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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

ENGINEERING APPLICATIONS OF GEOLOGY

Foundation Conditions in Canadian Cities—Geologists Useful in Construction of Catskill Aqueduct—The Loetschberg Tragedy—Paper Read Last Thursday Before Ottawa Branch, Can.Soc.C.E.

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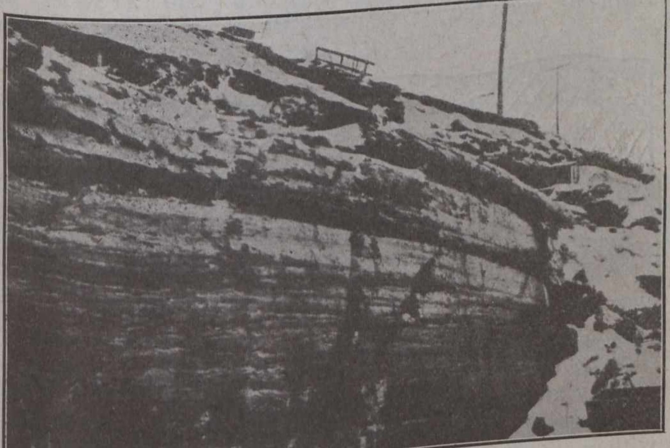
THE engineer has to do with the design, erection, construction and operation of engineering works which are constructed in or on the surface of the earth. Therefore, geology, a science which treats of the history of the earth, is of great importance to the engineer. In fact, geology is often of real practical value, from the simple (apparently) task of sinking a well for water to the driving of long tunnels through great mountain ranges. The application of geology to engineering work is, therefore, so wide and diversified that it is not possible to deal with all the underlying principles within the time allotted to this paper.

In Canada we have engineers who are thoroughly competent to deal with all kinds of engineering work. Similarly, we have engineering geologists who are thoroughly qualified to apply this branch of science to engineering.

This paper deals principally with Pleistocene geology as applied to engineering, and, as the deposits of this period and later are more or less unconsolidated, the problems presented have to do with the soil, subsoil and unconsolidated material resting on the solid rock. A knowledge of the geology of these deposits can be applied



Ice-moulded Face of Escarpment, Excavation for New Customs Building, Sussex Street, Ottawa

practically in connection with the following classes of engineering work: Dam construction, foundations, railway construction, canals, water supply and materials of construction.

Structural geology, or that which deals with the rocks themselves, their kind and relation to each other, is not discussed in this paper. It is of equal importance to the civil engineer, and is of practical value in connection with the following: Railway construction and maintenance, artesian wells for water supply, tunnels of all kinds, canals and materials of construction.

The object of the paper is to point out the necessity for the collection and interpretation of geological data

Showing the Intimate Association of Stratified and Unstratified Drift Within Short Distances

with reference to engineering and to give a few examples illustrating its practical value.

Glacial Deposits

Glaciers are not of great importance to the engineer, even though they may be of considerable scientific interest, but the work which they have performed in the past, and the deposits which they have built up, are matters of considerable value to him, and often present interesting problems in connection with various subsurface operations, such as tunnelling, dam foundations, aqueduct construction, underground water supply, etc. Glacial deposits sometimes serve also as a source of materials of economic importance.

All Canada and the northern portion of the United States were formerly covered by a vast continental glacier. As a result of this the engineer at the present day finds himself confronted with a number of phenomena, which sometimes seem very perplexing, but whose understanding is often of vital importance from the financial standpoint.

The glaciated area in Canada is covered with a more or less continuous mantle of drift of variable thickness. Over any region the thickness of the drift may vary within short distances. The rock surfaces are very uneven and hence the bed rock often lies at a variable distance below the surface, a fact that engineers should remember in sinking foundations.

Coarse River Gravels, Hull, Quebec

The glacial deposits consist in general of boulders, cobbles, pebbles, sand and clay, forming a confused, unassorted mass; the stones of the drift, although worn, are not rounded but rather subangular in form and are often striated and polished. Many of the rocks distributed through the drift are of kinds occurring many miles to the north of where they are now found.

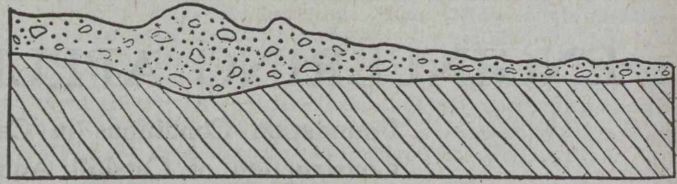
Large ice-transported boulders, many tons in weight, are also found scattered over the drift-covered area, regardless of topography. Large boulders in the drift are sometimes mistaken for bed rock in drilling, especially

Glacial Drift, Coarse and Fine Together

where wash borings are made. In fact, a case came under notice in Montreal where a test bore hole was put down to what was believed to be solid rock but which later, after the contractor got into difficulty, proved to be a boulder of Laurentian gneiss.

Boulder clay usually affords good foundations, but occasionally it has within it seams of water-laden sands that frequently are of the nature of quick-sands which give trouble and cause heavy expense if not guarded against.

Many of the present streams occupy the partly, or completely, filled pre-glacial valleys. During the glacial period these valleys or gorges became completely clogged with glacial drift so that after the recession of the glacier



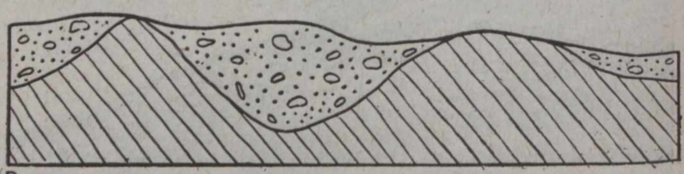
Section Through Glacial Drift and Bed Rock, Showing How Disposition of Morainal Material Has Made Surface More Irregular

these streams had to cut new channels. Abundant modification of stream drainage has resulted. In some cases a stream has sunk its channel through the thickness of the drift; in others not, while in still others the deflection to one side of its former valley had enabled it to cut through the underlying hard rock. Again, others are flowing in new channels on the drift cover.

The Catskill Aqueduct

One of the best examples of geology as applied to engineering was in connection with the location and construction of the Catskill aqueduct. In connection with the location of the aqueduct, cut and cover was adopted as much as possible. The length of the aqueduct was 92 miles and the difference in level between the point of supply and the point of distribution in New York City was only 300 feet. While this was sufficient head to permit gravitational flow, it meant that in order to maintain a flowing grade in all tunnels, channels or tubes it was necessary when a depression had to be crossed that the pressure be maintained so that the water may rise again to a suitable level on the other side.

The undertaking resolved itself into a series of problems, each having its own characteristics and peculiar

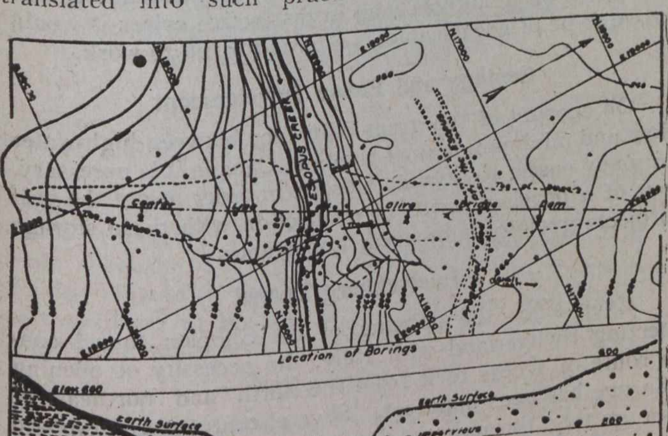


Section Showing How the Disposition of Glacial Drift Has Reduced Surface Irregularities

difficulties and methods of solution and each requiring a thorough understanding of the topographic features of the vicinity and a working knowledge of geologic conditions. For example, one has scarcely left the great reservoir, with water flowing at 580-90 feet above tide, before the broad Rondout Valley is reached, with a width of 4½ miles, nowhere at great enough elevation to carry the aqueduct at grade. If it is to be crossed at all, and it must be crossed to reach New York City, some special means must be devised. If a trestle be proposed, one finds that it would have to be 4½ miles long (24,000 feet), and in some places 300 feet high, and at all points large enough and strong enough to carry a stream of water capable of delivering 500,000,000 gallons daily—a stream that, if confined in a tube of cylindrical form, would have a diameter of about 15 feet.

A steel tube might be laid to carry the water across and deliver it again at flowing grade, but here one is met with the fact that it would require a tube of unprecedented size and strength, and if divided into a number of smaller ones the cost would be greater than that of a tunnel in solid rock.

The other alternative is to make a tunnel deep enough in bed rock to lie beneath surface weaknesses and superficial gorges and in it carry the water under pressure to the opposite side of the valley. This is the plan that seems best suited to the magnitude of the undertaking and would seem to promise most permanent construction. But no sooner is this conclusion reached than it is realized that there are now several hitherto unregarded features that assume immediate and controlling importance. Some of these, for example, are (1) the possibility of old stream gorges that are buried beneath the soil, (2) the position of these old channels and their depth, (3) the kinds of rock in the valley, (4) their character for construction and permanence, (5) the possible interference of underground water circulation, (6) the possible excessive losses of water through porosity of strata, (7) the proper depth at which the tunnel should be placed, (8) the kinds of strata, and their respective amounts that will be cut at the chosen depth, (9) the position and character of the weak spots with an estimate of their influence on the practicability of the tunnel proposition. Then, after these have all been considered, the whole situation must be interpreted and translated into such practical engineering terms as



Location of the Ashokan Dam at Olive Bridge Site and a Geological Cross-section

The small dots in the plan indicate exploratory borings. The section shows the rock profile indicating a preglacial channel of the Esopus. The present Esopus flows in a new postglacial channel at a higher elevation.

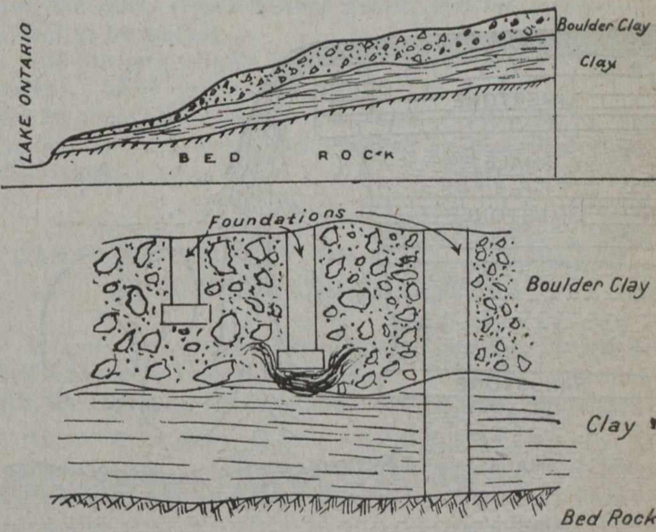
whether or not the tunnel method is practicable, and at what point and at what depth it should cross the valley, and at what points still further exploration would add data of value in correcting estimates and governing constructions and controlling contracts.

This is a general view of one case, the first one of any large proportions in following down the aqueduct. There are many others. In nearly all of them the importance of geologic questions is prominent. Many of them, of course, are of the simplest sort, but, on the other hand, some are among the most obscure and evasive problems of the science.

The deepest channel was that of the Hudson Valley in the Highlands, where the tunnel had to be carried 1,000 feet below sea level to get under the buried gorge of the Hudson.

Foundations

In Canada we have been long accustomed to building two, three or four story buildings designed for light loads. The modern tendency is toward the construction of so-called sky-scrapers, consequently the question of securing foundations to withstand the greater load upon



Condition of Subsoil at Toronto

them is of great importance. In Toronto, for example, it was customary to place the foundations very little below the floor of the basement, but in the construction of the modern high buildings in that city it is often found necessary to carry the foundations down some 60 feet to the solid rock.

Geology of Montreal and Ottawa

The influence of geology on the erection of foundations in Montreal and Ottawa will now be briefly discussed.

Montreal: The mantle of drift covering the island of Montreal allows of separation into the following divisions:

Recent—Lake deposits, including lake clays; shell marls, peat, etc.; river gravels.

Pleistocene—Saxicava sand and gravel; leda clay; boulder clay.

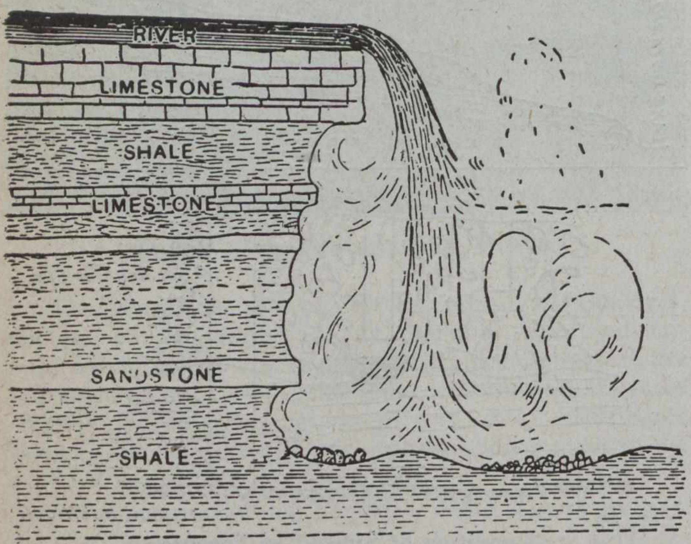
Boulder Clay—This material was formed from the continental ice sheet and has the characteristics before mentioned.

Leda Clay—This material was laid in an arm of the sea which extended up to Montreal. The beaches formed during the lowering of level of the water until the St. Lawrence became fresh, are marked by the saxicava sand deposits. There is no definite information as to the exact level at which the St. Lawrence became fresh in the Montreal district, but it would appear that this level is represented to-day by the 100-foot contour.

The island of Montreal is characterized by an almost flat surface, due to pleistocene deposits. The exposed surface of the boulder clay is produced by erosion and is fairly uniform, but the surface of the boulder clay on which the leda clay was deposited was very uneven. While the boulder clay usually affords good foundation, it sometimes passes into a variety which has the appearance of an unstratified leda clay. Again, by the suppression of the boulders and of the clayey part of the matrix, a variety is produced which may be called a quicksand.

Beside the normal variety of leda clay, there are others which pass into quicksand.

Ottawa: The present physical features are of varied origin and are the result of erosion and deposition by various agencies. During a long period of time, previous to pleistocene or glacial times, the region was above sea level, as is shown by the absence of marine tertiary deposits and by the development of stream valleys partly filled with pleistocene deposits. During this time the major features of the bed rock topography were formed by process of weathering and stream erosion. Erosion of the solid rock is shown by the appearance of the side wall of the small valley leading up from the Ottawa River at Sussex Street in the city of Ottawa, but the character of the sides of the valley in places also shows that the valley existed before the advance of the ice sheet and was only slightly modified by ice erosion. The partial filling of many of the rock valleys by glacial deposits shows also that the valleys were largely formed in pre-glacial times.



Conditions which Exist at Niagara Falls

Niagara Falls maintains its vertical crest due to the nature of the rock over which it flows. The water flows over the head capping of limestone and undermines the soft shales below, giving rise to the "Cave of the Winds." When the limestone is undermined far enough, it breaks off, forming a vertical crest as the process is repeated.

The deposits occupying the surface of a large part of the Ottawa area are superficial deposits, which differ from the bed rock or solid rock underlying them in that they are largely unconsolidated and vastly younger in age. They belong to the latest of the geological periods, the Quaternary, which is sub-divided into pleistocene and recent. During pleistocene or glacial times the ice advanced southward across the Ottawa and St. Lawrence valleys into New York State. When the ice melted it left the surface covered with glacial drift. Near the close of the pleistocene epoch this area was depressed relatively to sea-level so that, as the glacier retired, the sea water entered by way of the Gulf of St. Lawrence and formed what is known as the Champlain Sea. The waters of this sea covered the land in some places in the Ottawa Valley to a depth of several hundred feet. In these waters large quantities of sand, silt, and clay were deposited. More recent uplift of the land has driven the sea out of this region and has set the streams at work eroding the glacial and marine deposits.

Boulder Clay—Small surface distribution but covers an extensive area beneath the marine sediments.

Leda Clay—The maximum extent of the sea in the Ottawa area is shown by the distribution of the marine deposits. The highest shore line near Kingsmere has an altitude of 690 feet above sea level.

The clays have a maximum thickness in places to nearly 200 feet and are best developed in the stream valleys and lowest parts of the area. The central portion of the city of Ottawa is also underlain by marine clay occupying a basin in which the clay has a maximum thickness of nearly 100 feet. The basin-shaped area extends southward along Bank Street from Albert Street to the Glebe, westward to Bronson Avenue and northeastward to the Rideau River, including a large portion of Ottawa east. The Victoria Museum was built upon a bed of leda clay. Sandy Hill is underlain by marine clay, showing that the clays were originally more extensive but have been removed by stream erosion.

Should Preserve Records

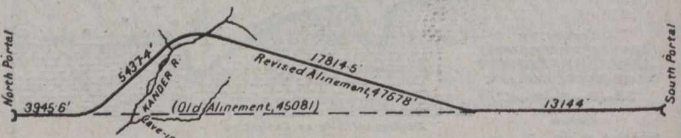
Owing to the importance to builders of knowing the kind and nature of the subsoil, it is desirable that all engineers preserve records of this nature in connection with works under their supervision. In connection with the numerous excavations attendant upon building construction, sewer and gas main laying, water system installation, etc., the municipal engineer frequently sees exposed strata of the upper geological horizon. He can easily take an accurate measurement of the elevation and position of, for example, a deposit of clay, a layer of limestone, or the line between subsoil and made ground and record same in his note book. If this information was laid down on a suitable map in distinctive colors it would prove to be of great value as a basis for future work.

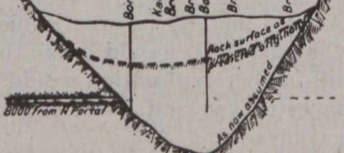
Geology and Power Development

On account of the great difference between high-water flow and minimum flow of rivers in Canada it is necessary, in many cases, to provide storage in order to get the best out of a development. In connection with these storage projects geology is of great importance.

Loetschberg Tunnel

Even since the opening of the Simplon tunnel connecting Switzerland with Italy, the necessity of opening a route of access to it from the north and northeast of Europe has been apparent. Several routes were proposed for getting through the Bernese Overland. The route

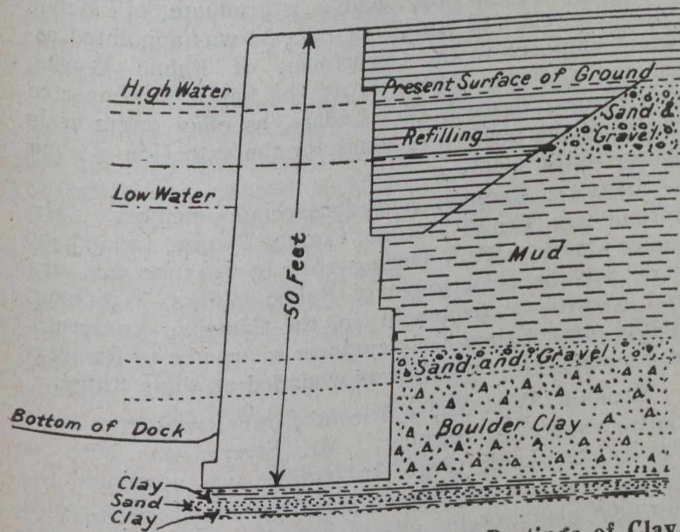




Loetschberg Tunnel

finally chosen was that of passing under the Loetschberg Mountains by means of a tunnel some nine miles in length. According to the geological predictions, where the north end of the main tunnel is 590 feet below the floor of the

Gasthern Valley, the ravine filled with detritus finished at a depth of 328 feet below the bed of the valley, and consequently the tunnel would be driven through solid rock. Unfortunately, this prediction did not prove true, for when the heading had reached a point 8,000 feet from the portal it struck a pre-glacial valley filled with sand, gravel and water. There was a sudden and violent inburst of these materials, which in a few moments filled up the



Dock Which Failed Due to Two Small Partings of Clay by a Thin Layer of Sand. The Sand Washed Out, Bringing the Clay Surfaces Together and Causing the Dock to Fail

tunnel for a length of over a mile, burying twenty-five workmen and all the drills and other installation beyond any possible hope of recovery. To avoid any further possible eruption of the materials the tunnel was walled up by a 33-foot wall at a point about 5,000 feet from the portal. Borings to a depth of 940 feet below the bed of the valley showed nothing but detritus. It was therefore found necessary to deviate the line and cross the valley further up-stream.

Topography

The making of, interpretation of, or use of topographic maps is almost a daily operation of the engineer. Topography is the expression of geologic structure, or in other words, the surface of the earth as it appears to-day is the resultant of the operations of eroding agencies and the resistance of the rocks, the time of their exposure, the initial position of the surface and the earth movements suffered. The topographer whose duty it is to represent these features on a topographical map can do so correctly only when he comprehends the geologic reasons for them. It is impossible for any topographer, whether equipped with a knowledge of geology or not, to measure the altitude and the size of every little knoll, and to fix on the hill-side every little irregularity. He cannot delineate with perfect exactness the degree of slope on one side as contrasted with the degree on the other side of a ravine. There may sometimes be considerable areas which the exigencies of the case will not permit him to fully examine. He may have general data indicating unfailingly the form of a valley, but not detailed positive facts regarding its smaller shapes, or he may know the general shape of a subordinate hill without having measured it on all sides. If the topographer in such cases be also a geologist he is the more likely, in the construction of his map, to fill in these lacking data with correctness and rapidity.

Since river valleys have a beginning and pass through various stages of development, it is important that the engineer recognize in what stage it is in. Narrow and steep-sided valleys cut in a land area of a humid region are said to be young and the territory traversed by them is in its topographic youth. Young streams are usually swift. They cut vertically rather than horizontally and their grade is often interrupted by rapids and falls. At this stage the stream has acquired but few tributaries. Valleys approaching base level develop flats. As these flats widen, and the tributaries increase in number and size, the valley slopes become gentle, and the topography is said to be mature.

Old streams usually have a low-grade and a sluggish current. They erode during floods and deposit their load and fill their channels at other times. Meandering is a characteristic feature of old streams, as illustrated in the Mississippi.

CANADIAN SOCIETY OF CIVIL ENGINEERS ELECTIONS AND TRANSFERS

At a meeting of the Council of the Canadian Society of Civil Engineers held in Montreal on Tuesday, November 27th, the following elections and transfers were announced:

Aggiman, Jacques, of Port Alfred, Quebec, transferred from student to junior member. Mr. Aggiman was born at Constantinople in 1892. He is a graduate of McGill University, class of 1917. In 1916 he was appointed engineer in charge of the extension of St. Lawrence Pulp & Lumber Co.'s mills at Chandler, Que., and in 1917 he had charge of laying the water supply for the town of Port Alfred, and designing and erecting the filter plant. At the present time he is assistant superintendent of the Ha Ha Bay Sulphite Co., Limited, of Port Alfred, Que.

Bradley, James Harrison, of Kingston, Ont., elected associate member. During 1915-16 he was ordnance engineer for the Dominion Bridge Co., in charge of all technical work relating to munition contracts, installation of machines, etc. He is at the present time assistant inspector of shells for the Imperial Ministry of Munitions, Kingston sub-district.

Bremner, Douglas, of Westmount, Que., transferred from student to associate member. Mr. Bremner was born at Montreal in 1892. He is a graduate of McGill University, class of 1915. In 1915 he became connected with A. F. Byers & Co., in responsible charge of all construction work undertaken by them and in 1916 was elected a director of the company.

Brown, Ernest, of Montreal, Que., transferred from associate member to member. Mr. Brown was born at St. Helens, Eng., in 1878, and is a graduate of Victoria University, Eng., obtaining his degree of B.Sc. in 1897. He is at present professor of Applied Mechanics and Hydraulics at McGill University, Montreal.

Desbaillets, Charles Jules, of Montreal, Que., elected associate member. Mr. Desbaillets was born at Geneva, Switzerland, in 1884. From 1911 to date he has been district engineer to the Canadian Westinghouse Co., Limited, in charge of all engineering work in the province of Quebec and Maritime Provinces. On September 1st, 1917, he commenced duty as manager and chief engineer of public utilities of the city of Sherbrooke, Que.

Ferguson, Robert, of London, Ont., elected associate member. Mr. Ferguson was born in Scotland September 1st, 188[illegible]. In 1917 he was appointed chief draftsman and supervising engineer with the Public Utilities Commission, London, Ont. Mr. Ferguson is at present with Messrs. Archibald & Holmes, contractors, Toronto, in charge of engineering.

Forbes, Frederic Warren, of Trenton, Pictou County, N.S., elected associate member. Mr. Forbes was born at Little Harbour, N.S., 1880. Graduate of McGill University, Applied Science. From 1905 to 1908 he was on surveys and locations and in charge of construction of transmission lines in province of Quebec for Shawinigan Water and Power Co.; 1908 to 1913 and from February, 1915, to May, 1916, provincial land surveyor on surveys of Crown lands and farms, designing and in charge of construction of Trenton sewerage and water systems; 1913 to 1915 and 1916 to date, town engineer, Trenton, Nova Scotia.

Keith, John Burton Clark, of Moose Jaw., Sask., elected associate member. Mr. Keith was born at Smith's Falls, Ont., 1886. He is an honor graduate of Toronto University in the 1911 class. From 1912 to date he has been engineer in charge of construction for the city of Moose Jaw, Sask.

Lamont, Archie Wilfrid, of Winnipeg, Man., elected junior. Mr. Lamont was born at Mount Brydges, Ont., 1889, and is a graduate of Toronto University, 1910 class. He is at present sales engineer with the Canadian Westinghouse Co., Winnipeg.

Lawrence, Alfred John, of Outremont, Que., transferred from junior to associate member. Mr. Lawrence was born at Montreal in 1890 and is a graduate of McGill University, class of 1914. He is at present assistant district inspector of shells for Eastern Ontario.

Mack, John, of Victoria, B.C., elected associate member. Mr. Mack was chief draftsman for the G.T.P. Railway from 1909 to 1911, in charge of construction work, and from 1911 to date, in charge of the office of Green Bros., Burden & Co., surveyors, Victoria, B.C. Mr. Mack was born at Coatbridge, Scotland, in 1883.

McKinnon, Roderick Will, of Winnipeg, Man., elected associate member. Mr. McKinnon was born at Battleford, Sask., in 1886. During 1913-14 he was in charge of construction of sewers, water and water filtration plant for the Manitoba government. His present position is engineer in charge of roads, bridges, ferries and drainage, from township 17 to north township 33, from Pr. Meridian West to Lake Manitoba, for the provincial government.

Phillips, Edward Horace, of Regina, Sask., elected associate member. Mr. Phillips is a graduate of the School of Practical Science, Toronto University; 1900, D.L.S.; 1902, S.L.S. In 1907-12 he was district surveyor and engineer for the Department of Public Works. He is at present acting chief surveyor for the land titles office, Regina, Sask. Mr. Phillips was born at Whitby, Ont., in 1878.

Potter, Alexander, of New York City, transferred from associate member to member, is a graduate of civil engineering, Lehigh University. Mr. Potter is at present retained as consulting engineer on the design of a system of sewers, etc., for the cities of Wilkes-Barre, Scranton, Coatesville, South Bethlehem and Warren; also retained by Philadelphia and Reading Coal and Iron Co., government of Cuba. Mr. Potter was born at Gibraltar in 1886.

Sinclair, Malcolm, of Moose Jaw, Sask., appointed associate member. Mr. Sinclair was born at Edinburgh, Scotland, 1880. He is a graduate of Edinburgh University and Watt College, and is an associate member of the Institute of Civil Engineers. Mr. Sinclair, from 1915 to date has been inspecting shells for the Imperial Ministry of Munitions at Saskatchewan Bridge and Iron Co., Moose Jaw, Sask.

Small, Frank S., of Cedars, Quebec, transferred from student to associate member. Mr. Small was born at Johnston, N.B., in 1877, and is a graduate of McGill University, class of 1914. In 1914 he was appointed assistant engineer to the Department of Public Works, Canada, and since March, 1917, he has been connected with Fraser, Brace & Co., Cedars, as office engineer in charge of the revision of plans for the extension of their hydro-electric plant.

Sproule, George, elected associate member. Mr. Sproule was born at Fintona, County Tyrone, Ireland, on January 12th, 1884. During 1913 to 1915 he was surveyor for the Department of Public Works, Winnipeg, and in 1916 was lieutenant in the Canadian Engineers. At the present time he is engineer instructor to Pioneers in France. Mr. Sproule was wounded at Vimy Ridge.

Storrie, William, of Toronto, transferred from associate member to member. Mr. Storrie was born at Paisley, Scotland, 1883. In 1909 he was appointed assistant resident engineer on construction of slow sand filtration plant for the city of Toronto, and during 1912 and 1913 was waterworks engineer for the city of Ottawa. From 1913 to date he has been chief engineer of the John verMehr Engineering Co., Limited, on water purification plants for Toronto and other places.

Walkden, William, of Norwood, Man., transferred from junior to associate member. Mr. Walkden has since 1912 been in charge of the C.N.R. office, Winnipeg, under the late Mr. W. L. Mackenzie, and is at the present time in responsible charge. Mr. Walkden was born at Great Warford, Cheshire, Eng., in 1885.

Walker, James Alexander, of Ottawa, Ont., transferred from junior to associate member. Mr. Walker was born at Guelph, Ont., in 1887, and is a graduate of the University of Toronto, class of 1908, obtaining his degree of B.A.Sc. in 1910. In 1913-14 he was in charge of surveys along G.T.P. Railway for the British Columbia government. He enlisted in 1916 and is now on active service as lieutenant of the Royal Engineers and optical stores, in charge of the test plant.

Wilkes, Egbert Dean, of Oakville, Ont., elected associate member. Mr. Wilkes is a graduate of Toronto University, class of 1908. He is at present in private practice (Wilkes & Wallace), contractors in charge of works for Toronto, Leaside and Hamilton.

Wilson, Reginald Palliser, of The Pas, Manitoba, elected associate member. Mr. Wilson was born at Liverpool, Eng., 1872. He is at present divisional engineer to the Hudson Bay Railway Co., The Pas, Man.

The Fifth Canadian and International Good Roads Congress will be held in Hamilton some time in February, 1918.

In order to expedite the work on the present enormously augmented volume of ship contracts of its subsidiary companies, the Bethlehem Steel Corporation has arranged to consolidate under one management all its various shipyards. For this purpose a new corporation is being formed under the laws of the state of Delaware to be known as Bethlehem Shipbuilding Corporation, Ltd., with an authorized capital of $12,500,000

THE PRESSING OF SEWAGE SLUDGE*

By Kenneth Allen,
Engineer of Sewage Disposal, Board of Estimate and Apportionment, New York City.

THE first sludge pressing plants were established in England between 1880 and 1884 at Aylesbury, Merton and Wimbledon, and in Germany about 1887, where, however, they have only been used in connection with the lignite or "Degener" process at Spandau, Potsdam and Tegel.

Sewage irrigation experienced but a limited development in the United States, chiefly in Massachusetts and the far west, but between 1887 and 1900 chemical precipitation was adopted at Coney Island (1887), Round Lake, White Plains, the 26th Ward, Brooklyn, Sheepshead Bay, New Rochelle and Far Rockaway, N.Y.; Long Branch and East Orange, N.J.; the Mystic Valley and Worcester (1890), Mass.; Canton and Alliance, O., and Providence, R.I. (1900). Of these, the sludge has been pressed at Long Branch, East Orange, Worcester, Alliance and Providence, but has been abandoned at all these towns but Worcester and Providence.

Sewage Sludge

The density, composition, appearance and odor of sludge depend on the sewage from which it is derived, whether from the separate or combined system, domestic, or with a large proportion of trade wastes, fresh or stale, etc., and also on its manipulation, whether by mere settling, chemical precipitation, digestion in septic or Imhoff tanks, or aeration in the activated sludge process.

The volume produced daily per 1,000 population is, according to Dr. Imhoff, 1.57 cu. yds. in the sedimentation tank, 0.79 cu. yd. after drawing off the supernatant liquor, 0.262 cu. yd. after digestion from combined sewers and 0.131 cu. yd. from separate sewers.

Sludge Data

Derived from	Moisture %.	Cu. yd. per m.g.	Lb. per cu. yd.	Dry matter tons per m.g.
Imhoff tanks	80-85	2-4	1,740-1,840	0.161
Plain sedimentation	88-96	4-10	1,700-1,780	0.580
Chemical precipitation	86-94	20-30	1,710-1,790	1.435
Activated sludge process	98-99	20-80	1,690-1,700	0.67

With strong sewages or those carrying much grit, especially where treated by plain sedimentation or in Imhoff tanks, these figures may be exceeded. The weight of sludge from chemical precipitation is, of course, increased by the chemicals added.

The weight of sludge after dewatering may be readily determined by the well-known formula:—

$$X = \frac{100\ S}{100 - P}$$

in which

X = lb. of sludge after dewatering.
S = lb. of solids in wet sludge.
P = per cent. moisture in product.

*Abstract by special permission from Transactions of the American Society of Municipal Improvements.

For example, a cubic yard of sludge, 90 per cent. moisture, weighing 1,740 lbs., would weigh, after dewatering to 60 per cent. moisture,

$$\frac{100 \times (10\% \text{ of } 1{,}740)}{100 - 60} = 435 \text{ lb.}$$

Different sludges vary in their adaptability to pressing. Plain, settled sludge or a sludge greasy in its nature is difficult to press. If fine in composition, it flows too freely through and then clogs the filter cloths, leaving the cake in a pasty condition that will not cohere.

Septic sludge varies greatly in consistency, depending on the thoroughness of digestion. Ordinary septic tank sludge is fine in composition, and offers much the same difficulty as plain, settled sludge in passing through the filter. Elsner, however, claims that septic sludge, as well as lignite sludge, is more amenable to pressing without the addition of chemicals than plain, settled sludge.

Conveying Sludge by Channels and Pipes

From the concentration tank the sludge usually flows to a pump well, whence it is pumped to the presses. If it flows by gravity, the required slope of the chute or pipe depends upon the condition of the sludge. According to Elsner, "For any easy, automatic flow (in a chute) with settled sludge containing at least 90 per cent. of water, a slope of 1 : 10 to 1 : 15 is necessary, depending on whether there is much sand and coarse material, or whether there is a fine fluid sludge. Very liquid sludge with about 95 per cent. of water and but little sand may under some circumstances be given a slope of 1 : 100, but 1 : 80 is better. For sludge obtained with interrupted operation a fall of 1 : 40 to 1 : 50 is necessary. The plants of the Emscher Association have slopes of 1 : 20 to 1 : 40, while the pipe conduits at Elberfeld have 1 : 30. At Fitchburg a slope is provided of 1 : 90, while the new concrete channels for Imhoff sludge at Columbus are given a slope of 1 :56.

Pumping Sludge to the Presses.

Screened sludge may be pumped by almost any type of pump if designed for this service, including pulsometers, ejectors, chain pumps, bucket elevators, the air lift, membrane pumps, pneumatic receivers, centrifugal pumps, and plunger pumps.

Pulsometers, chain pumps and ordinary ejectors are inefficient and suitable only for occasional or emergency use, or where the volume is so small that economy of power may be disregarded.

Sludge Pressing

There are several forms of filter press. That most commonly used consists of a series of parallel plates from 30 to 54 in. square and with depressed surfaces, so that when the rims are in contact they enclose a series of cells from ¾ in. to 2 in. thick. The plates are usually of cast-iron, from 2 in. to 3 in. thick at the rim, and where in contact are machined so as to form a true and tight joint. The depressed surfaces are either grooved vertically, in concentric circles and radially, or else in two directions at right angles to each other, forming numerous little pyramids, in order to facilitate drainage. Each plate has a 6-in. hole in the centre through which the sludge flows by gravity from a tank or is pumped to the series of cells. The pipe to the press is usually 8 in. in size.

Between each pair of plates there are placed two pieces of cloth with holes 4 in. to 6 in. in diameter in the centre opposite the holes in the plates. The two cloths on the opposite sides of each plate are then sewed or clamped together at the hole to prevent the sludge from entering and escaping between.

Sludge Cake

In practice precipitated sludge is reduced to cake having about 20 per cent. its original weight and containing from 50 to 70 per cent. moisture. The moisture is not uniform in the cake, being greatest near the point where admitted to the press. The weight of this cake is about 8 2-3 tons per million gallons of sewage (Rideal). The cakes run from an inch or less in thickness to 1½ or 2 in. if greasy and well dosed with lime. On breaking it up the weight per cu. yd. is reduced to about 1,350 lb., when the voids are found to be about 40 per cent. By air-drying under cover this weight may be further reduced by about 50 per cent.

Analyses of sludge cake as produced at Chorley and Dorking, England, are given in the fifth report of the Royal Commission on Sewage Disposal. The sewage in each case is domestic. At Chorley, with combined sewage, 9 grains per Imp. gal. of alumino ferric is used for precipitation, and at Dorking, which is partially sewered on the separate system, 5 grains per Imp. gal. of lime. The cake as delivered contains about 50 per cent. moisture, but the samples analyzed were dried at 110 degrees C.

	Chorley.	Dorking.
Grit	25.30	6.84
Oxides of iron and aluminum	9.37	3.46
Lime	10.32	23.16
Phosphoric acid	0.98	0.66
Nitrogen (total)	1.28	0.89

At Leeds in the year 1913-14 the average composition of the cake was as follows:—

	Per cent.
Water	60.1
Volatile matter	16.7
Nitrogen, 5.9 per cent.	
Total grease, 6.3 per cent.	
Mineral residue	23.2
Calcium phos., .94 per cent.	——
	100.0

The solids from the sewage normally comprised 35.3 per cent. of the cake.

The average of four analyses of commercially dried (10 per cent. moisture) activated sludge, with especial reference to their fertilizing value, are given by William R. Copeland as follows:—

	Per cent.
Nitrogen as ammonia	4.68
Available phosphoric acid	0.57

Disposal of Cake

The cake may sometimes be disposed of for a nominal sum, say, 10 to 25 cents per ton, to farmers, but if there is no demand for it, it may be used for filling at about an equal cost. When deposited in depths up to 12 feet in water-soaked land near Leeds it was observed to shrink about 33 per cent. in two years and to generate more or less heat.

While there is more or less odor in the presshouse, this does not carry far, and if kept under cover it is quite inoffensive. Fresh cake kept moist by rain, especially if the weather is warm, will give off a certain amount of odor, but, if first air-dried to 20 or 30 per cent. moisture, objectionable odors are usually prevented.

An advantage in lignite sludge, besides being inodorous, is that it can be utilized by burning under the boiler, and experiments by W. L. Stevenson at Philadelphia show that by the addition of a small amount of combustible material to ordinary air-dried sludge from plain sedimentation there will be obtained a material having a moderate value as fuel.

The foregoing remarks have been confined to the plate type of press, often spoken of as the "Johnson" filter press, this having been almost universally used for the pressing of sewage sludge heretofore. There are, however, several other more recent types which deserve mention.

THE EFFECT OF INTRUSIVE WATER ON THE STABILITY OF A MASONRY DAM*

By A. A. Stoddard, D.Sc., Assoc.M.Inst.C.E.

THE allowance to be made in the design of a masonry dam for the effect of water penetrating the foundation has been the subject of a good deal of discussion at various times. There has never seemed to be a very clear conception of the matter, but one of the two following opinions is commonly held—that allowance for the upthrust of water penetrating the base of a dam should be made on the assumption that it varies from an amount due to the full hydrostatic head at the up-stream toe, to zero at the down-stream toe; or, the up-thrust should be considered as being equal to that due to the full hydrostatic head over the entire base of the dam. In the design of the Vyrnwy Dam, for instance, allowance for this factor was made on the first of these assumptions. In Fig. 1 the hachured triangle A B C represents the distribution of the water pressure under the base on the first assumption, and in Fig. 2, which illustrates the other view, the up-thrust distribution is represented by the hachured rectangular A C D B, A C being the pressure due to the full head on the foundation in each case.

2. The first hypothesis appears to the writer to be utterly untenable, for it must necessarily imply a steady flow, or creep, of water under the base, escaping at the down-stream toe; no reduction of pressure could possibly occur otherwise. Furthermore. this creep must take place as a continuous sheet of water over the entire width of the foundation, localized flow, through foundation fissures only, could not affect the head of pressure anywhere else but in its immediate vicinity. If this occurred the dam would not be in contact with the foundation at all, for the foundation reaction cannot have two values at any one point at the same time, one due to the resultant of the weight of the structure and the pressure of the impounded water, and the other due simply to water pressure under the base. The total reaction from the foundation must be exactly equal to the total weight of the dam (and water resting on the up-stream face, if this is curved or battered), and it is manifestly impossible for this necessary relation to hold under the first assumption as to the distribution of water pressure under the base.

3. The second hypothesis might theoretically be realized in certain special circumstances, which will be

*"Engineering," London, Eng.

indicated shortly. In general it can only be possible for water to penetrate the base joint up to a certain point, there can be no flow if the structure is stable (except along fissures, which, as just pointed out, does not concern the present argument), and the foundation pressure, from the up-stream toe to this point, must necessarily be uniformly equal to the full hydrostatic head at the up-stream toe. In Fig. 3, D is the limit of penetration, and up to this point the dam is not in intimate contact with the foundation, but is water-borne. Beyond the point D the structure must remain in contact with the foundation, and the foundation pressure must increase towards the down-stream toe in order that the total pressure may be equal to the weight of the structure. In the case of an actual dam it is quite impossible to determine the distance to which water might penetrate the base and so estimate its effect on the stability of the structure, for this must depend on the manner in which the base of the dam is bonded into the foundation, and on the cohesive strength of the foundation joints, amongst other factors. Only under the purely hypothetical conditions, never remotely realized in practice except when complete failure is imminent, of total absence of bond with the foundation and complete lack of adhesion along the base joint, is it possible to investigate the effect of an intrusion of water under the base. In these circumstances it would be possible for water to penetrate the base joint up to the point at which the vertical component pressure intensity due to all the applied forces became equal to the hydrostatic pressure intensity at the up-stream toe. Up to this point the dam would be water-borne and the foundation pressure would be uniform, as stated above; beyond this point it may be assumed that the pressure increases uniformly to a maximum at the down-stream toe. The distribution of the vertical component of the foundation pressures would be as shown by the hachured figure A B E D C in Fig. 3.

4. The following theory of the effect of intrusive water seems rational:—

In Fig. 3 let—

- b = width of base of dam.
- x = distance of penetration of water under base.
- a = horizontal distance of centre of gravity of dam, and the water resting on the up-stream face, if this is curved or battered, from the up-stream toe A.
- W = total weight of structure and water resting on the up-stream face.
- h = hydrostatic head at up-stream toe.
- p_w = intensity of pressure due to the head $h = wh$.
- p_1 = intensity of normal component of pressure at the down-stream toe.
- w = weight of unit volume of water.
- ϵ = density of the dam material.

Then the total vertical pressure on the base A B is

$$p_w b + \frac{(p_1 - p_w)}{2}(b - x) = \frac{1}{2}[p_w (b + x) + p_1 (b - x)].$$

This must necessarily equal the total foundation load W.

$$\therefore \; p_w (b + x) + p_1 (b - x) = 2W$$

whence

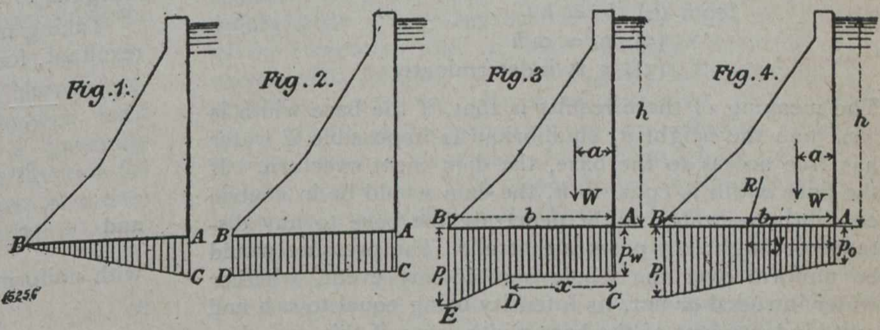
$$p_1 = \frac{2W - p_w (b + x)}{b - x} \quad - \quad - \quad - \quad (1)$$

The moment of the total base reaction about the toe A is

$$p_w \frac{b^2}{2} + \frac{p_1 - p_w}{2}(b - x)\left(b - \frac{b - x}{3}\right) =$$

$$\frac{p_w}{6}(b^2 + bx + x^2) + \frac{p_1}{6}(b - x)(2b + x).$$

For equilibrium, this must be equal to the sum of the moments of the total horizontal thrust of the impounded water and the weight of the structure W, which latter will



include the water resting on the up-stream face, if this is battered, about the same point, *i.e.*:—

$$\frac{wh^3}{6} + Wa = \frac{p_w}{6}(b^2 + bx + x^2) + \frac{p_1}{6}(b - x)(2b + x).$$

Substituting, in this expression, the value of p_1 given by equation (1) and for p_w putting its value wh, the equation reduces to

$$x = \frac{wh(b^2 + h^2) - 2W(2b - 3a)}{2(W - wbh)} \quad - \quad - \quad (2)$$

In any given case the possible distance of water penetration can be determined from this last expression, and, on substitution in equation (1), the vertical-pressure component at the down-stream toe, *i.e.*, p_1, is arrived at. If the determination of the necessary width of base required to limit the maximum pressure component p_1 to a previously chosen intensity is desired, W and a must be known, or approximately known, in terms of b and h, and then the base width required can be evaluated from equations (1) and (2).

5. To simplify matters, consider a dam of approximately triangular section with a vertical back, which most modern dams practically are, or are tending to become, then

$$W = \frac{\epsilon wbh}{2}; \text{ and } a = \frac{b}{3}$$

Equation (2) reduces to

$$\frac{x}{b} = \frac{\left(\frac{h}{b}\right)^2 - \epsilon + 1}{\epsilon - 2} \quad - \quad - \quad - \quad - \quad (3)$$

Equation (1) reduces to

$$\frac{p_1}{wh} = \frac{\epsilon - 1 - \frac{x}{h}}{1 - \frac{x}{b}} \quad - \quad - \quad - \quad - \quad (4)$$

Substituting the value of $\frac{x}{b}$ given by equation (3)

$$\frac{p_1}{wh} = \frac{(\epsilon - 1)^2 - \left(\frac{h}{b}\right)^2}{(2\epsilon - 3) - \left(\frac{h}{b}\right)^2} \quad - \quad - \quad - \quad - \quad (5)$$

or,

$$b = h\sqrt{\frac{\frac{p_1}{wh} - 1}{(2\epsilon - 3)\frac{p_1}{wh} - (\epsilon - 1)^2}} \quad - \quad - \quad (6)$$

6. These formulæ enable us to realize what the effect of intrusive water would be, if its access to the foundations were unimpeded. First of all, the case of $\epsilon = 2.0$, the dam being of triangular section, or approximately so, is especially interesting.

In this case

from (6), $b = h$
" (5), $p_1 = wh$
" (3), x is indeterminate.

The meaning of these results is that, if the base width is less than the height h, equilibrium is impossible if water has free access to the base, the dam must overturn. If the base width is equal to h, the dam would be in neutral equilibrium—water might penetrate the base to any distance or might not penetrate at all. The pressure would be uniform over the whole base in any event, whether water intruded or not, its intensity being equal to wh and quite independent of the base width, even if this were less than h and the dam overturning. All this is really obvious at first sight in this particular case, but its deduction from the above theory is an interesting confirmation of its rationality.

In general, when ϵ is greater than 2.0 (it is never less in practice), and the ratio $\frac{x}{b} = 1.0$, *i.e.*, intrusive water extending over the entire base, it is obvious from equation (4) that the pressure at the down-stream toe p_1 must suddenly change from wh to an infinitely great intensity. This state of affairs would theoretically occur when the base width $b = \frac{h}{\sqrt{2\epsilon - 3}}$, as given by equation (3), putting $x = b$.

For any smaller value of b stability could not be obtained, quite apart from the possibility of the masonry being crushed at the down-stream toe under the high intensity of pressure.

7. It seems quite clear, then, that it is irrational to assume that a dam can be subjected to up-thrust, from intrusive water, of uniform intensity over the entire base, for there is only one ratio of base width to height, with a given density of dam material, which could render this state of affairs theoretically possible, and with this base width the structure would not be stable.

For example, take $h = 250$ ft. and $b = 204$ ft., the dam section being approximately triangular.

First, take $\epsilon = 2.5$, a very usual value.

Then, from equation (3), $x = 0$.

With this density of the dam material, water could not penetrate the base joint at all.

Next take $\epsilon = 2.25$.

Then, from equation (3), $x = 1.0$.

In this case, if water had free access to the foundations, the dam would fail by crushing of the masonry at the down-stream toe and overturning.

This example shows the enormous influence which a slight variation of the density of the dam material would exercise on its stability, if water could intrude to this theoretically possible extent.

8. It is interesting to compare the base width necessitated by compliance with equation (6) with the width b_1, say, required to induce the same intensity of the vertical pressure component p_1 at the down-stream toe, in the absence of intrusive water.

For this, in Fig. 4, let

b_1 = width of base of dam,
y = horizontal distance of point of application of resultant pressure on the foundation from the up-stream toe,
p_m = mean intensity of normal pressure on the foundation,

all other symbols having the same meaning as in the foregoing.

Taking moments about the point of application of the resultant, for equilibrium

$$\frac{wh^3}{6} = W(y - a); \text{ or, } y = \frac{wh^3}{6W} + a$$

$$p_m = \frac{W}{b_1}$$

and $$p_1 = 2p_m\left(3\frac{y}{b} - 1\right),$$

with uniformly varying stress.

$$\therefore p_1 = \frac{2W}{b_1}\left(\frac{wh^3}{2Wb_1} + 3\frac{a}{b_1} - 1\right)$$

$$= \frac{1}{b_1^2}\left[wh^3 - 2W(b - 3a)\right]$$

In this last expression the term containing W is always small in a rationally designed dam, and for present purposes, since we are considering a dam of approximately triangular section, we may take $b = 3a$.

Then, in the absence of intrusive water,

$$p_1 = \frac{wh^3}{b_1^2} \text{ or, } \frac{p_1}{wh} = \left(\frac{h}{b_1}\right)^2$$

Substituting this value of p_1 in equation (6) gives

$$b = h\sqrt{\frac{\left(\frac{h}{b_1}\right)^2 - 1}{(2\epsilon - 3)\left(\frac{h}{b_1}\right)^2 - (\epsilon - 1)^2}} \quad - \quad - \quad (7)$$

$$b = b_1\sqrt{\frac{\left(\frac{h}{b_1}\right)^2 - 1}{(2\epsilon - 3) - \left(\frac{b_1}{h}\right)^2(\epsilon - 1)^2}} \quad - \quad - \quad (8)$$

Taking $b_1 = 204$ ft. and $h = 250$ ft., as before, from equation (8)

$b = 212$ ft. with $\epsilon = 2.25$,

and from equation (3)

$x = 0.56b; = 119$ ft.,

$$p_1 = \frac{62.5}{2240} \times \frac{250^3}{204^2} = 10.5 \text{ tons per sq. ft.}$$

9. The results just found serve to show how very small is the margin between safety and complete failure of the structure if it were possible for water to creep under the base to the extent indicated by the above theory, which could only occur under the assumed conditions of total absence of foundation bond and cohesion. Under these conditions it has been shown that, in the particular example chosen, the down-stream toe would crush under the high local intensity of stress at that point, water could intrude over the entire base, and the dam would overturn if its base width were only 204 ft., while an increase of width of only 8 ft., or 4 per cent., suffices to limit the maximum intensity of the normal pressure component to a safe amount.

10. In actual practice, with a dam built on sound rock, the foundation bond and the cohesive strength of the base joint prevent the intrusion of water to the extent

which would certainly be possible in the complete absence of these factors. The danger of its occurring to a certain degree is nevertheless very real, in view of the discovery of the existence of high tensile stresses at the up-stream toe, arising out of recent researches (*vide* Proc. I.C.E., vol. clxxii.), and it is of the highest importance that either the base be made wide enough to entirely eliminate this source of danger, or means be provided for draining any seepage taking place to the tail water. The latter alternative is the one most commonly adopted in modern practice, the precautions taken in the recently completed Kensico Dam, in this respect, furnishing a good example.

11. The base width required to prevent all seepage, other than the almost unavoidable creep through local foundation fissures, which is harmless on a generally sound rock foundation, is at once found from equation (2) in the general case, or equation (3) in the case of a dam of approximately triangular section, by putting $x = 0$. Thus, from (3), when $x = 0$,

$$b = \frac{h}{\sqrt{(\epsilon - 1)}} \quad - \; - \; - \; - \; - \quad (9)$$

It is easily seen that this is the width required to make the normal pressure at the up-stream toe equal to the water pressure. For, if p_0 = normal pressure intensity at the up-stream toe, then,

$$p_0 + p_1 = 2p_m = \frac{2\,W}{b} = e\,w\,h$$

for triangular section.

$$\therefore \; p_0 = e\,w\,h - \frac{w\,h^2}{b^2}$$

On substituting for b its value given by equation (9), we find $p_0 = w\,h$.

Applying this to the example taken above, the required width is found to be 223 ft., which is only about 9¼ per cent. in excess of the width at which the dam would fail if all foundation bond and cohesion were lacking.

12. The foundation joint is not the only part of the structure which might be subjected to the upthrust of intrusive water; of course this might happen anywhere if conditions permitted it, such as the existence of a more or less horizontal fissure in the up-stream face caused by temperature effects or faults of design and construction. The failure of the Bouzey Dam in 1895, for instance, was undoubtedly due to faulty design and the use of poor materials in construction, in the first place. The density of the material of this dam was little more than 2.0, and at the level of the plane of failure the up-stream face was under tension amounting to 1¼ tons per square foot before the opening of the fissure which was the immediate cause of failure (*vide* Proc. I.C.E., vol. cxxvi, page 93), and once the fissure started it is easy to appreciate how great the effect of the water penetrating it would be. In order to entirely eliminate this source of danger M. Lévy has suggested that the dam section should be everywhere wide enough to cause the vertical pressure component at the up-stream face to be at least equal to the hydrostatic pressure at the same level (Comptes Rendus de l'Academie des Sciences, 1895 and 1898; Annales des Ponts et Chaussées, 1897). In the case of a dam of approximately triangular section, if this principle were adopted, the width of section would require to have the value given by equation (9) as a minimum; that it, until the height of the dam becomes sufficiently great as to necessitate a still greater width in order to restrict the maximum principal stresses induced at the down-stream toe to safe intensities. The usual rule governing the width adopted for the upper part of a high dam where, in modern practice, the up-stream face is quite vertical is the well-known one $b = \frac{h}{\sqrt{e}}$, with which width the resultant pressure on a horizontal plane falls exactly on the outer middle third. The width of section required by compliance with formula (9) is therefore, roughly, 13 per cent. in execss of that adopted in usual practice, with the density of the dam material lying between the values 2.25 and 2.5. This would mean a very appreciable enhancement of the cost of the structure, and in high and large dams the most economical method of thoroughly safeguarding the structure from the effects of intrusive water would generally lie in the provision of an efficient drainage system near the up-stream face, throughout its whole height, connecting with cross-drains leading to the tail water, as exemplified in the Kensico Dam.

13. A question apart from the possible intrusion of water under the base of a dam and into cracks elsewhere in the up-stream face is that of the presence of infiltrated water in the interstices of the dam material. It is a matter of common observation that many dams show signs of sweating on the down-stream face. This is most marked while the dam is still green, and, as a rule, as the structure ages the action ceases or becomes scarcely perceptible. There are cases, however, of a persistence of this sweating in old dams. The uplifting effect of this interstitial water cannot be estimated with any degree of accuracy, but it is obvious that it must be practically negligible. The sweating shows that there is a very slow and minute flow of water through the dam from face to face; the pressure at any level must therefore decrease in a practically uniform manner from that due to the hydrostatic head at the up-stream face to zero at the down-stream face. Also, since all the material lying above the level considered is saturated with water, its density is increased, and as the dam section is practically triangular, the centre of gravity of the interstitial water practically lies directly over the resultant up-thrust. The difference between the amount of the uplift and the weight of infiltrated water contained above any plane considered will depend on the shape of the voids in cross-section, but if the balance lies in favor of the uplift, it must be negligibly small.

14. In conclusion, it is hoped that the foregoing attempt to obtain a clear picture of the possible action of intrusive water and of its bearing on the design of a masonry dam will prove to be useful.

TORONTO SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

About sixty members were present at the last meeting of the Toronto Section of the American Institute of Electrical engineers. Quite a new light was thrown on the subject of testing current transformers by Mr. Harry Baker in describing the test ring method developed by himself.

A large number of new applications for membership in the American Institute of Electrical Engineers is now being received which would seem to indicate that the members realize the necessity of maintaining technical efficiency at the highest point.

SEWAGE AND ITS PRECIPITATION*

By Reginald Brown, M.Inst.C.E., M.I.Mech.E.

IN March, 1916, the author had the honor of reading a paper before the society on the above subject in which he dealt with experiments carried out on the precipitation of sewage by the use of three kinds of precipitants or combination of precipitants, *viz.*, (1) Ferric sulphate (solid); (2) ferric sulphate (solid) and lime; and (3) sulphate of alumina and lime. Since that date an opportunity was offered him of carrying out further tests with liquid ferric sulphate (the analysis of which was given in the author's first paper), and at the same time it was thought advisable to try some experiments with lime alone, this having been suggested by one of the speakers in the discussion on the previous paper. The object of this second paper is, therefore, to place on record the results of these experiments for the benefit of the members of the society.

The author, when commencing this second set of experiments, thought it best to include a further test with sulphate of alumina and lime, so that, if possible, some grounds of comparison with the first series might be obtained; hence the tests in this paper include: (1) Lime only; (2) ferric sulphate (liquid) and lime; and (3) sulphate of alumina and lime. In carrying out a series of working tests on sewage purification one is always confronted with the fact that the quality of the sewage is constantly changing. In the laboratory such difficulties are not met with because the experiments, being on a comparatively small scale, can all be carried out with the same quality of sewage, and this could only be copied by carrying out the working tests simultaneously, which, obviously, in practice could not be attained without a considerable amount of trouble and expense, the latter not being warranted, because the results would frequently only be applicable to one class of sewage. The importance of the varying quality of sewage and the necessity of an engineer and a sewage works manager having an intimate knowledge of the quality of the sewage he has to deal with every hour in the day is emphasized by the analyses in this paper, which importance is greater or less according to whether trade wastes are or are not admitted into the sewers.

In passing, the author would like to state that on the question of admission of trade wastes to sewers the law is in a very unsatisfactory state. While not wishing to interfere with industrial development in any way, he is of opinion that local authorities should be possessed of wider powers, while they should not be compelled to accept the discharge of trade effluents into their sewers from factories over the domicile of which they have no control; they ought to be in a position to insist upon adequate preliminary treatment if they decide to receive such trade wastes. The simplest plan would seem to be to give local authorities the power to sanction or refuse the erection of factories in their district, and if sanction was given, then the local authorities should be compelled to take the trade waste after effective preliminary treatment —but this is by the way.

In addition to the varying quality of the sewage to be considered in tests there is also the question of cost of treatment, and any comparison with previous experiments must take into account any increase or decrease in cost of precipitants. When considering the question of these further experiments the author was confronted with the facts that not only was the sewage much stronger than in the first series, but it was also of a different nature, and, further, the price of precipitants had risen. The strength and nature of the sewage dealt with in the present experiments are given in the following pages, and their importance can easily be gathered from a comparison with the sewage dealt with in the tests described in the author's previous paper.

How, then, should a comparison be made between any series of tests carried out, maybe, at long intervals apart? Should this comparison be based on the quality of the sewage or the cost of treating same? The author is not satisfied that either of these can be counted upon with any degree of accuracy, and he suggests that the best method of comparison can only be arrived at by taking the same quantities of precipitants, irrespective of the quality of the sewage or the price of the precipitants, because by doing this one has a fixed basis to work upon. The costs per ton for the various precipitants used in the first series were: Sulphate of alumina, 58s. 9d.; ferric sulphate (solid), 45s.; Clay Cross lime, 22s. 6d.; while in the second series the costs had increased to: Sulphate of alumina, 92s. 6d.; Clay Cross lime, 26s. 11d.; and ferric sulphate (liquid), 50s. per ton. Having therefore taken certain quantities as a basis in the former paper, and arriving at definite results as purification compared with costs of treatment, and showing that these later were practically the same, the cost of treatment for the present and future experiments can be ignored and the results of the treatment with definite quantities adhered to. There is, however, a limit to this adherence, which need not be mentioned here, because it does not concern the object of this paper.

The following are the particulars of the experiments carried out:—

Lime (Alone)

The lime used was Clay Cross lime, and the experiments extended over a continuous period of twelve days, and during that period nine average daily samples were analyzed. The amount of lime was 7.6 grains per gallon, calculated on a dry-weather flow of 1¼ million gallons. The lime was automatically passed into a mixer and water added, and then stirred, the liquor flowing in a continuous stream into the sewage. In this and the other experiments no chemicals were added until after the sewage had passed through detritus tanks, so that the results of these tanks are those due to simple deposition and are not due to chemicals.

The analysis of the sewage during its various stages of purification gave the following average results:—

Table 1.—Lime (Alone). Average Results of Nine Average Samples in Parts of 100,000

	Crude sewage.	Detritus tank effluent.	Precipitation tank effluent.	Per cent. purification on crude sewage.	Effluent from filters.	Per cent. purification on crude sewage.
4 hours' oxygen absorption..	8.43	8.07	5.49	35.2	0.91	89.2
Free and saline ammonia (in terms of N)	2.48	2.32	2.25	—	0.17	—
Albuminoid ammonia (in terms of N)	0.57	0.53	0.38	33.3	0.12	78.9
Chlorides (in terms of Cl) ..	20.6	20.9	21.2	—	19.5	—
Suspended solids	18.9	16.4	5.5	70.9*	5.9	68.8
Colloidal matters (measured by the 4 hours' oxygen absorption)	1.96	—	1.5	23.4	—	—
Nitrites	—	—	—	—	0.03	—
Nitrates	—	—	—	—	1.79	—

Rainfall during period: 0.26 + 0.20 + .09 + 0.23 + 0.21. Total, 0.99 in.
Maximum temperature of air: 80 deg. Fahr.
Minimum temperature of air: 36 deg. Fahr.
*If calculated on the detritus tank effluent (partially settled sewage) the percentage purification is 66.5.
The percolating filter effluent was averaged for the week before the suspended solids were estimated.

*Abstracted from paper read before the Society of Engineers, England.

Ferric Sulphate (Liquid) and Lime

These experiments extended over a continuous period of thirteen days, the lime in composition and the manner of addition to the sewage being similar to that described in the last test. The liquid ferric sulphate was mixed with water and allowed to drop into the sewage as it passed along a channel to the tanks. The quantities worked out at 2 grains of ferric sulphate per gallon and 4 grains of lime per gallon. During this period ten average daily samples of the sewage during its various processes of purification were analyzed with the results given in Table 2.

Sulphate of Alumina and Lime

These experiments extended over a continuous period of thirteen days as in the case of those in which ferric sulphate (liquid) and lime were used. The proportions used were 1.88 grains of sulphate of alumina to 2.8 grains of lime per gallon, and were added to the sewage as described in the first experiments.

Table 2.—Ferric Sulphate (Liquid) and Lime. Average Results of Ten Samples in Parts per 100,000

	Crude sewage.	Detritus tank effluent.	Precipitation tank effluent.	Per cent. purification on crude sewage.	Effluent from filters.	Per cent. purification on crude sewage.
4 hours' oxygen absorption..	9.25	8.69	6.0	35.1	0.98	89.4
Free and saline ammonia (in terms of N)	3.07	3.01	2.84	—	0.242	—
Albuminoid ammonia (in terms of N)	0.715	0.625	0.44	38.4	0.138	80.7
Chlorides (in terms of Cl) ..	21.8	23.3	22.7	—	21.6	—
Suspended solids	18.8	13.6	4.1	78.2*	4.5	76.1
Iron (in suspension)	1.66	—	1.22	—	—	—
Iron (in solution)	0.51	—	0.40	—	—	—
Colloidal matters (measured by the 4 hours' oxygen absorption	1.74	—	1.37	21.2	—	—
Nitrites	—	—	—	—	0.05	—
Nitrates	—	—	—	—	2.44	—

Rainfall during period: 0.24 + 0.07 + 0.10 + 0.04. Total, 0.45 in.
Maximum temperature of air: 88 deg. Fahr.
Minimum temperature of air: 42 deg. Fahr.
*If calculated on the detritus tank effluent (partially settled sewage) the percentage of purification is 70 per cent.
The percolating filter effluent was averaged for the week before the suspended solids were estimated.

During the period seven average daily samples of the sewage during its various processes of purification were analyzed with the following average results:—

Table 3.—Sulphate of Alumina and Lime. Average Results of Seven Samples in Parts per 100,000

	Crude sewage.	Detritus tank effluent.	Precipitation tank effluent.	Per cent. purification on crude sewage.	Effluent from filters.	Per cent. purification on crude sewage.
4 hours' oxygen absorption..	8.86	7.83	4.45	49.8	0.97	89.0
Free and saline ammonia (in terms of N)	2.96	2.91	2.85	—	0.105	—
Albuminoid ammonia (in terms of N)	0.71	0.61	0.405	43.0	0.105	85.2
Chlorides (in terms of Cl) ..	20.7	20.3	17.9	—	18.1	—
Suspended solids	22.4	16.9	4.8	78.5*	4.1	81.7
Colloidal matters (measured by the 4 hours' oxygen absorption)	2.20	—	1.59	27.7	—	—
Nitrites	—	—	—	—	0.055	—
Nitrates	—	—	—	—	2.11	—

Rainfall during period. Nil.
Maximum temperature of air: 104 deg. Fahr.
Minimum temperature of air: 54 deg. Fahr.
*If calculated on the detritus tank effluent (partially settled sewage) the percentage purification is 71.6.
The percolating filter effluent was averaged for a week before the suspended solids were estimated.

It will now be interesting to compare the average percentage purification obtained in the three tests when using the precipitants described. For convenience these are set out in the following table:—

Table 4.—Comparative Percentage Purification in Parts per 100,000

(The figures in the brackets refer to the final effluent from the percolating filters, the others to the tank effluent.)

	4 hours' oxygen absorption.	Albuminoid ammonia.	Suspended solids.	Colloidal matters.
1. Lime (alone)	35.2 (89.2)	33.3 (78.9)	70.9 (68.8)	23.5
2. Ferricsulphate (liquid) and lime	35.1 (39.4)	38.4 (80.7)	78.2 (76.1)	21.2
3. Sulphate of alumina and lime	49.8 (89.0)	43.0 (85.2)	78.5 (81.7)	21.2

To render the tests complete, further experiments were carried out by settling average daily samples of crude sewage for two hours and syphoning off the supernatant liquid. The only comparative test was—as in the first series—that for oxygen absorption, the sewage and tank effluents being portions of those included in Tables 1, 2 and 3. The results are shown in Table 5.

Table 5.—Tests on Settled Sewage and Tank Effluents in Parts per 100,000

	Lime (alone).		Ferric sulphate (liquid) and lime.		Sulphate of alumina and lime.	
Test No.	Settled sewage.	Daily averages of tank effluent.	Settled sewage.	Daily averages of tank effluent.	Settled sewage.	Daily averages of tank effluent
1	3.52	4.32	7.04	4.76	5.56	4.44
2	6.28	4.52	8.0	7.52	4.64	4.16
3	6.68	5.96	7.6	7.20	5.16	4.76
4	6.56	6.08	7.56	6.76	5.16	4.28
5	6.32	6.24	4.48	4.92	6.04	3.72
6	4.16	4.60	7.44	5.28	5.56	5.24
7	6.88	5.16	7.52	6.88	5.48	4.56
8	7.00	6.40	6.72	6.52	—	—
9	7.68	6.16	6.20	5.24	—	—
10	—	—	4.28	4.96	—	—

Note—The figures in Tables 1, 2, 3 give 8.07, 8.69 and 7.83 parts per 100,000 respectively, for partially settled sewage from detritus tanks (due to continuous flow), while the figures in Table 5 are obtained from quiescent settlement in the laboratory. It will be noted that in test 6 (lime), and tests 5 and 10 (ferric sulphate and lime) the settled sewage (laboratory) gave better results than the respective tank effluents, and on the whole the lime treatment shows a 10.3 per cent. improvement, while the ferric sulphate and lime shows a 10 per cent. improvement. With the sulphate of alumina and lime treatment the tank effluent was in all cases better than the settled sewage, and on the whole the improvement reaches 17.2 per cent.

It is unnecessary to repeat the information as to daily flow, varying flow of the sewage during the day, the treatment adopted, or a description of the works, as these were given in the author's previous paper, but it is necessary, to make this paper complete, to draw attention to certain points in the two series of tests. Lime (alone) was not used in the first series of tests, but has been used in the second series for the reason previously given, but not because the author thought that its use—alone—would be effective; ferric sulphate, in its solid form, was used alone in the first series but not in the second, because the results obtained by its use in the former series were not altogether satisfactory for the object in view, and there was thus no reason why any further tests should be carried out. Ferric sulphate in its liquid form was not used in the first series because the author was not in possession of a sufficient quantity to make the test, and it was only after the termination of the first series that the makers generously placed at his disposal the quantity required, the reported satisfactory results by its use in some other places being a sufficient encouragement for the tests to be carried out. Sulphate of alumina and lime were used in both series of tests to give, for what they are worth, some basis of comparison.

AMERICAN SOCIETY PROPOSES CLOSER RELATIONS WITH CANADIAN ENGINEERS

The secretary of the Canadian Society of Civil Engineers has received a welcome letter from Dr. Chas. Warren Hunt, secretary of the American Society of Civil Engineers, in which Dr. Hunt advises the Canadian Society of very gracious resolutions which have been passed by the Board of Direction of the American Society, looking toward closer relations with their Canadian brethren. The letter is as follows:—

"I have the honor to state that at a meeting of the Board of Direction of the American Society of Civil Engineers held October 9th, 1917, the following resolutions were adopted:

" 'Whereas the American Society of Civil Engineers and the Canadian Society of Civil Engineers are both organized for the purpose of promoting, in every practicable way, co-operation, good feeling and fellowship, and the professional and personal interests of the engineering profession of both countries, and for the maintenance of high professional and personal standards and ethics of conduct, and

" 'Whereas many of the members of each of these Societies have become members of the other, and

" 'Whereas it is in the highest degree desirable that the utmost co-operation and the most cordial relationship should exist between the two Societies, especially in view of the present world crisis, which should draw into closer relationship the United States and Dominion of Canada, be it

" 'Resolved that the Board of Direction of the American Society of Civil Engineers formally expresses to the Council and members of the Canadian Society of Civil Engineers, its desire that the two Societies should cooperate for mutual advancement, to the greatest extent possible, and that the board extends to the members of the Canadian Society of Civil Engineers a cordial invitation to avail themselves of the facilities offered by the American Society of Civil Engineers, to make themselves at home in its rooms, and to attend its meetings whenever they may visit New York, and further,

" 'That inasmuch as both Societies are engaged in the effort to solve the same problems, for which purpose mutual acquaintance and intercourse will be of benefit to both Societies, the Board of Direction of the American Society of Civil Engineers expresses its approval of a plan of holding joint meetings of the two Societies at such times and places as may be found convenient, and further,

" 'That a copy of these resolutions be sent to the Council of the Canadian Society of Civil Engineers.'

"I beg leave to request that you bring these resolutions to the attention of the Council of the Canadian Society of Civil Engineers."

In reply, Secretary Keith has forwarded to Dr. Hunt a copy of the following resolutions passed by the Council of the Canadian Society of Civil Engineers:—

"Whereas, the Council of the Canadian Society of Civil Engineers has received a copy of the resolutions adopted by the Board of Direction of the American Society of Civil Engineers at a meeting held on October 9th, 1917, expressing the desirability of the closest co-operation and cordial relationship between the American Society of Civil Engineers and the Canadian Society of Civil Engineers, and

"Whereas, the Council of the Canadian Society of Civil Engineers is in full accord with the sentiments and principles so clearly enunciated in the said resolutions, therefore be it

"Resolved, that the Council of the Canadian Society of Civil Engineers record its hearty appreciation and express its thanks to the Board of Direction of the American Society of Civil Engineers for the kindly interest shown by the resolution, and be it further

"Resolved, that the Council of the Canadian Society of Civil Engineers co-operate with the Board of Direction of the American Society of Civil Engineers to the end that the terms of the said resolutions may be carried into effect, and that the Council reciprocate the action of the Board by inviting the members of the American Society of Civil Engineers to take advantage of the facilities offered by the Canadian Society of Civil Engineers and make themselves at home in its rooms and attend its meetings whenever they may visit Montreal.

"Be it further resolved, that a committee of the Canadian Society of Civil Engineers consisting of the president, a past president and two members of Council be requested to communicate with the Board of Direction of the American Society of Civil Engineers with a view to making arrangements for giving effect to the terms of the said resolutions, and further

"That a copy of these resolutions be sent to the Board of Direction of the American Society of Civil Engineers."

CANADA'S RAILWAY SERVICE

"Canada is to-day getting the best and cheapest railway service in the western world," is the opinion of the Canadian Railway Association, expressed in a statement just issued. "In spite of the car shortage created by the abnormal balance south-bound over north-bound traffic, in spite of war requirements, higher labor charges, the necessity of importing coal for engines, and the low efficiency of the coal due to lower winter temperatures in Canada, there is a greater degree of efficiency reached in the operation of Canadian railways than anywhere else in the new world. Car shortage is being reduced day by day. The percentage of freight cars out of service for repairs in Canada is lower than the percentage on United States roads, and the average cost to the Canadian traveller or shipper is less.

"For the year ending June 3th, 1916, the charge for moving an average ton of freight one mile in the United States was .716 of a cent. In Canada it was .653 of a cent. In the United States the average passenger mile cost the passenger 2.006 cents. In Canada it cost him 1.954 cents. At the same time the Canadian railways were hauling their coal from foreign mines and paying duty on it. They were getting less work from the same coal because of the lower winter temperatures in Canada. They paid more for labor, and yet charged the public less for their services than any of the other roads on this continent."

Commenting on the statement at Washington that the United States railways have curtailed passenger service by over 20,000,000 passenger train miles per annum, the Canadian railways, through their association, point to a reduction of over 10,000,000 passenger miles per annum in Canada, which, in view of the lower total mileage in the Dominion as compared to the United States is a vastly greater pro-rata reduction.

"Certainly," they say, "no reduction in freight and passenger rates in Canada are being looked for as the result of railway economies now being effected by the association.

American shipyards will complete 1,000,000 tons of ships by March 1, Chairman Hurley, of the Shipping Board, told a conference of Atlantic Coast builders and government officials, called to discuss speeding up the shipbuilding programme. "In the whole of 1916," said Mr. Hurley, "we turned out little over 750,000 tons. We will achieve in the next four months far more than we achieved in 12 months. The new goal of our expectations is ten times the production of 1916."

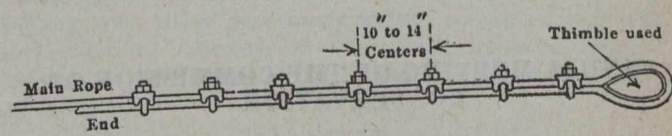
NOTES ON THE PERFORMANCE OF HOISTING ROPES*

By Messrs. M. C. Height and O. F. Tillson

THE ropes used were 1⅛ ins. diameter, plow steel, 6 by 19 regular lay and 6 by 7 long lay. They support a skip weighing empty about 2¾ tons, with an average ore load of about 6 tons and average weight of "rope out" of about 1,000 ft. or 1 ton. They are wound over 10-ft. diameter drums and 12-ft. diameter head sheaves, and are supported in the shaft by 9-in. diameter idler pulleys spaced 30 ft. apart on the shaft slope of 47° 30'. Each rope is 2,000 ft. long.

The hoisting ropes are examined each day before regular hoisting starts, and at this time the rope is run very slowly past the inspectors, who look for broken wire or other signs of weakness. A lubricant is used on the rope, but it is such that it does not coat the rope so that the wires cannot be seen. The rope is attached to the bale of the skip with a thimble and clevis, not with a socket. Seven clamps (see Fig.) are used to fasten the rope and these are all so placed on the rope that the U-bolt part of the clamp bears on the turned up end of the rope and the broader piece bears on the main rope.

Tests have indicated that this method of attachment permits the support of a load equal to the ultimate strength of the rope, but when the rope clamps are alternated the rope may fail at 80 per cent. or less of its normal strength because of the concentration of stresses where the U-bolt constricts the standing portion of the rope. Experience with various types of ropes has given results favoring a plow-steel Lang-lay rope of 6 strands and 7 wires per strand for use where the sheave wheels and hoist drums are of sufficient diameter to avoid excessive bending (in this case 12 ft. [3.66 m.] and 10 ft. [3.04 m.] respectively), since a greater reduction of diameter by wear may be suffered without fracture of the wires. This wearing service is, of course, more important in a slope shaft than a vertical one. With the regular lay ropes first installed, the type selected had a special arrangement of large wires at the outside of each strand (known as Seale patent lay) and this type of rope gave good service. Ropes with Seale's patent lay of wires have also been tried in the Lang-lay type, but they increased in diameter at various points with a loosening of the outer wires (or "bird caging") so the stress was carried largely by the few inner wires. This condition was undoubtedly aggravated by the fact that the hoist drums will not hold all the rope in one layer so there is a beating or slapping effect as the second layer is guided over the first layer. "Bird-caging" is also more severe when a swivel attachment of a 6 x 19 Lang-lay rope is made to the bale of the skip because the twists of both the wires in the strands and the strands of the rope are in the same direction of rotation. Therefore, as the rope is stretched the pitch of the strands becomes greater, and the wires in the strands are untwisted a certain amount. The outer wires of the strands are lengthened in this manner disproportionately with the inner wires and "bird-caging" is the result. If there are only seven wires in the strand there is only one layer about the core wire, so the above effect is not produced. With a regular-lay rope a swivel is an advantage as it permits the rope to rotate as its length changes, and, since the wires in the strand are twisted in the "opposite hand" to the twist of the strands of the rope they tend to counter-



Clamps Arranged so that the Broader Surfaces Bear on the Main Rope, U-Bolts Bearing on Turned-up End

*Extracted from paper read before the American Institute of Mining Engineers.

Table I.

Type of rope.	Period in service.	Tons ore hoisted.	Foot-tons of work performed.	Remarks.
6 by 19, Seale patent, ordinary-lay, south rope	April 27, 1910, to Feb. 8, 1912, or 650 days	315,759	471,758,554	A
North rope (above plus)	Nov. 4, 1913, to Sept. 20, 1914, or 320 days	200,864	326,441,347	B
Total north rope	970 days	516,623	798,199,901	
6 by 19, Seale patent, Lang-lay south rope	Feb. 8, 1912, to Nov. 4, 1913, or 634 days	408,867	651,957,881	C
North rope	Feb. 8, 1912, to Sept. 20, 1914, or 954 days	609,732	978,399,228	D
6 by 7, Lang-lay, each rope north and south the same	Sept. 20, 1914, to June 1, 1917, or 983 days, and still in service June 28, 1917	955,470	1,468,287,514	E

Remarks.—Foot-tons of work does not include weight of skip empty and rope when lowering. The above figures should be increased approximately 38 per cent. to cover this item.

A. North and south ropes taken out of service because of the number of places broken wires showed; the maximum number of broken wires within one foot was 12.

B. North rope returned to service as an emergency after Lang-lay 6 x 19 north rope became badly "bird-caged" and had a number of broken wires in one strand ravelling, since breaking tests of sample gave confidence in the rope.

C. Lang-lay south rope removed for reason given in remark "B." It was turned end for end on April 4, 1913.

D. Lang-lay 6 x 19 north rope "bird-caged" considerably after it was in service a short time, but had few breaks of wires until September 20, 1914, when there were possibly 16 breaks in three feet.

E. Lang-lay 6 x 7 north and south ropes were turned end for end on July 6, 1916, as a matter of policy, but show not more than four broken wires each at present, and these are now wrapped on the drum. The north rope has suffered severe stresses twice because of skip derailments during hoisting. They appear in excellent condition.

act the untwisting of the rope and their outer wires are made tighter. As a result of the excellent manner in which it is standing up under severe service, the 6 x 7 Lang-lay ropes are preferred in slope shafts provided with well-proportioned head-sheaves and hoist drums.

Table I. gives a record of service of various types of rope with the corresponding foot-tons of work performed. These ropes were taken out of service when the appearance of a number of broken wires in proximity made this safety precaution appear advisable.

ANNUAL MEETING OF THE COMMISSION OF CONSERVATION

Subjects of interest from an engineering standpoint occupied a prominent place on the programme of the Commission of Conservation at its annual meeting on Tuesday and Wednesday, November 27th and 28th. The sessions were well attended, frequent reference being made to the effectiveness of the work being done by the Commission.

Among the prominent engineers and technical men present were Sir John Kennedy, R. A. Ross, Dr. Frank Adams, A. V. White, C. A. Magrath, S. T. Dodd, of General Electric Co., Schenectady, N.Y., E. J. Zavitz, Dr. Howe, Dr. Haanel and J. P. Babcock. There was a large attendance of commissioners.

Sir Clifford Sifton, chairman, after explaining the reasons for calling the annual meeting at the present time, and referring to the large attendance, read his annual review of the activities of the commission and of the general position of conservation and development of natural resources in Canada.

In a very able manner Mr. Arthur V. White, consulting engineer to the commission, dealt with the water power situation on the St. Lawrence, particularly with that phase of it which is of an international character. The recent application for permission to construct a dam at the Coteau Rapids has directed attention to this question.

Sir John Kennedy, in discussing the above paper, referred particularly to the difficulties of development on the St. Lawrence and ice troubles due to the fact that the river flows from the warmer to the colder areas and consequently causes an early break-up of the ice and resultant high water. Sir John suggested the establishment of an international commission of engineers to develop a scheme for the utilization of St. Lawrence powers on the international section, on completion of which it could be handed over to a body similar to the International Joint Commissioners for administration. On the power being developed, if Canada did not require all her share of the power it could be exported, but only upon such conditions as would be satisfactory to Canada, and upon short-term leases only.

Mr. R. A. Ross, C.E., of Montreal, in further reference to the paper by Mr. White, corroborated to a large extent the remarks of Sir John Kennedy. Referring to the utilization by electro-chemical works, he advocated the idea of a general survey of the water-power resources, and the allocation of certain powers for electro-chemical industries which would not likely be required for domestic or manufacturing power, the essential of a successful electro-chemical plant being a large amount of power at a low cost.

C. A. Magrath, fuel controller, gave in a concise manner a resumé of the fuel situation. He dwelt upon the demand for economy in the use of fuel, the difficulties of transportation, the arrangements made and profits allowed to the coal dealers, and the necessity for sifting of ashes by consumers. Where wood could be secured he advocated its use. Mr. Magrath evidently has the situation well in hand and predicts, with the exercise of economy, that all will have a sufficiency of fuel this winter.

Dr. Haanel discussed fully the development of the peat fuel industry, dwelling at length upon the necessity for only fully qualified peat engineers undertaking the planning and equipment of peat fuel plants. He cited several instances in which large expenditures of capital had been wasted and much plant discarded owing to errors by inefficient engineers. Dr. Haanel maintained that the only feasible way of drying peat is by natural means, the spreading out of the moist peat on portions of the area and allowing the sun to evaporate the moisture. The peat fibre is of such a nature that pressure would not effect the result required. The increased use of peat as fuel was strongly advocated, one of its chief advantages being its combustion with only a small ash residue. Its bulkiness, however, is a drawback where storage of fuel is necessary.

Dr. C. D. Howe, of Toronto University, very clearly elaborated the condition of our wood pulp resources. The necessity for their conservation was emphasized if Canada is to continue a pulp and paper manufacturing country. Protection of forests from fire, scientific methods of cutting, and the replanting of cut-over areas were means suggested for perpetuating this, one of Canada's greatest natural resources.

Mr. S. T. Dodd, electrical engineer of the General Electric Co., Schenectady, N.Y., very ably and technically discussed the electrification of railways, dwelling principally upon the results secured upon the Chicago, St. Paul & Milwaukee Railway mountain section. The development of water-powers, the concentration of many individual plants under one controlling system, he emphasized, was necessary for efficient operation of railways by electric power. Mr. Dodd had with him many slides and moving picture films which he used to illustrate his address.

Ontario's new forest protection programme was outlined by Mr. E. J. Zavitz, provincial forester. Ontario has at last taken up in earnest the protection of its remaining forest areas, and many new plans are being put into effect. Sir Clifford Sifton took occasion to impress upon Mr. Zavitz, and through him upon his superior officers, the necessity of all appointments to the forest service being based upon merit only; political appointments only leading to the abuse and neglect of the forest protection systems.

The production of sulphate of ammonia in the United States in 1916 is estimated to have been 325,000 tons, an increase of 75,000 tons over that of 1915. Of the 1916 total, 272,000 tons are credited to coke-ovens, and 53,000 tons to gasworks and bone carbonizing plants. The 1916 output of coke in the United States was a record for both beehive and by-product ovens, amounting to over 54,000,000 tons.

The power transmission lines of the Nevado-California Power Company's system are said to form the longest chain yet projected, being about 666 miles from north to south. The current is generated by water power, an interesting feature of the plant being the utilization of two high heads differing by 530 ft. in the same power-house and on the same 8,000 horse-power impulse wheel.

Latest statistics show that 23 new steamships and 13 sailing vessels were built in Holland during the first six months of this year, as compared with 16 steamships and eight sailing craft during the same period in 1916. The total number of new vessels for the Dutch flag built up to July 1 this year was 38, 24 steam and 14 sail, having an aggregate tonnage of over 81,000 tons, as compared with 54,000 tons built in 1916.

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Principal Contents of this Issue

COAL AND POWER SHORTAGE

In his paper before the recent annual meeting of the Commission of Conservation, Mr. Arthur V. White, of Toronto, dealt with the power and coal shortage in the province of Ontario in a broad and statesmanlike manner. He showed clearly that the shortage most to be feared is not that due to present exigencies arising out of war conditions, but is the shortage which may persist for many years after the war, due to conditions of home demand which may be more or less beyond the control of the United States government, even with the very best of intentions toward Canada. The shortage of coal in the United States is now becoming marked to such an extent that even the Great White Way, as New York City's Broadway is universally called, is almost dark throughout the night excepting for three hours, from eight to eleven, the United States fuel controller permitting none of the great electric signs to be illuminated for any longer time on account of the coal required to generate the considerable amount of power used by the signs.

The coal problem in Ontario demands the best statesmanship for its permanent solution. The acute shortage of the past two years gives merely an inadequate idea of how much suffering and loss would follow a permanent continuation of the present conditions. This problem is of vital significance to Canada, and its solution will depend largely upon Mr. White, F. A. Gaby, C. A. Magrath, H. G. Acres, James White, R. A. Ross and other engineers who have made a special study of the situation, particularly as related to power problems.

Mr. White has called frequent attention to the problem in articles in the University Magazine, the Toronto Daily News, the Monetary Times and *The Canadian Engineer*. His article in the University Magazine in 1910, long before any shortage was experienced, showed a clarity of vision and grasp of the details of the situation that, in the light of subsequent events, were almost prophetical. It would be well, therefore, for officials at Ottawa to heed the concluding remarks of Mr. White's latest address:—

"No country can be expected to send out of its borders that which is essential to its own existence. Canadians should appreciate the fact that the United States has been dealing with them generously in the present distressing coal situation. Canada, however, must conserve, against the day of her own need, such resources as are available for barter."

MORE WAR ORDERS FOR CANADA

Negotiations conducted by the Imperial Munitions Board at Washington have resulted in the placing of a large order for 75-millimetre shells to be produced by Canadian plants for the United States government. From 6,000,000 to 7,500,000 shells, under the arrangement, will be produced in Canada during the first seven months of 1918. The value of these orders is approximately $40,000,000.

The value of munition orders placed by Great Britain in Canada up to September last was $925,000,000 and by the end of this year the total will be $1,000,000,000. The orders from the United States will stimulate still further our industrial and general activities. They will help also to balance the changes made a few months ago by the Imperial Munitions Board in regard to the sizes of shells required by Great Britain. We must not overlook the fact, however, that Britain will continue to purchase vast quantities of our products as long as the war lasts, for war purposes, but only if we give considerable help in financing them. That is one purpose of our recent Victory Loan. As Mr. E. R. Wood, of Toronto, has pointed out in his Victory Loan pamphlet, Britain has always been our best customer. She is our best customer now. She will be one of our best customers in the future.

Britain could sell back to us hundreds of millions of our securities and thus finance her purchases here, but we are unable to buy them back. We can, however, establish credits here, from month to month, by dint of thrift and economy and substantial investment in war loans.

The British food controller, and the grain commission, state: "We require your wheat, your meats, and other food products."

The British minister of munitions has advised: "We want the munitions which you are now supplying; indeed, if you could arrange to do so, we would like to secure an increased, not decreased, supply from Canada."

The British minister of shipping has expressed himself as wanting to arrange for the building and purchase of further ships in Canada in addition to those now under construction.

The admiralty controller has advised: "It would be of great service if arrangements could be made whereby ship's plates could be rolled in Canada."

The chairman of the air board has requisitioned for further training camps, with additional aeroplanes. The aeronautic supply department has made an earnest demand for the production of silver spruce, which will require a somewhat extensive expenditure in the development of facilities in British Columbia for the production of the large quantities which are needed.

Mr. Wood has truly said that the answer which the British treasury makes to all these demands is: "We do not know how we can provide dollar credits in Canada to meet the bills. We have asked for additional assistance from Canada so that the necessitous supplies for the war may be made available, and the foodstuffs for the army and the civilian population provided."

The magnificent result of the Victory Loan—about 630,000 subscriptions totalling approximately $405,000,000—makes it certain that many of these needed credits can now be established, bringing more war orders to Canada and ensuring the country's prosperity in many lines for at least another year.

OBITUARIES

Flight.-Lieut. J. NELSON CUNNINGHAM, who was a graduate of the School of Practical Science, Toronto, has been killed in action.

Major GORDON POWIS, a B.Sc. of McGill University, and formerly the representative of the Canadian Westinghouse Co. at Edmonton, Alta., has been killed at the front. He fell at Passchendaele.

Capt. A. J. LATORNELL, B.A.Sc., is reported to have died of wounds. He went overseas as a lieutenant in a Cobourg battery. His brother, Mr. A. L. Latornell, is employed in the Toronto sewers department. Prior to enlistment, Capt. Latornell was city engineer of Edmonton, Alta.

PERSONALS

H. B. LEE has been appointed manager of the Bond Engineering Works, Toronto, a subsidiary of the Bond Foundry and Machine Co., Manheim, Pa.

C. H. BROMLEY, in charge of the water and public works department of Grimsby, Ont., has been elected a member of the Institute of Municipal Engineers of Great Britain.

Corp. J. N. WILLIAMS, B.A.Sc., is reported wounded. Corp. Williams enlisted from the University of Toronto in March, 1915, and served with the 25th Battery at the front for several months.

Flight.-Lieut. JONES, according to a cablegram received a few days ago by his brother, L. M. Jones, city engineer of Port Arthur, is now a prisoner at Karlsruhe, Germany, having been captured October 24th.

ROSS GARFIELD EDWARDS, assistant superintendent of the Montreal Terminals division, Quebec District, has been appointed assistant superintendent, Trenton division, Ontario district, C.P.R., Havelock, Ont. Mr. Edwards has been in the service of the C.P.R. since December, 1900.

KENNETH G. CAMERON, connected with the bridge department of the Canadian Government Railways at Moncton, N.B., has been granted leave of absence in order to act as chief examiner for the Imperial Munitions Board at the works of the Nova Scotia Steel and Coal Co., New Glasgow, N.S.

G. R. MACLEOD, of Montreal, has been appointed by the Imperial Munitions Board to an important position of an organization now being established at Washington, D.C., for which he has been granted leave of absence for an indefinite period. Mr. MacLeod was head of the sewer department at Montreal.

Brig.-Gen. H. H. MCLEAN, K.C., of St. John, N.B., has been transferred to the retired list with honorary rank of Major-General. He was member for Queens-Sunbury in the last parliament and is now a candidate for the representation of Royal, N.B. Brig.-Gen. McLean was formerly president of St. John Railway.

S. J. HUNGERFORD was recently appointed general manager of the eastern lines of the Canadian Northern Railway, the position recently vacated by L. C. Fritch. Mr. Hungerford's first official appointment was that of chargeman for the Canadian Pacific Railway at Montreal. From that position he gradually rose and in 1908 he was made superintendent of shops. In 1910 he joined the Canadian Northern Railway at Winnipeg as superintendent of rolling stock for the Canadian Northern Railway, Duluth, Winnipeg and Pacific Railway. On May 1st, 1915, he was moved to the head office, Toronto, and his jurisdiction extended to include the rolling stock on the 10,000 miles of trackage of the Canadian Northern.

W. P. KELLETT, now president of the American Steel Products Corporation, has held important positions in the engineering world. Previous to his present post he was president of the Dominion Steel Products Co., Brantford, Ont., and before that manager and chief engineer of the Lake Erie and Northern Railway.

CAN. SOC. C.E. ANNUAL MEETING

The annual meeting of the Canadian Society of Civil Engineers will be held at headquarters, 176 Mansfield Street, Montreal, on Monday, Tuesday and Wednesday, January 21st, 22nd and 23rd, 1918. Full information concerning the meeting, program, etc., will be sent out to all members within a few days.

DIRECTORY OF NATURAL RESOURCES

The first comprehensive and authoritative directory of Canada's natural resources is to be published without delay by the Commission of Conservation. Sir Clifford Sifton gave the first intimation of this at the annual meeting of the Commission last week and the details respecting the undertaking are now made public. The task was begun in 1910 as being fundamental to the work with which parliament expressly charged the Commission, *viz.*, to consider all questions relating to the conservation and better utilization of the natural resources of Canada and to "make inventories, collect and disseminate such information."

Coast to Coast

Alliston, Ont.—The Hydro transmission line, extending from Barrie to Alliston is well under way, and it is expected to be completed before the New Year. It will be extended to the municipalities of Beeton, Tottenham and Bradford, and will serve the southern portion of Simcoe County, the source of power being the Big Chute plant on the Severn River.

Amherstburg, N.S.—The Council have under discussion plans submitted by Mr. Knowles, engineer of the Essex Border Utilities, for a proposed new waterworks, pump house and pumping plant, to be erected by the Brunner-Mond. The plant is designed to have an average capacity of 500,000 U.S. gallons per day, with provision for increase in the future by small additions to the plant to a capacity of 1,000,000 gallons per day. The pumping plant will have a fire capacity at the rate of 1,400,000 gallons, equal to four or five fire streams, and an average storage capacity for filtered water of over 100,000 gallons; the pumps to have sufficient capacity to furnish a quantity varying from 360,000 gallons in the middle of the night to 1,000,000 gallons during the time of highest consumption, such as on Monday morning, due to washing, or some hot day in summer, due to lawn sprinkling, or in cold weather in winter when water is run to waste to prevent pipes freezing; the pipes to be three low lift at 750 U.S. gallons per minute each, four high lift at 750 gallons per minute each; three filters at 500,000 gallons per day each with space reserved for one additional unit.

Brandon, Man.—The city has just completed the installation of an automatic telephone exchange supplied by the Automatic Electric Co., Chicago. It now has 1,794 city and 479 farm telephones in service, representing 11.3 telephones for every 100 people. Up to the beginning of the present year manual equipment had been in service in Brandon, but as they found it necessary to build a new exchange, it was, at the same time, decided to install automatic apparatus similar to that already in use in a number of cities in Western Canada.

Drummondville, Que.—The plant of the Aetna Explosives Co. is again being operated after being closed down for some months. The acid departments are being operated at capacity to manufacture sulphuric and nitric acids, and the output is at the rate of 3,000 tons monthly.

Moncton, N.B.—The last span was riveted into position on the steel structure of the Moncton-Coverdale bridge. It is the intention to place a temporary flooring on the bridge for the coming winter, so that traffic can be carried out over it. Work will continue until the heavy snows fall, and will be resumed again as quickly as possible in the spring. The approaches are now being placed in condition for traffic.

Montreal, Que.—An additional order has been received from the Dominion Bridge Co., Montreal, for 10,000 tons of fabricated steel from the American International Corporation. Some two weeks ago orders from the same source amounting to 40,000 tons were announced, so that the total has now been increased to 50,000. The American International Corporation will require 335,000 tons of steel for the construction of 130 boats, contracts for which have been received from the Emergency Fleet Corporation.

Montreal, Que.—The Canadian Vickers Company has successfully launched the 7,000-ton steamer "Porsanger," the largest ocean-going vessel constructed in Canada, and built for a Norwegian concern. The christening ceremony was performed by Mrs. W. H. Lynch, wife of the general manager of Canadian Vickers.

Montreal, Que.—The city will ask the Quebec Legislature for power to allow the city or a board of engineers to control and regulate the erection of poles on the streets by different companies, and for this purpose to amend the acts incorporating the Montreal Light, Heat and Power, Montreal Tramways Company, and their subsidiaries. Further, to annul the agreement entered into between the former town of Sault-au-Recollet and the Back River Power Company as regards the guarantee of the bonds of the company.

Ottawa, Ont.—An embargo on the exportation of iron and steel products has been established by a Canadian order in council of November 15. The following articles are placed under prohibition of exportation to all destinations abroad other than the United Kingdoms, British possessions and protectorates: Pig iron, steel ingots, billets, blooms, bars and slabs, iron and steel plates, iron and steel shapes (comprising beams, channels, angles, tees and zees), iron and steel fabricated for structural work and shipbuilding. Earlier embargo lists have included hematite, pig iron, iron and steel plates, and iron and steel fabricated for structural work and shipbuilding, all of which were prohibited to be exported to foreign countries in Europe and on the Mediterranean and Black Seas other than France, Russia, Italy, Spain and Portugal.

Pacofi, B.C.—The new kelp plant at Pacofi, Queen Charlotte Island, the property of the International Chemical Co., will shortly be ready for operation. It is equipped to handle 300 tons of kelp per day. In addition to extracting potash from the kelp, the company expects to manufacture potassium and it also possesses equipment for handling dogfish by-products.

Port Arthur, Ont.—The Port Arthur Pulp & Paper Co. will be ready to commence active operations in about six weeks' time, according to General Manager A. G. Pounsford. There are about 2,500 cords of wood on hand and 70,000 cords have been contracted for.

Province of Alberta.—J. D. McArthur, president of the Alberta and Great Waterways Railway, is reported to have said in Winnipeg, November 18, that steel had been laid to McMurray, on the Athabasca River, that the line would be finished up and a full train service put in operation next year, and that it is expected to arrange for a regular steamboat service from McMurray to the Arctic Ocean when financial conditions become easier. The line starts from the Edmonton, Dunvegan and British Columbia Railway at Carbondale, 143 miles from Edmonton, and runs northerly and easterly to McMurray, 290 miles. Track was laid to mileage 174.5 at the end of 1915, and was resumed in December, 1916, it being estimated that 40 miles additional had been laid to the end of that year. The point to which traffic is now being operated is on the river, and connection with McMurray is made by means of scows.

Toronto, Ont.—Favorable progress on the reclamation work at Sunnyside by the Toronto Harbor Commission is being made, and it is expected to have the filling in completed by about December 10. The hydraulic dredge, which has a capacity of between 10,000 and 20,000 cubic yards per day, started work about the middle of October. The dyke is practically finished, and the filling in will be continued until the present level is raised between five and seven feet, or within two feet of the dyke of earth. This will make the new boulevard considerably higher than the present roadway. The plans provide that the present Lake Shore Rd. will be raised 17 feet, and will be used as the radial line allowance, while the new road will be surveyed on the reclaimed area.

Toronto, Ont.—One of Canada's large agricultural industries, the Massey-Harris Co., Toronto, now control the old established implement house, the Johnston Harvester Co., Batavia, N.Y., which has been in existence for 40 or 50 years. They have had a large business in Europe and South America for the past 25 to 30 years, and have branch houses in several centres in the United States, as follows: Batavia, N.Y.; Harrisburg, Va.; Columbus, Ohio; Lansing, Mich.; Indianapolis, Ind.; St. Louis, Mo.; Kansas City, Kansas; and Fargo, N.D. They own an up-to-date, finely equipped plant at Batavia, N.Y., consisting mostly of fireproof reinforced concrete buildings, including a malleable iron plant. The Massey-Harris Co. is also interested in another company in the United States, the Deyo-Macey Engine Co., of Binghamton, N.Y., owning the entire capital stock. At this factory there are manufactured gasoline engines and spraying outfits.

Winnipeg, Man.—Delegates attending the Union of Manitoba Municipalities Convention last Wednesday, advocated the construction of 1,600 miles of trunk roads throughout the province at a cost of between $5,000,000 and $6,000,000. The executive committee, in its report, suggested that the government be asked to construct and maintain the trunk highways. If the report is carried into effect the government will appoint an independent commission of three members to locate the roads. The funds for the work would be provided by the sale of government bonds, and the revenue derived under the Good Roads Act, if not required for administration purposes, would assist in maintaining the proposed roads. Building operations would not begin until the war ends or until the money markets improve, it was announced.

York County, Ont.—The expenditure for construction work on the roads of York County, Ont., during the present year has been $139,684. Of this amount the city of Toronto pays $41,905, or 30 per cent. The maintenance cost for the same period has been $19,611, of which Toronto pays $7,845.