REMARKS

ON THE

PRINCIPLES AND PRACTICE

OF

ROAD-MAKING,

AS APPLICABLE TO CANADA.

BY THOMAS ROY,
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TO HIS EXCELLENCY

The Right Honourable Charles, Baron Sydenham,

OF SYDENHAM, IN THE COUNTY OF KENT, AND OF TORONTO, IN CANADA,

ONE OF HER MAJESTY'S

MOST HONOURABLE PRIVY COUNCIL,

GOVERNOR-GENERAL OF BRITISH NORTH AMERICA,

AND

CAPTAIN-GENERAL AND COMMANDER-IN-CHIEF

IN AND OVER THE PROVINCES OF

CANADA, NOVA-SCOTIA, NEW-BRUNSWICK, AND THE ISLAND OF PRINCE EDWARD,

AND VICE-ADMIRAL OF THE SAME:

THESE REMARKS,

ON THE

PRINCIPLES AND PRACTICE OF ROAD-MAKING,

AS APPLICABLE TO CANADA,

ARE, BY PERMISSION,

MOST RESPECTFULLY DEDICATED,

BY HIS EXCELLENCY'S

VERY OBEDIENT SERVANT,

THOMAS ROY.

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REMARKS, &c.

One of the first objects which occupies the attention of an energetic people, when they are striving to advance in the march of improvement, and to take a higher standing amongst the nations of the earth, is the forming and establishing of roads and other mediums of communication, in order to promote the development of the resources of their own country, and to enable them to maintain a commercial and social intercourse with foreign nations.

Just as these mediums of communication are perfected, and in a direct ratio to the degree of perfection to which they are brought, is the advancement of comfort and opulence, and the diffusion of the refinements and elegancies of life amongst any people. We might prove this position by reference to the histories of all countries, in all ages, from the eras when the roads of ancient Egypt, Mexico, and Rome, were constructed, down to our own times, wherein the far more useful, and all but perfect roads, canals, and railroads of England afford full proof of our statement. But, however interesting and instructive such a discussion might be, it is not necessary to enter upon it, for we believe our position will not be disputed.

In the Province of Canada, our circumstances are fraught with many peculiarities, and in nothing more than in those matters which concern our roads and lines of communication. Almost the whole of our population, at least in the upper portion, are natives, or descendants from natives of countries where such lines of communication are established in a greater or lesser degree of perfection, and no circumstance tends so much to paralyze the exertions of our settlers from the old country as the want of good roads.

Upon the first laying out of the Townships in the Upper Province, even a superabundance of reserves was left for roads; but these concession lines and side-lines run straight on, across ravines and rivers, over hills, through swamps, lakes, and other hindrances, and could never have been intended to serve as leading lines of communication when the Province became settled, and good roads became necessary for the conveyance of produce and goods to and from distant markets. Their intention is to serve the same purpose as the parish roads in England, or to connect the various parts of the Townships with leading roads, to be constructed upon proper locations, and in proper directions, as circumstances may require.

It is not the improvement of these concession and side-lines which we propose to discuss; this ought to be done in the best manner that circumstances will permit, by the statute labour, or the commuted statute labour of each Township. But it is to draw attention to the best and most economical methods of constructing leading lines of road throughout the Province, in such locations as shall most effectually open up every portion of it, and progressively develope its vast resources.

One objection to forming a general system of common roads in this Province may as well be met here. It is often said, why lay out large sums upon common roads; they will soon be superseded by railways? Those who raise this objection, do not appear to have taken a very accurate view of the subject. Railways are of great and paramount advantage to densely populated countries, where there is great travel, and a constant transit of goods; especially between shipping ports and manufacturing towns, or, in mining districts, from the mines to the works, or to the shipping ports; but it is doubtful if there are more than three or four locations in the Province of Canada where railways are really required, and where the returns would pay a dividend upon the cost of construction, for at least twenty years to come.—In support of this position, let us advert to the geographical situation of this Province. For, when investigating this subject, we ought to keep out of sight advantages, real or imaginary, which it is said may be derived from United States intercourse. These may be fit subjects for Joint Stock Companies to speculate upon, but ought not to bias the Legislature of the Province.

In Lower Canada, that portion of the country which is most fit for settlement extends a few miles back from the sides of the St. Lawrence River. Even where the distance is greatest, produce would be brought down to the shipping ports on the river by the farmers' waggons, if good roads were formed, in preference to sending it by railways. Above Montreal, the Ottawa River will (when locks are constructed at the rapids) afford four hundred miles of inland navigation. These locks, common roads, and a few branch canals to the small lakes, would most entirely open up the Ottawa valley to the ocean. Again, were common roads constructed, the whole of the country between Montreal and Kingston would be rendered accessible to the ocean by the St. Lawrence River and the Rideau Canal. The numerous ports on Lakes Ontario, Erie, St. Clair, and Huron, afford an access to the ocean from the countries adjacent to their shores, provided common roads were constructed from the interior to these ports. But there is a large extent of country, chiefly in the London and Brock Districts, which is too remote from the Lakes to be fully benefitted by their navigation, unless some more effectual medium of communication than common roads is provided.—Two methods present themselves: a railway from London to Hamilton, and a boat-canal from the Rondeau, on Lake Erie, through the valley of the Thames to Woodstock. As the chief article of transport would be agricultural produce, it is needless to say that the last would be the most useful and effective; but common roads, even in these Districts, will not be the less necessary to lead to these main arteries. The remaining portions of the Province are that extensive, rich, and fertile, but yet unsettled country, on the south shore of Lake Huron, and the Lake Simcoe, and the Balsam Lake countries. The first of these possesses the fine harbour of Owen's Sound, but the two latter, although they possess the navigation of their respective lakes, have no outlet to the ocean for their productions. These parts appear to be the only portions of Canada where the construction of railways is all but indispensable. But it is not our object to speculate upon these matters.

From the above sketch of the situation of the Province, and assuming, that if good roads were constructed, every farmer who resides within twenty-five miles of a shipping port, would prefer carting his produce with his own teams to paying the fare for it upon a railway, we can see no reason to apprehend that common roads will be superseded in Canada by railways.

But there is another aspect, equally important, in which the subject ought to be viewed, that is, the probability that railways may be rivalled by steam-carriages upon common roads. This is no chimerical idea. Great exertions are making at this present time to bring these carriages into use, and every season produces some farther improvement. The chief hindrance has been the steep acclivities still to be found on many of the old roads in England. It is however allowed, by the ablest Engineers who have studied the subject, that steam-carriages could work well upon common roads, provided there were no acclivities exceeding one in thirty, and that there were no sharp turns upon the roads. Upon such roads they grant that steam-carriages could convey goods and passengers at a velocity of sixteen miles an hour. This fact ought not to be lost sight of when laying out new lines of road in Canada, for, owing to the general levelness of the country, there are few situations where a skilful Engineer would fail in obtaining lines of road, with acclivities even less than one in thirty, without materially increasing the expense, provided he had full liberty to choose the location.

Having thus stated that our object is to endeavour to point out the best methods for laying out, and constructing good and effective lines of common road in the Province of Canada, we shall consider—

First—The laying out of a road.

Secondly—The formation of a road.

Thirdly—The materials for making a road, and the methods of applying them.

Fourthly—The causes which have produced constant failures in attempts at road-making in this Province.

Fifthly—The means by which failures may in future be prevented.

THE LAYING OUT OF A ROAD.

Every road should be considered as a portion of a general system of roads, and should have a reference to two or more given points, and to the opening up of the intermediate country through which it is destined to become the medium of intercourse.

As every public road is intended to promote the general interests of the country, these general interests ought never to be lost sight of, nor departed from, for the sake of local or private interests.

In selecting a line of road where two lines present nearly equal advantages and disadvantages, the cheapest route ought to be preferred, but in making the selection reference ought to be had, not only to the original cost of construction and the future repairs, but also to the relative expense of animal strength required to draw carriages upon each line.

As commercial intercourse is the object proposed to be attained in laying out every line of road, it ought to be a primary object to secure a route upon which the greatest possible quantity of labour can be done at the least possible expense of animal strength.

Roads ought to be carried along a level line as nearly as possible, and having only gentle acclivities and declivities, for a greater distance on a road nearly level, is productive of less expense of animal strength, than a lesser distance passing over considerable elevations. Hence the necessity of carefully selecting, examining, and levelling every proposed line of road.

The following tables will render the truth of the above propositions manifest. Tables Nos. 1 and 2 are drawn from a series of experiments made on the Holyhead road by order of the Parliamentary Commissioners. No. 1 was on a well formed and well consolidated part of the road. No. 2 was on a portion of the road made with limestone, but less perfectly formed, and not so well consolidated. It may be added that the results agree very nearly with the results of the theoretical formula, "That the required force of traction is inversely as the co-secant of the angle of inclination." The table No. 3 is calculated from Professor Leslie's formula for the force of traction exerted by horses—which has also been verified by numerous experiments. The table No. 4 was calculated by Mr. McNeil, Assistant Engineer on the Holyhead road, from data obtained in the course of making the experiments from which the tables No. 1 and No. 2 are drawn.

TABLE No. I.

Force of traction required on various inclinations of a well formed, well consolidated granite road—load 21 cwt.—velocity 2½ miles an hour:—

Rate of Inclination.	Force required.
Horizontal.	47 lbs.
1 in 229	78
1 in 49	115
1 in 27	152
1 in 22	171

TABLE No. II.

Force of traction required on various inclinations upon a less perfectly formed, and unequally consolidated road of limestone. Load and velocity as in No 1:—

Rate of Inclination.	Force required.
Horizontal.	97 lbs.
1 in 66	115
1 in 45	128
1 in 20	270

TABLE No. III.

A horse can exert the following moving forces, at different velocities, for 6 hours per day:—

Miles per hour.	Strong Horse.	Ordinary Horse.
2	169 lbs.	100 lbs.
2½	156	90
3	144	81
3½	132	72
4	121	64
5	100	49
6	81	36
7	64	25
8	49	16
9	36	9

TABLE No. IV.

Expense of drawing one ton over one mile, at different rates of inclination, by waggon, velocity 2½ miles an hour:—

Rates of Inclination.	Pence and Decimals.	Rates of Inclination.	Pence and Decimals.
1 in 10	52 07	1 in 90	14 22
1 in 15	28 77	1 in 100	14 04

Rates of Inclination.	Pence and Decimals.	Rates of Inclination.	Pence and Decimals.
1 in 20	22 83	1 in 150	13 46
1 in 30	18 5	1 in 200	13 18
1 in 40	16 79	1 in 300	12 91
1 in 50	15 82	1 in 500	12 69
1 in 60	15 20	1 in 1000	12 53
1 in 70	14 77	horizontal.	12 36
1 in 80	14 46		

We cannot illustrate the value of these tables better than by giving the following quotation from the late Mr. Telford's report to the Parliamentary Commissioners, when he gave in the results of the experiments, from which they are chiefly derived:—

"Having the results of these accurate trials to refer to, leaves it no longer a matter of conjecture in what manner a road should be made to accomplish most effectually the main object, that is, diminishing to the greatest possible degree the labour of horses in draught.

"Although the observations of scientific persons have led to nearly similar conclusions, others have been in the habit of laying down rules for road-making, at variance with all the established laws of motion. It is satisfactory to be able to produce a positive proof, by actual experiment, of their opinions being wholly erroneous."

As commercial men are most sensibly affected by any increase or decrease in the charges of trade, we would most particularly draw their attention to the increasing ratio of expense shewn by the table No. 4. It will be perceived, that the cost of drawing one ton upon a mile of level road is 12 36-100 pence—and that the cost of drawing one ton upon a mile of road having a rise of 1 in 15, is 28 7-10 pence.—There are inclinations as steep as 1 in 15 on all our Home District roads. These inclinations, however, are generally short, and do not increase the cost of traction in that extreme ratio; but, it may be fairly assumed, that 20 53-100 pence is about the true tabular value of the cost of traction per ton per mile upon these roads, or it is an increase of 8 17-100 pence per ton per mile, compared with a level road. This, upon 20 miles, is an increase of thirteen shillings and seven-pence per ton, upon all goods or produce conveyed upon these roads for that distance.

THE FORMATION OF A ROAD.

The width of the roads in this Province appears to be established at 66 feet. This width (except in the vicinity of towns) we consider to be too much, for it requires too great a rise in the middle to keep the road dry, and consequently increases the expense of formation and repair, without producing any equivalent advantage. We would propose 48 feet as the width of a road; that is, 5 feet for a ditch on one side of the road, 38 feet for the carriage-way, and 5 feet for a foot-path on the other side of the road. This width will be found adequate to every purpose required.

The first operation ought to be carefully to level the proposed line of road, and to place levelling-stakes at every 100 feet, or at other suitable distances. Sections of the line ought to be made, and the whole laid out to be worked into true levels or inclinations. This will facilitate future operations, and will also tend to lessen the expense, by enabling the Engineer to reduce the quantity of excavation and embankment to a minimum, and will afford such data as to enable him to compute the quantities to be excavated and embanked, so as to make the one as nearly as possible equivalent to the other.

Where excavation is required to be done, deep cutting, if possible, ought to be avoided, for two cubic yards of surface cutting can generally be done for less money than one cubic yard at a depth of ten or twelve feet. Attention to this circumstance is the more necessary, because so much money has been wasted in cutting the sides of ravines, without any previous measurements of elevation, or computation of the quantity of excavation and embankment required. Instances are not rare in this Province where more money has been expended in obtaining a rise of 1 in 14, or 1 in 16, than would have constructed an inclined plane of 1 in 25, in exactly the same position, under better management.

Drainage is an affair of primary importance in road-making, and requires much skill to execute it in a proper manner.—The ditch ought to be upon that side from whence the flood-water flows toward the road. Its capacity should be regulated by the quantity of water which it has to convey, and the distance to which it has to convey it before reaching a lateral outlet. Lateral outlets should be capacious, and, if possible, frequent. The strata of the soil should be carefully studied, and means used to convey all water from springs, however small, into the ditch. It may even be necessary to carry the process of draining far beyond the area of the road, but no general rules will apply to such a case.

As many roads may be laid out in this Province which will not be covered with broken stone or other material for a considerable period after, we shall first describe the manner of laying out a road without reference to the material with which it is intended to be covered.

The levels and inclinations of the road longitudinally should be truly kept, and all short undulations carefully avoided. The surface of the road transversely should be rounded into the form of the segment of an ellipsis—that is—the dip should increase from the centre to the sides. The height of the centre upon a road 38 feet wide, ought to be about 13 inches above the edge of the ditch, and the edge of the water-run inside the footpath. The whole of the surface of the road to be made and kept as smooth and even as possible, to prevent water from standing upon it. A shallow water-run to be constructed between the road and the footpath to receive the rain-water from the road, and to convey it to lateral outlets, or to the ditch through culverts under the road. The footpath to be raised to the same elevation as the centre of the road, to slope one foot from the water-run, and to have a smooth surface 4 feet wide on the top. The culverts to be laid deep enough to admit of their being covered with earth, and not to present any rise or depression on the surface of the road.

After a road has been so prepared, no more is required when it is to be paved with broken stone or gravel, than slightly to level the centre of the road, and to use the earth taken off in raising the sides to the required additional height. But when the road is to be paved forthwith, it is a considerable saving in labour and expense to construct the metal bed as the road formation proceeds; and it would be desirable that this should always be done.

The cost of so forming a mile of road in the forest—taking out the roots of trees, &c. &c. (exclusive of deep cutting and embankment) will be from £220 to £280,—varying according to the nature of the soil, the strength of the timber, &c. &c.

THE MATERIALS FOR MAKING A ROAD, AND THE METHODS OF APPLYING THEM.

Stone of various descriptions has hitherto been almost the only material used for road-making. In some instances dressed cubes of stone, or even moderately sized rounded pebbles are laid as pavement, especially in the streets of large towns. These dressed cubes, when well formed and properly laid upon a firm, well consolidated bottom, are better adapted than any other material for paving a street where there is a constant and heavy traffic, but the first cost of this mode of paving has hitherto prevented it from being used in constructing common roads. A pavement of rounded pebbles forms a very rough, objectionable road; it is constantly sinking at the parts most used, and it is difficult to keep it in repair. For these and other reasons, it has nearly gone out of use in modern times. Gravel, when properly applied, forms a good road, and is extensively used in England. But stone broken into cubes of about 1½ inches is decidedly the best material for constructing common roads, and wherever it can be procured at a reasonable cost, has superseded all other materials for road-making. Timber has been proposed in this country as a road-making material—we shall allude to it hereafter.

The size of the broken stone onght to bear a proportion to the hardness and adhesion of the material used. Perhaps this object will be best attained by making weight the standard. Thus, if 6 ounces be given as the maximum, the size of the various descriptions of stone used will be in proportion to their specific gravity. An exception, however, ought to be made in the case of stones which break with a splintery fracture, or in a wedge-like form; these ought not to exceed 1½ inches longitudinally. This description of stone may be used for bottoming a road, but, unless in cases of necessity, should not be used on the surface.

After the metal bed has been levelled transversely, and made as firm as possible, the metal, or broken stone, should be so laid as to render it impervious to water. This can only be effected by laying it on in thin layers, and giving each layer time to be settled by the action of the wheels and the horses' feet, before the next in succession is laid on. The first layer should be about 5 inches thick, quite level, and should be well pressed down upon the metal bed, and consolidated so as to form a species of concrete bottoming for the road, before the next layer is put on. Should the road be about 16 feet wide, and the traffic light, another layer of about 5 inches average thickness will form a good road; but if the road is wider, and the traffic heavy, it will require two layers of about 4 inches each, which will form a road strong enough for any situation. The form of the surface of the metal, when finished, ought to be the segment of a circle. If the width of the metal-bed, or the chord, be 16 feet, the versine, or rise, should be 2½ inches nearly. Thus, if an average of 10 inches of metal is to be given, the thickness at the edges should be 8¾ inches, and at the middle it should be 11¼ inches. This curve is quite sufficient to drain off the water, and it is strictly in accordance with the required strength of the road at the centre and at the sides, for, by observation, it is found that on a road much used by waggons, the waste is in the following proportions:—

Action of the atmosphere,................	20 per cent.
Carriage wheels,...........................	35 " "
Horses' feet...................................	45 " "

Therefore, if the atmospheric action and the action of the wheels be diffused in a nearly equal degree over the breadth of the road, and the action of the horses' feet be most frequently on, or near the centre, it follows that the centre ought to be stronger than the edges, in the proportion of 7 to 9. The 11 feet of earth or gravel-road, on each side of the metal-bed, should dip about 7 inches from the metal to the edges of the ditch, and of the water-run at the foot-path; thus forming the surface of the road, when finished, into the segment of an ellipsis.

Hollow arching of the materials ought to be carefully guarded against, for a percolation of water from the surface will take place wherever it exists. This hollow arching cannot be avoided when the full thickness of the metal is put on at once, therefore it ought never to be done. Covering the surface of the road with loose materials, such as sand or gravel, has a still more pernicious effect. It prevents the angles of the stones from combining, and, a road so used, must ever remain hollow underneath, pervious to water, and subject to expansion and contraction from atmospheric changes. In this country, the roads sustain much injury from heaving up by the frost. This would be, in a great measure, prevented by adopting a better system of drainage; and it would be still farther remedied if, when forming the metal-bed on a clay soil, a few inches of vegetable mould were placed over the clay, and the broken stone placed upon the vegetable mould.

The broken stone should never be shot out in cart-loads, or even in wheel-barrow-loads, and then be spread out upon the road. In every case, it should be taken out of the cart, or wheel-barrow, by shovel, and spread evenly and regularly upon the road, so as to promote an equal consolidation.

Excavation and embankment, ditching, providing and breaking stone, and some other works, may, and perhaps ought to be done by contract; but forming the metal-bed, laying on the metal, and finishing the road, ought, in every case, to be done by men permanently employed, who have been well trained to, and are experienced in the business.

In England it has been found, on roads where great traffic exists, that if they are made of clean, hard, broken stone, placed on a firm foundation,—rendered impervious to water, and sufficiently strong not to yield under the pressure of the wheels,—the wear is about 1 inch in thickness per annum; but on weak, ill-drained roads, pervious to water, the wear of materials has been as much as four inches in thickness per annum. In Canada, so far as our experience guides us, it would appear that the wear of materials upon a firm, well-formed road is even less than the wear of materials in England. This no doubt arises from the transitions from dry to wet, and from wet to dry, being less frequent. It is only during a few weeks in the autumn, and at the going off of the frost in spring, that roads in Canada suffer much from atmospheric influence. We may instance the streets of Toronto, which are constructed upon the same principle as the best English roads. King Street was paved on the sides and formed with broken stone in the centre in 1836. During the previous year, a common sewer had been constructed under the centre of this street, and the earth over the sewer was imperfectly consolidated. For about the distance of one-third of a mile, in the most frequented part of the street, the thickness of broken stone averaged nine inches. At this present time, after five years' wear, the average thickness exceeds seven inches; or, the wear on this much frequented road, has been about one-third of an inch per annum. This street has been much broken up, by cutting drains from new buildings to the common sewer, and in a few places by the subsiding of the earth over the common sewer. Had it not been for these causes, it is probable that up to this time it would not have required any repairs. Nearly another half mile of the same street was constructed during the same season, with an average thickness of eleven inches of broken stone, the wear upon this portion does not appear to exceed 1 inch, and the only apparent injury arises from the causes above mentioned. But about 1200 feet of the eastern end of the same street was done by contract. The metal-bed was imperfectly formed, and the workmanship inferior. This portion has been constantly in want of repairs. We may remark that, from the exclusion of a free circulation of air, and other causes, the wear on the streets of a city has been found to be greater in proportion to the traffic, than the wear on a well-constructed country road.

Granite, trap, and other chrystalline rocks (except perhaps those in which feldspar is in excess) are good road-making materials. The boulders, which are found so abundantly in many situations, when broken and mixed together, are excellent road-making materials.

Most of the varieties of limestone, properly applied, make good roads; but from the action of the atmosphere, and other causes, they do not wear so well as the granitic stones, and seldom become so well consolidated, although the consolidation is more easily effected.

Gravel, when well cleaned and properly applied, forms good roads. Their endurance depends upon the nature of the pebbles of which the gravel is composed.

When making contracts for the delivery of stone, the mode of payment should always be specified to be by the toise, or cubic yard of broken stone. This affords an equitable mode of measurement, and generally prevents the contractor from bringing forward such soft stone as crumbles to dust under the hammer. It will require 326 toise of broken stone, 8 cubic yards to a toise, to make one mile of road, 16 feet wide, average thickness of metal, 10 inches.

The price usually paid per toise for boulders, in the Home District, has been £2., and the cost of breaking has been £1. 10s. The cost of carting, and spreading on the metal, and of using the rakes, &c. during the process of consolidation, will amount to about £100. per mile. Therefore, the cost of a mile of road, made with such materials, at these rates, will be—

Road formation, as above,................£	250	0	0
326 toise stone, @ 40s....................	652	0	0
Breaking do. @ 30s.	489	0	0
Laying on do. and finishing the road,	100	0	0
	£1491	0	0

Exclusive of deep-cutting, bridges, &c. &c.

It is not likely that the above description of stone will be obtained much cheaper, but the price hitherto paid for breaking has been too high. When road-making shall proceed upon a greater scale, and the hands become used to the work, three shillings per cubic yard will afford them good wages.—This will produce a saving of £97. 16s. per mile, and after men are properly trained, a sum of from £70 to £80 will be sufficient for laying on the materials. Thus, £1370. may be given as the value of a mile of road so constructed.

As limestone is the material most abundant in this country, and which will be much used, the following may be given as the value of a mile of road made with limestone:—

Road formation, ...	£250	0	0
326 toise of stone, @ 12s. 6d.	203	15	0
Breaking do. @ 20s.	326	0	0
Laying on do. and finishing the road,	100	0	0
	£879	15	0

The above sum will be sufficient to make a mile of road within two miles of a limestone quarry; at greater distances, the additional expense of cartage must be added. It is believed that the greater cost of a granitic road is fully compensated for by its greater endurance.*

There are many situations where extensive deposites of gravel, very fit for road-making, are found. We may remark, that all gravel consists of rounded pebbles, unequal in size, and more or less mixed with sand, clay, &c. &c. In order to prepare gravel for road-making, it must be screened, and the pebbles be entirely separated from the sand and clay; then the larger pebbles must be separated from the smaller, and must be broken up into angular portions; even a piece of 1½ inches diameter must be broken, for consolidation will not take place unless there is a due proportion of angular pieces.

The preparation of the metal-bed is the same for a gravel road as for a road of broken stone. In practice, the angular broken pebbles are sometimes again mixed with the small round pebbles, at other times they are reserved for those central parts of the road which are most exposed to wear.—These different modes of application must be left to the judgment of the road-maker, as the advantages or disadvantages of either form will depend upon the quality of the material and other circumstances. The gravel must be placed upon the metal-bed in precisely the same manner as broken stone, except that after the first layer, none of the succeeding layers should exceed the thickness of two inches, and every layer should be well consolidated before the next in succession is placed upon it. The thickness should be regulated by the quality of the gravel. The constant use of rakes to keep the surface of the road smooth during the process of consolidation is indispensible.

A well constructed, well consolidated gravel road, is extremely pleasant and smooth in fine weather, but it is more subject to injury from atmospheric influences than a road constructed with broken stone. This mainly arises from the difficulty of entirely separating earthy matters from the gravel. These are subject to expansions and contractions in wet and dry weather, and in heat and cold to such a degree, that a gravel road requires constant care.

Where stone is difficult to be procured, gravel has been advantageously used in another way. Where a road has been required to be 20 or 24 feet wide, about 12 or 14 feet in the centre has been made with broken stone, and 5 or 6 feet upon each side with gravel. In practice this answers well. Beach gravel, which is plentiful upon the lake shores, would suit very well for this purpose, or even for bottoming roads, but it is necessary that it should be broken small.

There is a system of road-making which has lately been pushed into notice, and which has excited considerable attention in this Province, namely, laying down string-pieces on the central part of the road, and covering them with 3 or 4 inch pine planks. This system deserves serious consideration, for a benefit will arise to the country from it, should it prove to be useful, but a great and certain loss to the finances of the Province must be the result if it is over-rated, and is placed in the way to divert funds and attention from better, and even more economical systems of road-making. In order to arrive at a just estimate of the value of such roads, we shall consider, Firstly—The strength and endurance of such a road. Secondly—Its cost relatively to a road of broken stone.

The most accurate method by which we can arrive at the strength of a plank road, will be to examine the deflection of planks of various thickness under a given weight, when the plank is supported upon sleepers 4 feet apart, and also, the loads which would break planks so supported. The two following tables will exhibit this information:—

TABLE No. I.

Shewing the deflection of pine planks 12 inches wide, of various thickness, supported upon sleepers 4 feet apart, under a load of one ton.

Thickness of plank	Deflection in inches and decimals.
4 inches.	0.054 inches.
3	0.128
2	0.432
1½	1.025

TABLE No. II.

Shewing the ultimate strength of pine planks 12 inches wide, and of various thickness.

Thickness of plank.	Will break under a load of—
4 inches.	17,632 lbs.
3	9,918
2	4,408
1½	2,479
1	1,102

By the above tables it is shewn that planks 12 inches wide, and 4 inches thick, supported upon sleepers 4 feet apart, will require a load of 8 tons to break them, and that they will not be very sensibly deflected under a load of 1 ton; but a 3-inch plank, of the same width, and similarly supported, would break under a load of 4½ tons, and would be very sensibly deflected under a load of 1 ton. A 2-inch plank, similarly placed, would break under a load of 2 tons, and would be deflected about ½ an inch under a load of 1 ton. This deflection, frequently repeated, would tear out the trenails or other fastenings. A 1½-inch plank would break under a load of less than 1¼ tons, and would be deflected more than 1 inch by a load of 1 ton, whilst a 1-inch plank would break under a load of about ½ a ton.

These results are most important, for they shew us that, in order to obtain a road which will be firm under ordinary pressure, it must be laid with 4-inch plank,—that 3-inch plank will vibrate and soon become loose,—that 2-inch plank will vibrate so much that it cannot be kept firm in its position,—and that 1½-inch plank is unsafe, and may break under an ordinary load. Now, it may be objected, that 1½ inch plank, or 2-inch plank, will not be used for road-making. We grant that; but it does not change our position, for 4-inch and 3-inch planks will soon wear down to these thicknesses.—These results fix the ultimum of useful wear in a 4-inch plank to be 2½ inches, and in a 3-inch plank to be 1½ inches.

In following out this investigation, we are at a loss for experimental results upon which to found our deductions.—The action of hammering or rolling, as is well known to the Indians, separates the fibres of timber, and causes the annual rings to loosen the one from the other. This will be one cause of wear upon plank roads, and thus, the rolling action of the wheels will not a little aid the action of the horses' feet, the greatest cause of wear upon any kind of road. Upon planks, horses' feet act with a most powerful effect; indeed this is the reason why about wharfs and other places, in European cities, iron railways, and other expensive expedients, are adopted to convey goods to such places as the carts can reach, without allowing the horses' feet to tread upon the wooden platforms. But we are always referred to the plank road east of Toronto. We fear the circumstances under which this road has lasted so long are but imperfectly known; for timber will not change its qualities even there. Somewhat more than a mile of this road was planked in 1836.—This portion has a general, in some places a steep ascent from the city. As soon as it was finished, the planks were covered with 3 or 4 inches of sand, and were carefully protected from the horses' feet. Under these circumstances they were not exposed to any wear, except natural decay. This sand caused a heavy draught, but, as the chief portion of the traffic is toward the city, or down hill, the increased force of traction was not very objectionable. The hill was very bad before; and the road, such as it is, gives satisfaction. Since that time, several miles more of the same road has been planked. This part has not been covered with sand; but it is beyond the distance where there is heavy traffic, for the Markham traffic scarcely enters upon it, and the difficult pass at the Rouge hill, nearly cuts off the traffic with Toronto from the eastward. Besides, the greater portion of the traffic upon that part of the plank road which is not covered with sand, is by farmers' teams, some drawn by oxen, and others by horses without shoes, so that, in reality, it has been subjected to very little wear, and ought not to be held up as a proof of the efficiency and endurance of plank roads

But it may be well to give some farther experimental proofs upon this subject, although scientific persons will hold them to be quite unnecessary. We shall draw them from the city of Toronto, where, although the general traffic is not heavy, yet the horses are all shod, and consequently it affords a better proof of what the action of horses' feet will be upon plank roads.

In the spring of 1837, Mr. Brown covered his new wharf with 3-inch plank; by last winter it was entirely worn out, and he had to cover it again. This gives an endurance of three seasons, under the traffic to and from the wharf.

In 1836, when Yonge Street was paved; several of the inhabitants expressed a wish to have wooden crossings placed in the pavement,—it was unfortunately agreed to, and three planks, 6 inches thick, were placed at each crossing. During the third summer after, they were cut through by the horses' feet. Shewing a still shorter endurance in this busy street. Several other instances might be given, but these may suffice.

We shall next examine the cost of a plank road, relatively to a road of broken stone.

We shall hold the expense of road formation to be the same in each case, for it would be as necessary to work a plank road into true levels and easy acclivities, as any other description of road. The value of a mile of plank road, 16 feet wide, at the present prices of plank and value of labour, would be about £800. for 4-inch plank, and £600. for 3-inch plank. In each case, add £250. for road formation, and the result will be £1050. per mile for a road covered with 4-inch plank, and £850. per mile for a road covered with 3-inch plank, exclusive of deep-cutting, bridges, &c. This proves that a road, covered with 3-inch plank, is very nearly as expensive as a road of broken limestone; and, taking £1370. to be the expense of a mile of road constructed with broken boulders, it will only cost £320. more per mile than a 4-inch plank road.

Next, let us inquire into the relative expense of maintaining a plank road, and a road constructed with broken boulders.

There is a misunderstanding concerning the repairs of a well constructed road of broken stone, which it may be as well to obviate. We have shewn that the first layer of stone, about 5 inches thick, should be well consolidated, so as to form a species of concrete bottoming to the road, before the next layer of stone is put over it. Now, it is not intended that this concrete bottoming shall ever again be exposed to the action of the wheels, or of the horses' feet, after it has been covered, but that whenever the road has been worn down to the thickness of 5½ or 6 inches, another entire layer of stone shall be placed upon it. We shall assume, as before, that the original average thickness of metal is 10 inches. Therefore, the quantity of metal to be worn down, before a general repair is wanted, will be 4 or 4½ inches. Now, by the data drawn from the wear on King Street, Toronto, which supports full three times as much traffic as any country road in Canada, this is shewn to be one-third of an inch per annum, which gives 12 years, after formation, as the time when a well constructed road of broken boulders would require to be covered with another layer of stone. But here again we must observe that, although many parts of the road will be worn so weak as to render an additional layer of stone advisable, yet, there will be many parts of the road, both longitudinally and transversely, which will be much thicker than 6 inches, and when these are loosened by the pick and levelled, (the bottoming must not be loosened) the general required thickness of metal, to restore the road to its original average thickness of 10 inches, will not exceed 3 inches, or about one-third of the quantity originally required to make the road.—Now, the cost of such repair, by which the road will be rendered as good as it was when first constructed, may be given as under:—

109 toise of stone, @ 40s.	£218	0	0
Breaking do. @ 30s.	163	10	0
Picking up and levelling the old road, laying on the stone, and finishing the road,	75	0	0
	£456	10	0

Thus, if £1491. is taken as the original cost of a mile of road, constructed with broken boulders, and the above sum of £456. 10s. be added, we obtain £1947. 10s. as the cost of such a road for 24 years. There are, however, certain yearly repairs, such as cleaning water-runs, making good small failures from local and accidental causes, &c. &c. which must be punctually attended to. These vary so much, under different circumstances, that they cannot be valued with any degree of accuracy; but when close attention is given by the persons in charge, the amount per mile is not great. We have shewn that, when road-making is proceeding upon a greater scale, and the hands become accustomed to the work, a mile of such a road can be constructed for £1370. Now, reducing the general repairs in the same proportion, we obtain £1782. as the value of one mile for 24 years, exclusive of the yearly repairs.

Let us next inquire into the cost of maintaining a plank road.

By Table No. II, it will be seen that a pine plank, 12 inches wide, and 1½ inches thick, supported upon sleepers 4 feet apart, will break under a load of 2479 pounds; or, if a cart were loaded to that weight, and some sudden jerk, or other cause, were to throw the whole weight upon one wheel, the 1½-inch plank would break under the wheel. Again, if a similar jerk were to throw a weight of 1 ton upon one wheel, passing over a 2-inch plank similarly supported, it would bend nearly half an inch,—a degree of flexibility which would soon work the planks loose. Now, from this data, we arrive at the following conclusion:—That the ultimate efficient wear of a 3-inch plank road is 1½ inches of the thickness of the plank, and of a 4-inch plank road it is 2½ inches; or, in other words, after these amounts of thickness are worn off from the planks, they will no longer possess sufficient strength to support the traffic upon the road. We shall set aside the planked part of the Kingston road near Toronto, for reasons already given, as not affording sufficient data from whence to deduce the endurance of a plank road. But we shall take the wear of the planks upon Mr. Brown's wharf as our guide. There the traffic is certainly less than upon any of the roads out of Toronto, but nearly all the horses working upon it wear shoes. From this data it appears, that the wear under this amount of traffic is half an inch of thickness of plank per annum, or, that 3-inch plank will last for 3 years, and that 4-inch plank will last for 5 years. Under a heavier traffic, where the horses are nearly all shod, the endurance would be proportionally less. This is evidenced by the Yonge Street experiment, the result of which has been already given.—From the above, we obtain the following as the cost of a 3-inch plank road for 24 years:—

Road formation and first planking, ...	£ 850	0	0
Planking, 6 times renewed, @ £600,	3600	0	0
	£4450	0	0

Cost of a 4-inch plank road for 24 years:

Road formation and first planking, ...	£1050	0	0
Planking, 3 times renewed, @ £800,	2400	0	0
	£3450	0	0

Exclusive of annual repairs, such as cleaning water-runs, fastening planks, replacing worn out and broken planks, &c. &c. It can scarcely be doubted but that these annual repairs will be as expensive as the repairs upon a road of broken boulders.

The 4-inch plank shews a balance of £1000. in its favour every 24 years; but, against this, it must be remembered that the softer parts of the plank will wear out first, and that a 4-inch plank road will be nearly as rough, during the last two years which it will wear, as the old corduroy roads of the country.

Taking the cost and maintenance for 24 years of a road formed of broken boulders (exclusive of annual repairs) to be £1782., it will be £2668. cheaper than a 3-inch plank road, and it will be £1668. cheaper than a 4-inch plank road, (also exclusive of annual repairs).

These results are extremely different from the results which have been lately so industriously handed about. It may be proper to exhibit a few of the errors upon which these statements are founded.

The cost of road formation, for a road covered with broken stone, is given as £400, whilst the road formation for a plank road is given as £200. We deny that there will be any difference, if each is to be reduced to true levels and moderate acclivities. Again: the repairs of a road of broken stone are over-rated. We deny that a well-formed, well consolidated road, will ever require what has been called lifting. And farther, we have rather under-rated the endurance of such a road at 12 years, under any traffic in Canada: provided the sun and air are not excluded from it.

Again: the endurance of a plank road is given as 8 or 10 years; and that portion of Kingston road which was planked five years ago, and has required no repairs, is adduced in proof. This we have already shewn to be a mere delusion; but even if we grant the endurance to be 8 years, the value for 24 years will stand thus:—

Road formation and first planking, 3-inch,	£850	0	0
Planking twice renewed, at £600, - -	1200	0	0
	£2,050	0	0

Or, taking the expense of a road of broken boulders for 24 years to be £1,782, exclusive of annual repairs, it will be £268, cheaper than a 3-inch plank road, also exclusive of annual repairs, even granting the endurance to be 8 years.— But at the end of 24 years the plank road will be worn out, whereas the bottoming of a broken stone road will be entire, and the road can be renewed; and rendered as good as when first formed for the sum of £412 per mile.

In arriving at all these conclusions, we have assumed that pine plank will be obtained 16 or 20 years hence at the present prices. We believe, however, that a proposal to contract for a supply of pine plank for the use of the Kingston road, during the ensuing 24 years, at present prices, would startle any of the commissioners of the road, even if the plank were to be delivered at their own saw-mills.

We have also the cost of the first mile of Yonge Street road, out of Toronto, and of the Kingston and Napanee roads, and of the Home District roads, generally held up as models of the cost of broken stone roads, nobody can deny that these roads were both expensive and badly constructed. So far are they from being models to work from, that they should serve as beacons to point out what ought not to be done. In fact they are just such roads as that grand improver of bad roads, Macadam, would have lifted and relaid. This process, if executed according to his method, would entitle them to the designation of Macadamized roads. The roads which we propose to construct are entirely different from these in almost every particular, except the breaking of the stone.

We might quote largely from the evidence of those eminent Engineers, under whose management the roads of England have reached their present degree of perfection, to prove that ill made roads are most expensive in their first formation—that it is all but impossible to keep them in repair—and that, in order to obtain good roads, scientific adaptations must be resorted to—and that, where these are properly applied and adhered to, the cost of construction will be lessened, and the expense of repairs will be inconsiderable.

The most absurd reference of all, in order to shew the cost of constructing roads of broken stone, is to the roads in the Gore District. It is well known, that the road from Dundas to West Flamborough, and the road from Hamilton to Ancaster, present difficulties of no ordinary magnitude, which could only have been overcome at great expense. Then why adduce these as proofs of the cost of an ordinary road? It is true that the inclinations on both these roads are too steep; but, under the peculiar circumstances, they are tolerably well wrought, and do credit to the gentlemen who conducted the works.

It may be deemed superfluous to have said so much concerning plank roads, as there can be no difference of opinion amongst scientific persons upon the subject. But we have before us a publication of Reports, Letters, &c. by the Legislature of 1825, wherein the utility of wooden locks for canals is enforced by arguments sadly at variance with chemical and hydrostatical laws; yet we know that the mania for wooden locks has produced direful effects upon the Province. Let us hope that the present mania for plank roads may be arrested, before it produces so much evil.

There is one use to which we conceive plank roads would apply. We have shown that a 4-inch plank road, well laid and fastened, would not very sensibly vibrate under a carriage weight, one ton to each wheel. Were steam-carriages for running on common roads to be introduced, such a road would suit them well, and if it were reserved solely for these carriages, as there would be no wear from horses' feet, and the wheels ought to be 4 inches broad, the planking would endure as long as the timber continued sound, and free from decay.

Although timber placed in its compressible form, or as planks, is unsuitable for road-making, where a moderately heavy traffic exists; yet timber placed in its incompressible form, or placed on end, is well suited for road-making, and will last under any traffic until it is wasted by natural decay. The following extract from specifications for a timber road sent to Sir John Colborne in 1833, but never acted upon in this Province, will describe this method of using timber in forming a road:

"The material to be used is round or angular timber, cross "cut by a saw into lengths of 24 inches, or 18 inches, or any "other suitable length as the ground to be passed over is soft "or hard. These blocks of timber to be set on end, and the "one to join into the other, (as per sketch), always breaking "the band as is done in paving with cubes of granite. The "diameter of the blocks not to exceed 12 inches, unless "where such are difficult to be got. When the ground is "firm the blocks can be held fast at bottom by the sides of "the earth or gravel road (see plan.) The space D. E. (or "width of the paved road), to be cut 9 inches, or 12 inches "deep before the paving blocks are laid. The earth thus "got out to be laid upon each of the sides, by which means "the road will be raised more than one foot above the general "level of the adjoining fields. Where this can be done, a "stay from the outside block, drove or sunk into the ground, "will keep the whole firm. Where the ground is soft and "swampy, a species of frame-work will be necessary to keep "the sides firm. Where a deep swamp is to be passed, it will "be proper to have the blocks longer, and to firm the ground "by drainage, or by an embankment of brush and turf, or "other materials, or perhaps by all these means. The spaces "left between the paving blocks in all cases to be filled up "with some material such as can be cheaply and conveniently "got. Round sand, or fine gravel will be best. This to be "put on the top, and swept into the crevices during the "process of ramming down the blocks. A grouting of lime-"water to be poured in, which will convert the gravel into "a species of concrete, and cause the rain-water to run off, "and will also tend to preserve the timber."

The specifications make provision for a peculiar mode of drainage, and point out simple methods for repairing the road. In moderately firm ground we believe that blocks of 15 inches in length would be sufficient. In situations where stones are scarce and timber plentiful, the timber could be got out rough hewn, and delivered on the road for 10 shillings per hundred feet. This 100 feet of timber could be cut into 80 paving blocks for about one shilling and sixpence. At these rates the value of one mile of road would be—

Road formation, - - - - - - - - -	£250	0	0
Paving Blocks, - - - - - - - - -	608	0	0
Placing do. - - - - - - - - -	53	0	0
Staying for the sides, - - - - - - -	45	0	0
Sand, Lime, and Ramming, - - - -	80	0	0
	£1036	0	0

This estimate is only given as an approximation. However, if hands were used to the work it is probable that a mile of such a road could be done for less than the above sum. Taking its cheapness and durability into account, it is probably the most suitable road for many parts of Canada.

We would close this division of the subject by remarking that in order to construct the roads, and other public works of the Province, in an economical, useful, and durable manner, a much higher standard of education and training for Civil Engineers must be required than heretofore. To have passed through a course of Mathematical, Physical, and Chemical instruction, is not sufficient. This must be followed up by a practical application of these sciences to the arts of construction, and other useful purposes. In England the Civil Engineers who are selected to do Government works have all first become eminent in their private professional practice. It would be well if the same system were adopted here.

THE CAUSES WHICH HAVE PRODUCED CONSTANT FAILURES IN ATTEMPTS AT ROAD-MAKING IN THIS PROVINCE.

Hitherto it has been the practice to apply to the Legislature for a loan of money to make such a given portion of road. When the application has been successful several Commissioners have been appointed, in some instances by the Legislature, in other instances the appointment has been vested in the Governor. At this point the errors commenced, and the bad working of the system began to develope itself. There was no unity of design. The management of the roads was vested in a number of small trusts. A general system of roads for the Province was not even thought of, and every separate road was considered as a local affair. The Commissioners in general were totally ignorant of the duties they were appointed to perform. Yet, as if the appointment conferred competent scientific knowledge and experience for the difficult task of road-making, they did not confine themselves to a general superintendence and management of the funds, but in most cases they actually directed the whole operations, with the assistance of a foreman frequently as incompetent to the task as themselves.

The first source from whence much of the evil arose was the difficulty of selecting suitable Commissioners. Along with others, store-keepers, millers, tavern-keepers, and tradesmen of various descriptions, were appointed. It might have been foreseen that persons whose business it was to supply food, clothing, and other articles to the labourers employed, and tools and materials for the work, could not act long as Commissioners without reproach. We do not say that any of the accusations brought against them were true, and we shall not say that they were false.

These Commissioners in time became too numerous; they had all local interests near their respective lines of road, and it became matter of accusation that their own local interests were preferred to the public advantage. Something of this kind may have occurred, but we believe there was much exaggeration in these statements.

These numerous small trusts prevented the Commissioners, even had they been so inclined, from availing themselves of the services of persons fully competent to conduct the necessary operations, because the sphere of action was too limited to afford the expense. Hence in some measure have arisen the very objectionable and expensive proceedings so much to be regretted.

Another evil arising from the multiplying of trusts was that it prevented unity of design, and the formation of a general system of roads for the Province. However for this the Commissioners were not in any great degree to blame. For, previously to giving grants of money for road-making, the Legislature ought to have provided for a general Inspector of Roads, whose duty it ought to have been to lay out, or at least to inspect, and approve or disapprove, of all lines of road for which grants were made, and also occasionally to have inspected the works in progress, and the manner in which the funds granted were applied—and to have reported annually to Parliament upon all these matters.

The multiplying of trusts also prevented the essentially necessary separation between the deliberative or Commissioners' department, [redacted], or Engineers' department. In effect, the Commissioners acted in both departments to the manifest injury of the work, and the loss of those salutary checks upon expenditure—an Engineer's superintendence and an Engineer's inspection and certificate previous to payments being made.

During this state of things it necessarily followed, that there was no person in the confidence of the Commissioners of superior scientific acquirements, and practical experience, to lay out and attend to the works, and to instruct and direct the superintendents and foremen on the various roads. Hence no efficient, well-instructed staff of superintendents and foremen could be formed, and the benefits of those scientific adaptations and appliances so essentially necessary in an economical, useful, and durable system of road-making, were totally neglected, and the work was left to be done by what are here called practical men, who are generally the slaves of custom, and follow some form, good or bad, from which they cannot change, and the results of which they are incapable of calculating.

Let us take a review of the working of this system.

The grants were generally obtained to improve, or, as it is called, to macadamize a road leading from one town to another, or it might be that a certain concession line was mentioned upon which the road was to run. This form of making grants for the purpose of improving certain definite lines, without duly examining their capabilities, and also without examining the adjoining country to discover whether or not a better or cheaper line could be found, was highly objectionable, and has led to enormous unnecessary expense. Let us instance Yonge Street road. The grants were made "to macadamize

Yonge Street road from Toronto to the Holland Landing, near Lake Simcoe." Now Yonge Street road was so located that it was extremely difficult and expensive to form it into a tolerably good road. On that portion which has been already done, nearly as much money has been expended in cutting hills, building bridges, &c. &c. as in road-making; yet several of the inclinations are as steep as 1 in 14. That portion which remains to be done is still more difficult, and will be more expensive. Now, if, previously to commencing the work, an experienced Engineer had been instructed to examine the country, and to lay out a road upon the best ground which he could find between "Toronto and the Holland Landing," he would have discovered that between 3 and 5 miles west of Yonge Street road, a line of road could have been got from Toronto to the base of the Ridges, (about 25 miles) without crossing one ravine, or meeting any difficulty, except the hill to the northward of Toronto; and farther, that the Ridges could have been crossed in that direction without involving any considerable difficulty. The result is, that the same amount which has been expended in making about fourteen miles of a very indifferent road, would have made about thirty miles of excellent road, leaving no inclinations steeper than 1 in 40; a circumstance which would have produced a great annual saving in repairs, and in expense of animal strength; or, as is shewn by Table No. 4, would have produced a saving of about sixpence per ton per mile upon all goods carted upon it.

It is, however, invidious and unpleasant to dwell upon works where money has been already wasted, although we fear that even these errors, severe as the loss has been, are not sufficient beacons to prevent shipwreck upon the same rocks. We may instance the proposed road from Oakville to Garafraxa, which it is said is to run upon a concession line through the Townships of Trafalgar and Esquesing, until over the limestone ridge. This will be eventually one of the most important roads in the Province, for it will become the great thoroughfare from the Waterloo District and the West, to Toronto. Now if the road were laid out from a point in the Township of Eramosa, about 5 miles northward from the town of Guelph, to cross the limestone ridge at the best point which can be selected, and then to proceed diagonally through the Townships of Esquesing and Trafalgar to a point on Dundas road near the Credit river, the distance between the point of commencement and Toronto would be shorter by 10 or 12 miles than by the Concession line, besides affording opportunity to select the best and easiest ground upon which to place the line of road; whereas, by adhering to the Concession line, difficulties similar to those which have been met with on Yonge Street road, will have to be encountered—and a similar scene of expense and inefficiency will ensue.

The only reason which we have heard urged in favour of adhering to Concession lines is, that it saves the price of the ground for a new line. The cost of cutting one hill would amount to more than the full price of all the ground required for 20 miles of road, besides the saving in expense of animal strength.

We shall not proceed further with these illustrations of the importance of properly locating and laying out roads, and of the waste of money which is produced where this is improperly done, although instances might be adduced from almost every road hitherto made in the Province. In fact it is in the first laying out of a road, that the main objects are secured or lost. These are, cheapness of construction, and the capability of doing the greatest possible quantity of labour upon the road at the least possible expense of animal strength; and it cannot be disputed but that this important consideration in road-making, "The amount of animal strength required to draw a given weight upon various inclinations," has hitherto been entirely lost sight of in this Province.

The Act of last Parliament for consolidating the trusts in each District, apparently remedied some of the above errors. Many of its enactments are good, especially those in which provision is made for separating the duties of the deliberative from the executive department; but the benefits expected from it were in a great measure lost by continuing all the former Commissioners as Trustees under the Act, and even adding to their numbers. It was only in the Home District that it was put to the test; it did not work well, and matters went on much the same as before. In the matter of choosing an Engineer, it was proved that neither the choice nor the standing of the Engineer ought to rest implicitly with the Trustees, but that some test of qualification should be required, and that a negative should rest somewhere.

THE MEANS BY WHICH FAILURES MAY IN FUTURE BE PREVENTED.

Having already given what we consider to be the most prominent causes of failure in former attempts at road-making in this Province, it will be the more easy to point out certain means by which such failures may be guarded against in future. We have ascribed most of the evils to arise from the smallness of the road trusts,—the too great number and inefficiency of the Commissioners,—the want of a scientific, vigorous, and experienced Executive, or Engineer's department,—and the want of a proper separation between the duties of the Commissioners' or the deliberative department, and the Engineers' or executive department.

In order to remedy the first, it would be necessary to divide the country into trusts even larger than the present districts, or in fact as large as one Engineer's exertions could extend over, to lay out, construct and attend to the whole of the roads, exclusive of concession and township lines.

We may illustrate our position by a reference to what was Upper Canada. For instance, the Home District and the Lake Simcoe District, might form one trust. There might be two trusts formed out of those districts to the East of the

Home District; and two other trusts might be formed out of those districts to the West of the Home District. Thus, dividing the whole into five road trusts, any of these trusts could be subdivided when its duties became too much for the Engineer to attend to, or else the Engineer could be allowed one or more assistants.

Each of the trusts to be under the direction of a board of twelve or fifteen Trustees. The Trustees might either be appointed by the Governor and Council, or the trust might be divided into twelve or fifteen electoral districts, each one of these districts to choose a Trustee. The Trustees to remain in office three years, and to go out by rotation four or five in each year, but to be eligible to be chosen again. This form of election would give the people an interest in the management of the roads, and it would tend to ensure that the Trustees were connected with, and resided in all the different portions of the trust. It would also afford a guarantee that they would not, as a body, be influenced by local interests and prejudices.

The next important object would be to secure a scientific, laborious and experienced executive.

In order to secure unity of design, and a general superintendence, an Inspector of roads ought to be appointed by Government. His duty should be to lay out, or to inspect and report upon all lines of road for which grants of money are made by the legislature, and also occasionally to inspect the works in progress, and the manner in which the funds granted are being applied, and annually to report to Parliament upon these matters. He ought also to have a general superintendence of the Engineers on the several trusts. The person to be appointed to this office ought to possess high scientific acquirements, and much practical experience, to enable him to perform his important duties with advantage to the country, and to secure to himself that respect and influence with the Engineers of the several trusts, which will cause them to act cheerfully upon his suggestions. The office ought not to receive a political character, or it will excite the morbid sensibilities of the country, and cause even the most praiseworthy acts of the person filling it to be ascribed to political motives. The appointment to this office ought to be vested in the Governor and Council.

It is indispensable that an Engineer of scientific acquirements and practical experience be appointed for each trust, to act under the direction of the Trustees, in laying out new roads—directing the execution of the works upon them—attending to alterations and repairs—directing and examining all work done by contractors, and certifying that it is done according to contract before payment—directing and overseeing the superintendents and foremen upon the works, and in general taking charge of all works, and auditing and certifying all accounts for labour and materials before payment, &c. &c.

The appointment of an Engineer might be vested in the Trustees; but the Inspector of roads ought to examine into his acquirements and capabilities for the duties of the office, and to have a negative upon the appointment.

In order to prevent disputes about responsibility, all instructions from the Board of Trustees to the Engineer should be given in writing, and should be duly certified and recorded; and all reports from the Engineer to the Trustees also should be in writing, and should be recorded.

The Engineer ought to have the appointment of the superintendents and foremen who are to act under his directions. It will be necessary for him at first to bestow much care and attention upon training them for their respective duties; but when he has got a sufficient number trained, he will have more leisure for duties of a higher order, and will be able to extend his sphere of action.

The care of the funds forms an essential part of the Commissioners' duty; but if a Treasurer is chosen worthy of his office, and proper Collectors, the duty will be performed in a satisfactory manner, without much difficulty, yet the directing and duly superintending the Engineer's department, and the Treasurer's department, and examining and deciding upon various questions and cases as they occur, will render the situation of a road Trustee upon so large a trust no sinecure.

Such is a general outline of the machinery which we would propose to put into operation for the construction and management of roads in this Province. But we would close these remarks by observing, that although a knowledge of the principles of road-making may be conveyed by writing, the practice of road-making is subject to so many contingencies, that nothing but experience can produce any degree of perfection. Therefore, the degree of perfection to which a road can be brought will ever depend upon the talents, scientific knowledge, and practical experience of the person conducting the work.