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ECONOMICAL DEVICES IN CRIBWORK CONSTRUCTION

DETAILS OF CONSTRUCTION OF SKIDWAY USED IN CONNECTION WITH BUILDING OF CRIBS UP TO FIFTY FEET IN LENGTH

By A. E. EASTMAN, A.M.Can.Soc.C.E.

IN the following article the writer does not attempt to advance, perhaps, anything new, or claim to be the originator of any of the devices described. He is of the opinion, from observation during his experience, that it often proves that some cheap, easily built and easily maintained device will save its value, or cost, to a contractor many times for certain work. Hence these notes. The devices described will be seen to be chiefly applicable to cribwork. No attempt has been made to give fixed dimensions, but each case would have to be governed by existing circumstances.

Fig. 1 gives the general plan and necessary details for a skidway or ways on which may be built light cribs up to, say, fifty feet long. In the particular case where this style was used the ways were located on a canal bank, and the crib was forty feet long. The longitudinal or under timber was 12 in. by 12 in., solidly blocked up to the required height, and made level throughout its length. The ways were of the same size timber. Under each way and just back of where it rested on the longitudinal, another piece of 12 in. by 12 in., from three to five feet long, was securely bolted to the way, the object of this being that, when the crib was launched, the ways would not go into the water, but be held by this block. The ways were not fastened to the longitudinal.

On these ways were placed the "butter-boards." These boards were 4 in. by 12 in. plank, with a piece of 3 in. by 8 in. securely bolted to each side to act as guides to keep the "butter-boards" straight on the ways during launching, and thus assist in keeping one end of the crib from going too fast. As a lubricant between ways and "butter-boards" a mixture of tallow and oil was used and placed before starting a crib.

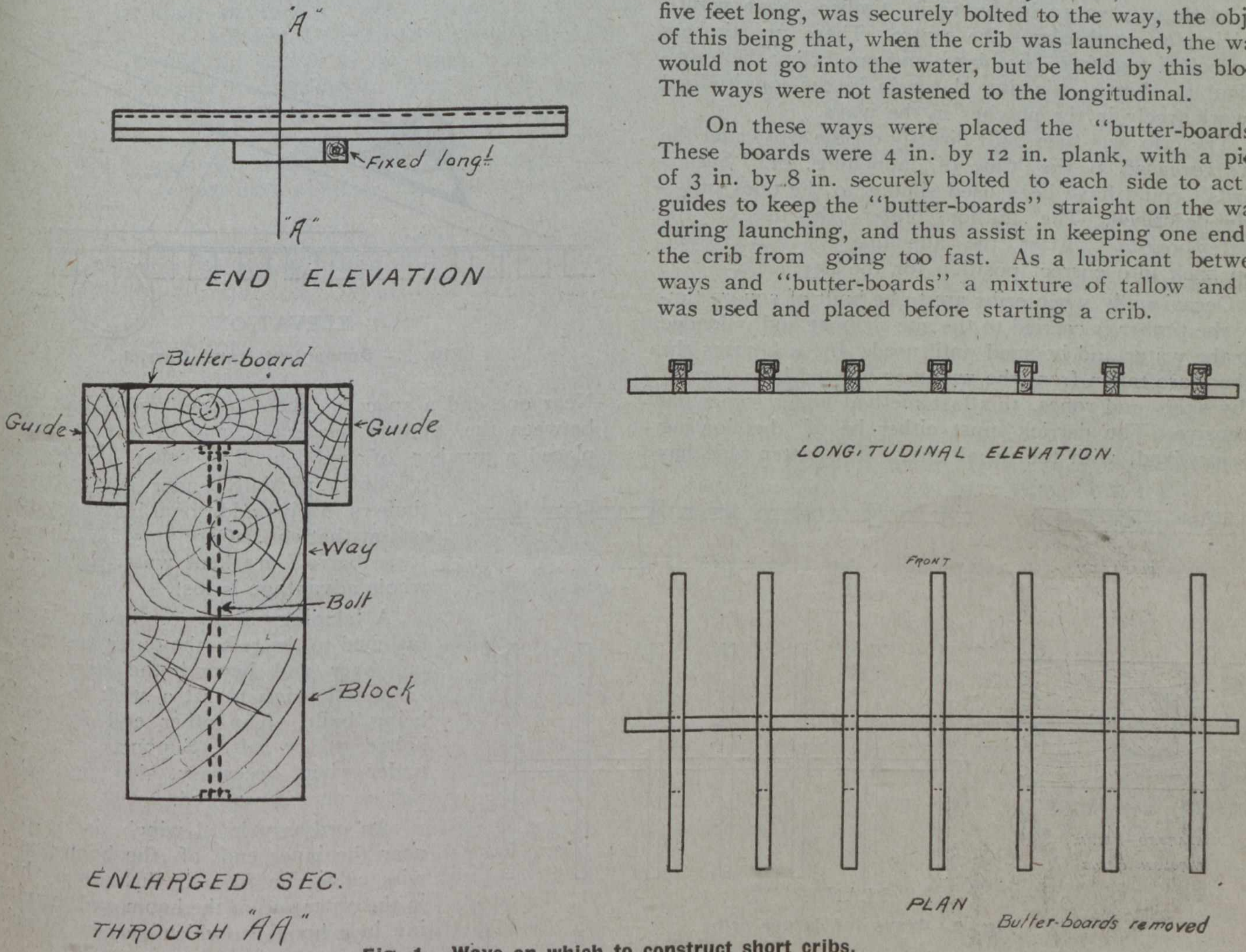

Fig. 1.—Ways on which to construct short cribs.

The "butter-boards" being in position, a crib was begun, the bottom being made to conform to the dredged crib-seat as determined by soundings, blocking being placed, where necessary, between the lower courses and the "butter-boards." Care was taken to keep the centre of gravity of the crib back of the longitudinal, but as near it as possible, consistent with danger of premature launching. When the crib was built to the required height, the rear ends of the ways were raised by using planks as levers, and the crib slid easily into the water. As soon as the crib was afloat the ways dropped back into approximate position. All that was necessary was to get the "butter-boards" from beneath the crib launched and place them. The writer saw a number of cribs launched from these ways, and the operation of launching and getting ready for the next crib took but a few minutes in each case, and no mishap occurred at any time.

Fig. 2 shows the general plans and enlarged section of important details of a type of ways for heavier cribs than the one just described. This type would do equally well for small cribs, but would cost more to build, and this first cost might not be warranted.

The longitudinal in this case would be, say, 12 in. by 12., or, in some cases, 15 in. by 15 in. would be better. This longitudinal would, of course, be made solid and level throughout. At the required intervals along this longitudinal, where the ways would be placed, the longitudinal was gained down to 12 in. or 15 in. round, depending on the original size of the timber. Each way was made of two 12 in. by 12 in. timbers, each with a semicircular notch about the centre. These two timbers were bolted together, one above and one below the longitudinal as shown, allowing the gain in the longitudinal to work freely in the notches in the ways.

The crib was then built directly on the ways and the ways greased at the time of launching, or "butter-boards" could have been used similar to the ones previously described. The author prefers the use of the "butter-boards." After the launching the ways would drop back into correct position for the next crib.

Occasionally, when cribs are to be built of square timber, the timber is carried to the site by boat and unloaded into the water and boomed until used. In such cases the timbers are taken from the water as wanted by a derrick or by skids and ropes, this last method being somewhat expensive. The derrick must either be of the floating type or fixed, with the usual guys. The latter type has the disadvantage of being fixed, and materials, etc., must be brought to it. The work sometimes will not warrant a large steam-operated floating derrick.

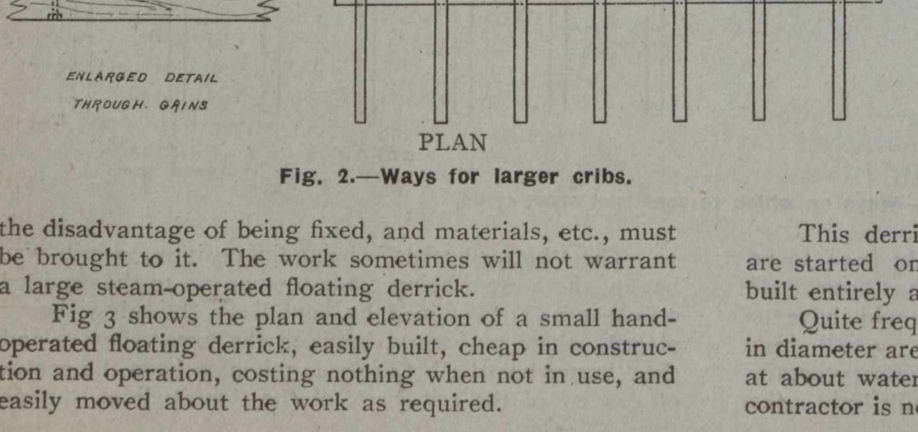

Fig. 2.—Ways for larger cribs.

Fig 3 shows the plan and elevation of a small hand-operated floating derrick, easily built, cheap in construction and operation, costing nothing when not in use, and easily moved about the work as required.

A stout raft, of size according to the sticks to be lifted, is built of 12 in. by 12 in., or any suitable sized material, and decked where necessary. Merely spiking the decking to the timbers would construct the raft. Near one end a space of about a foot and a half is left between the timbers undecked, and in this space are placed a number of wooden oil or other barrels, held wholly or partially under water by the timbers to give additional buoyancy to the raft at that end. Care must be taken that these barrels are kept water-tight or the whole advantage is lost.

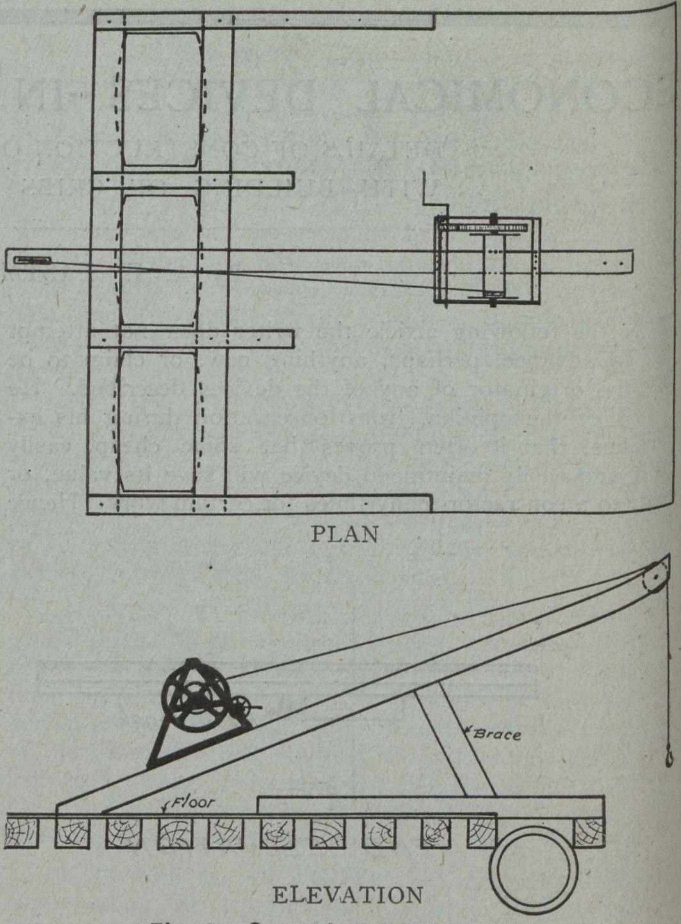

Fig. 3.—Convenient Hand Derrick.

A sloping beam or boom is then fastened to the raft, the outer end extending over and beyond the barrels, and sufficiently high to lift a stick to the crib being built. The other end is securely bolted to the raft. Supports are placed under where necessary, also guys to the raft corners if required.

An ordinary hand winch is mounted near the inner end of the boom, and a wire cable run from it through a sheeve in the outer end of the boom and terminating in a hook, to which may be attached the timber hooks.

This derrick would prove useful either where cribs are started on ways and launched, or where cribs are built entirely afloat.

Quite frequently tie rods or bolts of up to three inches in diameter are required to be driven in cribwork or docks at about water line. Holes for these are bored, but the contractor is not allowed to make these holes much larger than the rod or bolt to be driven. As a consequence, there is much discomfort to men driving them from the splashing that is usually unavoidable. The writer watched a gang of men driving short tie-rods at water line, easily, effectively and in comfort. In placing and starting the rods a raft of 12 in. by 12 in. timbers had been used to work from. After the rod had been started the men fastened one end of the raft loosely to the cribwork and used this fastening as a sort of hinge. One man on the raft pushed the free end away from the crib by a pole, and the rest by means of a rope pulled it back again, striking the bolt and driving it home. A more effective blow was delivered than could be done by a sledge, and it was more comfortable to the men.

CORRECTION OF ALIGNMENTS AND GRADES IN EXISTING HIGHWAYS.*

By A. Fraser, A.M.Can.Soc.C.E.,
Engineer, Department of Roads, Quebec.

THE importance of the alignments and grades is very apparent to all engineers who have had to do with the building of roads. When making a special study of this question I was impressed at first sight from the variety in the details of the many opinions expressed and the practices followed. But, after a careful examination of each particular case, I soon found that such variety has been mostly the result of the special circumstances in accordance with which the many aspects of the question have been dealt with and the various problems solved.

The methods used in the construction of roads vary to a certain extent according to the political, economical, commercial, topographical and climatic conditions of each country and the different periods of history. For instance, the famous Roman roads were, as a rule, laid out in approximately straight lines. Mountains, hills and valleys were crossed almost without any regard to topography. Hills were cut through and deep ravines filled in. But everybody will agree that the economical and political conditions of that time were quite different from those which we have to contend with to-day and it would be absurd to attempt to follow their example.

I will confine myself to a brief discussion of the question from the point of view of the construction of our trunk roads in the province of Quebec, setting aside the special conditions in mountainous country.

In the province of Quebec, as well as in all the other provinces, as those trunk roads have mostly to go across agricultural districts, settled many years ago, they have to follow the existing roads.

The engineer who has to secure the best alignments must always keep in mind that as those trunk roads are specially destined to promote agricultural development and the material welfare of the country through which they go, they will also have to bear an ever-increasing automobile traffic. Everybody knows that a great many of the automobile accidents are due to bad alignments. Of course, we cannot make our roads "fool-proof," but the country people and the careful tourist, unfamiliar with the road, have a right to protection against the speed lunatics who drive at from 40 to 60 miles per hour.

No hard and fast rules can be laid down about the alignments and grades. Although I will try to give the general principles which I have by experience found the most practical and important.

The curves should be planned to afford a sight distance; that is, the greatest distance at which the drivers of two approaching vehicles may see each other's machine—of not less than 250 feet. This is the most important rule. I might say that the whole question of alignment and grade is a question of the line of sight of unobstructed vision

Radius of Curvature.—In the province of Quebec, we have adopted the minimum radius of 300 feet wherever possible without incurring a prohibitive cost. If we have to shorten that radius to 150 feet and under, we put danger signs at 400 feet from the B.C. and the E.C.

The pavement itself should be widened in the curves and banked. For the widening, I found the following formulæ, given by Byrne, very useful:

$$R' = \sqrt{\left[R + \frac{W + w}{\frac{1}{2}}\right]^2 + l^2}$$

R' = minimum radius of outer curve.
R = radius of the inner curve of the road.
W = width of road on tangent.
w = total width of vehicles.
l = total length of vehicles, including teams.

For the banking of the curves, the following rules are advisable: On a curve of between 2,000 and 800 feet radius the outer side of the pavement should be 6 inches higher than the inside one; between 800 and 550 feet radius, 7 inches; between 550 and 400 feet, 8 inches; between 400 and 300 feet, 9 inches; and under 300 feet, 10 inches.

When a curve occurs on an ascent, the grade at that place must be diminished in order to compensate for the additional resistance of the curve. When it is necessary to make a radius of curvature less than 300 feet, we usually follow the principle of reducing the grade on the curve at the rate of one per cent. for every 50 feet that the radius has to be reduced; so that where we are locating a five per cent. grade and have to put in a curve with 200 feet radius, we give a three per cent. grade.

As a rule, there ought to be a tangent of about 100 feet between two curves. Quick reverse curves are disagreeable and dangerous with automobile traffic and are to be avoided.

To cross all obstacles as nearly as possible at right angles. The cost of skew structures increases nearly as the square of the secout of the obliquity.

The road on each side of an obstacle should be straight on a length of at least 50 feet when there is a possibility of doing so without incurring prohibitive expenses.

Do not overestimate the advantage of straightness. The curved road around a hill is often no longer than the straight road over it. In addition, a more or less sinuous course is an advantage from a maintenance standpoint, as on a winding road the wheel traffic has a tendency to spread over the entire surface.

Carry the road along the southern or western slope of ridges, if possible, so that it may be less exposed to storms and dry out more quickly after heavy rains and the melting of snow.

The difference in the length between a straight road and one which is slightly curved is very small. On the Montreal-Quebec Road, we have eliminated all the bad curves wherever possible and through that fact we have reduced the first 50 miles of roads from Montreal by only 400 feet. As a matter of fact, we generally follow the

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line of the old roads as long as there is no bad curve and no danger for the automobile traffic.

The maximum grade on our trunk roads is five per cent., and the exceptions to this rule are very few. It has been demonstrated by careful observers that a horse, for a limited period of time, can exert 40 per cent. of his weight in tractive force; then, for a short distance, it is better to place a 6 or 7 per cent. grade over a limited distance than to make a deep and expensive cut.

In the province of Quebec we generally make the grade follow the natural undulations of the ground as long as we remain below the maximum grade and the sight distance is at least 250 feet. The expenses incurred in making a level or nearly level road would not be warranted by the traffic anticipated for many years to come. Farmers are satisfied with a maximum grade of 5 per cent. and this grade meets with no objection from owners of motor vehicles of any type. Some experiments made by Mr. H. Kerr Thomas and Mr. O. Ferguson, of Buffalo, New York, for the Pierce Arrow Motor Co., show that the class and kind of surface exert more influence upon the motor vehicle than the per cent. of grade and that it requires practically the same tractive force on a one percent. grade in sand and loose stone to handle the same load as it does on a 27 per cent. grade on concrete.

A farmer or teamster would rather go up a mile of 5 per cent. grade on a good alignment than a mile and a half of curves on a 2 or 3 per cent. grade, with a possible surprise party awaiting him at every turn of the road. It is generally admitted that an automobile of ordinary power can operate on high gear wherever the grades do not exceed 5 per cent.

Grades as high as 10 per cent. or over must be avoided at all cost in our country because they are very dangerous, both for horse and motor traffic in frozen and icy weather.

Deep cuts must be avoided as much as possible on account of the snow and the resulting difficulties for traffic in winter and spring.

There is occasionally a road upon which the summit of two intersecting grades is a source of danger, because the drivers of cars which happen to meet just at the top cannot see each other until just before they meet. This meeting point of two grades should be rounded off by a vertical curve so as to insure a sight distance of at least 250 feet.

One of the most important questions that we have to take care of in determining the grades and the alignments is that of drainage.

Drainage is the most important factor in the construction of roads and we cannot get proper drainage if the road has not been properly located.

To summarize, I might say that we must correct the alignments and grades so as to insure a good drainage and eliminate all dangers where possible.

At a time well within the memory of most road builders, the element of safety commanded relatively little attention in road work. Neither in design nor in construction was a safe road kept in mind as the kind to be built, and little effort was made to eliminate danger points in existing roads. The road builders of that time were not greatly at fault on account of the traffic which was rather a slow traffic. As the automobile evolved from a curiosity to an everyday business and pleasure, conditions have changed. And, in the future if our successors find some defects in the roads that we are improving to-day we will have deserved their criticism.

It is contended by those who advocate the construction of relatively permanent surfaces for country roads that such pavements will have a considerable value as foundations for other pavements after the expiration of their life as a wearing surface. This is undoubtedly true if the alignment and grades on the highway are satisfactory at that time. Otherwise, the old pavement will constitute a liability rather than an asset. May not, then, the added cost of right-of-way and grading necessary to make the location the best obtainable be offset to some degree by the value of the old pavement at the expiration of its life?

ROAD OILS AND TARS.*

By Arthur H. Blanchard, M.Can.Soc.C.E.,
Consulting Highway Engineer, New York City.

ROAD oils and tars will be considered from the standpoint of their use in connection with the maintenance of broken stone and gravel roads. Dust laying, as the primary object of the use of oils and tars will not be discussed, as it is believed that special attention, at the present time, should be devoted to such methods of using these materials as will economically preserve the surface of the roads and also render them practically dustless. As the subject will be presented with a view to general adaptability of conclusions and recommendations, it is evident that only conservative practice can be advocated. Local conditions, however, must always be given great weight in the final determination of the method and material to be used.

Definition.—Before proceeding with the discussion of the construction of bituminous surfaces, it is advisable, in order to avoid misunderstandings, to quote the definition of bituminous surface as recommended by the special committee on "Materials for Road Construction" of the American Society of Civil Engineers: Bituminous Surface—A superficial coat of bituminous material, with or without the addition of stone or slag chips, gravel, sand, or material of similar character.

Development.—Since the formulation of the fundamental principles of the successful construction of tar surfaces by the engineers of the Department of Roads and Bridges of France, in 1903, bituminous surfaces have been used extensively in Europe. As an illustration may be cited the construction of 5,000,000 square yards of tar surfaces in a single county of England in 1911 under the supervision of H. P. Maybury, at that time county surveyor of Kent. During the past ten years, American engineers have used bituminous materials in this manner as a standard method for the maintenance of roads and pavements.

Bituminous Materials.—Considerable development has taken place in the use of different kinds of bituminous materials. Tars, of both water-gas and coal-gas types, continue to be used to a large extent. During the past two years an asphalt cut-back with naphtha has been successfully employed in the construction of bituminous surfaces. Oils are not advocated for general use in the construction of bituminous surfaces for the following reasons: (1) Medium and heavy oils generally require considerable time in which to set up; (2) most petroleum products, while in a fluid state, act to a certain extent as lubricants; (3) it is therefore evident that more or less movement of the roadway surface will take place under traffic during the setting-up period; (4) the bituminous

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mats or carpets formed invariably become wavy and full of humps and ruts under heavy traffic; (5) due to the character of the resulting surface further maintenance is rendered difficult and costly; (6) prior to the re-treatment of oil-coated roads, it is often necessary to remove considerable portions of the bituminous mats with picks and shovels or with scarifiers.

Specifications Covering Bituminous Materials.—The following specifications for refined tars, used hot, and cut-back asphalt for surface treatments have given satisfactory results:—

Water-gas Tar—(1) The refined tar shall be homogeneous, free from water and shall not foam when heated to 121° C. (250° F.).

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.140 nor more than 1.160.

(3) When tested by means of the New York Testing Laboratory float apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 45 seconds nor more than 65 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 96.0 per cent. and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 30.0 per cent. shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method, of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause 5 shall be not more than 75° C. (167° F.).

Coal Tar—(1) The refined tar shall be homogeneous, free from water, and shall not foam when heated to 121° C. (250° F.).

(2) Its specific gravity at a temperature of 25° C. (77° F.) shall be not less than 1.170 nor more than 1.230.

(3) When tested by means of the New York Testing Laboratory float apparatus, the float shall not sink in water maintained at 50° C. (122° F.) in less than 40 seconds nor more than 100 seconds.

(4) Its bitumen as determined by its solubility in chemically pure carbon disulphide at room temperature, shall be not less than 82.0 per cent. nor more than 95.0 per cent., and it shall show not more than 0.2 per cent. ash upon ignition of the material insoluble in carbon disulphide.

(5) When distilled according to the method adopted by the American Society for Testing Materials in 1916, it shall yield no distillate at a temperature lower than 170° C. (338° F.); not more than 20.0 per cent. shall distill below 270° C. (518° F.), and not more than 25.0 per cent. shall distill below 300° C. (572° F.).

(6) The melting point as determined in water by the cube method of the pitch residue remaining after distillation to 300° C. (572° F.) in accordance with the test described in Clause 5 shall be not more than 75° C. (167° F.).

Cut-back Asphalt (Philadelphia Specification)—The material shall be a cut-back asphalt prepared in a still by compounding approximately 35 per cent. of a distillate meeting Specification "A" and 65 per cent. of an asphalt meeting Specification "B."

Specification "A"—Beaume gravity, 53 to 60; end-point of distillation, 350° F.

Specification "B"—Specific gravity, 77° F., 1.02 (minimum). Penetration, 100 grams for 5 seconds at 77° F., 85 to 100. Loss 50 grams, 5 hours, 325° F., not more than 3 per cent. Soluble in carbon bisulphide, not less than 99 per cent. Soluble in carbon tetrachloride, not less than 99½ per cent. Ductility (Dow method) at 77° F., not less than 45 cm.

The cut-back asphalt made from a combination of the above two products shall conform to the following tests: Specific gravity, 0.900 (minimum). Penetration of residue after heating for 5 hours 325° F., from 35 to 45. Viscosity, 50 c.c., at 77° F., in Engler viscosimeter, 275 to 350 seconds. Distillate off below 300° C. shall show a gravity of 53 to 60 Beaume. Ductility of residue (Dow method) not less than 30 cm.

Methods of Construction.—In the case of broken stone and gravel roads, the most efficient method of procedure is to clean the surface thoroughly by sweeping with hand brooms, or horse sweepers and hand brooms, the final sweeping being done with bass or other fine-fibre brooms. The bituminous material, which is used both cold and hot, is applied to the surface in amounts varying from ¼ to ½ gallon per square yard, with the aid of pouring cans, hose attached to tanks, hand-drawn gravity distributors, horse-drawn or motor-truck gravity or pressure distributors. Some kind of mineral coating is generally applied to cover the bituminous material. The degree of cleanliness of the surface obtained by sweeping will depend to a large extent upon the details of the original construction. It has been found that a road with a thoroughly rolled and well-puddled broken-stone wearing surface, composed of road metal from 1 inch to 2½ inches in longest dimension may be easily cleaned, and the essential adhesion of the bituminous surface readily secured. This method is characteristic of the modern practice of many of the foremost English and French engineers.

Specifications Covering Construction.—As an illustration of the method of covering essential details of construction of bituminous surfaces with hot tar, the following specifications for certain local conditions are cited.

Heating Refined Tar.—The refined tar shall be heated in kettles or tanks so designed as to admit of even heating of the entire mass, with an efficient and positive control of the heat at all times. It shall be heated as directed by the engineer to a temperature between 93° C. (200° F.) and 121° C. (250° F.). All refined tar heated beyond 121° C. (250° F.) shall be rejected. No tar shall be heated in kettles or tanks containing any oil or asphalt cement. The contractor shall provide a sufficient number of accurate, efficient, stationary thermometers for determining the temperature of the refined tar in kettles or tanks.

Preparation of Surface of Road.—All sections of broken stone roadways containing depressions, pot-holes, waves, ruts or other irregularities shall be repaired as directed by the engineer, prior to the final preparation of the road for the construction of the bituminous surface, by the use of broken stone which will pass over a one-half (½) inch screen and through a one and one-half (1½) inch screen, stone screenings passing a one-quarter (¼) inch screen, and water, which materials shall be thoroughly compacted by tamping or rolling. Prior to the application of the refined tar, the surface of the broken-stone road, when thoroughly dry, shall be swept clean of all dust, dirt or other loose material by using, first, stiff fibre hand brooms or a horse-drawn stiff fibre sweeper and, second, bass or other fine fibre brooms, as directed by the engineer. When the cleaning is completed the upper surface of broken stone shall be exposed, forming a clean mosaic surface.

Application of Refined Tar.—After the surface shall have been cleaned to the satisfaction of the engineer, and when thoroughly dry, the refined tar shall be uniformly applied over the prepared surface of the road by means of a pressure distributor as hereinafter specified and in accordance with the directions of the engineer. The refined tar, when applied, shall have a temperature between 93° C. (200° F.) and 121° C. (250° F.). The total amount of refined tar to be used in the construction of the bituminous surface shall be applied in one application and shall not be less than 0.35 nor more than 0.45 gallons per square yard, the precise quantity being determined by the engineer.

Pressure Distributor.—The pressure distributor employed shall be so designed and operated as to distribute the refined tar specified uniformly under a pressure of not less than twenty (20) pounds nor more than seventy-five (75) pounds per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationary thermometer in the tank containing the refined tar and with an accurate pressure gauge so located as to be easily observed by the engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the refined tar will be at once shut off. It shall be so designed that the normal width of application shall be not less than six (6) feet and so that it will be possible on either side of the machine to apply widths of not more than two (2) feet.

Application of Broken Stone Chips.—Immediately after the application of the refined tar, a layer, between twelve (12) and fifteen (15) pounds per square yard, of broken stone chips, which will pass through a one-half (½) inch screen and over a one-quarter (¼) inch screen, shall be spread and broomed as directed by the engineer over the surface of the refined tar and shall be at once rolled as directed by the engineer with a roller weighing between five (5) and twelve (12) tons.

Interruption of Traffic.—In cases where the entire roadway cannot be closed to traffic during the construction of the bituminous surface, only one-half of the roadway surface shall, at one time, be closed to traffic while the bituminous surface is being constructed thereon. The bituminous surface shall not be subjected to traffic until after the covering of broken stone chips has been rolled.

Seasonal and Weather Limitations.—No refined tar shall be applied when the air temperature in the shade is below 10° C. (50° F.), except by the written permission of the engineer.

Failures of Bituminous Surfaces.—The causes of failure of bituminous surfaces are numerous. They may be considered from the standpoint of the condition and character of the original surface, the material used, the method of construction, and local conditions.

The failure of bituminous surfaces from the standpoint of the character of the original surface is many times due to failure on the part of those in charge to place the surface in satisfactory condition before the application of the bituminous material. Many cases are noted where bituminous materials are applied over a surface in which are found many pot-holes and ruts, or which is dirty, due either to accumulated dust and dirt or to the original method of construction. In many cases a damp condition of the surface has resulted in failure.

From the standpoint of the physical and chemical properties of the material, many instances may be cited in which failure is due to materials not having the proper characteristics for the conditions under which they are employed. The large percentage of volatile constituents contained in certain asphaltic oils has rendered surfaces constructed with them unsatisfactory because of the long period required for these surfaces to set up so that the bituminous material will not track or the carpet thus formed will not creep and form waves and humps. In certain cases the use of light oils on tar or asphalt surfaces has softened the original bituminous surface to such an extent as to render the road or pavement unsatisfactory for use.

From the standpoint of construction, failures are due both to the use of too small an amount of the bituminous material and to an excess of material. Improper application, resulting in uneven distribution, is accountable for many failures of bituminous surfaces, while in other cases a lack of sufficient covering of stone chips or material of a similar character has rendered the surface sticky and mushy.

There are numerous instances where bituminous surfaces have been adopted under conditions which call for the construction of bituminous concrete pavements or even some type of block pavements. A mat type of construction, which has been employed to a considerable extent, has proved inefficacious in cases where the amount of motor-car traffic was not sufficient to iron out satisfactorily the caulk holes caused by the horse-drawn vehicular traffic.

ROAD FOUNDATIONS AND DRAINS.*

By R. Crawford-Muir, A.M.Inst.C.E., A.M.Can.Soc.C.E.
Assistant Engineer, Department of Public Highways, Ontario.

THE first problem in road construction is the location and gradient, but in connection with the travelled surface the chief factors are the drainage and the foundation. Drainage is so closely allied to foundations that it is difficult to speak of one without taking the other into consideration.

Too much cannot be said of the importance of drainage. It is important in connection with any class of road construction.

The drainage of roadways is of two kinds, viz., surface and subsurface. The first provides for the speedy removal of all water falling on the surface of the road. The second provides for the removal of the underground water found in the body of the road, a thorough removal of which is of the utmost importance and essential to the life of the road surfacing.

Subsurface, or underdrainage, is not always required, but in seepy ground is a necessity; a road with a subsoil of a sandy or gravelly nature underdrainage is not required. On the other hand, a clay soil which readily retains water will become almost impassable unless properly drained. In low places, where the water settles at the side of the road, keeping the subsoil constantly saturated, subdrains will effect a marked improvement. Springs on hillsides, which, unless led from the road by drains, will soften the soil, with a consequent failure of the surface at these points. Quicksands have absolutely no supporting power, but if properly underdrained they may serve as a suitable foundation.

A road cannot be maintained in wet ground. Sometimes blind drains will carry off the water. At other times it may be necessary to lay longitudinal or transverse tile drains. Blind drains are not as efficient as tiling on account of their liability to become partially clogged by silt.

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*Paper read before the Third Annual Conference on Road Construction, Toronto, March 27th to 30th, 1917.

Side ditches, if properly constructed, often will drain a damp roadbed. These ditches play an important part and must be looked after at all times. Even when underdrainage is not needed, good side ditches are always required. Ordinarily, they need not be deep; but, if possible, should have a broad, flaring side toward the roadway. The outside bank should be flat enough to prevent slipping. When the road is in an excavation, ditches should be provided so as to prevent the water from running down the centre of the road; the steepest grades need the ditches most. Where grades exceed 4 per cent. and the soil is loose and sandy, the ditch should be paved with cobblestones or field stone in order to protect the shoulders from wash. These gutters can also be used to advantage at intersecting roads where there is not sufficient headroom for a culvert.

As a rule, the ditches, culverts and the roadside in particular, along our highways do not receive the attention they deserve. Often we find weeds and brush growing along our main roads, blocking the flow of water and preventing it from escaping quickly to the outlets, and besides, their existence is not pleasing to the eye. It is not a rare occurrence to see culverts almost wholly blocked with weeds and silt, thus causing unnecessary flooding and damage. It is admitted on all sides that drainage is of the utmost importance to all roads. Such being the case, it behoves us to see that everything be done to keep the highway in as perfect a condition as possible.

In providing for cross-drainage only permanent material should be used, for the failure of a cross-culvert will not only block the drainage, but will damage the road surface and may cause accidents. Cross-culverts are required to distribute the water to natural channels, so that the side ditches do not carry too much water. While the cost of carrying water away from the side ditches often seems prohibitive, the expense is always warranted by the better construction obtained. When impossible to provide complete drainage the elevation of the subgrade should be at least two feet above high water level.


Showing Effect of Poor Drainage on Concrete Road.

The main object in underdrainage is to lower the water level in the soil; in other words, to intercept the ground water before it reaches and soften the subgrade.

In many cases a line of tile on one side of the road is usually sufficient. In these cases the tile should be placed on the high side of the road, preferably under the ditch where the greatest depth can be obtained with the least excavation and where the water is caught as it flows out of the hill. Sometimes a section of a road is wet because of a spring, or perhaps the road is muddy because of a stratum which brings the water to the road from higher ground; in either case, the source of supply should be tapped with a line of tile instead of trying to improve the road by piling up earth.


Tile Drains More Desirable than Blind Drains.

All drains should be carried to a proper outlet, either to a culvert, to another drain, or through a bank. When the drain is carried through a bank the outlet end should be protected by a masonry or concrete wall which extends back along the pipe for a distance of three feet, thus preventing the water from undermining the pipe at this point.

There are places along a road where the water may be turned off at either side, such places, for instance, as a fill, with the ground sloping away from the road on both sides. If there is much water to be turned over the bank it will be necessary to protect the bank from washing out. A small amount of water running down high banks composed of sandy soil is liable to cause great damage, for the small gullies made by the water may rapidly extend back into the road surface. The bank should be protected by sod, or a paved channel should be constructed down the side of the bank to carry the water. In soils where there might be some question as to the advisability of using a gutter, a vitrified pipe or a wooden trough may be constructed down the side of the bank.

In planning the drainage for a road improvement it is well to make as few changes as possible from the existing scheme.

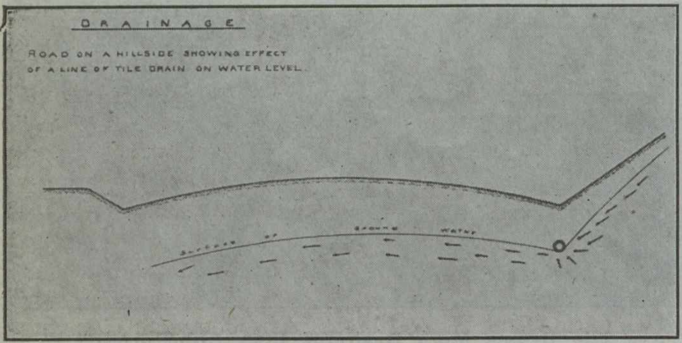
After drainage is secured, the important points in road foundations are the removal of all vegetable matter and to build up the foundation uniformly. Dragging and planing the subgrade as it is being built will prevent the waviness of surface which develops occasionally after the completion of a road.

The subject of foundations will be considered under two heads, viz., Natural Foundations and Artificial Foundations.

With the exception of earth roads, the construction of all of the more common types of roads might be described as three distinct steps, viz.: the construction of the subgrade or natural foundation, the construction of an artificial foundation, and the construction of the wearing surface. Therefore, the lower courses of either a macadam or a gravel road might be considered as types of artificial foundations.

Any subsoil will generally be improved by rolling, and such a process will show up weak spots that should be replaced with other material.

As a rule, the subgrade does not receive the attention it should in construction; it cannot be too carefully prepared. It should be thoroughly drained and compacted, soft material removed and fills allowed to settle before the foundation, which is to carry the wearing surface, is laid. It is the subgrade that carries the load and resists the blows of heavy traffic. The real foundation of a road is the earth subgrade, and it develops its greatest bearing power when dry.



A Natural Foundation is one where the surfacing material is laid directly upon the subgrade. Gravel or a sandy loam, when properly prepared, makes a suitable foundation for macadam or concrete.

Before concrete is laid as a surfacing or a foundation on an earth surface, a layer of cinders, gravel or crushed stone as a cushion should be spread to keep the moisture away from the base of the surfacing. This construction would lessen the number of cracks in the concrete surface.

When gravel is used as a sub-base for concrete surfacing it should be absolutely free from clay or loam, and rather sandy.

Surfacing with gravel constitutes a large portion of rural road work, and a great deal of money is wasted in not properly preparing the foundation for this surfacing. Common practice is to place gravel to a depth of from 6 to 8 inches on clay soil, frequently on a newly-shaped roadbed. Until compacted the coat of gravel serves as a sponge, holding the water until the subgrade is softened, thereby allowing the material to be cut through and much gravel lost, with a consequent rutted and uneven condition of the surface.

Foundations for gravelling should be firm and hard, and on new work this may be accomplished by forming a crust with a mixture of 2 or 3 inches of sand and gravel with clay subsoil, rolled to a smooth surface. On a sand subsoil it is equally necessary to have a foundation to prevent loss of gravel, and in such cases clay mixture is required.

Most gravel contains a proportion of silt or loam sufficient to draw moisture, so that the frost will work into it, and, of course, when the frost thaws, it leaves the material porous, spongy and wet. This condition is made worse by the traffic, which tends to puddle the surface, drawing the moisture from below Such a result may not be serious if the road is of gravel or waterbound macadam, for such can be easily and cheaply repaired, but if the surface is bituminous, it may be ruined. It should be borne in mind that a road may stand up two or three years over a poor sub-base with little apparent trouble, but go to pieces the third or fourth year. This fact has caused a great deal of trouble; for the inexperienced man, finding that a road stands all right the first year, assumes it will continue to do so, proceeds with the same type of construction under similar conditions until the first fails and the whole road is ruined.

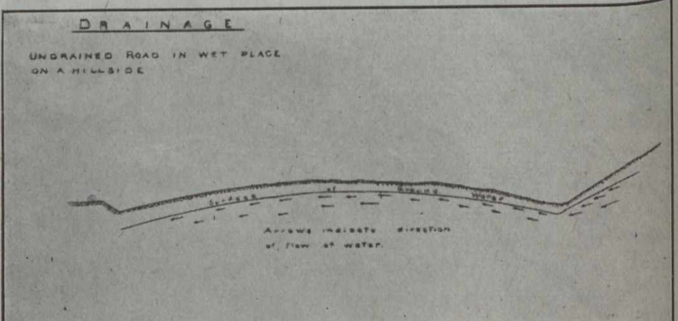
Artificial Foundations.—Among the artificial foundations suitable to lay a surfacing to meet the traffic requirements are concrete, rubble, telford, broken stone or gravel. The character of the foundation to use depends on the volume of traffic, the type of surfacing to be placed thereon and the natural soil conditions.

A gravel foundation should be thicker than a crushed stone foundation, as the fragments do not interlock as firmly as crushed stone. The choice between a gravel or a crushed stone foundation rests entirely on the relative cost.

When crushed stone is used as a foundation the size of stone should be 2¾ to 3¾ inches, but where local stone is used the size may be from 1 to 3¾ inches in order to take up the total output of the crusher. Crushed stone must never be laid on a soft subgrade. The distributing power of this course depends largely on the stone fragments being firmly interlocked. If the stone is placed on a soft subgrade and rolled, the earth will squeeze up between the fragments and separate them. The course should be rolled until no movement is under the roller.

One of McAdam's theories was that no stone larger than two inches should be used in a road. But experience has shown that this size of stone is unsatisfactory for foundations and is only suitable for surfacing. With crushed stone the units are so small they have little bearing, and, as they have no cohesion when wet, sink readily. It should also be borne in mind that the cost of crushed stone is greater than the larger size stone.

A type of foundation used to a great extent in the United States is the V-drain. A V-drain, so called because it is really the shape of a flattened "V," is constructed by excavating the roadway for its full width, from 4 to 8 inches deep at the sides and from 12 to 18 inches deep at the centure. This excavation is filled with stones not over 8 inches in size. The larger stones are placed at the bottom of the trench and the smaller stones at the top. This V-drain is a combination of foundation and drain. The water flows in a channel in the centre of the road, whence it is led off by bleeders to proper outlets. A V-drain should only be used where the road lays over a wet or heavy soil.



The objection to the V-drains is that, owing to the extra depth of stone in the centre of the road, the frost action is not as great at that point as at the edges, where the stone is lighter, and a considerable distortion is occasioned in the road surface when frost sets in.

Field-stone or flat, rubble stone are sometimes substituted for the V-drain foundation. When flat stones are used, they are laid on the subgrade on their broadest face and small stones thrown on the surface to fill the crevices; the whole is then rolled until hard and firm. This type of foundation has given satisfactory results and is much cheaper than the Telford foundation. If a bituminous surface is to be placed on this foundation, a layer of clean sand should be spread over the surface of the foundation, so as to fill the voids. This is rolled without wetting and any surplus material swept off. The sand is only used to prevent loss of bituminous material, and is not an essential part of the foundation. Bleeders are used, where necessary, to drain the water from the foundation.

The Telford foundation as a base for macadam surfacing is well known. Properly laid, the supporting value and stability of such a foundation is high, and in many cases its use has been economical. On the other hand, the development of traffic conditions has resulted in such severe strains on these foundations that they have failed, probably most of the failures being due to unevenness of surface obtained, and a consequent lack of uniformity in the thickness of the surfacing. A Telford foundation which has been used as a base for a water-bound macadam surface, from which the macadam has been worn off, makes almost an ideal foundation, when brought to a true surface, upon which to lay a bituminous surface; provided that the stones have been originally set on a proper subgrade.

When roads are constructed with a view of utilizing in the future such construction as a foundation for some form of surfacing, the Telford method of construction is one that should be considered.

The quality of the material used as a foundation need not be as good as that on the surface, since it will not be subjected to the wear of the traffic.

Artificial foundations constructed with stone aid the drainage, besides directly improving the bearing power of the soil.

Concrete, apparently the highest type of artificial foundation, has become an approved foundation for any block or asphaltic concrete pavement, and is used chiefly on city streets. The necessity of using a cushion on the concrete foundation is one about which opinions differ.

The foundations for higher types of road surfacing, such as bituminous and concrete, require perhaps even more attention than for gravel or macadam roads. The material must not only be firm, with adequate provision for drainage, but the subgrade must be thoroughly drained out before the surfacing is placed. Most of the cracking and failure of concrete roads has been due to moisture in the subgrade at the time frost sets in.

Often we hear that a waterproof surface requires little or no foundation, because no water can get through it to the soil beneath, so the base is kept dry. This statement is entirely erroneous. A little consideration of the capillary action of the soil, which water from the sides of the road and underground sources, as well as the water that will seep through the soil from higher points, will show that a waterproof surface is not sufficient unto itself without a proper foundation. Each road is a problem in itself, and no standard treatment can be devised that will fit all conditions. There are many factors entering into the problem: soil, drainage, traffic, available material—all should be considered.

An economical design of foundation for macadam roads may be summarized as follows:—

For moderate traffic use pit-run gravel, local gravel if available, varying the depth to suit the soil. If gravel is not available, use crushed stone for ordinary soils and field-stone for bad foundations. The economy in the design of macadam roads is greatly increased by utilizing local material, preferably uncrushed, to its fullest extent. If the supply of local material is limited it should be used for as much of the road as possible, and advantage should be taken of the different local supplies by changing the design to allow their use with short hauls.

In planning the construction of a new road it is wise to go over the road in the spring when the frost is coming out and notice the bad spots, the spots that heave, and then when you build your road you can take these spots and provide some method for taking care of the ground water. If not, then in the summer the road is as hard as any other part.

The stability, permanence, and the maintenance of any road depends upon its foundation. If the foundation is weak, the surface will quickly settle unequally, forming depressions and ruts.

The essentials necessary to the forming of a good foundation are:—

(1) The drainage of the subsoil wherever necessary.

(2) The entire removal of all vegetable matter.

(3) The thorough compacting of the natural soil by rolling.

(4) The placing on the natural soil so compacted a sufficient thickness of an impervious material which will effectually cut off all communication between the soil and the bottom of the surfacing.

To ensure the stability of a road surfacing it is essential to have as firm and as good a foundation as for any other structure.

NEW PLANT FOR THE MARITIME PROVINCES.

What is said to be the largest concrete tile, pipe, brick and block factory east of Toronto has been fully equipped at Fredericton, N.B. A three-story brick and concrete factory 50 x 100 ft. has been equipped throughout by the Fredericton Concrete Co. with the most modern machinery for turning out the product entirely automatically and at high speed.

All products, as they come from the machines, are conveyed on cars to curing kilns and steam-cured for forty-eight hours. Sand and gravel are elevated from a storage pit in the basement by chain carriers to a large revolving screen at the top of the building. This screen separates the sand from the gravel, the sand going to a bin placed over the mixer. Over-size gravel and stones are carried to the crusher and then fed to crushing rolls, the pulverized product being carried back to the sand-pit. From this storage bin the material feeds to the power mixer from which the flow of concrete gravitates to different machines. As a result of this arrangement, the material is hardly touched from the time it is delivered at the factory until it comes out as a finished article.

The brick press puts a pressure of 200,000 lbs. on the material with a double repress. It has a large capacity and covers a wide range of work. The sewer pipe machine makes pipe from 5″ to 48″ in diameter, and from 24″ to 30″ long with either square or socket joint ends. The tampers on this machine work between the revolving core and casing, striking 450 blows per minute with a 400-lb. force on each blow, compressing the concrete thoroughly.

The drain tile machine makes 3″, 4″, 6″ and 8″ tile 12″ long, and 12″, 14″ and 16″ tile 18″ long with square joint ends. This machine has a capacity of several thousand tile per day. The block press develops a pressure of forty tons, making a very strong building block of excellent fireproofing, moisture-proofing and frost-proofing qualities.

EARTH PRESSURES: A PRACTICAL COMPARISON OF THEORIES AND EXPERIMENTS.*

By L. D. Cornish, M.Am.Soc.C.E.

Of all structures which the engineer of to-day is required to design for conditions of static loading, there is probably none which is so irritating as the ordinary retaining wall. This, of course, is due to the lack of definite and correct data relative to the pressures exerted by the various kinds of earthy materials and to the variety of formulas which have been proposed for determining the amount and direction of the resultant earth pressure which acts on a retaining wall.

The writer has studied with a great deal of interest all the books and papers he could obtain concerning earth pressure theories, and the formulas or graphical analyses derived therefrom. Such study has been confined principally to a comparison of solutions based on the Rankine theory with those based on the sliding-wedge theory, and certain facts were developed which appear to discredit, in certain particulars, these commonly accepted theories. It is quite probable that other investigators have observed at least some of the same results, but, as the writer had never seen them discussed, he thought the matter of sufficient importance to assemble the results of his studies in this brief paper.

The nomenclature used in Figs. 1 to 15, and discussion thereof is that used by Cain in his paper discussing Leygue's experiments, and, for the remainder of this paper, is the same as that used by Ketchum in his "Walls, Bins, and Grain Elevators." The differences are few and should cause no confusion, and the use of both will facilitate quick comparison with the works of the authors mentioned.

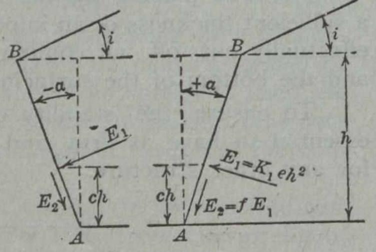


Fig. 1.

h = vertical height of wall;

ch = vertical height to centre of pressure on AB, Fig. 1,

$$c = \frac{1}{3};$$

ph = width of base of wall;

p = ratio of base to height;

e = weight of earth per cu. ft. (Cain-Leygue);

w = weight of earth per cubic foot (Ketchum);

W = total weight of earth per linear foot;

w_1 = weight of wall per cubic foot;

W_1 = total weight of wall per linear foot;

P = resultant earth pressure per lin. ft. of wall;

P_H and P_V = the horizontal and vertical components, respectively, of P;

$E_1 = K_1\ eh^2$ = normal component of P (Cain-Leygue);

$E_2 = E_1 \tan. \phi^1$ = component of P parallel to back of wall (Cain-Leygue);

k = cohesion, in pounds per square foot (Cain-Leygue);

K_1 = coefficient of E_1 (Cain-Leygue);

i = inclination of surface of earth to horizontal (Cain-Leygue)

δ = inclination of surface of earth to horizontal (Ketchum);

α = angle between back of wall and the vertical, counted as positive or negative, as in Fig. 12 (reproduced herein as Fig. 1) (Cain-Leygue);

ϕ = angle of repose (internal friction) of the earth fill;

ϕ^1 = angle of friction of the earth filling on the back of the wall;

θ = angle between the back of the wall and a horizontal line extending into the fill = $90 + \alpha$;

$r = \frac{1 - \sin. \phi}{1 + \sin. \phi}$ = the Rankine ratio of horizontal to vertical earth pressures = k, as used by Ketchum.

In discussing his solution of the sliding-wedge theory, Cain refers to various experiments, among which are those made by Leygue and in Table 3 of his paper before this Society. Cain gives certain results of Leygue's experiments. Leygue's experiments were made with dry sand and retaining boards, AB, which could be rotated about the bottom, A, in order to produce any desired inclination to the vertical, as shown by Fig. 1. Suitable observations were taken and results obtained, from which the values of K_1, as given in the last column of Cain's Table 3, could be computed. The reader is referred to Cain's paper "Experiments on Retaining Walls and Pressures on Tunnels," for additional details.

The values of K_1 show the relative variation in the total normal thrust against walls under different conditions of loading and inclination of the back of the walls, but convey no immediate idea of the dimensions of the walls necessary to withstand such thrusts, and, after all, the dimensions are of most interest to the practical engineer or designer.

As a preliminary to the discussion of the formulas in common use, and to provide for subsequent comparison of designs based on theory with those based on experiments, retaining walls were designed to satisfy the experimental values of K_1, as given in the last column of Cain's Table 3. In designing the walls, the unit weight of earth, e, was assumed at 100 lbs. per cu. ft., and the weight of wall, w, at 140 lbs. per cu. ft. The resulting designs are shown by Figs. 2 to 8, and it may be noted that the values of e and h selected are such that eh^2 = 10,000, and, consequently, the normal thrust, E_1, is 10,000 times K_1, or the significant figures of E_1 of the designs and of K_1 of Cain's Table 3 are the same.

The width of the base of the walls, ph, was computed from the equations for p shown for Figs. 2 to 15, which equations are conditional on the resultant of all forces piercing the outer-third point, and the design was checked graphically as shown in the figures.

It may be noted that the required width of base steadily increases from Fig. 2 to Fig. 8. It is believed that any engineer, given these seven different cases at the same time and in a graphical form, would expect such a progressive increase, and that, in all cases, he would assert that an increase in the angle of surcharge, i, would require an increase in the width of the base. It is this point only which the foregoing discussion of Leygue's experiments is intended to emphasize for subsequent reference thereto.

In his paper, Cain showed that, in considering Leygue's experiments, the effect of cohesion should not be neglected, and, by graphical constructions and computations, he derives theoretical values of K_1, as given in

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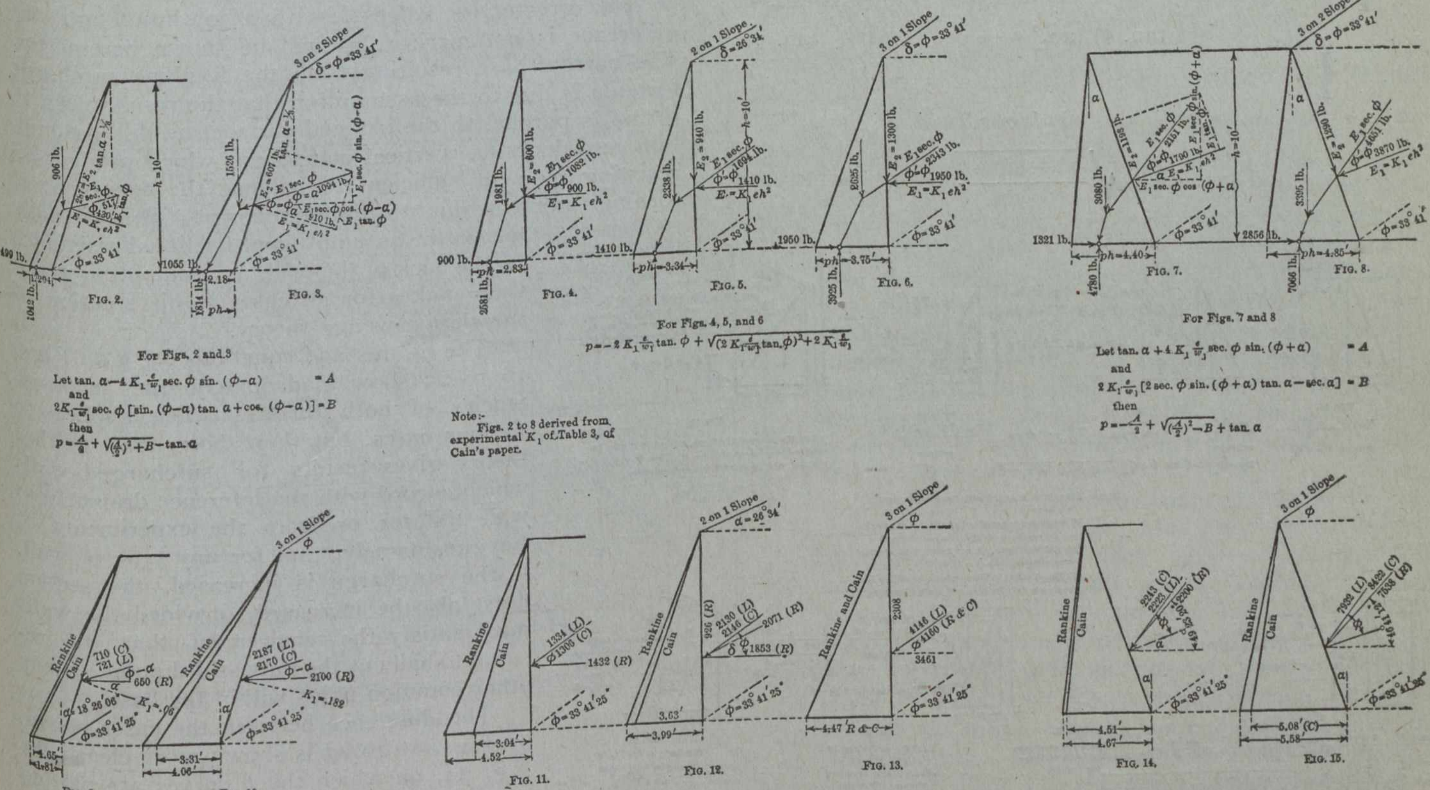
*Proceedings of the American Society of Civil Engineers.

the next to the last column of his Table 3 for assumed values of cohesion, k, as given in the third column of that table. It may be noted that the experimental values of K_1, as used in preparing Figs. 2 to 8, agree closely with the theoretical values, for k is equal to 1 lb. per sq. ft. Cohesion is usually neglected in practical designing, and, to show the effect of such neglect, walls, as shown by the smaller sections of Figs. 9 to 15, were designed for the theoretical values of K_1 corresponding to $k = 0$. All other assumptions were the same as those used for Figs. 2 to 8 and, therefore, the increase in section or base width is due entirely to the neglect of cohesion. The theoretical values of K_1 were derived by Cain from his theory; hence these are also the sections which result from the use of his formulas, and are marked for identification with his name.



For Figs. 2 and 3

Let $\tan.\alpha - 4K_1\frac{e}{w_1}\sec.\phi\,\sin.(\phi-\alpha) = A$

and

$2K_1\frac{e}{w_1}\sec.\phi\,[\sin.(\phi-\alpha)\tan.\alpha+\cos.(\phi-\alpha)] = B$

then

$p = \frac{A}{2} + \sqrt{(\frac{A}{2})^2 + B} - \tan.\alpha$

For Figs. 4, 5, and 6

$p = -2K_1\frac{e}{w_1}\tan.\phi + \sqrt{(2K_1\frac{e}{w_1}\tan.\phi)^2 + 2K_1\frac{e}{w_1}}$

For Figs. 7 and 8

Let $\tan.\alpha + 4K_1\frac{e}{w_1}\sec.\phi\,\sin.(\phi+\alpha) = A$

and

$2K_1\frac{e}{w_1}[2\sec.\phi\,\sin.(\phi+\alpha)\tan.\alpha - \sec.\alpha] = B$

then

$p = -\frac{A}{2} + \sqrt{(\frac{A}{2})^2 - B} + \tan.\alpha$

Note:- Figs. 2 to 8 derived from experimental K_1 of Table 3, of Cain's paper.

Note: The letters C, R and L in parentheses indicate that the figures accompanying them were derived, respectively, from formulas of Cain Rankine (modified), and theoretical values of K_1 for $k = 0$, as given in Table 3, of Cain's paper. The figures are shown for checking and comparison.

Figs. 9 to 15 Cain, or from Equations 36 to 43, Ketchum, page 49.
" 9 and 10 Rankine, from data 17f; Ketchum, page 35.
" 11 to 15 " " Equations 6, 8 and 8a. Ketchum.

Figs. 2 to 15.

The base widths required for the same conditions were computed from the Rankine formulas, as modified by Ketchum or Howe, and the resulting sections are the larger ones marked Rankine in Figs. 9 to 15.

A study of these fourteen sections discloses three points of interest which warrant further investigation.

The first and most apparent point is the Rankine section of Fig. 12, which is smaller than the Rankine section of Fig. 11, although it is apparent by inspection that it should be larger on account of the 2 : 1 surcharge slope of the earth behind the wall. That it should be larger is proved by Leygue's experiments, as Fig. 5, with 2 : 1 surcharge, has a base 18% wider than Fig. 4, which has no surcharge. It is also noted that the Rankine section, Fig. 13, for a 3 : 1 slope has a base about 1% less in width than the Rankine section of Fig. 11, which has no surcharge. These discrepancies between theory and experiment indicate that the formulas derived from the Rankine theory are erroneous, at least for certain conditions. This particular disagreement between theory on one side and reason and experiment on the other will doubtless be as surprising to many engineers as it was to the writer, and it will be discussed hereinafter in greater detail and for various conditions.

The second point of special interest is that, whereas the base of the experimental section, Fig. 4, is 30% wider than that of Fig. 3, yet the corresponding theoretical section, Fig. 11 (Cain), is 9% narrower than that of Fig. 10 (Cain). This indicates that, for walls with backs sloping toward the back-fill, the Cain and modified Rankine formulas give sections unnecessarily large. Walls of this kind are so unusual in practice that the writer, as yet, has made no further investigation of this case.

The third point is that the increase in base width of Figs. 14 and 15 (Cain) over that of Figs. 7 and 8 (Leygue), is much less than the corresponding increase for other comparable sections. This indicates that possibly the use of Cain's formulas for surcharged walls with a battered back results in sections only a little larger than for a case of no surcharge. Such is the case for walls with a vertical face and battered back, as will be shown hereinafter.

In order to put the formulas of Rankine and Cain in a comparable form, equations were deduced for p, the base width of triangular walls expressed as a percentage of the height. All the formulas for earth pressures as used are given by Ketchum ("The Design of Walls, Bins, and Grain Elevators"), and his nomenclature has been adopted for the following discussion in order to facilitate references.

The wall sections and equations are shown by Figs. 16 to 19 for the Rankine formulas, and by Figs. 20 to 23 for the Cain formulas. For the derivation of p, as shown, it is required that the resultant of all forces shall cut, and that the moments shall be taken about, the outer-third point of the base. The derivation of p for Figs. 16, 17, 18 and 20 is evident by inspection, as Figs. 17 and 20 require only the solving of the quadratic equation of moments.

For Fig. 19, the earth thrust, *P*, against the wall is the same as the thrust against the vertical plane, *bc*, of height, h_1. The height, $h_1 = h + h \tan.\alpha \tan.\phi$

$$= h\,\frac{(\cos.\phi\cos.\alpha + \sin.\phi\sin.\alpha)}{\cos.\phi\cos.\alpha} = \frac{h\cos.(\phi-\alpha)}{\cos.\phi\cos.\alpha}$$

By substituting this value of h_1, the equations shown on Fig. 19 are obtained, which equations are in a convenient form for practical problems.

It is somewhat easier to derive *p* by substituting for h_1 its value, $h\,(1 + \tan.\alpha \tan\phi)$.

The equation of moments now becomes,

$$\frac{wh^3}{6}\Big[\sin.\phi\cos.\phi\,(1+\tan.\alpha\tan.\phi)^2\tan.\alpha + (1+\tan.\alpha\tan.\phi)\tan.^2\alpha - \cos.^2\phi\,(1+\tan.\alpha\tan.\phi)^2\Big] = 0;$$

whence $\tan.^2\alpha\,(1+\sin.^2\phi) - \cos.^2\phi = 0;$

$$\text{and } \tan.\alpha = \sqrt{\frac{1-\sin.^2\phi}{1+\sin.^2\phi}} = p$$

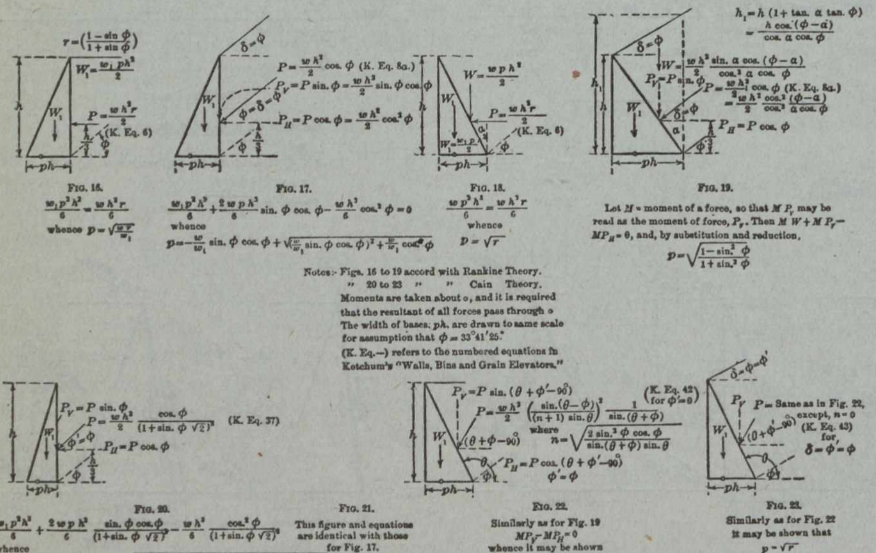


FIG. 16.

$$\frac{w_1p^2h^2}{6} = \frac{wh^2r}{6}$$

whence $p = \sqrt{\frac{wr}{w_1}}$

FIG. 17.

$$\frac{w_1p^2h^3}{6} + \frac{2wph^3}{6}\sin.\phi\cos.\phi - \frac{wh^3}{6}\cos.^2\phi = 0$$

whence

$$p = -\frac{w}{w_1}\sin.\phi\cos.\phi + \sqrt{\left(\frac{w}{w_1}\sin.\phi\cos.\phi\right)^2 + \frac{w}{w_1}\cos.^2\phi}$$

FIG. 18.

$$\frac{wp^2h^3}{6} = \frac{wh^3r}{6}$$

whence

$p = \sqrt{r}$

FIG. 19.

Let *M* = moment of a force, so that MP_V may be read as the moment of force, P_V. Then $MW + MP_V - MP_H = 0$, and, by substitution and reduction,

$$p = \sqrt{\frac{1-\sin.^2\phi}{1+\sin.^2\phi}}$$

Notes:- Figs. 16 to 19 accord with Rankine Theory.
" 20 to 23 " " Cain Theory.
Moments are taken about o, and it is required that the resultant of all forces pass through o
The width of bases; *ph*, are drawn to same scale for assumption that $\phi = 33°41'25''$.
(K. Eq.—) refers to the numbered equations in Ketchum's "Walls, Bins and Grain Elevators."

FIG. 20.

$$\frac{w_1p^2h^3}{6} + \frac{2wph^3}{6}\frac{\sin.\phi\cos.\phi}{(1+\sin.\phi\sqrt{2})^2} - \frac{wh^3}{6}\frac{\cos.^2\phi}{(1+\sin.\phi\sqrt{2})^2}$$

whence

$$p = -\frac{w}{w_1}\frac{\sin.\phi\cos.\phi}{(1+\sin.\phi\sqrt{2})^2} + \sqrt{\left(\frac{w}{w_1}\frac{\sin.\phi\cos.\phi}{(1+\sin.\phi\sqrt{2})^2}\right)^2 + \frac{w}{w_1}\frac{\cos.^2\phi}{(1+\sin.\phi\sqrt{2})^2}}$$

FIG. 21.

This figure and equations are identical with those for Fig. 17.

FIG. 22.

Similarly as for Fig. 19
$MP_V - MP_H = 0$
whence it may be shown that $p = \sqrt{r}$ or the same as for Fig. 18

FIG. 23.

Similarly as for Fig. 22 it may be shown that
$p = \sqrt{r}$

Figs. 16 to 23.

For Fig. 22, the equation of moments is,

$$P\sin.(\theta+\phi-90)\frac{h\tan.(\theta-90)}{3} = P\cos.(\theta+\phi-90)\frac{h}{3};$$

whence $\tan.(\theta-90) = \cos.(\theta+\phi-90) = p;$
or $\cos.\theta = \tan.(\theta+\phi);$
and $\cos.\theta - \tan.\theta - 2\tan.\phi = 0;$
but, $\cos.\theta = -p;$
therefore, $p^2 + 2p\tan.\phi - 1 = 0;$
whence,

$$p = -\tan.\phi + \sqrt{\tan.^2\phi + 1} = \sqrt{\frac{1-\sin.\phi}{1+\sin.\phi}} = \sqrt{r},$$

which is the same as for Rankine Fig. 18. It also may be shown that P_H and P_V (Cain) are equal in amount to *P* and *W*, as shown in Fig. 18.

For Fig. 23 it may be shown in a similar way that $p = \sqrt{r}$, but, in this case, P_H and P_V are greater in amount than for the similar forces of Fig. 22. (They are four times as great when φ = 30°.) Therefore, an analysis of Fig. 23 shows that the surcharge merely produces greater compressive stresses in the wall, and the equations for *p* indicate that surcharging a wall does not increase its tendency to overturn so long as the unit compression stress remains within safe limits. Such an indication is so contrary to one's preconceived ideas of the effect of surcharge that the theory from which it results can scarcely be accepted until it is substantiated by experimental proof.

It may be noted that for Figs. 18, 19, 22 and 23, the equations for *p* show that the width of the base is independent of the weight of either the wall or the back-fill.

The equations for Figs. 16 and 17 give identical values of *p* for $\frac{w}{w_1} = \frac{100}{140}$ and φ = 0°, 30°, or 90°; but *p* for Fig. 17 is the lesser for values of φ between 30° and 90° and greater for values less than 30°, although the difference is not marked, as will be shown hereinafter. The narrow base resulting from the Rankine surcharge formula is due to the assumption that the resultant earth thrust is parallel to the inclined surface, as this assumption introduces a vertical component which produces a resisting moment sufficient to balance the excess overturning moment due to the surcharge. This virtually means the assumption of frictional resistance on the back of the wall, an assumption which Cain makes for all cases in his solution of the sliding-wedge theory.

The figures and equations for *p* on Figs. 16 to 23 show inadequately the inconsistencies of both theories when applied to various cases, but they show that neither theory gives results for surcharged walls which accord with the inference drawn from wall failures or from the experiments of Leygue, namely, that for any type of wall, if the surcharge is increased, the section must also be increased, provided the walls must satisfy the requirement that the resultant shall cut the outer-third point, or any other common point within the base.

The difference between the cases shown by Figs. 16 to 23 is shown more clearly by Fig. 24, on which the *p* curves are plotted with reference to the rectangular co-ordinates, φ and *p*. The reference numbers on the curves refer to Figs. 16 to 23. The equations of the curves are either shown or reference is made to Figs. 16 to 23 on which they may be found, and for all equations including the weight of the wall and the earth, it was assumed that $\frac{w}{w_1} = \frac{100}{140}$.

Curves 1 to 8 of Fig. 24 show the difference between the Rankine and Cain formulas and also the formulas for the extreme conditions of no surcharge and maximum surcharge, but give no indication of the peculiar results obtained by the Rankine formula for Fig. 12, which is so much smaller than the corresponding wall, Fig. 11, which is not surcharged. This, however, is shown by the curves, *2a* and *2b*, in the equations for which φ is a constant and δ a variable between the limits, zero and φ. These curves indicate that surcharging a wall increases its stability against overturning, and that a minimum base width is required when the angle of surcharge is only a few degrees less than that of repose or of maximum surcharge. Curve *4a* has no minimum for finite values of δ, but is similar to the others in indicating a rapid decrease in *p* for small decreases in δ from its maximum value of φ.

The equations of Curves 2*a*, 2*b* and 4*a* are as follows:

Let $A = \cos.\,\delta \dfrac{\cos.\,\delta - \sqrt{\cos.^2\,\delta - \cos.^2\,\phi}}{\cos.\,\delta + \sqrt{\cos.^2\,\delta - \cos.^2\,\phi}}$, (*K.* Equation 8), in which ϕ is a constant; then for 2*a* and 2*b*,

$$p = -\frac{w}{w_1} A \sin.\,\delta + \sqrt{\left(\frac{w}{w_1} A \sin.\,\delta\right)^2 + \frac{w}{w_1} A \cos.\,\delta};$$

and for Curve 4*a*,

$$p = \sqrt{\frac{A \cos.\,\delta}{1 + A \tan.\,\delta \sin.\,\delta}}.$$

It is obvious that inferences, relative to surcharged earth pressure, to be drawn from Curves 2*a*, 2*b* and 4*a*, and from the similarity of Curves 1 and 2-6, are fallacious, and that, consequently, the Rankine theory—that the resultant earth thrust is parallel to the inclined surface of surcharge—is erroneous.

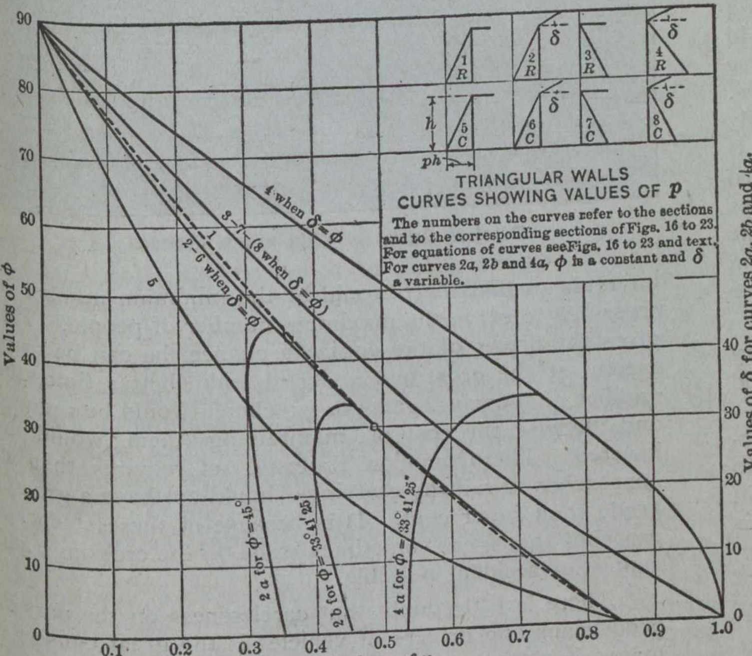


Fig. 24.

The writer has never been able to find or think of any good reason for assuming that the slope of surcharge should govern the slope of the resultant earth thrust for great depths, but will refrain from discussing it, as it is not the object of this paper to present a theoretical discussion, but to show, in as practical a way as the writer could devise, the results obtained from the application of the two principal existing theories.

By the end of 1916 the electric railways and tramways of Switzerland numbered 104, and their lengths aggregated 1,678 km. According to the tabulation given in the "Schweizerische Bauzeitung, of February 3, 1917, the length of the ten standard gauge railways is 172 km.; of these, 20 per cent. are on the continuous-current system, 22 per cent. on the three-phase and 58 per cent. on the monophase system. On the 63 narrow-gauge and rack railways (one of which, 8.6 km., is standard gauge), of 1,020 km. length, continuous current predominates strongly, 87 per cent. of the lines being on this system, and only 4 and 9 per cent. on the three-phase and monophase systems. The 31 tramway lines, 1,486 km. in length, are with one exception (monophase system) equipped for continuous current. On standard-gauge railways the preference for monophase service has long been pronounced.

INCREASING THE SAFETY OF OUR HIGHWAYS.*

By W. H. Losee, B.Sc.,
Assistant Engineer, Department of Public Highways, Ontario.

Owing to the growing volume of traffic on our highways and the increasing speed of vehicles the type of roads that were once built for the slow-moving horse traffic are not now adequate for the fast-moving motor traffic. Not only is the character of the road surface itself not adequate but the alignment and grades are receiving more attention now than they did twenty years ago.

Because we are still using the roads with steep grades, crooked alignment, and in some places narrow roadbed, many accidents occur where a few years ago an accident of the same nature was unheard of and we must begin to correct these defects or accidents will increase as steadily as the use of the motor vehicle is increasing.

Besides the accidents that occur from the above causes, the most serious and common kind are those which happen at level railway crossings, and their prevention is becoming a very important matter.

Since the motor vehicle has become so universally used the tendency has been for the city dweller to live somewhere in the suburbs and go back and forth to his office in his car. This has increased the traffic on streets that the railways are bound to cross and automatically increases the dangers of level crossings. Motor traffic in the suburban areas is very heavy between the hours of 7.30 and 9 a.m., and 5 and 6.30 p.m.

On the other hand, the man who lived in the country a few years ago, used only the roads that took him to his post office, to church, and to his market place and shipping point. Ten miles was an average radius for any farmer and he generally knew the dangerous crossings, and about the time any fast train would be crossing them; the result being that there were very few accidents.

But the motor vehicle has changed these conditions entirely. Motorists are continually going into new country, railway crossings are encountered everywhere, and sometimes when they are least expected. Generally a car carries from four to five people who must depend upon the judgment of the man at the wheel. He cannot, therefore, afford to be careless because any accident is bound to injure more people than the driver, and it does not seem fair that people should be exposed to danger by a man who tries to be too "smart" or careless. Crossings should therefore be made as nearly as possible "fool proof."

There are many different methods of protecting a railway crossing. There is the overhead crossing, the subway, the gates, the watchman, the electric bell, and the "danger" sign post.

Let us first consider the subway. This measure of protection is undoubtedly the best one of all, but the cost of its construction, except in thickly settled districts, almost makes it prohibitive. It may cost anywhere from $30,000 to $150,000 to construct one subway, and as the crossings in Ontario are many, any undertaking to separate all crossings would bankrupt the province.

There are subways already built in Ontario that are so constructed that they are now a menace to the travel-

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*Read before the 3rd Annual Conference on Road Construction, March 27-30, 1917.

ling public. The centre line of the subway was generally built at right angles to the line of the railway instead of being parallel with the centre line of the highway. The result is a bad turn at the entrance and exit of the subway and the view along the highway is so obstructed as to make a serious accident possible.

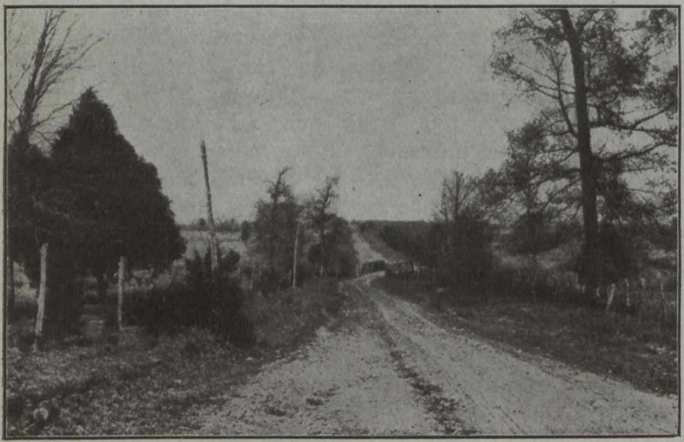
This trouble can now be largely done away with as the plan for each proposed subway must be submitted to the Dominion Railway Board or the Ontario Railway and Municipal Board by whom local conditions are thoroughly investigated.

The next best way of protecting a crossing is by means of gates. These can be operated at about $800 per year, and have been in use for many years, but they are defective because people often run under them and the bars have been broken many times by vehicles running into them.

Watchmen have also been used for a long time as a means of protection to the public at crossings, but should a crowd or a reckless motor driver or an unruly horse wish to cross the tracks, he is powerless to prevent them. The watchman is, as a rule, never dressed any differently from the ordinary person and there are times when it is difficult to distinguish him. A great help in this regard would be to dress him in some kind of distinctive clothes and have a uniform standard of signals that everyone would understand and, if it be found possible, give him the power of a constable so that he could arrest anyone who disobeyed him or the law.

The electric bell is used to a great extent on country railway crossings and it has proven to be a very good warning signal. They, however, have been known to get out of order and ring for days before they are repaired, the result being that travellers would come up to the crossing, wait for a while and then when no train would come, cross over. Anyone fooled that way is naturally apt to disregard them entirely.

Lastly we have the sign of "danger." These are placed by all railways on the right-of-way at the crossing. If a driver should come around a corner or any obstruction that would be near the crossing, suddenly upon the crossing he may be too close to stop and the sign at the crossing is naturally of little use. It would be much better if all danger signs were placed about 400 feet from the crossing and were so placed that they would be readily seen. They should be painted white so that they have the best chance of being seen at night.



A Dangerous Bend.

The manner in which subdivisions have been laid out in parcels of land that are cut by a railroad have been the cause of much expense to railways and municipalities when these lands are built upon. Surveyors paid little attention to the number of crossings that would be necessary in the event of the growth of the town. According to their surveys a crossing is necessary where each street on the plan crosses the tracks, but had they allowed for a narrow street paralleling the railway on each side of the track, subways could be built or gates put up at proper intervals so that there would be the minimum number of crossings to serve the maximum number of people. This gives the driver of the engine a chance, he can be more careful at the crossings and still make better time, the number of subways, gates or watchmen would be reduced and likewise the cost of maintaining them would be lowered. The Dominion Railway Act requires that all approaches to railway crossings should not have a greater grade than 5 per cent. It is because of these steep approaches that a car sometimes stalls on the crossings and makes an accident possible.

Ditches Such as This are a Menace.

There is little doubt that carelessness on the part of pedestrians and drivers of vehicles is the great cause for many accidents and if people can be taught to be careful, the number of accidents will be considerably reduced.

The Ontario Safety League and the Ontario Motor League, with the aid of the government and the railways, are doing a grand work along the line of educating people to be careful, and we can all do missionary work along these lines. The phrases "Safety First," and "Stop, Look and Listen," are commonly used now. But how many people heed the latter phrase at a railway crossing? Very few people stop and look, some slow up and look, some just look one way and others never slow up or look at all; they simply take a chance.

In an article entitled, "Accidents at Grade Crossings," written by Mr. Alex. Gordon, a commissioner of the State Railroad Commission of California, there are some very interesting facts with regard to the carelessness of the travelling public.

He says: "The Southern Pacific Railway Company recently made test observations at thirty-four crossings. They observed over 17,000 motor vehicle drivers and found that 69.5 per cent. looked neither way before crossing the tracks, 2.7 per cent. looked in one direction only and but 27.8 per cent. looked both ways. 19.3 per cent., or the incredible number of 3,300 drivers ran over crossings at a reckless rate of speed. Only 35 drivers or two-tenths of one per cent. stopped their machines before crossing the tracks.

"Four thousand nine hundred drivers of teams were observed, 39.4 per cent. of whom looked in neither direction, 8.6 per cent. looked one way only and 52 per cent. looked in both directions. Of 6,300 pedestrians observed, 49.1 per cent., or practically one-half of the total, looked neither way; 15 per cent. looked in one direction only, and 35.9 per cent. looked both up and down the track." The same company has tabulated the accidents on grade crossings which have happened during the last five and one-half years in an attempt to secure the reasons for these accidents with the following results:—

	Killed.	Injured.
Ignored train and its warning	35.0%	37.1%
Ignored train and its warning and warning of crossing bell, automatic and human flagman, and warnings of other persons	13.8%	12.6%
Ran into side of train	10.1%	15.3%
Stalled on track	7.8%	4.2%
Tried to beat train to crossing	16.0%	9.3%
Other causes	17.3%	21.5%
	100.00%	100.00%

This company during two years had 525 crossing gates broken by vehicles which drove into them when they were down.

In the United States during the year ending June 30th, 1916, there were 1,310 people killed and 3,184 injured on highway grade crossings of railways.

On the Central Railway of Georgia, 78,275 drivers of motor cars, motorcycles and horse-drawn vehicles were observed at railway crossings and of these 59,700 did not look in either way before starting across the railway, or in other words, about 75 per cent. took no precautions whatever, even though they were approaching the danger zone of the railway.

Nor do accidents always occur at dangerous crossings. At Thamesville, Ont., last year at the Grand Trunk Railway crossing, three people who were driving in an automobile were killed. The crossing was equipped with an electric bell, there was a red warning light designed to show the approach of a train, and 50 feet from the crossing there was a clear view of the track for two miles.

In order to make people be more careful, a law in Paris, France, was enacted which made it possible to arrest any pedestrian who was hit by a moving vehicle between street intersections. This resulted in the reduction of accidents by 50 per cent. On the other hand, any driver who was found guilty of breaking the traffic regulations had his license cancelled. The people soon learned that the proper place to cross a street was at an intersection where the vehicular and foot traffic was regulated by a police officer.

As was mentioned at the beginning of this paper, there are many other features of our highways that take their toll in accidents.

The narrow road with the high crown that compels motorists to stick right on the top and make the man with the horse move well off or lose control of him has caused more than one casualty. Besides the harm done to the road by continuous travelling in the same rut, the road with too steep a crown is dangerous. If it happens to be wet and slippery motorists, believing that it might be difficult to get back on the road, or fearing they would slide into the ditch, do not care to turn out.

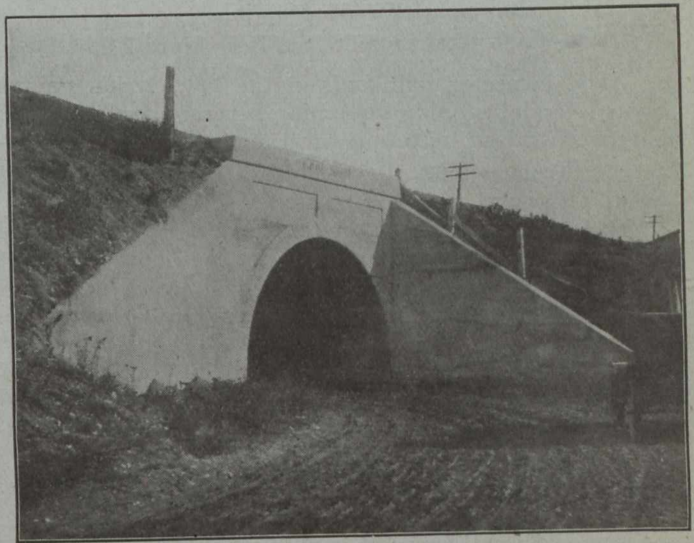
If it is a man with a load of hay, there is a possibility of it overturning when he pulls out on the steep side.

The width of road is pretty well governed by the traffic it has to withstand. It should have a crown that would shed the water, and yet be wide enough so that traffic would be diffused over the whole surface. It should always be borne in mind when contemplating construction that immediately a road is built traffic will increase and the type of road should be designed with this increase of traffic in view.

The steep, narrow road on a hill with a sharp turn at the bottom is another source of danger and makes many anxious moments for the driver of a heavy load or a motor vehicle. Sometimes the brake refuses to act and he is going so fast that he cannot make the turn at the bottom and plunges headlong through the flimsy railing, causing destruction to the car and certainly injury to its occupants.

A dangerous condition like this can generally be averted by a change in the location of the approach to the bridge or of the bridge site itself; perhaps a longer, easier grade could be found or by raising the bridge the approach to it could be rendered less liable to cause a serious accident.

Owing to the nature of our early surveys there are many jogs and sharp turns on our roads. In one county there are turns greater than 90°. It has caused this county no small amount to make these turns safe and still keep within the road allowance. This was done by raising the outside of the road by the addition of more stone, which enables the driver of a car to make the turn without a chance of an accident. An improvement on this is to lengthen the curve by using a piece of the land adjoining.



A Dangerous Turn in Road.

The grade of the steep hills could be reduced and the sharp turns eased, if the owner of the adjoining land could be brought to see the great benefit he would confer on the travelling public, and the words of commendation he would bring from everyone, if he would consent to sell it at a reasonable figure.

All narrow fills, approaches to bridges, and deep ditches, should be protected by a good strong guard rail. The deep ditches in the clay sections of Essex and Kent counties are very dangerous. When the clay road surface is wet it becomes so slippery that to turn out in some of the narrow places is a very hazardous undertaking.

These roads should be surfaced with any material that would reduce the slipperiness and a guard rail should be built at the edge of the ditch. Many of the ditches were dug years ago when the traffic was not as it is at present.

They were put within the road allowance when they should have been dug in the adjoining field. From now on it is going to cost something to render them safe.

Warning notices of steep hills, sharp turns, and railway crossings should be erected at proper distances from them. It would be advisable to have these signs standard in form and placed in the most conspicuous position.

The Ontario Motor League have done something in this regard, but their signs are often stuck up on telegraph posts, and in places where they are not always readily seen. These signs are a great help on the main travelled roads but the motor car is now found in the most remote districts and it is there where the dangerous roads are, and where signs denoting danger are badly needed.

Another matter that is giving some concern to the county road superintendents and motorists is the erection of rural mail-box posts too near to the travelled road. It makes it difficult to grade properly and they are sometimes so close to the road as to be a menace to the safety of the travelling public. This has been inquired into and the following are the rulings of the law clerk of the Post Office Department:—

Circular No. 86.

CIRCULAR TO POST OFFICE INSPECTORS.

The inspector will find, in the law clerk's opinion quoted herein, a ruling governing several questions which have been raised, affecting rural mail delivery service:—

1. Responsibility for accidents resulting from collision with rural mail box posts.
2. Right of township or county authorities to compel the removal or displacement of rural mail box posts.
3. Action to be taken by municipal authorities where it is considered that the box posts are in a dangerous position.
4. Right-of-way to be exercised by courier in performance of service.

"The authority under which the Post Office Department is acting is paragraph (n) sub-section I. of section 9 of Post Office Act, as amended by 3-4 George V., chap. 38, section 2:—

"This Act is public Act.

"1. The amendment referred to authorizes the postmaster-general to cause the erection, on rural mail routes, of posts for rural mail boxes at such places as to him appear convenient.

"In my opinion such posts can, in no circumstances, be considered as an obstruction, but as public works for public utility.

"In these circumstances, no responsibility lies with the Department (or with the owner of mail box) for accidents which might happen through collision with said posts or otherwise.

"2. The township authorities have no power whatever to compel the removal or displacement of rural mail posts.

"3. Should, however, any rural mail box posts be inconveniently erected, the proper course for the township authorities to follow, is to petition the superintendent of rural mail delivery, Ottawa, who will have the matter investigated.

"4. The Act also authorizes the postmaster-general to make regulations to render the said Act effective.

"The rural mail regulations so made, provide that the courier shall collect and deposit mail matter from and in mail boxes without being obliged to leave his rig.

"This, therefore, authorizes the courier to cross the road from right to left when necessary to serve a box, and, naturally to stop on the left side of the road the required time to diligently serve said box.

"He is consequently given such privileges and rights of way as are required and necessary to perform his duty as courier.

"But outside of the above, the Act or Regulations confer upon him no special right-of-way on public roads.

"In such rights as are conferred upon the courier are protected by Section 125 of the Post Office Act, which makes it an indictable offence to obstruct wilfully the progress of the mails.

"(Signed) A. Bolduc,
"Superintendent."

Post Office Inspector, Kingston, Ont.

In conclusion, we should all remember that carelessness is the cause of a great percentage of accidents. Education along these lines, although seemingly slow, is achieving results; and everyone should bear in mind that "an ounce of prevention is worth a pound of cure," and we should do all in our power to reduce the number of accidents that are taking the lives of our citizens, when human lives have more value to the country than they ever had before.

BRITISH COLUMBIA ENGINEERS VISIT PREMIER

Requesting that the British Columbia government use engineers at present in the province, or at least in the Dominion, before going elsewhere for engineering services, a deputation from the British Columbia Society of Civil Engineers interviewed the provincial premier last week.

The question of a charter for the new society was touched upon and the premier expressed his pleasure that it was not the intention of the society to ask for a closed corporation, but that their object was "to unite the engineers of the province so that the status of the profession might be kept at a high state and that the members might benefit by exchanging their individual knowledge on the different specialized branches of their calling."

The deputation consisted of E. N. Horsey, resident engineer of the B.C. Electric Railway Co.; Mr. Seaton, engineer of the Public Works Department of the Dominion Government at Vancouver; Mr. Robertson, resident engineer at James Island for the Canadian Explosives Co.; Frank M. Preston, assistant engineer of the Sewer Department of Victoria; Bateman Hutchinson, civil engineer and land surveyor of Victoria; Mr. Macrae, assistant Dominion Government engineer on the breakwater work and honorable secretary of the society.

The Dominion Steel Foundry Co., Ltd., and the Hamilton Steel Wheel Co., Ltd., are to be amalgamated through an exchange of shares of the two companies for shares of a company to be incorporated under the name of the Dominion Foundries and Steel, Limited.

What is believed to be the longest concrete trestle in the world was completed by the California State Highway Commission and formally opened last year. The trestle is nearly three miles long, and traverses the Yolo basin, a marshy tract more than 120 miles long, which is flooded for six or eight months annually. There is a clear width of driveway of 21 feet. The average height of the trestle is 20 feet. It consists of reinforced beam and slab construction in 20-foot spans resting on reinforced concrete piles 32 to 50 feet long. The material cost $148,000 and the construction $246,000. The work was done by contract, the material being furnished by the commission.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Manufacturing Costs and Accounts. By Hamilton Church. Published by the McGraw-Hill Book Co., Inc., New York. First edition, 1917. 452 pages, 139 figures, 6 x 9¼ ins., cloth. Price, $5. (Reviewed by H. W. Cowan, consulting engineer, Toronto.)

This work is divided into three parts, giving outline of manufacturing accounts, of cost accounting, of factory reports, respectively; copiously illustrated with forms and diagrams, and well indexed.

It is a valuable addition to the multitudinous works on cost accounting, so many of which are but explanations of systems in use in present plants, having comparatively small educative value.

Here the author rather deals with the practical application of fundamental principles, throughout keeping before his readers the necessity of paralleling the commercial accounts with those of manufacturing, a point often omitted in practice though essential to the success of any administrative scheme.

The latter part of the book explains how the costing system should be used to obtain the benefit of its records, instructive both to the student and business manager.

Everyone interested in manufacturing administration will obtain much of value from a volume covering so complete a field, embodying the soundest practice, while remaining free from pedantic padding.

Standard Methods for the Examination of Water and Sewage.—American Public Health Association, 126 Massachusetts Avenue, Boston. Price, $1.25. (Reviewed by Joseph Race, City Bacteriologist and Chemist, Ottawa, Ont.)

The present edition of this volume, like that of the second edition of 1912, is divided into three sections—Chemical, which also includes the Physical, Microscopical and Bacteriological.

The chemical and physical methods recommended are the result of co-operation of Committees of the American Chemical Society, the Society of Official Agricultural Chemists, and the American Public Health Association, and are very little different to those of the previous edition. A welcome modification is a definite recommendation for a standard procedure in the determination of the oxygen absorbed by water and sewage in place of the alternative processes given hitherto. The method now adopted—30 minutes' immersion in boiling water—is, perhaps, very little used in Canada, but those who have used active boiling for five minutes would find only minor differences in their results with the new method. Those who have been accustomed to the European method, which, by the way, is again incorrectly reported in this edition by stating that the temperature of digestion is room temperature instead of 27° C., would have to entirely readjust their standards, as digestion at 100° C. often results in the absorption of 100 per cent. more oxygen than at 27° C.

For the detection of free chlorine in water the toluidine method has been adopted and a method given for the preparation of permanent standards. The toluidine process is undoubtedly more generally suitable than the starch iodide test, but in highly colored waters the natural color somewhat simulates that produced by the reagent and may lead to errors.

More definite recommendations might advantageously have been made regarding the quantity of sample to be used in the determination of free and albuminoid ammonia in sewage. Investigations regarding this point made eighteen to nineteen years ago appear to have been overlooked, but those who have made many analyses of sewage have confirmed this earlier work, and realize the importance of endeavoring to use such quantities of samples as contain approximately equal amounts of nitrogen.

The amplification of the chemical section by the addition of paragraphs containing directions for the analysis of chemicals used in water purification is, indeed, a welcome one, and might very well have been extended by the addition of a standard method for testing bleach.

The bacteriological section of the report was prepared in conjunction with the Society of American Bacteriologists, but several additions were made to the committee report on presentation at the Cincinnati meeting in 1916. The additions were in the nature of supplementary tests for the differentiation of fæcal and non-fæcal types of B. coli, but until these have been more firmly established it would probably have been better policy to make them merely tentative and to recommend them for further study. The bacteriological section has been entirely revised, and many paragraphs that contained matter more or less extraneous to the subject of the report have been eliminated. The section is also free from the ambiguities of the 1912 report, and in this respect marks a distinct advance.

The committee recommends the use of gelatin at 20° C. in addition to agar at 37° C. for bacterial counts, and has made important alterations in the procedure for the detection and estimation of B. coli. In 1912 the committee adopted lactose bile as the enrichment medium, and expressed the opinion that this medium was preferable on account of the inhibition of attenuated organisms. The 1917 report goes to the other extreme by adopting lactose broth containing no inhibiting agent whatever. Whilst plain broth is preferable to the bile medium, which was variable in composition and too inhibitive, it is open to the objection that it yields an excessive number of anomalous results caused by overgrowths. It is exceedingly regrettable that the changes in the standard B. coli medium have always been so drastic as to render it almost impossible to compare present-day results with those obtained in the past, and have to this extent nullified the value of bacteriological records. Even though a method is not all that may be desired, it is often good policy to retain the old method for the sake of the continuity of comparable results, and the conservative policy is the only safe one when there is no guarantee that the revised methods are only ephemeral. Constant revision begets a desire for revision until it becomes a habit, and stability, which is the essence of standard methods, is never obtained. It is to be hoped that the policy of the committee on the B. coli question will be one of masterly inactivity for the next few years.

The committee have apparently not given the attention to McCrady's method for the enumeration of B. coli that it deserves. This is reported as involving complex mathematical calculations, whereas the preparation of tables is fairly simple, and once made they are good for all time. This method is the only accurate one for the examination of individual samples.

The report is pleasing in appearance, free from typographical errors, and should be added to the library of everyone who is interested in the examination of water and sewage.

Differential Calculus.—By H. B. Phillips, Ph.D., Assistant Professor of Mathematics in the Massachusetts Institute of Technology. Published by John Wiley & Sons, Inc., New York City; Canadian selling agents, Renouf Publishing Co., Montreal, P.Q. First edition, 1916. 162 pages, 5 x 7½ ins., illustrated, cloth. Price, $1.25 net. (Reviewed by R. L. Hearn, B.A.Sc., Hydraulic Department, Hydro-Electric Power Commission of Ontario.)

Dr. Phillips, in this little book on the differential calculus, has treated this subject admirably from an engineering student's viewpoint. He has covered the differential calculus very clearly and concisely, and has presented it in such a manner that many of the obstacles that the average student encounters in the ordinary treatise on this subject are cleared away.

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whatever. Whilst plain broth is preferable to the bile medium, which was variable in composition and too inhibitive, it is open to the objection that it yields an excessive number of anomalous results caused by overgrowths. It is exceedingly regrettable that the changes in the standard B. coli medium have always been so drastic as to render it almost impossible to compare present-day results with those obtained in the past, and have to this extent nullified the value of bacteriological records. Even though a method is not all that may be desired, it is often good policy to retain the old method for the sake of the continuity of comparable results, and the conservative policy is the only safe one when there is no guarantee that the revised methods are only ephemeral. Constant revision begets a desire for revision until it becomes a habit, and stability, which is the essence of standard methods, is never obtained. It is to be hoped that the policy of the committee on the B. coli question will be one of masterly inactivity for the next few years.

The committee have apparently not given the attention to McCrady's method for the enumeration of B. coli that it deserves. This is reported as involving complex mathematical calculations, whereas the preparation of tables is fairly simple, and once made they are good for all time. This method is the only accurate one for the examination of individual samples.

The report is pleasing in appearance, free from typographical errors, and should be added to the library of everyone who is interested in the examination of water and sewage.

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LETTER TO THE EDITOR.

Stone-Filled Sheet Asphalt.

Sir,—Referring to your March 8th issue and the letter printed therein, criticizing the article under the above title that appeared in your February 15th number, your correspondent is mistaken in thinking that the relative slipperiness of standard and stone-filled sheet asphalt surfaces "can be scarcely more than a matter of opinion." That may be true for those who have had little or no actual experience in mixing and laying, and later observing the different bituminous sheet layer surfaces. It is unfortunate to have to base one's judgments upon what may be found in the books upon this subject, for they are but few, and those few are very inadequate.

But it is a matter of known fact that the addition of stone chips to any sheet asphalt surface mixture produces a pavement that is not only less slippery, though "almost as smooth" after the initial roughness has worn off, but that is also harder to mark up, easier of traction, less liable to displacement, and less expensive to make than the mixture not containing the stone-chip filling.

Experiences and tests of the most practical sort, the driving of horses and automobiles almost daily over many such surfaces that we have ourselves constructed, do not result in a "matter of opinion" on the first three points. The fourth is almost self-evident, and supported by the general observations of many; the fifth is easily demonstrated.

The way in which an asphalt surface "marks up" in warm weather is a valuable indication of its quality. Much less marking is compatible with good quality in a stone-filled than in a standard asphalt surface, due to the resistance offered by the fine stone chips dispersed through the former.

While the failure of a surface to "mark up" to a certain degree, dependent upon the type of mixture of which it is laid, is an indication that the asphalt cement is too hard, its acquiring of certain markings does not even prove that the cement is sufficiently soft. There are several other elements that enter into the matter and affect the result materially.

The "marking up" is not a desirable feature. It would be better if pavements that were otherwise all right could be so laid that they would not mark up at all. The advantage gained by the horse in better footing is overcome by the greater tractive resistance of the load on the markable surface. As the pavement cools off, the marks disappear under traffic.

Your correspondent remarks that "This condition, we always believed, was controlled by the filler and the penetration of the bitumen." Well, we had given your readers credit for knowing that much. The hardness produced by stone chips in the mixture, to which we had reference, is additional to any hardness that such mixture may possess from other causes. This additional hardness is much greater than might be thought.

On the matter of cost, your correspondent seems also to be misinformed and uninformed. His price for ¾-in. stone is not in reasonable relation to the other prices used; and, in comparing a two-course surface to a one-course surface, he has apparently overlooked the necessity and added expense of laying, raking and rolling the former surface in two courses. He has also charged himself with five pounds too much stone dust, unless he intends to use that in his close binder, which, though not usual, would be very commendable as long as the "bitulithic" people did not object that his "close binder" infringed their patents.

But why compare a two-course to a one-course surface in this instance? The writer recommended that the "binder course be eliminated," and that the "stonefilling be introduced," and then stated that "either change might be made to advantage without the other." Why not compare one inch of binder and one inch of standard surface to one inch of binder and one inch of stone-filled surface? The latter would still be about 2½ cents per square yard cheaper.

Or, if a two-course surface must be compared to a one-course surface, then compare a 2-inch two-course surface to a 1½-inch one-course surface, as these are about the thicknesses that would be thought to be of more comparable values. Also, do not forget to add the additional labor cost for laying the two courses instead of one. The writer, however, would not recommend the laying of the two-course surface, even if it were as much cheaper as your correspondent would make it, as cheapness in first cost is not necessarily economy, and would not be apt to be in this case.

Concerning your correspondent's request to know why stone-filled sheet asphalt is recommended for adoption by "most" cities instead of by "all" cities, the writer must confess that the principal reason is that he does not know "all" cities. Other reasons are that some cities are built on hillsides, some cannot secure stone chips at a reasonable price, and still others are affected by local conditions peculiar to themselves or their geographical districts. There are many variables in the road and street paving problem.

Regarding your correspondent's final facetious remark that he is "from Missouri," the writer is not. Whenever the writer has been unable to "see" what was told him, he has usually proceeded to do his own "looking" instead of waiting to be "shown."

C. A. MULLEN,
Director of Paving Dept., Milton-Hersey Co., Ltd.
Montreal, March 29th, 1917.

NEW LINE OF CENTRIFUGAL PUMPS.

The Bawden Machine Co., Limited, of Toronto have incorporated a subsidiary company called the Bawden Pump Co., Limited, for the manufacture of centrifugal pumps for waterworks, sewage, filtration and industrial purposes, and also intend manufacturing valves and other waterworks specialties, and to supply turbines, engines, motors, etc., for pump drives.

The Bawden Machine Co., Limited, have been manufacturers of boiler feed pumps for many years past, but only recently decided to go into the larger field of centrifugal pumps.

C. N. Schrag, formerly sales engineer in charge of the Ontario District Office of Canadian Allis-Chalmers, Limited, was induced to join the organization as sales manager, and T. M. Jones, designer at Canadian Allis-Chalmers, Limited, as chief engineer and general manager.

Of the quantity of coal and coke produced in England in 1915, over 155,000,000 tons were carried on the railways, compared with 7,135,000 tons by canals.

Editorial

PAYMENT FOR GOOD ROADS.

Under the above title an Ottawa daily newspaper editorially calls attention to the fact that equitable taxation must precede any great expansion of the good roads movement. This is an important point and the Ottawa paper has not laid any too great stress upon the necessity of equitable method of collecting the payment for good roads.

Col. Sohier, the chairman of the Massachusetts State Highway Commission, who attended the Good Roads Congress this month in Ottawa, assured *The Canadian Engineer* that equitable taxation and uniform assessment are vital to the good roads movement if injustice is to be avoided. In Col. Sohier's state, legislation is now being passed which tends to adjust matters of this kind and which will give state aid for maintenance of town roads to the amount of $3 per annum per thousand dollars of valuation on the road. This amount, we understand, applies only to towns of less than $500,000 total assessed value.

The necessity of some such aid for maintenance is shown in the fact that the valuation of property on Massachusetts roads varies from $20,000 per mile to $2,500,000 per mile, the average being about $200,000 per mile. One mill added to the tax rate for maintenance of roads would give Boston $2,500 per mile for maintenance, while it would give some other communities only $20 per mile, and would give the average town throughout Massachusetts only $200 per mile. State aid to the smaller municipalities is evidently a necessity. The same lines of reasoning would apply even more forcibly to the Canadian provinces, nearly all of which are much larger than Massachusetts yet with smaller populations.

In the construction of state roads in Massachusetts the necessity of state aid was shown by the fact that the roads are often nearly as valuable as the towns through which they pass. Twenty-four miles of the Mohawk Trail in Massachusetts goes through three towns whose total assessed valuation is less than the cost of the "trail" that passes through them.

With the growth of the good roads movement in Canada, and with our many sparsely settled communities, the same situation will arise in this country unless liberal provincial and Dominion aid is extended upon some suitable plan. The first step in the plan is equitable taxation.

A little over three years ago the Ontario provincial government appointed a commission to report on the public roads of Ontario. The commission consisted of C. A. Magrath, chairman, W. A. McLean and A. M. Rankin, M.P.P. In concluding paragraphs of this report the commission says, "The good roads movement begins with the assessment roll * * * The subject of good roads is closely associated with questions of taxation and taxation methods.

"Good roads mean money, and money for public purposes must be furnished by the people in one form or another. * * * An examination was made of recent sales in certain registry offices in the province, and then the assessed values of these properties were obtained from municipal rolls. It was found that the ratio of assessment to sale figures varied from 6% to 96%.

"The good roads are to lace together all the townships within the various counties; the people are to be taxed for those roads; the amount of taxation will depend upon the assessment; and if the people within those townships are to be fairly and equitably taxed for such purposes, there should be some method of creating uniform assessments."

INDUSTRIAL CENSUS FOR 1917.

Manufacturers throughout Canada, and all those who have to do business with industrial concerns, will derive satisfaction in the announcement just made by Sir George Foster that a comprehensive census of the industries of Canada will be taken for the year 1917 by the Census and Statistics Office. The period of reconstruction which will follow the war will necessitate the fullest possible data with regard to industrial undertakings of all kinds. Sir George is to be congratulated upon initiating the new census at this time. The figures of the census of 1911 have now become quite useless as a basis for any close estimation.

It is stated that the organization within the Census and Statistics Office has been placed upon a better basis, and that more skilled collectors can be placed on this work than are usually used for the enquiries regarding population, agriculture, etc. Sir George announces that in the future the industrial census will always be taken apart from the census of population and agriculture, and in a different year, so as to equalize the flow of work for the census office and also so as to afford the possibility of better organization with regard to the industrial census.

In the official government announcement it is stated that the enquiry will be the most comprehensive of its kind ever undertaken in Canada, and that the government will co-operate with the various provincial departments and with those of the Dominion departments which have technical experience of industrial processes and conditions. It would undoubtedly be of very great assistance to the census office in this connection if the Canadian Society of Civil Engineers, with its large and well-organized membership, extending throughout all of Canada and including men who are familiar with every phase of industrial development, could be persuaded to assist the census department officially in connection with the gathering of these statistics.

GOOD ROADS INCREASE ACCIDENTS.

In an address before the Dominion Good Roads Congress at Ottawa this month, R. B. Morley, general manager of the Ontario Safety League, said that men recently assigned to observe the conduct of people approaching and passing over railroad tracks, on important highways, turned in some startling statistics in their report. Of 17,000 drivers of motor cars and other vehicles, 3,300 ran at a reckless speed, and 11,815 seemingly did not care enough for their own lives or the lives of those in their charge to look in either direction to note whether a train was approaching.

We understand that these observations were made at Southern Pacific crossings in California, but that a prominent United States railroad man said that it would be found that these conditions apply wherever a good highway crosses a railroad.

If these figures are true, it is evident that a very extensive campaign of carefulness, or safety education, will have to accompany the good roads movement or else the increase of good roads in Canada will mean a very great increase in the number of fatal accidents.

COMPARATIVE COST OF STERILIZATION BY HYPOCHLORITE AND LIQUID CHLORINE.

Some interesting figures on the comparative cost of sterilization by hypochlorite of lime and liquid chlorine are contained in a paper read a few weeks ago by Mr. M. S. Dutter, before the Illinois section of the American Waterworks Association. The plant from which these figures were obtained was put into operation the latter part of January, 1915. The water supply is taken from a comparatively small stream, and is at all times subject to contamination by sewerage and waste water from coal mines. Two triplex plunger pumps pump the water from a low-lift pump house to the filtration plant, three-quarters of a mile away. The water flows through a weir-box mixing chamber, two coagulating basins, three filter units, and thence to a clear well under the filter house. From this clear well the water flows to another larger clear well, from which the service pumps take their suction. It was at a point between these two clear wells where the application of either liquid chlorine or hypochlorite has been applied. The plant has a capacity of 900,000 gallons per day, and was originally constructed with tanks for applying hypochlorite. In February, 1916, a chlorinator was purchased. Comparing the month of January, 1916, when hypochlorite was used, with June, 1916, when liquid chlorine was used, the following results were obtained:—

	January.	June.
Total pumpage, gals.	10,230,700	8,501,500
Average daily pumpage, gals.	330,000	283,380
Total hypo. used, lbs.	153.2	....
Total liquid chlorine used, lbs.	....	12

With hypochlorite at 7 cents per pound and liquid chlorine at 20 cents per pound, the average cost of sterilization by means of hypochlorite was $1.07 per million gallons of water treated and $0.28 per million gallons when using liquid chlorine.

The average reduction in bacteria count of daily plates made on nutrient agar incubated at 37° C. for 24 hours was as follows: In January, when hypochlorite was used, the average raw water count was 6,300 and the filtered water count was 15. In June, when liquid chlorine was used, the average raw water count was 7,980 and the filtered water count was 11. In Bacillus coli tests the raw water shows 100 per cent. for both months, while the filtered water shows 1.6 per cent. in January and 0.0 per cent. in June. These results were obtained by means of 1 c.c. samples in all cases. While hypochlorite was used 0.46 p.p.m. of chlorine was applied and while using liquid chlorine 0.22 p.p.m. of chlorine was applied.

PERSONAL.

Sir HENRY EGAN has succeeded the late Sir Henry Bate as chairman of the Ottawa Improvement Commission.

JAMES STABLES has been appointed chairman of the Vancouver and Districts Joint Sewerage Board, to succeed FRANK BOWSER, who has retired.

R. E. W. HAGARTY, A.M.Can.Soc.C.E., has been appointed engineer with Messrs. MacFarlane, Pratt & Hanley, engineering constructors, in connection with the construction of a 1,000,000-bushel reinforced concrete elevator at Midland, Ont.

R. D. FEATHERSTONEHAUGH, mining engineer of Edmonton, Alta., who is in charge of the development of the Copper Chief mine near Trout Lake, B.C., was caught in a snowslide recently and narrowly escaped death.

E. B. SKEELS, resident engineer of the Lethbridge, Alta., division of the C.P.R., has severed his connection with the company and leaves shortly for Chicago. It is understood Mr. Skeels will identify himself with some other branch of contracting and engineering than railroad work.

Col. J. D. STEWART, who has performed useful service at the front, and has been placed in command of railway construction work for the Allies in France, has also been promoted to the rank of brigadier-general. He is a well-known Canadian railway contractor and a member of the firm of Foley, Welch & Stewart.

GEORGE BURY, vice-president of the Canadian Pacific Railway Co., is now in London, England. He was a member of the Allied Commission to Russia, which was headed by Lord Milner. After the commission left Russia, Mr. Bury remained there for a month at the request of the Russian Government.

Professor BORIS BAKHMETEFF, who it will be remembered delivered a most instructive address before the Ottawa Branch of the Canadian Society of Civil Engineers last October, on "The Russian Engineer and the War," has been appointed vice-minister of trade and industry in the new Russian government.

C. R. RICHARDS, M.Am.Soc.M.E., formerly professor of mechanical engineering, University of Illinois, Urbana, Ill., and head of the department since 1911, has been appointed Dean of the College of Engineering and Director of the Engineering Experiment Station of the University of Illinois, to succeed Dr. W. F. M. Goss, who has resigned to become president of the Railway Car Manufacturers' Association of New York.

Lieut. CONN. SMYTHE, of the Canadian Field Artillery, has won the Military Cross. He is a son of A. E. S. Smythe, of the editorial staff of the "Toronto World," and was in his fourth year at the School of Practical Science, taking a course in civil engineering, when, in March, 1915, he enlisted as a gunner. In the following July he received his commission and he left Toronto with his battery early in 1916.

OBITUARY.

Lieut.-Col. W. W. STEWART, a prominent architect of Hamilton, Ont., has been killed in action.

GERALD LOMER, president of the firm of Gerald Lomer, Limited, Montreal, passed away very suddenly last week. Mr. Lomer was taken ill at his office and died a few minutes after reaching a hospital. He was born in Brooklyn, N.Y., 67 years ago, but was a resident of Montreal for the past 63 years. He was a member of the Engineers' Club.