

stone, as a thinner covering of fine (and more expensive) material is required. Where flake stones are used in this way, perfect under-drainage is desirable; otherwise the larger material is heaved by frost, and the finer metal gradually works downward, the large stones coming to the surface. Instead of laying the stone flat, they may be placed on edge, the largest at the centre of the road, the top angles being chipped off and wedged into the voids between the stone. This last method is known as a "Telford" foundation, and is to be recommended for weak sub-soils, or where drainage is difficult.

Instead of a base of large stone, there may be spread a foundation layer of gravel, on which to spread the broken stone. This method is useful where gravel of an inferior quality is plentiful. The gravel makes a stronger foundation than does the natural earth, while the crushed stone makes a more durable wearing surface.

Good results may be had in some cases by using large flake stone for a base and placing gravel on top. This process is useful principally where the earth foundation is very weak, and a gravel of first-class quality can be obtained within reasonable haul.

A common method consists of using pit-gravel in the ordinary manner, without stone. Unless of very exceptional quality, gravel roads are not so lasting as broken stone, particularly for heavy or constant traffic—but it is a question of traffic as well as metal. As a rule, broken stone should be used near large towns. This provides for heavy traffic, with a short wagon-haul if the stone has to be brought in by rail.

A profitable method of using gravel is to pass it through a crusher and screen out the excess of sand and earthy material. Use the screenings as a base, and place the stone on top for a wearing surface. By using a well-equipped plant, and loading wagons from a bin, the saving in cost of loading may be made to pay the cost of crushing and screening, particularly for short hauls from the pit.

In the choice of stone there is room for much variation in the quality of the road. After gravel, the most commonly used material in Ontario is limestone. In this there is much difference in quality, even in the same quarry. Limestone while softer than most other rocks, gets its value largely by the power of its dust and screenings to cement and re-cement, making an exceptionally waterproof covering, and so bonding as to distribute the concentrated wheel load. The most durable class of road metal is trap rock, but unfortunately there is little available. Granite and gneiss are used with considerable success. Sandstone is very inferior, as it grinds readily into dust, and has little cementing value. Granite and gneiss have not good cementing value, but are harder and more resistant to wear.

The strength and durability of a road is dependent largely upon the binding material used, as developed by thorough sprinkling, and the use of a steam roller. When rolling a road the roller should be preceded by a sprinkler, and the stone kept well saturated. Limestone screenings are most valuable as a binding material, but some limestones have a much stronger cementing value than others. Crystalline limestones are in some cases of little more value in this respect than sandstones. Sand is a very inferior binder. Road metal should be clean, for clay and loam are weak binders. Crushed gravel, bonded with limestone screenings, makes a surface much superior to gravel only.

The width of roads is an important detail in surface treatment. Throughout Ontario all varieties of ideas prevail in this regard. We find the roads graded almost from fence to fence, the full width of the road allowance. In

other cases the opposite degree is sought. From study of road conditions in Ontario I am convinced that the width of a road from ditch to ditch should be no greater than traffic demands. The width of road metal should be such that there will not be an earth track at the side. Wide grades are very desirable when kept in good repair, nor are they much more expensive to construct than narrow roads. But they are vastly more difficult and expensive to keep in repair. The choice, except under special conditions, will be between a narrow road that is good and a wide road that is bad. Few municipalities in Ontario, or indeed in any part of the world, will be found so wealthy that they can afford to maintain an unnecessary width of road. When a strip of macadam is flanked by wide, flat clay shoulders, the early destruction of the macadam is certain. Standard European practice is 18 or 20 feet between gutters, and while many roads are wider, others are narrower. This is a point of economy which, for the sake of good roads at least, municipalities in Ontario could well copy. As traffic increases, widen the metal rather than the grade.

The camber or crown of a road gives much play for difference of opinion. A high crown is not desirable so far as traffic is concerned. A new road, however, should first be turnpiked and crowned too high, otherwise it will soon get too flat. A road just right when first constructed will be water-logged at the end of a couple of years. All forces of gravity and traffic are at work to bear down on the camber and grade, the flattening tendency is constant. Under ordinary circumstances in Ontario a crown of one inch to the foot for the stone covering, and two inches to the foot for earth shoulders, is not too great. In the case of town streets, if constant attention is given to repair and the roads are macadamized from curb to curb, this can be reduced; but in the country, narrow roads, sharply crowned, are the roads which return most for the expenditure on them.

The coming of the automobile has drawn attention to the exceedingly dusty condition of roads in summer. The extended use of these machines requires that there be some palliative, both for the property owners along the roads and for the maintenance of the roads themselves. While light motor vehicles travelling at a moderate speed will not seriously injure the roads, the dust removed by heavy touring cars travelling at a high speed removes the binding material, and the stone unravels. A large amount of experiment has been carried on with a view to finding a remedy. Many materials, patented and otherwise, have been brought to public notice. Their careers are usually ephemeral. Tar and tar products are the only materials that have been used with marked success in England, France or the United States. A thoroughly servicable and cheap system has not been developed. The majority of methods are either too expensive for the ordinary use in Ontario, or they are unsuited to our conditions of climate.

This is one of the fields in which there is room for invention in road construction. At the International Road Convention in Paris during October of last year, all departments of road construction received careful and scientific attention. In the conclusions of that convention, however, it has not been shown that any marked advance has in recent years been made in methods of construction. The field is still an open one, and there is much to be hoped for in achieving a type of construction that is at once serviceable, durable and economical.

QUEBEC.—Survey parties have been organized by Mr. A. R. Decary, district engineer of the Department of Public Works, in connection with the preparation of a report on the possibilities of improving the harbour facilities at Quebec.