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Are Abrams' and Edwards' Theories Both Wrong?

Article Written Specially for "The Canadian Engineer," Stating Bureau of Standards' Opinion Regarding "Surface Area" and "Fineness Modulus" Methods of Proportioning Concrete—Methods Agree, Both Faulty, Claims Engineer in Charge of Bureau's Research

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WHILE I am inclined to agree with R. B. Young's statement in the November 27th, 1919, issue of *The Canadian Engineer*, that the "surface area" and "fineness modulus" theories are in agreement in final conclusion, I further believe that both theories are faulty and the conclusions erroneous because of the disregard of the basic and fundamental requirement that concretes must have the same consistency or flowability to be comparable.

In Lewis Institute Bulletin No. 1, describing the fineness modulus theory, Professor Abrams states that for a given plastic condition of the concrete and same mix there is an intimate relation between the fineness modulus of the aggregate and the strength and other properties of the concrete. It is further stated that the grading of the aggregate may vary over a wide range without producing any effect on concrete strength so long as the water-cement ratio remains constant. Referring to the sieve analysis curves of the aggregates used, it is said that any other sieve analysis curve that will give the same total area below the curve corresponds to the same fineness modulus, and will require the same quantity of water to produce a mix of the same plasticity, and gives concretes of the same strength, so long as it is not too coarse for the quantity of cement used. In other words, the fineness modulus theory concludes that for given concrete materials, the strength depends upon one factor only,—the ratio of water to cement.

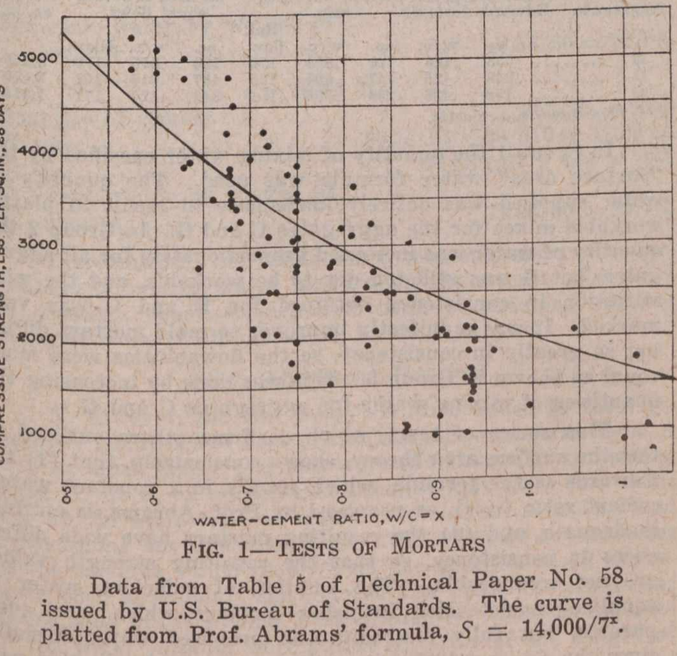

FIG. 1—TESTS OF MORTARS

Data from Table 5 of Technical Paper No. 58 issued by U.S. Bureau of Standards. The curve is platted from Prof. Abrams' formula, $S = 14{,}000/7^x$.

The surface area method of proportioning assumes as its basic principle that the physical properties are primarily dependent upon the relation of the volume of the cementing material to the surface area of the aggregate. It is further stated that the strength of the mortars are dependent upon the quantity of the cement in relation to the surface areas of the aggregates, and the consistency of the mix. Also, that strengths of mortars of uniform consistency, containing sand aggregates of varying granular combinations are directly proportional to the quantity of cement they contain in relation to the surface area of the aggregate. Mr. Edwards states that "normal" uniform consistency mortars of varying cement content and of varying sand gradings were produced when the quantity of water used in the mix was made equal to that required to reduce the cement to a normal consistency paste, plus an amount equal to the surface area of the sand in square inches divided by 210. That is, water (cc.) = weight of cement (C) times percentage of water for neat normal consistency paste, plus total surface area of sand (sq. ins.) divided by 210..........(1)

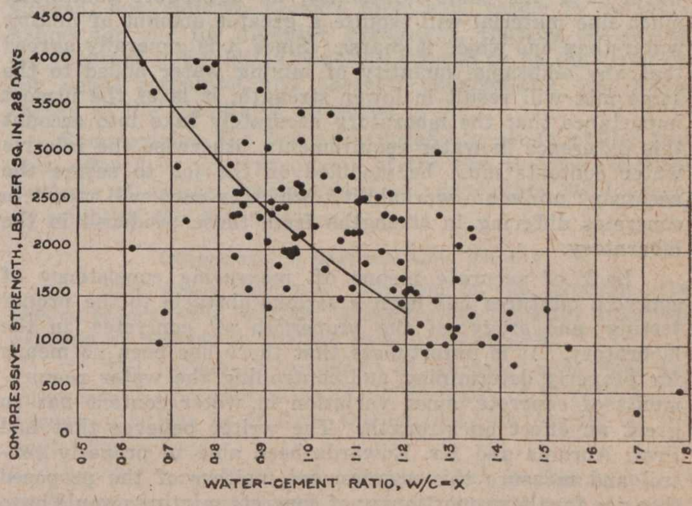

FIG. 2—TESTS OF CONCRETE

Data from Tables 8, 9, 10, 11 and 12 of Technical Paper No. 58 issued by U.S. Bureau of Standards. The curve is platted from Prof. Abrams' formula, $S = 14{,}000/7^x$.

The similarity of the two theories in final conclusion can be seen in a study of the water formula:—

Let C = Weight of cement in grams.

p = Percentage of water for normal consistency of the cement.

A = Total surface area of the aggregate in sq. ins.

$N = A/C$ = square inches of surface area of aggregate per gram of cement.—Arbitrarily selected before the test.

w = Cubic centimeters of mixing water.

c = Volume of the cement in cc. = 0.67C.

As stated in (1),

$$w = pC + (A/210) \quad \text{.........................(2)}$$

From above,

$$A = NC \quad \text{..................................(3)}$$

Substituting (3) in (2),

$w/C = p + (N/210)$, in which p and N are constants.

To express the weight of the cement in volume measure, $w/0.67C = pN/210$ = constant, which is the water-cement ratio proposed by Professor Abrams for equal strength, or $w/c = K$.

Arrive at Same Conclusion

Expressing this result in words, the surface area theory, after fixing a ratio of cement to surface area of the aggregate, arrives at the same final conclusion as does the method proposed by Professor Abrams,—that strength depends only upon the ratio of mixing water to cement.

The fineness modulus theory states that strength is dependent only upon the water-cement ratio, and the surface area theory arrives at the same final conclusion after providing a relation between the quantity of cement and the surface area of the aggregate.

On any concrete work, it is necessary that the concrete have some minimum plasticity, consistency or flowability, in order that it may be placeable with a reasonable amount of work. For the same flowability, an aggregate containing much fine material will require a greater amount of mixing water than one which is coarse. Since it is generally agreed that any additional quantity of mixing water added to the same mix will result in lower strength, it is of the utmost importance that the laboratory accurately take into account this difference in water requirements, otherwise the relative water contents must be modified on the job to secure the necessary minimum workability, which in turn will result in concretes differing in strengths from those produced in the laboratory.

Lack of accurate means of measuring consistency of concrete mixtures has been a serious obstacle to the proper testing and study of the properties of concretes in the laboratory. It is unfortunate that there has been no means for properly determining and controlling the water requirements of concrete, since variation in water content has so great an effect on strength. The writer believes that had Prof. Abrams and Mr. Edwards been able to properly control and measure this requirement, neither of the proposed theories for the proportioning of concrete mixtures would have been presented to the public in their present form.

Must Have Same Consistencies

The proponents of both theories are agreed that concretes must have the same consistencies to be comparable. In Lewis Institute Bulletin No. 1, Prof. Abrams states that the 27 concretes shown in Table 2 had the same consistencies as measured by the cylinder slump test, the column of results marked 100% consistency having slumps of ½-in. to 1-in. as measured in this test.

Mr. Edwards in A.S.T.M. proceedings for 1918, page 253, states: "The marked influence of consistency of the mix upon the ultimate strength of mortars renders it especially important that test mortars be made of uniform consistency. The importance of this investigation as a preliminary to the making of tests tending to prove or disprove the validity of the primary theory of the surface area method of proportioning is self-evident." Following this statement Mr. Edwards gives the surface area water formula as shown above.

There is no question that both investigators fully recognize the basic requirement that equal consistencies must be obtained, but tests of their own aggregate gradings show that both failed to secure such comparable concretes in practice.

Eight of the aggregates included in Table 2, Lewis Institute Bulletin No. 1, were prepared by screening Potomac river sand and gravel and recombining them to conform with the sieving analyses shown in this table. Concrete was made of the proportion 1: 5, using equal quantities of mixing water in all as specified by the water formula described on page 13 of Bulletin No. 1.

Both the cylinder slump test and the vibrating steel plate, another method used in the laboratory for measuring flowability, indicated wide differences in consistency for these concretes. In two cases the cylinder form was withdrawn and the masses of concrete picked up by hand and carried back to the mixer without losing their shapes. Two other aggregates gave slumps of 7¾-ins. and 8½-ins.

Later tests showed that these concretes which were described as having equal consistencies, actually varied more than 25% in this respect; that is, the amount of water in the wettest of the mixes was more than 25% greater than that required to yield the consistency of the driest of the mixes. The differences in strength found for these mixes is of secondary importance, since concretes differing so widely in consistency are not comparable.

Wide Variations in Consistency

Equally wide variations in consistency were found among mortars made with aggregates having the same gradings as those used by Mr. Edwards. The three aggregates C, E, and G, in Table 7, page 256, of the above-mentioned A.S.T.M. proceedings, were reproduced. The quantity of water specified by the Edwards water formula was found to be entirely insufficient. The quantity was increased by a constant in order to obtain mixtures which had some degree of workability, and the resulting wide differences in consistency were very apparent to the eye and verified by the flowability test. The test data are shown below:—

MIXING WATER

Aggregate.	Group 1 Specified by the Edwards formula.		Group 2 As increased to obtain workable mix.			Group 3 As used to obtain equal flows.			Comp. strength, lbs. per sq. in.
	cc.	w/c.	cc.	w/c.	Rel. flow.	cc.	w/c.	Flow.	
E	553	.426	720	.555	170	720	.555	170	3,855
C	343	.426	447	.555	125	497	.616	168	3,170
G	178	.426	234	.555	No*	342	.820	171	1,810

*No flow; not plastic.

In Group 1 the quantity of mixing water specified by the "surface area" water formula was used. The quantity of water supplied was entirely inadequate to result in plastic workable mixes for the aggregates C and G. In Group 2 the quantity of water was increased proportionately for all aggregates, but G was still too dry to be workable, and the wide variation in consistency obtained for E and C was very marked. It was manifestly improper to mold mortars differing so greatly in consistency, so the flowabilities were made equal as shown in Group 3. This was done by increasing the quantities of mixing water for aggregates C and G.

This series of tests, which confirms others outlined to test the surface area theory, shows conclusively, that (1) the Edwards water formula, which results in a constant water-cement ratio (w/c), as proposed by Prof. Abrams, is entirely inadequate, and (2) the resulting mortars have wide differences in consistency, so that the resulting strength values are not comparable. The addition of sufficient water to equalize consistencies furnishes mortars which are comparable, but fully discredits the proposed water formula, since the (w/c) relation is no longer constant. In this particular case, (w/c) varied from .555 to .820.

Using Standard Ottawa Sand

A comparison of the amount of water which the Edwards formula would furnish to a 1: 3 standard Ottawa sand mortar, as used in the routine testing of cement, is also interesting.

Assume the percentage of mixing water required for normal consistency of a given cement to be 24.

Surface area standard Ottawa sand = 400 sq. ins. (approx.) per 100 grams.

Assume batch of 500 grams cement and 1,500 grams standard Ottawa sand.

By "surface area" water formula,

Water = $(0.24 \times 500) + 6{,}000/210 = 148.6$ cc., or 7.42%.

The United States government specification for Portland cement specifies 10.5% mixing water for a 1:3 mortar made with such a cement.

Water = $10.5 \times 2{,}000 = 210$ cc.

Those familiar with routine testing of cement are aware that such a mortar with 10.5% water is by no means a flowing, plastic mix, yet the proposed surface area formula furnishes 61.4 grams, or 3.08%, less mixing water. Since natural sands often require several per cent. more mixing water than standard sand for the same consistency, no further comment should be required.

Variation in Areas Disregarded

It is stated that the factor, total area divided by 210, takes into account the varying water requirements due to differences in surface areas of the aggregates. It was shown in the preceding discussion, however, that w/c equals a constant, so that water is actually based only upon the cement content of the mix, while the large variations in surface areas, which the author admits require varying quantities, are disregarded. It is an admitted fact that the granular composition or grading of an aggregate is reflected by the amount of water required to produce concretes of the same flowabilities, but this formula is equivalent to one which bases the water requirement on cement content only, as is shown by the following:—

Assume sands A and B having surface areas of 300 and 600 sq. ins. per 100 grams, respectively; a cement requiring 25% mixing water for normal consistency; and proportions of 1 gram of cement for each 10 sq. ins. of surface area.

Sand A.

Quantity of cement	300/10 = 30 g.
Water	$30 \times .25 \times 300/210 = 8.93$ cc.
W/C	$8.93/(.67 \times 30) = .443$
Per cent. water by weight of cement	8.93/30 = 29.7%

Sand B.

Quantity of cement	600/10 = 60 g.
Water	$60 \times .25 \times 60/210 = 17.86$ cc.
W/C	$17.86\ (.67 \times 60) = .443$
Per cent. water by weight of cement	17.86/60 = 29.7%

Disregarding the sands for a moment, since the percentage of mixing water based upon the weight of cement, is constant, equal consistencies will be obtained for the cements alone if all the water provided is used.

Why Differences Resulted

If, however, the two sands are then added to their respective quantities of neat pastes, the mix containing Sand A will be much stiffer and less workable than that containing Sand B. It is, of course, also assumed that these two sands are of the same type as would result from screening and recombining any first-class sand. The effect on consistencies is the same as would result from the addition of an aggregate, such as standard sand, to the first paste and a siliceous beach sand to the second. Less calculation would be required if the water formula were stated in terms of the weight of neat cement only.

As stated above, the tests of the Abrams aggregates included in Table 2, Lewis Institute Bulletin No. 1, resulted in concretes varying widely in consistency, although the author stated that equal consistencies were obtained. A study of the proposed "fineness modulus" water formula makes clear why such differences in consistency should result without the employment of the actual tests, which later fully verified the opinion first formed from such a study.

The expression for the quantity of mixing water is as follows:—

$$x = w/c = R[3/2p + (30/1.26^m + (a-c)n].$$

It is stated that with m, fineness modulus, constant, and n, proportion of cement to aggregate, constant, the same consistency will result and the same strength will be obtained, whatever the grading of the aggregate within rather wide limits.

As shown in Table 2, Bulletin No. 1, with m constant, there may be wide differences in total surface areas of aggregates. For the aggregates shown, the variation in surface areas is approximately 600%. Concreting practice has established the fact that for the same consistency a fine sand requires more mixing water than a coarse sand; that a sand similar to a beach sand requires more than a coarse, well-graded river sand. Inspection of the granular analyses of sands used for concrete work throughout the country may vary over several hundred per cent. in surface areas. In spite of this well-understood condition, that a "fine" aggregate having a relatively high surface area will require more water than a "coarse" aggregate, it is claimed that the above water formula will result in the same consistency for any group of aggregates having the above-stated conditions constant.

"Undermines Whole Theory"

Although not expressed in so many words, the Abrams water formula is equivalent to the statement that whatever the gradation, aggregates having the same fineness modulus, although varying as much as 600% in surface area, require the same quantity of mixing water for the same consistency.

The addition of any factor to this formula to properly take into account this varying surface area of an aggregate (a condition which Mr. Edwards also admits must be considered, but fails to provide for), will result in different values for w/c for different gradations, thereby destroying the constant w/c relation which is claimed to be the criterion for equal strengths, and thereby undermining the whole theory of the "design of mixtures."

Summarizing the foregoing briefly, a study of the test data offered by the proponents of the two theories, checked by tests of similar combinations of aggregates, would seem to establish the following:—

Objections to Surface Area Theory

1. The water formula proposed in the surface area theory reduces to a constant water-cement ratio for any fixed relation of cement to surface area of aggregate.

2. The important property of surface area does not enter into the determination of the quantity of mixing water, except in so far as it fixes the quantity of cement at the beginning.

3. The formula is not only incorrect in theory, but is inadequate in practice, and results in mortars and concretes varying widely in consistency, which are, therefore, in no sense comparable on the basis of strength.

4. Tests indicate that compressive strengths increase as the ratio of cement to surface area decreases, although such increase is by no means proportional to the decrease of the ratio.

Objections to Fineness Modulus Theory

1. The foundation of this theory is a water formula which gives no consideration to the varying water requirements of aggregates varying in surface areas.

2. It is shown that, with a given fineness modulus, the total surface areas of aggregates of different gradings may vary as much as 600%.

3. In spite of this wide difference in surface areas, it is claimed that resulting concretes of the same mix will have the same consistency.

4. Tests have shown that the consistencies actually obtained varied more than 25% with the above constant conditions, and such differences were measurable by all known consistency methods as well as apparent to the eye.

5. The strengths obtained in tests of such concretes are not comparable, since the condition of equal consistency ad-

mitted as necessary and fundamental by the proponent of the theory, cannot result.

6. The addition of any factor to the water formula to properly take into account these varying water requirements, destroys the constant water-cement relation which is the criterion for equal strengths.

7. The strength results given in Table 2, Lewis Institute Bulletin No. 1, would seem to discredit the surface theory as advocated by Mr. Edwards. However, these tests are not competent to either deny or affirm that theory, since equal consistencies were not obtained. The strengths of the concretes would be considerably modified by the addition of sufficient water to result in equal consistencies.

Comments on Mr. Young's Paper

The following comments refer more specifically to Mr. Young's discussion of the two theories.

Mr. Young states that "the Bureau's .... tests indicate that for constant flowability the water required varies with the surface area of the aggregate." Our tests show that aggregates of high surface areas require more water than those having smaller areas, but the increase in water is by no means proportional to the increase in area. This is the very factor which neither of the foregoing formulas takes account of.

As to the results which Mr. Young states Prof. Talbot has obtained, they appear to be quite in accord with our own experience so far as the water requirement is concerned. There are also indications that strengths increase slightly, in some cases at least, with increase in surface of aggregate, when cement is proportioned in the usual volume method, but some rather consistent exceptions make it unwise to draw any definite conclusions until additional work is completed.

However, such a conclusion that strength does increase with surface area, is in this case directly opposed to the surface area theory. These concretes were proportioned in the customary way, one volume of cement to so many volumes of aggregates, so that the ratio of cement to surface area decreases as the surface areas increase, contrary to the theory proposed by Mr. Edwards.

With reference to the results of the investigations of the Hydro-Electric Power Commission of Ontario, the conclusion that "fineness modulus is but another and somewhat approximate method, etc., ...," is not substantiated by a study of aggregates in common use in various sections of the United States. The wide variations which may result is well shown in Table 2, of Lewis Institute Bulletin No. 1.

As to conclusion 2, if the cement is proportioned with relation to surface area, the Edwards water formula will result in wide differences in consistency, as shown above, while if the cement is proportioned in the customary manner, an increase in strength with increase in area of aggregate is directly opposed to the surface area theory.

Conclusion 3 is true beyond doubt, since with the same cement, the same aggregate, and the same age for test, water is the only ingredient to be varied, and the variation in strength with change in water content under such conditions is too well recognized to require proof.

"Will Result in Soupy Consistencies"

Strict adherence to the surface area theory, if sufficient water is supplied to make workable the mixtures having a low surface area, will result in very soupy consistencies for the richer mixtures having the greater surface areas, so that much of the gain in strength which should result, will be thrown away.

It is very apparent that "there is no mathematical relation between surface area and fineness modulus," since it has been shown that with a given fineness modulus the surface area may vary more than 600%, while aggregates with any given surface area may have moduli differing considerably. Fig. 1 in Mr. Young's article shows this fact, and were he to plot on this diagram aggregates in use in other localities, he would find the points scattered over a wide zone, rather than along a single line. With the wide differences in surface areas which may be had with a given fineness modulus, it is difficult to understand how the expression of this term may be considered as another way of expressing the surface area.

Fig. 5 in Mr. Young's article furnishes a clear demonstration of the fallacy of averaging tests of concretes, especially when such concretes are not comparable, owing to wide differences in consistency. It is clear from a study of this diagram, which has been widely used as a proof of the accuracy of the "fineness modulus" theory of proportioning, that no consideration has been given to the consistencies of the concretes represented by the plotted points.

This diagram has little value beyond showing graphically that the function of increase in mixing water, whatever may be the mix or combination of the aggregates, is to lower compressive strengths. With the same mix, cement and grading of the aggregate, a line may properly be used to indicate the reduction in compressive strength with increase in water content, and the general trend of such a curve will be somewhat like the one shown in the figure.

But, even assuming that strict consideration has been given to the necessity for equal consistencies for all concretes included, the variations in compressive strength between mixtures having the same *w/c* relation, is seen to be as high as 50%. The inclusion of more tests will tend to increase this difference. The strength trend as influenced by the amount of mixing water can best be represented by a broad band or zone rather than by a line.

"Conclusions From Few Tests"

In Mr. Young's Fig. 7 he shows six plotted points which he states were taken from Technical Paper 58 of the Bureau of Standards, and which he believes indicates the concordance of the results of that report with the conclusions of the two theories. A full study of the tests reported in that paper will in no way confirm his conclusions, but, on the other hand, that report furnishes data which controvert the claims of both theories, and show the fallacy of drawing conclusions from a few tests, as has been done in the case of Fig. 7.

In Fig. 1, accompanying, are shown the relation of the water-cement ratios to compressive strengths of the large group of sands included in Table 5, Technical Paper 58. The results are comparable, since the same consistencies were used for all mixtures.

In Fig. 2, accompanying, are shown the concrete strength results given in Tables 8, 9, 10, 11 and 12, plotted in the same manner. The aggregates used in these tests were mainly limestone and gravel, with a few samples of granite and trap rock. The extremely wide variations in strength for any given value of *w/c* are probably due to the different types of aggregates, but the values for either gravel or limestone alone can only be represented by a broad zone rather than by a line.

The results given in the above-mentioned tables of Technical Paper 58 furnish further evidence to discredit the surface method of proportioning, as the relations can be seen at a glance without the computation which was required for a study of the *w/c* relation. Two sands, differing little in surface areas, were generally used, with a large number of coarse aggregates, and since the area of a coarse aggregate is usually less than 10% than that of a sand, the total areas of the mixtures do not greatly differ. Therefore, for any given proportion we should expect to obtain equal strengths, but such a relation is not found.

Actual Tests Required

Rather than furnish proof of the accuracy of these two theories, the results included in Technical Paper 58 still appear to justify the conclusions in that paper that "no standard of compressive strength can be assumed or guaranteed for concrete of any particular proportions made with any aggregate unless all the factors entering into its fabrication are controlled"; and "the relative compressive strength of concrete to be obtained from any given materials can be determined only by actual tests of those materials combined in a concrete."

Later tests seem to indicate that the gradation of the sand, which is made of great importance in the surface area theory, is of less consequence than has generally been supposed, although it is a factor which cannot be disregarded.

The criticisms which Prof. Abrams has made of the gradings of the aggregates used in recent Bureau of Standards tests were fully answered in the August 14th, 1918, issue of "Engineering News-Record." With reference to the aggregates which were included in Table 4, and which were made up similar to those of Table 2, Lewis Institute Bulletin No. 1, the following statement was made:—

"The aggregates used in the concretes of Table 4 are criticized as being too coarse, probably on account of the low strength results obtained in some cases with the constant water-cement ratio. These low strengths are not due to coarseness but to adherence to the Abrams water formula, which provides too much mixing water for coarse aggregates, resulting in concretes having unequal flows which are not comparable. It should be noted that these so-called poor aggregates 2, 3, 7 and 8, when tested with flows constant, showed good strength increases, which indicated them to be the best aggregates in the group. It would seem that any standard of coarseness which would rule out such aggregates must be seriously in error.

"Aggregates 7 and 8 are criticized as being decidedly freakish, in that all material is contained on the 28 or 48-mesh sieves. This same criticism can equally well be made of the Abrams' aggregates 271 and 276, Table 2, Lewis Institute Bulletin No. 1. However, tests show that all of these aggregates are satisfactory from the standpoint of workability and compressive strength, when proper account is taken of flowability."

It seems clear to me that no tests, other than those reported by the proponents themselves, are required to disprove the theories. Mr. Young's discussion is based upon the assumption that the test data offered by both are correct and fully represent the true values which should be found for the aggregates employed. He disregards the basic requirement of equal consistencies, which is accepted by both proponents but apparently employed by neither in obtaining the test data used to support their respective theories.

I have attempted in the foregoing discussion to point out what seems to be the fundamental error, both in testing and in interpreting the results of the tests reported. Whatever further tests along such lines may show, the test data so far presented seem to discredit both theories.

However, a few tests, made by those who are interested in the subject of proportioning concrete, will do more to settle the points involved than any amount of discussion.

Since the first and main criticism of these theories deals with the question of consistency or flowability, it should be an easy matter for any laboratory equipped with sand sieves to screen and regrade an aggregate to correspond with the gradings used by the advocates of these theories in their work. Reproduction of a few of the mortars and concretes used by each should furnish test data to conclusively affirm or deny their claims.

"Hydro's" Reply to Bureau of Standards' Criticisms

Mr. Williams' Contentions Said to Hinge on Question of Consistency--"Hydro's" Laboratory and Field Experiences Contrary to His Conclusions

By RODERICK B. YOUNG

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MR. WILLIAMS' contentions in the above article hinge on the question of consistency, and here the issue he raises is one of fact. He claims that because he was unable to duplicate the results reported by Messrs. Abrams and Edwards, that their results could not have been as stated. Our opinions are based on the assumption that the test data offered by these gentlemen were correct, and on the supporting evidence of some thousands of tests along similar lines made in our own laboratories. These experimental studies do not support Mr. Williams' contentions, but agree in the main with the results obtained by Messrs. Abrams and Edwards.

Our field experience has also been contrary to Mr. Williams' conclusions. We are obtaining concretes of the required strength by proportioning their mixtures to obtain the water-cement ratio previously established by test as corresponding to that compressive strength for the materials being used.

We are obtaining mixtures of uniform mobility by proportioning the cement and water according to the surface area of the aggregates after establishing the relation between these for the desired consistency.

With this method we are getting concrete mixtures of the consistency we are after; we are getting these consistencies continuously in spite of the variations encountered in the gradation of the agregates; we are getting from these mixtures concretes of the expected strength (as has been repeatedly proven by our field tests); and we are getting these results with less cement than would have been necessary had we followed the usual methods.

We believe that it is possible—in fact, probable—that the theories under discussion do not hold for extreme conditions, such as dry concretes, freak gradings and mixtures, etc. Evidence in hand seems to show that they are true only within well-defined limits, but our experience is that these limits cover the range of consistencies and materials ordinarily encountered in good practice. To most of us engaged in actual concrete construction this is the important feature; what happens outside these limits is only of academic interest.

It is not my intention to discuss in any detail Mr. Williams remarks, but I would like to ask him one question: What has fineness modulus or surface area got to do with differences in locality?

Both fineness modulus and surface area are functions of the grading, and the same grading, if encountered in any number of localities, would have the same value for fineness modulus and surface area.

Mr. Williams has but to plot the fineness modulus of the first fifty sands of Table 1 of the Bureau of Standards' Technologic Paper No. 58 against their surface area, and he will obtain a chart similar to Figs. 1, 2, and 3 of my paper. These fifty sands represent materials from 21 states, scattered from Massachussetts to California on the one hand, and from Minnisota to Texas on the other,—a sufficient range of locality to satisfy the most critical.

We do not consider Technologic Paper No. 58 as good evidence against these theories. The results from which my Fig. 7 was taken, represent the only series which we were able to find in this paper in which the range of proportions used were confined within practical limits and in which there were a sufficient number of mixtures of similar aggregates comparable on the basis of workability, from which to plot a curve. It was interesting to us, and we thought to others, that in this case their results were similar to those being obtained by Prof. Abrams and ourselves.

Figs. 1 and 2 of Mr. Williams' discussion can possibly be explained from the fact that all manner of aggregates of widely different mineralogical composition and structural value were used in these tests. Fig. 2 also includes a large number of rather impractical concrete mixtures, such as 1:1:5 and 1:2:7. Under such conditions it is our experience that concordant results are not to be expected.

REVIEW OF PRESENT STATUS OF ONTARIO HYDRO-ELECTRIC POWER COMMISSION'S RADIAL RAILWAY PROJECTS

Some Details Regarding the Toronto–Northeastern, Toronto–Eastern, Toronto–London, Toronto–St. Catharines, Hamilton–Elmira–Guelph and Welland–Bridgeburg Lines

DURING the six years which have elapsed since the passing of the first Ontario Hydro-Electric Railway Act, the Hydro-Electric Power Commission of Ontario has received requests from approximately 300 municipalities to prepare reports on the construction and operation of electric railways in their localities, and in response approximately 3,000 miles of projected lines have been surveyed. Practically all these lines are located in South-western Ontario, the exceptions being: (1) two short lines in the Muskoka district, (2) lines in the Prince Edward county district, (3) Kingston to Cornwall, and (4) Ottawa to Morrisburg.

Toronto-Northeastern Railway

In October, 1914, municipalities between Toronto, Uxbridge and Port Perry, voted on a 100-mile line, and with the exception of Newmarket and Uxbridge township, all approved by-laws authorizing the construction of the railway. The agreements were ratified by an Act in 1915, and Newmarket, Whitchurch township, Uxbridge township, and the town of Uxbridge were excluded. The line authorized is 72.36 miles long.

This proposed line will start from the eastern limits of the city of Toronto, parallel the C.N.R. for a short distance, turn north and approximately parallel the G.T.R. to Unionville and thence to Stouffville Junction on the Markham-Whitchurch township line. From Stouffville Junction the line will run east through Stouffville and the township of Pickering, to Claremont. The railway will also run east from Unionville to Brooklin, and there join the line running south from Port Perry through the township of Whitby.

From Brooklin the line will parallel the road allowance as far south as the C.P.R. in the town of Whitby, where it will be diverted to Henry street, and thence to the lake front. The estimated cost of this railway is $3,159,234. The Act of 1916, amending the Hydro-Electric Railway Act, forbade construction during the war, and consequently construction has not yet been started.

Toronto-Eastern Line

The Toronto-Eastern line will be 43½ miles long, and the estimated cost is $8,360,734, which includes the construction and equipment of a railway from the proposed Toronto terminal to connect with the Toronto-Eastern right-of-way in Scarboro' township, the extension of construction along that right-of-way to the end of grading near Pickering, and the completing and repairing of the remainder of the line from Pickering to Whitby, Oshawa and Bowmanville.

When the by-laws were passed authorizing the construction of the Toronto-Northeastern railway, the municipalities asked the "Hydro" to endeavor to purchase the Toronto-Eastern from the Mackenzie-Mann interests, but at that time, this could not be effected. The Toronto-Eastern was taken over by the Dominion Government last spring, and the municipalities again asked that the line be acquired. Hon. Dr. Reid, on behalf of the Dominion government, offered that portion of the Toronto-Bowmanville line which had been already constructed, at cost price. Nine of the ten municipalities have voted by large majorities in favor of obtaining control of this line. York township has not yet voted, but will do so next Saturday, January 17th.

The intention of the "Hydro" is to give service this summer over the Toronto-Eastern where it has been constructed. The line must be repaired before this service can be started. It is expected that before the end of this year the whole line will be completed into Toronto as far as Danforth avenue. It will then be extended over the harbor board's property to the centre of the city, and will also provide an entrance for the Markham and Port Perry line.

Toronto-London Line

From the proposed Toronto terminal to be located near the foot of Yonge street, the Toronto-London line will run westerly to Sunnyside, thence to the Humber river paralleling the G.T.R., as at present constructed, as far as Port Credit. From Port Credit the line will run north of Sheridan to Milton. Crossing the C.P.R. west of Milton, the location lies in the general direction of the Eramosa river to Guelph, then westerly to Kitchener, Baden, Stratford and St. Mary's, southwesterly through St. Mary's, Biddulph township, and London township to London. It will cross the Thames river in London to a point on Bathurst street, then easterly along Bathurst street to connect with the London and Port Stanley railway.

Five townships, responsible for only a small portion of the necessary financial guarantee, have not yet submitted the scheme to their ratepayers; three other townships, namely, North Easthope, Waterloo and East Zorra, voted against the by-laws. No construction work on this line will be started until it is known what is to become of the Grand Trunk Ry. Six of the municipalities located between Toronto and Port Credit have passed resolutions agreeing to guarantee 10% more than their share in order to make up for those municipalities that have voted adversely, and have requested that their section be added to the Port Credit-St. Catharines line, which is to be commenced at once so as to give service as soon as possible from Toronto to St. Catharines without awaiting the construction of the whole Toronto-London line. The length of the Toronto-London line is 137 miles, and the estimated cost is $13,734,155.

Toronto-St. Catharines Line

The by-laws authorizing the Toronto-St. Catharines line have been submitted to 16 municipalities,—all that are interested excepting the township of West Flamboro, which has not yet voted on the question. In Hamilton, Nelson and Saltfleet townships the by-laws at first failed to pass, but in March, 1919, a re-vote was taken, resulting in the by-law being carried in Hamilton and Nelson townships, but not in the township of Saltfleet. Fifteen municipalities have agreed to an extra 10% guarantee, or as much of it as necessary to make up for Saltfleet's portion, and debentures are now being issued and final surveys prepared, so as to start construction in the spring.

From a point on the projected Toronto-London line, approximately one mile west of the village of Port Credit, it is proposed to parallel the G.T.R. to Clarkson's, thence to Oakville, and after crossing the Bronte creek to parallel the present Hamilton radial railway to Burlington. Passing through Hamilton, the railway will run near Stony creek, and near Fruitland to Winona and Grimsby, and easterly to Beamsville and Jordan, entering St. Catharines near Victoria and Permilla streets, thence along Permilla street to the west end of the new bridge over the old Welland canal.

The estimated cost of this 60 miles of railway between Port Credit and St. Catharines is $11,360,363. The six municipalities between Toronto and Port Credit which desire to add their financial support to the Toronto-St. Catharines project, are Toronto, Mimico, New Toronto, Port Credit, Etobicoke township and Toronto township. In order to effect a considerable saving and prevent further "cutting-up" of the streets, the city of Hamilton has expressed a desire that the "Hydro" should use the Grand Trunk tracks for its entrance to that city, and the proposed union radial railway terminal.

Hamilton, Elmira and Guelph

The "Hydro" proposes to build a new line from Hamilton, through Dundas, to Galt, connecting at Galt with two Grand Trunk branch lines, one running from Galt through Kitchener to Elmira, and the other from Galt to Guelph. It is also proposed to acquire the Guelph street railway. The total length of track, including spur lines, street railway, etc., is approximately 78 miles, and the total cost is estimated at $6,530,659. In this line 17 municipalities are interested. Three, the town of Hespeler, Puslinch township and Guelph township, have not yet submitted by-laws, but intend to do so in the immediate future. Of the 14 which have voted on the question, including the cities of Hamilton, Kitchener, Galt and Guelph, all carried it by large majorities with the exception of West Flamboro, which may either re-vote or have its guarantee absorbed by the other municipalities.

Welland-Bridgeburg Line

The proposed Welland-Bridgeburg line will extend from East Main street, Welland, along the east bank of the Welland canal, through Humberstone and Port Colborne. From Port Colborne eastward, the railway will run south of Sherkston, north of Crystal Beach, east of Ridgeway and past Crescent Beach and Erie Beach to Fort Erie, thence northward to Central avenue, Bridgeburg. The length of this proposed line is 28 miles and the estimated cost $2,208,716.

Eight municipalities carried the necessary by-laws in January, 1917, but owing to unnecessary paralleling which would otherwise be caused, no work can be undertaken until the route of the Niagara-St. Catharines line and the disposal of the G.T.R. have been decided.

Sandwich, Windsor and Amherstburg

For three years the municipalities of Sandwich, Windsor and Amherstburg have been trying to persuade the "Hydro" to take over the operation of the Sandwich, Windsor and Amherstburg Railway, but the Detroit United Railway, who were the owners, were not prepared to sell. An attempt was made to effect a deal, but the price asked by the D.U.R. was considered too great. Later negotiations were renewed and the company decided to accept $2,039,000 in 40-year 4½% "Hydro" bonds.

Eight municipalities obtained a large majority in favor of this deal. Anderton township opposed the by-law, but the others have agreed to absorb the guarantee and the "Hydro" is now taking over and will operate the railway.

The "Hydro" has estimated the value of the lighting and power system belonging to the railway as $190,000, and that amount will be charged against the Windsor hydro-electric system and the power placed at its disposal. It is anticipated that $250,000 will soon be spent on improvements to this railway.

Other "Hydro" Railway Activities

Among other radial railway activities of the Hydro-Electric Power Commission of Ontario have been the electrification of the London and Port Stanley railway, the operation of the Peterboro street railway, and the Niagara construction railway. The last mentioned railway is one of the busiest lines on this continent. It consists of nearly 45 miles of tracks, 28 locomotives and 200 large dump cars.

The total mileage of the London and Port Stanley railway is now 44.5 miles, and the cost of rehabilitation, electrification, equipment, new buildings, park improvements, etc., up to June 30, 1919, totalled $1,234,866. This amount was provided through advances of $1,131,000 guaranteed by city debentures, and the reinvestment in the property of $103,866 from the surplus earnings of the railway.

The Peterboro street railway was acquired along with the central Ontario power system. The "Hydro" recently made minor extensions to its trackage.

B. Stuart McKenzie, consulting engineer, Winnipeg, has reported to the administrative board of the Greater Winnipeg Water District that he has investigated the section of the Shoal Lake aqueduct which is being affected by alkali, and he urged the board to undertake drainage as early in the spring as possible, stating that a certain portion of the aqueduct is in serious danger.

Applications will be received by the Board of Control of the city of Toronto until January 20th for the position of city architect and superintendent of building for the city of Toronto. Applications must state qualifications, experience, etc., and must submit references as to capability. Applications are to be addressed to the chairman of the Board of Control, Toronto, and the envelopes should be endorsed "Re city architect."

PILE DRIVING WITH MOTOR LORRY ON THE SALONICA FRONT

By Capt. L. S. Daynes, D.C.M., R.E.
Formerly of the 240th Light Railway Forward Company, B.E.F.

PREVIOUS to the allied offensive in April, 1917, it was necessary to have the main road running parallel to the Karasule-Dorian railway put into a fit state for all traffic up to 6-in. guns. This entailed the driving of several pile bridge and spans on the old Turkish road to replace those which had been previously destroyed.

The work was assigned to the various field companies in their respective areas. The crossing of the Selimb river was urgently needed, being subject to mountain torrent. The river sometimes rose from 7 to 10 ft. in less than 12 hours. The bed of the river was gravel, clay and quicksand, so a four-pile bent bridge was decided upon and the work was given priority.

The equipment supplied was a frame driver with 30-ft. leads, a 1,200-lb. hammer, and a hand-winch worked by four men. This winch was discarded after the first hour's driving and a team of horses was used, but owing to the heavy rains the ground was in such bad condition that progress was very slow.

The motor transport companies were getting uneasy, and being anxious to see the bridge completed, generously offered a four-ton Peerless lorry if we could use it. Their offer was quickly accepted. The lorry was set up on the west bank, the left-hand rear wheel was jacked up and blocked 10 ins. from the ground, and the other three wheels were snubbed and staked to the ground. The lead rope was given a turn on the brake drum inside the wheel, one man operating the loose end.

The distribution of labor was as follows: One motor driver, one signal man, one on lead rope, three on pile driver and two sharpening and putting on pile rings.

The piles used were 12 by 12 ins., 40 ft. long, and were placed in leads by the lorry. The number of piles driven was 48 to a penetration of 24 ft. Work was continuous in three 8-hr. shifts, and the bridge was completed for traffic in twelve days. None of the sappers had had any previous experience with a pile driver. After the completion of the bridge, the lorry was tested for strain or deflection of axles, and was found to be in as good condition when returned as it was when received.

NORWOOD CO. OPENS MONTREAL OFFICE

ARRANGEMENTS have been made by the Norwood Engineering Co., of Florence, Mass., manufacturers of water purification plants, mechanical filters for industrial purposes and paper-finishing machinery, to transfer their Canadian office from Cowansville, Que., to 71A St. James St., Montreal. Archambault & LeClair, contractors, Montreal, will be their representatives for the province of Quebec.

In 1914 a Canadian company, the Norwood Engineering Co. of Canada, Ltd., was organized and purchased a factory at Cowansville, Que. Owing to the war, very little filter work was obtained and the company devoted its factory to the making of shells. Since the armistice the factory has been almost entirely idle and the Norwood Engineering Co. recently sold it to the Colonial Machinery Co., Ltd., and made arrangements with that company to manufacture the Norwood products in Canada.

Last year the Norwood company completed a modern filtration plant for the town of Hawkesbury, Ont. They have also installed filters for municipal purposes at Dorval, Que., Shawinigan Falls, Que., Lindsay, Ont., and Niagara-on-the-Lake, Ont. They recently obtained a contract from the St. Maurice Lumber Co., Three Rivers, Que., for one of the largest industrial mechanical filtration plants in Canada, to filter twenty million gallons of water per day.

C. B. & C. I. CONFERENCE AT OTTAWA

Circular Letter Issued by President J. P. Anglin Definitely Changes Date to February 2nd to Avoid Conflict with Engineering Institute's Meeting

FOLLOWING is a circular letter that has been issued by J. P. Anglin, president of the Association of Canadian Building and Construction Industries, announcing the change in dates of the second annual conference of that association:—

"In order to avoid conflicting with the annual meeting of the Engineering Institute of Canada, we have decided, after consulting with members of our National Council throughout the Dominion, to alter the dates previously set for our second general conference.

"We shall now meet on Monday, Tuesday and Wednesday, the second, third and fourth of February.

"Sessions will be held in the Chateau Laurier, Ottawa, commencing 10 a.m., Monday, February 2nd.

"In view of the importance of the problems which face the building and construction industries of Canada this season, we earnestly urge you to attend this conference.

"It will be advisable for you to make your own hotel reservations early in order to obtain accommodation. Please advise our secretary, on receipt of this notice, that you intend to be present."

RECONSTRUCTION OF TRUNK HIGHWAYS*

IT would be unwise to draw definite conclusions from factors which are still indefinite in the building of roads and pavements, so only a report of progress can be made by the committee† on "Reconstruction of Narrow Roadways of Inter and Intra State Trunk Highways with Adequate Foundations and Widths for Intensive Motor Truck Traffic."

In our preliminary report we subdivided our topic into the following heads as being best adapted for our discussion:—

1. Width (a) of the pavement, (b) of the shoulders.
2. Drainage (a) surface, (b) sub-surface.
3. Foundations (a) of new construction, (b) of previous construction.
4. Pavement surfaces.
5. Desirability of maintaining traffic during construction.
6. Economic improvement of line and grade.

We realize that in the choice of these elements for discussion, we have restricted the scope of our work. The line had to be drawn somewhere and the topics above may be interpreted broadly enough to cover the essentials of our subject.

Width

We reaffirm our recommendation on width; that is, that the paved surface of the roadway on trunk highways should be at least 20 ft. in width. For each additional line of traffic, 9 ft. more should be added.

We recommend that the minimum of the shoulder be 5 ft. except in cases where new right-of-way is to be acquired; then the additional width of shoulder should be at least 9 ft. in order that, should additional traffic require it, four lines of traffic may be accommodated without requiring additional right-of-way.

Drainage

We reaffirm our recommendation that the present drainage systems be examined and placed in such condition that they will function properly. Such additions should be made as are necessary to keep the sub-grade dry.

We suggest that where under-drains are necessary, that they be placed alongside of the pavement and not directly under it. The advantage of this method is that they can be cleaned without disturbing the pavement surface, and to a large extent safeguarded from vibration, which has a tendency to fill them. It has been found in many cases that a line each side of the pavement requires less linear feet of drain than a single line with spurs running under the pavement.

Foundations

Where of new construction, we reaffirm our recommendation that all foundations be of concrete or other suitable material. We do not recommend thickness for the different kinds of foundation, because the data in regard to experiments being carried on by the federal government are not yet available. Valuable as these will be, we believe that before definite recommendations are made, they should be supplemented by reports of traffic census and service conditions on many types of road now in use, in order that we may properly anticipate the motor truck need of the future.

Where the present pavement can be utilized, we recommend that the widening be of the same kind of construction as the portion to be utilized. Where, however, it appears feasible to anticipate future needs, then we recommend that the widening be of a type appropriate to them. It is suggested that when widening a pavement, edging be used to prevent lateral movement.

No definite conclusions have been formed as yet with regard to bituminous macadam foundation. The cases that have been brought to the attention of the committee are so limited in extent that we are not prepared to make a definite recommendation at this time.

Pavement Surfaces

We recommend that pavements on trunk line highways be of concrete, brick, wood block, stone block, asphalt block, bituminous concrete of the mixed type, or sheet asphalt.

Maintaining Traffic

We wish to suggest that all detours be made adequate for the traffic that they must carry; that they be maintained during the time of detour; and that they be put in passable shape at the completion of the work. The expense of the detours is to be assumed by the governing body doing the main construction work.

We also suggest that where there are two main lines in the same direction between two centers of population, only one should be improved at the one time, in order that traffic may have one through route at its disposal.

We reaffirm our statement that the best possible methods should be used to maintain traffic.

Line and Grade

We recommend a thorough study of line and grade in order that sharp turns and steep grades may be eliminated at the time of reconstruction.

It is suggested that greater safety may be had by cutting back existing banks on the inside of curves, thereby giving greater sight distance. In all reconstruction work, curves should be eased to give greater sight distance.

*Report of committee to American Road Builders' Association.

†H. Eltinge Breed, chairman; Prof T. R. Agg; Maj. Fred. A. Reimer; W. G. Thompson; Lt.-Col. W. D. Uhler; and Chas. M. Upham.

There is a revival of plans originated nearly two years ago to extend the high pressure and domestic water distribution system of Winnipeg. Tests have been carried on extensively during the past year by the city engineer's staff in order to determine the necessity of increasing the pressure and the capacity of the mains. Several additional mains are recommended, including an 18-in. main from the central pumping station along McPhillips, Maryland and Notre Dame streets. Alterations to the McPhillips street station will cost $22,075, and to the high pressure plant, $6,000, with an additional $25,000 for a 10,000,000-gal. pump.

IMMEDIATE IMPROVEMENTS TO GUELPH'S WATER SUPPLY TO COST $140,000

AFTER a careful study of the entire situation, and having regard both as to efficiency and economy, says F. McArthur, city engineer of Guelph, Ont., in a report to the water works committee of that city, I am of the opinion that the work outlined in the following paragraphs will place the water supply of Guelph in first-class condition. I would, therefore, make the following recommendations:—

That the springs in galleries 1, 2 and 3 be opened up and developed to their full capacity; spring basins constructed to properly protect these springs; and the connections from these basins to the main pipe line made water-tight.

That the springs in galleries 4, 5, 6 and 7 be developed to full capacity; spring basins constructed; and the collecting galleries connecting these springs to the central basin opened and the trench wall on the lower side treated with an application of clay puddle, in order to divert the subterranean flow into the collecting pipes; the top two feet of backfilling be also made of clay puddle in order to keep out as much of the surface run-off as possible; and also that the branch lines connecting the central spring basins with the main conduit be made water-tight.

To Reconstruct Main Conduit

That about four or five of the largest of the springs which have not yet been touched, be developed in a manner similar to that described above and connected up with the pipe line.

That the entire main conduit, with the exception of the short cast-iron sections from the lower end of the inverted syphon to the head springs, be reconstructed, using wood pipe in place of sewer pipe. It may be that when the entire line is stripped, some short sections in the high ground will be found in fairly good condition and admit of such repairs as would make them perfectly tight. In such instances it would not be necessary to replace the pipe.

That the sections from the lower end of the inverted syphon to the reservoirs be stripped. If these be found in reasonably good condition, the leaks which do exist may be sealed and thus avoid the necessity of replacing the pipe with other material. From the investigations made this would appear possible.

That the cracks in the reservoir be sealed and the walls and floors treated with an application of water-proofing of some approved material.

That a measuring weir, equipped with an automatic recording device, be constructed where the conduit enters the reservoirs.

That a venturi meter be placed on the force main at the pumping station.

I have not yet at my disposal sufficient information to give an accurate estimate of what the works as outlined above will cost, but as near as I can figure at the present time it will require $100,000 to effect these improvements.

Mandatory Orders Issued

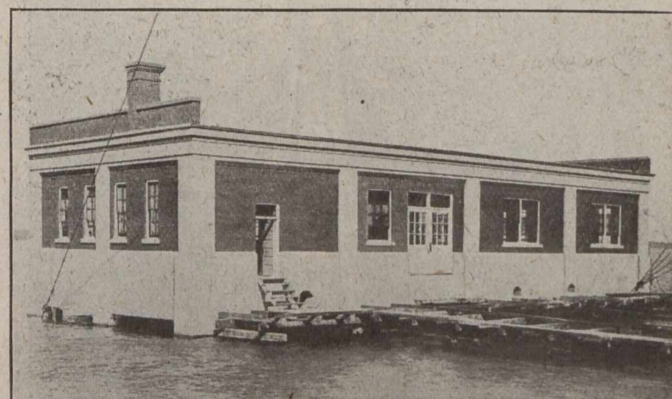
The conditions as set out, more or less fully above, are well known by the provincial health authorities, and when I made application to the provincial board of health for permission to raise money to place the water supply system in a proper condition, the board not only gave this permission but issued mandatory orders which empower the city to proceed with the work and raise the necessary funds without having to submit a by-law for the purpose to the ratepayers.

The mandatory orders state that the provincial board of health is of the opinion that it is necessary in the interests of the public health that new pumping equipment, comprising one 750-gal.-per-minute pump, one 1,350-gal.-per-minute pump, and one 2,100-gal.-per-minute pump, together with the necessary valves, piping, motors and other appurtenances, be installed, together with alterations and repairs to pump house and improvements to water supply system, at a total estimate cost of $35,000, and also that the following equipment be installed: Low-lift pump for the purpose of pumping water from the river to pumping well in case the reservoirs run dry; and in connection therewith an auxiliary chlorine disinfection apparatus to especially treat the water taken from the river; also for the necessary renewal or repair, as may be found advisable, of the supply conduit; and the construction of basins and other works for the needed development of the main springs; and for their control and protection; at a total estimated cost of $105,000.

Letters to the Editor

AMHERSTBURG FILTER PLANT

Sir,—We notice that your issue of December 11th has a short article on the Amherstburg filter plant. The article gives us credit which is not due us, and we would appreciate it if, in justice to Brunner-Mond, Canada, Ltd., you would correct the portion of the article which states that the plant was constructed by the Foundation Co., Ltd., of Montreal,



PUMP HOUSE FOR BRUNNER-MOND, CANADA, LTD.

for Brunner-Mond, Canada, Ltd. This work was carried out by Brunner-Mond, Canada, Ltd., themselves, and all the credit for it belongs to them.

The work which we did for them was closely associated with the filter plant, and we are enclosing herewith photograph which shows the pump-house which we designed and built for them. This plant is built in the Detroit river and pumps the water from there for the filter plant.

FOUNDATION CO., LTD.,
Per L. A. Wright.

Montreal, Que., January 9th, 1920.

LET YOUR CONTRACTS EARLY!

Sir,—I notice in your issue of December 4th, in the Construction News Section, under "Water, Sewage and Refuse," an item re "Drumheller." The work was done under contract with the writer, and the reason for the non-completion this year was the delayed delivery of the pipe especially, and the fittings generally. I think this an opportune time to impress upon your readers the advantage of getting their programs ready and their contracts let early in the season, for no doubt a great many of them are in positions of advantage in furthering this. I am speaking more particularly of the west, on account of the distances to material markets of this nature, for the common practise has been to keep "putting off," resulting in a grand rush at the finish of the working season. Drumheller's experience is a result of this practice, and certainly should be avoided. One extension, of about a half-mile, runs to their new hospital and had to be left over.

C. L. DE VALL, General Contractor.

Edmonton, Alta., December 12th, 1919.

CONCRETE IN WATER WORKS CONSTRUCTION

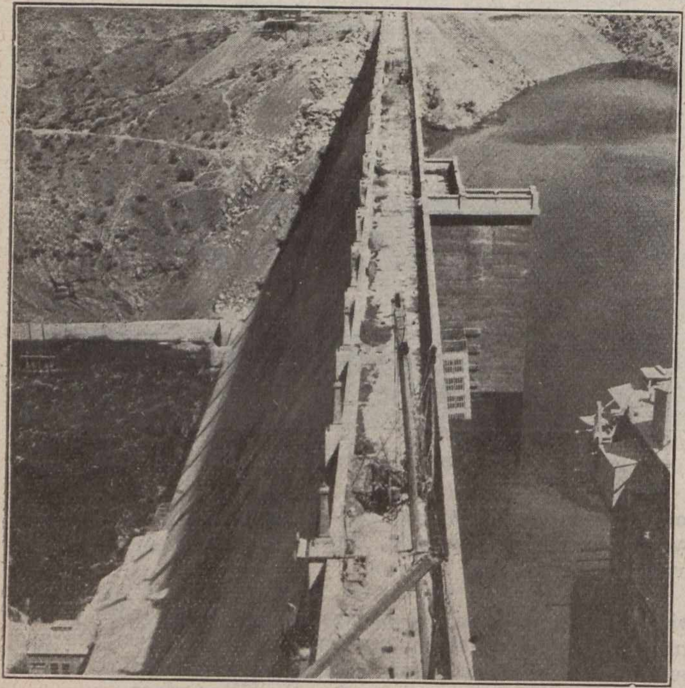
Its Use in Dams, Reservoirs, Pipe, Filters, Pump Houses, Standpipes and Tanks—Paper Read Before Iowa Section, American Water Works Association

By A. C. Irwin
Engineer, Structural Bureau, Portland Cement Association

CONCRETE has been used very extensively in various parts of water supply works such as dams, reservoirs, pipe lines, tanks, standpipes, filters, settling basins, power houses, etc. Obviously, a detailed discussion of all these is beyond the limits of a single paper and it will be necessary to confine the discussion to very general terms in order that we may touch upon each of these items.

Dams

Dams for impounding water are very generally of concrete. Concrete dams are usually cheaper than cut-stone



Gravity Type Dam, 1,674 Ft. Long, 318 Ft. High

masonry dams and allow the utmost flexibility in meeting special local conditions.

Earth dams, though sometimes low as to first cost when filling material may be excavated from side hills and dumped directly into the dam site, nevertheless have inherent weaknesses. Water flowing over the crest of an earth dam under flood conditions usually marks the failure of the dam. The activity of boring animals has also been responsible for earth dam failures since seepage or a small leak soon grows into a washout unless observed and corrected.

Concrete cores in earth dams constitute a step in the right direction and sometimes make the earth dam justifiable, but cannot be said to satisfy all the requirements of permanent dam construction under all conditions. Such a dam may fail by overflow or by a slide of filling material.

Concrete dams may be divided into four general types: (1) Gravity dams; (2) simple arch dams; (3) multiple arch dams; and (4) buttress and slab dams.

Choice of the type best suited to any particular case must be the result of thorough investigation and consideration of all of the local conditions.

Some of the highest and most massive dams in the world are of the gravity type. However, for long and relatively high dams the selection of this type has usually been due to certain very favorable local conditions as to supply of

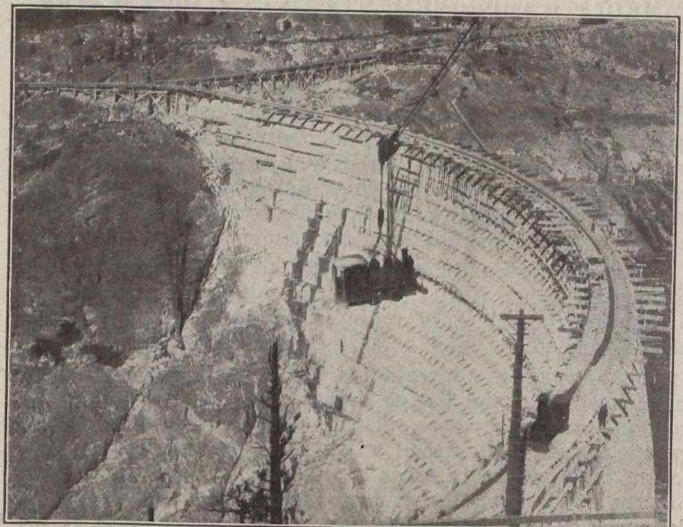


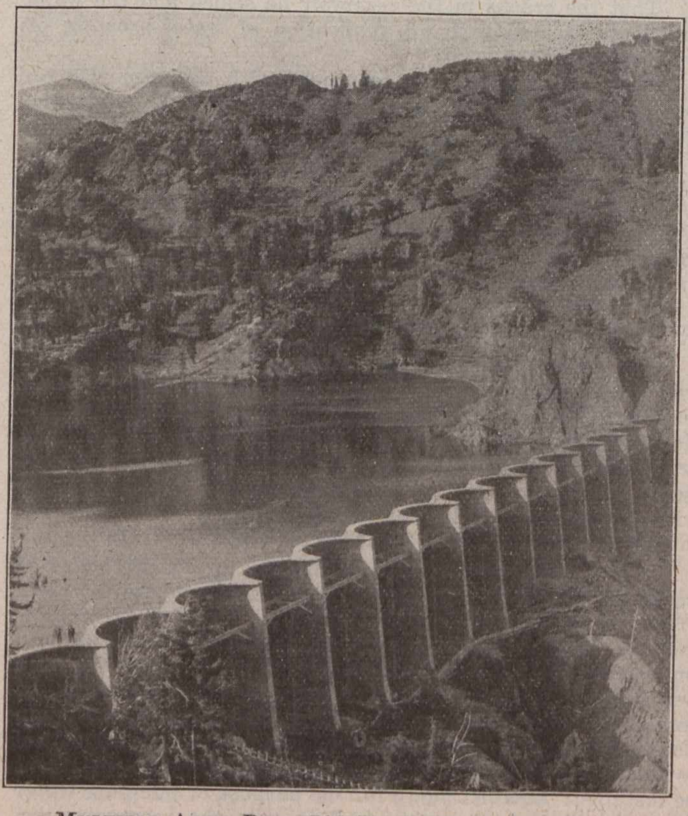
Photo copyrighted, International Film Service Co.

Arch Dam, 600 Ft. Long, 260 Ft. High

materials in large quantities or to a lack of sufficient investigation of other types.

Gravity Dams

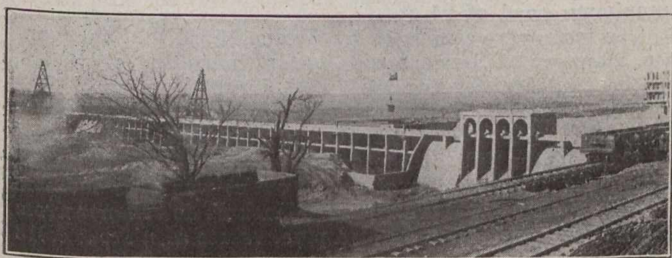
The gravity dam, of course, maintains its position and resists the thrust of the water by virtue of its great weight. Foundation conditions for high and heavy gravity dams must be very favorable in order to assure success within economical cost limits. Foundation conditions which, because of seams, will allow water to get under the dam or which are favorable to disintegration or erosion, require special treatment such as the construction of a deep cut-off wall under the base of the dam proper, filling the seams in the rock with grout and the construction of aprons both above and below the dam. The upward pressure exerted by water under the base of a dam may be responsible for failure. However, where foundation conditions are favorable, the gravity type will usually be found economical for relatively long and low dams.



Multiple Arch Dam, 700 Ft. Long, 84 Ft. High

In this connection it may not be out of place to discuss briefly the use of plums, or large stone, in gravity dams. Difference of opinion relative to the advisability of using plums exists among engineers, but a decision in regard to this point usually may be reached by considering the economies of the particular case.

Where the section of the dam is great, and if large stones are available at the dam site, together with proper handling equipment, plums may be used. These, however, should be kept at least one foot from the face or back of the dam, and care should be observed in embedding them to see that no air pockets or hollow spaces exist, especially under the plums. In specifying the use of large stones in gravity dams, it is safe to specify that the plums be limited to about 20% of the volume, and that in proportioning the mixture the plums be considered as so much coarse aggregate.



AMBURSEN BUTTRESS-AND-SLAB TYPE DAM

Simple Arch Dams

Where a high dam is required to close a narrow opening between solid-rock side-hills, a simple arch dam will usually be found most economical. The load is uniform horizontally and exactly known at all points of the height. This enables the engineer to evolve an economical design.

It has been argued that the flow of water over the spillway or through the flood pipes of a dam sets up vibration which in the end proves disastrous. There is, however, little or no data obtained from experience to justify such apprehension.

All types of concrete dams except the gravity type are, of course, reinforced, and the existence of countless reinforced concrete bridges and buildings which are constantly subjected to vibration is sufficient proof of the ability of this material to withstand whatever vibration is set up in dams.

Multiple Arch Dams

The multiple arch type consists of a series of arches with inclined axes supported by buttresses spaced from 30 to 50 ft. apart. The buttresses take the thrust of the arches and are braced horizontally by struts in continuous lines. Some very high dams of the multiple arch type have been constructed and plans are now being prepared for one in California which will have a height of considerably over 100 ft.

This type, as well as the buttress and slab type, is especially adapted to locations where the foundation is rather seamy or unsuited to the gravity type because of the great expense involved in the preparation of the foundations. The footings of the buttress and the lower end of the arches constitute the only points of contact between the foundation and the dam, and these limit unfavorable foundation conditions to relatively small areas, so that these conditions can be easily cared for.

It is apparent that if one of the arches of a multiple arch dam fails, successive failure of the remaining arches of the dam may take place. This possibility can be obviated by constructing every fourth or fifth buttress as a large pier to take the entire thrust of an arch on either side of it, unassisted by the thrust of the adjoining span, or by designing some of the horizontal ties between buttresses to take the thrust of the arches.

The multiple arch type has an advantage over the buttress and slab type in that it affords economy of construction when foundation conditions or great height require that the buttresses or piers be placed at considerable distances apart. In other words, the additional cost of longer spans of the arch type is much less than where concrete slabs are used.

Construction of expansion joints is, of course, a rather difficult problem in multiple arch dams, and it is very doubtful whether they need be constructed at all, since expansion and contraction merely produce deflection of the arch rings.

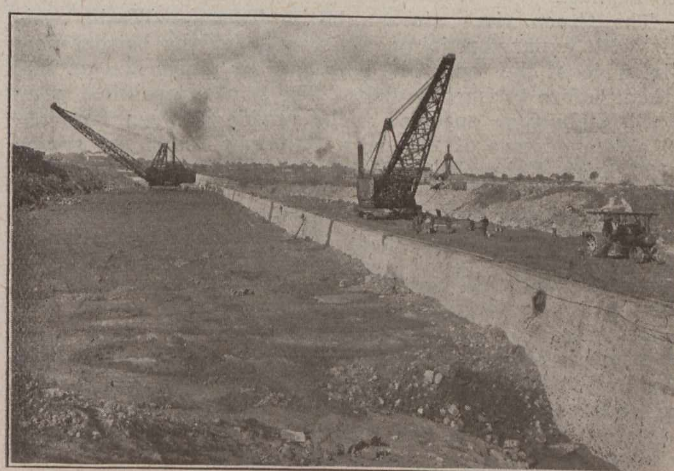
Buttress and Slab Type Dams

This type is especially adapted to long and low dams where the foundation conditions are more or less uncertain. It consists essentially of buttresses or piers, the spacing of which need not be uniform, carrying slabs in an inclined position. The principle, of course, is the same as that of the well-known counterfort retaining wall but the design is much simpler and more accurate, since the thrust of the water is accurately known. In this type of dam, expansion joints are easily constructed and variations in the distance between buttresses to take care of unfavorable foundation conditions at particular points can easily be made. High buttresses should be braced together with horizontal struts or with diaphragms.

Reservoirs

Reservoirs are usually a part of the water supply system. Impounding or natural reservoirs, formed by damming the flow of a stream are common, and the cost of them, in so far as construction is concerned, amounts for the most part to the cost of the dam.

In planning an impounding reservoir, an investigation should always be made of the practicability of impounding more water than is necessary for the supply. The water over and above that required for supply purposes can be utilized to generate power, which will very often justify a much higher and longer dam and the construction of such additional power plant facilities as are necessary. The power so developed may be used for lighting or power purposes in the city served, and is usually a large factor in encouraging the location of manufacturing enterprises, providing sufficient power at a reasonable cost may be had.

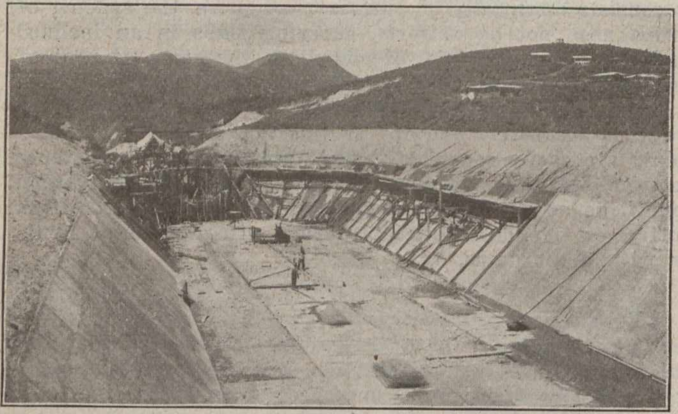


CONSTRUCTING EARTH DAM WITH CONCRETE CORE

In addition to large storage reservoirs the distribution of water for a large city will usually require secondary or distribution reservoirs, usually on a hill or high point of the surrounding country.

Prevention of seepage losses from reservoirs is an important item and especially so where the water is pumped into the reservoir. Seepage losses then constitute a constant loss which is directly chargeable to construction and which must be made up in water rates charged. Such losses should be prevented by making the sides and bottom of the reservoir as impervious as practicable. Paving with stones laid in mortar has been resorted to, but it is obvious that concrete linings offer a very attractive and efficient means of preventing seepage losses. Concrete linings are admirably adapted to any type of reservoir whether of vertical or sloping sides. If the reservoir is entirely above ground it will of course be nothing more than a tank, but the usual construction provides that the top of the reservoir be even with or only slightly above the surface of the earth backing.

For slope wall reservoirs the incline is usually from 1½:1 to 2:1. The thickness of concrete lining for slope wall reservoirs is from 4 to 8 ins. and is usually placed in slabs from 10 to 20 ft. square, depending on whether or not the slabs are reinforced. The slabs are usually laid with butt joints, with their ends resting on a sill and the space



5,000,000-Gal. Concrete Reservoir

between the ends of the slab filled with some elastic material to form an expansion joint. Expansion joints between slabs have been very successfully made by calking with oakum and overlaying the joints with strips of burlap, well painted with asphalt.

The Green river storage basin, Tacoma, Wash., was built with expansion joints ¼-in. wide at the bottom and ¾-in. wide at the top. The sills had tar paper laid on top of them before taking the slabs. The joints were filled with refined asphaltum, specified to be pliable between freezing and a temperature of 200 degs. Fahrenheit, and not sticky at 100 degrs. Fahrenheit. This joint has proven very satisfactory.

As a general proposition slope wall reservoirs as low as 300,000 gals. capacity may be built more economically than one having vertical walls.

Concrete Pressure Pipe

I have a suspicion that some at the outset are skeptical in regard to the use of concrete for water pressures involving heads of 100 ft. or more, but as a matter of fact concrete pressure pipe has been successfully used with pressures up to 90 lbs. per sq. in., and there is no doubt but that the pressure which may be handled by concrete pressure pipe is limited only by economy in design and construction.

There are certain requirements which pressure pipe must fulfill, among which are the following:—

(a) Ability to resist external and internal pressures; (b) low coefficient of friction; (c) minimum leakage; (d) low maintenance charges; (e) permanency; (f) provision for contraction and expansion; (g) low cost consistent with the above requirements.

Concrete pressure pipe designed to withstand internal pressure will be found to be strong enough to withstand all ordinary external pressures, as from backfill, to which it will be subjected. Reinforcing steel is, of course, placed in the shell of concrete pipe to asist in withstanding the bursting pressure, and some designers use sufficient steel to take the entire bursting pressure. This steel is, of course, not in continuous sheets and therefore requires no complicated and extensive process of manufacture. For long lines of large pipe, the pipe is constructed in place or at a convenient point near the general location of its use. Thus transportation expenses are low and the manufacture of the pipe can be given continuous inspection.

It is not my purpose to discuss the design of concrete pressure pipe, but I do wish to say that regardless of whether or not the strength of the concrete itself in tension is taken into consideration in design, it nevertheless does exist and contributes no small part of the actual strength of the pipe. Where it is not considered in the design, this strength of the pipe affords an extra factor of safety.

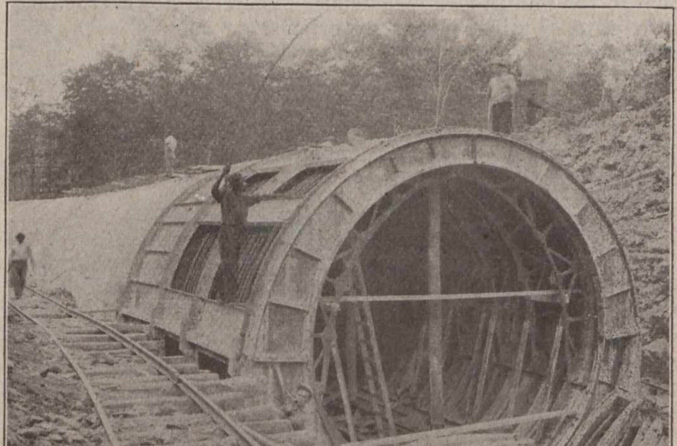
Correct methods of manufacture will produce concrete pipe with a low coefficient of friction and negligable leakage. A friction test was conducted on the Sooke lake water supply conduit for the city or Victoria, B.C. The pipe line is of 42-in. diameter, 27½ miles long, and contains 50% of curves with radii varying from 90 to 150 ft. There are in the line seven siphons having a maximum head of 94 ft.

The tests were conducted by Wynne Meridith, San Francisco, manager of Sanderson & Porter, consulting engineers, and the coefficient of friction (*n* of Kutter's formula) was found to be 0.01058 at the inlet end, and 0.0117 at the outlet of the 27½ miles, with the pipe running full at the inlet and six-sevenths full at the outlet. With 20 ins. of water at the inlet, the water level at the outlet was 19½ ins.

Some years ago Marx, Wing & Haskins determined from gaugings on a 6-ft. steel riveted pipe, values of *n* from 0.013 to 0.018.

The reinforced concrete pressure pipe line constructed as a part of the Gunpowder water supply for the city of Baltimore consists of 5,000 ft. of 108-in. diameter pipe and 3,000 ft. of 84-in. diameter pipe. This line carries 120,000,000 gals. daily, and when tested under a head of 85 ft., the leakage in 24 hrs. on the entire line amounted to 13,000 U.S. gals., or less than two-hundredths of one per cent.

Contraction and expansion will occur in pipe of any material, and suitable expansion joints must be provided in concrete pressure conduits if the leakage at joints is to be kept at a minimum. Such joints have been developed for use in precast reinforced concrete pipe and have been successful in practice. As the construction of pipe lines is usually done at temperatures higher than that of the water



Constructing Reinforced Concrete Aqueduct

which will flow through the conduit, it necessarily follows that contraction will occur. This will produce cracks at the joints through which leakage of considerable amount will occur if provision has not been made to care for the contraction.

An expansion joint that has been found to take care of expansion and contraction consists of a crimped copper band continuous throughout the circumference of the joint. As the pipe contracts, the crimp opens; and as the pipe expands, the crimp closes. This joint is used in pipes of 36 ins. to 108 ins. in diameter.

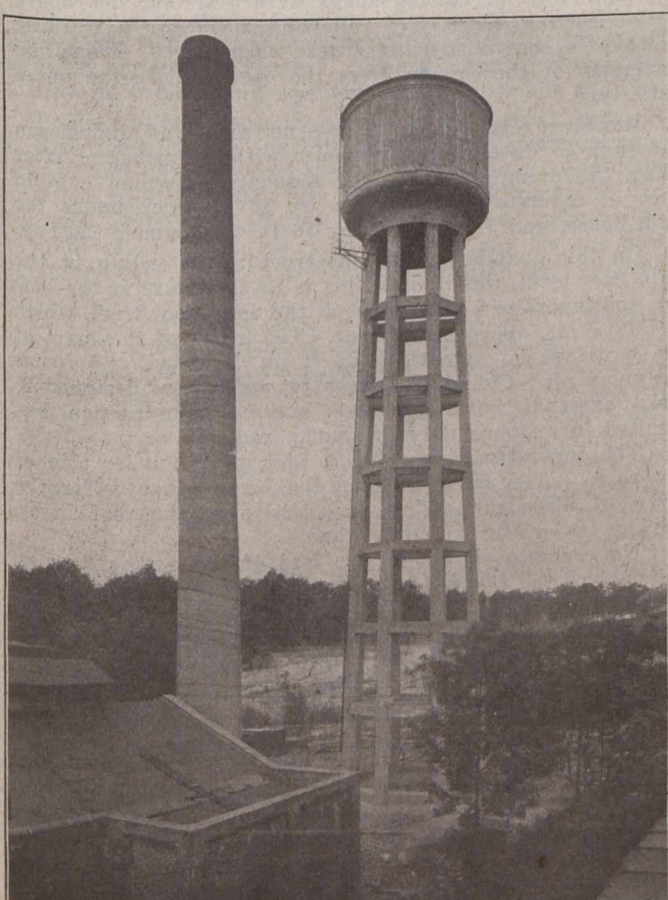
It is well to reduce the number of joints by making the units as long as practicable, and each unit should be equipped with an expansion joint. Trench conditions, such as bracing and handling, etc., will usually determine the practicable length to be about 8 ft.

Pipe are cast on end and the molds of sheet steel and cast-iron must be erected on substantial base or foundation of reinforced concrete, the surface of the foundations being truly level, and finished so that when the cast iron base mold is set and the sheet steel casings are erected, the casings will be truly vertical.

In the manufacture of most pre-cast concrete pressure pipe, it is necessary to use 1 volume of portland cement, 1½ volumes of sand and 2½ volumes of coarse aggregate, and this means that 2½ barrels, or 950 lbs., of cement is used per cubic yard of concrete. In the manufacture of pre-cast pipe for the Winnipeg aqueduct, it was found necessary to use but one sack of cement to 3.8 cu. ft. of mixed aggregate, or approximately two Canadian barrels, or 700 lbs., of cement per cubic yard of concrete.

This minimum quantity of cement was found practicable owing to the very excellent grading of the mixed aggregate which was supplied by the Greater Winnipeg Water District from their own pit, at which was located a screening and remixing plant. The concrete is mixed to a quaking or jelly-like consistency, which will easily flow to place when slightly puddled.

The mortar for spigots is made of 1 part cement to 2 parts sand, and is mixed to the same consistency as the concrete, so as to obtain the same rate of setting as nearly

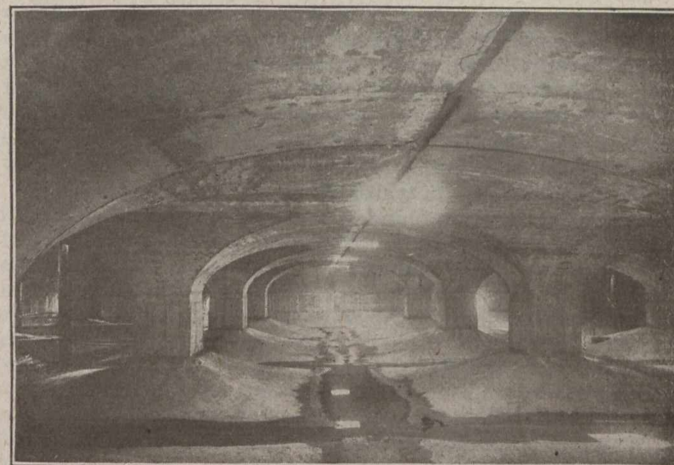


Concrete Chimney and Concrete Water Tower

as possible. As the spigot mortar settles, more mortar is added until the settlement ceases, when the joint is finished.

Concrete pressure pipe may be successfully manufactured in cold weather with proper appliances for supplying heat and moisture. In fact, where high speed of manufacture is desired, steam curing should be resorted to and this may be carried on regardless of temperature conditions. For the manufacture of large sizes, appropriate handling equipment and appliances should be provided, such as traveling derricks, locomotives, cranes and light industrial tracks, cars and locomotives.

Good pipe under a test pressure of 50 lbs. per sq. in. should show a leakage of only about 335 Imperial gallons per mile per 24 hrs. This result can be secured by the use of



Montebello Clear-Water Reservoir

well designed equipment, well graded aggregate, proper methods of manufacture and unremitting care.

In Seattle a trunk water conduit operates under a head of 90 ft. and every pipe was tested to 2½ times the working head. Tests were made on short sections of completed line and the leakage was nil.

In addition to the copper-expansion-joint type of reinforced concrete pressure pipe, there has recently been developed a new type of expansion joint which is very efficient. This joint is proposed for reinforced concrete pressure pipe in diameters of 10 to 48 ins. and in lengths of 12 ft., each section of pipe being provided with cast iron spigot ring at one end and a cast iron bell ring at the other, the rings being cast into the concrete.

The faces of the rings bear upon a lead gasket and are accurately machined, providing a very true circular surface. The spigot ring is provided with a seat for the gasket, the object being to provide a greater thickness of gasket at the seat and to prevent the gasket being withdrawn when the pipe contracts or is deflected.

The lead gasket consists of a thin lead pipe filled with fibre and is compressed into the space between bell and spigot when each succeeding length of pipe is shoved home. A light rope of cotton or jute is placed and a weak joint filler of cement mortar is applied, filling the calking space. The joint has remained tight under test at 110 lbs. pressure per sq. in.

Tanks and Standpipes

Familiarity with the success that has been attained in the use of concrete pressure pipe prepares us at once to accept the reinforced concrete standpipe or water tank. Here again we have simplicity in design because of accurate knowledge of the pressures to be withstood. Obviously, if concrete pipe can be constructed uphill and down, and with curves in and out, to withstand over 100 ft. head of water pressure, there should be no difficulty in building a standpipe of like height, and in fact many examples are in existence of concrete standpipes of much greater height than 100 ft.

The Fulton standpipe, at Fulton, N.Y., is 100 ft. high to overflow and is 40 ft. in diameter. The circular concrete tower and tank at Middleboro, Mass., is 123 ft. high. The concrete cylindrical tower and tank of the Central of Georgia Ry., at Savannah, is 188 ft. high.

The supporting tower of elevated tanks may be either of concrete framework or of the cylindrical type. The latter has a number of advantages. The same forms may be used to construct the supporting tower as are used in the construction of the tank support. These forms are usually what are known as moving or sliding forms; that is, they move gradually upward as the concrete is being placed, thus giving a continuous monolithic concrete shell without any construction joints whatever. In addition to this particular advantage in construction, the cylindrical tower furnishes a housing for the riser pipe which protects it from low temperaturess and may even be utilized for storage or office purposes.

In the design of concrete standpipes, and in fact in the design of such structures of any material, the critical point is usually found in the junction of the shell with the base.

The Fulton tank above referred to is an example of a successful method that has been used to take care of the expansion and contraction at the bottom of a standpipe shell due to variations in water level and temperature. The central portion of the foundation for this tank was constructed higher than the point of contact between the bottom of the shell and the foundation. Thus, space was formed between the inside of the shell and the central raised portion of the foundation. This space was filled with an asphaltic material. The shell of the standpipe proper was not connected to the foundation but rested on a slip joint which allowed movement at the base of the shell to provide for change in the diameter of the standpipe due to variations in pressure. The top of the concrete foundation on which the shell rests was first covered with graphite paste, and sheet copper was laid immediately on top. The walls of the standpipe thus rest upon the sheet copper plate, which is free to move on the graphite.

This standpipe was constructed with sliding forms and was completed from foundation to overflow in 52 working days. It has been in constant use since 1913 and has proven entirely satisfactory.

Filters

Filters, whether of the intermittent or mechanical type, have quite generally employed concrete. The intermittent type requires large areas of filter beds, much attention and a very considerable first cost. I believe also that it is safe to say that a mechanical system of filtration is the one usually adopted in modern water works construction. A very complete and extensive plant of this kind was installed some years ago for the city of Baltimore at Lake Montebello.

Special features of the Montebello filters include handling of wash water at settling reservoirs, head house arrangement, pumping station and covered reservoirs. Complete accounts of this notable water supply development have been previously published in the technical press, and I shall therefore confine myself to a very general description of certain portions of it.

About 50,000 cu. yds. of concrete were used in the construction of the filtration plant, and most of this concrete withstands water pressure or heavy loads. All buildings are of similar design and have reinforced concrete framework.

No waterproofing compounds were used in these structures, as good workmanship and materials were relied upon for securing waterproof work. Steel forms were used in the construction of the groined arches and walls and columns, but were not found to be entirely satisfactory for columns and arches on account of difficulty in erecting and removing them. The steel forms for walls were entirely satisfactory.

It is worth while to note in passing that at the present time steel forms are available for construction of this sort, which add a great deal to the ease with which it can be accomplished, and I feel quite sure that in the design of such a filtered water reservoir at the present time, a flat slab construction would be used in place of the groined arches and that standard steel forms for columns and slabs would be used.

The concrete filter tanks of the Montebello filters are 32 to 35 ft. outside dimensions and are supported on the reinforced arches forming the roof of the filtered water reservoir.

The head house of the Montebello filters is also of concrete and a feature of it is the elevated tower 4 ft. square and 80 ft. high, containing the chemical storage bins. This tower has 15 bins which will each hold about two carloads of chemicals.

The pumping station is circular in plan, 84 ft. in diameter, with its walls concentric with the intake shaft and 16 ft. in diameter. The intake shaft is located with its centre over the axis of a 12-ft. tunnel that brings the city water supply from Lock Raven. The bottom of this tunnel is 49 ft. below the floor of the pump pit, or 72 ft. below the surrounding ground level.

Pump Houses

The use of concrete in the construction of buildings of a general nature is too well known to need any particular comment. A pumping station, of course, has some special features required by the fact that it houses machinery and boilers. A pump house best adapted to its purpose, therefore, is one which will be free from vibration, furnish adequate light and afford security against fire. These requirements are all most ideally met by concrete.

An interesting example of pump house construction is that recently completed for the city of Louisville, Ky. This pumping station is located on the bank of the Ohio river just east of the city's old pumping station. As the structure had to rest on sand and gravel, and as it was necessary to build the foundation so as not to affect the adjacent buildings, the open-dredging-well caisson method was used. Outside dimensions of the caissons were 90 ft. square by 33 ft. deep, with a bay on the river side 61 by 22 ft. and 33 ft. deep. Interior cutting edges were 5 ft. 2¼ ins. above outside cutting edges, thus allowing room for a working chamber in case obstructions were encountered, compelling conversion of the caisson from the open well to the pneumatic type.

However, this contingency did not arise and the caisson was sunk to its final resting place without mishap. After filling the dredging wells, the foundation became a solid block of concrete 90 ft. square by 28 ft. thick under the main house, and 51 by 22 ft. by 16 ft. thick under the bay.

On this foundation the substructure, extending to the main floor level, was built. This is 83 ft. square at the bottom and tapers to 75 ft. square at the main floor level, which is 7 ft. 6 ins. above high water. The inside of this part of the structure is cylindrical, 67 ft. in diameter, and forms the pump pit. Cylindrical pump pit walls were designed to resist external water pressure, and the construction has resulted in an absolutely dry pump well.

The superstructure is 48 ft. high to the under side of the roof. The walls between the large windows form a series of piers supporting, in addition to the roof loads, runway girders for a 30-ton crane.

No concrete shows on the face of the superstructure, but back of the 6 and 9-in. ashlar surface is a concrete wall 30 ins. thick, which in reality amounts to piers between the high windows and, as previously noted, supports the runway girders for the 30-ton crane. Stone facing was used in order to make the new station as much like the old one as possible in external appearance.

Fuel Oil Tanks

At the present time there is a very marked tendency to use fuel oil in the place of coal for the generation of power. There are certainly many advantages to be derived from the use of this fuel. It does away with a considerable amount of the handling expense, leaves no ashes and cinders to be disposed of, and produces but relatively little smoke. Firing with fuel oil is a simple matter and effects economy in labor.

In order that fuel may always be available and that the purchasers of it may have the opportunity to take advantage of market conditions, storage capacity should be provided. The storage of fuel oil has been, and is still, subject to considerable discussion, especially in regard to the effect that the presence near buildings of such combustible material has on the fire hazard. It is my understanding that there is an almost universal practice to add a very heavy penalty because of the presence of fuel oil in open tanks above ground. This penalty, however, is not added when the oil is stored in concrete tanks below ground. There are further arguments for the underground storage tank. Such tanks do not occupy space near the power plant, which space is usually needed for other purposes. They are entirely out of sight, as well as protected against the likelihood of fire from lightning or from other origin.

The design and construction of concrete oil tanks is little or not at all different from concrete water tanks. In fact, it is usual to design them for ordinary hydrostatic pressures, and experience shows that, when well constructed, entire confidence may be placed in their ability to hold the oil without leakage. Naturally, where the surface of the tank is level with the ground surface and will have to carry loads, the cover must be designed accordingly, and usually requires the use of columns which rest upon the tank bottom.

THE FUTURE OF PUBLIC UTILITIES*

IT is well known that within the last few years all material and labor required for the construction, maintenance and operation of water works systems has advanced very greatly in cost; and in addition, it is the general experience that the amount of labor output per man in most occupations has decreased, all resulting in a very much higher cost per output of service than existed before the war, which has left in its wake many problems of readjustment and reorganization, upon the wise solution of which the future of the world must be determined. These increased costs exist not only in water supply systems but in all public utilities.

Public utilities generally are a most important factor in our daily lives, ministering directly to our comfort and convenience and affecting our health. If we should eliminate the public utilities to-day, we would go back almost to the dark ages. Every one of them is essential, and rather than eliminate any of them, we could afford to pay for the services which they render, a great deal more than their present cost.

It is, we believe, a fact, however, that utility charges have not increased, because of contract or other legal limitations, or because of public opposition, in anything like the proportion that the cost of the service which they render has increased; many of them which are privately owned are in the hands of receivers; many others are struggling for their lives; and very few of them are in a position to extend and maintain their services as they would be if they could always be assured of adequate return for the services which they render.

The fact is that neither publicly owned nor privately owned utilities can be conducted to best advantage until the public, as a whole grasps the idea that every service must earn its cost and that the recipient of every item of service should always pay the full average cost of the items of service which he absorbs, leaving no portion of said cost to be carried by any who do not receive a service of some character from said utility. Once this idea is generally admitted, it will be easy to induce capital to invest in privately owned public utilities and to maintain said privately owned utilities as well as publicly owned utilities up to any standard of service which the public desires and is willing to buy.

Utilities for Scattered Populations

Much more careful study than is usually given is needed for the proper classification of the actual items of service which utilities perform, and there is a wide scope of discretion or option as to the basis of such classifications, especially in publicly owned utilities.

For instance, cities now are tending to a great scattering of population in surrounding suburbs. The cost of a water service for the well-built portion of the city, for adequate domestic and fire supply for its whole population, will be met by a certain definite service charge per meter and price per 1,000 gallons of water supplied and taxed on assessed values for surplus capacity for fire protection and increased demand; but if one extends the system to double the mileage of mains required to give adequate service to the reasonably well-built portion of the city, in order to give possibly one-fifth as many scattered premises the same character of domestic supply and fire protection, it is obvious that the rates per these various units must be higher for all, or else that one must have two or more rates, the one rate covering the actual cost for the well-built sections of the city, and the other rates the very much higher costs, due to the scattering of population in outlying areas.

Because of the great tendency to scatter population, leaving much unused property sandwiched between occasional improved areas, the actual cost of all municipal improvements and utilities is enormously increased, and property in the well-built and thoroughly served sections of many cities is allowed to depreciate in value and usefulness. More carefully and justly arranged schedules of utility rates and schemes of taxation for municipal improvements based always upon the idea that every beneficiary of every service should pay as far as possible the cost of such service, and that the service should only go to those who do pay their share of its cost, would tend strongly toward the checking of premature development of outlying and unnecessary areas, and thus allow the more consistent and thorough development of all services within such areas as are actually required for the comfortable accommodation of the whole population.

Improvements Unduly Delayed

For several years conditions have precluded anything more than the most essential extensions and developments of water supply systems, and to-day the cost of material and labor for improvements is in many cases out of all proportion to the rates which are charged for service, with the result that extensions and improvements which the growth and development of our cities really require are being unduly delayed.

Such delay often shows no obvious depreciation of service up to a certain maximum demand, or breaking point, and the people who are getting all the service they desire are always skeptical of the necessity for improvements of which the plant management is painfully aware. Eventually, however, a big fire, with inadequate water supply to provide proper protection, or a general increase in insurance rates, or deterioration in the character of the water because of the overload imposed upon the purification system, and possibly an outbreak of typhoid, brings the public to attention, and it is found that large expenditures in improvements are a few years past due and will require that many years to complete in the face of a depreciating service due to the further increasing demand while the improvements are in progress.

Water works especially, and other public utilities as well, are essential, economical and vital factors in public comfort, well-being and health. It pays to keep them up to the maximum state of efficiency which the community which they serve can afford to pay for. Both publicly owned and privately owned utilities must fail in service, and even cease to serve at all, if they are not sufficiently compensated for the service which they render to permit them to pay living wages to the large number of employees who are engaged in their service, to provide generally better conditions of employment and compensation for their employees than they have heretofore, and to earn their reasonable interest and depreciation and operating costs.

Conditions since 1913 have changed enormously. A new price level has been reached and is tending toward stabilization on a much higher level than then existed. Labor, especially, is and will remain higher. Improved methods of production or building, and economies or substitutions, it is reasonable to hope, will in some degree lower the general cost of living from its present scale, and the cost of utility developments as well, but if anything is manifest, it is the common belief that the average man must in the future obtain a better opportunity and a better share of the comforts, luxuries and security of life for the service that he renders than heretofore; and if this is to be obtained, general wages, relatively, must remain higher than heretofore.

*Excerpt from report of the Committee on Water Works of the American Society for Municipal Improvements.

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PRINCIPAL CONTENTS

ARE ABRAMS AND EDWARDS WRONG?

VERY disturbing is the assertion by G. M. Williams, associate engineer of the U.S. Bureau of Standards, in his article in this issue, that the surface area and fineness modulus theories of proportioning concrete mixtures are both faulty; but after the many logical arguments and abundant data that have been presented in support of these theories by their respective sponsors, Lewellyn N. Edwards and Prof. Duff Abrams, supported by the practical results achieved by the Hydro-Electric Power Commission of Ontario through the application of these theories in field and laboratory, engineers will be very reluctant to discard them.

As Mr. Williams intimates, it should be relatively easy for any properly equipped laboratory to prepare aggregate gradings and make tests that will prove or disprove either or both of the theories. Fortunately, arrangements are now being made for a definite series of tests, to be made concurrently and in precisely the same manner, by a number of different laboratories. These tests will be under the auspices of the Concrete Committee of the American Society for Testing Materials, having been planned at a meeting held last November in Chicago. A report of that meeting and its results was published in this column in the December 4th, 1919, issue.

It may be found to be true that neither Prof. Abrams' nor Mr. Edwards' theory will hold for absolutely all possible mixtures, but engineers will not be very seriously concerned about that, provided that they do hold true within the rather limited range of workable mixes. Mr. Williams does not definitely assert that the theories would be found faulty if applied only within the range of workable mixes, but appears to base his main criticisms upon the fact that they will not hold true for all mixtures.

Mr. Williams' article demonstrates that there is some work yet to be done in regard to these theories for the proportioning of concretes, and his criticisms will undoubtedly influence the number and character of tests made under the direction of the A.S.T.M. Concrete Committee, and may lead to certain modifications of the Abrams' and Edwards' theories.

It is certainly to be hoped, however, that the surface area and water-cement ratio theories will prove themselves in the A.S.T.M. series of tests, and it is indeed hard to see why they should not be borne out by the tests of all practical mixtures, as these theories are logical, clear and convincing, and have all the earmarks of well-founded truths.

Somewhat ambiguous reference is made by Mr. Williams to the test data offered by Messrs. Abrams and Edwards, and some readers may interpret his remarks as an impeachment of the accuracy of the data. We are sure that Mr. Williams could not have meant to call into question either the methods of testing or the validity of the data, as the reputation enjoyed by both Prof. Abrams and Mr. Edwards is sufficient guarantee in this respect. It is well known that nowhere have more careful and precise methods been used than at the laboratory of the Lewis Institute.

Moreover, it must be borne in mind that these theories have been actually put into practice upon a large scale by the Hydro-Electric Power Commission of Ontario, and with great success. The "Hydro" rejects Prof. Abrams' fineness modulus theory, and substitutes therefor the more direct surface area measurement, but rigidly applies Prof. Abrams' water-cement ratio theory. The "Hydro" laboratory determines the proper economical mix for the desired strength and normal consistency for the particular materials to be used, and supplies the field engineer with the proper surface area constants and water-cement ratio for those materials. Then, when the grading is changed, the field engineer can readily ascertain the proper amount of cement to use in order to obtain the same strength and workability according to the surface area theory, it being assumed that he maintains the same water-cement ratio. If the "normal consistency" indicated by the laboratory be too dry to suit field conditions, as much more water can be added as the field engineer desires, without affecting the strength, provided that sufficient additional cement is used to keep the cement-water ratio constant. R. B. Young, who is in charge of the concrete research work for the "Hydro," states that this scheme is actually working efficiently in the field at High Falls and on the Queenston-Chippawa work; that concretes of uniform strengths are being obtained despite variations in grading and consistency; and that much higher strengths are being obtained (with the same amounts of cement) than are being secured from the same materials by means of the old methods of volumetric proportioning.

C. B. & C. I. CHANGE IN DATES

ENGINEERS who are interested in the annual meeting of the Engineering Institute of Canada, to be held January 27th to 29th in Montreal, will heartily appreciate the action taken by the officers of the Association of Canadian Building and Construction Industries in changing the date of the association's conference at Ottawa, which had been scheduled for January 27th-30th but which has been postponed to February 2nd-4th in order to avoid conflict with the institute's meeting.

The change in the association's dates was made with difficulty and at considerable expense, as is indicated by the fact that it was necessary for the president and secretary to telegraph approximately thirty members of their national council residing in various cities from coast to coast; also speakers in many parts of Canada; the management of the Chateau Laurier; and various provincial associations of building and construction industries, in order to avoid conflict with other meetings.

The Ottawa conference has now been arranged so that the engineers who attend the meeting of the institute will be able to go directly from that meeting to the one at

Ottawa. The annual meeting of the Provincial Builders' Association of Ontario takes place February 10th-13th, so that nearly a week intervenes between the conference at Ottawa and the meeting of that provincial body.

By its action in postponing the conference, the Association of Canadian Building and Canadian Industries again proves its desire to interest in the association all engineering-contractors and those civil engineers who deal with construction problems.

PERSONALS

A. C. GARDEN has been elected chairman of the Hamilton harbor commission for 1920.

W. J. CUNNINGHAM has been appointed superintendent of the Edmonton power plant.

J. C. MITCHELL, formerly superintendent of construction, Toronto Harbor Commission, has been appointed assistant to E. L. Cousins, general manager of the commission. F. Rockwell replaces Mr. Mitchell as superintendent of construction.

N. C. MILLS, vice-president and general manager of the Montreal Armature Works, Ltd., Montreal, has entered private practice in partnership with A. J. F. MONTABONE, Mr. Montabone has specialized in power projects, particularly for pulp and paper mills. Mr. Mills is a member of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers. Mr. Montabone is a member of the American Institute of Electrical Engineers.

ARTHUR M. CRANE, general sales manager of the New York Continental Jewell Filtration Co., has been appointed general manager of that company, succeeding the late Robert E. Milligan. D. C. Williamson, who has been responsible for the design of the company's plants and apparatus for nearly 20 years, continues as chief engineer; and E. K. Sorenson, who was assistant to Mr. Milligan for many years, remains as secretary. These three gentlemen are also directors of the company.

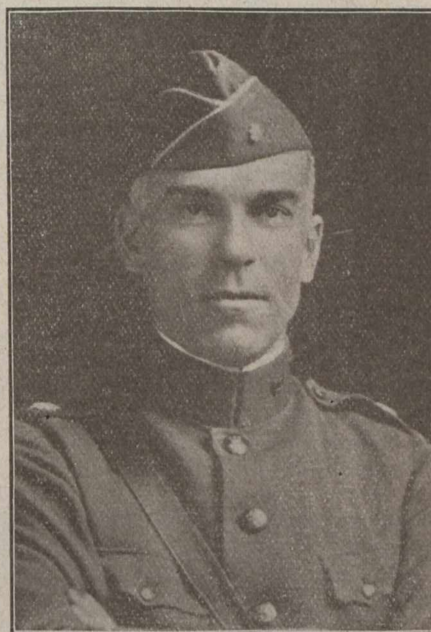
J. G. MINGLE, formerly manager of the Cleveland office of the Rust Engineering Co., Pittsburgh, Pa., has been appointed general sales manager of that company, with headquarters at Pittsburgh. Mr. Mingle is well-known in Canada, this country having been included in the territory which he "covered" from Cleveland. It was recently reported that Mr. Mingle intended to join the staff of a consulting engineer as Detroit representative, but he has decided to remain with the Rust Engineering Co.

E. R. GRAY, city engineer of Hamilton, Ont., whose resignation was erroneously reported recently in a Hamilton daily newspaper, has not resigned but has been given two weeks' leave of absence for the inspection of asphalt pavements in Toronto and Detroit. Mr. Gray also expects to visit Milwaukee to study the activated sludge process, as he intends to build a central sewage disposal plant in Hamilton within the next few years, and to carry to it all the sewage of the city by means of a proposed intercepting sewer to be laid along Burlington street.

GORDON MITCHELL, who graduated with honors in civil engineering at the University of Toronto with the class of 1915, has been appointed assistant to the superintendent of construction for the Beaver Engineering & Contracting Co., New York, on the construction of water works extensions for East Hartford Conn. Mr. Mitchell went to England toward the end of 1915 and obtained a commission in the Royal Engineers. In France he won a captaincy and the M.C. He returned to Canada last June and has since been employed by Loudon & Hertzberg, consulting engineers, Toronto.

WILLIAM GEORGE SWAN has been appointed chief engineer of the Vancouver Harbor Commission. Mr. Swan recently returned from France, where he was in the army for nearly three years as major in a railway construction battalion. He is well known in British Columbia, as for some time prior to the war he was in charge of Canadian Northern Railway construction in that province, with headquarters at New Westminster. He supervised the construction of the C.N.R.'s Pacific mainland terminals and the wharves at Port Mann, and designed the False Creek reclamation scheme. Mr. Swan is not related to A. D. Swan, of Montreal, who is consulting engineer to the Vancouver Harbor Commission.

RUSSELL W. STOVEL, who was recently appointed consulting engineer on the staff of Westinghouse, Church, Kerr & Co., Inc., was born February 22nd, 1877, in Toronto, Ont. He attended Upper Canada College, Toronto, and Ridley College, St. Catharines, and graduated in 1897 as a gold medalist in electrical engineering, with the B.A.Sc. degree, at McGill University, Montreal. In 1900 he received the M.Sc. degree from McGill as a result of post-graduate work. In 1898 he went to the United States and joined the engineering staff of Westinghouse, Church, Kerr & Co., and all of his work since that date has been in the United States, excepting the design and construction of the C.P.R. passenger terminal and steamboat pier at Vancouver, B.C. Soon after entering the employ of W.C.K., Mr. Stovel became an assistant engineer, then successively engineer-in-charge, mechanical engineer, and managing-engineer of the company. He remained with W.C.K. from 1897 until 1914, when he resigned to become managing engineer for Gibbs & Hill, consulting engineers, New York City, for whom he took charge of the Paoli and Chestnut Hill electrification of the Pennsylvania Railroad, the Elkhorn grade electrification of the Norfolk & Western Ry., and the electrification of the New York Connecting Ry. In October, 1917, he enlisted in the United States army, and was assigned to duty in France with the chief engineer of the Transportation Service. In August, 1918, he was appointed electrical and mechanical engineer in charge of the Pier Utilities Branch, Terminal Facilities Division, and one month later he was designated chief of that division, with rank of lieutenant-colonel, and placed in charge of all French terminal facilities under the jurisdiction of the Army Transport Service. Lt.-Col. Stovel returned from France last November. His work with W.C.K. will be devoted entirely to electrical and mechanical problems. Among the outstanding construction jobs which he directed while with the company prior to 1914, in addition to the C.P.R. work above mentioned, were the following: Power plants for the Utah Light & Ry. Co., the Meriden Light & Ry. Co., the Edison Electric Illuminating Co., the Pennsylvania Railroad, the Wabash-Pittsburgh Terminal, and the New York, New Haven & Hartford Railroad; and machine shop for the Chicago Railway Equipment Co.



That the Walkerville Water Co., Ltd., be requested to take immediate steps toward the installation of a filtration plant, was a resolution carried at the last meeting of the Walkerville, Ont., council. The question arose on the receipt of notices of appeal by the city of Windsor and the township of Sandwich West against the appraisal of the Windsor water works, and the apportionment of credit by the Essex Utilities Commission.

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
Calgary, Alta., construction of public building	Feb. 5.	Jan. 1.	48
Finch, Ont., road construction	Jan. 19.	Dec. 4.	45
Guelph, Ont., supply of wood pipe	Jan. 19.	Jan. 1.	54
Meteghan, N.S., repair to break-water	Jan. 21.	Jan. 8.	52
Toronto, Ont., centrifugal pumps	Feb. 10.	Dec. 18.	54
Toronto, Ont., work on new schools	Jan. 22.	Jan. 1.	52
Toronto, Ont., sewer construction	Jan. 20.	Jan. 8.	46
Toronto, Ont., construction and equipment of the St. Clair Ave.—Mount Pleasant Rd. street railway line	Feb. 17.	Jan. 8.	52
Winnipeg, Man., erection of school	Jan. 31.	Jan. 8.	50
Winnipeg, Man., motor trucks and trailers, gyratory crusher, railway dump cars and passenger coaches	Jan. 17.	Jan. 8.	52
Winnipeg, Man., generators	Jan. 26.	Dec. 25.	48
York Tp., Ont., cast-iron pipe, cast-iron specials, gate valves, hydrants and cast-iron valve covers and frames	Jan. 17.	Dec. 11.	54

BRIDGES, ROADS AND STREETS

Athabasca, Alta.—The construction of a cross-country wagon-road from Athabasca to Fort Vermilion is being advocated by Col. J. K. Cornwall. The provincial government will probably be asked to look into the question as a part of its 1920 program. Estimated cost, $150,000.

Brantford, Ont.—A start will be made early next spring on the construction of a macadam highway from Brantford to Hamilton, a distance of 25 miles, according to a statement made here recently by Hon. F. C. Biggs, Provincial Minister of Public Works, Toronto.

Chatham, Ont.—It is rumoured here that the government will solve the provincial highway controversy by constructing two roads, one along the Longwoods road, from London to Chatham, thence along the River road through Raleigh township to Tilbury and on to Windsor. The other will be along the Talbot road, commonly known as the Lake Shore route, from London through St. Thomas, then direct to Windsor.

Escott Tp., Ont.—A by-law to improve a certain portion of the road in R.D. No. 17 was given its first and second readings by the township council. Clerk, Ernest C. Kelly, Mallorytown, Ont.

Granby, Que.—The city of Granby recently took action against the Montreal and Southern Counties Railway to compel them to carry out their contract to build a bridge at Irwin St. and judgment was rendered ordering the company to build the bridge work to commence within sixty days.

Levis, Que.—The vote on the loan by-law for the construction of permanent roads will be taken on January 26th.

Merriton, Ont.—By-law passed authorizing construction of curbs. Clerk, Richard Clark.

Montreal, Que.—The Perrot Bridge Commission, which was formed last May for the purpose of uniting the Island of Montreal from the west end with the mainland, necessitating the construction of two bridges, will hold a meeting on January 22nd to further consider the scheme, of which Gustave Boyer, M.P., is the organizer.

Moose Jaw, Sask.—A movement is on foot for construction of a subway at the south-east corner of 18th Ave. City clerk, R. P. Riddell.

Port Lambton, Ont.—The ratepayers ratified a by-law repealing the present system of road work, as passed by the Council last year. It requires the ratepayers to pay for their road work in their taxes, and the work will be done by a commission.

Quebec, Que.—If the Federal Zinc and Lead Co., of Montreal, is granted the privileges it is asking in a bill which it will submit to the legislature during the present session, a new toll road will be constructed in the counties of Bonaventure, Matane and Gaspe.

Saskatoon, Sask.—The local board of trade is taking up the matter of constructing a bridge across the Saskatchewan River near Langham.

South Vancouver, B.C.—Among the road improvements which will be carried out during this year will be the hard-surfacing of Victoria Rd., from Kingsway to Forty-sixth Ave. Clerk, Wm. T. Riley.

St. John, N.B.—It is expected that a substantial highway bridge to cost probably $200,000 will be built over the St. John River, between Edmundston and Madawaska, Maine, this year. The new structure will connect modern highways recently built in Quebec Province, New Brunswick and Maine.

Toronto, Ont.—Works Commissioner Harris plans to pave part of Jones Ave. next spring with bitulithic.

Victoria, B.C.—Johnson Street bridge by-law, which provides for the loan of $420,000 as the city's share in the cost of constructing the proposed bridge, will be submitted January 15th,. City engineer, F. M. Preston.

Winnipeg, Man.—Plans are under way by the Provincial Department of Public Works for the construction of two summer roads in the two principal mining districts of Manitoba. Approximate cost, $150,000. Minister of Public Works, Hon. Geo. A. Grierson.

Winnipeg, Man.—Public Parks Board is asking assistance from the provincial government for the erection of a reinforced concrete bridge over the Assiniboine River at the westerly boundary of Assiniboine Park. Estimated cost, $125,000. Secretary, W. Blackwood.

WATER, SEWAGE AND REFUSE

Dresden, Ont.—By-law authorizing expenditure of $16,000 on extension and improvement of the waterworks system was passed. Clerk, J. T. Bridgewater.

Fredericton, N.B.—City council decided to purchase water meters. City clerk, G. R. Perkins.

Halifax, N.S.—City Engineer F. W. W. Doane recommended the construction of a sewer from the present one on