

vehicles, but the road covering as well.

(2.) The surface covering of broken stone or gravel, which resists wear, and distributes the concentrated wheel load over a greater area of sub-soil.

If one of these is of more importance than the other it is the former—the natural or sub-soil—and it is the one, the proper treatment of which is most frequently neglected. The right way to make a good gravel or broken stone road is to first make of the natural soil, on which the gravel or stone is to be laid, the best earth road that the soil is capable of producing. This is a matter of drainage and grading, and if possible, rolling. The grading and drainage are largely the same thing, and have to be considered together. That is, the grading should be such as to give good surface drainage.

The first step that naturally presents itself in opening an entirely new road, is to throw up in the center of the road allowance, a smooth and level wagon track. This work is most cheaply and effectively done with a grading machine. In throwing up this grade, the excavation of earth at the sides forms the open drains.

The completed earth grade should, for the average country road, have:

(1.) A circular rise or camber of about two inches to the foot from the bottom of the side drains to the center of the road. This "crown" will carry water from the roadway to the side drains.

(2.) A slope following the axis of the road such that the open drains at the side will have a constant fall to a free outlet. That is, the side drains should carry water away—not hold it in pockets and depressions. Drains which hold water instead of carrying

it away are as useless in draining roads, as they would be in draining farm land.

Almost any soil, when kept dry, is strong enough to support the traffic of loaded vehicles. Good drainage is the only means of keeping the soil of a road dry, and consequently strong. If the open drains are not sufficient, then deep tile drainage can be adopted.

The effect of deep drainage is that whereas the raised grade and the open drains beside it may keep the natural soil dry for a foot or so in depth, the tile will greatly increase this thickness of dry soil, which will give proportionate strength of foundation.

The round shape of the roadway is particularly important. It sheds water quickly to the side drains. Whereas if flat or hollow in the center, the rain falling on the road does not run off, but is held on the surface to soften it and turn it into mud.

The soils found in the sub-grades may be described in three general classes: (1) clay; (2) sand or gravel; (3) sandy loam.

Clay.

(1.) Clay, as found in the sub-grade, is variable in quality. It may be a pure blue clay, or it may have sand mixed with it in different proportions. With blue clay, the ground water must be removed as far as possible if stable results are to be secured. In addition to the open surface drains, one or two deep tile drains should be laid along the roadside underneath the open drains, and leading to free outlets. It is customary to place one tile drain on an up-hill side, and one on each side in a cut or on a level grade.

If the clay contains a considerable proportion of coarse sand, it drains more freely than does pure blue clay, and one tile drain along the roadway