earth or gravel on pretence of binding and never with stone or any special foundation. He persistently insisted that clear broken stone will combine by its own angles into a smooth, solid surface that cannot be affected by vicissitudes of weather or displaced by the action of frost. Macadam always contended that stones laid in this manner would, with the travel over them, become bound together so firmly and compactly as to become entirely impervious to water. This he contended was the whole secret of roadmaking, the great object being to keep the earth dry, the only use of the stones being to form a roof for this purpose. He contended that the ground was the road and must bear the weight of the stones as well as the vehicles passing over it, and held that nothing can make as good a road as dry earth, and that the thickness of the coating should only be regulated by the quantity of material necessary to form such impervious covering and never by reference to its own power of carrying weight; and he further contended that the wear of the road through travel over it is very much greater where the surface coating is underlaid with an unyielding substance, as on rock, than when on a slightly elastic foundation such as dry earth, and for this reason he always objected to a stone foundation of any kind and insisted that these tended to let in water to the earth below which was the destruction of the road. He always considered such a foundation to be a useless and unnecessary expense but experience has proven it to be positively injurious. For the same reason he never allowed any clay or other substance mixed with the stones, as he said it tended to make the coating more pervious to water.

TELFORD ROADS

These roads are made with a foundation of large stones covered with those finely broken, and are the most comon in this country. They differ from a road made of stone broken small and of uniform size in having the foundation first made in the shape of a roughly made pavement of stone six or eight inches in depth, this being first covered with stone coarsely broken and then with a coat broken quite small and afterwards covered with a coat of gravel or screenings from the crusher and the whole compacted with a heavy iron roller. It is the practice to mix some clay with broken stone in making this kind of a road to help combine the whole in a solid mass. When properly constructed they are the best for country districts. A Telford road is the least costly and lasts as well or better than any other. In this climate where frost if liable to penetrate very deep it is doubtful whether the covering that Macadam specifiies would be sufficient.

Where a depth of a foot or more of stone is necessary, if one-half of these may be of unbroken stone and of a cheaper quality—as is allowable in Telford roads—a considerable saving may be made in the cost, and it does look reasonable to suppose that a foundation of large stone if properly laid, will resist the tendency of heavily loaden vehicles to press them into the earth and form ruts on the surface. We can only reconsile the theory of Macadam, that a mixture of any kind of refuse with the stone is unneccessary, and positively hurtful, on the supposition that his experience was not with stone of the hardest and best quality. We consider it probable that in his experience, which consisted largely in lifting the stones from old roads and having them finally broken and properly replaced, that much of this material was of a kind that soon ground up with the traffic over them, and afforded material for consolidating the mass. Experience shows that when the material used is not of the best quality, it will consolidate more readily than that which is harder and better.

It may now be considered as settled that where the best quality of furnace slag is used, screening from this or some other substance must be added to consolidate them. And again, when we consider that the interstices in a body of loose broken stone comprise one half the bulk of the mass, and when pressed as solid as it may be, the open spaces comprise one fourth of the bulk of the mass. It is hard to conceive how this can be impervious to water, unless the crevices are filled with something.

Cost of Construction.

The side ditches should be, on an average, two and one-half feet deep, two feet wide across the bottom, and with side slopes of one foot horizontal to one foot vertical. This would be four and one-half cubic yards to the lineal foot. Twelve cents per cubic yard is a fair allowance for this class of excavation, making the cost $211.20 per mile for drains on both sides of the road. With the use of proper grading-machines, managed by two teams of horses and two men, at a cost of $8.50 per day, allowing forty rods for a day's work, would be $68 per mile. With the additional manual labor to fix the roadbed, make trenches, etc., say $125 per mile. In all cases the cost of draining and grading will be the same. Where the gravel can be obtained within five miles of the work, it will cost $3 per cord to team it, 50 cents per cord for the gravel and 25 cents per cord for spreading, making the total cost of the gravelling $3.75 per cord on the work. If gravel cannot be obtained within this distance, its use is not advisable. Flake stone for foundations can be secured at the quarry at 75 cents per cord; teaming the same at an average distance of five miles, $3 per cord; laying, 50 cents; making the total cost of the flake stone foundation $4.25 per cord. Crushed stone at the quarry costs $3 a cord The total cost will be $6 when procured within an average haul of five miles. If necessary to freight it fifty miles, $1.75 must be added to this estimate. Two teams and two men, taking the work in long stretches, would thoroughly roll one mile of road in a day. Allowing for this $10, the estimates for the different roads will, therefore, be as follows:

Earth roads:

Excavating 1,760 cubic feet in ditches, at 12c. per yard	$ 211 20
Grading, eight days, with machine, at $8.50	68 00
Labor on cross trenches, and finishing grade	60 00
Rolling	10 00
Commission expenses	25 00
	$ 374 20

Gravel roads (material obtained within five miles):

Draining	211 50
Grading	125 00
250 cords of gravel, at $3.75 a cord	937 50
Rolling	10 00
Commission expenses	50 00
Per mile	$ 1,334 00

Gravel roads, with flake stone foundation (material obtained within five miles):

Draining	211 20
Grading	125 00
250 cords of gravel and stone	1,000 00
Rolling	10 00
Commission expenses	50 00
Per mile	$ 1,396 20

For freighting stone where necessary, add to this, $281.25, making the cost $1,677.45 per mile.

Broken stone (material within five miles of the work):

Draining	211 20
Grading	125 00
200 cords of stone, at $6	1,200 00
Rolling	10 00
Commission expenses	50 00
Per mile	$ 1,596 20

For freighting, fifty miles, $350. Total, $1,946.20 per mile.

A crushed stone road would cost from $1,596.20, say $1,600, to $1,946.20, say $2,000 per mile, according to the length of haul. A safe estimate of average cost per mile of first class road is $1,800. This, at the present prices, with a limited demand, would be considerably reduced by the increased amount of work to be done.

Railway companies will certainly reduce the cost of carrying material, on account of the intimate relations between the railways and highways. So far as artificial roads are concerned, almost everything depends upon the facilities afforded by the railroads for hauling the required material at a moderate cost. Without this the making of first class roads would in general be expensive. There are many liberal-minded railroad officials who are far-sighted enough to see that the prosperity of their railroad is largely identified with the prosperity of the country contiguous thereto, and knowing that the common roads are the natural feeders of the railroads, are disposed to aid all they can in their improvement.

In constructing permanent roads it is necessary to avoid running into extremes, either in the amount of work to be done or the material to be employed. The convenience and relative value of the materials at hand for affecting the improvements should be considered. All culverts, bridges and abutments should be made as permanent as practical. The work of construction should be continued over a number of years, and the payments over a long term—say forty years. Those who come after us will reap the benefits of these good roads, and there is no injustice in asking them to pay part of the cost. There is ample skilled labor to perform the work, and the money can be raised in the manner stated. Every other enterprise in public improvements finds sufficient capital to put it through. It is freely admitted that there is no way in which money can be spent that would afford better returns to every part of the community.

To illustrate how these figures would apply to township municipalities, the following estimate of cost of improving 175 miles, being the road mileage at present maintained in the township of Yarmouth, in the county of Elgin, has been prepared by A. W. Campbell, city engineer of St. Thomas, and will form a basis for calculating the cost of the different kinds of roads in any municipality.

175 miles, at $1,800 per mile	$ 315,000 00
Equal annual payments, four per cent., thirty years	18,216 45
Maintenance, at $20 per mile	3,500 00
Total yearly payment	$ 21,716 45
Present maintenance, including statute labor at $1 per day	9,000 00
30 years actual extra rate	12,716 45
Total	$ 21,716 45

Total acreage in township, 70,000.

Assessed value, $2,700,000; per 100 acres, $3,850.

Estimated actual value, $4,000,000.

Extra rate required for annual payment, four and three-quarter mills.

Estimated increase in value of property, 10 per cent., $400,000.

In constructing 175 miles of stone road, 50 per cent., or $157,500, would be expended for labor that could be performed by the ratepayers. This would be equal to $225 per each 100 acres.

(To be continued.)