

fore, necessary that this covering should be protected from accidents caused by the lack of resistance of the substructure without its being necessary to proceed before laying said covering with preliminary works of consolidation which should have been made at the time of the first improvement of the earth road or at the time of the placing of the gravel.

Yet a covering of gravel placed on a solid substructure costs very much less for maintenance than another covering on a damp and badly prepared ground.

Laying the Gravel Covering.—There are two principal ways of laying the gravel:—

(1) Covering the entire width of the road between the ditches with one layer. Then it is given a fixed thickness in the centre, which gradually diminishes towards the sides, where it is reduced to one or two inches.

(2) Spreading a layer of gravel over the centre of the road for a determined width (ten, twelve or sixteen feet, for example, according to the importance of the road), with earthen shoulders three to four feet wide at each side to keep the gravel in place. In this case the thickness of the layer is uniform over all its width, or only slightly deeper in the middle, and the roadbed may be crowned from a half to three-quarters of an inch per foot.

In this second method a slight layer of gravel may also extend over the shoulders, allowing it to spread as far as the ditches. This gives the road a better appearance, makes the shoulders more practicable for vehicles and prevents the growth of weeds, facilitating also the maintenance of the roads, and also the surface drainage of rains from the centre of the road towards the ditches. In the first method it is also a good thing to give a slight crown to the substructure before placing the gravel.

For heavy traffic the system with trenches is best.

The system without trenches, which is not quite so costly, is generally employed for light traffic.

The average thickness of the layer of gravel depends upon the resistance of the soil and upon the importance of the traffic.

A good gravel on good, solid ground may be reduced to an average thickness of four or five inches, measured after settlement. In the case of grounds with less power of resistance, the gravel may be as thick as twelve inches or more. The spreading of the gravel on the road may be done by first dumping it in heaps close together, which may then be spread with shovels, rakes or a horse-scraper.

Pebbles exceeding two inches in size are carefully raked ahead of the gravel, so that they will be spread on the bottom of the trench and be overlaid by the gravel in such a manner that when the road is completed none will be found within three inches of the surface. Roads so gravelled may be rolled with a steam or horse-roller if it can be easily procured. The rolling accelerates the settling of the road, and it consolidates more quickly under the influence of traffic.

An energetic harrowing of the layer of gravel before rolling acts in the same manner and is to be recommended.

When gravel is very sandy it may be laid in two layers by interlacing between the two a third layer of half an inch to an inch of clay, marl or earth. The whole is carefully harrowed and then rolled.

The dry rolling of a bed of gravel is generally difficult, especially if the roller is heavy. If water can be had it is preferable to sprinkle the layer of gravel before rolling.

When the road has been completely crowned it should have a crown of an inch to an inch and a half per foot. If the crowning is left to traffic it is necessary to give a little more crowning when laying the gravel, two inches per foot, for instance, because vehicles have the tendency to push gravel towards the sides. If a gravel road is not rolled at once it will take a season or two to completely settle and harden, and sometimes more, according to the quality of the gravel and of the soil and the nature of the traffic. During this time it is frequently necessary to employ the split-log drag to fill in the ruts, to level the surface and to re-establish the crown until the road is completely consolidated.

Gravelling on Stone Foundation.—When stone of good quality and of moderate size, say, 4-in. to 6-in., is plentiful in the fields, and when it is difficult to advantageously procure good gravel, a foundation of stone may be interlaced between the bed of gravel and the prepared surface of the road. When the traffic is light and moderate this system gives good results, and will prove a good foundation for future macadam. It is economical and permits municipalities to await the development of traffic before going to the expense of water-bound macadam or of other more costly top courses, while enjoying meanwhile the advantages of a good gravel road.

Qualities of Gravel.—The gravel to be employed should not contain too large a proportion of sand; 20 per cent. to 25 per cent. is sufficient. Sand is here understood to be that part of the gravel which will pass through a screen of a quarter-inch mesh. It should not be too earthy. The little pebbles of which it is composed should be hard and of good quality.

Certain gravels contain too large a proportion of sand or earth. In this case it is necessary to resort to screening, not leaving any more sand or earth than can be avoided, or else to employ a much heavier layer of the gravel than usual.

In this last case the rain transforms the sand and earth into mud, which may be got rid of by the frequent use of the split-log drag and through the drying up of the mud into dust, which is gradually scattered by the wind or scraped or swept from the road. At the end of one or two seasons there remains upon the surface of the road a layer of small, hard and well-cemented pebbles.

Some gravels contain a certain proportion of very soft pebbles, which crush under the wheels of vehicles. When the proportion of them is large the result is the same as in the two preceding cases. Between these extremes occur all the intermediaries. All gravel which contains soft pebbles should be completely rejected. It is not worth its transportation, even for short distances.

Certain gravels bind with difficulty; others easily. Quartz gravel from the beds of rivers belongs to the first category. However, some silicious gravels coming from banks outside of watercourses bind well with time, notwithstanding their freedom from earthy matter. The same thing naturally applies to those containing a certain proportion of such matter.

Some river gravel and some unwashed sandy gravel, which contain a proportion of soft pebbles, often bind very well. These soft pebbles, crushing under the wheels of vehicles, help to cement the union.

When a hard gravel does not bind well, a certain portion of clay or marl or limestone dust may be employed by incorporating it with the layer by the use of the harrow or by other economical means. This use of clay or earthy matters with the gravel has been severely