow is undisturbed, the board being pressed down just sufficiently so that the cloth surface is flush with the snow surface. The snow board should be inspected every day whether it snows or not, so as to keep its surface flush with the snow surface at all times.

The use of a cloth is twofold. (1) It provides a surface with friction conditions much more closely resembling those of snow than could be obtained by the use of the board alone. (2) It provides a surface as nearly as can readily be obtained, equivalent to a snow surface in its capacity to absorb and radiate heat, and so prevents loss by melting when snow falls in relatively warm air.

*From "The Measurement of Rainfall and Snow" in the March proceedings of the New England Water Works Association.

The water equivalent of accumulated snow on the ground at any given date is an important factor in relation to the water supply available to fill reservoirs, provide water for public usage, or irrigation, or to produce floods. In order to obtain data from which the available water supply of the coming spring may be estimated in advance, snow surveys have been extensively carried out, especially in the Rocky Mountain region, during the past few years.

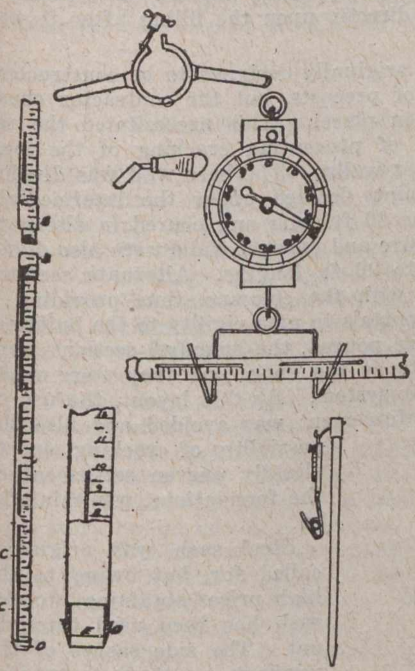


FIG. 4
MT. ROSE SNOW SAMPLER

Methods of the accurate measurement of snow in the mountains where it sometimes accumulates to a depth of 20 ft. or more have been developed, but no attempt will be made to treat those methods in detail. It is not a difficult matter, with proper apparatus, to keep a record, say, once a week, of the water equivalent of accumulated snow on the ground; and such a record, in conjunction with an ordinary record of rainfall and snow, will afford a valuable check on the latter, and furnish useful information besides.

Among the earliest records of accumulated snow and its water equivalent kept in the United States were those kept by Charles A. Mixer, at Rumford Falls, Me., in 1901 to 1903, and by the writer at Utica, N.Y., in 1903 and 1904. Apparatus for snow sampling and weighing developed at Utica formed a pattern for subsequent improved apparatus of the United States Weather Bureau. Figs. 4 and 5 illustrate snow-sampling tubes, measuring staffs, and weighing scales of the most improved type.

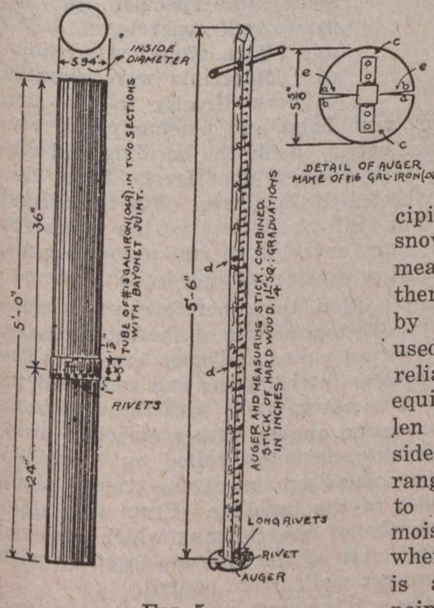


FIG 5
THE KADEL SNOW SAMPLER

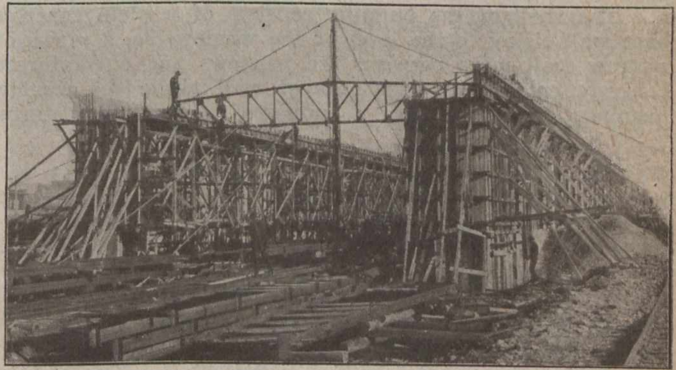
There is a popular opinion that 1 in. of rain is equivalent to 10 ins. of snow, and a method of estimating precipitation in the form of snow, consisting of first measuring the snow and then dividing the depth by 10 ins., is sometimes used. This method is unreliable. The water equivalent of freshly fallen snow varies to a considerable degree. It may range from 1 in. of water to 6 ins. of snow, for moist or dense snow, when the air temperature is around the freezing point, to 1 in. of water for 10 or 12 ins. of snow at lower temperature. These rules do not apply to accumulated snow, the density of which nearly always increases as winter advances. Commonly, deep snow lying on the ground for some time will have a water equivalent of 1 in. for 2½ to 4 ins. of snow.

REINFORCED CONCRETE BUILDING

For Canadian National Railways Coach Cleaning and Storage Yard, Halifax Ocean Terminals, Halifax, N.S.

BY J. J. MACDONALD
Canadian National Railways, Moncton, N.B.

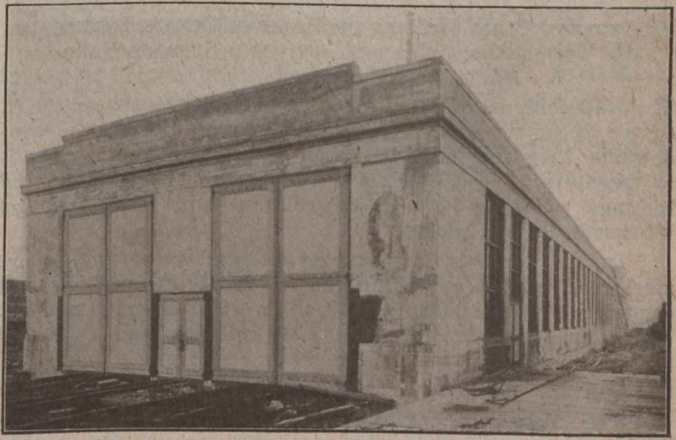
As part of the program of work laid down and carried on in 1918 by the Canadian Government Railways (now the Canadian National Railways) at the Halifax Ocean Terminals for the transfer of the passenger traffic from the old North End station to the new terminal site, a permanent reinforced concrete building has been erected to provide shop facilities and to accommodate the plant and stores for the first unit of the coach cleaning and storage yards.



COMPLETE CAR-CLEANING SHOPS, STORES AND ICE HOUSE

The layout of this yard and the location of the building is shown on the accompanying general plan. The yard is equipped with steam and compressed air connections, car-watering hydrants, car-gassing hydrants, vacuum cleaning outlets and battery-charging receptacles.

As indicated on the general plan, trucking platforms are provided between alternate tracks and along the east side of the building, which connect to the continuous end platform. The platforms are at approximately the same level as the floor of the building, to which ample connection is provided by a series of double doors.



CAR-CLEANING SHOP DURING CONSTRUCTION

The building is 380 ft. long by 51 ft. wide. Beginning at the south end, a car cleaning shop occupies a length of 200 ft. This section is single story and is provided with care repair pits and accessories. The vacuum cleaning machine is also located in this shop.

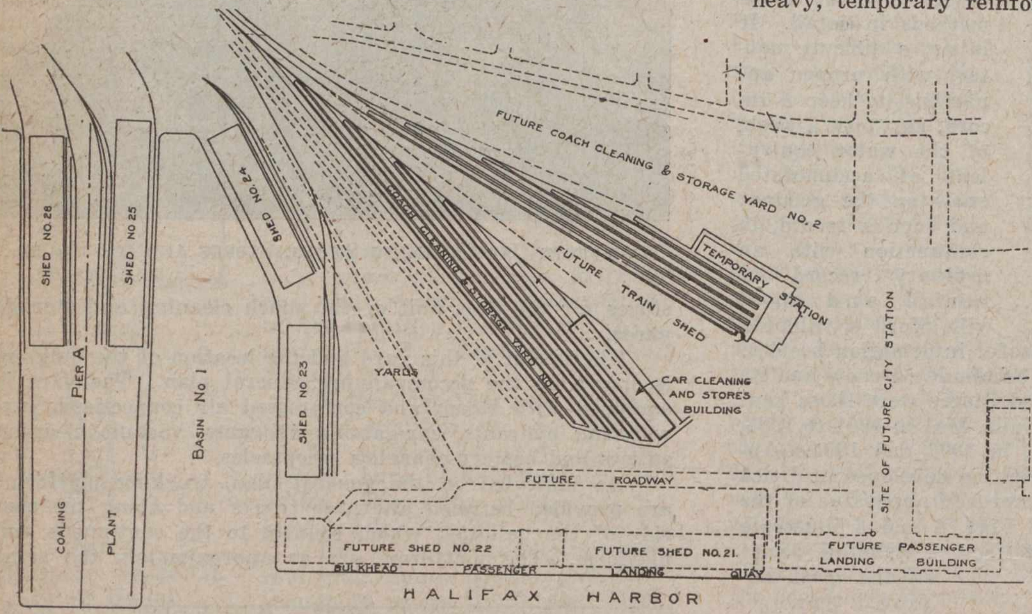
The remainder of the building is of two-story construction and contains the service or plant room, offices and stores rooms with the different car departments, ice storage room and refrigerators.

In the service room are installed an air compressor, Pintch gas compressor, a motor-generator set for car-charging, switchboards, etc. The ice storage located near the north end occupies one bay for the full height of the building.

Refrigerator compartments are placed in the extreme north bay of the building. The bay immediately north of the car-cleaning shop is fitted up for locker rooms and lavatories.

The site of the building is made ground, composed of from 20 ft. to 35 ft. of rock fill, handled by steam shovel from railway cutting, and built out from the original shore line by side-dumping cars, about three years ago. The harbor bottom here was rock covered by a few feet of mud. The foundations of the building, which were designed for a maximum unit pressure of 3¾ tons per sq. ft., were placed directly on the rock fill.

The shell of the building consists of a plain concrete base wall rising to the level of the windowsills, a series of narrow wall piers between the windows and a reinforced concrete entablature and parapet wall above the window openings. The base wall is supported on its own footings.



General Plan of Part of Halifax Ocean Terminals, Showing Coach Cleaning and Storage Yard

The wall columns of the main bents, which are spaced 20 ft. centre to centre, are of reinforced concrete. Below the windowsills they are carried down with their reinforcement as pilasters of the base wall to enlarged sections of the footing. Midway between the column bents are placed the intermediate wall piers.

In the single-story portion, the wall columns support steel roof trusses extending the width of the building and carrying a 3-in. timber mill roof on steel channel purlins. The connections between the wall columns and the steel trusses, together with the knee braces, form a series of transverse portals.

The second-story portion of the building has a wall construction, similar to that described above, except that the long windows are divided by a spandrel section at the second floor. Two rows of inside columns are used under the second floor and the roof. The floor is of flat slab construction and the roof is of timber. A live load of 150 lbs. per sq. ft. was assumed in designing the floor slab.

The type and details of the insulation for the ice storage and refrigerator compartments received special study owing to the difficulty of obtaining cork and the usual insulating materials. Ten inches of well-packed spruce shavings, enclosed by two plies of ⅞-in. T. & G. spruce sheeting, separated by two layers of heavy, deodorized, asphalted felt, were used for the walls and ceilings. The floors of the refrigerator compartments were insulated by 2½-in. layers of cork placed in a concrete slab.

Considerable filling was required under the lower floor. Broken stone from the foundation pits was used in the car-cleaning shop. In the remainder of the building, 3 or 4 ft. of sand filling were placed by dump wagons. The concrete floor slab was placed directly upon the filling after it was compacted.

The building was originally designed to be constructed, above the base wall, of precasts, but the contractor chose to pour the concrete in place. This necessitated the re-study of the problem of preventing cracking of the long entablature and parapet walls. The base wall was divided by keyed tar-paper joints located under the intermediate wall piers into sections 20 ft. long and poured in alternate lengths. The entablature and parapet walls were also divided by keyed joints into 20 ft. lengths. Alternate sections were poured integral with the columns, thus providing a series of longitudinal portals to give rigility to the building. After the columns were poured, the spandrel sections were placed with slip joints at the ends, and they were made separate from the floor system. By this layout, the use of heavy, temporary reinforcement was avoided and also the possibility of cracking, due to slightly uneven settlement of the foundations, was minimized.

Steel sash was originally called for, but owing to the high prices obtaining, wooden sash has been used throughout. The side sashes of the windows are made to open as hinged casements.

The interior partitions were built of cement-sand brick which were manufactured at the site by the general contractors.

Five-play tar and gravel roofing was used.

It is the intention to tool-dress all the exposed exterior concrete surfaces. For plain concrete a 1:2:5 mix (2-in. stone) was specified, and for reinforced concrete a 1:2:4 mix (¾-in. stone) was required. Materials were shunted in cars directly to the site. A gasoline-drive mixer, with hoist and placing plant, was used. This machine was set up inside the building and discharged into a hopper at the second floor level. From this hopper, concrete was wheeled to the forms. For the second story portion, staging was built at the level of the forms for the top sections of columns, entablature and parapet walls, and concrete was wheeled up to this staging by long ramps.

For the single-story section, the concrete columns were poured to the level of the bottom chords of the roof trusses, and the bolts for the bearing plates and knee braces of the trusses were set in templates in the forms and concreted in. The steel trusses were then set in place with the wall bolts inserted in the end connection angles, with a sufficient number of purlins and bracing members bolted on to steady them, and plank staging placed on top of the trusses along the forms on both sides of the building. From this staging, the remaining lengths of the columns which received the wall bolts from the ends of the trusses, together with the entablature and parapet walls, were poured.

The concrete for the greater part of the entablature and parapet walls was placed in the early winter, when the temperature ranged between 15 degs. and 20 degs. above zero. By using heated water, warm sand and aggregate, and tarpaulins at night over the new work, good results were obtained.

Ross & Macdonald, of Montreal, were the architects and prepared the general plans and specifications. The layout of plant and construction details were attended to by the engineering staff of the railway.

The Bate, McMahon Maritime Co., Ltd., of which the late Col. R. S. Low was manager, were the general contractors. C. R. Fancy was the contractor's resident superintendent.

The writer had charge of the work for the railway under the direction of W. A. Duff, assistant chief engineer.

TORONTO ENGINEERS' SMOKER

MEMBERS of the Toronto Branch of the Engineering Institute of Canada held a lively smoker last Thursday evening at the Engineers' Club. Before the entertainment, W. S. Harvey, the secretary, read the minutes of previous meetings and reports of committees. A report from the Employment Sub-Committee was read by E. T. Wilkie, explaining the proposed method of securing employment for engineers out of engagement. After some discussion, the report was adopted.

Willis Chipman reported on the work done by a special committee of the institute with the view to obtaining legislation for the registration or licensing of engineers. Further discussion will take place on this important subject. Mr. Chipman was tendered a hearty vote of thanks for the work he did on the committee.

L. J. Wookey opened the entertainment with a vigorous solo, "Dear Old Pal of Mine," which was followed by "When You Come Home" as an encore. E. M. Proctor related a number of amusing anecdotes. J. A. Brown sang "The Merry Cavalier," and in response to applause, "Morie, My Girl."

W. J. Blackburn entertained the members by a series of clever card tricks, after which refreshments were served. Capt. Roy Cockburn described his experiences in France and Palestine in connection with sound-ranging for the artillery, which afforded a fund of instruction and amusement. Capt. C. R. Young gave an interesting address on his work at Niagara Falls Camp with the men of the Polish regiments, of whom over 24,000 were trained there and are now on their way to Poland.

R. O. Wynne-Roberts sang the "Admiral's Broom," Mr. Brown "Tommy My Lad," and Mr. Shuttleworth one of his own patriotic songs. A. H. Harkness, the chairman of the branch, presided. The meeting terminated with "Auld Lang Syne" and "God Save the King."

In his annual report for 1918, Supt. J. W. Turner, of the Edmonton Water Works Department, says that some of the water mains are being destroyed by electrolysis. An injurious amount of electrical current is passing along the mains and is having a damaging effect, particularly upon the larger mains.

The American Association of Engineers announces that the proceedings of the Chicago conference of March 17th and the hearing at Washington of March 31st, are now ready for distribution. A copy will be mailed to any engineer who sends a request to the association's headquarters 29 South LaSalle St., Chicago.

What is claimed to be a record for obtaining new members in an engineering society has been established by the American Association of Engineers, which received 123 applications for membership in one day, April 18th. Of these applications, 62 came from Portland, Ore., where a chapter of the association is being formed.

The following cablegram, dated April 24th, has been received by the British Government Trade Commissioners in Canada:—"All subsidies and control over prices and material with regard to orders for pig iron, manufactured iron and steel and tin plates will be withdrawn April 30th subject to provisions of existing contracts and any export regulations. This means that manufacturers and merchants in the United Kingdom are free to make their own terms with regard to price and delivery from May 1st."

PHYSICAL PROPERTIES OF MORTARS AND CONCRETES

(Continued from page 422)

forms. Forms should preferably be of finished lumber as a concrete of high finish is very desirable. This hard cement skin on the outside of a concrete offers a strong resistance to the entrance of alkali waters. In our tests in the laboratory there has been practically no action observed in the cast of neat cement briquettes, or if there is any it is only confined to the skin.

Although I have previously made the statement that to choose a mixture of materials which will give a concrete of high density is not desirable, since rich mixes have in general less density than lean mixes, I should qualify this statement by saying that once the mixture of materials is decided upon, it is essential that this mixture be so mixed and placed as to secure the maximum possible density with the selected mixture. To secure such a result with the present methods of placing concrete, the quantity of water can be cut down to a minimum and especial attention can be paid to the spading and working of the mass when placed; but beyond these precautions we are limited in the degree of compacting of the material to the head of concrete on the work. Near the surface there is practically no head and to get the materials at the top as closely compacted as possible the concrete should be spaded for a considerable time to overcome the inertia of the materials and actually to push them into place.

The cement-gun has now come into extensive use for lining structures with a hard, impermeable layer of mortar. It has been used successfully in concrete ship construction and for many other purposes; the material being shot into place is very closely compacted. I have not been able to secure any figures for relative density as compared with the mortar settled naturally, but recent experiments at the United States Bureau of Standards have shown that test pieces cut from gunite have a very high strength and modulus of elasticity even for mortars as lean as 1:3. Extreme difficulty was experienced in cutting material for the test pieces. Structures such as dams can be poured with lean concrete and a 4-in. layer of gunite can be shot on, thus providing a closely compacted waterproof material. No cases are yet on record where gunite has disintegrated under alkali action, but it is not yet known whether it is entirely proof against alkali. I have recently been informed that concrete tanks lined with gunite have been used to contain a solution of sulphuric acid 15% strong. These tanks have been in use for a considerable period with no signs of deterioration through disintegration. It would appear in this case that, since the gunite is very dense, the solution cannot penetrate beyond the surface. The calcium sulphate formed at the surface, being relatively insoluble, will tend to prevent any further penetration.

Shortly before the end of the recent session of the Ontario legislature, a bill was passed to repeal the clause in the Hydro-Electric Radial Act which forebade the construction of "hydro-radials" during the war.

The nominating committee of the American Water Works Association has named the candidates for office for the ensuing year, and as there have been no additional nominations by petition, the official ballot has been issued with the following names:—Carleton E. Davis, nominee for president, chief of the Bureau of Water, Philadelphia, Pa.; M. L. Worrell, nominee for vice-president, formerly general manager of the Water Department, Meridian, Miss., and now captain in charge of utilities, Camp Hancock, Georgia; James M. Caird, nominee for treasurer, chemist, bacteriologist and supervisor of filtration plant operation, Troy, N.Y. W. H. Randall, nominee for trustee from the first district, was for many years superintendent of maintenance of the Water Department, Toronto, but recently accepted the managing-directorship of the Neptune Meter Co. of Canada, with headquarters in Toronto.

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PRINCIPAL CONTENTS

A SURPLUS OF ENGINEERS?

HON. F. B. Carvell, Minister of Public Works, made the statement recently in the House of Commons that his department had been "driven to the wall" last year for architects. "There were plenty of engineers, however," declared Mr. Carvell, "and the services of a number of splendid men could be dispensed with."

PREVENTED TYPHOID OUTBREAK

FEARING a typhoid outbreak, and suspecting the water supply, the authorities at the Deseronto Camp of the Royal Air Force telephoned to the General Supply Company of Canada, Limited, at Ottawa, Ont., asking for protection. The General Supply Co., who are the Canadian agents for the Wallace & Tiernan Co., Inc., of New York, at once expressed a Wallace & Tiernan chlorinator, and that night one of the company's engineers arrived in Deseronto. By noon of the next day, the equipment was installed and operating,—within twenty-four hours of the time the call for help was received.

That is real public service. The General Supply Co. and their principals are to be congratulated upon their initiative. It will be comforting to many Canadian municipal engineers and waterworks officials who cannot now receive from their councils the necessary appropriations for a permanent chlorinating installation, to know at least that in case of an outbreak, there is prompt help at hand.

Municipalities would be well advised not to depend upon such emergency help as this, however, because a very great deal of harm can be done by polluted water before the pollution is detected, and before even an emergency chlorinating equipment can be installed. Hundreds of typhoid cases can arise from a few hours' pollution.

The number of lives that have been saved by filtration and chlorination during the past decade are innumerable, and it is a great satisfaction to *The Canadian Engineer* to reflect that it was in these columns that the chlorination of water supplies was first advocated in Canada, and that the first installation of a chlorinating plant in this country was made as the result of the repeated arguments in favor of chlorination that were printed in this paper.

MINISTRY OF PUBLIC HEALTH

THE powers of the ministry of public health that is being created by Act of Parliament, will include all matters relating to the promotion and preservation of the health and social welfare of the people of Canada.

Certain particular powers are mentioned in the bill, such as co-operation with provincial and other health authorities; authority to deal with questions relating to the preservation of child health and child welfare generally; medical care of immigrants; supervision (as regards public health) of railways, ships and all methods of transportation; supervision of federal public buildings in respect to the health of civil servants and other government employees; enforcements of the rules and regulations of the International Joint Commission in respect to the pollution of boundary waters.

The bill also provides for the creation of a Dominion council of public health, consisting of the deputy minister of the federal department, the chief executive officers of the provincial departments or boards of health, and three others to be named by the governor-in-council.

WINNIPEG WATER DISTRICT FINANCES

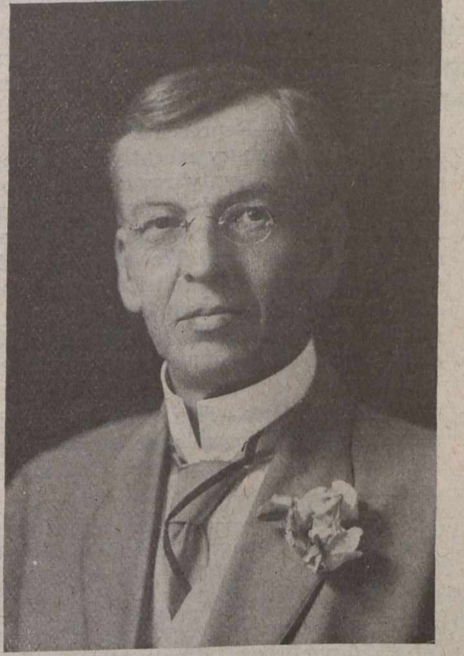
THE arrangement by which the Greater Winnipeg Water District was to be financed with the assistance of property taxes, has evidently not been satisfactory, judging by the efforts that have been made during the past few weeks to have it placed upon a self-supporting basis. The system has been financed under the agreement validated by Winnipeg and the adjoining municipalities in 1913, when the district was organized. This agreement was incorporated in the provincial legislation creating the district and can be altered only by the legislature. The suburban municipalities consider that they have been called upon to pay a disproportionate share of the cost and endeavored to secure a legislative amendment at the recent session of the House. Opposition on the part of the city of Winnipeg was so strong, however, that the government decided to refer the subject to a commission.

The only difference between the operation of this system and that of an ordinary municipal utility is that several municipalities are here involved, and the agreement was a contract among several municipal corporations; naturally some municipalities will desire that it should be strictly adhered to. It was scarcely to be expected, however, that an arrangement reached at the inception of such a large public work should be found to be strictly equitable after several years of operation. The provincial government should not hesitate to make such changes as are now found to be in accordance with justice to the users and to the ratepayers.

Owing to the fact that the Winnipeg Water District was incorporated for the specific purpose of providing water, it obviously cannot make up a deficit from general revenue as can an ordinary municipality. The principle of self-supporting public utilities is generally accepted in Canada. As regards the distribution of the cost within the body of users, most cities levy a uniform rate approximately in proportion to the amount used. The Winnipeg system covers such an extensive area, however, that it would be scarcely equitable to have users located near the aqueduct pay at the same rate as those more distantly situated.

PERSONALS

WILLIS CHIPMAN, consulting engineer, Toronto, has just concluded a very active month's work on behalf of the engineering profession of Canada. Mr. Chipman is the representative of the Toronto branch of the Engineering Institute of Canada on the special Legislation Committee formed by that institute, and has taken a very active part in the work of the committee in preparing a report on a standard bill for the licensing and registration of engineers. Mr. Chipman graduated, with honors, in engineering at McGill University, class of 1876, having previously been engaged for a brief period as a high school teacher. After graduation he served on the staff of the Canadian Geological Survey, later becoming assistant engineer of Toronto's water works department. Since 1888 he has been engaged in private practice with head office in Toronto, and has designed and superintended the construction of a large number of water works and sewerage systems throughout Canada. He is an O.L.S. and also a D.L.S., and a member of the American Society of Civil Engineers. He became a member of the Canadian Society of Civil Engineers within a few months after the organization of that Society in 1887. In 1899 he served for a year as a councillor of the society, and in 1901 was re-elected for two-year term. In 1886 Mr. Chipman organized the Association of Ontario Land Surveyors, and was its first secretary. After the incorporation of the association in 1892, he was its president for a year. In 1899 he was instrumental in organizing the Engineers' Club of Toronto and was its first secretary. In 1912 he served for a year as president of the club. Mr. Chipman has always taken a great interest in the advancement of the engineering profession, and in 1899 acted as chairman of an Ontario committee that endeavored to secured legislation incorporating the Ontario members of the Canadian Society of Civil Engineers, but the bill was vigorously opposed and failed to pass the private bills committee of the legislature.



GEO. E. MACDONALD, of Vancouver, has been appointed general manager of the Pacific Great Eastern Railway.

LIEUT. ALAN HUGH MUNRO has returned from France and has rejoined the engineering staff of the Trent Canal, Severn Division. Lieut. Munro enlisted in 1914 with No. 6 Company, Canadian Engineers, and was wounded in 1916. He is a graduate of S.P.S., University of Toronto, Class of 1910.

J. J. MACDONALD, of Moncton, N.B., who for a number of years has been a structural engineer on the staff of the Canadian Government Railways, has resigned and has sailed for England, having accepted a position with a firm of London engineering-contractors who have a number of large reconstruction contracts.

J. P. MCRAE, of Ottawa, has returned home after two years in Germany as a prisoner of war. Mr. McRae enlisted with the Mechanical Transport, but was transferred to the Air Force and was shot down by machine-gun fire while flying over the German lines. He was wounded and captured. Mr. McRae is an engineering graduate of McGill University. Before the war he was associated with his brother John B. McRae, consulting engineer, Ottawa.

LIEUT. L. B. KINGSTON, of Ottawa, has received his discharge from the army and will resume his position on the engineering staff of Morrow & Beatty, Ltd., contractors, Peterborough. Lieut. Kingston enlisted in January, 1916, and won the military cross. He is an engineering graduate of McGill University and had been with Morrow & Beatty, Ltd., for some years prior to the war, having previously had experience in the consulting office of Kerry & Chace, Ltd., Toronto.

E. T. DRIVER is sailing from England to take a position as technical adviser with the British Aluminum Co., Toronto. Mr. Driver is a graduate in electrical engineering of the Northampton Engineering College, London, Eng., and is also an honor graduate in science of London University and an associate member of the Institution of Electrical Engineers. For the past two years he has held a commission in the Royal Air Force and has initiated improvements in the wireless equipment of aeroplanes.

ARTHUR SIMONS CLARSON, of Montreal, has been appointed general secretary of the Association of Canadian Building and Construction Industries, and has opened an office at 1013 New Birks Bldg., Montreal. Mr. Clarson came to Canada nearly ten years ago having previously had engineering experience in Great Britain and the United States. At one time he was on the staff of the Montreal Electric Co. and was later city engineer of Verdun, which position he resigned some months ago. He is an associate member of the Engineering Institute of Canada and a fellow of the Royal Institute of London.

OBITUARIES

HARVEY COURTRIGHT BRICE, engineer in charge of the Sumas Lake reclamation scheme in British Columbia, died recently following an operation for stomach trouble. Mr. Brice was born in 1862, at Brice Prairie, near Onalaska, Wis., and in 1904 he went to British Columbia as engineer in charge of location and construction of the V.V. & E. Ry. from Blaine north. He had also been in the service of the G.N. Ry. and was chief engineer for the Western Division of that road previous to entering private practice.

JAMES W. LEONARD, general manager of the Toronto Terminals Co., died last Monday afternoon at his home at Brampton, Ont., at the age of 62. Mr. Leonard was born at Epsom, Ont., and entered railway work at the age of 14 as a telegrapher. From 1884 to 1890 he was superintendent of the C.P.R., Toronto, and from 1893 to 1901 was general superintendent of the Ontario-Quebec division and then of the Western division until 1903, when he became assistant general manager of Eastern lines, and in 1908 general manager Eastern lines. After 1911 he was assistant to the vice-president.

LIEUT. WALTER O. BOSWELL, formerly of the engineering staff of the Hydro-Electric Power Commission of Ontario, died recently in England. Lieut. Boswell was on the way home when he was attacked by pneumonia. He enlisted in the motor boat patrol service of the British navy and was stationed at Port Said, Egypt, for more than two years. He was 29 years of age and had three brothers, who all saw active service, one of whom was killed in action in France. The last position which Lieut. Boswell held with the Hydro was on sub-station design and inspection of apparatus at Toronto. He had previously been resident inspector of construction at the Essex transformer station, near Windsor.

A tentative program has been arranged for the convention of the American Water Works Association to be held June 9th to 13th in Buffalo, N.Y.

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.

ADDITIONAL TENDERS PENDING

Not Including Those Reported in This Issue

Further information may be had from the issues of *The Canadian Engineer*, to which reference is made.

PLACE OF WORK	TENDERS CLOSE	ISSUE OF	PAGE
Esquimalt, B.C., military hospital	May 8.	Apr. 24.	44
Ingersoll, Ont., drain	May 3.	Apr. 24.	41
Kenora, Ont., improvements to lot	May 5.	Apr. 24.	46
Lotbiniere, Que., bridge	May 12.	Apr. 24.	414
McTaggart, Sask., telephones	May 5.	Apr. 24.	46
Ninette, Man., dam	May 6.	Apr. 24.	42
Norquay, Sask., school	May 15.	Apr. 24.	44
North Temiskaming, Que., bridge	May 13.	Apr. 24.	414
Sault Ste. Marie, Ont., addition to school	May 7.	Apr. 24.	46
Sherbrooke, Que., pavements	May 12.	Apr. 24.	41
Stonewall, Man., grading	May 3.	Apr. 24.	41
St. Severe, Que., roads	June 2.	Apr. 10.	42
St. Thomas, Ont., roads	May 2.	Apr. 24.	41
Swan River, Man., roads	May 5.	Apr. 17.	43
Viceroy, Sask., culverts and grading	May 5.	Apr. 24.	41
William Head, B.C., repairs to wharf	May 2.	Apr. 24.	46
Winnipeg, Man., cable	May 5.	Apr. 24.	42
Winnipeg, Man., insulators	May 5.	Apr. 24.	42

BRIDGES, ROADS AND STREETS

Bird's Hill, Man.—Tenders addressed to the undersigned for the construction of 1 2-3 miles of the Hoddinott Rd., will be received at the office of the undersigned until noon, May 3rd. Plans, profiles, specifications and forms of contract may be seen and form of tender obtained at either the office of the Highway Commissioner, Parliament Buildings, Winnipeg, or at the office of the undersigned. W. Gorham, secretary-treasurer, Rural Municipality of East St. Paul, Bird's Hill, Manitoba.

Brampton, Ont.—Tenders addressed to the undersigned will be received up to 6 p.m., May 12th, for the construction of concrete pavements, curb and underdraining. C. M. Corkett, town clerk. Official advertisement on another page of this issue.

Bright, Ont.—Tenders addressed to G. Oliver, Clerk of the Township of Blandford, Bright, Ont., will be received until noon, May 12th, for construction of a 40-foot steel bridge over Horner's Creek. Plans and specifications may be seen at the office of F. J. Ure, Township Engineer, Woodstock, or at office of Township Clerk.

Bright, Ont.—Tenders will be received by the undersigned until noon, May 12th, for construction of steel bridge and concrete abutments for the Township Council. George Oliver, clerk.

Calgary, Alta.—Work will start soon on improving main road between Calgary and Banff. Estimated expenditure, $30,000. Hon. A. J. McLean, Minister of Public Works.

Chatham, Ont.—The Board of Works has commenced the work of repairing pavements in the city, which will be completed before the work of constructing new pavements is commenced. Mr. Fitsimmons, chairman of the Board of Works.

Dauphin, Man.—Tenders will be received by the undersigned up to 6 o'clock p.m., May 6, for gravelling six miles of road. Tender forms and conditions governing tenders may be obtained at the office of the municipality. J. A. Gorby, secretary-treasurer, Dauphin, Man.

Delta, B.C.—Nine miles of road will probably be paved by the Municipal Council this summer. Clerk, N. A. McDiarmid.

Galt, Ont.—Representatives from various towns and cities in this vicinity recently held a meeting at Galt to discuss provincial county roads. The proposition to build one from the Wentworth County line through Galt, Preston, Kitchener and Waterloo to Elmira was endorsed, and also that the Dundas and Waterloo Rds. should be extended to Guelph through Galt and Hespeler. Failing the construction of a provincial highway from Toronto through Guelph, Kitchener and Stratford, the meeting came to the conclusion that a provincial county road should connect Kitchener and Stratford.

Guelph, Ont.—The City Engineer, F. McArthur, has been requested to call for tenders for resurfacing of St. George's Square and Lower Windham St., also part of Woolwich St.

Halifax, N.S.—At a recent meeting of the City Council the matter of paving several city streets was discussed. Estimated cost, $17,000. Clerk, L. F. Monaghan.

Kenora, Ont.—A. T. Fife and Co. has been given the contract for cement required for the proposed new sidewalks at $3.56 per barrel. The contract calls for about 900 barrels.

Lindsay, Ont.—Tenders will be received by J. R. McNeillie, County Clerk, Court House, Lindsay, until 5 p.m., May 6th, for erection of two bridges. Plans and specifications may be obtained at the Court House or at the office of the undersigned. Bowman and Connor, engineers, 31 Queen St. W., Toronto.

Lindsay, Ont.—The Town Council contemplates repairs to William and Wellington Sts. B. L. McLean, mayor.

Lindsay, Ont.—Work will start immediately on construction of asphalt pavements on Queen St. Contractor, Mr. Davis.

Listowel, Ont.—Tenders are in for construction of 7,106 feet of cement pavement. John Roger, county engineer, Mitchell, Ont.

Mimico, Ont.—Tenders will be received up to noon, May 17th, by J. A. Telfer, town clerk, for construction of permanent pavements on Church St. and Mimico Ave., James, Loudon and Hertzberg, Ltd., consulting engineers, 36 Toronto St. Official advertisement on another page of this issue.

Moorefield, Ont.—Tenders will be received until 2 p.m., May 3rd, for building concrete bridge. W. W. Scott, township clerk, Moorefield, Ont.

Ottawa, Ont.—Construction of concrete sidewalks on Percy St. is contemplated. N. H. H. Lett, city clerk.

Peterborough, Ont.—The Board of Works Committee has awarded the contract for the new Hunter St. bridge to Russell, Townsend Co., Harbor Commissioners' Building, Toronto. Estimated cost, $249,000.

Point Grey, B.C.—Plans have been prepared by Municipal Engineer Greig for grading Alma Rd. for the purpose of making it suitable for street railway traffic. Estimates for five different schemes submitted range from $20,975 to $116,475.75.