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ROAD IMPROVEMENT IN THE PROVINCE OF QUEBEC

SHOWING HOW THE EXPENDITURE ON ROAD CONSTRUCTION AND MAINTENANCE HAS INCREASED FROM THIRTY DOLLARS IN 1895-96 TO SIX MILLION DOLLARS IN 1914-15

IN the report of the Roads Department of the Province of Quebec the remarkable growth of the good roads movement since its inception is interestingly described. The development of each type of road is outlined in the following paragraphs abstracted from the Minister's Report, published a few weeks ago.

Earth Roads.—The maintenance of earth roads has been the object of the government's attention for over fifteen years. At the beginning of that period, although the advantages of hard surface roads were known, it was quite naturally thought that the most pressing matter should be attended to and the farmer be induced to keep the municipal road in order as it already was: that is, with its irregular shape, its more or less steep grades, its insufficient drainage and almost ever doubtful means of carrying off the water from its surface. The idea of improved roads was then so slightly developed, while traffic was so far from having the requirements of the present day, that one can understand why maintenance should be only temporary work, to meet the needs of limited wheel traffic and of trade whose rapid growth was not yet in the least suspected. Neither had the automobile then revolutionized transportation, in this country at least.

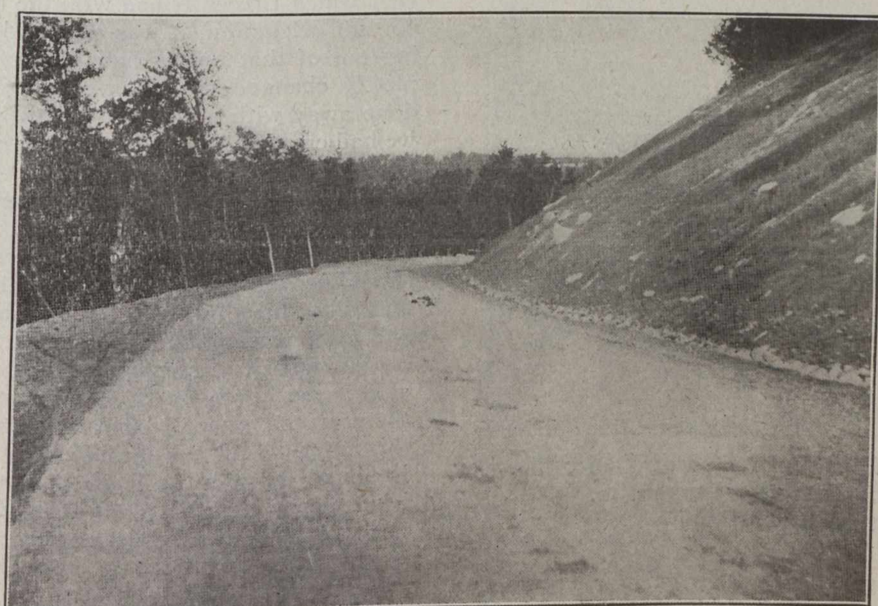


Fig. 1.—Montreal-Quebec Road, Donnacona (Portneuf). Macadam Done in 1915.

Our industry, our agriculture, our means of communication all were nevertheless destined to soon undergo a transformation. On the eve of such transformation, bad roads, while an immense obstacle to progress and an unexplainable economic error, were tolerated by the mass of the population. On the morrow, a change became necessary; without insisting at once upon having macadamized roads, public opinion called for properly kept roads or, at least, if it did not manifest itself openly, they whose business it is to know public opinion, to listen to it, to interpret it and, at times, to forestall it and satisfy its just aspirations, did not fail in their duty and, with praiseworthy foresight, they laid the basis of a regenerative movement which has not ceased to grow since then.

In a country of such inexhaustible resources and such prospects for the future as Quebec, earth roads are destined to become gravel or macadamized roads or roads treated with bitumen or paved with concrete. This means that when traffic with vehicles drawn by animals, later with automobiles and motor trucks, becomes greater, then earth roads will become insufficient and will have to be gradually replaced by the surfaces just mentioned or by other equivalent or better ones.

With these facts in view, the following conditions were imposed on municipalities who received grants for road maintenance from the government, the object being to make the work done serve for future developments. These consist: (*a*) in lowering the hills to a grade of 6 per 100 feet, or in going around them; (*b*) in re-making the ditches and giving them a regular slope of at least 5 inches per 100 feet; (*c*) properly draining damp and low spots; (*d*) straightening too sharp bends; (*e*) to removing all stones from the road and removing all rocks where its width is not sufficient; (*f*) properly rounding off the road for a length of one mile, taking care to not put more than a layer of four or five inches at a time and to pack it before running the machine over it again; (*g*) replacing the old wooden culverts by tile, concrete, corrugated iron, etc., ones.

The repairs mentioned do not represent all the permanent repairs that could be done, but it was thought advisable not to overload the programme. The municipal councils in charge of the work acted on the conditions and not only fulfilled them but did more. They widened roads not included in the programme; improved longer stretches of road than required, and made various other improvements. All this was done at a cost less than previously, even though the various councils had decided to do the work regardless of the poor state of financial affairs. This shows the friendly attitude of the public toward the good roads movement in the province of Quebec.

Gravelling.—Without overlooking the remarks just made respecting the gradual substitution of hard surfaces for earth, it may be said that the gravel road is destined to render great services. When well made, its surface is as suitable for automobiles as for vehicles with metal tires and there is no reason why it should not be used instead of macadam, especially on account of its comparatively small cost. Gravel costs about one-third and sometimes one-fourth the price of macadam. In connection with gravelling, there are some principal points to be considered: the distance over which it must be carted and the quality of the gravel. For a distance of one or even two miles—if it cannot be done otherwise—carting gravel is inexpensive, especially when the gravel is of superior quality. Some gravels possess cohesiveness, require no rolling nor sprinkling, are compressed by the sole weight of the traffic (provided it be always followed by running the double drag over the road), and their use does away at once with a rather considerable expenditure. On the other hand, the same gravels have in most instances, a co-efficient of hardness lower than that of less earthy gravels. The latter are harder, but have less cohesiveness and this defect must be overcome by rolling and sprinkling, although, properly speaking, the most economical method and that generally followed calls for neither rolling nor sprinkling. Good gravel which binds well and which lies at a normal distance should evidently be used in preference to a harder gravel lying too far from the spot where it is to be used. Only in the case of bitumen gravelling is it advisable to use gravel not sufficiently hard, even if found close by. The principle on which this theory is based is that it would be unwise to use capital for an improvement most of which would not be permanent. Although the gravel surface wears out as the earth one does, and as also does a stone surface, if the road, when gravelled, is properly kept, a very considerable portion of the gravel remains and serves as a foundation, as it were, for fresh layers of gravel.

Fig. 2.—Edward VII. Road, Parish of Napierville. (Upper) Laying Gravel on Fluxphalte. (Lower) Finished Road.

Gravel which does not contain more than 20% of earthy substances cannot be accepted for normal gravelling. In such cases, the use of stone covered with such gravel is recommended. Specifications are never drawn up before the gravel is examined in the laboratory. The engineers also make a study of haulage distances and organization of labor for the benefit of the municipalities.

Fig. 3.—Montreal-Quebec Road—St. Paul-l'Ermite (L'Assomption). Macadam Done in 1915.

In the course of his report, the Hon. M. Tessier says: "Another thing to be considered in studying the the most economical methods of construction, is the extraordinary development of our road policy. At an interview which I recently had with the members of a very important delegation, it was observed to me that the carrying out of that policy had upset everything, had completely changed the ideas of the rural population, had done away with all opposition to the new state of things we had created; that we no longer needed to have lectures given, to carry on a campaign; that the province now came to us, begged us to not stop, even asked us to set aside the precautions which the present financial situation imposes on us. Such dispositions on the ratepayers' part should not displease us, for we really have wished for such mentality, have brought it about and we wish to maintain and even develop it if necessary. But, as we said at the beginning of last season, we must continue on a reasonable upward path that is in proportion to the resources of the province, in accordance with the march of events. At this moment, our political life, or at least our financial life, is bound up with the financial life of the whole world. That means the obligation under which we are placed to not arrest the impetus that has been given to seek the more easily accessible means to meet first needs for a certain time. We have not failed in it; after deciding, last spring to spend a certain amount, we set to work and divided up that amount in the most rational and equitable manner possible. After several weeks of arduous labor, we succeeded in starting work again throughout the province

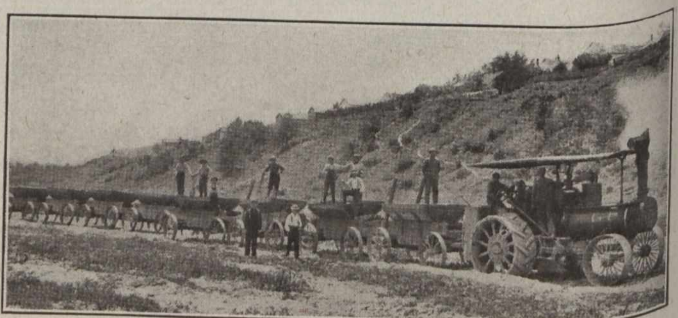


Fig. 4.—Levis-Jackman Road—St. Georges (Beauce). Conveying Gravel with a Traction Engine and Trucks.

and, considering the late date at which we began, it will be seen that, notwithstanding the financial crisis, the many difficulties due to rectifying estimates and applying such rectified estimates, the amount of work done is not only not less, but is greater, all proportions considered, than the amount of work previously done. The total length of roads made with gravel or stone by municipalities last season was 97.68 miles.

Macadam.—As in 1914, the province was divided into districts for the purpose of inspecting the macadam in course of construction. The supervision of such important and costly work is one of the things whose organization we have most at heart. We strive to improve it from day to day and to get the maximum of efficiency from each inspector.

As is indicated in the instructions issued to inspectors, they are expected to teach the instructors how to make macadam and how to handle the road gangs. They are instructed to see that specifications are followed precisely as intended. He is a road maker and should work with the instructor.

Inspections are made in sections of 200 feet, which are staked out beforehand. Width of road, thickness of foundation and number of layers of stone are noted. Drainage facilities are inspected with a view as to whether the slope of watercourses in culverts and under bridges is correct.

The important roads which are being macadamized are: The Montreal-Quebec Road, the Levis-Jackman Road; the Sherbrooke-Derby Line Road, the Chambly Road, King Edward VII. Road, and many smaller roads. The following figures will show the mileages of roads built in 1915 and the money expended: 295.60 miles of macadamized roads (municipal and provincial) were made in the province under the direction and with the aid of the government; 140.70 miles of gravel roads (municipal and provincial) were made under the direction and with the aid of the government.

Since 1911, 1,173.10 miles of macadamized roads and 494.57 miles of gravel roads (being 1,667.67 miles of roads permanently improved) were made in the province under government control.

Since 1911, the government of the province has paid for the maintenance and improvement of earth roads, as well as for making macadamized and gravel roads and for the expenses of administration of the Roads Department, $14,584,681.12.

The following statement of sums spent during the last 20 years by the Quebec government for road improvements shows the astonishing rate at which the good roads movement has grown in that province:

Year.		Year.	
1895-96 ....$	30.20	1905-06 ....$	9,661.88
1896-97	5,953.34	1906-07	15,404.56
1897-98	7,795.56	1907-08	20,117.85
1898-99	10,203.29	1908-09	60,146.92
1899-00	14,510.00	1909-10	60,000.00
1900-01	13,000.00	1910-11	95,000.00
1901-02	6,000.00	1911-12	494,277.66
1902-03	17,572.79	1912-13	1,069,810.35
1903-04	11,000.00	1913-14	4,018,916.68
1904-05	18,250.58	1914-15	6,140,273.13

There is an excellent demand for magnesite for furnace linings. In Quebec several properties are being operated, and it is to be hoped that the industry will become well established while the demand is so good.

MAKING BOTTOM FOR PILES BEFORE DRIVING.

It is quite common practice to deposit filling of some suitable material between and around the piles of a pier both to increase the resistance of the structure as a whole to lateral displacement and to increase the columnar strength of the piles themselves by decreasing their unsupported length, and also, but to a less extent, increasing their bearing power by additional skin friction. Care must be taken while depositing the fill to bring it up uniformly, so that the lateral pressure on the piles as units may be equal on all sides. A concentration of material at one point is capable of disastrous results, *viz.*, springing the piles out from under the caps or bowing the piles, with a consequent eccentricity of load, or even shearing off the piles near the mud line. Nevertheless, the fill is usually heaped up along the axis of the pier, sloping both ways from the centre line, giving the structure a "backbone," as it were. Sand, gravel, broken stone, or rip-rap is the usual fill material.

This method of filling is described by F. L. Simon in the Journal of the Engineers' Club of Baltimore, who says that while it has been employed successfully many times, yet it has the decided disadvantage of difficulty in controlling the distribution of the fill, resulting in one notable instance in the collapse of the structure. Why not, then, make the fill before starting the construction? The difficulty of controlling the distribution still obtains, but—and herein lies the great advantage of this method—strict uniformity of distribution is not essential and the entire hazard of the first method is obviated. There are no lateral pressures on the piles, indeterminate in amount and direction, as in the previous method, and no tendency toward a settlement of the piles with that of the fill. Secondly, there is the advantage of economy, due to the fact that shorter piles may very often be used because of the increased skin friction of the fill and compressed mud beneath it, giving equal or better test penetrations than in the first method, and due also to the relative ease of depositing the fill from scows previous to the erection of the pier.

The superiority of this second method was ably demonstrated during the construction of a pier 62 ft. wide by 830 ft. long. A number of test piles driven over the area of the pier revealed unusually severe bottom conditions—18 to 20 ft. of water and 45 to 60 ft. of mud overlying sand and clay—from which it was obvious that a large percentage of the piles would have to be in lengths of 85 to 95 ft., and most of them spliced. Fears were entertained, too, for the ability of a pier in such bottom and of such scant width to resist lateral thrusts, even though properly braced with batter piles. The safety of the assumed safe load per pile used in calculating the design was questioned.

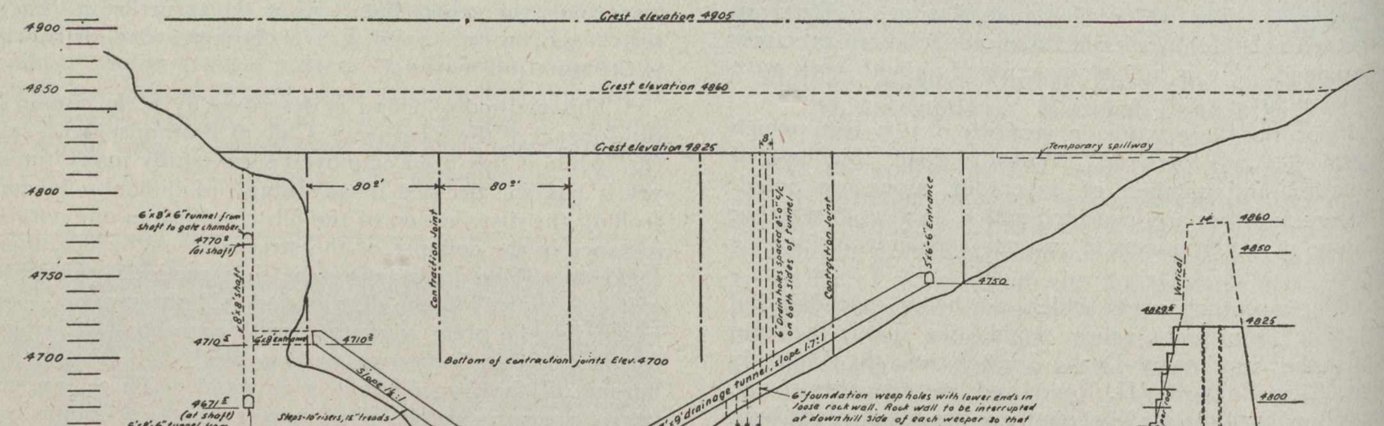
It was suggested, therefore, that a bottom be "made" before driving the piles by dumping heavy material from bottom-dump scows over the area of the pier. The plan was approved and the bottom deposited. The material used was mixed sand and gravel, dredged from the river, weighing about 2,800 to 2,900 lbs. per cubic yard. The river mud appeared to absorb the fill; it was compressed rather than displaced, although there was a slight upheaval on both sides of the deposit and some shoaling of the water over the deposit. Piles generally 10 ft. shorter than originally contemplated were driven to satisfactory final penetrations. Not one spliced pile was used. The fill served the additional purpose of staying the piles at the mud line and stiffening the structure laterally.

EXAMPLES OF CONSTANT ANGLE ARCH DAMS.

In *The Canadian Engineer* for March 9th, 1916, were outlined the chief points in the design of the constant angle arch dam, wherein, it will be remembered, a considerable saving of masonry may often be effected The following descriptions by the author, Mr. L. R. Jorgensen, by whom the design of this type has been developed, relate to two important installations of this type. The attention of our readers is called to mention of these structures by Messrs. A. P. Davis and D. C. Henry in the article on Masonry Dams which appeared in our issue for January 27th.

Lake Spaulding Dam.—This dam is located on the South Yuba River, near Emigrant Gap, Cal., and is owned by the P. G. & E. Co. The distance from the Southern rock was conveyed from under the storage bins to the top of the mixing house by means of belt conveyers, and from here distributed into measuring hoppers. The cement was brought in by a belt conveyer from the storage house and the mixing of the gravel and cement was done on the second floor of the mixer house. On the first floor of the mixing house were four 1-yard mixers driven by electric motors. Stretched across the canyon above the dam were two cableways each having a span of 1,400 ft. The cables were 2 in. in diameter with a breaking strength of 170 tons. The operating cabins contained a variable speed hoist and traversing line, centrally operated by a 112-h.p. induction motor. These cableways handled all material except concrete.

The concrete from the mixers was transported to the dam by gravity in a 30 in. wide by 12 in. high wooden



Contraction Joint.

Fig. 1.—Sections of 225-foot Lake Spaulding Dam.

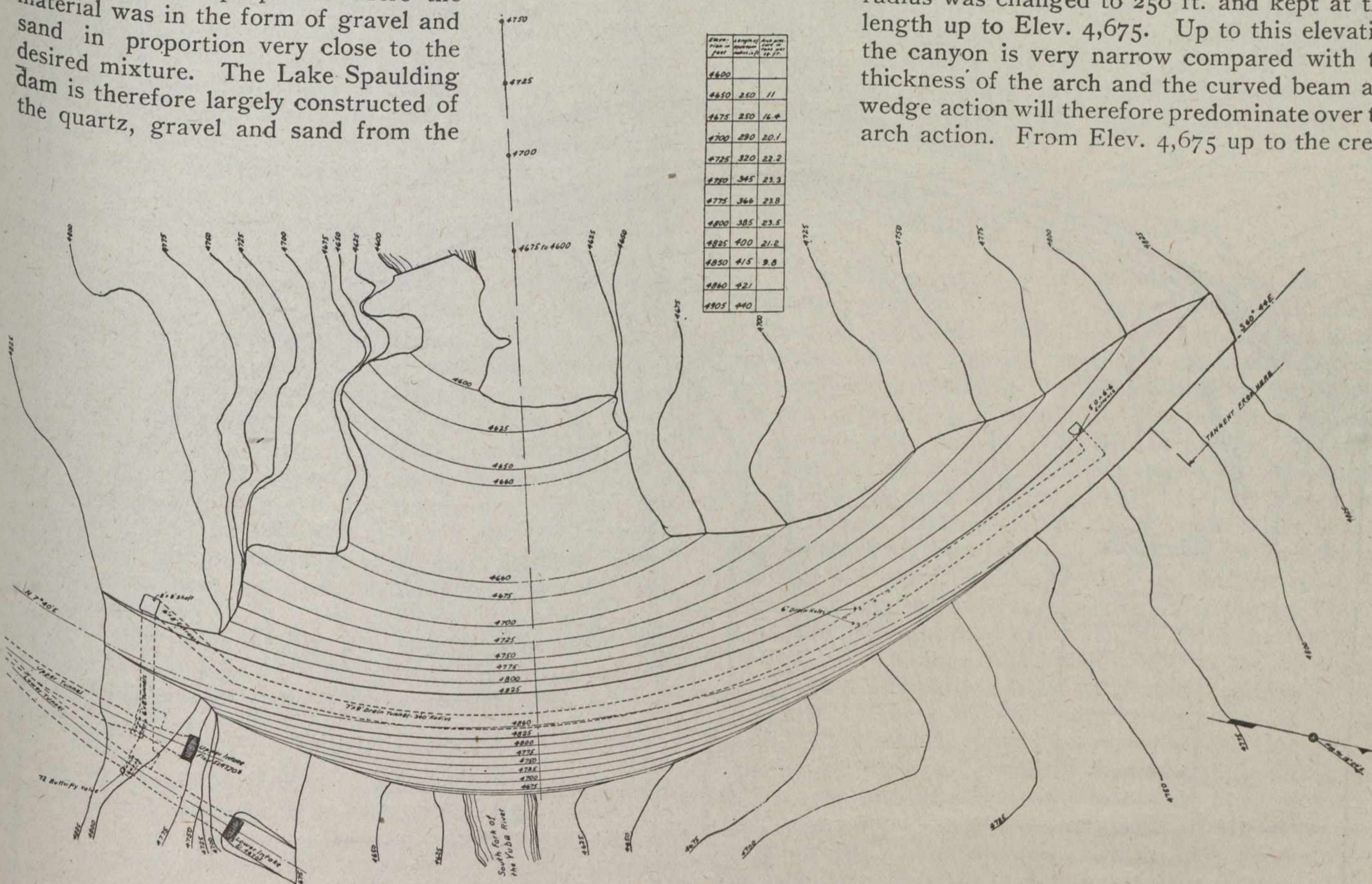
Pacific Co.'s railroad at Smart to the dam site is only 2.3 miles. Over this distance the company themselves built a standard gauge track to facilitate the transportation of material and men. The track terminated at the works plant elevated somewhere above the crest of the dam. The works consisted of a compressor house, a mixing plant, storage bins for crushed rock and gravel, and two rock crushers. It was possible to place the crushed rock in the bins or to dump sand and gravel from the cars in the bins as required. On the hillside below the bins was located the mixing house, built in four stories. Gravel or flume, lined with 5/8-in. thick cast iron plates on the bottom. This flume had a slope of 1 : 3 down the hillside to a nearly vertical cliff at the south abutment. A tower was constructed below the cliff provided with short sections of chutes built as baffles, allowing the concrete to drop to the bottom of the tower, where it was discharged into a number of distributing chutes. When the crest of the dam had reached the top of the tower the concrete could no longer be distributed by gravity flow, and a series of 30-in. belt conveyers with a slope of 18° was installed along the top of the dam. The support for these conveyers was made of steel and left in place, jets of compressed air swept the belts clean of concrete at points of discharge. Fifty thousand yards of concrete was handled in this manner.

The material of which the dam has been built was subject to much study and experimentation before being used. There was discovered several sand deposits within a short distance of the dam, but this sand contained a certain amount of silt, so that washing would have been necessary and the amount of sand required could not have been furnished fast enough to maintain the progress decided upon. A source of supply in the Bear River, near Colfax, about 60 miles away, was chosen as the best one available for the purpose. Here the material was in the form of gravel and sand in proportion very close to the desired mixture. The Lake Spaulding dam is therefore largely constructed of the quartz, gravel and sand from the Bear River, with but a small proportion of other gravel and rock, necessary to mix in at times when the bank run of the natural gravel deviated the desired proportion. Throughout the work, samples of green concrete were taken from the dam after concrete had been deposited, these samples being obtained at various points in the dam. Enough samples were taken every day to supply three for a 7-day test, one for a 28-day test, one for a 60-day, one for a 90-day and one for a 5-year test. Each day the test samples, as their time became due, were broken, and very complete records were made on each to determine the condition of the mix and to make any corrections necessary.

The average minimum crushing strength per square inch was about as follows: 7-day specimens, 400 lbs.; 28-day, 900 lbs.; 60-day, 1,000 lbs. or more. The ultimate strength should considerably exceed these amounts. The proportion of the mix generally used for the lower portion was 1 part of cement, 2½ of sand, and 4½ of gravel. Towards the crest the mix was made richer, about 1:6, using up to 1¼ barrels of cement per cubic yard. A wet mix was used, which was turned for 1½ minutes in the mixers before being discharged into the gravity flume. By experimenting, it was found that 1½ minutes was the minimum time to thoroughly mix a batch, so as to ascertain maximum compressive strength.

Design.—It was first proposed to build a gravity dam, arched in plan, having an upstream radius 600 ft. long. Such a structure was started in 1912 and during that year reached an elevation 28 ft. above the river bed at the upstream face and less at the downstream face, as shown on Fig. 1. During the winter the original plans were changed and the construction of the dam continued the following summer in accordance with design shown on Figs. 1 and 2. At Elev. 4,628 the length of the upstream radius was changed to 250 ft. and kept at this length up to Elev. 4,675. Up to this elevation the canyon is very narrow compared with the thickness of the arch and the curved beam and wedge action will therefore predominate over the arch action. From Elev. 4,675 up to the crest, the length of the upstream radius increases so as to keep the subtended central angle as constant as possible, as shown by the table in Fig. 2. This subtended angle is not as large as could be desired, but is as great as the site would permit, considering that the ultimate proposed crest elevation is to be at Elev. 4,905, and considering that this type of dam had to be built on top of the other type already started. The proper place for the new type would have been about 100 ft. further upstream.

The Lake Spaulding dam is provided with an inspection tunnel, a drainage system and contraction joints; which are usual features in dams of large proportions. These details are shown plainly in Figs. 1 and 2. The section of the arch above Elev. 4,660 is of such dimensions that it will stand an extension of 35 ft. in height above the present crest elevation (4,825) without any addition to its thickness. The maximum arch stress (q in Formula 1, page 317, *The Canadian Engineer*) will exist at Elev. 4,775 with the water level at Elev. 4,860, or 260 ft. above the river bed, and will amount to 23.8 tons. It is fairly



Elevation in feet	Length of upstream radius in ft.	Arch pressure in tons per sq. ft.
4600		
4650	250	11
4675	250	16.4
4700	290	20.1
4725	320	22.2
4750	345	23.3
4775	366	23.8
4800	385	23.5
4825	400	21.2
4850	415	9.8
4860	421	
4905	440	

Fig. 2.—Lake Spaulding Dam and Tunnel Intakes.

constant over the greatest portion of the structure, as can be seen from the table in Fig. 2.

In order to cut down the first cost of the structure the section was not given the required thickness for the ultimate height of 305 ft., but only the thickness necessary for a 260-ft. dam. So, when the time comes to extend the crest of the dam to Elev. 4,905, a slab of concrete must be added to the downstream face, and, in order to effect a good bond between the present dam and the new slab, the downstream face of the present dam has been stepped off and a sufficient number of iron rods (old rails) have been left protruding several feet to grip the new slab and hold it in place.

The two outlets have their intakes through solid rock at a point about 50 ft. upstream from the upstream face. These intakes are covered with a heavy grating of flat steel bars set on edge, and are the ends of short steel pipes which extend into tunnels to a gate chamber in each. The intake pipe tapers from 10 ft. to 6 ft. at the gate. The gate has a cast steel butterfly valve which is operated through a lever and gear mechanism by either hand-wheel or 7½-h.p. induction motor specially designed for the purpose. Access to this chamber is provided through a tunnel which connects with the inspection tunnel into the dam, this tunnel being driven through the rock, and by means of a vertical shaft is brought above the dam to the gate house. One intake is to Elev. 4,670 and the other is located 100 ft. above. The upper intake slopes downwards about 48° until it meets the lower tunnel, this slope starting a few feet back of the upper butterfly valve. About 1,000 ft. downstream the single pressure tunnel, which is concrete lined, ends in an adit, and is there provided with a second butterfly valve and also with two pressure reducers. Later, it is intended to install a 5,000-kw. turbine and to let this act as a pressure reducer by utilizing whatever head there may be in the reservoir. From this point the water flows by gravity towards the power house below, of which one is built, and four more projected using the same water.

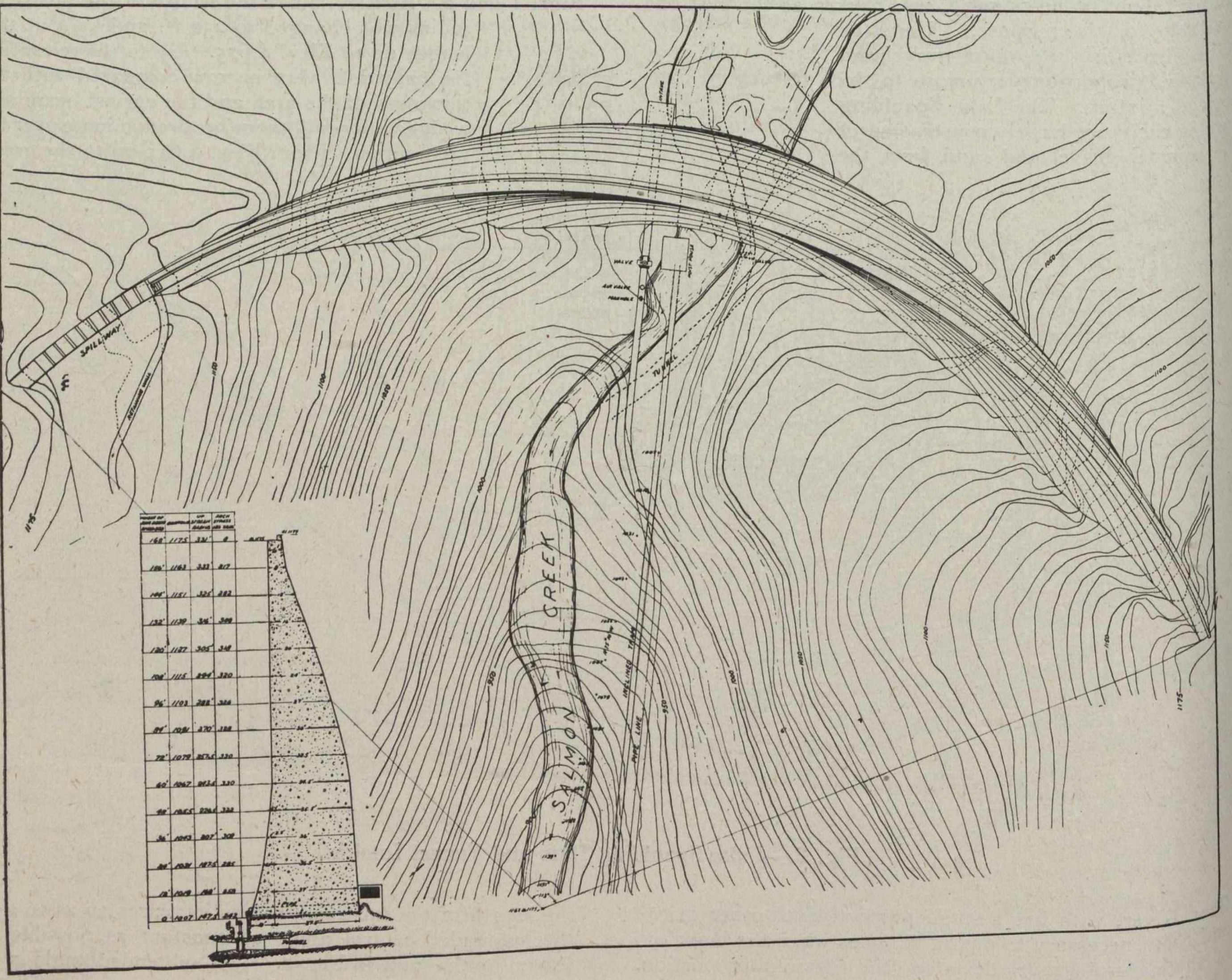


Fig. 3.—Salmon Creek Dam, Near Juneau, Alaska.

In the actual design as used (Fig. 2) the writer's arch theory and the shape of the upstream face suggested in designs submitted by him, have been followed except near the foundation, as already explained.

This dam has developed one vertical crack between each contraction joint, tending to show that, for this case at least, 80 ft. between each of these joints was too great a distance. The cracks and the contraction joints close when the water pressure comes on the structure. The dam, as far as completed, contains 153,000 cu. yds. of concrete. A saving of 46,000 cu. yds. was brought about by the new design. The cost, including everything except outlet mechanism, was $8.50 per yard. The expected unit cost for the completed dam is $6.30.

Salmon Creek Dam, Near Juneau, Alaska.—This dam is built by the Alaska Gastineau Mining Company for the purpose of storing 18,000 acre-feet of water. The catchment area is only 7.5 square miles, but the precipitation is more than 100 inches per annum, giving a run-off of about 7.3 second-feet per square mile.

Fig. 3 shows the plan and section of this dam, 168 ft. high above the river surface, containing 52,000 cu. yds. of concrete, having 1.25 barrels of cement and 5 per cent. of hydrated lime per cubic yard. The unit cost of this dam, including everything, was very nearly $7.50 per yard.

As can be seen from the contour map, the sides of the canyon form an unusually regular V, and therefore all the different arch centres could be located on one common centreline. The crest width of the dam is approximately 550 ft., measured in a straight line, and the arch at this elevation subtends an angle of 113°. The centres and the lengths of the upstream radius are shown for various arch slices 12 ft. apart in elevation, and the unit axial stresses are given in the table adjacent to the section of the dam (Fig. 3).

To provide better accommodations for the spillway, the curve for the top 12 ft. of the dam was struck from the same centre, therefore the warping of the faces commences 12 ft. below the crest, and continues down to the foundation. The form work for this type of dam is no more difficult than for an ordinary arch dam, as far as the carpenter is concerned; he gets his points about every 10 ft. apart, and it makes no difference to him whether he builds up the face of a cylinder or an inverted cone (approximately). The surveyor, however, has to be more careful than with the layout of an ordinary arch, as, in the present case, there are more calculations to be made and to be followed.

From the table on Fig. 3 it can be seen that the length of the longest upstream radius is 333 ft., and the length of the shortest 147.5 ft., the ratio between the two being $\frac{333}{147.5} = 2.26$. Had the length of the upstream radius been kept constant, the thickness of the dam at the bottom would have had to be increased 2.26 times for approximately the same axial stresses. Relative to this, it should be noted that the arch stresses in the table assume the arch to take the total load, but in reality the stresses are somewhat smaller, as the cantilever takes part of the load. The triangular piece, 10 ft. wide at the bottom, is not considered in the table giving the arch stresses. This is added to the lower part of the dam on the downstream side for the purpose of stiffening the cantilever where it is highest.

To have kept the subtended angle constant at 113° at all elevations would have necessitated a greater ratio than 2.26 between the length of the two upstream radii already referred to. Had this ratio been increased the structure would have been overhanging too much in places, and therefore this increase could not be made. This simply shows that it is not always possible to make theory and practice coincide exactly. To have kept the central angle constant at 113° in this case would have required greater bottom width of the site. The saving of this type of dam compared with an ordinary arch dam for this site was somewhat over 20 per cent. The construction material was gravel from the reservoir bottom in the immediate vicinity of the dam. This gravel was scraped into a hopper by means of a drag bucket. From there a 24-in. belt conveyer elevated the same to a screen, where it was separated into sand and pebbles in order to be remixed later into correct proportions. The oversize pebbles were delivered to a crusher and after crushing, returned to the screen. Two 18-in. belt conveyers carried the sand and pebbles respectively to the mixing house located near the central hoist. After leaving the mixer the concrete was hoisted, say, 50 ft. above the dam level and distributed by gravity through steel chutes to the different parts of the works. Ordinary good progress was 400 cu. yds. per day. This dam is provided with two expansion joints which was deemed sufficient on account of the fairly slender, and therefore more elastic, body.

The structure has been in use for two seasons and only one crack has developed, located near the spillway. Cubes made from the concrete were crushed from time to time and results obtained were about as follows: 1,100 lbs. per sq. in. at 28 days, and 1,800 lbs. per sq. in. at 60 days. This dam was not plastered on the upstream side, and experience has proven that this is not necessary, either.

HUDSON BAY ROAD

The acting minister of railways, Hon. Dr. Reid, recently gave the House at Ottawa some information respecting the Hudson Bay Railway. Up to the end of last year, the expenditure upon this road, which will be an everlasting tribute as to what politics can thrust upon a country, was $15,465,304. The length of the line from Le Pas to Port Nelson will be 424 miles. As acting minister of railways, Dr. Reid apparently felt it necessary to defend the road from its critics. He did it in a way which makes us believe that away back in Dr. Reid's innermost thoughts where political considerations are not allowed to enter, an opinion exists that the road is a farcical enterprise. He said, among other things, "While I myself may have had grave doubts as to the feasibility of this undertaking, yet I have come to the conclusion . . . that this road will be of value to the country in time to come." There was no doubt in his mind as to the navigability of Hudson Bay and Straits "for several months of the year." "But," he added, "it is true that during the first season, two vessels were cast away right at Nelson under circumstances which have never been satisfactorily explained," and "which have absolutely no bearing upon the practicability upon the Nelson route."

Dr. Reid even allowed his enthusiasm to say that he believed for the amount which the road will cost, it will "in years to come have a military value which will be well worth while," information which should be of interest to the minister of militia. "It is not expected, of course," said Dr. Reid, "that there will be any great rush during the first few years after the completion of this road and harbor." Continuing in the same strain, he says: "It is, of course, unfortunate that this great expenditure was commenced only a short time previous to the outbreak of war."

Dr. Reid's eulogy of the Hudson Bay railroad reads as if he, an unwilling victim, had been thoroughly instructed as to what to tell the House. But he said his piece very badly. However, what can we do when The Graingrowers' Guide, for example, says: "The East may as well understand that the West believes in the Hudson Bay route and will brook no interference with the scheme." Experience sometimes has to be bought dearly.

A surveyor in an English municipality is making investigation as to the growing of osiers on sewage works.

THE PROPER USE OF GRAVITY CHUTES.*

THE concrete gravity plant has had a very rapid development because of its undoubted economy in the time and labor cost of distributing concrete and its practically universal adaptability to all classes of concrete structures. The straight lift in a tower for the vertical distance between the mouth of the mixer and the top of the forms, and then an additional lift of about 1 foot for every 3 of horizontal distance between the two before turning the concrete over to gravity to carry it across from the tower to the forms, is about as near to Nature's absolute foot-pound requirement as can well be devised.

Like any new process which, because of easily apparent advantages, comes rapidly into general use, its use has outrun the rules of practice which a more conservative introduction would have established for it, with the result that every user has made his own rules with little guidance except his own experience and with as variable a product as this procedure might suggest. It is well, therefore, that some thought be given to the statement of some of the fundamental conditions which must obtain to insure a good concrete, which is of absolute importance, as well as to realize the largest ultimate factor of economy in operation, these two ends being obtained by the same means, the one depending on the other, the best concrete being the most economical to handle.

The typical plant consists of a tower with a hoist bucket which takes the batch of concrete from the mixer, a receiving hopper with a controllable gate near the top of the tower into which the batch is dumped from the hoist bucket, and a series of chutes or troughs which carry the concrete to the forms. The tower is frequently as high as 200 feet and the line of chutes may carry the concrete as far as 500 feet from the tower; and by using a relay tower the concrete is placed in the forms at 1,000 feet from the mixer. The chutes may be connected in a straight continuous line from the hopper to the forms, or this line may be interrupted by line gates through which the concrete is dropped a vertical distance through a closed pipe and then to the forms; or by an assembly of horizontal swivel-connected chutes it may travel in a more or less zigzag path, dropping from the end of one chute into the swivel head of the chute below as it proceeds.

The matter of first importance to the successful operation of the gravity plant, as well as of any method of distribution, is the condition of the concrete when it is discharged from the mixer. Concrete is in proper condition for the gravity plant when it has been subjected to the action of a well-designed mixer long enough to thoroughly incorporate all of the aggregates, the batch being assembled with the proper amount of water to hold all of the aggregates in suspension, the resultant mixture being a viscous, homogeneous mass. As to how long the batch should stay in the mixer and as to the amount of water in percentages which this requires, our interest, so far as the chutes are concerned, must be confined to resultants and we must consider these questions as proper subjects for separate discussion. The concrete should not be so dry that it will not level off on top as it stands in the bucket, nor should it be wet enough to show water on top of the bucket if left standing for an appreciable length of time, nor to allow a stone to sink much over its thickness when placed on top of the mass.

Too dry concrete limits unnecessarily the range of distribution from a tower of a given height by requiring a steeper chute to carry it. A wet concrete which allows the heavier aggregates to settle to the bottom will separate in travel and is to be avoided as one of the unpardonable sins. By all means let the concrete be too dry rather than too wet; but there is the right consistency which avoids both extremes. But these problems are problems of mixing, however vitally they may affect the economy of the distributing plant. Properly assembled and well mixed concrete will maintain its integrity by whatever method it may be distributed, and concrete which is too wet will allow the stone to settle to the bottom of the form and the mortar will come to the top regardless of the means used to carry it there, while concrete properly assembled, but too hastily mixed, will be very much improved by the movement through a line of chutes as against any other method of transportation. It must be borne in mind, however, that the gravity plant is a plant for distribution and not for mixing and that the concrete must be good concrete, well mixed when it is delivered to the hoist bucket, or it cannot be expected to be good concrete when the forms are removed.

If the concrete reaches the chutes as a homogeneous mass the slope of the chutes is not of vital importance. That slope is generally the best which will allow the concrete to flow with the least velocity which will insure its passage, although a vertical drop in a closed pipe is a feature of many installations on important work. Such vertical lines, however, should have baffles every few feet to arrest the drop and the concrete should be distributed at the bottom by means of a horizontal chute whenever possible and not directly from the vertical line into the forms. The required minimum slope to carry the concrete properly will vary with the character of the aggregates, the average slope for small, round gravel being 1 of rise to 3 of run, or an angle of about 18 degrees with the horizontal; the slope for 1-inch stone, about 1 to 2¾, or 20 degrees; for 1½-inch stone, 1 to 2½, or 22 degrees; and for 2-inch stone, 1 to 2¼, or 24 degrees with the horizontal. It is better practice on a long line to hang the chutes with a gradually and very slightly increasing grade as they travel toward the lower end, such a grading being less likely to cause an overflow in the chutes than the reverse. The final distributing section which places the concrete in the form should retard the concrete to as slow a movement as will carry it at all.

In the travel through the chutes the concrete should flow in a constant, uniform stream so far as possible. The man on the tower at the hopper gate is a very important member of the operating crew. An intermittent rush of concrete is apt to congest the chutes, causing overflows, shut-downs, the retaining of concrete in the tower hopper for an undesirable length of time, and damaged work.

The concrete should be placed by the chute as closely as possible at the point where it is to remain. For floors and shallow beams the final chute section should be easily portable with the mouth close to the forms and the concrete travelling as slowly as it can be made to run. For column forms and deep girders the gravity plant provides a closed, flexible drop pipe with frequent baffles or arresters for placing the concrete in the bottom of the form, obviating the objectionable practice of dropping it in the open from the top. If concrete is dropped from the top of a column form in the open, or even in a closed pipe without obstruction, the kinetic energy of the stones in the aggregate will drive them toward the bottom of the mass, separating them from the mortar; while if frequent baffles are places in the vertical pipe the mass will retain its homogeneous character.

*A paper presented before the American Concrete Institute by W. H. Insley and C. C. Brown of Indianapolis.

REFUSE REMOVAL AND DISPOSAL IN MOOSE JAW

A DESCRIPTION OF PRACTICE SUITABLE FOR CITIES OF TEN THOUSAND TO FORTY THOUSAND POPULATION, GIVING TABLES OF COSTS.

By Geo. D. MACKIE, City Engineer.

A CAREFUL record was kept during last year of the quantity of refuse removed and disposed of, and the cost of removal and disposal, and these figures are presented here, not with the idea that the results achieved are specially good, but rather that they may form a basis of comparison by engineers of other cities and towns.

Unfortunately the keeping of records and the collection of data in connection with this phase of municipal work has not been extensively practiced by engineers, more especially in Western cities, and this is no doubt due to the fact that during the last few years the major portion of a city engineer's time has been spent in the designing and carrying out of new works, rather than in supervising and managing the many utilities which usually fall within the sphere of a city engineer's activities.

It is unfortunate, but none the less true, that many cities spend large sums of money on civic enterprises, and after these works have been completed, councils grudge the necessary money to assure that these same works shall be run economically, and in the best interests of the city. The council of the city of Moose Jaw, however, have not been slow to recognize the fact that the money spent on the management of the various works under their control is money well invested.

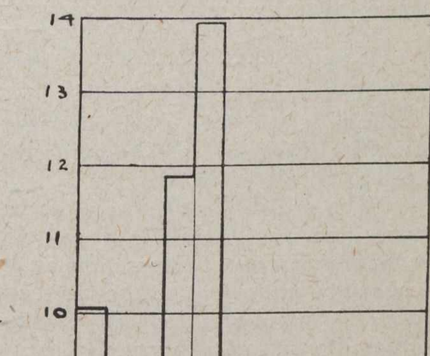


Diagram 1.—Monthly Variation in Percentage of Garbage and Refuse Removed.

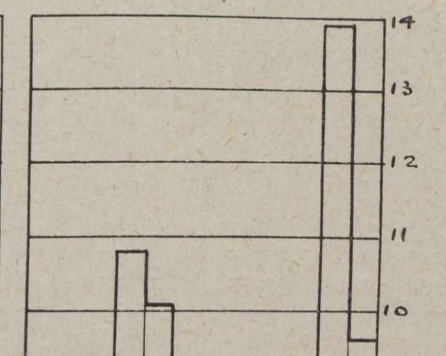


Diagram 2.—Monthly Variation in Percentage of Total Refuse Removed.

Prior to March, 1915, the management of the scavenging department was under the control of the health department, but at that time was transferred to the city engineer's department, and by this transference many economies have been effected, more especially in the number of teams employed. The whole work is carried out with the city's own teams, and prior to the work being taken over by the city engineer, it occurred time and again that the health department might be short of teams to carry out their work, while the engineer's department might have a surplus of teams, and no work to put them to.

In the removal of household refuse an organization is required that is sufficiently elastic to take care of the wide variations in the quantity of refuse that has to be dealt with from month to month, and where a scavenging department has no other work to engage in, the consequence is that at certain seasons there is an insufficiency of teams to cope with the work, and at other times it is necessary to hire teams to overtake the work. When, however, this department is combined with, say, the street maintenance department, and in this connection it must be understood that the writer has especially in mind the work required to be done in cities of, say, from 10,000 to 40,000 population, the combined departments will possess the necessary equipment to take care of all the work without having on hand any idle teams, or having such a rush of work that it is necessary to hire teams. This statement is borne out by Table 1, which shows an increase of garbage and ashes removal in November as compared with October, of over 156 per cent., which was overtaken by the engineer's department without the necessity of hiring a single team.

As already stated, the operation of the refuse removal and disposal departments is under the control of the city engineer, and is operated by the works department branch. The city possesses its own stud of horses, and the necessary wagons and other plant for the operation of the department. All horses, wagons, etc., owned by the city are controlled by the works department, and are hired out by that department to the various departments requiring teams, at a rate of $5 per day of ten hours. Any surplus, after paying the cost of running the stables, repairs to rolling stock, etc., is divided amongst the different department in proportion to the amount spent by them in team hire.

Moose Jaw has a built-up area of 4.87 square miles, and an estimated population of 20,000. All household refuse is removed weekly, and is separated into two classes for removal, *viz.*, (1) garbage, which includes animal and vegetable wastes, and household rubbish, and (2) ashes. The garbage is disposed of by burning in the city refuse destructor, which is situated about 1.33 miles from the centre of the city. The ashes are used for filling up low-lying places in the city. Householders must supply a covered galvanized can of about 2 cubic feet capacity for garbage, which must be placed at the rear end of the lot for convenience of handling by the teamsters. The wagons used in garbage collection are of wood with canvas cover, and of 3½ cubic yards capacity. No effort has been made to insist on ashes being deposited in cans; householders simply deposit these at the rear of their lots, so that they may be readily collected and removed. Last year the average number of teams employed removing refuse was 5.9; the largest number used was 9.8 in May, and the minimum 4.1 in August.

Table 1.—Refuse Removal, 1915.

Month.	Garbage (tons)	Ashes (tons)	Total (tons)
January	354.17	169.50	523.67
February	296.77	196.50	493.27
March	284.15	157.50	441.65
April	406.85	246.00	652.85
May	479.59	134.25	613.84
June	297.94	201.00	498.94
July	211.08	135.50	344.58
August	237.57	117.00	354.57
September	239.59	136.50	376.09
October	238.73	88.50	327.23
November	231.02	607.50	838.52
December	152.45	430.50	582.95
Totals	3,429.91	2,618.25	6,048.16

Diagram 1 shows the monthly variation in percentages of garbage removed annually, and Diagram 2 the monthly removal in percentages of the total refuse removed.

Table 2 gives the quantity of refuse removed and detailed statement of the expenditure for removal, as well as the cost per ton.

Table 2.

Quantity of refuse removed—	
Garbage	3,429.91 tons
Ashes	2,618.25 tons
Total	6,048.16 tons

Cost of removal—	Total cost.	Cost per ton.
Teaming	$7,217.75	$1.202
Supplies	98.93	0.006
Superintendence	688.65	0.112
Engineer's office expense	145.10	0.024
Insurance	100.44	0.016
Totals	$8,250.87	$1.36
Less credits	618.25	0.10
Net cost	$7,632.62	$1.26

The percentage of garbage removed to ashes was:—

Garbage and rubbish	56.71 per cent.
Ashes	43.29 per cent.
	100.00 per cent.

The cost of removing each class of material was:—

	Cost.	Cost per capita.
Garbage and rubbish	$6,017.63	$0.30
Ashes	1,614.99	0.08
	$7,632.62	$0.38

The quantity of each class of refuse removed per capita was:—

	Per capita per annum.	Per capita per day.
Garbage and rubbish	342.98 lbs.	0.94 lbs.
Ashes	261.82 lbs.	0.72 lbs.
Total	604.80 lbs.	1.66 lbs.

Based on the above figures, and assuming six persons per family, which is a fair average for Moose Jaw, the quantity of refuse removed per family per annum was 1.81 tons at a cost of $2.28.

The refuse destructor is of the Heenan and Froude type, and was erected in 1912. It has a capacity of 50 tons per day of 24 hours, and in 1913 it was run at full capacity, but owing to the decrease in population which occurred in Moose Jaw, in common with all Western cities, it was only operated 56 per cent. of the total possible hours of working, and as a consequence, the cost per ton of incineration was much higher than in 1913.

The total quantity of refuse destroyed was 6,027 tons, and Table 3 shows the expenditure in detail, together with the cost per ton.

Table 3.

	Total cost.	Cost per ton.
Wages	$ 7,595.88	$1.261
Repairs and supplies	701.53	0.116
Hauling clinker	519.20	0.086
Light and water	338.80	0.056
Insurance	137.27	0.023
Engineer's office expenses	51.74	0.008
Total operating cost	$ 9,344.42	$1.55
Depreciation	553.04	0.091
Interest on invested capital	2,378.86	0.394
Gross total	$12,276.32	$2.035
Less steam sold	454.46	0.073
Net cost for 1915	$11,821.86	$1.96

Summing up, these results show the following costs of refuse removal and disposal for 1915:—

Table 4.

	Removed or destroyed (tons).	Cost.	Cost per capita per annum.	Cost per family per year.
Refuse removed	648.16	$ 7,632.62	$0.3816	$0.044
" destroyed	6,027	11,821.86	0.591	0.068
		$19,454.48	$0.0726	$0.112

All refuse is weighed at the destructor. The weight of ashes is computed.

A charge of $2 per load is made for the removal of trade refuse. The city does not remove all manure.

Closely connected with this subject is the question of night soil removal. All houses in Moose Jaw not having sewer and water services, are required to provide suitable outside closet accommodation, and the city provides suitable pails of 1½ cubic feet capacity each, at a total cost to the householder of $3.05. The contents of these pails are removed weekly. In summer the removal is carried out at night, and in winter during the day. The contents of the pails are discharged into the detritus chamber at the sewage disposal works, situated 1½ miles from the centre of the city. After removal of contents, the pails are steamed with steam from the incinerator, and disinfected. Two men are employed at the pail-washing shed, and in summer four teams are used for carrying out the work of removal. The contents of the pails are emptied into an approved swill tank, the dirty pail is taken to the pail-washing house to be cleaned, and a fresh pail left in its place. In winter the pails, with contents, are removed to the disposal works.

Table 5 gives details of last year's operations.

Table 5.

Number of pails removed, cleaned and contents disposed of	102,497
Average number per week	1,971
Total cost of work	$10,429.49
Total cost per pail removed, cleaned, returned and necessary repairs, etc.	$0.10

TREATED WOOD BLOCK FOR FACTORY FLOORING AND MISCELLANEOUS USES.

Since 1900 there has been a steady and rapid increase in the use of creosoted wood blocks for paving the streets of our cities. A more recent development, and one which promises to become an important source of business to the manufacturers of these blocks, has been their adoption for a variety of uses other than street paving, according to C. H. Teesdale in the current issue of "Wood Preserving." Those qualities which make the wood block desirable for street work, it seems, should also make it desirable for flooring where heavy trucking, the moving of heavy machinery, etc., make the maintenance of floors a serious problem.

Plants producing the largest quantity of this material, point out that the wood block flooring problem naturally divides itself into two classes: (*a*) Blocks used in very dry situations, as in factories and warehouses; (*b*) those used in alternately wet and dry, or in wet situations, as in stable floors, docks, wharves, slaughter houses, etc., where the blocks are exposed to the weather, to flushing with water, etc.

The treatment and method of handling the blocks differs radically in the two cases. The concensus of opinion is to use a distillate creosote, especially for dry situations, and a heavier paving oil for wet conditions.

Comparatively light absorptions (from 5 to 8 or 10 lbs. per cubic foot) would prove satisfactory for dry situations. Heavier absorptions ranging from 8 to 16 lbs. per cubic foot, are recommended for alternately wet and dry or for wet situations.

Southern yellow pine 3-in. blocks air-dried, are preferred.

In a large proportion of cases it was reported that wood block was easy on the feet of the workmen and that they like to work on it. Noiselessness, ease of repairs, low upkeep cost, good trucking surface, saving of breakage in tools and fragile metal parts dropped on the floor, warmth, and cleanliness and durability were all reported as advantages of wood block flooring.

THE DESIGN OF PASSENGER TERMINALS.*

By J. L. Busfield, A.M.Can.Soc.C.E.

It is only necessary to compare the modern railway passenger terminal with some of the older types, to be struck with the great advances made, to the benefit of both the public and the railway companies. Not only have conveniences and arrangements been provided which were undreamt of a few years ago, but the great element "Safety first" has entered very largely into the operation of the trains.

Dealing with the subject from the point of view of the engineer, one's first impression is that a study of existing terminals is of little real value in the preparation of a design for a new terminal owing to the apparent lack of similarity in all of the important features of the terminals. A closer and more intimate study, however, reveals the important fact, that notwithstanding large differences in shape, size, traffic and local conditions, there is to be found a remarkable similarity in the general principles upon which the designs are being carried out in the terminals of to-day. It is proposed to deal mainly with these general principles in this paper, and although the financial side of the problem has been purposely omitted, great importance and ultimate bearing on any design must not be overlooked.

Architecture.—The subject of architecture as applied to passenger terminals is one on which, no doubt, volumes could be written, but there are one or two points to which it may not be inopportune to refer. One of these is the external design and appearance of the station building which should naturally express the generally accepted idea of a railway station, and also, especially in the case of a large city, have the character of a monumental gateway and entrance to a great city and great railroad.

Another important point is the necessity of co-operation between engineers, architects and operating officials. The architect is possibly a little inclined to err on the side of "a thing of beauty is a joy forever," while the engineer, on the other hand, is rather apt to be purely utilitarian in his ideas, and the operating officials are naturally most concerned in being able to handle the traffic in and out of the terminal in the most efficient manner. In order to obtain the best all-round results a thorough co-operation of the different departments is essential, and instead of turning over the preliminary plans to the architects, as is frequently done, a thorough study of operating methods, traffic and engineering problems should first be made, preferably by a committee representing the various departments interested.

Still another feature which both architects and engineers should try to remedy, is the long distance the passenger has to walk between the entrance to the station and his train. Any effort to reduce this distance to a minimum will be well repaid. In one of the most modern terminals in the States, the average passenger walks a distance approximately 1,000 ft., and although there is prevalent an idea that the public can be fooled into believing that once they enter the station portal they are close to their trains, after a few trains have been missed, however, it is realized that the station is not quite as convenient as might have at first been imagined.

While discussing architecture, mention must be made of the rather remarkable differences in sizes of waiting rooms and other facilities, even in terminals which cater

*Abstract from paper read before the Canadian Society of Civil Engineers, March 9, 1916.

to the same volume and nature of traffic. A study of the actual figures reveals the fact that the sizes of waiting rooms vary from 0.1 to 5.0 sq. ft. per passenger using the station. Apparently, therefore, there is a large amount of guess work entering into the design of station buildings.

Electric Operation.—The electrification of railways in terminal zones has done more than any other single circumstance to alter and improve the conditions existing in large passenger stations. The abolition of smoke and steam, together with their resulting dirt, not only improves the whole atmosphere, but also leads to brighter, cleaner and generally better conditions of all the various parts of the station. Apart from the improved atmospheric conditions, electric operation has made possible a type of terminal in which the tracks are entirely underground, or at any rate, covered over by the station building or offices. The importance of this possibility is that large areas of valuable city real estate need not be entirely

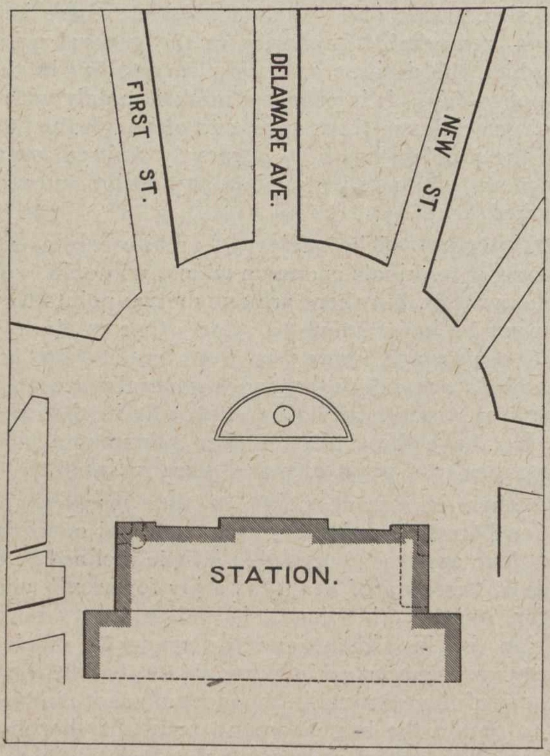


Fig. 1.—Plan of Approaches to Washington Union Station.

devoted to trackage, but can also be used for revenue-producing purposes, such as offices, hotels, etc. A terminal such as the Grand Central in New York would have been an impossibility without the use of electric power.

In addition to this feature there are others of equal importance developed by the use of the electric locomotive. For example, the greater acceleration of this type of engine compared with the steam engine results in the general speeding up of the train and switching movements in the yards, which is a great benefit at any large traffic centre. It is also often possible to utilize steeper grades when electric locomotives are used, this feature again being illustrated in the Grand Central, New York, where there are grades of 3% leading to the suburban level. The operation of a terminal with electric power is also frequently simplified by the fact that only one type of locomotive is used for all the various movements, whether they are empty drafts, long distance trains, or only switching services.

Trainsheds.—There has been a marked change in the standard form of trainshed, the old type of large single-span roof being more or less obsolete as far as the modern terminal is concerned. This type had a number of disadvantages which are mostly overcome by the improved form of umbrella shed now used. That this idea is not new, however, is shown by the following item taken from a copy of "Engineering News" nearly twenty years ago:—

"An arrangement to facilitate the ventilation of and the carrying off of smoke and steam from the interior of train sheds is proposed by Geo. C. Croker, of Boston. It is more particularly applicable to low roofs of moderate span, and consists of a continuous ventilator or chimney over the middle of each track, and running the whole length of the track. Whatever may be the desired height of the ceiling or roof this ventilator extends down nearly to the top of the smokestack."

The use of this type of shed at the Windsor Street Station, Montreal, the Central Station, Ottawa, and at many other important stations, has made it so familiar that no further description is necessary. Apart from the abolition of the smoke nuisance they have the advantage over the large span roof in that they are less costly to erect, less costly to maintain, and also safer. The condition of the air which accumulates in the top of the dome-like structure of the single-span roof has been proved to shorten the life of the steel very considerably.

Site.—In selecting the site, good judgment has to be used in order that undue restrictions will not occur, such as might be caused by streets, valuable properties and natural conditions. It has often happened that restrictions of this nature have occurred to such an extent as to be actually obstructive to the construction of an efficient layout of the tracks and buildings.

Neighboring Conditions.—It is not only the natural controlling features within the station site that affect the layout of any terminal, but it is also necessary to make a complete study of the immediate neighborhood, both with regard to the railway, and also with regard to the adjoining part of the city. One feature playing a prominent part in any design is the elevation of the tracks, in relation to the natural ground level, as terminals with the approach tracks either above or below the latter will usually be of a very different type to those where the tracks are at grade. Terminals with two or more stories are far more common than they used to be owing to the fact that it is often difficult to approach a terminal on the ground level without having a number of grade crossings, which to-day will not be countenanced. In some cities, however, the natural features favor the adoption of a layout with the tracks level with the adjoining streets, without any grade crossings, but the two-story terminal has a number of advantages, such as economy of ground space, facility of handling baggage at a separate level from the platforms, and the segregation of traffic. The relative location of the station, the coach yards and engine sheds have an important bearing on the final layout of the terminal on account of the switching movements necessary for the moving of the empty trains. When the coach yards are located at some distance from the terminal the road engine usually makes an independent run, while the empties are handled by yard engines, making it desirable that a means should be provided for running the engine around the train, otherwise it will be tied up for a lengthy period in the platform. As an alternative the train may be pushed into the trainshed backwards, but this method is not considered to be good practice if the distance is at all great. A large number of the movements involved in these forms of operation are eliminated in the case where the coach yard is adjacent to the terminal, and the road engine can hitch on to its train and back it into the trainshed.

It should hardly be necessary to mention the desirability of having the station face an important thoroughfare or public square, but in cases where there is competition between different railways the prominence of a terminal building is apt to be of vital importance. A little study of this aspect and perhaps a little expenditure on real estate will usually be repaid by the improvements effected. This is a feature which is given considerable prominence in Europe, as almost every city of any importance has a dignified and spacious approach to its railway station, frequently made into the form of a public garden. It is not to be expected that railway companies will go to the entire expense involved in every case, but it is to the interest of the municipality to see that the approaches to its "gateway" are worthy of the city, because, after all is said, the visitor's first and last impressions are those which, unconsciously, perhaps, will be retained. A terminal which may be considered a model for a fine location with regard to the immediate vicinity and approaches is the Washington Union Station, illustrated in Fig. 1. This result, however, was largely obtained by the co-operation of the District of Columbia and the railway companies interested in the terminal.

Nature and Volume of Traffic.—The size of any proposed terminal is naturally dependent on the volume of anticipated traffic. This volume has to be carefully analyzed, because it is not the volume alone, but the relative percentages of suburban and main-line passengers, and also the quantity of mail, baggage and express matter that determine the necessary size and requirements. Taking the effect of the predominating kind of passenger traffic on the station building it will be found that the commuter requires different and less facilities than the long-distance passenger. The requirements of the former are few, his usual idea being to rush through the station to or from his train in the shortest time possible, although he may occasionally stop at the bookstall, ticket office, etc., but not frequently. The latter, on the other hand, puts in quite a considerable amount of time in the station, visiting parcel, baggage, waiting and lunch rooms in addition to the ticket office, so that all these facilities have to be provided to a greater or less extent depending on the proportion of this part of the traffic. At stations where many connections are to be made, it is necessary to provide for a large number of people in the waiting rooms.

The nature of the traffic not only affects the station building, but it also has a direct bearing on the size of the track-layout. The handling of a definite number of passengers requires less trains if they are commuters than if they are long-distance travellers, and at the same time suburban trains can be dealt with at a quicker rate than long-distance trains, because they can be unloaded quicker and do not need to be placed at their platforms so long before their schedule time for departure. This fact, however, is somewhat offset by the heavy "peak" loads that occur in conjunction with the former class of traffic at the morning and evening rush hours. In Fig. 2 is shown a typical hourly distribution of suburban traffic throughout the day. Main line traffic has its variations principally with the seasons of the year, and at the same time there are a number of stations where extraordinary heavy loads have to be handled for short periods, an example of which is the inaugural crowds at Washington.

Through the courtesy of officials connected with each of the terminals mentioned therein, the writer is able to present in Appendix 1, a variety of statistics covering the operation of a large number of important terminals on this continent. Bearing out the above statements with regard to the relationship between suburban and express traffic, the following averages are taken from this appendix:—

	Long-distance.	Suburban.
Passengers handled per day, per track...	1,141	4,933
Number of trains per track............	15.4	29.4
Passengers per train	84	169
Time train is at platform before departure.	27	14
" " " " " after arrival ...	16	8

Segregation of Traffic.—On account of the differences, already mentioned, in the requirements of the commuter and the express passenger, it is advisable, when they both reach large proportions, to separate the one from the other as much as possible. The most notable example where the segregation of traffic has been carried out with completeness and success is the Grand Central Terminal of the New York Central in New York. Local conditions lent themselves to the consummation of this project because the property restrictions necessitated building the tracks on two separate levels, with the result that one level was retained for suburban and the other for express traffic. This idea was carried out not only with regard to the tracks, but also with the building itself, two entirely separate concourses being provided on the different levels together with their independent ticket offices, waiting rooms, entrances and exits. As both the New York Central and the New York, New Haven lines carry a large number of both classes of passengers, the result is that the 76,000 passengers using the terminal every day are able to do so with the minimum of inconvenience and delay. In addition to this separation of the two classes of traffic there is also a partial separation of the inbound and outbound traffic using the express level. A separate "inbound" waiting room together with corresponding exits and carriage ways is provided on a site immediately to the west of the main building and in the basement of the Biltmore Hotel.

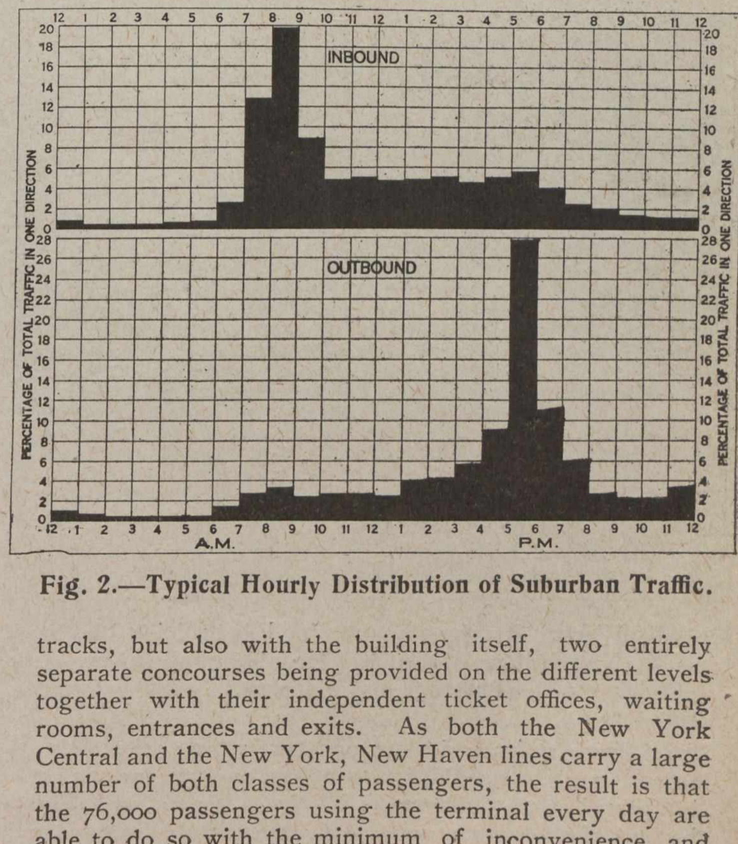


Fig. 2.—Typical Hourly Distribution of Suburban Traffic.

At the Pennsylvania terminal in the same city a rather different situation is encountered. This terminal serves both the Pennsylvania and Long Island Railroads, the former carrying express passengers almost entirely, while the traffic on the latter is of a purely local nature. The main idea carried out in this terminal was therefore the segregation of inbound and outbound passengers, but in addition to this, separate entrances and exits were provided for the Long Island commuters. The large difference in the elevations of the tracks and the neighboring streets gave plenty of available headroom for the construction of two concourses on separate levels, the lower of these being kept for inbound passengers entirely.

Platforms.—Before any plans can be commenced with any degree of detail, standards must be adopted for the size and general features of the station platforms because it will be their necessary number and dimensions that will partly determine the size of the terminal as a whole. The platform sizes, in turn, will depend not only on the traffic, but on the methods of handling baggage, and on the means of approach to the platforms.

Baggage Handling.—There is no question but that the most satisfactory way of dealing with this problem is that of trucking either above or below the track level, and raising or lowering the trucks, as the case may be, to the platforms at a point approximately opposite the baggage cars. In terminals where this system is in vogue baggage may usually be said to be conspicuous by its absence.

Stairways and Elevators.—In terminals where the concourse and baggage rooms are above or below the platform level, stairs and elevators, or as an alternative, ramps, must be provided, and before any conclusions can be formed as to the platform widths, a general idea must be had of the nature and extent of such obstructions to the clear width of the platforms. In the case of commuter traffic a stairway 20 feet wide is not uncommon, but is confined to those situations where large crowds have to be handled in a very short space of time, more particularly in subway stations than in railroad terminals. Taking the more general situation where not more than one or two hundred people per train are provided for, if the traffic on any one stairway can be confined to one direction only, a width of 6 ft. is sufficient. It is often necessary, however, to provide stairways for traffic in both directions, in which case a width of at least 8 ft. is advisable. Of course the width is to a large extent controlled by the rapidity with which it is necessary to clear a platform.

Fig. 3.—Electric Baggage Truck, for Use on High Platforms. (Note Rubber Mat of Old Hose Pipe to Protect Baggage and Flooring.)

The recognized practice in modern terminal construction is to eliminate stairways as much as possible by the substitution of ramps, the slopes of which have to suit local conditions, but which should not exceed 12 per cent., and when space permits 8 to 10 per cent. makes a slope well favored by the public. Elevators are used for the transference of both passengers and baggage from platforms to concourse, and vice versâ, but for the former purpose they are generally used in a purely subsidiary manner, and rarely exceed 5 or 6 ft. in width. Baggage elevators, on the other hand, have to be sufficiently large to readily accommodate the largest baggage trucks, sometimes even two at a time, with the result that it is not unusual to find an overall width of 8 or 9 ft.

Width of Platform.—When a platform is practically free from structures and baggage trucking is eliminated a width of about 16 ft. is found from experience to give satisfactory results, and in other cases, such as where the platforms are only occasionally used for local trains, perhaps, this width can again be reduced. Widths as great as 30 ft. are sometimes necessary when a heavy and continuous inbound commuter traffic has to be dealt with expeditiously.

Height of Platforms.—Although platforms level with the car floors have always been the standard practice in Great Britain, it is only in recent years that they have been in use at all on this continent, except on subways or elevated roads. The Pennsylvania Railroad must be given the credit for first adopting the high platform in a railway terminal in America, and their operation proved so successful that the example set by this road was immediately followed by the New York Central Lines, and to-day they are in extensive use on many of the lines in the East.

The advantages of the high platforms may be briefly stated as follows: (*a*) Facility and rapidity with which trains may be loaded or unloaded; (*b*) the prevention of the public crossing the tracks; (*c*) in stations below street level, a saving of about 3 ft. in the vertical height to be travelled by the passengers; (*d*) in some cases they form a convenient place for the housing of ducts, cables, elevator machinery, signal equipment, etc.

On the other hand, they have certain disadvantages when used in conjunction with our present system of terminal operation, in addition to that of the additional cost. The most important factor against their use is that of the passenger coaches which must be remodelled to serve both high and low platforms. A second objection to their use is the difficulty of trucking across the tracks, and a third is the fact that a special form of baggage truck must be provided, having its floor as low as possible. These disadvantages are not so serious that they can not be readily overcome, and the type of baggage truck used by the Pennsylvania Railroad is shown in Fig. 3. A rubber mat is provided to protect baggage and floor. A rather more serious disadvantage which sometimes arises in connection with the use of the high platform is that if a switch has to be placed in a track within the limits of the platform, it becomes necessary to put a curve in the line of the platform edge in order to provide sufficient clearance for the swing of the ends of coaches using the switch. This is not only unsightly but also dangerous, because if a car door happens to stop opposite the curve, an unobservant person might readily step into the space left between the car and the edge of the platform. Similarly, the outer ends of all platforms are usually curved for a certain length to conform to the layout of the tracks and on the outside of the curves the car doors swing out to an excessive distance from the platform. This is an objection which is difficult to eliminate unless the station site is of such ample dimensions that the platforms can all be confined to the straight part of the tracks.

DISCUSSION ON PAPER.

Hugh Valance, architect of the Grand Trunk, was asked by the chairman to open the discussion. Mr. Valance expressed his appreciation of the paper, especially that part dealing with design of buildings. He stated that in the early days the passenger station looked just like a station and nothing else—all stations were more or less alike. In those days an endeavor was made to work on models from France. The great difficulty is to get a proper expression on the umbrella form of train shed. He said that in architecture it was not so much a case of exact science but of your own choice in problems of design. What would be perfectly correct for him might not suit some other architect. If a man asked an architect to build a house, he could build it; but unless the architect was told his various tastes and requirements the house would be the expression of the architect's taste and not the owner's ideas at all. This holds true right through architectural work as compared to that of the engineer. Mr. Valance told of many engineering structures which with a little architectural treatment would have been very impressive. He spoke particularly about elevators, which are usually blots on the landscape. He explained that he intended no criticism for the engineer, as elevators were engineering problems and were handled from that point of view without regard to appearance.

Regarding terminals he said the question of the length of concourse was an important one. In the South Terminal at Boston, one has to pass 28 tracks sometimes before reaching his train. He thought the remarks in connection with two levels were quite to the point.

H. R. Safford, chief engineer of the Grand Trunk Railway, favorably criticized the paper. He said that for a great many years the public had not been regarded as having anything to do with the design of passenger terminals, but the question had been one for the railroads themselves. It took a long time for the railroads to understand that the public did express their views in this respect. However, he said that he could not see why the public should have anything to say beyond questions regarding their personal comfort while in the station. A passenger station is a non-productive and almost unprofitable investment in a broad sense, although sometimes, owing to competition, a structure of architectural beauty is necessary. Mr. Safford quoted some interesting figures in connection with the increase in traffic and use of terminals. He said that in the Illinois Central station in Chicago traffic had increased 200% in 20 years; Grand Central station, New York, 70% in 10 years, and the Union Station at Toronto, 110% in 25 years. The question the financiers of the railroads have to face is for how long a period of time will the structure they are about to build suit the traffic.

Mr. Safford stated that many advantages were to be had by building high platforms, chief of which is the reduction of liability to personal injury. The only disadvantage is that it is difficult to couple trains, but this will very probably be overcome.

Charles Parker, chief signal engineer of the Grand Trunk, then entered the discussion with some remarks on signal systems.

William McNab, in some remarks as to the architectural features of the paper, said that better stations would be possible if the public would share in the expense of building them. The stations should be feature points of a city. What is wanted in large terminal stations today may be summed up in two features: first of all, the operative features, and next, comfort to passengers. The Pennsylvania station is New York was a sample of extravagant concourse area. It took five or six minutes' walk from the Avenue to the train. He stated that baggage arrangements were better than they had been, but were still capable of improvement.

S. B. Brown suggested that it would be a good thing if a paper on freight terminals and a general paper on the terminal situation were read. It would be of great interest to the members.

A vote of thanks was tendered Mr. Busfield for his most interesting paper.

LIABILITY OF MILITARY RAILROADS

It has recently been decided in France that railroads, though operated under military authority, may be held liable before civil courts for loss and damage claims and for injuries to passengers. So states Walter S. Hiatt, the special European correspondent of Railway Age Gazette.

This decision was given in a test case brought against the Paris, Lyons & Mediterranean. One of its auto-trucks struck a street car and slightly injured a woman passenger. She sued the railroad, which denied its liability on the ground that the act was one of an employee who was mobilized as a soldier, and further, because the railroad itself was being operated under military authority. Various chambers of commerce, whose members had been unable to obtain satisfaction regarding complaints concerning non-delivery of freight, were also interested in any decision as to the railway's responsibility.

The minister of public works, who supervises the conduct of the railroads in times of peace, had issued various rulings regarding the precedence of military freights over civil freights, which at the same time sought to secure prompt handling for the latter, but he had not been able to establish the question of responsibility where shippers had a grievance.

Finally, the minister of war has settled the whole question by stating that the various rulings giving precedence to military transports would in no wise alter the common law rights of shippers or injured persons to sue the railroads through the usual channels of the civil courts in contradistinction to the military courts established in various parts of France for the purpose of hearing cases affecting the public safety.

On the other hand, the ruling has also been made that railroads are not obliged to permit soldiers detailed to munitions factories and other such work to travel at the one-quarter fares established for soldiers both in times of war and peace. Many thousands of soldiers, competent as mechanics, have been withdrawn from active military duty to work in the various government or private factories turning out munitions of war. The railroads charged these men full fares and were fairly deluged by complaints. In every railroad station, and at many street car stations in France, a complaint book is maintained by law for the benefit of the public, response to any complaint being required within one month. These soldiers detailed to civil duties seem to have made complaints through this means almost to a man. The dispute was settled in favor of the railroads on the ground that the men were being paid, in addition to the pay of five cents a day as soldiers, the full wages of the shops in which they were employed.

An underfeed stoker is able to smokelessly burn even high-volatile coals, because when the volatile is distilled, it must pass through the hottest part of the fuel bed before getting out into the furnace. Besides a sufficiently high temperature, the only other chief requirement for the proper burning of the volatile is time, just as it takes time for a cake of ice to melt at summer heat.

THE MOMENT DIAGRAM AND ITS RELATION TO THE REINFORCEMENT IN A CONCRETE BEAM.*

By S. C. Hollister.

IN the past the design of reinforced concrete beams has involved some intricate problems relative to the proper placing of the steel reinforcement in the body of the beam. Extensive analytical methods have been resorted to, or a series of graphic constructions have been necessary, to determine the relative position of the component parts of the reinforcing material.

In the present paper it is proposed to set forth a method of placing the reinforcement for both bending and shearing resistance entirely from the moment diagram. To explain the method it is deemed necessary to review the principles upon which later operations are based, after which its application will be made to a specific design.

Consider a simple beam, uniformly loaded, as in Fig. 1. Let two transverse vertical sections, (1) and (2), be passed through the beam, at distances x_1 and x_2 from the left support. Then from mechanics it may be shown that

$$M_2 - M_1 = \frac{V_1 + V_2}{2}(x_2 - x_1)$$

Whence

$$V = \frac{M_2 - M_1}{s} \qquad (1)$$

in which V equals the average vertical shear on the portion of the beam $(x_2 - x_1) = s$.

Or,—The difference in moment between any two points along a beam is equal to the product of the average shear over the distance between the points, and that distance.

For loads concentrated at points along a beam this law is not strictly true, unless in each case the concentration occurs at a point midway between the transverse sections chosen; but in the case of "concentrated" loadings by beams cast against the girders in concrete construction, and even by loadings on slabs transmitted finally to the girder, the concentration may not be sharply defined, and there is no determinate law of shear variation over such a region. Moreover, as this discussion will show later, the distance s is relatively small where shear is large. Within the limits of actual conditions in reinforced concrete construction, therefore, the above statement may be considered very approximate for the beam loaded with concentrated loads.

From the discussions given in Turneaure and Maurer, "Principles of Reinforced Concrete Construction," pp. 109 and 223, the amount of tensile stress required of a vertical stirrup to resist the shear stress is

$$\frac{Vs}{jd} \qquad (2)$$

in which V is the average vertical shear over the portion s of the beam. The idea of maximum shear intensity on a vertical section of the beam is retained in the above expression.

Since the tensile strength of the stirrup is relied upon to carry the above force, when s is the space between adjacent stirrups, the total strength of the stirrup, $a_s f_s$, would be equal to eq. (2), or

$$a_s f_s = \frac{Vs}{jd}$$

from which

$$V = \frac{a_s f_s jd}{s} \qquad (3)$$

which is the value of the average vertical shear over the portion s of the beam, to be resisted by the stirrup, in terms of the strength of the stirrup and certain dimensions of the beam.

In eq. (1) we have an expression of this average shear in terms of the change in moment along the portion s; so that by substituting in the above, we have at once,

$$M_2 - M_1 = a_s f_s jd \qquad (4)$$

Let it be considered that the portion s be so chosen that section (1), Fig. (1), lies over the left abutment, at which point the moment M_1 is zero. (In continuous girder design section (1) may be considered as lying at a point of inflection, since the moment at that place is

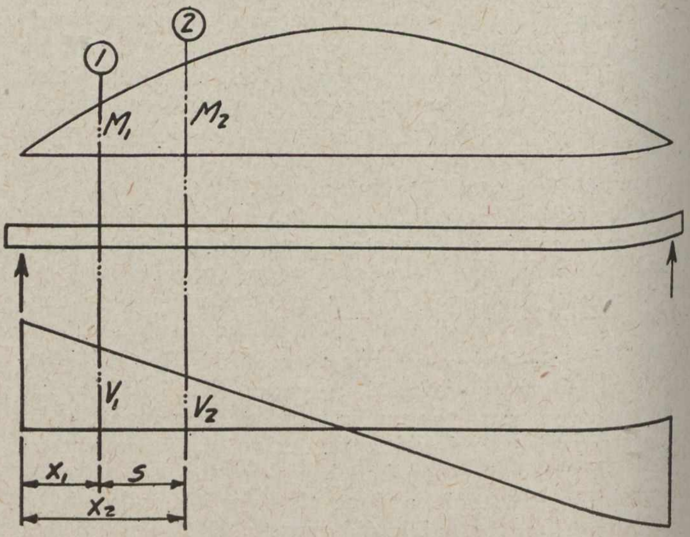


Fig. 1.

zero.) Let the moment increment from zero to M_2 be called M_i. Then from eq. (4),

$$M_i = a_s f_s jd \qquad (5)$$

It is to be noted that this moment increment represents the value of the adopted stirrup to resist the vertical component of diagonal tension over the portion s of the beam. Again, it should be clear that for any given stirrup of area a_s and of fiber stress f_s, the moment increment M_i varies directly with jd, a value dependent upon the characteristics of the beam; and that for a given beam and the given stirrup, the moment increment is a constant, irrespective of where the region s is chosen along the beam.

From values given in tests published in "Principles of Reinforced Concrete Construction," it may be noted that the safe working shear stresses are about three times as great in a reinforced concrete beam as when the beam is not reinforced. We may say, therefore, that the concrete will be permitted to carry one-third of the shear, and the remainder will be cared for by the reinforcement. Eq. (5) then becomes

$$M_i = 1.5\, a_s f_s jd \quad \text{(Vertical Stirrups)} \qquad (6)$$

If the stirrup is inclined at an angle θ to the horizontal, then,

$$M_i = \frac{1.5\, a_s f_s jd}{\sin\theta}$$

And when $\theta = 45°$ (7)

$$M_i = 2.1\, a_s f_s jd \quad \text{(Stirrups inclined 45°)}$$

*Read before the Engineering Society of the University of Wisconsin.

Eqs. (6) and (7) are the final working values of the resistance offered by a single stirrup in terms of an increment of moment.

The chart in Fig. 2 is a graph of the above equations when $j = 7/8$, a very common value in rectangular beam design. To use the chart, enter at the left with a given value of d, the depth of the beam; follow across horizontally to the line of the adopted stirrup area; then from this point move up to the fiber stress assigned to the stirrup; and finally passing to the right from this last point, the value of the moment increment for either vertical or inclined rods may be read.

Let us consider the portion of the beam shown in Fig. 3, loaded in such a manner as to produce the moment curve OA. It is desired to reinforce the portion shown with vertical stirrups, keeping in mind the principles just

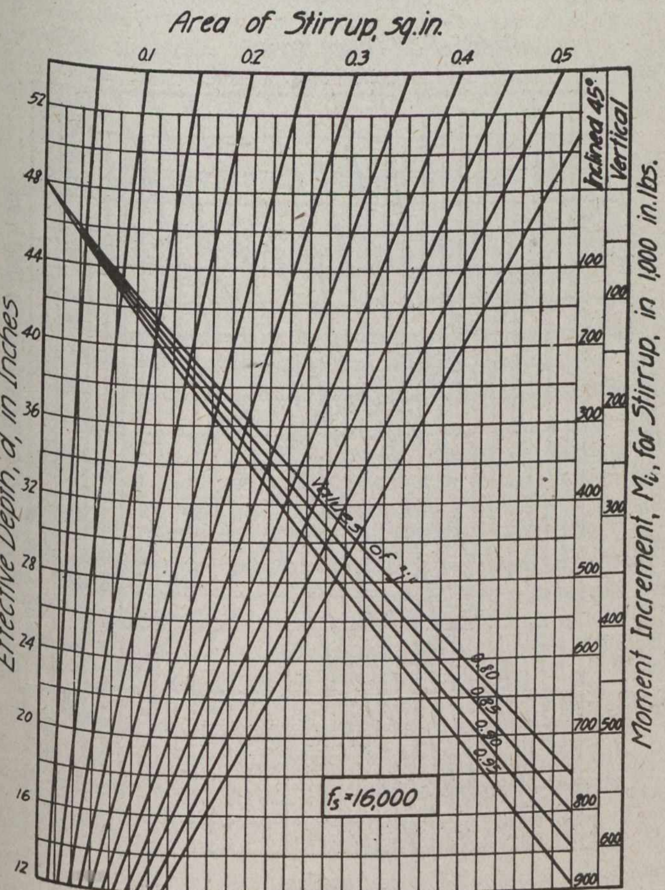


Fig. 2.

laid down. A certain stirrup has been adopted which for this particular beam gives the value of M_1 from eq. (6) equal to the vertical distance shown in Fig. 3*a*. The first increment intercepts the portion *Om* of the curve; the second, *mn*, and so on. Let one of these intercepts, as *mn*, be projected onto the beam, thereby defining an area ABCD on the diagram of the beam. From the preceding discussion this area is the portion of the beam in which the adopted stirrup will exactly carry the shear. The length *s* of the portion is seen to vary as the shear varies along the beam. Since the stirrup is required to carry the shear for this portion of the beam it will be placed through the centre of the portion. Likewise, each other portion of the beam defined by the projection of the intercept of M_1 will have a stirrup placed at its centre.

To eliminate the feature of dividing each portion of the beam, the following method is suggested: Lay off, as the first value, $\frac{1}{2} M_1$ (Fig. 3*b*). Let all other values equal M_1, as before. These increments have m^1, n^1, and so forth, for points of intersection on the moment curve. Let these points be projected onto the beam. Each projection will thus determine the position of the stirrup. This gives very closely the same results as before, since in this case each increment has been bisected, rather than bisecting the projection of the intercept on the curve. However, if the increment is large, as is sometimes the case with bent-up bars, it is likely to subtend a portion of great curvature, in which case the original method is advised. The second method will be found within practical limits for the spacing of vertical stirrups.

The design of a T-beam will now be followed through in detail. The span will be taken as 24 ft. between centres of supports. The thickness of the flange will be assumed to be limited by a 10-in. floor, and the total depth to approximately 3 ft. The following working stresses will govern the design: f_s = 16,000 lb/in.²; f_c = 650 lb/in.²; u = 80 lb/in.² (at the supports 50% excess allowed, or 120 lb/in.²); v = 35 lb/in.² for concrete and 105 lb/in.² for reinforced concrete. Attention is called to the ratio 1/3 of the two shear values just given. This is in accordance with the developments of eqs. (6) and (7). The total load on the beam will be taken as 4,000 lb/ft.

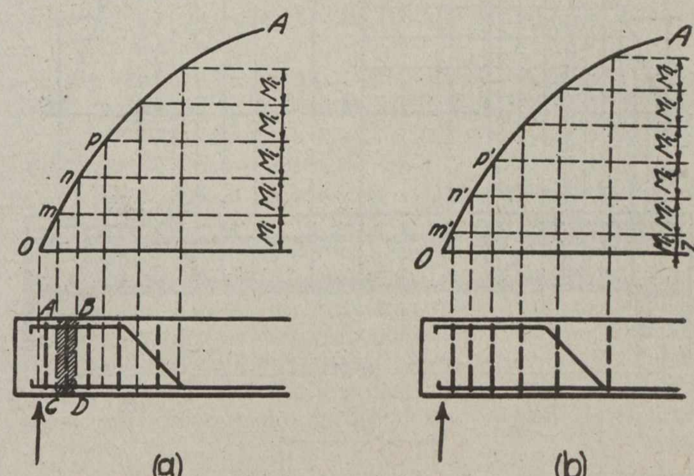


Fig. 3.

The maximum moment is found to be 3,460,000 in. lbs., and the shear at the support, 48,000 lbs. The required web area is 458 in.² or 33 in. deep and 14 in. wide. From Plate X, Turneaure and Maurer, b = 31 in., and jd = 29.2 in. A_s is found to be 7.4 in.² Eight rods 1 in. square will be used. The value in moment of one pair of rods is computed to be 932,000 in. lbs. The arrangement of the rods in cross-section is shown in Fig. 4*c*. The width of the web was changed to 15 in. for clearance between rods. The length of rod necessary to develop its tensile strength in bond is 50 in. At the support four rods are necessary to carry the bond stress.

With the above computations available, the placing of the steel in the beam may be done. Fig. 4*a* shows the bending moment diagram. The resisting moment of each pair of rods is plotted, resulting in the stepped diagram along the exterior of the moment curve. The point of contact of the line with the curve indicates a point of zero stress in the rods corresponding to the zone immediately above the point. This pair of rods may be bent up at this point, therefore, since they are no longer needed to resist moment. It is noted that the four lower rods are required to continue to the end of the beam without being bent up; hence only the upper rods will be bent.

It is proposed to make two arrangements of the steel, —one in which the bent-up rods are intended to carry a portion of the shear (right side of Fig. 4*b*), and the other in which the stirrups are designed to carry all the shear (left side of Fig. 4*b*). The second case, that of all shear being carried by the stirrups, will be treated first. Since it happened that in this T-beam the value of j is $\frac{7}{8}$, it will be permissible to use the chart in Fig. 2. In choosing a value of a_s, the area of the stirrup, a value should be so chosen that the last useful spacing, projected from the last full value of M_i at the vertex of the moment curve, does not exceed in general $\frac{3}{4}d$, and never more than d. It is possible to estimate by inspection a value of M_i that will give this final spacing. Entering at the right of Fig. 2 with this estimated value, then over to the line of fiber

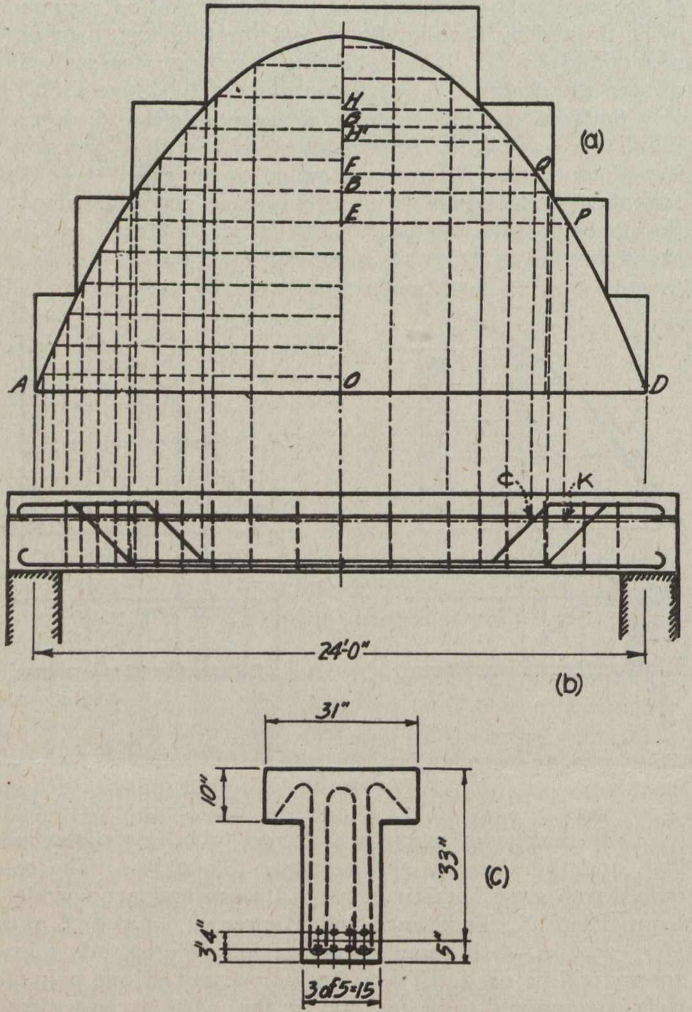


Fig. 4.

stress, and next down to the intersection with a horizontal line from the depth d, gives a tentative value of a_s which may be adjusted slightly to meet the commercial dimensions of the steel. With this corrected value of a_s, and passing through the chart from the left, a final value of M_i may be obtained very close to the desired value. The adopted stirrup is shown in Fig. 4*c*.

Following the suggestions relative to Fig. 3*b*, half of the value of M_i as determined above is first laid off; then the full value is laid off repeatedly until the vertex of the moment curve is reached. The intercepts on the moment curve, when projected onto the beam, determine the positions of the vertical stirrups.

The numerical value for the $\frac{3}{8}$ in. round stirrup, in terms of the moment increment, is 300,000 in. lbs. They develop sufficient bond to cause a tensile stress of 12,500 lb/in.[2]; and in addition they are hooked and bent to develop the full stress. At the bottom they pass below the horizontal steel.

In the case where the bent-up rods carry a part of the shear, investigation as to their strength in shear resistance must first be made before the point of bending can finally be fixed. Considering a pair of these rods as an inclined stirrup, a moment increment may be determined for the pair from eq. (7). This was found to be 1,960,000 in. lbs. This value is laid off vertically, as OB, Fig. 4*b*. The distance s corresponding to the pair of rods is much greater than d. The pair is then excessively strong to take the shear; and since the spacing given for bending the rods is also greater than d, the second pair of rods will be turned up, as shown from the bending diagram, while the first pair will be bent up at an arbitrary distance jd toward the centre from the bending point of the second pair. The arrangement is shown in the right half of Fig. 4*b*.

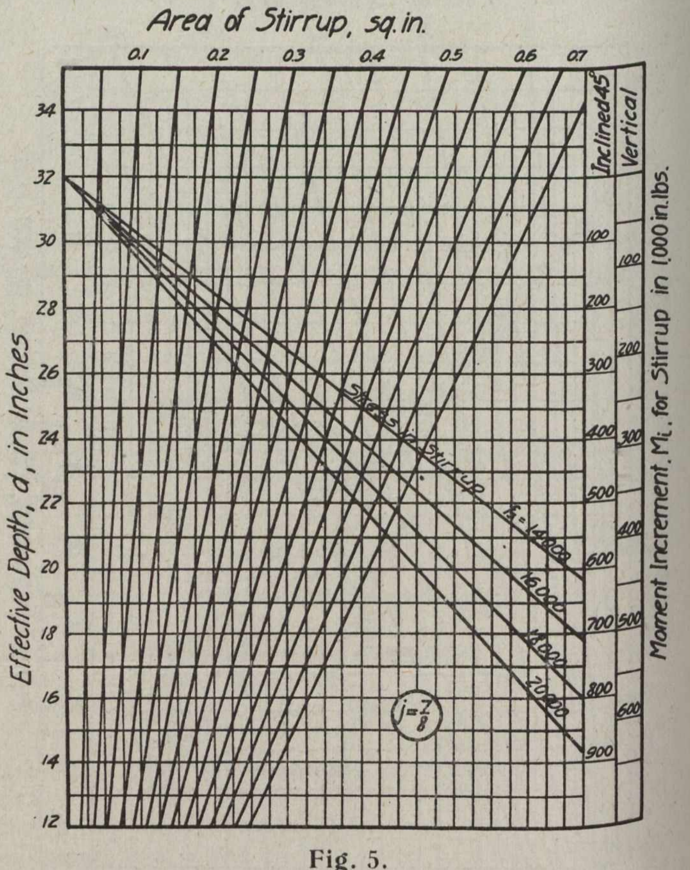


Fig. 5.

Point K represents a point midway between the intersections of the two pairs of bent-up rods with the neutral plane. The projection of K upon the moment curve is P, thereby determining the chord EP. Point C is the intersection of the first bent-up pair with the neutral plane, and its projection on the moment curve is Q, thus establishing FQ. EF, therefore, is half of the actual increment ascribed to the first bent-up pair, on the basis of spacing. EF is then laid off again, as FG, thus completing the increment EG. The portion of the curve from O to G, therefore, is cared for by the bent-up rods. Since OB is the permissible value for one pair, it is seen that they are amply strong to carry the shear, and that their placing was determined by the approximate maximum spacing.

Beginning with G, the stirrup increments are laid off, the first being half value, (GH), as previously explained. The intersections with these and the moment curve determine the positions of stirrups through the region between C and the centre of the beam. It is noted that the stirrup resulting from H is past the point of bending up the first pair of rods. The space to C is too great in the light of good practice, even though it may be very close to *d*. Point H' is therefore set, with GH = GH', and an extra stirrup placed. Between this stirrup and the support arbitrary stirrups are placed at approximately ¾*d* apart, for the purpose of supporting the bent rods during construction.

The rods turned up are carried 50 in. beyond, to develop the required bond. In addition, they are hooked at the ends.

The chart in Fig. 5 shows the solution of eqs. (6) and (7) when j is variable and f_s = 16,000 lb/in.² A set of similar charts may be made up, each with a different fiber stress. Such a set will apply to both rectangular and T-beams. Fig. 2 applies to nearly all forms of rectangular beams since j varies so slightly; but it is not applicable to T-beams except when j is ⅞, as was the case in the preceding problem. For T-beams j varies from .82 to .97 and therefore requires a chart that takes this change into account.

LETTER TO THE EDITOR.

Stresses in Lattice Bars of Channel Columns.

Sir,—In response to your letter of March 11th, I would submit the following notes on the ingenious and interesting paper "Stresses in Lattice Bars," by Mr. Pearse, published in *The Canadian Engineer* of February 24th, 1916:

(1) If Sc is the stress at which the material will be crushed, which may be inferred from the three lines at top of page 274, S_1 will be larger than 16,000 lbs. per square inch, the base stress used in Equation 3. In Proceedings of the American Society of Civil Engineers of December, 1915, I find tests showing unit ultimate strength in columns running as high as 45,000 lbs. per square inch. It is presumed that the base stress in the columns should be assumed as the utmost which they can carry, say, from 30,000 to 50,000 lbs. per square inch, for it is at this time when we are interested in the behavior of the lattice.

(2) In the third paragraph, page 274, it would appear that the total stress in the more highly stressed column should be $K\frac{A}{2}$, and not $2K\frac{A}{2}$. Note that S_1 is the base stress, when the added stress due to bending is K and not $2K$. The stress K is added to the stress S_1 in one channel and subtracted from the stress S_1 in the other.

(3) In Equation 3 the quantity $\frac{1}{12,000}$ in the denominator seems to be somewhat arbitrarily selected. In Merriman's "Mechanics of Materials," dated 1905, I find, on page 202, for the Rankine formula $\frac{1}{25,000}$, $\frac{1.78}{25,000}$ and $\frac{4}{25,000}$ given as the constants which meet average results in fixed, fixed and round, and round end columns. Again, on page 212, I find for the Ritter formula, which reduces to the Rankine when one constant replaces a theoretical expression, the factors $\frac{1}{34,000}$, $\frac{1.78}{34,000}$ and $\frac{4}{34,000}$. The Dominion Government Specifications of 1908 use $\frac{1}{9,000}$, $\frac{1}{12,000}$ and $\frac{1}{16,000}$, which are, of course, supposed to be conservative.

(4) The table gives only one distance apart for each channel pair, and the r given is that for the strong way of the channel itself. A round end condition is one that one does not expect to find in practice; using sines of two or three times the size used in the table, as indicated at bottom of first column of page 274, would produce other results. As to the width of lattice bars chosen, one may find them a bit large for the smaller sizes of channels; the Dominion Government Specifications require a width of 1¾ inches for lattice on 6-inch channels, which exceeds ordinary practice in building work.

(5) Equation 7 predicates a column of, say, $200\frac{l}{r}$ and over; Johnson says the Euler formula applies from $150\frac{l}{r}$. The results are applied to columns of less than this length.

(6) Equation 18 does not follow from Equation 17.

In the Engineering News of October 3, 1907, will be found a solution of lattice bars by Mr. A. M. Meyers. In the same number is an article of interest by Mr. Pritchard, suggesting, *inter alia*, 3% of axial stress to be taken in lattice.

Mr. Modjeski states in Engineering Record 68, page 356, that in the new Quebec Bridge lattice take a shear of 2% of the axial stress.

In the Quebec Bridge Commission report are some very interesting calculations on lattice theory. If this report is not at hand, it may be found in part in the Engineering Record of April 18, 1908.

I regret that I do not have at hand Bulletin 44 of the University of Illinois. In the Engineering News of March 16, 1911, there is, however, a summary of this bulletin. Here I read that the stresses in lattice bars were very variable as between different bars; and the authors, Talbot and Moore, are quoted as concluding: "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations, or on data now available."

Mr. Pearse's theoretical solution of this annoying problem is suggestive and very interesting. I fear, however, that the problem is one of which the complete solution is not in our possession. The same may be said of column formulæ. We can, of course, make satisfactory designs, but the perfect theory and the perfect practice seem still somewhat doubtful.

C. M. GOODRICH,
Designing Engineer, Canadian Bridge Co.

Walkerville, Ont., March 14, 1916.

[In our issue of February 24th we published an article by William Worth Pearse, city architect of Toronto, dealing with the derivation of theoretical formula for calculating stresses in lattice bars of columns. The article created a good deal of interest, and we are pleased to be able to publish the above letter containing some further notes on Mr. Pearse's paper, and trust that others of our readers will be disposed to give our readers the benefit of what information they have on this most interesting subject.—EDITOR.]

The Siamese Government, to which one would not generally look for engineering progress, use to a very great extent reinforced concrete poles, both for street and park lighting and for electric transmission lines. The concrete pole is not only more elastic than teakwood, but it is fireproof; it is easily made and fixed, and is, of course, impervious to the depredations of the white ant.

COAST TO COAST

Toronto, Ont.—The villages of Mimico and New Toronto have applied to the Legislature for authority to build a joint water supply.

Victoria, B.C.—J. P. Kean, in a paper read before the Slocan Board of Trade, advocates the establishment of a zinc refinery in Canada.

Prince Rupert, B.C.—The Grand Trunk Pacific will inaugurate its steamer service between this port and Alaskan points on March 30th.

Winnipeg, Man.—Premier Norris will move a resolution asking the Dominion Government to hasten the construction of the Hudson Bay Railroad.

Vancouver, B.C.—Engineer Hueckel reports that Norris McDiarmid & Co. are entitled to $6,474 extra for work done on the Georgia-Harris viaduct.

Carp, Ont.—Engineers of the Hydro-Electric Commission addressed the ratepayers on the question of cost of installing hydro-electric power here.

London, Ont.—A further request for $39,000 for the London and Port Stanley electrification has been granted. This brings the total cost to the ratepayers up to $900,000.

Ottawa, Ont.—In the annual review of the work of the Department of Railways and Canals a great increase in mileage and prosperity of the government railroads is reported.

Calgary, Alta.—City Engineer Craig reports that the treatment of sewage with chlorine gas would cost $23,300 yearly. It is not expected that the council will adopt the proposal.

Welland, Ont.—The Canadian Steel Foundries Ltd., have started operations at their plant here. The 12-in. mill is now in operation and the 22-in. mill will be started very shortly.

Montreal, Que.—The transmission line of the Shawinigan Water and Power Company has been completed to Quebec and power is being delivered to the Public Service Corporation there.

Peterborough, Ont.—It is expected that the Trent Valley Canal between this city and Lake Ontario will be opened for navigation this spring. The total cost of this division will be $7,660,000.

Victoria, B.C.—Work on the new breakwater is progressing favorably. Divers engaged on the Sir John Jackson contract are now working on the granite blocks at the bend of the main arm.

Quebec, Que.—The Quebec Railway, Light, Heat and Power Company has commenced to construct their own street cars. The first product of the new industry will be completed about April 1st.

Ottawa, Ont.—The Town Planning Commission recommends that the suggestions made by Andrew Bell, C.E., in 1901, regarding the prevention of spring floods on the Rideau River be carried out.

Ottawa, Ont.—Comprehensive plans for the beautification, development and re-planning of the Canadian capitol have been presented to Parliament in the report of the Federal Town Planning Commission.

Vancouver, B.C.—City Engineer Fellowes has advised the board of works not to undertake the responsibility of erecting bulkheads in lanes for protecting side cuts, as it is likely to establish a costly precedent.

Victoria, B.C.—Only eight miles of track remain to be finished before the completion of the Patricia Bay branch of the Canadian Northern Railway. Contracts will soon be awarded for the construction of slips on the mainland and Vancouver Island.

Ottawa, Ont.—T. J. Stewart, of Hamilton, is moving to amend the bill of the Ontario Niagara Connecting Bridge Co. by providing that no construction shall be undertaken on provincial property or the lands of the Niagara Falls Park Commission without the consent of the Provincial Government.

Vancouver, B.C.—The city engineer has reported to the council the completion of the contract by the Vulcan Iron Works for the supply of 14-inch main, and the expense the city was put to by reason of the construction of a temporary main to eliminate the damage from the leak at Essondale. The water committee will be asked to report on the whole question of what claim the city has against the contractors.

New Westminster, B.C.—Mr. C. C. Worsfold, resident engineer here for the Dominion Government, who has returned from Ottawa, states that the sum of $15,000 has been noted in the supplementary estimates for the work of carrying on the construction of the Fraser River main channel jetty, the second unit of which is now being built by the Marsh-Hutton-Powers Co. The supplementary estimates, however, have not yet been before the House. Under the Le Baron scheme, the north unit, that now under construction, was designed to be built in three units. The contract for the second unit was let at a price in the neighborhood of $400,000. The third, and longest, will cost probably $500,000, so that the sum put in the estimates, if voted, will only provide for a portion of the third unit, probably enough to continue the work throughout the summer and fall.

FEBRUARY COBALT ORE SHIPMENTS.

The following are the shipments of ore from Cobalt during February, 1916:—

	Tons.
Beaver Consolidated Mining Company	33.73
Buffalo Mines	37.69
Coniagas Mines	84.21
Dominion Reduction Company	220
La Rose Mines	87.08
McKinley-Darragh-Savage Mines	207.85
Mining Corporation of Canada (Cobalt Lake Mine)	122.41
Mining Corporation of Canada (Townsite City Mine)	84.68
Nipissing Mining Company	65.52
Penn-Canadian Mines	35.99
Peterson Lake Silver Mine (Seneca Superior Ore)	105.86
Peterson Lake Silver Mine (Mercer shipment)	17.21
Timiskaming Mining Company	38.92
Total	1,141.15
New Liskeard—Casey Cobalt Mine	29.5
Porquis Junction—Nickel ore	1,026.5

Coal ash contains silica, alumina, iron pyrites and other mineral matter. Depending upon the chemical composition and physical condition, these cause the ash to fuse more or less easily. The temperature at which firebrick will melt is sometimes influenced by the composition of the ash. For instance, a certain ash might melt at 2,600 deg. F. and a certain firebrick at 2,800 deg. F.; but together in a furnace both might melt at 2,500 deg. F.

Editorial

HYDRO-ELECTRIC DEVELOPMENT IN ONTARIO.

An announcement of no mean importance was that made last week by the Honorable G. Howard Ferguson, Minister of Lands, Forests and Mines for the Province of Ontario, to the effect that an agreement had been completed whereby the government takes over the entire business and assets of the Electric Power Company, including all their subsidiary companies, twenty-two in number. Under the arrangement by which these companies come under the jurisdiction of the Hydro-Electric Power Commission of Ontario, it is expected that not only will Central Ontario be served but North Bay and Nipissing District will be able to get the advantages of public hydro development.

It has been said that the strength of any nation can, to at least a large degree, be measured by the intelligence shown in the development of its natural resources. Water power in Ontario as a provider of human necessity is apparently destined to see great development during the next few years and the government is apparently determined that in order to fill the public needs for water power it is in the interest of the whole community that the water powers in the province should be developed as rapidly and as efficiently as possible.

By their very inherent nature, water powers are monopolistic. There is only one Niagara, and while the companies, both public and private, that control the power development possible through Niagara may control the water power of a large territory, a thousand companies could build steam power plants in the same territory.

Ontario is essentially the manufacturing province of the Dominion, and it is fair to assume that there will be a constantly increasing development of power of all kinds for industrial purposes. Present-day industrial and economic standards have made power a public necessity. Water power is a supplier of this necessity, and while the employment of water power is very old, more progress in its use had been made in the last twenty-five years than perhaps in all the years that have gone before.

Statistics show that we have coal for many years to come, but they also show that the economical deposits are being worked first and as the coal becomes deeper the cost of production increases very rapidly.

The popular notion is that when a water power is well constructed it costs so little to run that the power developed is the cheapest in the world. The facts do not appear to support this view, but rather disclose the fact that steam power is, under certain conditions, a very keen competitor of water power. Steam power is movable, flexible; water power is inflexible and not portable. Steam power can be taken to the factory in small or large units as may be required; on the other hand, the factory must, to a large extent, be taken to the water power.

Irrespective of the relative value of water power as against steam power, the fact remains that the announcement recently made by the Ontario Government is far-reaching in character and is significant in that it indicates that the government recognizes the importance of seeing to it that every section of the province is served so far as it is in its power to do so.

By this step it is said that many power developments will be made possible which have heretofore been held for a nominal rental, and unrelated as they should be to the industrial life of the community.

AN INTERESTING REPORT.

In this week's issue we publish an abstract of the report of the Quebec Roads Department, which was issued only a few weeks ago. In connection with this report there is one feature of it that should be specially noticed; that is the expedition with which it has been prepared and placed in the hands of those for whom it is designed. Hon. J. A. Tessier, Minister of Roads, and his associates are to be complimented upon the completeness of the report and the promptness with which it has been issued.

There are some very interesting features in connection with the report as indicating the very remarkable development that has taken place during the last twenty years in the good roads movement so far as Quebec is concerned. The table which is printed at the end of the article in this issue calls attention to the remarkable fact that whereas in 1895-96 the sum of money expended for good roads in the Province of Quebec was $30.20, the amount of money spent in the year 1914-15 was $6,140,273.13. This statement tells its own story.

PREPAREDNESS FOR INDUSTRIAL DEVELOPMENT.

A bill has been brought before the Ontario Legislature which is to create "The Trades and Labor Branch." By the establishment of this branch of the Public Works Department now it should be fully organized and ready to take its place as the representative of labor throughout the province, and will be in a splendid position to render great service when the great army of workers return from Europe. The branch is to be presided over by a superintendent who will have the powers and duties usually assigned to a deputy head of a department. Officers engaged in the administration of any of the laws relating to matters assigned to the branch will make their reports to the superintendent and will carry out instructions as directed by him.

For the present the branch will have charge of the administration of The Bureau of Labor Act, The Stationary and Hoisting Engines Act, The Building Trades Protection Act, The Factory, Shop and Office Building Act, and The Steam Boilers Act. Among other things, the duties of the branch will be to look after the general welfare of the industrial classes.

Another very important duty which will be assigned to this branch will be to enquire and report as to the establishment of new industries in Ontario, in any case where by reason of the production of raw material for such industry in Ontario, or the immigration of persons skilled in the particular industry or other circumstances which make it appear that such industries can be profitably carried on.

Along these lines the branch will be in a position to render a real service to engineers and engineering interests for, with the coming of new industries more work will be created for the engineer and an increased demand for technically trained men is bound to follow. This will relieve the situation which now exists in that a great many technically trained men have been forced to find new fields for their endeavor or else fit themselves for some vocation which is in demand at the present time. New industries will create a state of affairs which the technician has long looked forward to—he will be in demand, his status will be improved and incidentally his services will command a rate of remuneration more in keeping with the dignity of his profession. Similar bureaus in other provinces and a system of interchange of services and privileges would be in keeping with the development of the country as a whole and prepare us for the great industrial development that is coming.

PERSONAL.

W. H. FAIRCHILD, of Brantford, has been appointed city engineer of Galt, Ont.

F. W. EVANS has been appointed manager of the Toronto sales branch of the Canadian Fairbanks-Morse Company.

LORNE THOMPSON, head of the Stores Department of the C.N.R., has joined the staff of the munitions board at Ottawa to look after the transportation end of the board's business.

THOMAS HENRY, chief engineer of the Interurban Electric Company, has resigned that position and associated himself with the sales department of the Toronto Electric Light Company.

G. A. MOUNTAIN, chief engineer for the Board of Railway Commissioners, took part in the discussion at the monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers on March 9th.

C. A. BELL, who went overseas with the 2nd Field Co., Canadian Engineers, has received a commission. Lieut. Bell is a graduate of S.P.S. and was a mining engineer at Copper Cliff before enlisting.

J. McCORMICK, for the past nine years connected with the sales department of Mussens Limited, Montreal, has resigned, having accepted a similar position in the machine tool department of the Canadian Fairbanks-Morse Co., of Montreal.

ERNEST LANE, who has been acting local manager for the West Kootenay Light and Power Company for some time, has assumed a similar position at Trail, B.C., where the smelting and refining plant of the Consolidated Mining and Smelting Company is situated.

OBITUARY.

WM. SANDERSON, who was a mining engineer at Cobalt, has been killed in action in France.

The Swedish state railways have been making experiments with peat as fuel for locomotives. The peat is used in the powdered or pulverized form, and it is stated that locomotives using this fuel can haul as heavy trains and make as good speed as locomotives using anthracite coal. The railway directors have decided to undertake the development of this kind of fuel. Two methods will be followed. Two experts have been requested to give complete estimates of the cost of preparing a certain bog and the running expenses with the respective methods

THE TORONTO BRANCH OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers was held in the society's rooms at the Engineers' Club, 90 King Street West, on Thursday, March 9th. The meeting was devoted to the discussion of proposed amendments to the present by-laws as formulated by the committee appointed in 1915 to consider this matter. While the attendance was not what the importance of the subject should warrant, a very interesting discussion took place, and many good suggestions were made. A stenographic report of this discussion will be available in a short time for members wishing to consult it.

PERSONNEL OF COMMITTEES OF TORONTO BRANCH, CAN. SOC. C.E.

At a recent meeting of the executive committee of the Toronto Branch of the Canadian Society of Civil Engineers, the following members were appointed to the several working committees named below:—

Roads and Pavements.—M. A. Stewart (chairman), S. G. Talman, G. G. Powell, H. S. Van Scoyoc, W. Huber. Subject—Investigation of sand for concrete highway construction.

Steel Bridge Specifications.—A. H. Harkness (chairman), Frank Barber, H. L. Steenbuch, David Molitor, Thos. Taylor. Subject— Steel highway bridge specifications.

Sewage Disposal and Sanitation.—A. F. Macallum (chairman), P. Gillespie, W. Chipman, F. W. Thorold, J. H. Nevitt. Subject—Report on commercial success of treating sewage by aeration.

General Clauses for Specifications.—W. Chipman (chairman), E. W. Oliver, E. L. Cousins, Wm. Cross, D. Molitor. Subject—To consider last year's report and suggest modifications if desirable.

Reinforced Concrete.—Peter Gillespie (chairman), Frank Barber, A. W. Connor.

New Members.—J. R. W. Ambrose (chairman), H. E. T. Haultain, A. F. Macallum, G. A. McCarthy, J. H. Curzon.

Legislation Committee.—E. W. Oliver (chairman), J. G. G. Kerry, H. E. T. Haultain.

Power Plants.—L. M. Arkley (chairman), A. A. Bowman, Peter Bain, E. T. J. Brandon, F. G. Clark, A. G. Hill, Jas. Milne, A. L. Mudge. Subject—Uniform steam boiler specifications for the Dominion of Canada.

Hydraulics.—N. R. Gibson (chairman), T. H. Hogg, H. G. Acres, E. C. H. Dowson, C. L. Fellowes, D. Molitor, Wm. Cross. Subject—To continue work of last year on a standard specification for cast iron water pipe.

Track.—E. G. Hewson (chairman), A. F. Stewart, A. L. Hertzberg, F. B. Goedike. Chairman to choose work to be done by committee.

Library Committee.—A. L. Mudge (chairman), W. A. Hare, A. A. Bowman, Fraser F. Keith.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.