WEARING SURFACES.*

By Geo. W. Tillson,
Consulting Engineer, Borough of Brooklyn, New York City.

THE question of improved roads first became important when the transportation of commodities and passengers by wheeled vehicles came into vogue. This was in comparatively recent times, as the world's history goes, for as late as one hundred years after the reign of Queen Elizabeth regular pack trains for the transportation of goods were operated in England, and even at that time wheeled vehicles for passengers were very little used. Writers tell us that in the seventeenth century the nobles, in travelling from their homes to London in private carriages, were often robbed by highwaymen, so frequently indeed that a highwayman, when convicted, was punished with death. It is also stated that the bad condition of the roads aided the highwaymen very materially in making their hold-ups.

Ever since that time there has been much discussion regarding road construction, but it was not until 1764, when M. Tresaguet, in France, began to build broken stone roads of somewhat the same character as are now well known in America by the name of macadam, that much improvement was noted; and it was about sixty years after this that systematic road building was begun in England, under the direction of Telford and Macadam, from which latter name has come the term in general use for macadam broken stone roads.

It would seem, too, that road construction in those days received more attention than pavement construction in cities, as it is stated that an English engineer in 1826 publicly remarked that "however true it may be that an observant traveller cannot fail of being struck with admiration at the excellence of the turnpikes and other roads throughout this country, he must at the same time be very much surprised at the badness of the carriage pavements, even of the principal streets of the metropolis."

The importance of road building in this country has been known for many years, but it did not receive much attention until about 1895, when the advent of the bicycle and its great popularity for a time made necessary the construction of improved roads if the bicycle were to be used to its best advantage.

When the use of the bicycle began to wane, the development of the automobile caused the subject to be taken up anew, and with increased vigor. The people using the automobile were much more influential and wealthy than those using the bicycle, and the result has been that a wonderful good roads movement has been extended all over the country. It has grown to such an extent that in the state of New York alone during the past six or eight years issues of bonds to the amount of $100,000,000 have been authorized, and the greater part of this amount has been spent to date.

J. C. Pennybacker, chief of road economics, U.S. Office of Public Roads, recently stated that 16,000 miles of surfaced roads were constructed in the United States during 1913, and 18,000 miles during 1914, or a total of 34,000 miles in the brief period of two years. He estimated that the total outlay for 1914 for good roads was $225,000,000, while in 1904 the total expenditure in all states slightly exceeded $79,000,000. This $225,000,000 represents an expenditure of $2.25 per capita for the entire United States, being about $20,000,000 for New York State alone for one year.

These figures are enormous, and one has to wonder if the work can be kept up, and also if, with this enormous amount of road building, sufficient provision, both in organization and in money, will be provided for proper maintenance.

Earth Roads.—The cheapest form of road, of course, is the ordinary graded road, without any attempt to surface with any foreign material. Although this cannot be considered an improved road, still with proper attention to it, results can be obtained that seem remarkable when compared with an earth road that receives no care at all. By the use of road drags and a little attention during bad weather, earth roads can be kept in fairly good condition for ordinary traffic.

Sand-Clay Roads.—These roads are made either by the application of clay to the ordinary sand surface or the application of sand to a clay surface, according to the original condition of the road to be improved. In proportioning sand and clay in this method of construction it must be understood that the clay acts practically as does cement in cement mortar, and consequently an amount of clay sufficient to fill the voids only should be used. This is more important than in the case of mortar, because if too large an amount of clay is used it will allow the particles of sand to move too freely, while if the amount is too small the particles of sand will not be bound together.

It must be understood, too, in this general treatment, that the quantity of sand to be used depends upon the character of both the sand and clay, a clean, sharp sand requiring more clay than one which has a certain amount of loam, and, too, the quality of the clay is an important factor, whether it is pure or whether it has an admixture of sand.

When a clay road is to be treated, the surface should be brought approximately to the form that is desired and loosened up, when the sand should be spread over the surface in sufficient quantities and thoroughly mixed. The surface should then be smoothed off and compacted with a light roller or road drag.

When the original soil is sand, the road is levelled off and the clay spread upon it to the required width and thoroughly mixed with the sand, when the roadbed is shaped up, and, if necessary, more sand applied. The surface is then smoothed and compacted as for the clay subsoil.

Gravel Roads.—Very satisfactory and fairly durable roads can be made with gravel, the exact method of construction depending upon the quality of the gravel itself. But in the main, it is spread over the road to such a depth as to give proper thickness when completed and then rolled until it becomes hard and firm. Whether it will require any filling or binding in order to make the surface hard and compact depends upon the quality of the gravel. It can be said, however, that the softer the gravel, the more easily it will be compacted, but, for the same reason, it is less durable under traffic. These roads are often used in parks, and even on state roads where the traffic is light and where a permanent material is expensive. It is difficult to give an estimate of their cost, as this depends entirely upon the distances the gravel must be brought, and its first cost. An estimate of 50 or 60 cents per square yard would probably be not far from correct for a gravel road 6 inches deep.

Water-bound Macadam.—This is the well-known broken stone road surface, which is made up of different layers of broken stone, the surface layer being about 3 inches thick and formed of stone that will pass through

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