

## The Maintenance of Roads

When it is a question of comparing a number of different roads from the standpoint of economy, the most rational basis of comparison seems to be that of the "ton mile." It is well understood that this reference is to that part of the cost of the ton mile which belongs exclusively to the character of the roads. Now in the cost of the ton mile the following elements enter:

1st.—The interest of the capital employed in the construction of the road.

2nd.—The annual payments towards the redemption of this capital.

3rd.—The cost of improving the road.

4th.—The cost of maintenance of the permanent portion of the road.

5th.—The cost of maintaining the non-permanent part of the road.

6th.—The maximum grade of the hills. All these elements are necessarily related the one to the other. It is well understood, in fact, that in building a less costly road we can lessen the costs of interest and sinking fund, though at the expense of an increased cost of maintenance, while if an economy is realized by adopting higher grades for the hills the cost of vehicular traction will be proportionately increased.

The problem to solve is evidently to construct the road with the easiest grades possible, at the least possible outlay, and in so utilizing the expenditure that the cost of maintenance of both the permanent and non-permanent portions of the route should be reduced to a minimum.

As is well known, roads are in part permanent and in part non-permanent in character.

The permanent part comprises the earthwork, the culverts, the drainage, the under drainage, the protective works, and then the sub-base and the lower layer of the wearing course, properly so called.

The non-permanent part includes the top course of the road, that is to say, the wearing course itself.

The costs of maintenance should also be divided into two classes; those connected with the permanent part and those connected with the non-permanent part of the road. But attention must be directed to certain works which should not be included in those of maintenance. Such are those of amelioration or of protection which for one reason or another were omitted when the road was made, and which may have become necessary later; as for instance the replacing of old wooden bridges by others of metal or concrete; the protection of the body of the road alongside river, against erosion by means of rip-rap and the solidification of the side slopes of embankments and cuttings. With these works may also be classed the increasing of the thickness of the sub-base to meet heavier traffic conditions.

In certain cases and in certain localities the soil is dry at the time of construction and the foundation sufficient. Under some conditions it might happen that the action of subterranean waters becomes changed, moistening the ground and rendering it necessary to drain the sub-soil sometimes to increase the thickness of the sub-base.

All these works and others which it would take too long to enumerate, are of a permanent character, and should be considered as permanent improvements. They should not therefore be charged to "cost of maintenance" but to the account of "capital."

To better show the close connection between capital expenditure and costs of maintenance, a frequent illustration may be employed. Take the case of a low-lying road, subject to inundation. The original outlay may be increased by raising the roadbed several feet, for instance, in order to keep it above high water. The additional earth work will cost so much.

Coming to the question of the maintenance of the non-permanent part of the road we find things more complicated.

First of all it is necessary to understand what is the non-permanent part of the road. We may admit that generally speaking it is represented by the wearing course. In the case of asphalt roads there is no ambiguity in the term. It is the bituminous bed, which may be as much as four inches thick. All below it is the foundation. Neither is there ambiguity when the term is applied to brick, concrete or paved roads. It is not the same thing,

however, when we come to water-bound macadam. Here we may admit that the upper four inches are forming the top course, all below it will be considered as sub-base. When a macadam top course is worn out two inches for instance, the wear is not regular, depressions show themselves everywhere, and may sink down to a depth of four inches. It then becomes necessary to completely renew the top course by adding a new one.

The first macadams were composed of stones of a uniform size throughout their entire thickness. But the crushers now employed in the building of roads furnish stones of different sizes which have to be used. In utilizing them it is necessary to form the foundation of layers of stone of various sizes.

Only the lower course in contact with the soil, formed of the largest stones, and often unbroken, is generally considered as sub-base. The macadam properly so-called, which is placed above, is generally composed of two courses separately laid. However that which is in contact with the sub-base should also be considered as forming part of it, for it is rarely reached by the wheels of vehicles.

There are two methods of maintaining roads in good repair,—that by means of patrolmen who make patch-work repairs as they become necessary, and that of general recharging.

By the first method, the defects of wear are eliminated as soon as they make their appearance.

By the second method, the wearing course is left to the effects of wear and tear for a certain number of years and is then removed.

When the two methods are employed together the life of a wearing course may be prolonged, and the annuity consequently diminished, but at the same time the expenses of the patrolmen are increased.

It is often asked in what proportions the two methods should be employed. There does not yet appear to be any general reply to give to this question. Every thing depends on the nature of the wearing course, and the other circumstances of the case.

We find in Europe old macadamized roads dating back many years, in fact, to the middle of the last century, which have been maintained by the patrol system, and which are still as good as when they were constructed. Others have been maintained by the recharging method, with the same success.

Nevertheless it has been recognized in France that even when manual labor was cheap the patrol system was more costly than the other.

Since the epoch above referred to, the use of machines has been considerably extended. In certain States of the American Confederation the maintenance by patrolmen has been recommended, especially in the case of bituminous courses.

These wearing courses, which cost about \$6,000 a mile for a width of 166 feet, may last eight, ten, twelve, or more years, according to the quality of the bitumen, that of the stone, and the nature of the traffic.

Suppose that one of these wearing courses lasts ten years. The annuity required in this case will be about \$600 a year, if patrolmen are not employed. By employing them, the life of these wearing courses may be prolonged and the annuity consequently diminished, but at the same time it is necessary to add the cost of the patrolmen. It is easily understood that even in prolonging the life of such wearing courses by means of the "patrol system," it may possibly happen that the sum of the cost of the patrolmen and of the annuity reduced by the prolongation of the wearing course, may be higher than the simple annuity without patrolmen.

The pavements in granite and brick, and the roads in concrete are much more costly, but as they last longer they rather tend to reduce the maintenance annuity.

On the other hand, being more resistant, the works of the maintenance that they necessitate are much reduced, and the patrol system, which indefinitely prolongs their life and consequently reduces their annuity to nothing, apart from the interest, is applicable to them. Generally speaking, with these pavements, the sum of the annuities and of the cost of the patrolmen is less than with other and more inexpensive pavements.