

constructing roads in rural districts open ditches should be cut on each side of the road bed continuously at a distance of about twelve feet from the sides of the metaling. They should be of a size and declivity to readily conduct all water that will flow on the road or reach it from adjoining lands. They should be of sufficient depth to provide for the drainage of the foundation, at least eighteen inches below the subgrade. The strips of ground between the road and the open ditch should be properly graded to conform with the crown and grade of the metting, and should be seeded and as much as possible kept in sod. This serves on a country road the same purpose as a curbing on city streets. It will always be clean, pleasing to the eye, and very largely assists in preventing mud being carried on the road metting. Besides this, uniformity in the crown will always permit of teams passing each other. In wet seasons our roads are nearly impassible, because there is no system of drainage and no outlets for water, and usually the centre of the road is the lowest part of it. The ditches being used for the drainage of surrounding fields. In many sections of the country the ditches are choked, and are not in a condition to do the work expected of them. A drain or two of tile under the road bed would help materially in keeping the roadway dry. Without water there can be no mud.

The location of subdrains when required must be governed by the nature of the soil. When this is gravelly and pervious to water the open ditches on each side of the road, even if sixty six feet wide, are sufficient for draining the road bed; if there be any springs under the road, especially if they rise under an impervious soil, a subdrain leading directly to the side ditches will be required. Should the road be on a side hill a deep open ditch on its upper side may be sufficient. In such a case the surface water from the water table on the lower side of the road should be conducted across and under the road by an ordinary dry stone culvert.

Whenever water with or without frost is liable to render the foundation of the road insecure, provision must be made against it. There are perennial springs that anyone can see, and basins of rock, hardpan or clay, which become springs in wet weather. These are very apt to cause trouble when cuts have been made. The chances are too numerous for specification. Simple land drainage will improve lines of highways in frosty regions. Three inches of sand along the line of a wet meadow, underdrained, furnishes a dry foot path, and when it is overgrown with grass, thatch roofed as it were, frost never softens that sand, and we see illustrated the effect of solid stone floor roofing upon a ridge of drained clay highway.

In St. Thomas the engineer constructed one short street with flake stone foundation and gravel covering; and being anxious to keep the cost as low as possible, it was thought unnecessary to go to the expense of draining the foundation.

This piece of road was a valuable lesson. When all the other streets are hard and dry this is wet and spongy. During construction it was so dry that it would have apparently been a waste of money to drain it. During the wet season the wheels rut readily, while there is scarcely an impression on those that are drained. More labor and money has already been expended on this road which was constructed three years ago than would have been necessary to completely drain it in the beginning. This one example has clearly shown the great importance of perfect draining. Mistakes are often made in not carrying ditches to a proper outlet in the natural watercourses leading from the road into private property. Under the Ditches and Watercourses Act the municipality has the same power as a private individual, when the various owners fail to agree upon the construction of a drain. But municipalities, rather than force an outlet through private lands, end their drainage with imperfect outlets, and damage the road rather

than improve it. The authorities should not care who the owner of the adjoining property is, proceedings should be taken to enforce these outlets, and the owners should be obliged in every instance to pay their just proportion of the cost of such work.

Many a municipality has been prejudiced against road improvement owing to the bad work of contractors or the results of ignorance on the part of its own officials. A municipality may have been enterprising enough to decide to improve some of its roads, and the people may have been generous enough (sensible enough would be better) to have furnished the money, and the money may have been expended. Yet after the lapse of a few years the roads are as bad as ever. It may have been proved that to have maintained these highways in a state of excellence would have cost far more money than the people had to spend on the investment. This has been the experience of a great many municipalities, and the conviction held in these is that macadamized roads are a delusion, and has done much to retard the progress of the movement for the improvement of country roads. The real fault lies in the fact that it was imperfectly drained. Those who have not have much experience are not apt to realize the paramount necessity of maintaining a perfectly dry foundation of earth for their surface of broken stone to lie on. A protracted rain will soften it, and when a heavy load passes over it injurious ruts are sure to be the result. In latitudes where the frost penetrates deep, water in the soil will freeze, and its consequent contractions and expansions result only in the ruin of the road. In order to ensure a permanent road the dirt bed on which the broken stone is to be placed must be thoroughly drained, and after that the mass of stone which forms the surface of the road must be so consolidated and packed that it is practically water-tight. If these important matters are attended to the road will be durable and easily maintained.

All authorities agree that two rules must be followed in order to maintain good roads. First, take the water out; second, keep the water out.

Grading and Constructing of Roadways.

It is a mistake to suppose that narrow roads are the cheapest. Of course when constructing a new road the cost is in proportion to its width but a narrow road is always the more expensive to maintain, owing to the vehicles being compelled to keep more or less to one track, nothing is more destructive. The traffic on a wide road is always more evenly distributed, provided of course, that it is constructed on scientific principles and kept in good repair. There is another very important advantage that wide roads have i.e. They obtain a greater amount of light and air. It will always be found that a wide and open road will be dry, long before a narrow and confined one. When roads, especially mainroads, are laid out, care should be taken to secure plenty of land. The widening of an old road is always a most expensive work, and it is sometimes necessary to destroy trees and remove buildings. The cross section of a road is very important, and a question concerning which there is great difference of opinion. It should neither be too flat or too rounded. In the former case the surface water remains on the road instead of draining off into the side ditches whereas in the latter, owing to its great convexity vehicles can only travel with comfort or indeed with safety in the centre of the road, thereby soon making three tracks there, and, as before remarked, nothing destroys a road sooner. There is another disadvantage, that as soon as the traffic is driven off the centre of the road, a double wear takes place, owing to the tendency of vehicles to slide down the inclined plane by force of gravity and as this tendency is perpendicular to the line of draught, the labor of the horse and

the wear and tear of both wheels and road surface is much increased. The sole object in rounding the surface is to allow the water to run off freely, and it is now agreed that a slope of one or two inches to six feet width, according to the nature of road covering, is sufficient for all roads constructed of good hard material, provided, of course they are kept in good repair. MacAdam says; "I consider a road should be as flat as possible with regard to allowing the water to run off it at all, because a carriage ought to stand upright in travelling as much as possible. I have generally made roads three inches higher in the centre than I have at the sides when they are eighteen feet wide; if the road be smooth and well made, the water will run off very easily with such slope." The drainage of surface water is better obtained by selecting a course of the road that is not horizontally level because then the slightest wheel track becomes a channel to carry off the water, whereas in the case of a level road, it must be apparent to every one that no matter how rounded the surface may be, every track soon becomes a basin to hold it. The road bed should be excavated to the same contour as the finished road is to be, not with any idea of drainage because it must be remembered that as soon as the road becomes subject to rolling or the pressure of heavy vehicles, the road material becomes forced down into the road bed, and the soil in its turn worked up into the covering so that the whole becomes amalgamated, but because by so forming the road bed there will be an equal thickness of material over the whole surface, and if a road is made and maintained according to scientific principles, there is no reason why any one part should have a greater thickness than another. The great consideration in road making is to so construct the road surface that no moisture shall penetrate the foundation, and in this way prevent the formation of mud which would work up into the stone. To insure this there must be a compact and solid foundation. A road must be perfectly smooth both before and after a vehicle has passed over it, but if it sinks in the least this yielding presents a miniature hill up which the vehicle must be raised with loss of power. If the depression were one inch and the wheel four feet in diameter, an inclined plane of one in seven would be formed, and one seventh of the entire weight would need to be lifted up this inch. A road surface of india rubber of the most perfect smoothness, would therefore be the worst possible for traction, though very pleasant for passengers. The wheels would always be in depressions, and the horses would always be pulling up hill. An elastic bottom for a road such as a boggy substratum would, for this reason, cause great waste of draught. A solid, unyielding foundation is therefore one of the first requisites. A road made of broken stone laid on the earth without any foundation is defective. It will always be loose and open, and never consolidate into a compact mass. In winter, the water penetrates, is frozen and breaks up the road. After a thaw and in wet weather the road is a quagmire. At the best after a rain, the semi-fluid soil will rise up to the service and form a coat of mud, and after a drought the looseness of the stones will make them rub off their angles and soon wear out. Nor will any thickness of stone destroy the elasticity of the soil. The central part of the road may be macadamised for a width of only eight feet, which is about the least width that a vehicle can be readily driven on. In such a case it would not be advisable to make the entire roadway less than twenty feet wide, so that vehicles may pass on each side of the central portion, and that the macadamised part may be easily widened in the future.

To provide for constant traffic in both directions, the macadamised portion of the roadway should be sixteen feet wide, as the axles of wagons and buggies are usually five feet eight inches in length, or five feet two inches from one wheel to the further end of the axle. This allows a space of two feet from the further