remember that water upon the surface of the road cannot be carried away by the underdrains, since the water can reach them only after it has penetrated the road surface. The slope from the centre to the side ditch should be sufficient and the surface kept free from ruts.

Unless the excavations on the sides of the road have a sufficient and continual fall to outlets, they are not drains but merely elongated ponds. In this way mud is formed underneath the roadway and the surface. See that the water flows away, not soaks away.

Underdrainage.—The deep, unsightly, and in many cases useless, open drains at present in use on the public highways throughout the province, should be disposed of without delay, because they are entailing an enormous liability against the municipalities, not to speak of an existing menace to the travelling public. No farmer, however short-sighted, would think or attempt to drain his farm with open drains. The result of these open drains throughout the country is that at least 50 per cent. of our roads are receptacles or trench channels established to carry off the water from the adjoining farms.

Since the adoption of county roads in Ontario, miles of drains have been tiled. In every case results have been obtained infinitely superior to that of an equal expenditure on surface material. Side ditches are necessary to dispose of the water.

The size of tile required for any particular situation will depend on the length of the drain, the fall and the amount of water to be carried away. If smaller than 4-inch tile are used they are liable to become blocked by slight depressions and irregularity in laying.

The tile should be laid at the side of the road at a depth of 2½ to 3 feet. On hills the tile should be placed under the shoulders where the trench will not be washed out.

Soils.—It is of advantage to understand the manner in which underdrains act in different cases. With porous soils, in which the water rises under hydrostatic pressure, the water enters the tile from below. Just as the water rising in a vessel finds an outlet in the sides or flows over the top, so the underdrains supply the necessary outlet and lower the "water line."

With clay the process is different. Absorbing and holding as it does, like a sponge, a large quantity of water, drains are less effective but none the less necessary. Cracks and fissures which appear throughout the surface of a baked soil during the summer drought afford a clue to the action of underdrains upon the soil. As the clay yields up its moisture, it shrinks, and is torn apart. The fissures commencing at the drain spread in different directions and each fissure thus becomes a new drain leading to the tile. This keeps on year by year and these fissures become filled with sand, vegetable and porous material until they assume a degree of permanency and in clay soils thus underdrainage is more effective after several years than at first.

As a rule, a tile drain, laid in close clay soil, will drain six times its depth on each side. In porous soils they give good results for much more than this at times up to 15 or even 20 times the depth. With the exception of a stiff clay, a line of tile laid on one side of the road at a suitable depth will do almost as well for the roads as tiling both sides will do. The only road that will not be improved by the most perfect system of drainage that can be given it, is a road of pure sand.

Outlets and Catchbasins.—An unprotected outlet of a tile drain is very apt to be broken and obstructed by horses and cattle stepping on the tile. If the outlet is into an open ditch, or natural creek, the end of the tile should be protected by a small concrete abutment, or if the tiles are near the surface, as they often are, a very good method is to lay the tile in concrete and cover them over with, say, four inches of the same material, thus making a continuous concrete pipe of such length as the circumstances seem to require. If the outlet is to be in another covered drain, the junction should be made in a suitable catchbasin. Catchbasins are of great advantage to drain, if built in a permanent and suitable way. The best and therefore the cheapest is the one built in place, and of concrete, and should be about 16 in. x 3 ft. inside and have a concrete bottom and top, the latter to be fitted with a removable cast iron grating of sufficient weight to insure its remaining in proper place.

Some of the advantages of catchbasins are:—

(1) They admit surface water into the drain readily and insure the drain working to its full capacity even when the ground may be frozen.

(2) They are useful as inspection holes and enable one to ascertain if all parts of the drain are in working order.

(3) The pit in the bottom serves as a trap to catch all sediment that may get into the drain and

(4) They serve as a vent to let the air escape from the drain and enable it to run at its full capacity, which obviously a drain sealed at both ends will not do.

Good drainage is the basis of good roads. While road improvement in almost any form will yield big returns, it is safe to say that for the amount expended, with the one exception perhaps of the road drag, the largest dividends from any expenditure in highway improvement will come from an outlay on the perfecting of the drainage.

THE GEOLOGY OF ROAD BUILDING MATERIALS. By G. C. Parker, B.A.Sc., assistant engineer, Ontario Office of Public Highways.

In the opening paragraphs of his paper the author reviewed the causes of road wear and deterioration, and pointed out the necessity of a more intelligent selection of materials in view of the increasing severity of requirements imposed upon roads. The effects of horse-drawn and of motor traffic were outlined as under various climatic conditions, and their destructive influences analyzed.

There followed a detailed reference to the geological features of Ontario rocks and gravels suitable for road making. The varieties, three in number, *viz.*, igneous, sedimentary and metamorphic, were described as to formation, structure, color, etc. The traps, granites and felsites of the igneous rocks; the limestones, dolomites, conglomorates, sand stones and shales of the sedimentary series; and the limestone, gneiss, schist, quartzite, and slate of the lesser important metamorphic series were all described.

The suitability of rocks for road surfaces was then dealt with, the paper, in part, being as follows:

For the top course of the waterbound macadam road traps and felsites are the most suitable, particularly where traffic is heavy enough to supply sufficient binding material. They are tough and hard and the wedgelike particles into which they break assists in the compacting of the road. The natural binder from these rocks makes a strong bond with the pieces of the stone.