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Massachusetts Roads.

In connection with the cost of road construction the reports of the Massachusetts Highway Commission are frequently quoted, and the effect is apt to be discouraging. There are several reasons why the average cost of roads in Massachusetts is very great, and are therefore not applicable to Ontario. In its effort to accomplish the greatest good, the commission has undertaken to build the most difficult sections. In carrying out this policy it has been necessary to reduce heavy grades; to widen narrow roadways; to fill low places where they were overflowed by flood waters, or which were likely to fail in foundation on account of the nearness of ground water to surfacing; to build culverts for the quick removal of storm water; to place side drains for the removal of ground water; and to do many other things which increased the cost of building, but which would not appear on the finished road to the most careful observer.

It will thus appear that there are two distinct kinds of work in a first-class road: First, the surfacing; and second, the preparation for the surfacing and the placing of safeguards for its future protection. On some of the roads built under the direction of the commission the surfacing has not constituted a quarter of the cost, and in the hill or clay districts it is rarely the case that the surfacing has equalled one-half the entire cost.

As the work progresses, it should be done at a lower average cost, and a study of the tables in early reports of the commission will show that this is precisely what has taken place. While a reduction in the cost of Massachusetts State roads has been and still is possible, it is not to be expected that it will be as low as in other States. The length of a working day in Massachusetts is by legislative act nine hours, or eleven per cent. shorter than in New Jersey, while the price of labor and teams is twenty per cent. higher; and the total cost is nearly one-third greater from these causes alone.

The methods employed by the commission, in any event, aim at a very perfect type of road. Careful studies are made by the engineering force of soils, drainage problems, gravel, stone, grades and traffic, and the type of road to be built is based upon the results of these studies. With the exception of peat, muck and vegetable loam, all soils in this latitude make good support for roads during a greater part of the year. Sand, gravel and porous soils give no trouble at any time; while clay, sandy loam and all non-porous soils are much weakened by frost action, and in their natural condition afford poor support in the spring months. They can, however, be greatly improved by removing from them the ground water, which in a measure may be done by means of side drains.

The commission has estimated that non-porous soils, drained of ground water, at their worst, will support a load of about four pounds per square inch; and, having in mind these figures, the thickness of the broken stone, the downward pressure takes a line at an angle of forty-five degrees from the horizontal, and is distributed over an area equal to the square of twice the depth of the broken stone. If a division of the load, in pounds, at any one point, by the square of twice the depth of the stone, gives a quotient of four or less, then will the road foundation be safe at all seasons of the year. On sand or gravel the pressure may safely be placed at twenty pounds per square inch.

Acting on this theory, the thickness of stone on State roads varies from 4 to 16 inches, the lesser thickness being placed over good gravel or sand, the greater over heavy clay, and varying thicknesses on other soils. In cases where the surfacing exceeds six inches in depth, the excess may be broken stone, stony gravel or ledge stone, the material used depending entirely upon the cost, either being equally effective.

All broken stone used is separated into three sizes by passing it through a screen with meshes half-inch, one and a-half inches and 2½ inches in diameter. The largest size is placed at the bottom, and is covered with the successively smaller sizes. The different sizes of stone are spread in courses. The sub-grade and each course of stone are rolled thoroughly, and the top course is watered before rolling. All stone-crushing plants in the State, whether employed on State or municipal work, are fitted with elevators and revolving screens, so that the stone when thrown into the hopper passes through the crusher, to the elevator, to the screen, to the bins, and into the carts in sizes as required, without re-handling.

The rock used has come from quarries, banks, fields and river beds. There is great variation in the quality of rocks used. In the selection of road-building rock, traffic and cost are carefully studied. and the cost of maintenance as well as construction is taken into account. Trap rock is unquestionably the most economical material for the surface of roads of heavy traffic, and it has generally been used by the commission on such roads, In such cases where the trap rock has to be moved long distances and its cost is high, and where a low-cost native rock is available, the native stone is used as a bottom course and the trap rock as top or wearing course. This combination materially reduces the cost, without affecting its value. In a few instances the native rock surfacing has not worn well, the cost of maintenance has been considerable, and the surface of the road has been rough. These have been broken up by picks in the wheels of steam rollers, evened up, and re-surfaced with a coating of trap rock from two to three inches in depth, with the proper amount of screenings, water and rolling.

All state roads are compacted by the use of steam rollers, both during construction and permanent repairs. The steam roller gives quicker, better and more economical results than can be obtained by any other method. With a prepared sub-grade, and by rolling the sub-grade and each course of stone separately, no difficulty is experienced in the use of steam rollers that cannot be easily overcome.

The standard width of broken stone roadways, as built by the commission, remains fifteen feet, and on each side of this a width of three feet is shaped to the same cross-section as the broken stone. These side strips or shoulders, are covered with gravel on much travelled highways only; on all others the natural soil is used. Roadways of twelve, and of ten feet, have been built, and are satisfactory so far as the use is concerned, although the ten-foot way is not economical to maintain, except where the traffic is exceptionally light.

Either iron or vitrified clay pipes are used for culverts, up to twenty-four inches in diameter, the ends being in all cases protected by stone masonry. The larger culverts are built of rubble masonry the side walls being laid dry, the ends with cement mortar. Having in mind the experience of towns, the commission has felt justified in accepting only good materials and workmanship in all culvert masonry. The first cost of good work may be greater, but the final cost is surely less.

Reference has already been made to the necessity of removing ground water from the sub-grade of a road. This drainage is affected in various ways, the kind of drain being dependent upon the character of the soil. The drain mostly used by the commission is a vitrified clay pipe, laid with open joints, in a trench about three to three and a half feet deep, and from twelve to sixteen inches wide. This pipe is laid upon a two-inch layer of fine gravel, free from sand or dirt and covered to a depth of six inches, and is surrounded by the same kind of gravel. The remaining part of the trench is filled with stone varying in sizes from one to three inches in diameter. The pipe removes the water quickly to an outlet; the fine gravel allows a free flow of water, and at the same time prevents the passage of silt into the pipe; the removal of sand or dirt from the fine gravel surrounding the pipe removes the possibility of its entering the pipe; and the coarse stone in the upper part of the trench intercepts the ground water in its flow toward the sub-grade. These drains are placed on either side or both sides, as the contour of the ground requires.