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DATA AND NOTES DERIVED FROM TESTS ON CEMENT AND ALSO ON CONCRETE TAKEN FROM REGULAR BATCHES USED IN ACTUAL WORKS.

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The following tests on cement were made during the year of 1900, at Chaudiere Falls, Que., where a water power of 5,000 H. P. was being developed under the direction and supervision of T. Pringle & Son, Hydraulic Engineers, in accordance with their plans and specifications, by the Engineering Contract Company.

The work, in general, consisted of the construction of a timber crib 190 feet long on concrete piers, with a concrete abutment on the west end, the spaces between the piers being designed to allow the water to enter the head race under the crib, which was firmly bolted to these supports.

The head race is enclosed on the west side by an earthen embankment about 250 feet long, with a concrete core wall, which embankment also runs into the west bank of river at an angle of about 97 degrees to the side of head race, a distance of some 300 feet. It is bounded on the north and northwest by a concrete bulkhead with steel framing to carry the water racks, etc., built in the concrete, together with three steel plate cones, tapering from 9 feet to 8′ 3″ inside diameter in 29 feet length, and one cone tapering from 3 feet to 2′ 6″ inside diameter in the same length. To these cones are connected penstocks to carry the water down to the turbines, direct connected to generators situated in a power house some eighty feet below, the small pipe being used to operate independent turbines which drive the exciters.

On the east side of head race is a concrete weir dam about 140 feet long, and at an angle of about 103 degrees to the weir dam is a waste weir provided with stop logs for closing same in time of low water; and then in the same line with this is the main dam 824 feet in length of the overflow type running across the river, about 60 feet from the edge of the falls and terminating in a substantial concrete abutment on the east side of the stream.

The power house foundations and wheel pit are built of rubble masonry laid in cement mortar and arched with 1-2-5 concrete over the tail-race.

It is not the object in this paper to give more than an outline of the style of works being carried out where the following experiments were made, and a full detail description of this undertaking will be presented in a subsequent article.

The bulk of the cement which was used in these works was imported Portland cement, known as "Hemmoor brand," and was made in Hanover, Germany.

These tests on cement were carried out under the supervision of Mr. C. H. Hollingsworth, C.E., who was at that time the Engineer in charge; also the moulding of the concrete cubes referred to in the following pages.

The specifications under which all the cement was furnished for these works were as follows:—

Cement:—All cement used throughout the work shall be Portland cement ground to such a degree of fineness, that not more than 10 per cent. residue shall remain on a standard 100 x 100 sieve (10,000 meshes to the square inch.)

Specific Gravity:—Specific gravity of cement shall not be less than 3.10.

Soundness:—To be determined by Faija's method. A thin pat of neat cement will be carefully made on a sheet of ground glass, 4″ x 4″. The pat will be bevelled from centre to edges, where it shall not be more than $\frac{1}{12}$″ thick. Immediately after making, pats are to be supported above the surface of water at a temperature of 115° Fah. in a closed vessel for six hours. At the expiration of this time they will be immersed in the water, which will be kept at the same temperature, for an additional twenty-four hours. Separation of pats from the glass, cracking or presence of blow holes, etc., will be taken as indications of unsoundness.

Tensile Strength:—Samples taken indiscriminately from the centre of cement barrels or bags, shall be mixed with 20 per cent. of water and rammed into briquette moulds, with a pressure of 20 lbs. to the square inch. After being removed from the moulds the briquettes must have a tensile breaking strength of not less than the following:—

At the end of 7 days (1 day in air, 6 days in water), 400 lbs.
" " " " 28 " (1 " " " 27 " " "), 500 lbs.

Mortar mixtures of three parts of sand Standard *i.e.*, of such coarseness as to all pass the meshes of a 20 mesh sieve; 400 meshes per square inch, and all be retained on the meshes of a 30 mesh sieve, 900 meshes per square inch, to one part of cement with sufficient water to make a good plastic paste, and rammed into moulds with a pressure of 20 pounds per square inch, must show a tensile strength of not less than

145 lbs. at the end of 7 days (1 in air and 6 in water.)
225 " " " 28 " (1 " " " 27 " ")

All briquettes in neat cement and mortar tests will be covered with a moist cloth while setting, to exclude drafts of air.

At least one barrel in every 100 will be tested, and should the sample from the barrel prove defective, the whole 100 barrels shall be rejected.

If the cement used is packed in bags, at least one bag in every 500 will be tested, and if sample prove defective, the whole 500 bags will be rejected.

The contractor is to keep all cement on hand at least 30 days before using, so as to allow of testing. He may be required to stack cement in weatherproof sheds, if so thought necessary by the Engineers.

In case of any dispute arising as to the interpretation of this specification, or the manner of testing cement, the matter shall be referred to the Faculty of Applied Science of McGill University, Montreal, a decision from whom shall be final and conclusive. The cost of making tests at the University shall be borne by the party in fault.

The details of careful chemical analysis made of three samples of cement taken from 100 barrel lots, on the works, were as follows:—

	No. 1.	No. 2.	No. 3.
Silica	21.93	21.84	21.53
Oxide of Iron and Aluminia	12.84	11.84	12.35
Lime	64.17	65.36	64.41
Magnesia	1.11	1.14	0.96
Carbon Dioxide	0.22	Trace	0.37
	100.27	100.18	99.62

There was also minute quantities of sulphate present but it is of no special import.

CEMENT TESTS.

The briquette moulds used were made by the Fairbanks Company, having an area of 4 square inches by 1″ thickness, the sectional area in the centre being exactly one square inch.

The Fairbanks' patent automatic cement testing machine was used to obtain the tensile strength of the briquettes.

The Portland cement used in all these tests was Hemmoor brand imported from Hanover, Germany, and the fineness test showed a residue of 6 per cent. on a 100 mesh sieve (*i. e.* 10.000 per square inch), and a specific gravity of 3.18. The volume and soundness tests were satisfactory.

The following special tests were made besides the regular ones called for by specifications, but had no bearing as regards the acceptance of the cements:—

LOT I.

Four briquettes were made by filling moulds with water, and then shovelling in dry cement with a small spatula, without ramming. The briquettes were placed in water when 24 hours old, and were taken from the water when test was due and broken immediately—2 at 7 days old and 2 at 28 days old; the results were:— 7 days old, 222 and 214 lbs. per sq. inch; 28 days old, 445 and 337 lbs. per sq. inch, tensile strength.

LOT II.

Four briquettes were made by filling moulds with water and sifting in cement without ramming. They were placed in water when 24 hours old. One of the briquettes scaled off slightly after being in the water for 24 hours. Two briquettes were broken when taken from water after 7 days, and two at 28 days, and showed a tensile strength per square inch, as follows: 7 days old, 132 and 232, 212 lbs., and at 28 days old 257, 254 lbs. per sq. inch. tensile strength.

LOT III.

Four briquettes were made by filling moulds with dry cement and pouring in all the water they would absorb but without tamping. When treated similar to lot II, the results at 7 days old were 232, 212 lbs., and at 28 days old 257, 254 lbs. per sq. inch tensile strength.

LOT IV.

Four briquettes were made by mixing cement with 20 per cent. of water and tamping into moulds with a 1 lb. nail hammer. When 24 hours old they were placed in water until ready for testing. Two were tested when 7 days old and showed a tensile strength of 722 and 738 lbs., and two at 26 days old showed 707 and 747 lbs. per sq. inch.

LOT V.

Four briquettes were made by mixing cement with 20 per cent. of water and placing in moulds without any tamping whatever. When 24 hours old, they were placed in water until ready for testing. The results of this test were very poor; at 7 days old they broke at 28 and 32 lbs. per sq. in., and at 28 days old at 41 and 47 lbs. per square inch.

LOT VI.

Four briquettes were made by mixing the cement very wet (about 30 per cent. water), and placing in moulds without ramming, then letting them stand with a pressure of about 3 lbs. per sq. inch for 24 hours. They were then submerged in water until tested. The results at 7 days old were 393 and 355, and at 28 days old, 613 and 588 lbs. per sq. inch tensile strength.

In the following lots VII., VIII., IX., X., XI., XII., two briquettes were made of each by mixing cement with 20 per cent. of water, and placing in moulds under pressure of 20 lbs. per sq. in. When 24 hours old they were all placed in water and allowed to remain there until they were seven days old, with the exception of 24 hours during this period (as noted opposite each lot), when they were exposed to the action of frost for the length of time denoted. They were all tested in tension at the end of seven days, as follows:—

LOT VII.

Frozen for 24 hours after they were 24 hours old, then thawed out and put in water until 7 days old, when they broke in tension under 476 and 590 lbs. per sq. in. respectively.

LOT VIII.

Frozen for 48 hours after they were 48 hours old and then thawed out and put back in water until 7 days old, then tested with these results 505 and 490 lbs. per sq. in. in tension.

LOT IX.

Frozen for 24 hours after they were 3 days old, and then thawed out and placed in water until 7 days old; results of tension test 380 and 460 lbs. per sq. in.

LOT X.

Frozen for 24 hours after they were four days old, and then thawed out and placed in water until seven days old, results being 485 and 487 lbs. per sq. in.

LOT XI.

Frozen for 24 hours after they were 5 days old, then thawed out and placed in water for the remaining day, then broken under load of 530 and 410 lbs. per sq. in.

LOT XII.

Frozen for 24 hours after they were 6 days old, and then thawed out and tested; these broke at 465 and 475 lbs. per sq. in.

In lots XIII., XIV., XV., XVI., XVII., two briquettes were made of each by mixing cement with 20 per cent. of water, and placing in moulds under pressure of 20 lbs. per sq. in. When 24 hours old they were all placed in water. The subsequent treatment of each lot was as follows:—

LOT XIII.

Was frozen in water when 48 hours old, and thawed out when 7 days old by exposing to a temperature of 120° Fah., and then broken in the machine, showing a tensile strength of 454 and 416 lbs. per sq. in.

LOT XIV.

Was frozen in water when 48 hours old, and thawed out when 7 days old by exposing to a temperature of 120° Fah., and then tested, the results being 448 and 417 lbs. per sq. in.

LOT XV.

Was frozen in water when 3 days old, and thawed out when 7 days old, by exposing to 120° Fah., and tested, the tensile strength being 460 and 405 lbs. per sq. in.

LOT XVI.

Was frozen in water when 4 days old and thawed out when 7 days old by exposing to a temperature of 120° Fah., and then tested, the results being 474 and 486 lbs. per sq. in.

LOT XVII.

Was kept in the water at a temperature of 60° Fah. until seven days old, and then tested, and showed a tensile strength of 590 and 492 lbs. per sq. in.

When the briquettes in Lots XIII., XIV., XV., XVI., were frozen, the temperature ranged between + 32° to — 14 degrees Fah.

LOT XVIII.

Six briquettes were made with 20 per cent. of water moulded under a pressure of 20 lbs. per sq. inch. When 24 hours old they were exposed to the weather and allowed to freeze, and kept frozen until 7 days old. They were not immersed in water at all, but were thawed out by exposing to heat for about 45 minutes. No flaking or chipping of briquettes whatever occurred. The results, when tested at seven days old were, 342, 315, 341, 340, 353, 376 lbs. per sq. inch.

LOT XIX.

Was made similar to Lot XVIII., and was immersed in water when 24 hours old, and taken therefrom when 3 days old, exposed to weather until 28 days old. The results of 28 days test being 297, 356, 268, 351, 285, 406 lbs. per sq. inch.

LOT XX.

Five briquettes made same as Lot XVIII., and exposed to the weather when 6 hours old, not placed in water at all, thawed out before testing when 7 days old. The loads were 212, 260, 235, 283, 391 lbs. per sq. inch.

The cement on these briquettes was chipped or flaked off on both sides and edges when exposed to heat—about 1/32 of an inch from each face—this would reduce the sectional area somewhat. The above are the actual loads under which briquettes were broken.

LOT XXI.

Six briquettes made similar to Lot XVIII. and exposed to the weather when 12 hours old, and allowed to freeze. They were left exposed until 28 days old, the range of temperature being from — 20 to + 35 degrees Fah., as per chart. The briquettes broke under the following loads when 28 days old, 327, 322, 300, 317, 303, 247 lbs. per square inch.

As some quantities of steel framing for racks, stop log checks, etc., had to be built into the concrete of the bulkhead, the concrete would act as a protection for the steel embedded in it to a certain extent, and as the expansion of concrete and steel are nearly the same, it was reckoned they would stand without cracking when once well joined together, but it was desired to protect the exposed portion of the steelwork from oxidation if possible with some kind of paint or composition to which the mortar of the concrete would adhere, so a few experiments were made to determine whether red oxide or asphaltum paint would be most adhesive in this position and also to determine whether the clean dry steel or rusty plates would hold to the cement better than the painted surfaces.

The method adopted was to place a piece of ⅛″ steel plate one inch square in the centre of the briquette moulds at right angles to the flat surface of same, and the cement which was mixed with 20 per cent. of water in the usual manner (by hand) was filled into the mould on both sides of the steel plate and rammed against same, care being exercised in this operation so as to keep the plates central.

LOT XXII.

The plates used in this lot were exposed to the weather for a period of fourteen days and were thoroughly rusted, but not corroded, before being placed in the moulds.

The briquettes were immersed in water when 24 hours old, then removed after 36 hours, and left in a damp place until seven days old, when they were broken in the testing machine.

Only two briquettes were successfully moulded of this lot, and when tested they broke at 60 and 70 lbs. per square inch respectively, the fracture taking place at the junction of the steel plate and cement.

LOT XXIII.

The 1″ x 1″ x ⅛″ steel plates in this lot were clean and smooth when placed in the moulds, and cement tamped in on both sides of same. The briquettes were immersed in water when 26 hours old and left for 24 hours, after which they were removed and placed as to be damp until 7 days old when they were tested with these results, 37, 15, 40 lbs. per sq. inch. All briquettes broke at the plate, the same remaining attached to that part of briquette in the lower jaw of machine.

LOT XXIV.

The 1" x 1" x ⅛" steel plates used in this test were thoroughly cleaned, then heated and while hot were painted with asphaltum paint. The plates were allowed to stand for twelve days, then placed in briquette moulds and cement mixed in usual manner and placed on each side of plate in mould. The briquettes were taken from moulds when 10 hours old and placed in water. After 24 hours in the water they were taken out and placed in a damp place until tested, when 7 days old. The results were: 30, 35, 22, 60 lbs. per square inch.

In the first three tests the asphalt pulled off the plate; in the fourth case it adhered to plate in many places.

The average tensile strengths of the briquettes in the tests described above will be found in the accompanying table I.

Two attempts were made to make briquettes with steel plates in them, that had been painted with two coats of red oxide, the first coat being applied 12 days before the second, and they were placed in moulds 10 days after the second coat of paint was applied, but all briquettes broke at plate when being removed from the moulds, in the usual manner. It was found that the cement would not adhere at all to the steel when painted with this pigment.

It is regretted that more tests were not made in this direction, as there are several other paints that might have been experimented upon, and as steelwork is being used more and more in connection with concrete dams, bulkheads and other structures of this nature more or less exposed to atmospheric changes, it is to be hoped that in the near future complete data on this subject will be forthcoming.

CONCRETE TESTS.

Tests on concrete taken from regular batches on works were made from time to time, as the work progressed, and account was kept of where the batch of each special lot of concrete was being placed together with any other notes that had any special bearing on the work. At the same time, as the concrete was taken, a sample of the cement used was obtained and tested neat and in mortar test, and the results of tests will be found in the table II.

CEMENT.

The most of the concrete work was done with Hemmoor brand of Portland cement, but some of Heidelberg brand was also used, both these were imported. The Canadian cements used were "Star" and "Beaver" brands, and from the results of these tests it will be seen that these latter brands compare very favourably with the imported article.

SAND.

The sand used was obtained from a pit within a mile and a half from the Falls, near Chaudiere Station, and is known as siliceous sand; it was free from loam and of good quality.

The voids in the sand when measured loosely were found to vary from 37 per cent. to 41 per cent., and this was obtained by filling a vessel with the sand and then pouring in enough water to fill the vessel. The amount of water required to fill the voids, multiplied by 100 and divided by the amount of water alone, which the vessel would hold when filled to the same height, gave the percentage of voids in the sand. A better method would have been to have determined the specific gravity of the sand, and from that the weight of a unit of volume of the solid, and also weight of a unit of volume of the sand. The difference between these weights divided by the former would give the proportion of voids.

STONE.

The stone used for the concrete was a mixture of boulders of Laurentian rock and Felosphatic sandstone or Arkose, all broken to pass 2″ ring, in three crushers, two kinds of which were on the works, namely, the Gates gyratory crusher and the Jaw crusher. From the crusher the stone went over a screen, which allowed everything but the dust to pass over same into the stone pile.

The crusher designated as Eagle crusher was a jaw crusher, with the pitman hinged at top and the bottom of same oscillated by means of a toggle plate. The other machine was the reverse of this one, as the pitman was hinged at the bottom and worked at the top with a toggle plate.

The voids in the rammed broken stone, found in a similar way to those in sand, averaged 46 per cent.

PROPORTIONS.

The proportions used in the concrete for the bulkhead and overflow dams were 1 of cement, 2 of sand and 4 of broken stone. This was adopted after testing a few cubes of 1, 2 and 5, which gave considerably lower results as Table II. will show.

It is necessary in order to guard against lack of uniformity in the aggregate, imperfect mixing, insufficient tamping, etc., to have more mortar than is sufficient to fill the voids in the stone. The usual excess of mortar is from 15 per cent. to 25 per cent. The method of determining the proportions so as to have this excess of mortar is as follows:—

1st. Assume the proportions 1-2-4, and test the sand and stone for voids.

Say, voids in loose sand = 39 per cent.
" " " rammed stone = 46 per cent.
Cement measured in barrel.
Solid material, cement 1; sand, 1.22; stone 2.16.
Voids, cement, 0; sand, 78; stone, 1.84

or 1 cubic foot of cement plus 1.22 cubic feet of sand will give 2.22 cubic feet of mortar to fill 1.84 cubic feet of voids.

Mortar in excess of voids = 20.6 per cent.

In the above it will be seen that there is 28 per cent of cement in excess of the voids in the sand, and a possible saving might have been made by using less cement, but as a very rich concrete was desired, this excess of cement was allowed to remain.

The percentage of water used in the concrete averaged 20 per cent.

CONCRETE MIXING.

When the mixing was done by hand, the cement and sand were mixed dry in the proper proportions of each, and turned over with shovels four or five times, and on damp days, even six times, to thoroughly mix them. Then water was sprinkled on until sufficiently wet, next the mortar was spread out on the mixing platform, and on top of this a bottomless box was placed, which would contain the proper proportion of stone when filled to the level of the top of same. The box was filled with stone, then removed, allowing the stone to remain; the whole mixture was then turned over four stone to remain; the whole mixture was then turned over four times, besides the shovelling into barrow and dumping out into works. The concrete that went in the cube moulds was taken from the batch at the same time as they were placing the material in the wheelbarrow after being turned over four times.

When mixed with the Cockburn & Barrow mechanical mixer for constructing the bulkhead and wing dam, during the spring of 1900, the cement and sand were first mixed together by turning them over two or three times; then wet. The stone was then dumped on the mortar and the whole batch shovelled into the mixer, through which it ran, dropping out at the lower and into skips, which were dumped where wanted on the work.

Later on, when the Cockburn-Barrow mixer and the Sooysmith mixer were used on the main dam, the broken stone was of a very much better size and more easily mixed, the quantity of the sand also improved, so that the method of mixing adopted was as follows :—

A skip holding the proper quantity of stone was dumped on the mixer platform and spread out until about 6 to 8 inches thick. A smaller skip containing two barrels of sand was dumped on the stone and spread evenly over same, then one barrel of cement was spread on the top of the sand. The entire mixture was then shovelled into the mixer, all shovelling being done form the bottom of the pile; the water was added in the mixer. Under no conditions, however, were all the materials mixed together dry on the platform.

A gravity mixer, which consisted of an inclined iron box, having a number of iron pins distributed throughout its length, which caught the falling material and turned it over, and provided with a water pipe and valve in the upper section for wetting the mass as it was shovelled into it from a platform—was used down in the wheel pit of the power house to mix the 1, 2 and 5 concrete, which was used in the arches.

It would have been interesting to compare the results of the strength of the concrete mixed by this mixer and the mechanical mixers, but in all, except one lot of cubes which had been mixed mechanically, the proportions were 1, 2 and 4. However, the writer is of the opinion that the mechanical mixer will produce the best results, as far as strength of the concrete goes—if the same treatment is accorded the concrete after mixing.

MOULDS.

The moulds used for making the cubes were 9″ x 9″ x 9″ deep inside measure.

They were constructed of clear, dry pine, dressed to a thickness of 1½″, and the sides and bottom of the moulds were lined with No. 25 B.W.G. tin plate. The sides were put together in the form of two angles, and they were held with four ⅜″ bolts, and could be readily taken apart by loosening the wing nuts on the bolts.

The moulds were cleaned and oiled just before using, as it was found almost impossible to get the cubes out whole in less than three or four days, without the use of oil.

The concrete was placed in the moulds in 4″ layers, and rammed with regulation railroad tie tamper, being 3″ x 1″ on the face, and the flat portion being four inches long and slightly offset from the 1¼″ round bar, which formed the handle at the junction of the flat portion and the round part.

The moulds were filled slightly above the sides and tamped with a cast iron tamper 6″ square on face and weighing 15 lbs. This was, however, used lightly, and in some cases where the concrete was wet it was dispensed with entirely.

After the mortar had flushed to the surface the mould was struck off level with a straight flat iron bar, and the top smoothed over with the back of a shovel.

The moulds with the concrete in them were then placed in a shed and covered with a damp cloth for 24 to 48 hours, when the cubes were removed from the moulds and recovered with the cloth for six days, then exposed to the air until 21 days old, when they were boxed up and shipped by express to the Testing Laboratory of McGill University, Montreal, where they were surfaced off true with plaster of Paris on two opposite faces, which formed the sides in the mould, and stored in the cement laboratory until tested.

The cubes were nearly all tested in the Wicksteed machine after being surfaced with plaster of Paris, and scraped to a surface plate. The Emery machine, which had an ultimate capacity of 150,000 lbs., was used for a few of the first cubes made, but the concrete proved too strong for it, so all succeeding trials were made in the large machine which had an ultimate capacity of 215,000 lbs. This was subsequently increased to 217,500 lbs. by the addition of a slight increment on the length of the beam of machine.

The cube which was to be tested, after having the plaster of Paris surfacing previously referred to scraped to a surface plate, was placed on a planed cast iron plate 10″ square by 1⅜″ thick; this plate was then placed in the stirrup of the machine and on the top of the cube was placed a similar planed plate, on this was placed another plate with a spherical bearing, which thus insured an even distribution of pressure over the compressed surface. The whole was brought carefully into the centre of the space where the pressure was to be applied. Then a finely graduated steel scale, divided in inches, tenths of inches and hundreds of inches, was set up beside the cube between the two plates, and resting on the bottom one. A telescope, with cross hairs in it was then mounted opposite the scale, and an incandescent lamp hung, so as to illuminate the same, and with the aid of this telescope the hundredth of an inch could be split quite readily on the scale. The load was applied gradually and reading taken at every 5,000 lbs., atfer reading the scale with 1,000 lbs. on, which was called the initial load, and the zero mark on scale being at the reading under this load.

The load was increased at the rate of 5,000 lbs. every half minute, approximately, and while this was in progress two assistants scrutinized the exposed faces of the cube to detect the least crack that might develop; as soon as such appeared the person in charge of the record (usually the one who read the scale) was advised of the fact and the time and load noted. In some instances where the specimen appeared to be yielding appreciably under a given load this was not increased as rapidly at the rate just mentioned, and several readings of the increments of compression were taken under the same load.

When the cubes were strong enough to require more than 100,000 lbs to cause fracture, the load had to be taken off by running the weight on the beam of machine back to zero to put on the counter poise which was equivalent to 100,000 lbs. When the load was being removed the scale was read at every 20,000 lbs. decrease, and the reading compared with the reading under the same load, when increasing the loads. In some instances the reading was nearly the same, the material returning to its original state to within a small fraction of the first reading.

As soon as the counter weight was put on, the load was applied gradually again by a valve which controlled the hydraulic pressure, until 100,000 lbs. were registered on the dial, a reading was then taken and the time noted. The load was then increased 5,000 lbs. at a time, until the increments of compression showed signs of approaching fracture, when the load was increased more gradually and reading taken every half minute until the cube broke down.

In a number of instances the strength of the cubes was beyond the capacity of the machine, and where the opportunity offered, the cube was left in the machine under the highest pressure obtainable (215,000 to 217,500), and the time effect on the compression readings was noted at longer intervals. By examining the detail report sheets therewith, it will be observed how the compression increases as time goes on.

In explanation of Table II., it may be added that where no cracks developed under the maximum load the compression given is the last reading taken before removing the cube from the machine, and the time is also the total length of time the cube was under pressure.

A number of cubes were not tested on the day that they should have been when 28 days, 3 months and 6 months old, but this was unavoidoble on account of other work in connection with the University, which required the attention of the staff of the testing laboratory.

The writer wishes to acknowledge his indebtedness to Dr. Henry T. Bovey, for suggestions on this subject during his visits to the McGill Testing Laboratories, in connection with the tests referred to above, and his appreciation of the careful manner in which Mr. F. H. Whittycombe, who is in charge of the testing laboratories, conducted these tests at McGill University.

The writer is also greatly indebted to his principals, Messrs. T. Pringle & Son, for the privilege of using all of their notes and data, which were obtained by them at considerable expense in the preparation of the foregoing paper.

COMPRESSION TEST OF CONCRETE.

25 A. Cube 9¼″ x 9″. Weight 61 lbs., 13 oz.
Made 8th Sept., 1900. Proportion 1-2-4 "Beaver cement.
28 days old.
Tested in Wicksteed machine on 6th Oct., 1900.

Load.	Time.	Reading.	Remarks.
1,000	9.14.00	.000	
5,000	9.15.00	.000	
10,000	9.15.35	.000	
15,000	9.16.10	.0005	
20,000	9.16.50	.001	
25,000	9.17.30	.0015	
30,000	9.18.10	.002	
35,000	9.18.45	.003	
40,000	9.19.20	.0035	
45,000	9.19.55	.004	
50,000	9.20.45	.0045	
55,000	9.21.15	.005	

Load.	Time.	Reading.	Remarks.
60,000	9.22.00	.0055	
65,000	9.22.35	.006	
70,000	9.23.00	.007	
75,000	9.24.00	.007	
80,000	9.24.40	.0075	
85,000	9.25.15	.008	
90,000	9.26.00	.0085	
95,000	9.26.40	.0085	
100,000	9.27.25	.009	
80,000	9.28.45	.0075	
60,000	9.30.10	.0065	
40,000	9.31.10	.0055	
20,000	9.32.10	.004	
1,000	9.33.10	.0015	
100,000	9.36.30	.009	
105,000	9.37.05	.009	
110,000	9.37.40	.0095	
115,000	9.38.10	.0095	
120,000	9.39.00	.010	
125,000	9.39.30	.011	
130,000	9.40.10	.012	
135,000	9.40.45	.013	
140,000	9.41.30	.015	
145,000	9.42.10	.017	
150,000	9.42.45	.0195	
155,000	9.44.00	.021	1st crack.
160,000	9.45.00	.027	
160,000	9.45.30	.031	
160,000	9.46.15	.032	
160,000	9.47.00	.033	
165,000	9.48.00	.034	
165,000	9.48.30	.036	
170,000	9.49.30	.039	
175,000	9.50.35	.046	
175,000	9.51.00	.059	

COMPRESSION TEST OF CONCRETE.

25 B. Cube 9″ x 9.1 x 9.3. Weight, 62 lbs., 14 oz.
Made of Tested December 1st, 1900.

Load.	Time.	Reading.	Remarks.
1,000	3.10	.000	
5,000	3.11	.000	
10,000	3.12	.001	
15,000	3.12.30	.002	
20,000	3.13	.002	
25,000	3.13.30	.0025	
30,000	3.14	.003	
35,000	3.16	.0035	
40,000	3.16	.0035	
45,000	3.17	.0040	
50,000	3.18	.0040	
55,000	3.19	.0045	
60,000	3.20	.0045	
65,000	3.21	.0050	
70,000	3.22	.0050	

Load.	Time.	Reading.	Remarks.
75,000	3.31	.0050	
80,000	3.32	.0055	
85,000	3.33	.0055	
90,000	3.34	.0055	
95,000	3.35	.0057	
100,000	3.36	.0060	
80,000	3.39	.0055	
60,000	3.42	.0050	
40,000	3.44	.0045	
20,000	3.47	.0040	
50,000	3.48.30	.0030	
10,000	3.50	.0020	
100,000	4.08	.0085	
105,000	4.09	.0070	
110,000	4.10	.0080	
115,000	4.11	.0085	
120,000	4.12	.0090	
125,000	4.13	.0095	
130,000	4.14	.0100	
135,000	4.15	.0100	
140,000	4.16	.0105	
145,000	4.17	.0110	
150,000	4.18	.0115	
155,000	4.19	.0120	
160,000	4.20	.0125	
165,000	4.21	.0130	
170,000	4.22	.0140	
175,000	4.23	.0150	
180,000	4.24	.0160	
185,000	4.25	.0165	
190,000	4.26	.0180	
195,000	4.28	.0190	
200,000	4.30	.0200	
205,000	4.31	.0210	
210,000	4.32	.0220	
215,000	4.33	.0235	Small cracks apparent.
217,500	4.35	.0250	
217,500	4.40	.0265	
217,500	4.55	.0290	
217,500	5.05	.0300	
2nd. Load leaked off	12.0 p.m.	.0300	
217,000	12.02 p.m.	.0360	
217,000	1.0 p.m.	.0365	
3rd. Load leaked off	8.30 p.m.	.0300	
217,000	8.31 p.m.	.0370	Taken out of machine, could not crush.

COMPRESSION TEST OF CONCRETE.

25 C. Cube 9.15 x 9.0 x 8.0 x 8.9 x 9.2 height. Weight, 61 lbs.
Made of . 6 months, due Feb. 3, 1901.
Tested Feb. 25, 1901.

Load.	Time.	Reading.	Remarks.
1,000	12.10	.0000	
5,000	12.11	.0020	
10,000	12.11½	.0025	
15,000	12.12	.0030	

Load.	Time.	Reading.	Remarks.
20,000	12.12½	.0035	
25,000	12.13	.0038	
30,000	12.13½	.0040	
35,000	12.14	.0043	
40,000	12.14½	.0047	
45,000	12.15	.0050	
50,000	12.15½	.0052	
55,000	12.16	.0053	
60,000	12.17	.0054	
65,000	12.17½	.0055	
70,000	12.18½	.0057	
75,000	12.19½	.0060	
80,000	12.20½	.0062	
85,000	12.21	.0062	
90,000	12.21½	.0065	
95,000	12.22¼	.0068	
100,000	12.23	.0070	
80,000	12.25	.0060	
60,000	12.26½	.0055	
40,000	12.28	.0050	
20,000	12.29½	.0040	
5,000	12.31½	.0040	
1,000	12.32	.0030	
100,000	12.34	.0070	
105,000	12.35	.0072	
110,000	12.36	.0078	
115,000	12.37	.0080	
120,000	12.38	.0085	
125,000	12.39	.0088	
130,000	12.40	.0090	
135,000	12.41	.0093	
140,000	12.42	.0096	
145,000	12.45	.0098	
150,000	12.44	.0100	
155,000	12.45	.0105	
160,000	12.46	.0110	
165,000	12.47	.0120	
170,000	12.48	.0125	
175,000	12.49	.0130	
180,000	12.50	.0135	
185,000	12.51	.0137	
190,000	12.52	.0140	
195,000	12.53	.0145	
200,000	12.54	.0147	
205,000	12.55	.0151	
210,000	12.56	.0155	
215,000	12.57	.0158	
218,000	12.58	.0161	No signs of cracks.
218,000	1.0	.0170	
218,000	2.0	.0205	
218,000	3.0	.0225	
218,000	4.0	.0235	Machine wanted loads set off.
200,000	4.2	.0225	
180,000	4.3	.0210	
160,000	4.4	.0195	

Load.	Time.	Reading.	Remarks.
140,000	4.5	.0180	
120,000	4.6	.0168	
100,000	4.7	.0160	
80,000	4.8	.0155	
60,000	4.9	.0150	
40,000	4.10	.0145	
20,000	4.1-	.0130	
5,000	4.12	.0095	
1,000	4.13	.0080	

COMPRESSION TEST OF CONCRETE.

19 A. Made at Chaudiere Falls, P.Q., on the 17th August, 1900, of 1-2-5 Hemmoor cement in gravity mixer. Cube 9″ x 9″ x 9″. Tested Sept. 14, 1900, in Wicksteed machine at McGill University. Surfaced with plaster of Paris. 28 days old.

Load.	Time.	Reading.	Remarks.
1,000	9.29.00	.000	Initial load
5,000	9.30.00	.001	
10,000	9.30.40	.002	
15,000	9.31.05	.003	
20,000	9.31.35	.003	
25,000	9.32.05	.004	
30,000	9.32.45	.0045	
35,000	9.33.10	.005	
40,000	9.33.40	.0055	
45,000	9.34.10	.0065	
50,000	9.34.40	.007	
55,000	9.35.10	.0075	
60,000	9.35.40	.008	
65,000	9.36.10	.009	
70,000	9.36.35	.0115	
75,000	9.37.05	.012	
85,000	9.38	.017	
80,000	9.37.45	.0145	
90,000	9.39.10	.020	
90,000	9.39.20	.021	
90,000	9.39.30	.021	
90,000	9.39.50	.022	First crack.
95,000	9.40.40	.027	
95,000	9.40.40	.027	
100,000	9.41.50	.033	
100,000	9.42.00	.035	
100,000	9.42.10	.037	
100,000	9.42.20	.039	
100,000	9.42.50	.042	Cracked on all sides.
100,000	9.43.05	.043	
100,000	9.43.30	.045	
100,000	9.43.50	.047	
100,000	9.44.15	.049	
105,000	9.45.20	.057	
105,000	9.45.40	.061	
105,000	9.45.45	.064	
105,000	9.45.50	.069	
105,000	9.45.55	.073	Failure.

$\frac{105,000}{81}$ = 1296 lbs. per sq. inch.

COMPRESSION TEST OF CONCRETE.

19B. Cube 8.9" x 9.0" x 9.2" high. Weight 61 lbs., 0 oz.

Made of 1-2-5 Hemmoor in gravity mixer.

12 weeks old.

Tested 9th Nov., 1900, in Wicksteed, at McGill University.

Load.	Time.	Reading.	Remarks.
1,000	10.10	.000	
5,000	10.11	.001	
10,000	10.14	.002	
15,000	10.15	.003	
20,000	10.15.30	.0035	
25,000	10.16	.0040	
30,000	10.16.30	.0040	
35,000	10.17	.0045	
40,000	10.17.30	.0045	
45,000	10.18	.0050	
50,000	10.18.30	.0055	
55,000	10.19	.0060	
60,000	10.19.30	.0070	
65,000	10.20	.0090	
70,000	10.21	.0090	
75,000	10.22	.0100	
80,000	10.23	.0120	
85,000	10.24	.0140	
90,000	10.25	.0160	
95,000	10.26	.0180	Cracks showing on side only.
95,000	10.27	.0200	
95,000	10.28	.0220	
100,000	10.29	.0250	
100,000	10.30	.0270	Starting to bulge out slightly.
105,000	10.31	.0300	
105,000	10.32	.0300	Cracked all over surface.
105,000	10.33	.0315	
110,000	10.34	.0330	
110,000	10.35	.0350	
115,000	10.36	.0400	
115,000	10.37	.0440	
115,000	10.38	.0450	
115,000	10.39	.0460	
115,000	10.40	.0470	
115,000	10.41	.0480	
115,000	10.42	.0490	
115,000	10.43	.0495	
115,000	10.44	.0500	
115,000	10.45	.0500	
100,000	10.48	.0500	Run back to put on extra weights.
80,000	10.49	.0485	
60,000	10.50	.0470	

Load.	Time.	Reading.	Remarks.
40,000	10.51	.0460	
30,000	10.50	.0450	
5,000	10.51	.0420	
1,000	10.52	.0390	
100,000	10.57	.0520	
105,000	10.58	.0530	
110,000	10.59	.0540	
115,000	11.00	.0555	
115,000	11.1	.0580	
115,000	11.2	.0590	
115,000	11.3	.0595	
115,000	11.4	.0600	
120,000	11.5	.0620	
120,000	11.6	.0630	
120,000	11.7	.0640	
120,000	11.8	.0650	
120,000	11.9	.0660	
120,000	11.11	.0670	
125,000	11.12	.0700	
125,000	11.13	.0725	
125,000	11.14	.0750	
125,000	11.15		
125,000	11.16	.0790	
125,000	11.17	.0830	
125,000	11.18	.0890	
125,000	11.19	.0950	
125,000	11.20	.1000	
125,000	11.21	.1050	
125,000	11.21.30	.1100	
125,000	11.21.45		Breaking down rapidly.

COMPRESSION TEST OF CONCRETE.

19 C. Cube 8.9 x 9.0 x 8.9 x 9.0 x 9.15 high. Weight. 58¼ lbs.
Made of 1-2-5 Hemmoor in gravity mixer.
Tested at McGill University, in Wicksteed machine.
25 weeks and 5 days old.
Surfaced with plaster of Paris.

Load.	Time.	Reading.	Remarks.
1,000	4.51	.000	
5,000	4.52	.000	
10,000	4.53	.0015	
15,000	4.53.45	.0020	
20,000	4.54.30	.0025	
25,000	4.55.15	.0035	
30,000	4.55.15	.0040	
35,000	4.56.30	.0045	
40,000	4.57	.0050	
45,000	4.57.45	.0055	Interruption.
50,000	5.07	.0070	
55,000	5.08	.0080	
60,000	5.08.30	.0090	
65,000	5.09	.010	

Load.	Time.	Reading.	Remarks.
70,000	5.09.30	.0115	
75,000	5.10	.0130	
80,000	5.11	.0150	
85,000	5.12	.0165	
90,000	5.13	.0185	
95,000	5.14	.0230	
100,000	5.15	.0255	
105,000	5.16	.0325	Cracks showing on the sides only, particles falling off surface on each side.
105,000	5.17	.0350	
105,000	5.18	.0360	
110,000	5.19	.0390	
110,000	5.20	.0420	Bursting out on all faces.
110,000	5.22	.0430	
115,000	5.23	.0470	
115,000	5.24	.0500	
115,000	5.25	.0550	Breaking down rapidly. (apparently).
115,000	5.26	.0570	
115,000	5.27	.0590	
115,000	5.28	.0600	
115,000	5.30	.0610	
115,000	5.32	.0625	
115,000	5.35	.0640	
115,000	5.40	.0650	
115,000	5.45	.0660	
115,000	9.25	.0790	9.25 next a.m.. return to put on additional load.
100,000	9.26	.0785	
80,000	9.28	.0770	
60,000	9.30	.0760	Interruptions.
40,000	9.44	.0750	
20,000	9.45.30	.0735	
1,000	9.48	.0630	
1,000	9.46	.0630	
5,000	9.52.30	.066	
20,000	9.54	.070	
40,000	9.55	.0735	
60,000	9.56.30	.0755	
80,000	9.58	.0765	
100,000	9.59.30	.0785	
105,000	10.01	.0790	
110,000	10.02	.0800	
115,000	10.03	.0800	
120,000	10.04	.0800	Particles falling off.
120,000	10.05	.0810	
125,000	10.07	.0820	Badly fractured all over.
125,000	10.08	.0830	
125,000	10.11	.0850	
125,000	10.14	.0860	
125,000	10.17	.0870	
130,000	10.19	.0875	
132,700	10.20		Broke down completely.

COMPRESSION TEST OF CONCRETE.

11 C. Cube 9" x 8.8 x 9.2 Weight, 61 lbs., 2 oz.
weeks old.

Made of 1-2-4 Hemmoor cement. Mixed with Sooysmith Mechanical mixer.

Tested January 21, 1901, in the Wicksteed machine.
25 weeks old.

Load.	Time.	Reading.	Remarks.
1,000	3.10	.000	
5,000	3.11	.0005	
10,000	3.12	.001	
15,000	3.13	.0015	
20,000	3.14	.0018	
25,000	3.15	.002	
30,000	3.16	.002	
35,000	3.17	.0025	
40,000	3.18	.0025	
45,000	3.19	.0027	
50,000	3.20	.0027	
55,000	3.21	.0027	
60,000	3.22	.0027	
65,000	3.23	.0029	
70,000	3.24	.0031	
75,000	3.25	.0031	
80,000	3.26	.0033	
85,000	3.27	.0033	
90,000	3.28	.0035	
95,000	3.29	.0035	
100,000	3.30	.0037	
80,000	3.31.30	.0033	
60,000	3.33	.0030	
40,000	3.34.30	.0027	
20,000	3.36	.0025	
5,000	3.37	.0020	
1,000	3.38	.0010	
100,000	3.44	.0037	
105,000	3.45	.0038	
110,000	3.46	.0040	
115,000	3.47	.0040	
120,000	3.48	.0045	
125,000	3.49	.0047	
130,000	3.50	.0049	
135,000	3.51	.0050	
140,000	3.52	.0052	
145,000	3.53	.0055	
150,000	3.54	.0055	
155,000	3.55	.0057	
160,000	3.56	.0059	
165,000	3.57	.0059	
170,000	3.58	.0052	
175,000	3.59	.0067	
180,000	4.00	.0070	
185,000	4.01	.0075	
190,000	4.02	.0080	No cracks visible.

Load.	Time.	Reading.	Remarks.
195,000	4.03	.0087	
200,000	4.04	.00 5	
205,000	4.05	.0100	
210,000	4.06	.0109	
215,000	4.07	.0120	
218,000	4.08	.0130	No cracks apparent.
218,000	4.20	.0140	
200,000	4.22	.0135	
150,000	4.25	.0127	
100,000	4.30	.0117	
50,000	4.33	.0100	
5,000	4.35	.0075	
1,000	4.36	.0070	

COMPRESSION TEST OF CONCRETE.

11 C. Cube 9″ x 8.8″ x 9″ x 8.8 x 9.2. Weight, 61 lbs., 2 oz.
Made of 1-2-4 Hemmoor cement. Mixed with Sooysmith mechanical mixer.

Tested January 21, 1901, in the Wicksted machine.

25 weeks old.

Load.	Time.	Reading.	Remarks.
1,000	3.10	.000	
5,000	3.11	.0005	
10,000	3.12	.001	
15,000	3.13	.0015	
20,000	3.14	.0018	
25,000	3.15	.002	
30,000	3.16	.002	
35,000	3.17	.0025	
40,000	3.18	.0025	
45,000	3.19	.0027	
50,000	3.20	.0027	
55,000	3.21	.0027	
60,000	3.22	.0027	
65,000	3.23	.0029	
70,000	3.24	.0031	
75,000	3.25	.0031	
80,000	3.26	.0033	
85,000	3.27	.0033	
90,000	3.28	.0035	
95,000	3.29	.0035	
100,000	3.30	.0037	
80,000	3.31.30	.0033	
60,000	3.33	.0030	
40,000	3.34.30	.0027	
20,000	3.36	.0025	
5,000	3.37	.0020	
1,000	3.39	.0010	
100,000	3.44	.0037	
105,000	3.45	.0038	

COMPRESSION TEST OF CONCRETE.

11 B. Cube 9.2 x 9.1 x 9.05 x 9.10 x 9.05. Weight, 6 lbs., 1 oz.

Made of 1-2-4 Hemmoor cement. Mixed with Sooysmith mechanical mixer.

Tested October 24, 1900, in the Wicksteed machine.
12 weeks, 2 days old.

Load.	Time.	Reading.	Remarks.
1,000	4.47.3	.000	
5,000	4.48.05	.001	
10,000	4.48.45	.001	
15,000	4.49.30	.002	
20,000	4.50	.0025	
25,000	4.50.30	.003	
30,000	4.51.20	.004	
35,000	4.51.50	.004	
40,000	4.52.50	.0045	
45,000	4.53.30	.0045	
50,000	4.54.30	.005	
55,000	4.54.50	.005	
60,000	4.55.20	.005	
65,000	4.56.00	.0055	
70,000	4.56.25	.006	
75,000	4.57.10	.006	
80,000	4.57.55	.0065	
85,000	4.58.25	.007	
90,000	4.59.00	.007	
95,000	5.00.00	.0075	
100,000	5.00.30	.008	Run back to put on poise.
1,000		.002	
105,000	5.05.30	.0085	
110,000	5.06.30	.0085	
115,000	5.07.25	.009	
120,000	5.07.40	.009	
125,000	5.08.10	.009	
130,000	5.08.50	.009	
135,000	5.09.25	.009	
140,000	5.09.45	.0095	
145,000	5.10.40	.0095	
150,000	5.11.50	.010	
155,000	5.11.50	.010	
160,000	5.12.30	.018	
165,000	5.12.55	.0105	
170,000	5.13.40	.011	
175,000	5.14.20	.0115	
180,000	5.14.50	.012	
185,000	5.15.30	.0125	
190,000	5.16.00	.013	
195,000	5.16.50	.0135	
200,000	5.17.30	.014	
205,000	5.17.45	.015	
210,000	5.18.15	.0155	
215,000	5.19.30	.016	No signs of any cracks.

COMPRESSION TEST OF CONCRETE.

11 A. Cube 9″ x 9″ x 9″. Weight, 61¼ lbs.

Made of 1-2-4 Hemmoor cement. Surfaced with plaster of Paris.

Tested 29th August, 1900, in Wicksteed machine.

29 days old.

Load.	Time.	Reading.	Remarks.
1,000	10.01.30	.000	
5,000	10.02.50	.000	
10,000	10.03.00	.000	
15,000	10.04.00	.000	
20,000	10.04.30	.000	
25,000	10.05.00	.000	
30,000	10.05.30	.000	
35,000	10.06.00	.000	
40,000	10.06.30	.000	
45,000	10.07.00	.000	
50,000	10.07.30	.000	
55,000	10.08.30	.002	
60,000	10.09.00	.002	
65,000	10.09.35	.003	
70,000	10.10.20	.003	
75,000	10.10.50	.005	
80,000	10.11.20	.006	
85,000	10.11.45	.006	
90,000	10.12.35	.007	
95,000	10.13.10	.008	
100,000	10.13.40	.008	Ran weight back to put on poise.
5,000	10.18.00	.005	All load off to this w'ht.
100,000	10.26.40	.008	
105,000	10.28.15	.009	
110,000	10.29.00	.009	
115,000	10.29.30	.010	
120,000	10.29.45	.010	
125,000	10.30.25	.010	
130,000	10.30.50	.010	
135,000	10.31.30	.010	
140,000	10.32.10	.010	
145,000	10.32.40	.011	
150,000	10.33.15	.011	
155,000	10.33.45	.011	
160,000	10.34.25	.012	
165,000	10.35.00	.013	
170,000	10.35.30	.014	
175,000	10.36.10	.014	
180,000	10.36.35	.015	
185,000	10.37.10	.016	
190,000	10.37.50	.017	
195,000	10.38.25	.018	
200,000	10.39.00	.018	
205,000	10.40.15	.019	
210,000	10.40.50	.020	
215,000	10.41.30	.020	Cube perfectly sound. Capacity of machine.
215,000	10.45.00	.020	
215,000	11.05.00	.022	

Load.	Time.	Reading.	Remarks.
215,000	11.45.00	.025	Total load of 215,000 lbs. left on cube and readings taken.
215,000	12.15.00	.026	
215,000	2.00.00 p.m.	.028	
215,000	4.00.00 p.m.	.030	
215,000	9.00.00 p.m.	.031	
30th. 215,000	9.00.00 a.m.	.032	
215,000	11.00.00 a.m.	.033	
215,000	12.00.00 a.m.	.033	
215,000	3.00.00 p.m.	.034	
215,000	6.00.00 p.m.	.035	
31st. 215,000	9.00.00 a.m.	.036	Load taken off on 31st, gradually, and scale read.
150,000		.035	
125,000		.034	
100,000		.033	Rate of unloading, 10,000 lbs. per minute.
75,000		.030	
4,000		.028	

Cube perfectly sound after the whole experiment, and could not break it.

COMPRESSION TEST OF CONCRETE.

27 **A.** Cube 9.3″ x 8.7″ x 9.1″. Weight, 63 lbs., 3 oz.

Made of 1-2-5 Star brand cement, mixed in gravity mixer.

Tested 25th October, 1900, at McGill University, in Wicksteed machine.

Load.	Time.	Reading.	Remarks.
1,000		.000	
5,000	3.19	.001	
10,000	3.19.5	.002	
15,000	3.20	.0025	
20,000	3.20.5	.003	
25,000	3.21	.004	
30,000	3.21.5	.005	
35,000	3.22	.0055	
40,000	3.22.5	.006	
45,000	3.23	.0065	
50,000	3.23.5	.0070	
55,000	3.24	.0085	
60,000	3.24.5	.010	
65,000	3.25	.012	
70,000	3.25.5	.015	
75,000	3.26	.020	
80,000	3.26.5	.026	
80,000	3.27	.034	
80,000	3.28	.035	
80,000	3.29	.038	Cracks developing.
80,000	3.30	.040	
80,000	3.31	.041	
80,000	3.32	.042	
80,000	3.33	.042	
85,000	3.34	.045	
85,000	3.35	.046	

Load.	Time.	Reading.	Remarks.
85,000	3.36	.048	
85,000	3.37	.050	
85,000	3.38	.051	
85,000	3.38.30	.052	
85,000	3.39	.054	
85,000	3.40	.055	
85,000	3.40.30	.057	
85,000	3.41	.058	
85,000	3.41.30	.059	
85,000	3.42	.060	
85,000	3.43	.061	
85,000	3.44	.0625	
85,000	3.45	.064	
85,000	3.46	.065	Badly cracked all over.
85,000	3.47	.066	
85,000	3.50	.070	
85,000	4.5	.073	
85,000	4.14	.080	
85,000	4.44	.089	
85,000	5.0	.092	
85,000	5.30	.097	
85,000	6.0	.100	
85,000	6.30	.103	
Load leaked partly off.	Next a.m. 8.30	.118	
Load put up to 85,000		.120	Very badly broken on all faces, going rapidly, failure.
Inc. to 90,000			

COMPRESSION TEST OF CONCRETE.

27 B. Cube 8.8″ 9.0 and 8.85 x 9.0 x 9.2 high. Weight, 60 lbs. 13 oz. Made of 1-2-5 Star brand cement in gravity mixer. Tested December 20, 1900, in Wicksteed machine. 12 weeks old.

Load.	Time.	Reading.	Remarks.
1,000	11.0	.0000	
5,000	11.1	.0012	Corner broken off in transit, patched with cement.
10,000	11.2	.0024	
15,000	11.3	.0034	Surfaced with Plaster of Paris.
20,000	11.4	.0044	
25,000	11.5	.0054	
30,000	11.6	.0064	
35,000	11.7	.0072	
40,000	11.8	.0081	
45,000	11.9	.1188	
50,000	11.10	.0095	
55,000	11.11	.0103	
60,000	11.12	.0010	

Load.	Time.	Reading.	Remarks.
65,000	11.13	.0114	
70,000	11.14	.0123	
75,000	11.15	.0129	
80,000	11.16	.0135	
85,000	11.17	.0143	
90,000	11.18	.0152	
95,000	11.19	.0163	
100,000	11.20	.0175	Cracks showing.
80,000	11.21.30	.0174	
60,000	11.23	.0170	
40,000	11.24.30	.0165	
20,000	11.26	.0151	
1,000	11.27.30	.0100	
100,000	11.36	.0175	
105,000	11.37	.0180	
110,000	11.38	.0190	
110,000	11.36	.0190	
115,000	11.39	.0200	
120,000	11.40	.0210	
125,000	11.41	.0240	Started bursting out.
130,000	11.42	.0265	
135,000	11.43	.0300	
140,000	11.44	.0310	
145,000	11.45	.0340	
145,000	11.45.30	.0350	
145,000	11.46	.0360	
145,000	11.46.30	.0375	
145,000	11.47	.0385	
145,000	11.47.30	.0395	
145,000	11.48	.0400	
145,000	11.48.30	.0403	
145,000	11.49	.0405	
145,000	11.49.30	.0407	
	Load then increased.		
150,000	11.50	.0409	
150,000	12.33	.0440	
150,000	12.34	.0450	
150,000	12.35	.0460	
150,000	12.37	.0475	
150,000	12.41	.0500	
150,000	1.0	.0575	
150,000	1.15	.0600	
150,000	1.30	.0625	
150,000	1.45	.0650	
150,000	2.00	.0670	
150,000	2.15	.0700	
150,000	2.30	.0710	
150,000	2.45	.0720	
150,000	3.0	.0740	
150,000	3.15	.0750	
150,000	4.15	.0790	
150,000	5.0	.0800	
150,000	6.0	.0830	
150,000	8.0	.0850	
150,000	9.0	.0860	
150,000	10.0	.0875	
150,000	10.30	.0880	

Load.	Time.	Reading.	Remarks.
Dec. 21 150,000	9.0	a.m. .0925	
150,000	10.0	.0930	
150,000	11.0	.0940	
150,000	12.0	.0945	
150,000	1.0	.0948	Badly broken up on surfaces.
155,000	2.2	.0960	
160,000	2.3	.0970	
165,000	2.4	.0975	
170,000	2.5	.0978	
175,000	2.6	.0980	
180,000	2.7		Failed suddenly.

COMPRESSION TEST OF CONCRETE.

27 C. Cube 8.9 x 8.9 x 8.95 x 8.6 x 9.2″ high. Weight. 58½ lbs.
Made of 125 Star Brand Cement in gravity mixer.
Tested March 14, 1901.

Load.	Time.	Reading.	Remarks.
1,000	12.7	.000	
5,000	12.9	.001	
10,000	12.10	.0015	
15,000	12.10.30	.002	
20,000	12.11	.0027	
25,000	12.11.30	.0033	
30,000	12.12	.004	
35,000	12.13	.0045	
40,000	12.13.30	.0048	
45,000	12.14	.0052	
50,000	12.14.30	.0055	
55,000	12.15	.0057	
60,000	12.15.30	.006	
65,000	12.16	.0062	
70,000	12.16.30	.0065	
75,000	12.17	.0070	
80,000	12.17.30	.0076	
85,000	12.18	.0083	
90,000	12.19	.0090	
95,000	12.19.30	.0108	
100,000	12.20.30	.0115	No cracks visible.
80,000	12.23	.0110	
60,000	12.24	.0100	
40,000	12.25	.009	
20.000	12.26	.008	
5,000	12.27	.007	
1,000	12.28	.005	
5,000	12.31	.0095	
20,000	12.32	.0060	
40,000	12.33	.0075	
60,000	12.34	.0090	
80,000	12.35	.0110	
100,000	12.36	.0120	
105,000	12.37	.0130	
110,000	12.38	.0140	
115,000	12.39	.0145	
120,000	12.40	.0150	

Load.	Time.	Reading.	Remarks.
125,000	12.41	.0155	
130,000	12.42	.0160	
135,000	12.43	.0175	Slightly bursting out one side.
140,000	12.44	.020	
145,000	12.45	.022	
150,000	12.46	.024	Developing.
155,000	12.47	.026	
160,000	12.48	.028	
165,000	12.49	.0310	Cracked all over.
170,000	12.50	.0370	
170,000	12.51	.0400	Bursting out.
170,000	12.52	.0418	
175,000	12.53	.0440	
175,000	12.54	.0450	
175,000	12.55	.0460	
180,000	12.56	.0490	
180,000	12.57	.0540	
180,000	12.58	.0560	
180,000	12.59	.0600	
180,000	1.0	.0610	
180,000	1.5	.0680	
180,000	1.45	.0820	
180,000	2.13	.0860	Badly broken down.
180,000	2.32	.100	
180,000	2.34	.105	Breaking down fast.
180,000	2.37	.108	
180,000	2.39	.115	
180,000	2.40	.117	
180,000	2.41	.120	Going to pieces one side.
180,000	2.42	.125	
180,000	2.45		Completely broken down.

TABLE I.

Average Tensile Strengths of Briquettes in Lots I to XXIV.

Briquettes 1" x 1".

Lot Number.	No. of Briquettes.	Per cent of Water.	Pressure per in. on Briquette.	Average Tensile Strength lbs. per sq. in. 7 days.	28 days.	Remarks.
I.	4	.....	.....	217	391	Not rammed in moulds.
II.	4	......	......	167	340	" " " "
III.	4	......	......	222	256	Absorption test.
IV.	4	20	.....	730	727	Tamped into moulds with 1 lb. hammer.
V.	4	20	....	30	44	No tamping whatever.
VI.	4	30	3	374	600	
VII.	2	20	20	534	....	Frozen for 24 hrs. when 24 hrs. old.
VIII.	2	20	20	497	....	Frozen for 48 hrs. when 48 hrs. old.
IX.	2	20	20	420	....	Frozen for 24 hrs. when 3 days old.
X.	2	20	20	486	....	Frozen for 24 hrs. when 4 days old.
XI.	2	20	20	470	....	Frozen for 24 hrs. when 5 days old.
XII.	2	20	20	470	....	Frozen for 24 hrs. when 6 days old.
XIII.	2	20	20	435	....	Frozen in water when 24 hrs. old until 7 days old.
XIV.	2	20	20	432	....	Frozen in water when 48 hrs. old until 7 days old.
XV.	2	20	20	432	....	Frozen in water when 3 days old until 7 days old
XVI.	2	20	20	460	....	Frozen in water when 4 days old until 7 days old
XVII.	2	20	20	541	....	Kept in water at 60 F. until 7 days old.
XVIII.	6	20	20	344	....	Exposed to weather for 7 days when 24 hrs. old.
XIX.	6	20	20	....	327	Exposed to weather for 28 days when 3 days old.
XX.	5	20	20	256	....	Freezing test after 6 hrs. old.
XXI.	6	20	20	....	302	Freezing test after 12 hrs. old.
XXII.	2	20	......	67	....	Plates rusted.
XXIII.	3	20	......	30	....	Plates clean and smooth.
XXIV.	4	20	......	42	....	Plates painted with asphaltum paint.

TABLE II.

DATA AND RESULTS OF PHYSICAL TESTS made on the neat cement, cement mortar and concrete used in the construction of the Bulkhead, Main dam, Wing dam and arches in Power House at Chaudiere Falls, Que. for the Canadian Electric Light Company's Water Power Development. The concrete specimens were made of part of the regular batches of concrete being placed in the works. Plans and specifications prepared by, and work carried out under the supervision and direction of T. Pringle & Son Engineers, Montreal, P.Q. 1900.

Date of Moulding	No. in briquettes	Neat Cement Test, Tensile Strength lbs per sq. inch: 7 days	28 days	3 months	6 months	Mortar Tests: Cement	Sand	Tensile Strength lbs per sq. inch: 7 days	28 days	3 months	6 months	Brand of Cement	Kind of Sand	Kind of Stone	Style of Crusher used	Marks on Concrete cubes
May 12		No tests made				No tests made						Hemmoor	Siliceous	Laurentian boulders	Gates gyratory crusher	1-A
" 12												"	"			1-B
" 16												"	"			1-C
" 22												"	"	"	"	3-A
" "		"	"	"		"	"	"	"	"		"	"		"	3-B
May 22															"	3-C
June 20												"	"	"	"	5-A
" "		"	"	"		"	"	"	"	"		"	"		"	5-B
" 20																5-C
" 25												"	"	Laurentian boulders	Gates gyratory crusher	7-A
" "		"	"	"		"	"	"	"	"		"	"			7-B
June 25																7-C
July 6												"	"	Felspathic sand-stone and Laurentian boulders	Jaw Crusher	9-A
" "												"	"			9-B
" 6		No tests made				No tests made						"	"			9-C
" 24	10 ABC	537	711	681		1	2	202	256	444		"	"		"	10-A
" "		"	"	"		"	"	"	"	"		"	"	"	"	10-B
" 24		537	711	681		"	"	202	256	444		"	"		"	10-C
" 30	11 ABCD	580	693	810		"	"	255	396	428		"	"		"	11-A
" "		"	"	"		"	"	"	"	"		"	"	"	"	11-B
July 30		580	693	810		"	"	255	396	428		"	"		"	11-C
Aug 2	12 ABCD	422	751	766		"	"	258	391	529		"	"		"	12-A
" "		"	"	"		"	"	"	"	"		"	"	"	"	12-B
" 2		422	751	766		"	"	258	391	529		"	"		"	12-C
" 3	14 ABCD	638	654	757		"	"	325	365	448		"	"		"	14-A
" "		"	"	"		"	"	"	"	"		"	"	"	"	14-B
" 3		638	654	757		"	"	325	365	448		"	"		"	14-C
" 6	15 ABCD											"	"		"	15-A
" "		No tests made				No tests made						"	"	"	"	15-B
" 6												"	"		"	15-C
" 7	16 ABCD											"	"	Felspathic sand-stone and Laurentian boulders	Jaw Crusher	16-A
" "		No tests made				No tests made						"	"			16-B
" 7												"	"			16-C
" 13	17 ABCD	435	437	548		1	2	222	296	407		Hemmoor	"	Laurentian boulders	Gates gyratory crusher	17-A
" "		456	"	"		"	"	"	"	"		Heidelberg	"			17-B
" 13		435	437	548		"	"	222	296	407		"	"			17-C
" 15	18 ABCD	435	462	801		"	"	237	295	502		"	"	Laurentian boulders	Gates gyratory crusher	18-A
" "		"	"	"		"	"	"	"	"		"	"			18-B
" 15		435	462	801		"	"	237	295	502		Heidelberg	"			18-C
" 17	19 ABCD											Hemmoor	"	Laurentian Rock	Jaw Crusher	19-A
" "		No tests made				No tests made						"	"			19-B
" 17												Heidelberg	"			19-C
" 24	20 ABCD	480	500			1	2	242	325			Heidelberg	"	Laurentian boulders	Gates gyratory crusher	20-A
" "		"	"			"	"	"	"			"	"			20-B
" 24		480	500			1	2	242	325			"	"			20-C
" 25												"	"	Felspathic sand-stone	Jaw Crusher	21-A
" "		No tests made				No tests made						"	"			21-B
Aug 25												"	"			21-C
Sept. 1	22 ABCD	410	628	730		1	2	240	397	385		"	"	"	Gates gyratory crusher	22-A
" "		"	"	"		"	"	"	"	"		"	"			22-B
Sept. 1		410	628	730		"	"	240	397	385		Heidelberg	"			22-C
Aug 30	23 ABCD	885	743	755		"	"	311	444	X		Beaver	"	"	"	23-A
" "		"	"	840		"	"	"	"	"		"	"		"	23-B
Aug 30		585	"	755		"	"	311	444	X		Beaver	"		"	23-C
Sept 4	24 ABCD	595	667	794		"	"	338	374	445		Hemmoor	"	"	Gates gyratory crusher	24-A
" "		"	"	"		"	"	"	"	"		"	"			24-B
" 4		595	667	794		"	"	338	374	445		Hemmoor	"			24-C
" 8	25 ABCD	580	671	700		"	"	331	481	610		Beaver	"	"	Eagle crusher	25-A
" "		"	"	"		"	"	"	"	"		"	"			25-B
" 8		580	671	700		"	"	331	481	610		Beaver	"			25-C
" 10	26 ABCD	460	533	502		"	"	241	321	415		Heidelberg	"	"	Gates gyratory crusher	26-A
" "		"	"	"		"	"	"	"	"		"	"			26-B
" 10		460	533	502		"	"	241	321	415		Heidelberg	"			26-C
" 27	27 ABCD	497	523	567		"	"	282	394	527		Star	"	Felspathic Sand Stone	Gates gyratory crusher	27-A
" "		"	"	"		"	"	"	"	"		"	"			27-B
Sept 27		497	523	567		"	"	282	394	527		Star	"			27-C
Oct 9	28 ABCD	542	691			"	"	197 205	437			Beaver	"	Laurentian Rock	Eagle crusher	28-A
" "		"	"			"	"	195	"			"	"			28-B
" 9		542	691			"	"	280	437			"	"			28-C
" 10	29 ABCD	521	603			"	"	257	371			"	"	Laurentian Rock from Quarry	Eagle crusher	29-A
" "		"	"			"	"	"	"			"	"			29-B
" 10		521	603			"	"	257	371			"	"			29-C
" 17	30 ABCD	481	622			"	"	227	536			"	"	Laurentian boulders	Gates gyratory crusher	30-A
" "		"	"			"	"	"	"			"	"			30-B
Oct 17		481	622			1	2	227	536			Beaver	Siliceous			30-C

Marks on Concrete cubes	Proportions: Cement	Sand	Stone	% of water	Style of Mixer used	Temperature	Date of Test	Age of Cube	Weight: Total lbs. oz.	lbs. per cub. foot	Dimensions: Height	Compressed Surface	Sectional Area	Load to cause First Crack: Total	lbs per sq inch	Ultimate Strength: Total	lbs. per sq inch	Compression from initial load: First Crack	Final	Time of compression: First Crack	Ultimate	Where used on Works	Remarks
1-A	1	2	4	20	Cockburn and Barrow	40	June 9th	28 days	—	—	9"	9"x9"	81"	58000	716	58000	716	—	—	6	10	Bulkhead	
1-B	1	2	4	"			" 9th	" "	—	—	"	9"x9"	81"	50000	617	63800	787	—	—	4	10	Bulkhead	
1-C	1	1½	3	"	hand mix.	40	" 13th	" "	59-00	138.87	"	9"x9"	81"	75000	926	85000	1050	—	—	12	18	East End Abut.	
3-A	1	2	5	"	Hand mixed	63	" 18	" "	60-14	144.30	"	9"x9"	81"	32000	395	52900	653	—	—	—	10	North End	
3-B	1	2	5	"			"	"	60-14	144.25	"	9"x9"	81"	40000	494	51000	629	—	—	—	16	of	
3-C	1	2	5	20		63	June 19	28	61-13	146.40	"	9"x9"	81"	30000	370	49000	605	—	—	—	10	Core wall	
5-A	1	2	6	Very wet	Cockburn and Barrow	60	July 18	29 days	—	—	"	9"x9"	81"	105000	1296	125000	1543	—	—	16	20	Main	Cube 5-C bore load of 217500 lbs
5-B	1	2	6			"	Sept. 20	13 weeks 1 dy.	—	—	"	9"x9"	81"	140000	1735	175000	2160	.024	.064	26	33	Bulkhead	without rupture.
5-C	1	2	6			60	Dec. 7	24 weeks	61-01	146.40	"	9"x8.9	80.1	170000	2128	Unknown	—	.034	.116	38	[illegible]		
7-A	1	2	4	20	Hand mixed	66	July 24	28½ days	—	—	"	9"x9"	81"	140000	1728	215000	2654	—	—	20	34	East End	Cubes 7-B and 7-C bore load of
7-B	1	2	4	"		"	Sept. 26	13 weeks 2 d's	—	—	9.2	9"x9"	81"	Unknown	—	Unknown	—	—	.012	—	47	of	217,500 lbs. without rupture.
7-C	1	2	4			56	Dec. 10	24 weeks	63-11	146.88	9.15	9.1x8.9	81"	205000	2531	Unknown	—	.011	.014	66	[illegible]	Bulkhead	
9-A	1	2	4		Sooysmith	77	Aug. 3	28 days	—	—	9"	9"x9"	81"	120000	1481	160000	1975	.012	.030	21	46	Main dam	
9-B	1	2	4			"	Sept. 28	12 weeks	58-07	140.05	9.12	8.8x9	80.1	155000	1914	165000	2037	.028	.294	26	33	at	
9-C	1	2	4			77	Dec. 21	24 weeks	60-00	137.63	9"	9.2x9	82.8	160000	1911	185000	2329	.022	.090	32	62	Station 8+00	
10-A	1	2	4		"	70	Aug. 21	28 days	—	—	9"	9"x9"	81"	140000	1728	205000	2530	.039	.169	20	49	East	Cubes bore load of 217,500 lbs without rupture
10-B	1	2	4			"	Oct. 16	12 weeks	62-03	144.55	9.12	9"x9.05	81.5	Unknown	—	Unknown	—	—	.032	—	[illegible]	Spillway Pier	10-C began to burst out on all faces
10-C	1	2	4			70	Jan. 21	25 weeks 6 d's	61-13	143.33	9.2	9"x9"	81"	190000	2346	Unknown	—	.018	.034	44	2-0	Station 8+50	under load of 218000 lbs.
11-A	1	2	4		"	68	Aug. 29	29 days	61-04	145.20	9"	9"x9"	81"	Unknown	—	Unknown	—	—	.028	—	46	Main dam	These cubes bore loads of
11-B	1	2	4			"	Oct. 24	12 weeks 2 d's	62-01	143.84	9.2	9.1x9.05	81.8	"		"	—	—	.016	—	43	at	218,000 lbs. without signs of
11-C	1	2	4			68	Jan. 21	25 weeks	61-02	144.93	9.2	9"x8.8	79.2	Unknown	—	Unknown	—	—	.014	—	70	Station 8+00	cracking.
12-A	1	2	4		Sooysmith	66	Aug. 31	29 days	60-00	142.20	9"	9"x9"	81"	120000	1481	170000	2098	.091	.114	27½	35½	Main dam	Cubes 12-B and 12-C bore loads
12-B	1	2	4			"	Oct. 25	12 weeks	57-08	141.13	9.1	9"x8.6	77.26	215000	2810	Unknown	—	.016	—	30	30	at	of 218,000 lbs. without rupture.
12-C	1	2	4			66	Jan. 22	24 weeks 5 d's	58-00	137.50	9.2	8.7x8.9	77.8	Unknown	—	Unknown	—	—	.013	—	55	Station 7+50	
14-A	1	2	4		Cockburn and Barrow	67	Aug. 31	28 days	—	—	9"	9"x9"	81"	185000	2284	Unknown	—	.041	.051	18	26	Main dam	These cubes bore loads of
14-B	1	2	4			"	Oct. 26	12 weeks 2 d's	61-00	141.40	9.3	9.1x9	81.9	215000	2654	—	—	.014	.023	50	[illegible]	at	218,000 lbs. without rupture.
14-C	1	2	4			67	Jan. 24	24 weeks 6 d's	60-04	143.62	9.05	9"x8.9	80.1	Unknown	—	—	—	—	.074	—	1-28	Station 6+50	
15-A	1	2	4		"	65	Sept. 5	28 days	—	—	9"	9"x9"	81"	120000	1481	130000	1605	.023	.108	19	24½	Main dam	
15-B	1	2	4			"	Oct. 31	12 weeks	57-03	134.13	9.1	9"x9"	81"	150000	1852	165000	2037	.021	.038	25	28	at	
15-C	1	2	4			66	Jan. 24	24 weeks 1 dy	57-09	135.71	9.15	9"x8.9	80.1	115000	1435	185000	2309	.010	.046	40	69	Station 6+00	
16-A	1	2	4		Cockburn and Barrow	72	Sept. 5	29 days	—	—	9"	9"x9"	81"	130000	1605	145000	1790	.025	.060	20	27	Main dam	Cubes 16-B and 16-C bore loads
16-B	1	2	4			"	Oct. 30	12 weeks	63-01	144.56	9.2	9"x9.1	81.9	Unknown	—	Unknown	—	—	.015	—	40	at	of 218,000 lbs. without signs of
16-C	1	2	4			72	Jan. 23	24 weeks	62-00	141.46	9.35	9"x9"	81"	Unknown	—	Unknown	—	—	.016	—	[illegible]	Station 5+00	cracking.
17-A	1	2	4	20	Sooysmith	66	Sept. 10	28 days	—	—	9"	9"x9"	81"	125000	1543	140000	1728	.024	.084	20	31	Temporary	
17-B	1	2	4	"		"	Nov. 5	12 weeks	60-10	143.70	9"	9"x9"	81"	160000	1975	180000	2222	.038	.080	37	52	Spillway Pier	
17-C	1	2	4			66	Feb. 7	25 weeks 3 d	59-01	138.45	9.1	9"x9"	81"	115000	1419	180000	2222	.011	.085	27	47	Station 6+50	
18-A	1	2	4	22	Hand mixed	60	Sept. 12	28 days	—	—	9"	9"x9"	81"	115000	1419	125000	1543	.030	.082	18	25	Main dam	
18-B	1	2	4			"	Nov. 8	12 weeks 1 dy	61-10	142.11	9.15	9.05x9.05	81.9	140000	1709	170000	2075	.026	.092	23	54	Stations	
18-C	1	2	4			60	Feb. 8	25 weeks 2 d	61-04	141.26	9.25	9"x9"	81"	140000	1728	190000	2345	.016	.064	31	[illegible]	0+50 to 1+00	
19-A	1	2	4		Gravity of Chicago	69	Sept. 14	28 days	—	—	9"	9"x9"	81"	90000	1111	105000	1296	.022	.073	10	17	Wheel pit.	
19-B	1	2	5			"	Nov. 9	12 weeks	61-00	143.00	9.2	8.9x9	80.1	95000	1186	125000	1560	.018	.110	22	[illegible]		
19-C	1	2	5	22		69	Feb. 13	25 weeks 5 d	58-04	137.33	9.15	8.9x9	80.1	105000	1310	132700	1656	.032	.087	25	[illegible]		
20-A	1	2	4	Very wet	Cockburn and Barrow	84	Sept. 21	28 days	—	—	9"	9"x9"	81"	85000	1049	110000	1358	.005	.133	10	[illegible]	Main dam	
20-B	1	2	4			"	Nov. 14	11 weeks 5 d	60-00	139.75	9.05	9"x9.1	81.9	140000	1709	165000	2014	.016	.029	28	37½	Stations	
20-C	1	2	4			84	Feb. 14	24 weeks 6 d	60.08	140.27	9.1	9.1x9	81.9	155000	1892	192100	2345	.018	.105	50	2-28	1+00 to 1+50	
21-A	1	2	4	20	Hand Mixed	80	Sept. 22	28 days	59-03	136.70	9.13	9"x9"	81"	160000	1975	170000	2098	.029	.035	28½	30	Main dam	
21-B	1	2	4	"	Turned 4 times	"	Nov. 17	11 weeks 6 d	61-02	140.06	9.1	9"x9.2	82.8	215000	2596	215000	2596	.033	.075	39	46	Stations 4+50 to 5	
21-C	1	2	4	20		80	Feb. 15	24 weeks 5 d	59-09	138.88	9.1	9.1x8.8	80.0	180000	2222	210000	2592	.018	.030	54	72	bottom courses	
22-A	1	2	4	25	Cockburn and Barrow	72	Sept. 29	28 days	59-05	140.43	9.25	8.7x9	78.3	80000	1015	95000	1206	.019	.060	11	26½	Main dam	
22-B	1	2	4	"		"	Nov. 26	12 weeks 2 d	61-00	143.80	9.15	8.9x9	80.1	100000	1246	154000	1922	.015	.086	41	1-30	Stations	
22-C	1	2	4	25		72	Feb. 19	24 weeks 3 d	60-01	143.15	9.15	8.9x8.9	79.2	100000	1262	155000	1957	.015	.069	15	69	1+50 to 2+00	
23-A	1	2	4	20	Sooysmith	75	Sept. 27	28 days	62-01	146.06	9.06	9"x9"	81"	215000	2654	Unknown	—	.029	.095	40	65½	Main dam	These cubes bore loads of
23-B	1	2	4	"		"	Nov. 22	12 weeks	62-04	141.23	9.25	8.9x9.2	81.9	165000	2014	Unknown	—	.011	.029	31	2-14	Stations	218,000 lbs. without rupture.
23-C	1	2	4	20		75	Feb. 18	24 weeks 4 d	65-00	145.86	9.2	9.1x9.2	83.7	Unknown	—	Unknown	—	—	.019	—	4-17	4+50 to 5+00	
24-A	1	2	4	22	Cockburn and Barrow	68	Oct. 2	28 days	60-09	140.00	9.25	9"x9"	81"	155000	1914	165000	2037	.022	.055	32½	39½	Main dam	Cubes 24-B and 24C bore loads
24-B	1	2	4	"		"	Nov. 27	12 weeks	59-04	138.20	9.25	9"x8.9	80.1	210000	2622	Unknown	—	.029	.033	2-22	2-26	Stations	of 218000 lbs. without rupture.
24-C	1	2	4	22		68	Feb. 20	24 weeks 1 d	59-08	138.26	9.08	9.2x8.9	81.9	218000	2662	Unknown	—	.016	.026	57	[illegible]	2+50 to 3+50	
25-A	1	2	4	25	Sooysmith	55	Oct. 6	28 days	61-13	142.50	9.25	9"x9"	81"	155000	1914	175000	2160	.021	.059	30	37	Main dam	
25-B	1	2	4	"		"	Dec. 1	12 weeks	62-14	142.63	9.30	9"x9.1	81.9	215000	2625	Unknown	—	.023	.037	83	1-11	Stations	Cubes 25 B and 25C bore loads
25-C	1	2	4	25		55	Feb. 25	24 weeks 2 d	61-00	139.13	9.20	9.1x9	81.9	Unknown	—	Unknown	—	—	.023	—	[illegible]	4+50 to 5+00	of 218,000 lbs. without rupture
26-A	1	2	4	20	Cockburn and Barrow	58	Oct. 10	30 days	61-14	148.7	9.06	9"x8.9	80.1	115000	1436	135000	1685	.014	.067	[illegible]	[illegible]	Main dam	
26-B	1	2	4	"		"	Dec. 4	12 weeks 1 dy	61-01	142.36	9.15	9"x9"	81"	105000	1296	195000	2407	.009	.066	22	59	Stations	Cube 26C bore load of
26-C	1	2	4	20		56	Feb. 26	24 weeks 1 dy	61-11	144.72	9.3	9"x8.8	79.2	218000	2753	Unknown	—	.002	.027	52	4-14	3+50 to 4+00	218,000 lbs. without rupture.
27-A	1	2	5	21	Hand and Gravity of Chicago	54	Oct. 25	28 days	63-03	148.20	9.10	8.7x9.3	80.9	80000	988	90000	1113	.038	.120	10	[illegible]	Wheel Pit.	
27-B	1	2	5	"		"	Dec. 20	12 weeks	60-13	144.23	9.2	8.9x8.9	79.2	100000	1263	180000	2273	.017	.098	20	[illegible]		
27-C	1	2	5	21		54	Mar. 14	24 weeks	58-08	140.24	9.2	8.9x8.8	78.3	135000	1724	180000	2298	.017	.125	34	[illegible]		
28-A	1	2	5	20	Gravity of Chicago	50	Nov. 7	29 days	62-02	141.81	9.2	9.1x9	81.9	90000	1099	90000	1099	.040	.140	16½	43	Wheel pit	
28-B	1	2	5	"		"	Feb. 26	20 weeks	62-01	139.27	9.3	9"x9.2	82.8	170000	2053	200000	2416	.014	.025	55	64		
28-C	1	2	5	20		50	Mar. 28	24 weeks 2 d	61-08	143.38	9.15	9"x9"	81"	180000	2222	210000	2592	.021	.046	52	73		
29-A	1	2	4	25	Sooysmith	48	Nov. 7	28 days	61-14	143.43	9"	9"x9.2	82.8	90000	1087	95000	1148	.034	.110	19	36	Main dam	
29-B	1	2	4	"		"	Feb. 27	20 weeks	60-08	139.33	9.26	9.1x8.9	81"	145000	1790	190000	2346	.026	.090	43	76	Stations	
29-C	1	2	4	25		48	Mar. 20	24 weeks 2 d	58.06	134.57	9.27	9"x8.9	80.1	135000	1685	180000	2247	.029	.046	2-29	2-34	3+00 to 3+50	
30-A	1	2	4	21	Gravity of Chicago	40	Nov. 14	28 days	61-07	143.20	9"	9"x9.1	81.9	100000	1221	140000	1710	.013	.074	21	[illegible]		Cube 30-C bore load of
30-B	1	2	4	"		"	Feb. 27	19 weeks	61,00	141.57	9.1	9"x9.1	81.9	155000	1892	215000	2625	.010	.030	26	52	Wheel pit	218000 lbs. for 92 hours
30-C	1	2	4	21		40	Apr. 4	24 weeks 1 dy	62-00	142.18	9.2	9"x9.1	81.9	185000	2258	Unknown	—	.027	.096	56	93		without failure.

TEMPERATURE CHART – MAX. & MIN. FOR LOTS XVIII, XIX, XX, & XXI.