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The Canadian Engineer

A weekly paper for engineers and engineering-contractors

STORAGE DAM AT EUGENIA FALLS

PLANT AND METHODS EMPLOYED IN THE CONSTRUCTION OF THE CONCRETE-STEEL SECTION OF DAM ON BEAVER RIVER FOR THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

By G. R. HECKLE,
Managing Director, Ambursen Hydraulic Construction Co. of Canada, Ltd.

IN estimating the cost of carrying out any construction project two factors of the greatest importance are the time in which the work must be completed and the plant to be employed. These two factors are practically analogous, as, of course, the capacity of the plant governs the time required. If the capacity of any unit is not as great as was estimated, moreover, there is a grave probability that the other units of plant may be delayed in employment, and while their capacity may be as large as estimated, they may be unable to carry the extra load occasioned by the delay of some one unit, and the whole schedule of operations may therefore be completely disorganized. As the "overhead" charges, such as superintendence, maintenance of plant, etc., are all based on the estimated duration of the work, they immediately start to increase as a relative percentage of the other work, and the contractor's estimate of profit is possibly absorbed in the process.

In the old days of contracting when manual labor was largely employed, there was less liability for an error in judgment with regard to the time and cost, as the forces employed were much less complex, and more laborers could be easily added or more work could be produced by better management from a given number of men. In modern contracting, however, when the plant is once installed the time and expense of replacing any units which may fall below their estimated capacity will in all probability eat up the profit and possibly more, so that it is of great importance that first calculations be on the safe side, and a considerable margin be allowed for contingencies.

With the above preamble, the writer begs to call attention to a contract for the construction of a concrete-steel dam of the Ambursen type for the Hydro-Electric Power Commission of Ontario, which is now nearing completion. The work is located at Eugenia Falls, Ontario, about eighty-five miles west of Toronto, and about thirty miles east of Owen Sound, the site of the dam being about seven miles from the railroad. The dam will furnish storage for a power development on the Beaver River, which is being constructed and will be operated by the Hydro-Electric Power Commission. The total length of the structure is approximately 1,900 feet, of which 1,260 feet is Ambursen section and 640 feet is earth embankment with concrete corewall about equally divided at both ends. The Ambursen section is approximately 51 feet high from bottom of cut-off to top of crest at the highest section; the total concrete required for the entire work being about 10,000 cu. yds., practically all of which is in comparatively thin reinforced sections, and distributed over a large area. The stripping of the site involved about 14,000 cu. yds. of earth excavation and about 2,500 cu. yds. of rock, principally in the cut-off trench, which is in a stratified and seamy limestone and which has an average depth of about ten feet.

The contract for the construction of this dam was closed with the Ambursen Hydraulic Construction Company of Canada, Limited, in the latter part of June of the present year, and the company guaranteed to complete the dam to within fifteen feet of the crest by December 25th of this year, so that water from the spring freshet of 1915 could be stored for power purposes, the entire dam to be completed by July 1st, 1915. The work was undertaken on a unit price basis with liquidated damages for non-completion to the elevation noted previously at the date specified. The latter stipulation required that the dam should be entirely completed with the exception of about 2,000 cu. yds. of concrete in the top lift in a period of about six months from the receipt of authority to proceed, and it was obvious that in order to accomplish this result it was very necessary not to overestimate the plant capacity.

In a general way the following plant and methods formed the basis of the estimate: A Bucyrus traction steam shovel of ⅞ cu. yd. dipper capacity for earth excavation, equipped with 1-yard capacity dump wagons; air drills of the Holman hand-hammer type for the rock excavation; a 1-yard capacity Smith mixer; a cableway of five tons capacity and about 1,325 ft. clear span of our own design, for distributing concrete and handling forms, and Dowd 1-yard capacity controllable bottom dump buckets for concrete. A guy derrick equipped with a three-drum 8-in. x 12-in. Beatty engine, with Dake swinger operating a 1-yard Hayward orange peel bucket, dredged gravel from a pit adjoining the dam, which was

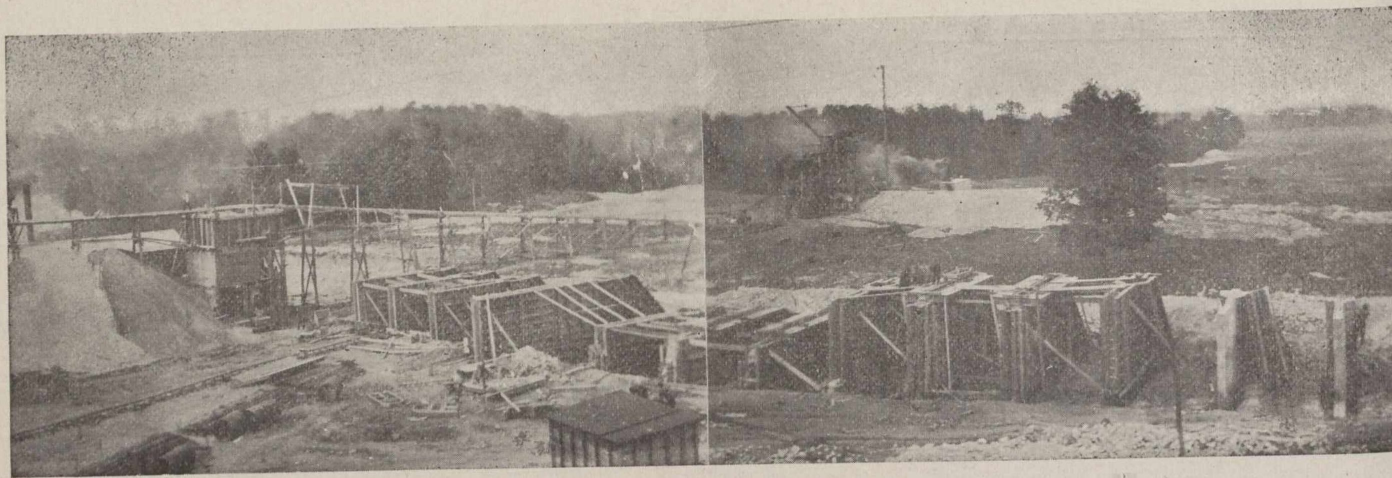


Fig. 1.—South Half of Dam at Eugenia Falls, as it Appeared on September 15th, 1914.

dumped into the hopper of a screening and washing plant, consisting of two revolving conical screens of ⅜-inch and 3-inch diameter holes respectively with automatic sand hopper of the Gilbert type. The product of this plant was hauled over the dam and gravel and sand bins on an inclined trestle by a small hoisting engine, and was either dumped directly into the bins or into storage piles immediately adjacent. By operating this plant day and night, the entire amount of sand and gravel required was furnished by about the last of October, and the derrick was then transferred to the storage piles for loading the bins, the difficulties due to operating a washing plant in freezing weather being thus avoided.

Steam power for operating the above plant, with the exception of the shovel and derrick, was furnished from two 40 and one 50-h.p. boilers of locomotive type, and the water for the sand and gravel washing was furnished by a 4-inch pulsometer assisted by a 2½-inch duplex boiler feed pump, another pulsometer also being used for unwatering the river section. For night work a small motor-generator driven by a steam engine furnished electric power for arc lights suspended from a cable attached to the cableway towers and spanning between them.

A small machine shop and carpenter shop were established immediately at the start of the work, the former being equipped with the usual blacksmith outfit, bolt machine, drill, pipe threader and cutter, and hand-lever shear for cutting reinforcing steel. The carpenter shop was equipped with band saw and air augers, driven by locomotive compressor of the Westinghouse type.

Fig. 1 shows the south half of the dam as it appeared on September 15th. At the left are seen the mixing plant bins and storage piles of gravel and sand. On the opposite side can be seen the screening and washing plant with derrick for loading. It will be noted that the mixing plant is approximately at the centre of the dam, thus cutting down the transportation of concrete by the cableway to a minimum.

With this general summary of the plant employed, it may be of interest to describe briefly its operation, and results obtained.

The shovel easily stripped ahead of the rock excavation and concrete work, and was afterwards employed in feeding the orange peel with gravel, thus saving the time and cost of moving this plant when the adjacent supply of gravel had been exhausted. It was also used for making the earth embankments at both ends of the dam.

The cut-off trench was carried on night and day, as it was much deeper than was anticipated, on account of the seamy nature of the rock, and the concrete plant was delayed somewhat in starting on this account. This trench had to be drilled and blasted with the greatest care to avoid disturbing the seamy rock as much as possible, and was the most difficult factor to contend with, with regard to both cost and time during the carrying out of the work. It was with great difficulty that rock excavation was kept from continually delaying the form and concrete work.

The form work was carried on in two shifts, one being of twelve hours, to take advantage of as much day-

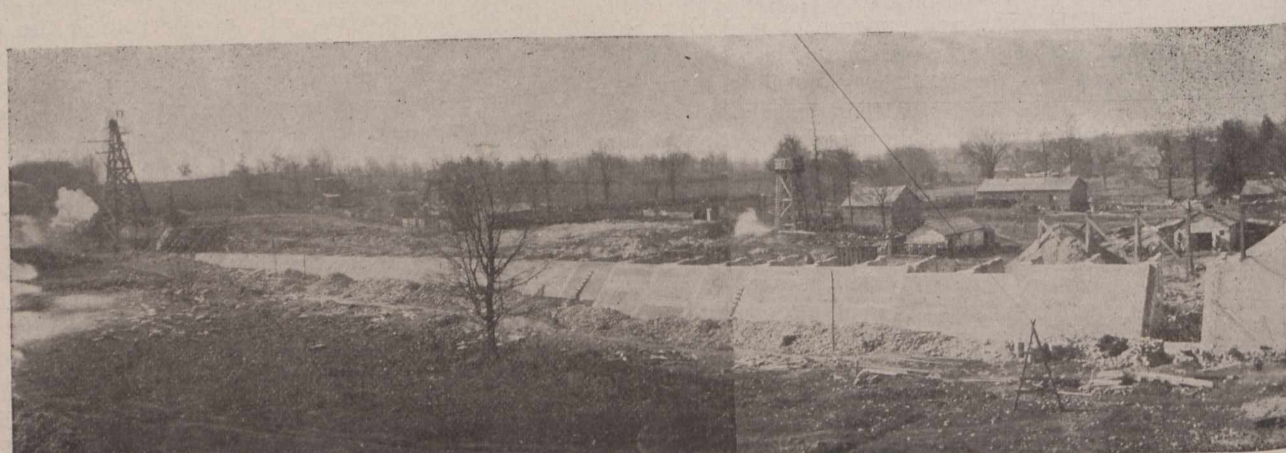
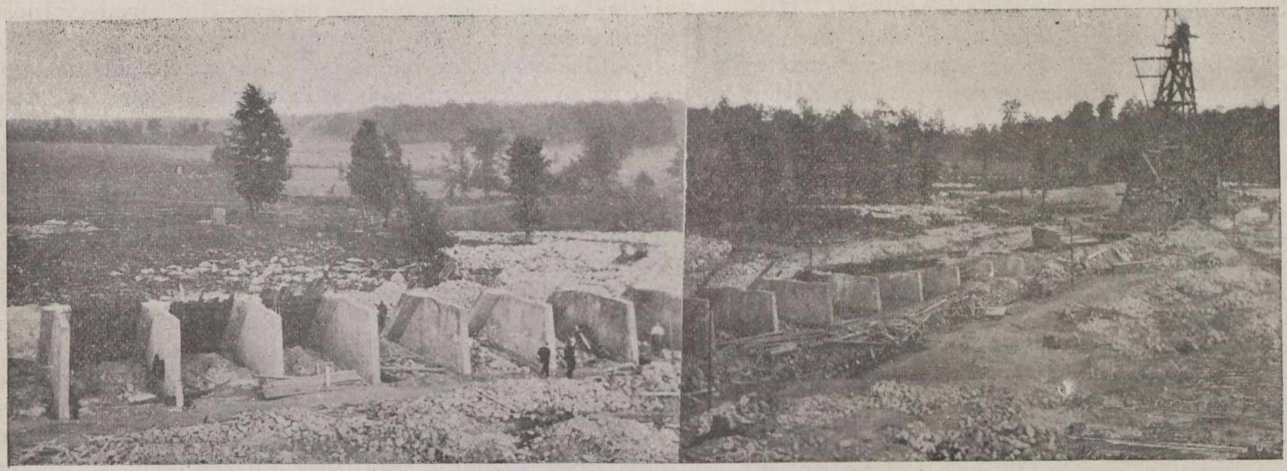


Fig. 2.—Dam and Cableway on October



(Mixing Plant on Left; Screening and Washing Plant in Background.)

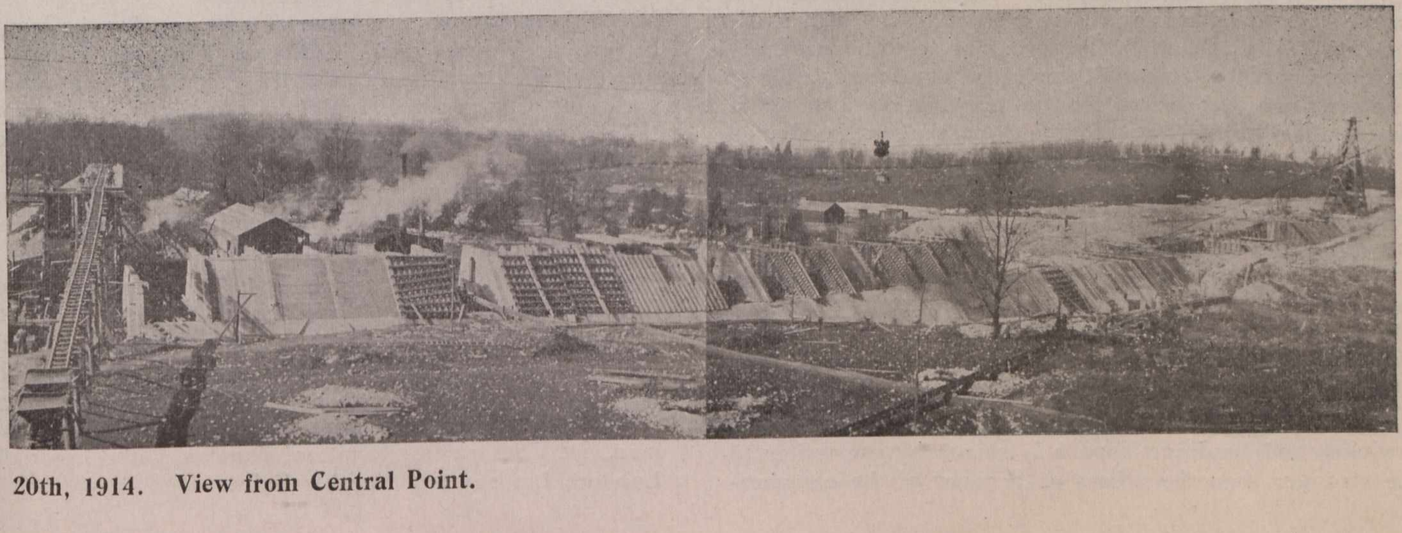
light as possible and the other of ten hours during the night, when the cableway was available for moving forms. In this way the required capacity from the concreting plant could be obtained by properly systematizing the gangs employed in form erection and stripping.

The progress of concrete was estimated as follows: Plant to be in operation about August 1st, figuring that this would insure approximately one hundred working days before December 25th, after deducting for Sundays and bad weather. To pour 8,000 yards in this time an average of 80 cu. yds. per day would be required. It was therefore apparent that one mixer would be more than sufficient, and that the form work was the governing factor. It was also apparent that the concrete plant had a large reserve capacity in case the estimated time of erection should be cut down, as turned out to be the case. It had been estimated that sufficient cut-off trench could be prepared by August 1st, while the plant was being erected, to allow form work and concreting to proceed at that date. On account of the much greater depth of cut-off required, however, and uncertainty at the start with regard to certain horizontal clay seams encountered, it was practically September 1st before the first concrete was poured. On account of this delay it was therefore necessary to exceed the estimated average progress of 80 cu. yds. daily, by at least 25 per cent., raising the rate to an average of 100 cu. yds. per day, and this condition was fully met by the concrete plant and form work, as shown in the following record.

During the month of September the average pouring was 99 cu. yds. of placed concrete per working day. In October the daily average was 140 cu. yds. In November the average for the month dropped to about 90 cu. yds. on account of stormy weather and the fact that most of the work was confined to the small sections at the top of the dam. This record, however, showed that the plant had placed in 78 working days about 9,000 cu. yds. of concrete, or an average of 112 yards per day, and that the "factor of safety" in its capacity was sufficient to make up for the unforeseen delays which had limited its working time. A large factor in the average attained was the high speed of the cableway, which easily reached a travelling speed of 1,500 feet per minute in operation.

Fig. 2 is a general view of the dam and cableway on October 20th, and in the direct foreground are two cars from the gravel plant starting up the incline to the mixer bins and storage piles. The top of the concrete at the left of the picture is about 15 feet below the crest of the completed dam.

Mr. F. A. Gaby is the chief engineer of the Hydro-Electric Power Commission, and the work has been directly under the department of Mr. H. G. Acres, hydraulic engineer. Mr. T. H. Hogg is responsible for matters pertaining to design and Mr. A. D. Watts is resident engineer for the Commission. Mr. A. J. Raymond is superintendent in charge for the Ambursen Hydraulic Construction Company, and Mr. G. A. Johnson is the company's engineer on the work.



20th, 1914. View from Central Point.

STEEL PASSENGER CAR FRAME CONSTRUCTION.

A PAPER presented at the December 3rd meeting of the Mechanical Section of the Canadian Society of Civil Engineers, by Mr. C. Brady, discussed in a very enlightening manner the differences existing in different types of frame construction designed for like loads and stresses. Mr. Brady emphasized the impossibility of drawing satisfactory conclusions as to the merit or weight of any particular type of framing when comparing cars built by different designers for different roads. This for the reason that variations in proportion and in size of plates and bars, together with different weights of other parts of the car and different general dimensions throughout, do not admit of close comparison. But the writer presents some interesting data respecting the four distinct types as they are actually built. These types are described as follows:

(1) Heavy centre sill construction, the centre sills acting as the main carrying member.

(2) Side carrying construction, the sides of the car acting as the main carrying member having their support at the bolster.

(3) Underframe construction, in which the load is carried by all the longitudinal members of the lower frame, the latter being interpreted to include the side girder below the windows.

(4) Combination construction, in which the side frames carry a part of the load, transferring it to the centre sills at points remote from the centre plates, so as to utilize the uniform centre sill area.

The writer does not submit particulars respecting the first type of construction, as it is quite unequal to the others in weight. Types 2, 3 and 4 are analyzed in detail with respect to the above considerations, and the reader is given a clear insight into what to look for in examining cars in service, or more especially, when the opportunity presents itself, to examine cars that have been in accident. The great importance of a minimum weight for a given standard strength is clearly emphasized. Ability to support its own weight and the usual maximum live load is brought out in the case of each, and each is proven entirely satisfactory in that regard. The same is said of end shocks in coupling and uncoupling, and in collisions, so long as the cars remain on the track in the same horizontal plane.

The condition that usually results in numerous injuries and loss of life is the telescoping of cars, as it is called, when the underframe of one car gets above the underframe of the next car and plows through the comparatively light superstructure. When this occurs it is impossible to express what happens in terms of a static load at a given location, but it has come to be generally accepted as inevitable that some damage must result to the vestibule and car end no matter what construction is used. The greatest protection to passengers is effected by making the end construction very strong, not necessarily to resist bending but rather to prevent tearing away at the fastenings. As a telescope contemplates conditions where the centre sills are not in line, some exponents of the comparatively light centre sill construction argue that the very large and powerful centre sills do not afford any additional protection but are actually objectionable because of the increased probability of their tearing away the end superstructure.

For resisting end shocks above the floor level, side swiping and bending, Type 2 is shown by the writer to be stronger than the others on account of the comparatively heavy top plate angle and the stronger post construction.

Advantages for the large heavy centre sills are not so easy to find, but there is one important condition where they would probably show up to advantage and that is in case of a collision where a locomotive strikes the car. A modern locomotive would not be at all likely to climb into the car, and if the speed was great even the heaviest car construction could not be expected to stand up against the massive castings and heavy steel plates used in locomotive construction; but it is quite reasonable to presume that the stronger the centre sill construction in the car the less the damage which would result.

From construction and operating standpoints the shallow centre sill car has the advantage of not interfering in any way with the locating of brake rigging and other equipment under the car, and it materially facilitates quick and thorough inspection in service.

ST. CATHARINES VIADUCT PLANS TO BE REVISED.

The proposed St. Paul Street bridge at St. Catharines, over the old Welland Canal, a description of which appeared in *The Canadian Engineer* for November 26th, 1914, is to undergo a slight change in plan to provide sufficient carrying capacity to accommodate the proposed Hydro-Electric railway between Windsor and the Niagara River. It has been decided to increase the strength of the bridge by approximately 20%, and the companies now tendering on the superstructure are being notified to that effect.

The bridge, as described in the article referred to, was designed to carry a 36-ton car, whereas, a 57-ton passenger car will probably be the requirement of the Hydro.

Although the Hydro-Electric Power Commission is probably not contemplating the early construction of this electric trunk railway line across the western peninsula, members of its engineering staff have conferred with the St. Catharines authorities in an advisory capacity with respect to the wisdom of providing for the future installation.

CANADIAN MANUFACTURE OF SHRAPNEL SHELLS.

As announced in these columns some weeks ago, the British War Office has awarded, through the Department of Militia at Ottawa, a number of contracts for the manufacture of shrapnel shells to different Canadian firms. It has just been announced that these contracts aggregate the sum of $2,500,000, and that practically all the material entering into their construction is being obtained in the Dominion. For instance, the Nova Scotia Coal and Steel Company supplies the steel, the Trail smelters in British Columbia supply the lead, and like materials come from various parts of the Dominion.

At present, about 200,000 shells have been contracted for, and they are being turned out at the rate of 30,000 a month. It is stated that there is capacity in Canada for the manufacture of 100,000 or more per month. The work is now going on at Montreal, Sherbrooke, New Glasgow, Amherst, St. John, Kingston, Toronto, Welland, St. Catharines, Hamilton, Dundas, Galt, Ingersoll, London, Lindsay and Smith's Falls.

IMPROVEMENT OF ORDINARY COUNTRY ROADS.*

By S. P. Hooker,
State Superintendent of Highways of New Hampshire.

IN a subject of this kind the first question to determine is the exact meaning of the title. What is light volume mixed traffic? How many vehicles are to pass over a given piece of highway and still be classed as light volume? What is their relative proportion as to motor-propelled and horse-drawn? The right interpretation of these terms is not clear. There are sections of the country where presumably the mixed traffic would consist almost entirely of horse-drawn vehicles, while in others a very large per cent. would be motor traffic.

The treatment of the surface of these two subdivisions would vary to a considerable extent. The writer is inclined to consider the subject as being the treatment of subsidiary roads which have only the horse-drawn traffic originating upon the road, together with motor traffic of the pleasure class and little or no freight traffic which is motor-driven.

With the immense mileage of roads, it would seem that a large proportion of the roads will never be improved under the types of construction which are now considered necessary for their improvement and that 90 per cent. of the entire mileage will be unimproved if it is necessary to improve them with the higher types of construction.

There must be a revulsion of feeling which will compel more mileage and lesser cost. Given, then, a country highway as it now exists and the proposition that for 10 miles of this road there is only available the sum of $25,000, what can we do to render this really an improved road which, under proper maintenance, will take care of the traffic upon it? A preliminary survey may show that a portion of the road is in a low-lying level section without proper ditches where at present the natural tendency of the road is to act as a sort of drainage canal for lands adjacent to it. The soil itself consisting partially of leaf mold containing a large amount of humus and which if used as a cultivated field would produce good crops.

The next portion may consist of a sand and gravel formation, containing boulders and on a grade of from 5 to 8 per cent., rolling over elevations and into hollows and gullies and eventually working out into clear deep sand. Succeeding this may be a hollow from which you rise upon a side hill cut through a clay bank. Here you face the proposition that the clay is of such a nature as to practically absorb all the water and where your drainage condition is most difficult to handle. Your last section may be through ledge of native rock or large boulders, the soil slightly covered with either hard-pan or sand and upon grades which easily wash under the annual rainfalls.

On almost all country roads several of these conditions will ordinarily appear, while, of course, it is an exaggeration that they will all occur within the 10-mile stretch.

Confronted with these conditions, it seems to be absurd to attempt a standardization of such a highway in order to economically work out the problem. The material which is comparatively local must be used and the treatment of each section will be different.

The width of the present highway must first be taken up and, in general, standardized for the ordinary traffic, probably a width of 21 feet between ditches is the most satisfactory standard and considering that this should be accepted as the width of the road, you are next confronted with the alignment and drainage.

In all probability the alignment will be comparatively easy over the level, fertile section, but the drainage on this section will be a problem. Here, in general, you must first provide by deep ditching for reducing the water level of the surrounding land and by deep ditching is not meant the ordinary ditch from which the crown of the road rises, but in many instances a ditch which acts to a considerable extent as a drainage canal.

Culverts must be provided at all points where the drainage may be taken away from the road at every accessible point, and however level the plain or plateau may be as a whole, you will doubtless find a large number of places by which the water will be conveyed entirely away from the road.

In most instances the grading material obtained from the ditches, though seemingly of very inferior quality, may be used to raise the general grade of the road and, if kept dry by the side ditches, will compact and make a fair subgrade.

The next essential is to obtain upon such raised grade a sufficient quantity of metal of some kind to prevent the cutting through of the road surface from water which falls upon the road or in flood seasons cannot be entirely carried away by the ditches. This may be obtained either from fields, stone fences or even drawn from section two, which has an entirely different soil. In some places it would be necessary to practically lay this stone as telford. In other places it is enough to simply dump it in the road and only partially place it by hand labor. In many places where a roller is available this may be the method and the stone simply forced into the soft material excavated from the ditches and not as yet thoroughly dried out from the service rendered by the ditches.

As for surface material, in many places it will be found that along or adjacent to the road there are hills or hummocks which contain soil not properly either hard-pan or clay, but in many places a combination of each containing considerable metal in the shape of either pebbles or fractured stone. Having obtained the bottom through drainage and the addition of stone so that the sub-base will be practically dry, you may apply 10 inches of the material containing a small amount of metal and by the use of road drags and road hones bring this first into section and next into a smooth, hard surfacing, which will prove satisfactory in all weather for traffic, provided it has constant attendance and is repeated after every rain dragged with the ordinary road drag. The drag removes every slight rut which may be started and does not allow the water to settle through the weak upper surfacing. The maintenance must be not intermittent, but constant. A somewhat slippery upper surface may still be found, in which case it will be necessary to add an inch or two of gravel or sand from section two. This may only require from 3 to 6 yards of gravel surfacing per 100 feet, and while it may be at a considerable distance from the improvement, it will not add materially to the cost.

The surfacing upon such a type of road will require practically 2,000 yards per mile, and if the material is from different banks along the roads the cost will not exceed 20 cents per yard. It is then perfectly feasible over this section to build such a highway, including the raising of the grade from 1 to 2 feet at a cost of not more than the estimated limit of $2,500 per mile.

*From a paper entitled "Surfaces for Light Volume Mixed Traffic," read at the Fourth American Road Congress, Atlanta, Ga., November 10-14, 1914.

On section two, as before described, there is a problem of grading, rather than of drainage. That is, the soil will readily dispose of water, but the grades must be reduced to a reasonable gradient and with a sandy material some method for compacting the road provided. The first to consider, then, is what shall be the maximum grade.

In this class of construction the writer proceeds backwards, rather than attempting to dictate an absolute gradient. That is, he takes the heaviest grade and sees to which per cent. he can reduce this with a reasonable amount of money, instead of saying arbitrarily that a 4 per cent. grade is the maximum, he figures how much it will cost for a 4 per cent., how much less for a 5 per cent. and what the saving would be, should even a 6 per cent. grade be allowed.

We will say that we may reasonable reduce the grade on this section to 5 per cent. This is established as a maximum and the other grades are brought to this maximum.

There will doubtless be considerable blasting on the large boulders to do on this section in order to properly widen the road, because the ordinary country road has no established width. In cutting the grades it will usually be found that a considerable portion of the material excavated in reducing the grade makes good surface material and almost the entire expense will be the shaping of the roadway and the drainage.

As we have imagined it, however, as the end of this section is approached you will have run through the gravel and into what is practically sand. Here the gravel on the other end will not properly compact or pack so as to make a suitable road surface and practically a sand-clay road must be built. The writer has not had good success with the sand-clay roads, unless he has practically telfordized the same by making the sub-base largely of metal.

In the treatment of this particular part of section two, we might endeavor, from the gravel pits used on the first part of it, to obtain the small boulders sufficient to build the entire bottom of the road to at least 6 inches in thickness of such pebbles. These might be filled with sand up to the top of the metal, then at least three alternating sections of clay and sand put on, repeating until the road is at least 10 inches thick, harrowing each section as it is built up, and seeing that the top surface is of sand rather than of clay. This portion of the section will doubtless cost much more than the sum per mile expended upon the gravel portion, but together they should leave the general average within the limit.

Section three, consisting largely of grade, is almost entirely a drainage proposition and it will be very necessary to practically tap the water coming from the side hill near the surface or originating within the road. It may be found necessary in many instances to run short drains for the express purpose of tapping the water holes, which come up in the road-bed proper, and it will doubtless be necessary on the inside of such a road to lay a side drain the entire length of every grade. A ditch should be dug on the upper side of the road to a depth of at least below frost line, a foot of sand being placed in the bottom and then an open drainage tile laid to as perfect a grade as possible, and the ditch filled in with sand, seems to be the most satisfactory way of cutting off this water.

Shaping the clay road is a comparatively easy matter, as such a road will retain its section and may be practically worked with a road machine and then covered with 2 inches or less of sand and gravel, harrowed in as thoroughly as possible. It is somewhat difficult upon a clay road to get the sand to work into it at first and the farther application during wet weather of at least 2 inches more will ordinarily give such a road a most desirable surface. The only caution is that the sand must not be applied in large quantities at a time, but this surface must be expected to require renewing frequently during the first two years.

We have assumed that we have now come to the ledge and boulder section and that all material must be drawn from a considerable distance to make a satisfactory road. Here, without question, the most feasible plan is to use a macadam roadway. The putting up of a local crusher and the macadam method of construction may facilitate building at a lower cost than would the use of the uncrushed material. Frequently, however, on such sections there is a great difficulty in getting sufficient water to properly flush a waterbound macadam road. The use of large quantities of water may be obviated by the use of bitumen, but this adds to the cost of your road.

Wherever macadam is used the same 21-foot section may be retained, though 15 feet should be the extreme width of the metalling. This will take 2,600 tons per mile of stone, and assuming the use of 2½ gallons of bitumen per square yard, the added cost will be something over $2,000 per mile. If water is fairly available, a waterbound road may be built and one-half gallon per square yard of bitumen applied as a cover coat at a cost of about $650 per mile, which will reduce the cost of the road for light traffic about $1,500 per mile. Unless there is considerable trouble about getting water, therefore, the use of waterbound macadam with the blanket coat is recommended.

The added cost of maintenance upon the macadam road, as compared with the cheaper forms, must also be considered, so that personally we should hesitate about using macadam whenever there is a possibility of using the cheaper surfacing.

Assuming a small apportionment available for the entire mileage needing improvement, the economic question is, what plan should be adopted for the treatment of such a highway? Will this 10 miles be practically completed with the money or will 3 miles of the higher type of roadway be built and the rest left unimproved? This seems to be the attitude adopted by most highway departments. They standardize their plans and specifications and are content with the small mileage of what they are willing to say is the best construction, and they dislike extremely to build for small cost what they term an inferior type of road.

The writer believes this to be a serious economic error and in most sections a road infinitely better than has previously existed may be built at a comparatively small cost to the great betterment of the roads in general and to the great help of the inhabitants of a community.

As far as automobile traffic is concerned, many of the inferior types of road are far more satisfactory to them in general than the highest type. The autoist cares little for a short section of the best possible road if at the end of it he plunges into what he is pleased to call an impassable road for three-quarters of the distance. The writer believes the development of roads in the future will be along the line of more mileage and less cost, and that this is the proper trend of development.

Cost of Maintenance.—Constant continuous maintenance is necessary upon all the types of roads that are built. It is indispensable, however, that upon the surfaces of the cheaper type of roadway the maintenance be both continuous and intelligent.

A road of what may be called natural surfacing, if left for even a week during the summer season without attention, loses all its features of a good road. It must be constantly patrolled, all holes in it which have worn must be filled, all weak spots which develop must be repaired within a few hours after discovery or the road will so rapidly degenerate that it is useless as an "improved."

The higher types of roadway may be left for varying periods of time without attention, and while this results in the end in being a more expensive method of treatment it is only a loss of money. You still have the road which may be repaired, but if you attempt this sort of treatment upon the cheap surface you eventually lose your highway entirely.

My experience is that a patrolman with a horse and cart, an efficient drag or hone, and the willingness to work, will keep in almost perfect condition from 5 to 7 miles of cheaply constructed roadway, at an approximate cost of from $175 to $200 per mile. Given the same mileage of the higher types of road, he will require a helper, a much larger equipment, and if working upon bituminous roads probably not less than $150 per mile for material in the way of bitumen, crushed stone, etc.

The average cost of maintenance upon the higher types of road including the use of a blanket treatment once in two years will not be less than $500 per mile, and in many instances it will greatly exceed this. On the expensive road also you are constantly facing the fact that within a reasonable number of years you must resurface at a cost approximating $6,000 a mile, while upon your cheaper road, if properly patrolled, you will find that the surface material is thicker than it was at the time the road was built, and has been in practically perfect condition during the entire period.

If the dust nuisance upon the cheaper road becomes intolerable it may be alleviated greatly and practically removed by the application of light bituminous oils or tars. The objection of this treatment, however, is the tendency on the part of a patrolman to allow the road to get out of section by neglecting to drag it after every rain, as he does not wish to destroy the skin coating on top, which is left after the treatment. The cost of this treatment adds about $150 per mile to the cost of maintenance and on the whole is not as satisfactory for light travel in its final results as adhering to the use of the natural soil and the regular treatment by dragging.

Road problems may be roughly divided into four subdivisions, and their order of importance is about as follows: Drainage, alignment, grade and surfacing. It is unfortunate that to most people the latter is more important, while relatively it is of far less importance than the other three. The surfacing material is frequently considered paramount and the settling of the question as to whether you have a bituminous road, penetration method or mixing, a concrete road, or a pavement type is the main subject of discussion, and with far more attention given to it than it rightly deserves.

The drainage, alignment and the change of grade are permanent features. The surfacing can never be permanent. I have sometimes wondered whether a bond issue to be paid for by posterity should ever be expended on any feature that is not permanent.

Concededly, surfacing of all kinds will require not only constant maintenance but rebuilding. With the essentials fully attended to, it is surprising how the surfacing may be maintained at a comparatively small cost. I believe that it is as necessary for us to turn our attention to the economic side of the road question as to the scientific. A highway must have an economic road rental, as well as a fixed road maintenance, and wherever the actual cost plus its maintenance exceeds its rental value we are wasting money in building too expensive a road. We must so adjust the scales that our costs are such as to provide a roadway for the traffic at the least possible expense.

PROGRESS ON THE PACIFIC GREAT EASTERN RAILWAY.

In the recent report of Mr. F. C. Gamble, chief engineer of the Department of Public Works, to Hon. Thomas Taylor, Minister of Railways, it is stated that track laying on the Pacific Great Eastern will likely reach the Fraser River at Lillooet, 120 miles from Squamish, early in January, unless work is impeded by exceptionally heavy snow falls. The rails are already laid from Squamish to the Lillooet River, in Pemberton Meadows, a distance of about 58 miles. Thence it will be continued over that river on a temporary bridge to Anderson Creek. This bridge is necessary while the Federal Government is deciding whether the Lillooet River shall be crossed by a movable or fixed span.

Between Lillooet River and Anderson Lake, a distance of about 28 miles, there will be two truss bridges, one over Owl Creek, with 100-foot span, and the other over Birkenhead River, with 125-foot span, besides small trestles. These two streams, however, may be crossed by temporary bridges to hasten the track to Anderson Lake, which it is expected will be reached this month.

The track having reached the latter point, timber for the trestles along the lake, which are for the most part small, will be put into the water and towed to the different sites, and erected ahead of the track. From the south end of Anderson Lake to the Fraser River there will be several small bridges.

Between Squamish and Pemberton Meadows there are 39,877 lineal feet of side tracks and sidings. These are laid in the Squamish yards and at various points up to Pemberton. The track, to within nine miles of Pemberton, is in excellent shape. There are steam shovels at work in the ballast pit near Squamish.

Of interest at this time is the completion, at the Canadian Locomotive Company's works, Kingston, Ont., of two oil-burning locomotives for the new line. Each locomotive, weighing 190,000 pounds without tender, has four driving axles, the driving wheels being 57 inches in diameter. The cylinders are 22 x 28 in. and are operated by Walshaert valve gearing. The steam will have a working pressure of 180 pounds per square inch, the locomotive being equipped with a Schmidt superheater adding about 250 degrees superheat. Other characteristic features of the locomotives are flexible boiler stay bolts, radial buffers between engines and tenders, and turbo-generator set supplying power for head-light and other lights.

WELLAND CANAL CONSTRUCTION.

Expenditures totalling about $6,000,000 have been made on the Welland Canal work this season (described in *The Canadian Engineer* for November 5th, 1914). The contracts for sections 1, 2, 3 and 5 are reported about one-quarter completed. Together they total over $20,000,000. The sections still to be contracted for will not be let until the existing contracts have advanced considerably further. Nearly 3,000 men are at work.

ENTRENCHMENTS AND OBSTACLES.*

By G. Bertram Hartfree.

IN selecting a site for defensive purposes, natural features are the first consideration, and these will be supplemented by entrenchments; another factor is its advantages to the defenders for counter attacks and to allow a powerful rifle-fire from the position, and it is necessary that the defenders be well screened and protected from the enemy's fire. In deciding the type of entrenchment, time, of course is a great factor, and if this be unlimited, a substantial and well-screened type can be adopted, but there is the possibility, however, that time will allow only of earthworks of a hasty character; these may be divided into three headings:—

1. Pits for sheltering skirmishers, sentries, etc.

2. Trenches for sheltering the main body of infantrymen and other reserve forces.

3. Pits to give cover for artillery.

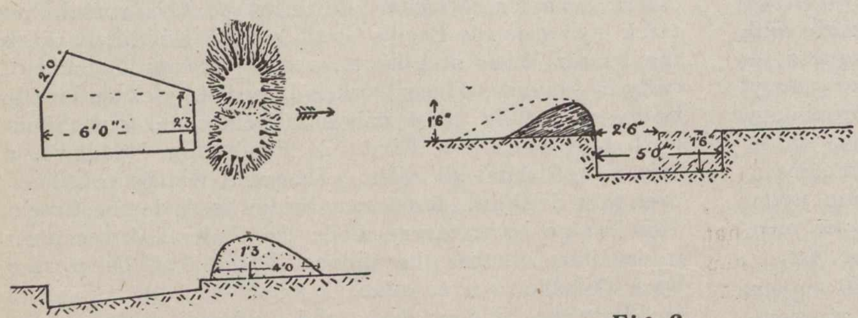


Fig. 1. Fig. 2.
Alternative Shelter Pits for One Man Kneeling.

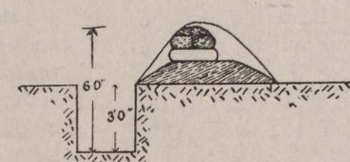
The simplest type is a pit to shelter one man, from which he would fire lying down; in such position the legs are usually inclined to the left. The length of the pit is about 6 feet, and the width 2 feet 3 inches, its depth about 9 inches. Two small adjoining mounds that leave a depression on which the rifle would rest, are constructed with the excavated earth to a height of 15 inches. When making the mounds, as the men's legs would incline to the left, as far as possible, shelter must be made in that direction. With a pick and shovel one man should construct such pit (Fig. 1) in 10 minutes. A better type of pit (Fig. 2) 2 feet 6 inches in width and 18 inches in depth, could be constructed in half an hour; in this a man can kneel when firing; should time allow, an hour's work would make a more comfortable and better protected pit, as shown by the dotted mound and hatching. By connecting adjoining pits, small shelter trenches may be formed, providing for groups of men. The usual allowance in width is 2 feet 6 inches per man. For a man to fire standing, a pit 3 feet in depth is required: this, with the excavated earth, gives a cover of 6 feet; the time taken in excavating and completing this by one man would be one and a half hours. For the foregoing, by commencing a shallower pit, as opportunity occurred, the greater depth could be reached. The ordinary earth mound necessitates a man firing over the top, which leads to an exposure of the head. For better protection loopholing is adopted, and is generally done by the use of sandbags, four of which are required per loophole, two being laid three inches apart as headers, and two resting on the top as stretchers. Fig. 4 shows how a kneeling pit may be developed, the original excavation "A" and embankment "a" may be increased as follows:—

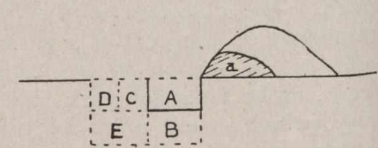
1. For men to stand close to bank, remove space marked "B"; by excavating part marked "C," a seat will be formed. Should a step or kneeling space be required, "B" would remain, and D, C and E would be moved. The breastwork shown on Fig. 5 is a development of the latter, the earth near the firing trench being pushed forward and an outer trench cut on the enemy's side.

The chief points to be considered when constructing shelter trenches are: (1) The making possible of an effective fire, uninterrupted by the configuration of ground or trees. (2) Presenting the smallest obtainable mark to the enemy's fire. (3) Wherever practicable, arrange for drainage. to avoid quagmires in rainy weather. (4) Sand and light earths are better defence than hard earths or plastic clays. (5) A trench should not be made in front of an elevation, particularly if not bullet-absorbing. In respect to the latter, a high sandbank of usual batter would be less disadvantageous to the defenders; but, given a hard rock or wall, on its being struck by a shrapnel shell, the contents would scatter at the rear of the trenches.

Infantry in the second line, either as supports or reserves, are, when possible, protected by natural depressions in the ground. In the absence of these, shrapnel-proof shelters may be requisitioned. These consist of excavations, roofed with timber and covered with earth dressed over to resist bullets and affording no mark to the enemy.

When cover is required for guns there are two





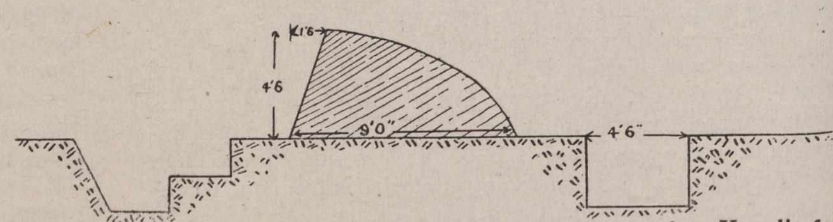


Fig. 3.—Standing Pit. Fig. 4.—The Development of a Kneeling to a Standing Pit. Fig. 5 (below)—Breastworks.

courses open: (1) Construction of an epaulment, or (2) sinking a gun pit. The choice depends on local conditions; given a soft soil with no natural shelter, the latter is preferable, as the excavated earth forms the embankment, and a reduced height above ground is required with less exposure to the enemy's fire. A roughly pitched base to take the wheels would be of advantage. Given a hard soil with natural banks, an epaulment would be preferable, the banks giving, in some part, natural shelter, and their existence requiring less soil for the completed earthwork. The advantage of the latter over the pit is the fact that it can be completed after the gun is in action,

*Read before the Institution of Municipal and County Engineers of Great Britain.

whilst, of necessity, the gun cannot be worked from the pit until its completion. Fig. 7 shows a gun pit which would take one man from 5 to 10 hours to construct, according to the nature of the soil; these pits rarely exceed fifteen inches in depth.

An epaulment is somewhat similar in plan, but varied according to local conditions.

Obstacles.—The strength of a post can be increased by the use of suitable obstacles. In selecting their position a site should be chosen where they can be well hidden from the assailants, but will allow an easy advance on the part of the defenders. No particular materials are specified for this purpose; the most suitable are those that cannot be removed by the ordinary weapons or tools that the attackers would carry. As an obstacle, that to the best of my knowledge is not mentioned in military manuals. I suggest broken bottles, etc., with bottoms set in concrete. Loose straw and leaves saturated with tar would be of advantage against a foe stalking on all fours. Orthodox obstacles include entanglements, pits and palisades; the former consist of wires: these, if set low, are about eighteen inches off the ground, fixed on stout stakes, well driven in and about six feet apart. The wires are twisted around the posts and carried horizontally and diagonally. An entanglement more difficult to negotiate is that with posts four feet above ground, with the wire from the base of one post taken to the top of another, and by crossing the wires a useful defence is made; barbed wire is, of course, preferable to plain.

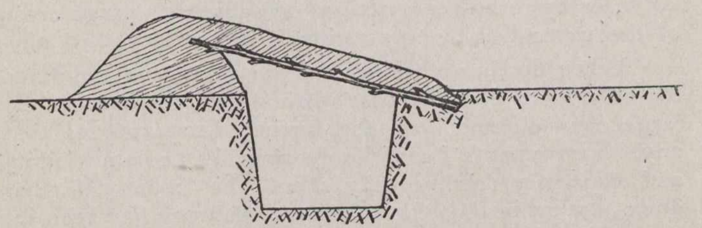


Fig. 6.—Cover for Reserves.

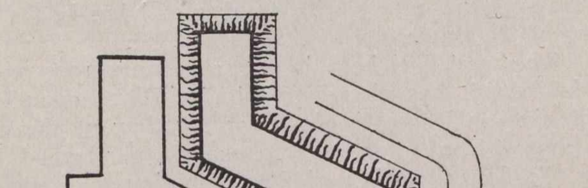


Fig. 7.—Plan and Section of a Gun Pit.

In the absence of wire, pickets with pointed tops, trees, or brushwood fastened with points in the direction of the enemy, will form difficult impediments.

Military pits are planned on lozenge pattern and consist of small holes containing pointed pickets; an entanglement of wire over the surface is of advantage, and further improvement is made by erecting on the enemy's side a glacis, formed of the excavated earth. This should be eighteen inches in height, as near vertical as practicable on the defenders' side, with an easy slope towards the attackers, to facilitate their progress and hide the obstacle until it is reached.

Palisades may be erected in ditches that are controlled by the defenders' fire. A useful material is the pointed form of galvanized iron fencing. In the absence of stock patterns, by the use of an axe on the top edge, the plain pattern can be made very effective.

STREET PAVING METHODS.

The repair of streets and roadways is one of the most important works that come under the direction of the municipal engineer. There are many causes for the defects that are constantly arising with ordinary paving, but perhaps the most prevalent is that the specification, in the first place, was not properly drawn up. Frequently pavements are laid with too weak a base, and cracks develop in all directions. Occasionally the lateral support is far from rigid. Where asphalt surface disintegrates in places it may be found that the decay is due to leakage from gas mains, in which case it is useless to try to patch the surface until things are properly adjusted underneath. The question is becoming pressing as to whether, in the course of the next few years, we shall not have to reconsider all our present methods of road-making. It is an open secret that many are investigating the behavior of materials under other methods of laying than those usually employed, under traffic conditions, and a number of interesting experiments have already been carried out. In connection with these it is interesting to recall the work done at Mankato, in Minnesota, a short time ago. First the driveway was narrowed to 30 ft., curbed and guttered, after which it was excavated to the depth of 6 in. and levelled. Five inches of dry crushed limestone, 1½ in. to 2 in. in diameter, was then put on and rolled down with a 10-ton roller. Ordinary tar, brought to the boiling point, was then applied until the whole surface was covered. Then a layer of broken stone of 1 in. to 1¼ in., mixed with coarse gravel, was applied on the surface, in the proportion of three parts of stone to one of gravel. This was first mixed dry on a platform and then thoroughly blended with hot tar, and applied on the surface to a depth of 2 in., and tamped into place to conform with the surface of the street. Dry domestic cement was then applied to the surface, and the street was again rolled, after which the road was heavily sanded and rolled for the last time. The road was allowed to stand for fourteen days before it was thrown open to traffic, and when hardened presented a very fine and somewhat resilient surface, which proved exceptionally durable.

FLOW REGULATION ON THE GRAND RIVER.

THE Grand River Valley, in Ontario, is well noted for its natural production and resources, its manufactures and trade, and its density of population. It is not the earliest settled part of the province, the eastern counties along Lake Ontario claiming that distinction. But with the advent of transportation facilities, the southwestern peninsula progressed and later surpassed the older settlement.

In line with its development, however, has been the partial sacrifice of one of the country's great natural resources—timber growth. Agriculture occasioned heavy invasions into magnificently wooded districts.

Another great natural resource is the perennial, never-failing, precipitation ensuring, with proper husbandry, the continuing productivity of the soil, and ensuring as well stream flow, ground water, water supply as required by large communities, and water power developments.

That the wasteful destruction of forest growth would have produced a marked effect on precipitation, is to be expected, from prevalent ideas of similar conditions elsewhere. That this is not the case, however, but that the effect has been rather on stream flow itself, is brought out in the following article. How the seriousness of the situation has aroused action to prevent damage by spring flood, and what steps are being contemplated to compensate for the axeman's intrusion upon Nature's mode of regulation was brought out in a most interesting manner before the Galt Board of Trade on November 27th, 1914, by W. H. Breithaupt, C.E., Mem. Can. Soc. C.E., Mem. Inst. C.E. Regarding the effect of land denudation, Mr. Breithaupt has this to say:

"Since the beginning of continuous observations, seventy and more years ago, in various parts of the peninsula, (at not many places but at enough to establish the fact), precipitation has remained practically constant, varying somewhat from period to period, but on the whole remaining about the same. Destruction of the great forests has not, as is sometimes erroneously held, diminished rainfall or snowfall. It has, however, caused great change in the flow of streams, the former characteristics of which, moderate floods on snow melting in the spring and well sustained flow throughout the year, having changed to destructive floods, and dwindling, almost disappearing, flow, in the low-water months of the year. The greatest factor of change in the run-off rate of a number of rivers in the Ontario Peninsula has been the drainage of the hundreds of square miles of swamps on the table land of the headwater area.

"With the destruction along the whole course of the river, particularly in the cities and towns along its banks, caused by the spring floods, now almost an annual occurrence, and the small flow of polluted river during the summer months, flood control, and regulation of flow, have become the most important conservation questions immediately concerning us in the Grand River Valley."

These matters were brought to the notice of the Provincial Government at various times. The result has been that for the past two seasons the engineering staff of the Hydro-Electric Power Commission of Ontario has been carrying on an investigation, by topographical survey and by precipitation and stream flow observations preliminary to the adoption of a plan of construction whereby future danger will be minimized. We abstract the following from Mr. Breithaupt's address, concerning the favorable results so far attained and concerning what, illustrated by existing cases of a similar nature, may be expected when the river has been subjected to a system of storage:

There are two main methods of preventing the overflow of a river channel: (1) By making such channel of sufficient cross-section and declivity, by means of walls or dykes on the banks, deepening and removal of obstructions in the channel, cutting off detours and otherwise straightening the channel so as to make it shorter and therefore its declivity greater. (2) By impounding water in excess of the capacity of the channel by means of reservoirs, or by retardation of flow on sufficiently large areas of the watershed by forestation.

When floods on a river are very large as compared to the normal flow the first method requires a relatively large channel, and has the further disadvantages that any improvements benefit only their immediate vicinity and may very detrimentally affect the country further down stream in that the velocity of delivery has been increased, and that the water which might have been held further upstream for sustained flow is wasted. The method of impounding excess waters, on the other hand, benefits the entire river below the reservoir, both in flood control and in sustained flow obtained by the gradual release of the impounded waters.

The St. Lawrence River, with its vast natural regulating basins, the Great Lakes, exemplifies on the largest scale the flow-regulating effect of large impounding reservoirs in the course of the river. On its largest tributary, the Ottawa, greatly increased storage is being obtained by raising the outlets of a number of lakes in the upper part of the watershed of the river.*

The work has been in progress since 1909 and material benefit has already resulted. When completed it will give an increase of low-water flow at the city of Ottawa of from 10,000 to 12,000 cu. ft. per second, bringing the flow for this period to a minimum of somewhat under 40,000 c.f.s. The great benefit of this conservation, in flood relief, equalization of flow and the raising of water level for navigation purposes, will, owing to very favorable natural conditions, be secured at an estimated total cost of less than one million dollars.

In general, the regulation of a river by means of storage reservoirs is more applicable on smaller rivers. On such rivers it has become a well recognized method, and has had numerous successful and highly beneficial applications. I shall here mention two, selected on account of their similarity in many respects to the Grand River regulation scheme, both of them in Germany.

The dam on the Eder River in the principality of Waldeck is 160 ft. high, above foundations, and makes a reservoir with storage capacity of 7,350,000,000 cu. ft., a little over 4½ sq. miles in area. The drainage area above the dam is 542 sq. miles, of which 40% is wooded. Average rainfall on the drainage area is 33 in. in the year. With only 10% of the capacity of the reservoir held as reserve the minimum flow is six times what it had been. The total cost of this undertaking was $4,902,380, of which $2,142,850 was for land and damages. Several small villages and many farms are flooded by the reservoir. One main purpose, beside flood prevention, was the development of water power. The large expenditure has already been found to be an excellent investment.

The largest dam in Europe is on the Bober River, a tributary of the Oder, and was completed in November, 1912. In keeping with its importance as an economic

*This storage on the Upper Ottawa was described in August 7, 1913, and December 4, 1913, issues of *The Canadian Engineer*.

work it was opened with great ceremony in presence of the Emperor. The contributary drainage area, mountainous and steep, with quick run-off, is 467 sq. miles, from which the maximum recorded discharge, in July, 1897, was 42,360 c.f.s., giving a very destructive flood which was the immediate cause of the building of the dam. In comparison to this discharge, that of the Grand River in Galt, from a contributary drainage area nearly three times as large, reached a maximum of between 30,000 and 35,000 c.f.s. on the evening of April 7th, 1912. The minimum flow of the Bober at the dam site is 53 c.f.s. The capacity of the reservoir is 1,765,000,000 cu. ft., large enough to impound the damaging part of the flood, the capacity of the lower river channel only being allowed to pass the dam. Owing to short duration of the flood flow, 60% of the capacity of the reservoir can be retained and used for water power development at the dam and for increase of flow downstream. The dam is 203 ft. high above foundations, and 918 ft. long and 23 ft. wide on the crest. It is a solid masonry structure. With the great depth of water in the reservoir its surface area is a little under one square mile when full. The cost of the dam was $1,416,000, and of land and land damages $576,000, total $1,992,000, of which the State of Prussia paid four-fifths and the province of Silesia one-fifth.

To make flow regulation of a river economically practicable by storage it is necessary that a natural storage basin, or basins, the fewer used for the required capacity the more economical, should exist in the course of the stream, with enough contributary drainage area to give the volume of water necessary to fulfil the requirements of regulation; enough that the impounding of the volume of water coming from it will materially lessen the volume further down stream, and enough that the water so impounded will, on being released at a fixed rate, give increase of flow down stream for a long enough period.

On the Grand River it has been sufficiently demonstrated that if the flood flow of the upper main river, extending to about the north line of the township of Waterloo, and the flood flow of the Conestogo tributary, can be held, in main part, the problem of prevention of destructive floods in the lower river will be solved. Let us see what this would imply. In the great flood of April 7th and 8th, 1912, the approximate maximum discharges, continuing at maximum only for short times and destructively high for two days at most at any place were: At Elora, being the bulk of the main upper river, 13,000 c.f.s.; at St. Jacobs, practically the whole of the Conestogo River, 12,300; at Bridgeport, 4 miles below the Conestogo outlet, 24,000; at Galt, 33,000; at Brantford, 51,000. It is clear that if 15,000 cu. ft. per second of flow of the upper discharge, including the Conestogo, could have been held back for two days the lower river would have remained within its normal channel.

The Hydro-Electric Power Commission began its work on the Grand River in the fall of 1912 with a reconnaissance survey extending from the outlet at Lake Erie to the headwaters of the river and also up all the main tributaries to their headwaters. This survey disclosed three sites on the main river practicable for reservoirs of considerable capacity, the largest one below Elora; two sites on the Conestogo River of fair capacity; two on the Speed River not large enough to be of material benefit; one on the Nith with fair capacity, and one on Whiteman's Creek. Levels were carried the length of the survey and bench marks established, mostly on bridge piers and abutments as far up as Belwood on the main river, and also on the Speed and on the Nith. Eighteen gauges were set, on the main river and tributaries. One in Galt is on the easterly pier of Concession St. bridge; its zero is 851 ft. above sea level. There is also one at Kerr St. bridge, Galt Creek.

Discharge observations began with July, 1913, and as the spring flood this year was an exceptionally light one no destructive flood discharge has yet been gauged by the Commission. Discharges are recorded for five stations on the main river, one on the Nith, two on the Speed, one on the Conestogo, one on Fairchild's Creek, one on Boston Creek, and one on Galt Creek at Kerr St. bridge.

Detailed topographical surveys of the larger reservoir sites have been the work of this year and it is here that important favorable conditions have been found. The largest practicable basin is on the main river in Pilkington Township, Wellington County, extending from about the southerly boundary line of the township, the northerly boundary of Waterloo County, into the gorge below Elora.

The general conformation along the river from the Canadian Pacific Railway bridge at West Montrose up shows a fairly straight, narrow valley, 2,500 to 3,000 ft. in width, with steep sides, about alike, for several miles, and then expanding into a wide basin, which again narrows toward Elora. Contours were established at 10-foot intervals and plotted on a large scale map. Two dam locations were considered, No. 1 dam some distance down the valley described, and No. 2 dam at its entrance at the neck of the wide basin. No. 1 dam gives considerably the larger capacity, 2,618,563,000 cu. ft., as compared to No. 2, 1,920,422,000 cu. ft. The elevation of the river bed at No. 1 dam is 1,065, and water level elevation for the capacity stated is 1,150 ft. Foundation investigations for the dam have not yet been made, but as limestone is exposed a little further upstream and is underlying at the site it is expected that a satisfactory foundation will be practicable. Allowing for depth to foundation and for height of crest above highest water the height of the dam will be 100 ft., or somewhat more, at centre. Its length will be approximately 2,800 ft. The area of the surface of the reservoir when filled to 1,150 ft. elevation will be almost exactly 2½ sq. miles; allowing for marginal land a total of about 2¾ sq. miles, 1,760 acres would be required. A large part of this land is stream bed or subject to overflow, the rest good farm land, including a number of farm steads with their buildings. Two roads and a bridge would have to be relocated. The mean depth of the reservoir when full would be 36.9 ft., maximum depth 85 ft. Assuming the water level not to fall below elevation 1,080 the dischargeable capacity of the reservoir would be 2,592,282,000 cu. ft., in round numbers 2,600,000,000.

The cost of this reservoir cannot yet be estimated with any close approximation. Assuming $75 per acre as an average for the total 1,760 acres we get for this item $132,000. The cost of the dam is as yet indefinite, but if the whole project can be carried out for $1,000,000, as now seems reasonable to expect, or even $1,500,000, it will well repay its cost.

The drainage area to this reservoir site is approximately 480 sq. miles. Assuming an annual precipitation of from 35 to 38 inches and a run-off of 1 ft., the annual run-off would suffice to fill the reservoir five times. The 1912 flood flow in Elora, 13,000 c.f.s., would take 55¼ hours to fill the capacity of 2,600,000,000 cu. ft. A considerable stream, the Irvin River, comes in just below Elora. This, with a smaller stream, gives over one-seventh of the drainage area of 480 sq. miles considered. Assuming the Elora discharge to be correspondingly increased, to 15,000 c.f.s., we get exactly two days, 48 hours, of maximum flood flow containable in the reservoir, and this would be the maximum relief afforded for the length of the lower river from this one reservoir, a relief that would reduce the 1913 maximum two days' flow in Galt by more than half.

It is, however, very desirable to also control the flood flow coming from the Conestogo. On this tributary the results have not yet been so fully worked out as for the Pilkington basin. No such capacity as that is found practicable on the Conestogo, but there is one site, fairly upstream, with drainage area of not over 250 sq. miles (the drainage area to St. Jacobs is 312 sq. miles) where it is approximately estimated that a capacity of one billion cu. ft. can be obtained. This, together with the No. 2 Pilkington dam (smaller than No. 1) would give better flood control in the lower river, in that a much larger volume could be held back, even if for shorter time. In this manner a volume approximating 20,000 c.f.s., the combined flow of both main river and Conestogo tributary, could be held back for 24 hours.

As to maintenance of flow for the low-water months, 2.6 billion cu. ft. of water would give a continuous flow of 300 cu. ft. per second for three months and ten days. In that period rainfall at various times could be expected, making up not alone for evaporation in the reservoir but also contributing to flow. On the other hand, evaporation appears, as far as observations of stream flow have gone, to have large diminishing effect on run-off, in the Grand River watershed.

At Belwood the mean discharge for the months of August and September, 1913, was only 5 c.f.s.; at Conestogo, drainage area 538 sq. miles, 24½ c.f.s.; while at Eugenia Falls, on the Beaver River, on the steep slope to Georgian Bay on the north side of the table land, the main discharge for the same time, with only 74 sq. miles of drainage area, was 30½ c.f.s., a very remarkable difference, due to two main conditions, the much greater declivity of the Beaver drainage area, and the fact that it contains swamps and is otherwise still largely wooded.

A reservoir above Elora and Fergus is very desirable in the complete scheme. At Belwood the drainage area is 270 sq. miles and the valley deep and apparently well defined. Investigations so far have not given a sufficiently favorable reservoir site.

One feature greatly simplifying the problem on the Grand River is that there is only one large flood in the year, in the spring on snow melting. The great floods in Ohio and Indiana last year were also in the spring, in March, but were caused by rainfall, almost wholly.

There was rainfall of 5.31 in. in 47 hours, 3 in. in 20 hours after the first saturation. Three inches of run-off in the drainage area of Galt would produce 9,500,000,000 cu. ft. of water to pass which, even in 36 hours, would mean a continuous, uninterrupted flow of 40,000 cu. ft. per second, greater than any maximum that has occurred here. Waves lasting for hours only would much exceed even this discharge. There is no record of any such discharge in the Grand River valley. At the present day it would mean destruction of property on an unprecedented scale. Precipitation in the central parts of the United States and Canada is largely from the Gulf of Mexico, as this was. It spread over a large area in Ohio and Indiana. Why did it stop at Ohio? The cool belt of equable temperature over the Great Lakes, around the Ontario Peninsula is, no doubt, a barrier against extreme meteorological disturbances.

It may be accepted as now established that flow regulation on the Grand River, control of destructive floods and maintenance of flow in low-water period, by impounding surplus waters, whether in one or more reservoirs, is economically practicable.

SAFE LOADS FOR ROPES AND CHAINS.

THE accompanying table shows the safe loads which can be carried by wire rope, crane chain and manila rope of various sizes, when used in different positions and combinations. This very useful information has been compiled by the National Founders' Association and published as a part of a safety bulletin recently issued. The following are from among the valuable pointers the bulletin contains:

Chain hooks and similar parts should slowly bend if overloaded and thus give warning of their unsafe condition. They should therefore be well annealed, and never tempered or hardened. A brittle part will snap outright and drop the load.

It is clear that hoisting appliances should be suitably designed and well made. It is yet more important that their use be carefully and intelligently supervised and their original strength maintained. There is evidently not so much danger when handling unusually heavy loads, for such operations are, as a rule, under the care of the most capable men, who anticipate the extra risk by careful preparation. Hoisting accidents more frequently occur when ordinary loads are being handled by ordinary men, and when the usual facilities are either too light, wrongly employed, or weakened by wear or use.

It is of first importance that men using hoisting accessories should know the strength of the same. It is not sufficient to know the size, unless the grade is also known. While 1,500 lb. may be a safe load for a single sling made of ⅜-in. plow steel wire rope, such a load would be excessive for an iron wire rope sling of the same diameter. This wide range of strength also occurs in different grades of chains and other accessories, but the difference is not readily apparent. It is therefore dangerous to provide several grades of slings and hooks in the same shop. Furthermore, a new workman, fresh from a shop in which only the strongest slings and hooks are employed, is liable to assume that the appliances in the new shop are equally strong. The safety of workmen, therefore, requires that all slings of equal size should be of equal strength, and of maximum strength, and that other details are proportionately strong.

While workmen who are accustomed to the use of slings acquire, by long experience, a valuable knowledge of the strength of chains and ropes under varying conditions, this should not be left to guesswork. It is advisable to post in conspicuous places in the shop, especially at the chain racks, and, where possible, at the point of operation of each crane, a chart showing the loads which can be safely supported by slings of various sizes, whether used normally or in a manner that decreases their lifting capacity. From a study of satisfactory crane practice in various large plants, a chart of safe loads has been compiled, which is published herewith. The loads recommended in this chart are more conservative than those usually specified, because it is intended to recognize the possible existence of slight, unobserved weaknesses in slings and the liability of excessive strains which may be applied to slings through misjudgment or accident.

It will be noted that the safe loads shown upon this chart are based upon the use of 6 by 19 or 6 by 37 plow steel wire rope; the best grade of wrought iron, hand-made chain; and four-strand long fibre manila rope. Here again the advantage of standardizing the grades of materials used for hoisting purposes is an advantage; otherwise the chart would be misleading.

Under no condition should hoisting appliances which are defective or unsafe be allowed to remain within the reach of the workmen. By carelessness or mistake, these may be used in place of perfect ones with serious results in the shape of an accident ensuing. A defective chain, hook, eyebolt, ring or other hoisting appliance should be removed from the shop on the instant of its discovery. In addition, they should be so damaged, if they are impossible of repair, that there is no possibility of a workman using them by mistake. One of the reasons which may tend to prevent enforcement of this rule, is an inadequate supply of slings and other accessories. Unless there are plenty of spare appliances, there may be hesitation in removing a sling from service for the purpose of repairs. It may be retained in use until a more convenient season, but during this interval it may become subjected to a greater strain than it can withstand in its weakened condition, and an accident with possible resultant loss of life may take place.

SAFE LOADS FOR ROPES AND CHAINS
(IN POUNDS)
Prepared by National Founders' Association.

CAUTION: When handling molten metal, wire ropes and chains should be 25% stronger than indicated in table.

NOTE. The safe loads in table are for each SINGLE rope or chain. When used double or in other multiples the loads may be increased proportionately.

	Dia.	Cir.	When used straight	When used at 60° angle	When used at 45° angle	When used at 30° angle
PLOW STEEL WIRE ROPE	3/8"		1,500	1,275	1,050	750
	1/2		2,400	2,050	1,700	1,200
(6 strands of 19 or 37 wires.)	5/8		4,000	3,400	2,800	2,000
	3/4		6,000	5,100	4,200	3,000
If crucible steel rope is used reduce loads one-fifth.	7/8		8,000	6,800	5,600	4,000
	1		10,000	8,500	7,000	5,000
	1 1/8		13,000	11,000	9,000	6,500
	1 1/4		16,000	13,500	11,000	8,000
	1 3/8		19,000	16,000	13,000	9,500
	1 1/2		22,000	19,000	16,000	11,000
CRANE CHAIN	Dia. of iron 1/4"		600	500	425	300
	3/8		1,200	1,025	850	600
(Best Grade of Wrought Iron, Hand-made, Tested, Short Link Chain.)	1/2		2,400	2,050	1,700	1,200
	5/8		4,000	3,400	2,800	2,000
	3/4		5,500	4,700	3,900	2,750
	7/8		7,500	6,400	5,200	3,700
	1		9,500	8,000	6,600	4,700
	1 1/8		12,000	10,200	8,400	6,000
	1 1/4		15,000	12,750	10,500	7,500
	1 3/8		22,000	19,000	16,000	11,000
MANILA ROPE	3/8"	1"	120	100	85	60
	1/2	1 1/2	250	210	175	125
(Best Long Fibre Grade.)	5/8	2	360	300	250	180
	3/4	2 1/4	520	440	360	260
	7/8	2 3/4	620	520	420	300
	1	3	750	625	525	375
	1 1/8	3 1/2	1,000	850	700	500
	1 1/4	3 3/4	1,200	1,025	850	600
	1 1/2	4 1/2	1,600	1,350	1,100	800
	1 3/4	5 1/2	2,100	1,800	1,500	1,050
	2	6	2,800	2,400	2,000	1,400
	2 1/2	7 1/2	4,000	3,400	2,800	2,000
	3	9	6,000	5,100	4,200	3,000

In the use of chain slings, the workman should be cautioned against striking heavy blows either upon the chain or the hooks to force them into position on the load. These blows are liable to injure the chain and cause a weakness, which will result in its eventual failure. Where multipart slings are used and it is necessary to equalize the length of each part, other material than cast iron should be used for insertion between the links of the chain. Cast iron pieces will break under load and the failure will cause a sudden shock on the chain links which may break or permanently injure it. In the use of wire rope slings, kinks must be avoided. These acutely bend the wires, which bends are suddenly straightened out under load. An excessive strain thereby comes upon the sling and breaks it.

INERTIA EFFECTS IN PIPE-LINES.*

By S. L. Berry,
Consulting Engineer, San Francisco, Cal.

An extended and detailed study of the conditions to be found in pipes conveying water, when the velocity of flow is changed, has led to the conclusion that there has not been an adequate recognition of the importance of considering the elasticity of both the water and the pipe walls. It has become clear that only by such consideration can correct results be obtained.

It is commonly admitted that the rapidly moving pressure waves set up, when a valve is opened or closed, are annoying and, when excessive, must be taken care of by relief valves, but it is claimed that they have no place in those greater and longer movements which accompany velocity changes. A formula which is often used to calculate these effects ignores the compressibility of the water and the elasticity of the pipe material. It is the purpose of this article to show clearly that this formula is absolutely and unequivocally wrong, has no foundation in fact, and must lead to erroneous results.

At the foundation of all these phenomena is gravity, the manifestation of nature which gives to bodies that quality called weight, which when opposed produces pressure and when unopposed produces movement. Should the opposition decrease, the pressure will decrease and the velocity increase, and vice versâ. This is universal and applies to all ponderable bodies. Such influences as friction, which cause a loss of energy, will modify the results in accordance with their magnitude.

Inertia is that quality of bodies which tends to keep them in a given state of rest or motion unless acted on by some force. A body in motion has energy in proportion to its weight and to the square of its velocity. It is evident, therefore, that to increase the velocity of a body it is necessary to put energy into it, and to decrease it, energy must be taken from it. This act is called overcoming the inertia of a body. It is furthermore true that with a given change of velocity, the amount of energy put in when accelerating will be the same as that taken out when retarding. In other words, acceleration and retardation differ only in direction, the energy change being the same with any given velocity change.

The above remarks are elementary in nature and are introduced solely for the purpose of laying a foundation for what follows.

Consider a pipe-line filled with water under pressure and provided with a valve at the lower end. When the valve is in a closed position the water is compressed and the pipe distended in proportion to the pressure. In this case gravity, being opposed, produces pressure. On

*From Western Engineering, August, 1914.

opening the valve the opposition to gravity decreases and movement results. This commences at once, and the velocity at a point behind the valve will be in proportion to the fall in pressure at that point. Whether a gauge located there will correctly indicate the fall in pressure will depend upon its accuracy and sensitiveness and upon the manner in which it is attached to the pipe. In this case the energy which must be put into the water to increase its velocity comes from the water itself and from the pipe walls, which are now under less stress, and which have given up a portion of the energy stored in them. This involves a change from potential to kinetic energy.

On the other hand, when the valve is moved in a closing direction, the opposition to gravity is increased, the velocity decreases and the pressure increases; the energy given up by the water as a moving body is stored in the water and pipe walls, the one being compressed and the other distended.

In both instances an unstable condition is set up, as in the first case the pressure is much below that due to the head, and in the latter much higher. The former persists until the energy taken can be restored, which occurs on the return of the wave from the reservoir, and the latter until the excess stored can be dissipated. Equal velocity changes are accompanied by equal pressure changes whether the water be accelerated or retarded.

The changes which commence at the valve are followed by changes along the pipe-line, pressure waves traversing the pipe at velocities dependent upon the material of the pipe walls and the ratio of wall thickness to diameter.

In a previous article formulæ and diagrams were given to determine the velocity of wave propagation and the maximum ram pressure attained under any given set of conditions, and reference is made thereto for these particulars.

It is to be noted that if, in a given case, a decrease in velocity of flow of 1 ft. per second is accompanied by a ram pressure of 50 lb., a like increase in velocity will be accompanied by a fall in pressure of 50 pounds.

The formula commonly used for calculating the inertia effects of velocity changes is

$$Ha = \frac{Lv}{gt} \text{ in which}$$

Ha = accelerating or retarding head in feet.
L = length of pipe in feet.
v = velocity change, feet per second.
t = time of change, in seconds.
g = 32.2 feet per second.

This considers that the pipe is rigid and the water incompressible. It necessarily includes, as a condition, that, in a uniform pipe, all the water shall have the same velocity at the same time; that any change in velocity at the lower end shall be accompanied simultaneously by the same changes throughout. This is indicated by the inclusion of L, the length of the pipe. As a matter of fact such a condition has been shown, theoretically and experimentally, to be impossible.

The most extensive and thorough experiments along these lines were made in 1897 and 1898, in Moscow, Russia, by three engineers, working under the directions of N. Simin, manager of the city waterworks. The results were worked up by N. Joukowsky, in 1898 and published in 1900.

These show conclusively that changes initiated at the valve produce changes along the pipe after a time interval dependent upon the distance and the velocity of wave propagation, and they prove, in a very satisfactory manner, the formulæ which have been developed by theoretical means.

To bring out clearly the difference in results between the correct elastic theory and the incorrect rigid formula, the following table has been prepared. It applies to a steel pipe, 24 in. diameter, ¼-in. wall, and having lengths as listed. The velocity of wave propagation is 3,370 ft. per second.

Pipe = 1,000 ft. long.

Time of gate closing, sec.	0.00	0.02	0.04	0.10	0.30	0.45	0.60
Pressure, rigid formula	00	675	337	135	45	30	22
Pounds, elastic formula	45	45	45	45	45	45	45

Pipe = 10,000 feet long.

Time of gate closing, seconds	0.00	0.02	0.10	0.30	1.00	3.00	4.00	5.00	6.00
Pressure, rigid formula	00	6750	1350	450	135	45	34	27	22
Lb., elastic formula	45	45	45	45	45	45	45	45	45

There are several interesting facts brought out in the table. In the rigid formula the pipe length has a decided influence on the calculated result, while in the elastic, it has none whatever as far as the amount of pressure is concerned, but it does control the duration of this pressure. This has been amply proved by experiment. In the rigid formula the time of gate movement has an inverse proportionate effect upon the calculated pressure, while in the elastic, within certain limits, it has no effect. There is this fact to be noted in this connection, that the rigid formula requires that the pressure shall instantly rise to the figure given and remain there during the entire closing movement of the gate, and that the elastic indicates that the rise will be gradual and in proportion to the decrease of velocity. Experiments have shown that the former is not true and that the latter is true.

The pressures agree for a closing time equal to the time required for the wave to reach the reservoir, but with the non-elastic formula, this pressure must be considered to have existed during the entire time, while in the elastic, the maximum is reached only at the end of the period. To obtain this pressure throughout the entire period, using the elastic formulæ, the gate would have to be closed instantly. With less closing time than that mentioned above the non-elastic formula gives results which are excessive, and with greater results which are too low.

There is nothing in the non-elastic formula to account for that lagging effect which is so well known and which causes recurring waves. These are perfectly accounted for by the elastic theory, and, under proper conditions, can be predetermined.

At the limits given in the table the pressures given by the elastic formulæ commence to fall off, decreasing with increase of closing time. It is readily seen that with long conduits a great variance in results will be found, and as the elastic formulæ are based on actual conditions fixed by natural laws, a choice should not be difficult to make.

The table is based on a velocity of only 1 ft. per second. For changes of 5 to 10 ft. per second the differences would be much increased, as the ram pressures in both cases increase in proportion to the velocity change.

It is evident that the non-elastic formula is based on certain assumptions, namely, that water is incompressible and that the pipe walls are rigid, which are not true; therefore the results obtained by its use cannot be correct. How great the variation will be will depend, as shown in the table, upon the time taken for the velocity change.

COMPUTING CROSS-SECTION AREAS.

The co-ordinate method of determining areas is not well understood, probably because of its simplicity. Were it to involve the use of higher mathematics every engineer would likely be more or less familiar with it.

Distances measured parallel to $X\,X$ are usually called abscissas, and those parallel to $Y\,Y$, ordinates. (See Fig. 1.)

The co-ordinates of any known point are usually computed from the co-ordinates of some other point to which the unknown point is tied by an angle and distance. The difference in co-ordinates between the known and unknown points will be obtained thus:

Difference in X = distance × sin. azimuth angle.

Difference in Y = distance × cos. azimuth angle.

Sometimes the unknown point is located by angles from two other points, in which case the distance between the two points whose co-ordinates are known can be computed and then the distance from one of the known points to the unknown point.

To Determine the Area of by Rectangular Co-ordinates.—The area of the figure 1, 2, 3, 4 (Fig. 1) is equal to the trapezoids:

$(a, 1, 2, b) + (b, 2, 3, c) - (a, 1, 4, d) - (d, 4, 3, c)$.

Expressed as an equation in terms of the co-ordinates the area is:

$$1, 2, 3, 4 = (y_1 - y_2)\frac{x_1 + x_2}{2} + (y_2 - y_3)\frac{x_2 + x_3}{2} - (y_4 - y_3)\frac{x_4 + x_3}{2} - (y_1 - y_4)\frac{x_1 + x_4}{2} \qquad (1)$$

$$= \tfrac{1}{2}\left[y_1(x_2 - x_4) + y_2(x_3 - x_1) + y_3(x_4 - x_2) + y_4(x_1 - x_3)\right] \qquad (2)$$

From this equation is derived the following rule for obtaining the area from the co-ordinates of its corners:

(1) Number the corners consecutively.

(2) Multiply each abscissa (or ordinate) by the difference between the following and the preceding ordinates (or abscissas), always subtracting the following from the preceding (or always subtracting the preceding from the following), and take half the sum of the products.

The adoption of this method of computing railway cross-sections or other earth bodies is quite simple. A cross-section is considered merely as an area, the co-ordinates of all corners of which are known—the cuts or fills being looked upon as ordinates, and expressed in terms of Y, the distance out from the centre being looked upon as abscissæ and expressed in terms of X, and the area being A. The general formula for any conceivable shape of section (Fig. 2) would be:

$$A = \tfrac{1}{2}\, y_0 \left[(x_1 - x_n) + y_1(x_2 - x_0) + y_2(x_3 - x_1) + y_3(x_4 - x_2) + y_4(x_5 - x_3) + y_5(x_6 - x_4) + y_6(x_7 - x_5) + y_7(x_n - x_6) + y_n(x_6 - x_7)\right].$$

The application of this formula is by no means so difficult as the formidable appearance of the algebraic or word statement would indicate. In making use of this formula (which is adopted to the computation of any conceivable shape of area) it may be necessary for one in figuring the first few sections to draw rough sketches of the sections in order to make sure he is not confusing the order of the points, but a very little experience soon enables him to compute the areas from the cross-section notes directly without this help. The formula may be taught in a few minutes to men with scarcely a grammar school education, while well educated engineers are frequently obliged to plot each section, and then laboriously either break it up into triangles or run the planimeters over it to find in the end only an approximate area.

The formula is not an approximation, as slope and other formulas are. It is mathematically exact as shown in Fig. 1, and is absolutely general. Its application to the simpler sections shows up, as well as the more difficult "three-level" section. The following concrete directions should be followed:—

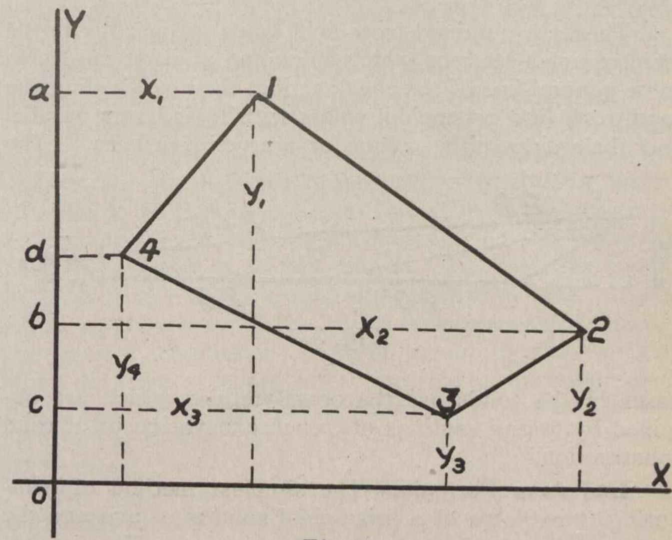


Fig. 1.

Begin at any point on the section and proceed in either direction (clockwise or counter-clockwise), multiplying each cut (or fill) in its order by the horizontal distance between the point just preceding and the point just succeeding. In cases where one passes to the right in measuring the horizontal distance from the preceding to the succeeding point the product obtained by multiplying this distance by the cut (or fill) at the intermediate point is of one sign and in cases where one passes to the left the product is of the opposite sign. Take one-half the difference between the sums of the products of opposite signs and the result is the area of the section.

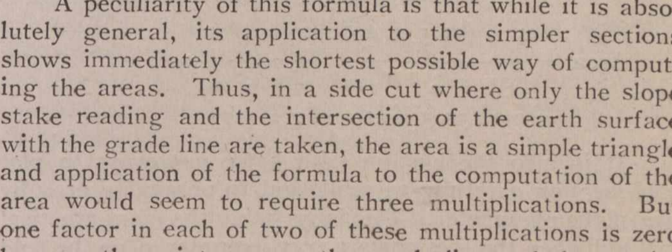


Fig. 2.

A peculiarity of this formula is that while it is absolutely general, its application to the simpler sections shows immediately the shortest possible way of computing the areas. Thus, in a side cut where only the slope stake reading and the intersection of the earth surface with the grade line are taken, the area is a simple triangle and application of the formula to the computation of the area would seem to require three multiplications. But one factor in each of two of these multiplications is zero because the points are on the grade line and the cut (or fill) equal to zero, and it is therefore necessary to perform only one multiplication and take half the product. Also in the case of the so-called "three-point section," or "three-level section," which is really a five-point section, two multiplications are similarly eliminated and two more (the outside slope points) can be worked together by first taking the sum of these cuts (or fills) and then multiplying by one-half the roadbed widths. This fact is apparent at once, because inspection shows that in every section each of the outside cuts (or fills) will be multiplied by half the roadbed width. Many more useful and interesting features of the application of the formula appear as one extends its use.

The data obtained from field notes are usually in the form of cross-sections which are taken at right angles to some general line of the construction, thereby dividing the earthwork into prismoidal solids with their bases parallel and their sides either plane or warped surfaces. The

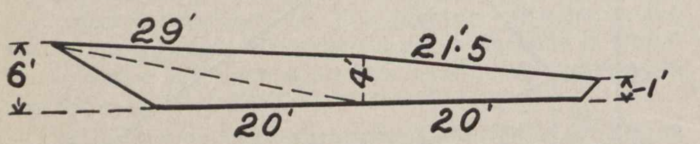


Fig. 3.

bases of the solids are the cross-sections which are obtained by taking sections of trench excavation or of road construction.

End Area Formula.—The simplest method of computing the volume of a prismoidal solid is to average the areas of the two bases and multiply by the distance between them, which, expressed as a formula, is

$$v = \frac{A_1 + A_2}{2} \times l \quad \text{(End area formula).}$$

in which A_1 and A_2 are the areas of the two end bases and l is the distance between them. This method is used to a very great extent throughout the country, although it does not give sufficiently accurate results for certain classes of work.

Prismoidal Formula. — The correct volume of a prismoid is expressed by

$$\text{Volume} = \frac{l}{6}(A_1 + 4A_m + A_2)$$

in which l is the distance between the two bases, A_1 and A_2; and A_m is the "middle area"; i.e., the area half-way between the two bases, which is obtained by averaging the corresponding dimensions of the two end areas, A_1 and A_2; it should not be taken as the mean of A_1 and A_2.

The end areas can easily be computed by dividing them into triangles, as shown in Fig. 3, the area of which can be found readily from the dimensions given in the field notes.

$$\text{Notes of section: } \frac{29.0}{+\,6.0} \quad +\,4.0 \quad \frac{21.5}{+\,1.0}$$

$$\text{Area} = \frac{4 \times (21.5 + 29)}{2} \quad \frac{20 \times (1 + 6)}{2}$$

$$= 2 \times 50.5 + 10 \times 7 = 171.$$

It is also the custom with some surveyors to plot each section carefully to scale and to obtain its area by use of the planimeter. This is probably the most practical method when the sections are very irregular since the field work does not warrant the use of very accurate methods.

There are several other methods employed in computing earthwork but the above are by far the most common.

Rough Estimates.—Rough estimates of the quantity of earthwork are often required for preliminary estimates of the cost of construction or for monthly estimates of the amount of work done. For preliminary estimates of road construction, very frequently the notes of alignment and the profile of the centre line are the only information at hand. From this profile the centre cuts or fills can be obtained, and the cross-sections can be assumed to be level sections and computed by the end area method. The slight errors resulting will be corrected in the final estimate.

In obtaining the required data from which to make an approximate estimate of the quantity of earthwork, the engineer has an opportunity to exercise his judgment extensively. Rough estimates do not, as a rule, call for a large amount of field work. It is important that as few measurements as possible should be taken and that these should also be at the proper places to give complete data and to allow simple computations. Too often engineers, as soon as they arrive on the work and before making a study of their problems, begin to take measurements, consequently they return to the office after hours of hard work with a mass of figures from which it will take several more hours to compute the quantities. A few moments' thought given to the choosing of the proper measurements to be taken in the field would give data which could be computed in a few minutes by use of the slide rule, affording results sufficiently accurate for rough estimates.

FAILURE OF TEMPORARY DAM.

The new power plant of the Ottawa and Hull Power and Manufacturing Company, which is being constructed at the Chaudiere Falls, has received a setback owing to the breaking of a temporary dam while excavation work was in progress. Foundation work includes a large amount of rock excavation. The lumber mills of J. R. Booth & Company are close by, and a temporary dam, which had been constructed of earth and cinders, was built on the edge of the power site nearest the mills. It is thought that owing to a sudden rising of water in the river and a simultaneous starting of the mills, a strong eddy was produced near the temporary structure. It was of such duration that before the water had subsided the cinder embankment had been worn away and the excavation flooded.

A cofferdam will be constructed without delay and the flooded portion pumped out.

YORK COUNTY (ONT.) ROAD WORK IN 1914.

At the November session of the York County Council, just closed, Mr. E. A. James, chief engineer of the York Highway Commission, presented the commission's report.

The commission was organized in 1911, with instructions to build 110 miles of road in the southern part of York County. During 1914 they constructed some 20 miles of roads, including bridges, at a cost of about $90,000. This makes completed to date some 80 miles of road at an expenditure, including bridges, of $500,000. The type of road includes gravel, water-bound macadam, tar-bound macadam, concrete and brick.

A new $300,000 post office was opened last week at Lethbridge, Alta.

Editorial

ONTARIO WORKMEN'S COMPENSATION ACT

The new Workmen's Compensation Act, passed at the last session of the Ontario Government, comes into effect on January 1st, 1915. Those who have given the matter serious consideration have not reasonable grounds to find fault with this advanced legislation.

It has taken a long time for the province to make proper provision for workmen injured by industrial accidents and their dependants. Under the old law the employer of labor had many defences which enabled him to resist, if desired, claims for compensation made by injured employees. This was the fault of the laws on the statute books relating to the liability of an employer for accidents to his employees. Under the new law, these defences are abolished. The fact of the injury alone will entitle an injured workman or his dependants to certain compensation provided by the act. The Ontario government, therefore, has shown a progressive spirit in enacting a new law to take the place of the obsolete one that has been in operation in that province since 1885.

But *The Canadian Engineer* cannot see eye to eye with the government regarding the plans they have adopted for the administration of the new act. Based on the German system, the new act has taken away the liberty of the employer in schedule known as number 1, preventing him buying his protection, or insuring, in the cheapest market. He is compelled under the grouping system to subscribe to an accident fund and is assessed with other employers of labor in the same group, according to the requirements of the case, in respect to current payments as well as deferred payments, as called for under the act. Great powers are given the commissioners in the matter of making assessments and transferring employers from one group to another as they may deem advisable. Indeed, the commissioners have the power at any time to take the employer out of Schedule I. and transfer him to Schedule II. or to put him beyond the scope of the act altogether. Schedule II. deals with industries, the employers in connection with which are individually liable to pay the compensation.

When an employer is taken out of Schedule I., which schedule subscribes to the accident fund, and is placed in Schedule II., the individual liability obtains. That is to say, he still comes under the provisions of the act, but is compelled either to carry his own risk or to insure with a casualty insurance company. This individual liability concession has been made, amongst others, to the big steam railway companies as well as to electric railway companies. It is obvious, therefore, that by putting these industries into Schedule II. a material concession has been made that does not apply to the employers grouped in Schedule I. In other words, the employers grouped in Schedule II. are permitted to buy their insurance in the cheapest market. The question arises whether these special concessions should be made only to big corporations, such as the railway companies, etc., while other industries are forced to pay into an accident fund on an assessment basis, thereby making it absolutely impossible for them to know what their insurance will cost. The weakness of this accident fund scheme, or grouping system, has already been demonstrated. The commissioners, according to the official Ontario Gazette dated November 28, have made numerous changes in the groups in Schedule I. and have read a number of industries out of the act altogether. Those that have been read out of the act are liable to common law actions. These changes cannot have been made by reason of any experience on the part of the commissioners in their administration of the act, because the act has not yet come into force.

The government evidently appreciate the weakness of their experiment and fortunately made provision in the new act for the transfer of any industry coming under Schedule I. to Schedule II., so that it is in the power of the commissioners to transfer any one or the whole of those in Schedule I. to Schedule II. In the latter event, the individual liability would apply to every case, just as it now applies only to the big corporations cited above. The present conditions brought about by the war are bound to have a telling effect on the assessment plan scheme, and it is questionable whether it is wise for the government to run the risk of seeing this new legislation fall to pieces.

The appointment of the commissioners is a most commendable feature of the new act. They are a final tribunal in adjudicating upon accident claims in dispute. Litigation should therefore be a thing of the past, as the commissioners' decision will be final. It is not too late for the government to remedy the mistake which seems to have been made. *The Canadian Engineer* does not advise deferring the effective operation of the act, but the commissioners will be conserving the best interests of employers and employees alike if they forthwith transfer to Schedule II. many or all of Schedule I. The workman has nothing to lose by the change. The employer is bound to do one of two things. He must take out insurance covering all the provisions of the new act or put up substantial security with the government to provide for any accidents for which he may be called upon to pay compensation.

THE EXPANSIVE FORCE OF ICE.

In the transactions of the Royal Society of Canada appears a paper by Messrs. H. T. Barnes, J. W. Hayward, and Norman M. McLeod, which contains some very useful information on the expansive force of ice, a matter of very great importance in engineering work in Canada. Allowance for the frost of the ice sheet has been the subject of considerable diversity of opinion, and the conclusions which these gentlemen have reached as a result of their studies, as yet of a preliminary nature, of ice expansion, will be found interesting:

(1) The crushing strength of ice is most probably 400 pounds per square inch.

(2) An ice block will yield under pressure at approximately 200 pounds per square inch, probably due to the slipping of the crystals.

(3) An ice sheet will form cracks on the upper and under surface due to unequal strain.

(4) A permanent expansion may result if the cracks become filled and frozen.

(5) According to the most trustworthy results of other observers, the ice frozen to concrete develops its full crushing strength, and the tensile strength of ice is under 200 pounds per square inch.

INITIAL OPERATION OF CEDARS RAPIDS PLANT.

The extensive power plant which the Cedars Rapids Manufacturing and Power Company has under construction on the St. Lawrence River, about 30 miles west of Montreal, has reached the stage of near-completion. At the present time the company is developing power to a limited extent and utilizing it for lighting the village of Cedars and for power for construction equipment. The work at present is largely of a cleaning-up nature, preparatory to actual commencement of operations next month. It will be remembered that the initial development of 80,000 h.p. has been contracted for, 60,000 of it by the Aluminum Company, for use at Messina Falls, N.Y., and the remaining 20,000 by the Montreal Light, Heat and Power Company. The design calls for an ultimate development of 160,000 h.p.

An incident of particular interest occurred on October 29th, when a berm acting as a cofferdam during the construction of the 2-mile head-race, prematurely gave way, filling the head-race and putting one of the large units into operation. Some small damage was caused as the unit was without oil in its thrust bearing.

The design and construction of this large power plant has been described and illustrated in previous issues of *The Canadian Engineer*. For the bulk of details respecting it, the reader is referred to issues of January 1st, 1914, and July 9th, 1914. The 2-mile earth bank forming the south wall of the canal and extending to the power house was joined to the shore at the head of the canal by an earth bank which acted as a cofferdam and shut off the water from the entire canal and power house site. The bank was of quite sufficient mass, but the company, anxious to make progress, set about to have as much as possible of it removed by steam shovels, so as to enable a speedy completion of the job, when the power house had been completed and ready for operation. The steam shovels had only excavated one cut along its bank when the water broke through, filling the entire canal in a few hours, submerging the shovels and breaking through one of the power house intakes, starting up a 10,800 h.p. unit.

It had been the intention of the contractors to remove the berm after the canal had been filled with water at a gradual rate extending over several days, so as to subject the dike forming the south bank of the head race to as gradual an increase of pressure as possible. The dike resisted the speedy application of hydrostatic pressure thrust upon it, however, and sustained no damage. The accident was undoubtedly a severe test for the dike, the specifications for which called for a concrete core-wall over 8,000 ft. in length.

As for the power unit, the only damage done to it was in the Kingsbury thrust bearing on the top of the generator. It is 5 ft. in diameter and supports a load of over 5½ million pounds. Although in operation for only a short period, before the intake was closed, the heat generated between the bearing surfaces, in the absence of oil, soon burned the babbit out.

According to statistics compiled by the American Iron and Steel Institute in 1913, about seven times as much steel pipe as iron pipe was made in the United States. In 1905 the amount of steel pipe was only a little more than double the amount of iron pipe. The amount of iron pipe produced year by year, however, remains about stationary or slowly declines, while steel pipe production has rapidly increased. The use of steel in making welded pipe was not successful commercially until about the close of the '80's, but has had a very rapid growth in the quarter century since it began, the output in 1913 having been 2,189,000 tons.

SPEEDY CONSTRUCTION AT ROGER'S PASS, B.C.

The following has been announced by Messrs. Foley Bros., Welch & Stewart as the record for November in the construction of the Roger's Pass Tunnel, 26,400 ft. in length through Mount Macdonald of the Selkirk Range:

East end centre heading, 588 ft. schist with some quartzite.

East end pioneer heading, 529 ft. quartzite with some schist.

West end pioneer heading, 817 ft., slate with small quartzite bands.

West end centre heading, 654 ft. slate with small quartzite bands.

The west end pioneer heading footage of 817 ft. in thirty days is believed to be the record for the American continent. It was driven down grade through rock that could not be broken over 6 ft. per round. The greatest footage in a single day was 37 ft.

In our issue of June 12th, 1913, we commented upon the record established by the Mount Royal Tunnel and Terminal Co. in driving 810 ft. in 31 days. In this instance the daily progress averaged 22 to 28 ft. for the greater part of the time.

It is very interesting to note that these two examples of speedy engineering construction are Canadian. While both typify the use to best advantage of the most modern plant and methods of construction, it is all the more interesting in that the tunneling methods differ materially. In the Roger's Pass enterprise the use of a pioneer heading is being tried out for the first time on such a gigantic scale, it being felt that considerable time could be saved by this method. Time was also a vital factor in connection with the choice of methods for the Canadian Northern tunnel, and a bottom centre heading method was adopted with this in mind.

At the present time the pioneer bore of the Roger's Pass tunnel is about two-fifths completed. It is anticipated that the entire work will be finished many months before the specified time. Mr. Joseph Murphy is assistant superintendent east end, and Mr. Joseph Fowler is assistant superintendent at west end.

SOUTH AFRICAN IRON INDUSTRY.

According to a consular report the manufacture of steel from steel and iron scrap has been started at Vereeniging by the Union Steel Corporation of South Africa, Limited. Rolling was commenced at the works of the corporation on August 1, 1913, and a Siemen's steel melting furnace was started on September 1, 1913, upon which date the first ingot of steel produced in South Africa was cast. The full equipment of the works consists of a 10 to 12-ton Siemen's open-hearth melting furnace, a 600-ton press, two Siemen's reheating furnaces and a 12-inch rolling mill. The whole plant is covered in by buildings of galvanized corrugated iron. The scrap yards now contain roughly 20,000 tons of scrap of which about 16,000 tons had been removed by the corporation from the Pretoria depot of the railway administration. The material produced consists of bar iron and steel of all sections, fencing standards, light colliery rails, and so forth.

The number of men employed at the works of the corporation is about 100 Europeans and 90 natives. Most of the skilled operatives have been brought out from England under contract.

THE CRUSHING STRENGTH OF ICE.

VARIOUS values, ranging from 325 to 1,000 pounds per square inch, as determined by a standard United States testing machine, have been presented for the crushing strength of ice. The importance of this, when calculating the expansive force of an ice sheet (referred to editorially on another page of this issue), makes it very desirable for hydraulic engineers to have more accurate knowledge. In 1871 a value of 208 pounds per square inch was given by Czowski for ice below the freezing point. Ludlow estimated it to vary from 100 to 1,000 pounds with an average of 575 pounds, from a study of ice on Delaware Bay. C. A. Mees arrives at a value of 400 pounds per square inch in the following way: He concludes that the crushing strength may attain a value of 800 pounds in a short column, but adds that wherever the effects of ice expansion have been carefully observed, it has been noted that bending takes place and this may be expected because we have, in an ice sheet, a long column effect. On this account, assuming one-half the crushing strength may be developed before bending, the maximum thrust may equal 400 pounds per square inch.

Table I.

Results of Compression Tests (Bell).

No. of test.	Size of cube.	Crushing strength.	Lbs. per sq. inch.	Temp.'s Ice.	Temp.'s Air.	Remarks.
1	2 x 2	1,926 lbs.	481.5	18	27	1 23/32 height after crushing.
2	2 x 2	2,059 "	516	18	27	1 23/32 " "
3	1¾ x 1¾	3,430 "	1,128	13	25	
4	1 15/16 x 2	2,074 "	535	32	40	Grain perpendicular to line of force.
5	1¾ x 2	2,224 "	636	32	38	Grain parallel to line of force.
6	1¾ x 2	1,884 "	538	32	39	" " " "
7	2⅛ x 2⅛	3,400 "	753	32	40	" " " "
8	2¼ x 2¼	2,474 "	488	32	40	These were 4 inches long and had grain parallel to line of force.
9	2¼ x 2¼	1,811 "	358	32	40	
10	1⅞ x 2⅞	3,214 "	783	32	40	Perpendicular to line of force.
11	2⅛ x 2⅛	3,449 "	765	32	40	Parallel to line of force.

Results of Adhesion Tests (Bell).*

No. of test.	Size ice.	—Bevel— Hor.	Vert.	Load at failure.	Unit compression at failure.	Unit adhesion to concrete.	Method of fail.	Temp. Fahr.
1	2⅛ x 3⅛	12	8	4,200	370 lbs.	195	crushing	30°
2	2¾ x 2¾	12	8	3,800	504 "	228	"	30°
3	3⅛ x 3½	8	12	3,856	395 "	158	crushed and sheared	32°
4	3⅜ x 3½	8	12	2,960	250 "	116	adhesion	32°
5	3⅛ x 3⅛	1	1	4,100	420 "	185[5]	compression	30°

*Adhesion of ice to concrete blocks.

Table II.

Date.	No.	Size of block.	Direction of axis with respect to direction of applied pressure.	Pressure when first crack was heard.	Pressure when block crushed.
Mar. 21	3	3½ x 6½ x 4¾	Parallel	87 lbs.	289 lbs.
"	4	6½ x 5 x 4¼	Perpendicular	123 "	247 "
"	5	4½ x 4¼ x 5¾	"	183 "	251 "
"	6	5¼ x 4 x 6	Parallel	166 "	335 "
Mar. 26	7	7¼ x 6 x 6	Perpendicular	183 "	424 "
" 26	8	7¼ x 6 x 6	"	183 "	364 "
" 26	9	6½ x 6 x 6	Parallel	....	485 "
" 26	10	7½ x 7 x 5¼	Perpendicular	....	238 "
" 26	11	7 x 7 x 6¼	"	200 "	400 "
" 26	12	7½ x 6 x 6	Parallel	121 "	304 "
" 26	13	7½ x 6 x 5½	"	159 "	398 "
" 26	14	7½ x 6¼ x 5¾	Perpendicular	140 "	292 "
" 26	15	7¾ x 6½ x 5¾	"	234 "	422 "
" 26	16	7 x 7 x 5½	"	227 "	568 "
" 26	17	7 x 6½ x 6	Parallel	....	224 "
" 26	18	6⅛ x 6 x 5⅞	"	248 "	557 "

Mean 370 lbs. per sq. inch, axis parallel.
" 356 " " axis perpendicular.

Mean of both 363 lbs. per sq. inch.

Table I. gives the results of a valuable series of experiments by George G. Bell, who used small cubes of approximately 2 inches.

This information is introductory to a paper on the subject presented last May to the Royal Society of Canada by Professor H. T. Barnes, of McGill University, Montreal. Dr. Barnes is inclined to neglect Mr. Bell's highest result, thereby securing more consistent values, ranging from 358 to 783 pounds per square inch. Mr. Bell himself states that he considers 400 pounds a fair estimate of the crushing strength of ice from all his tests.

Dr. Barnes describes experiments performed by himself to determine the crushing strength of perfectly clear ice on somewhat larger blocks. The ice was cut from the river and tested in a hydraulic press. One large piece 6 in. x 28 in. x 40 in., furnished the largest number of individual blocks. The direction of the crystalline axis was determined by knowing the plane of freezing, and the various blocks were cut by a hand-saw accordingly. The ends of the blocks were melted smooth on a hot plate to fit the plates of the press. When the pressure was applied, considerable melting resulted on the ends. The blocks were kept outside at a temperature ranging from —8° C. to 0° C. and were brought into the laboratory for the tests. One interesting fact was noted, that the blocks were heard to crack at a pressure, approximately one-half the ultimate crushing force. It was repeatedly observed that as soon as the pressure was increased sufficiently to cause the first audible crack, the block appeared to stiffen, and the pressure ran up much quicker, with much less melting. In some cases the melting appeared to cease altogether. Dr. Barnes concluded that the giving way of the ice under pressure allowed the melted ice to run into cracks, where it must have frozen and cemented the block more firmly, being unable to see any of the cracks which could be distinctly heard at half the crushing pressure.

The only effect of varying the position of the axis of the ice with respect to the direction of the pressure, appeared to be the way the block burst. When the axis was parallel to the applied pressure, the ice burst sideways into innumerable long needles, resembling a cake of ice which has all but fallen to pieces in the sun. The cake fell to pieces on being removed from the press. When the axis was at right angles to the applied force, the block cracked lengthwise and transversely without shattering.

Table II. gives the results of the tests performed by Dr. Barnes. It will be seen that the mean value for all the tests for parallel axis is a little higher than the mean for perpendicular axis, but the difference is too small to make it possible to draw any definite conclusions. The results show considerable variation, which may be purely accidental or may have some bearing on the character of the initial distribution of the pressure.

The relation between the first cracking of the ice and the final crushing force is one which, the experimenter states, must be further investigated.

In closing he remarks: "The question of the relation of temperature to the crushing strength is one of importance. It has been assumed that ice becomes stronger at low temperature. The hardness of ice increases considerably as the temperature falls to 0° F. but I am inclined to think that the ice also becomes more brittle. In the neighborhood of the freezing point, ice is much more plastic than it is at lower temperatures. The plastic effect is, however, masked by the regulation effect, and it is a question whether the ice mass is not really firmer near the freezing point than when cooled much below. This can, however, only be settled by further experiment."

A number of samples of radium-bearing ore from British Columbia have been received by the mines branch, Department of Mines, Ottawa, for investigation.

THE SUCCESSFUL BURNING OF LIGNITE.

In *The Canadian Engineer* for December 3rd, 1914, the investigations of the Saskatchewan government into the coal resources of the province were referred to, and an analysis was given to illustrate its serviceability as fuel for power and domestic purposes.

Following it we present herewith some notes respecting the burning of lignite in the State of Texas, in which state there is an estimated area of over 60,000 square miles, containing what is roughly concluded to be 30 billion tons of lignite. In many centres its use in manufacturing plants has been extensively adopted. The lignite resources of the state have been recently investigated by Professor Wm. B. Philips, of the University of Texas, who has made a study of its commercial use. In a recent report he alludes to the introduction of a grate specially adapted to burn lignite screenings, a grade that is sold at from 50 to 60 cents per ton. This grate is similar to the ordinary grate, being rectangular in cross-section, but slightly wider at the top than at the base. On its top face are marginal and transverse ribs or partitions, forming fuel pockets adapted to retain fine fuel. On its bottom face are recesses forming air pockets. These fuel pockets are from one-half to five-eighths of an inch deep and are connected with the air pockets by tapered ventilating holes, largest at their lower ends, being about three-eighths of an inch in diameter at the top and 50% larger at the bottom. The tapering form of the ventilating holes tends to cause a discharge of the air in jets into the fuel.

In ordinary grates, especially where a forced or induced draft is used, the air rushes through the weakest places in the fire. With this grate the individual air pockets underneath prevent the air from rushing past some of the ventilating holes and overcharging others. These air pockets form sources of supply to the separate groups of ventilating holes and cause an even distribution of the air to the fuel pockets in the top of the bar throughout the grate surface. A steam blower is used with these grates.

Much lignite is now fired by hand, and while this method unquestionably gives good results when proper care is taken, the stoker seems to be necessary for large establishments. There are no difficult obstacles to be overcome. The main points to consider are that lignite is a fuel which parts with its volatile combustible matter more quickly than does ordinary bituminous coal and that the fixed carbon is not of a coking nature. This means that a large quantity of air must be supplied within a short time after the fuel begins to part with its volatile combustible matter and is supplied at the requisite points. The smoke must be prevented from forming, for it is difficult to handle it afterwards. The fixed carbon will take care of itself, if prevented from falling through the interstices of the grate; it is the volatile combustible matter that has to be cared for.

It does not appear that there are greater variations in the composition of lignites than in the coals with which they are to compete, so that a stoker installation successful with one lignite should be capable of burning any other under comparable conditions.

It has been stated in Ottawa that the value of minerals produced in Canada this year will be considerably less than that of 1913, because of the scarcity of capital for mining development and also because of the low prices which have existed for silver and other minerals.

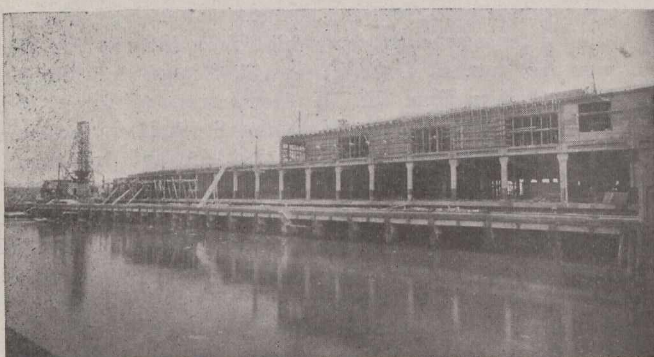
TIDEWATER ACTIVITIES AT HALIFAX.

CONSIDERING the effect which the war and the anteceding depression has had upon engineering work in general, the progress that has been made during the past several months on the Intercolonial Railway ocean terminals under construction at Halifax, is inspiring and more or less remarkable. The work on the superstructure of pier No. 2 has made material advancement, as has also the railway cuttings and other phases of the whole scheme. The general details of the terminal plans were given in *The Canadian Engineer* for July 30th, 1914. Briefly, the terminals will extend for 1¼ miles southward from Fawson Street along the western shore of Halifax Harbor. They provide for a bulkhead passenger landing quay 2,000 ft. long, and four new piers from 650 to 800 ft. long and 235 ft. broad, the whole protected at the southern end by a rubber mound breakwater a quarter of a mile long. Ample railway tracks and connections, sheds and equipment, grain elevator, etc., will be provided for the handling of passengers and cargo, and a special feature of the terminals will be the exceptionally good facilities for the handling of passengers, mails and express freight. Extensive immigration quarters will be provided at the passenger landing quay. The quays will provide for depths ranging up to 45 ft., and will therefore be ample for the largest transatlantic liners afloat.

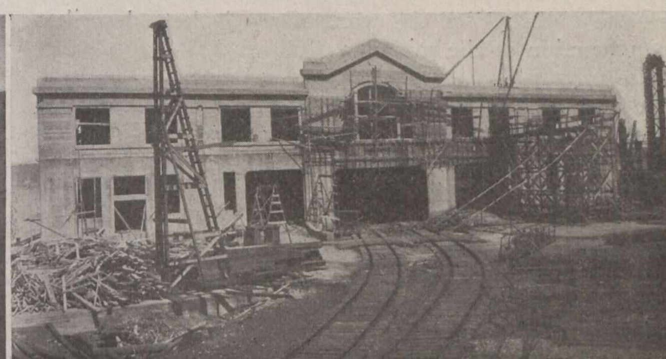
A part of the scheme is the Halifax Ocean Terminals Railway, a double track line from Rockingham, four miles from North Street station, Halifax, to the site of the new terminals. Thus the existing line of the Intercolonial will be connected with the quay. The line includes the formation of a freight terminal yard and a diversion of the I.C.R. at Bedford Basin and at Fairview. It passes under the Halifax and South Western Railway and follows the North West Arm to Young Avenue. This portion of the line includes a cutting, mostly through rock, and of sufficient depth to pass under all existing roads and streets with very slight alterations. Grade crossings have been entirely eliminated and the location of the railway along the North West Arm and the south end of the peninsula was decided upon with a special view toward the preservation of the natural beauty of these suburban and residential parts of the city. Railway construction work has included a large amount of filling along the west shore of Halifax harbor for the proposed bulkhead, quays and piers.

The contract for the grading of the railway was awarded a year ago last June to the Cook Construction Company and Wheaton Bros., and work commenced early last fall. Grading included earth cuts 22 ft. wide for single track with an additional 13 ft. for each extra track. In rock the widths were 20 ft. and 13 ft. respectively with slopes of ¼ to 1. Embankments were to have a grade width of 16 ft. or 18 ft. when under or over 16 ft. in height, respectively. The earth slopes were to be 1½ to 1. The maximum grade is 6/10%, compensated for curvature and the sharpest curve, 4%. This contract included the construction of the freight terminal yard and breakwater. Materials for both were provided by the excavations from the railway cuttings. The breakwater embankment consists of rock protected on the sides and seaward extremity by rubble rip-rap and paved on the top with large angular pieces of rock.

Specifications call for a core embankment 40 ft. in width at low-water level of ordinary spring tides. Side slopes 1 : 1 extend from the bottom of the harbor to low-water level. From its base to 30 ft. below water level the embankment consists of varying sized rocks. In the upper portion these rocks are not to weigh less than 1 ton each. The sides have large angular blocks for protection to 30 ft. below water level, these blocks weighing from ½ ton to 2 tons each. On the seaward slope the rip-rap is to be composed of blocks weighing from 2 to 8 tons. This is also the required weight of blocks from the top of the embankment at low-water level to the top of the breakwater. The breakwater will measure 30 ft. in width across the top, and is to be evenly surfaced with all interstices tightly packed.



View, Looking South, of No. 2 Shed, While Under Construction.



Entrance to Reinforced Concrete Freight Shed, Pier No. 2.

The buildings for the new terminal include a passenger station, the plans for which have recently been prepared by Ross & Macdonald, Montreal. Plans for other buildings to be constructed upon the piers are now being prepared. The contemplated arrangement includes a power house to furnish light, heat and power, a grain elevator and the large freight shed with abundant trackage facilities for the rapid handling of freight.

The pier, which is the widest in Canada, and which has a floor area of 258,000 sq. ft., is one which, owing to its piling problems, difficulties of concrete construction, length from bulkhead, spacious yard room, etc., has occasioned much admiration from the maritime provinces. At the present time concreting has been practically completed on the freight shed structure, and the building glazed. Accommodation is being provided in it for 2,000 passengers. This accommodation is but temporary and will be removed when the new passenger station has been built.

Four tracks along the south, two in the centre of the building and one on the north side of it, are being installed, the latter three running the full length of the shed. The present immigration building will be removed to permit the laying of the north tracks which will also require, for support, an extension of the bulkhead. This work will be held over until spring.

TELESCOPE FOR VICTORIA OBSERVATORY.

THE Dominion Government contemplates the erection next year of new observatory buildings on Saanich Hill, in the vicinity of Victoria, B.C. The telescope to be installed there during the year was the chief subject in an illustrated address delivered by Dr. J. S. Plaskett, of the Dominion Observatory, Ottawa, at a meeting on December 1st, of the Royal Astronomical Society of Canada, Toronto. The construction of the telescope has been under way for some time. The disc for the main mirror is being ground at the works of the John A. Brashear Co., Pittsburgh. It is 73⅝ inches in diameter and 13⅛ inches thick, and weighs 4,960 pounds. The aperture in the centre of the disc is 9 inches in diameter. The disc itself was made at the Belgian factory of the St. Gobain Glass Works, and shipped from there three days before the outbreak of the war. Dr. Plaskett describes the construction of the mirror as follows:

The mirror-disc is ground and polished on the back surface only approximately, not optically, flat. The front surface, however, the one facing the sky, is carefully and most accurately ground, polished and figured to the correct curve, which is a parabola of revolution. Then this surface is carefully silvered with a thin bright coat of silver, highly polished, reflecting back the light, which hence does not enter the glass at all. As long as the front surface of the glass is perfect, and the rest of the material is sufficiently homogeneous and rigid to hold this surface perfect and unchanged, it does not matter about its transparency or freedom from bubbles or minor defects.

After reflection at the concave surface of the big disc the light from the star proceeds back up the tube in a converging cone towards the focus of the upper mirror. It may be observed in three ways: (1) It may be received on a bent telescope, one with a right-angled prism in it, and the enlarged images may be viewed at the side of the tube. This is the prime focus arrangement. (2) A plane mirror at an angle of 5 degrees may intercept the cone of light about three and a half feet below the focus, thus forming the images at the side of the tube, where they may be viewed by the eyepiece. This is the Newtonian arrangement. (3) The light may be intercepted about seven feet below the focus by a convex mirror, which reflects the light back through the hole in the centre of the big mirror-disc, forming the images anywhere desired along the optical axis generally, of course, a foot or so below the big disc. Here they can be viewed by eye-pieces. This is the Cassegrain method.

The Cassegrain and Newtonian attachments intercept between six and seven per cent. of the light incident upon the big mirror, but when the images are viewed at the focus the quality is not affected at all; the quantity of light only is slightly diminished. Exactly the same effect would be produced by sticking a circular disc of paper one inch in diameter centrally over a four-inch objective. The image would not seem to be affected.

The construction of the telescope mountings has been under way for some time. The heavy steel castings are being made for the Warner & Swasey Company in Pittsburg and Cleveland and are to be delivered in about four months' time. All the mechanism and smaller parts are being made at the Warner and Swasey works, and it is expected that the entire mounting will be ready for shipment next October.

The plans for the dome and the building for the telescope are practically completed. The walls are to be about 35 ft. high, and the dome about 35 ft., making the total height over 70 ft.

The plan for the office building provide for a large library, which will also be used as a lecture room, with seating for 200 people.

The plans for the other buildings required are well under way. The contracts for the buildings first needed will be let as soon as possible in the New Year, so that construction may begin on April 1. There is every prospect, therefore, that the telescope will be installed during 1915.

AMERICAN ROAD BUILDERS' ASSOCIATION.

The eleventh annual convention of the American Road Builders' Association, to be held in Chicago, December 14th to 18th, inclusive, has attracted the attention of many Canadian highway engineers, and a more than usually representative attendance from this country will likely be in evidence. Among those who have signified their intention of being present are Hon. F. G. MacDiarmid, Minister of Public Works for Ontario; Hon. E. H. Armstrong, Minister of Public Works for Nova Scotia; Mr. John Stock, Deputy Minister of Public Works for Alberta; W. A. McLean, Provinical Highway Engineer for Ontario; W. G. Yorston, Provincial Highway Engineer for Nova Scotia; S. T. Robinson, chairman of the Highway Board of Saskatchewan; A. McGillivray, engineer to the Manitoba Highway Commission. Representatives of various Canadian cities, of the Toronto Harbor Commission, and similar bodies throughout the Dominion, will also be in attendance.

SOME INTERESTING MOTOR-TESTING EQUIPMENT.

There is an interesting installation in New York where investigations of various kinds on steam engines, particularly of the turbine and rotary type, are carried out. The equipment includes high-speed indicators of the "manograph" type by means of which diagrams can be obtained at speeds as high as 2,000 revolutions per minute, as well as at ordinary low, piston speeds. Another notable feature is the apparatus for making brake tests. This includes an 80 h.p. electric dynamometer with rocking fields, built by the Sprague Electric Works, and also a Heenan and Froude hydraulic dynamometer of the model used by the British Admiralty, having a maximum capacity of 600 h.p. at 5,000 revolutions per minute. Steam is available at 480 pounds per square inch. These facilities have recently been installed in the laboratories of Mr. Joseph Tracy, 1790 Broadway, New York.

The suggestion has been made, and it has been stated that the Government will likely act upon it, that aliens of enemy nationality, who have been placed in charge of the military authorities, be set to work cutting roads and clearing tracts for settlement in the clay belts of Ontario and Quebec.

Coast to Coast

Haileybury, Ont.—Messrs. P. H. Secord and Sons, contractors, have just turned over the newly-completed drill hall to the Department of Militia.

Porcupine, Ont.—The output of the Dome Lake mines has been increased by some 15 tons daily by the addition of extra tables and equipment, put into operation last week. This brings the capacity of the mill up to 50 tons per day.

Cranbrook, B.C.—The branch of the Kootenay Central from Cranbrook to Golden was formally open last week, connecting the Crow's Nest with the main lines of the C.P.R. and traversing one of the most fertile parts of the province.

Princeton, B.C.—Southern British Columbia is looking forward with great interest to the linking up of the boundary valleys with adequate railway facilities, and the good progress that is being made on the Kettle Valley Railway is an assurance that the advent of better transportation will not be long delayed.

Galt, Ont.—The Lake Erie and Northern Railway is ready for business. Work has been rushed along during recent months, ballasting has been proceeded with briskly, and the bridge across Mill Creek, paralleling that of the Grand Trunk Railway, was completed last week.

Portage la Prairie, Man.—The electric railway line into Stonewall is practically completed, there only remaining a little overhead work to be done. Regular service between Winnipeg and Stonewall will likely be in operation before the middle of the month.

Vancouver, B.C.—The greater part of $10,000 a month will be spent, to provide employment during the winter, in the grading of boulevards and streets. Mr. F. L. Fellowes, the supervising city engineer, has closely inspected the entire city, and has made a number of recommendations for extensive improvements in this respect.

Hamilton, Ont.—Engineers of the Department of Public Works, Ottawa, were in Hamilton last week inspecting a revetment wall on the Bay front, which for a distance of about 40 ft., has bulged 31 inches out of alignment as the result of pressure from back-fill. It is estimated that the expenditure connected with the straightening of the wall will be about $25,000.

Toronto, Ont.—Some difficult excavation work has been encountered by the sewers department in connection with the driving of the large trunk sewer tunnel under the C.P.R. tracks near Woodville Ave. At this point the sewer is about 40 feet below the tracks. Compressed air has been used on the job for preventing the intrusion of water, the seepage of which is overabundant.

Winnipeg, Man.—The W.S. and L.W. Ry. have completed the construction of their electric car line from Winnipeg to Stonewall and a service will be in operation about December 15th. Besides 17 miles of 13,200 volt line and track, this work included a subway beneath the C.P.R. Beach line at Middle Church, a sub-station and station house at Stony Mountain, and a station house at Stonewall.

Edmonton, Alta.—As announced in another column of this issue, a contract has been let to D. F. McArthur and Co., for the construction of a line 186 miles in length from Lac la Biche to Fort McMurray. The announcement was made last week by Mr. J. D. McArthur, president of the E.D. and B.C. Railway. It is expected that the new line will be finished by November of next year. It will involve an expenditure of about $2,000,000.

PERSONAL.

A. C. McKENZIE has been appointed town engineer of Preston, Ont.

H. M. PASSMORE has been appointed secretary to the Minister of Public Works of Ontario.

J. W. PUGSLEY has been appointed secretary of the Department of Railways and Canals, Ottawa.

LAWFORD GRANT, sales manager of the Eugene Phillips Co., Montreal, is at present in England on a business trip.

LIEUT. A. L. MIEVILLE is in command of the Toronto section of Canadian engineers now in training at Ottawa.

GEORGE A. JANIN, chief city engineer of Montreal, is to receive a commission enabling him to proceed with the company organized by himself, with the second contingent.

E. W. BEATTY has been appointed vice-president and general counsel of the Canadian Pacific Railway Co. Mr. Beatty has been associated with the legal department of the company since 1901.

H. O. FISKE, until recently connected with the Peterborough (Ontario) Light and Power Co., succeeds Mr. C. R. Howse as manager of the Utilities Commission of that city.

C. BRENNAN, one of the construction engineers of the Edmonton, Dunvegan and British Columbia Railway, is superintending the cutting of the right-of-way of a 60-mile section of the line beyond Smoky River.

Dr. C. J. HASTINGS, Medical Officer of Health for Toronto, was elected first vice-president of the American Public Health Association at the closing session of its annual convention in Jacksonville, Fla., last week.

GEO. W. CRAIG, city engineer of Calgary, had the misfortune to meet with a painful accident while in Omaha, Neb., last week. We are informed that Mr. Craig is improving and will return to Calgary in a few days.

W. A. McLEAN, Provincial Highway Engineer of Ontario, is president of the American Road Builders' Association, and will spend next week in Chicago, where he will preside over the sessions of the eleventh annual convention.

C. L. HERVEY, C.E., chief engineer of the new Glengarry and Stormont Railway, which connects Cornwall with the C.P.R. at St. Polycarpe, Que., was tendered a complimentary luncheon upon the occasion of the completion of the laying of steel last week.

FRED. D. NIMS, electrical engineer and general superintendent of the Western Canada Power Co., Limited, is leaving the service of that company to accept a position with the Olympic Power Co., of Port Angeles, Wash. Mr. Nims deserves special mention for his successful efforts to form a section in Vancouver of the American Institute of Electrical Engineers. Mr. Nims is a member of several of the standing committees of the Institute.

OBITUARY.

The death occurred at Ashtville, North Carolina, of J. T. M. Burnside, B.A.Sc., in his 40th year. Mr. Burnside was a graduate in engineering of the University of Toronto, graduating in 1899, and engaging in mining for several years. He then turned to military affairs, and held a commission in the 48th Highlanders Regiment. Later he transferred to the British army and for some time was stationed on the Gold Coast. A few years ago Mr. Burnside engaged in railway building in China, afterwards returning to Canada and devoting his attention to mining in the Cobalt region. Impaired health induced him to go South, where death overtook him.

Death came suddenly last week to Mr. Frank Rankin, of Haileybury, a member of the engineering staff of the Transcontinental Railway.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The meeting of the Mechanical Section of the Canadian Society of Civil Engineers, held in Montreal on the evening of December 3rd, was addressed by Mr. C. Brady, his subject being "Steel Passenger Car Frame Construction." Mr. Brady's paper was a neat and masterly treatment of the subject, and was well received by the members. An abstract of it appears on another page of this issue.

Following it an address was given by Lieut. Shirley T. Layton, A.M.Can.Soc.C.E., a graduate of R.M.C. and of McGill University. The speaker dwelt upon the primary object of artillery in modern warfare, explaining it to be for the protection of the advancement of infantry and assistance to its movements. The secondary object was the destruction of the enemy's war equipment. Such interesting points as the uses of different classes of artillery, including horse artillery armed with 13-pound guns, field artillery with 18-pounders, and others of larger order, made Lieut- Layton's paper a most instructive one for the members. He observed that in Montreal there were two heavy artillery batteries, armed with 60-pound guns, one having gone with the first contingent. The remaining battery was now armed with 4.7-inch guns, throwing shells weighing 45 pounds. This gun was well described by the speaker. Its mechanism and ammunition were illustrated by slides. The gun weighs about 4½ tons and the maximum range given on the sight drum is 9,600 yards. It has great power and is remarkably accurate at long ranges. The speaker emphasized its usefulness in bringing cross-fire to bear upon the enemy and also against buildings and fortifications. The recoil of the gun, method of loading and timing of shell explosion were explained in detail. The construction of different kinds of shells and the devices to prevent premature explosion were described.

It may be said of Lieut. Layton that some time ago he left the engineering staff of Walter J. Francis and Co., to accept a commission, and since that time he has recruited the whole number for the Montreal part of the Heavy Brigade, which will go with the next contingent. It is interesting to note in this connection that the Heavy Brigade in Montreal has been in charge of Lieut.-Col. Lacey R. Johnson, also a member of the Society. About 120 members of the Society are participating in active service.

NOMINATIONS, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The following is a list of members who have been nominated for the various offices of the Canadian Society of Civil Engineers for the year 1915:—

For President, F. C. Gamble, Chief Engineer, Public Works Department, Victoria, B.C.; for Vice-President for 3 years, A. E. Doucet, District Engineer, National Transcontinental Ry., Quebec; A. St. Laurent, Public Works Department, Ottawa. For Vice-President for 1 year, E. E. Brydone-Jack, Professor of Civil Engineering, Manitoba University; Gordon Grant, Chief Engineer, National Transcontinental Ry., Ottawa.

For councillors, District 1, S. P. Brown, Chief Engineer, Montreal Tunnel, etc., Canadian Northern Ry.; H. R. Safford, Chief Engineer, G.T.R.; A. Surveyer, Montreal; R. M. Wilson, Montreal. District 2, C. B. Brown, Chief Engineer, Canadian Government Railways, Moncton, N.B.; F. W. W. Doane, City Engineer, Halifax, N.S. District 3, A. Amos, Quebec; T. A. J. Forrester, Quebec. District 4, G. J. Desbarats, Deputy Minister Naval Service, Ottawa; A. J. Grant, Superintending Engineer, Trent Canal, Peterborough, Peterborough, Ont. District 5, S. B. Clement, Chief Engineer, T. and N.O. Ry., North Bay, Ont.; J. L. Weller, Engineer in Charge, Welland Ship Canal, St. Catharines, Ont. District 6, W. G. Chace, Winnipeg; F. H. Peters, Calgary, Alta. District 7, N. J. Ker, Vancouver; D. O. Lewis, District Engineer, Canadian Northern Pacific Ry., Victoria, B.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.

The following speakers are among those who have arranged to prepare papers for presentation at the coming convention of the Association in Toronto, January 26th, 27th and 28th, 1915:—A. C. McKay, Principal of Toronto Technical Schools, "Toronto Technical Schools and their Relation to the Manufacture of Clay Products"; W. W. Smith, Shallow Lake, Ont., "The Making and Burning of Drain Tile"; A. F. Greaves-Walker, Manager, Sun Brick Co., Toronto, "Kiln Kinks"; E. W. Knapp, "Possibility of Manufacturing High-Class Paving Bricks in Ontario"; Andrew Kruson, "Cheap Glazes for Use on Ontario Clays and Shales"; and Philip W. Green, B.A.S.C., A.M.Can.S.C.E., "Standardization of Clay Products from an Architect's Point of View."

TORONTO BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

A meeting of the Toronto Branch of the Canadian Society of Civil Engineers is being held this evening (December 10th), and is being addressed by J. E. Noulan Cauchon. The subject of his address will be the town planning problem, with special reference to the railway features.

COMING MEETINGS.

AMERICAN ROAD BUILDERS ASSOCIATION.—**Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.**

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.

AMERICAN WATERWORKS ASSOCIATION. — The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.