In connection with the cost of culverts, the size, class of construction and depth of fill should be noted, and in addition—for bridges—the height above the stream and work on approaches.

In constructing roads, particulars as to grading, rate of wages, metalling, rolling per mile of road-bed or surface material, will be valuable.

Proper records of the labor and material utilized in oiling roads will popularize this efficient system of maintenance.

Railings should cost the same per rod in different parts of the county, and where the cost of tile drains differs, the particulars should be included.

The wear and tear on machinery forms an important overhead expense, and a record of first cost, maintenance and service will be most valuable in preparing estimates including renewals.

## **Excellent Check on Efficiency**

A cost system is an excellent check on the efficiency of foremen. It is the ultimate test of good organization. It will enable a superintendent to meet criticism with facts, and maintain his position in submitting estimates.

It is not intended that all cost particulars be entered in the book above referred to; cards printed to suggest the information required should be used. These may be carried by the superintendent and kept in a card index in his office. The cost of permanent culverts, bridges and other work, when completed, should be entered in the book.

As already suggested, the foundation of a cost system is a proper report from the foreman in charge of the work. The form known as the Maintenance Foreman's Weekly Report will be more within the comprehension of the average patrol man, and may be substituted for the time-book or larger pay-sheet. When combined with the individual cheque system of payment and suitable voucher form, this will do much to assist in the business-like administration of road improvement expenditures. Last year it was expected that something would be done to secure more uniformity in county road bookkeeping. There is every necessity for this. The superintendents and treasurers all have ideas. A comprehensive report on the whole question should be available.

The formation of a western waterways association is being advocated by Mayor C. F. Gray, of Winnipeg, to encourage the development of waterways in the paririe provinces. As an example of what might be accomplished, says the mayor, the Saskatchewan river could be made navigable to permit the transportation of coal from western fields. This waterway, he points out, runs through an immense pulpwood area and a district which is rich enough in copper sulphite deposits to supply the whole continent with sulphuric acid.

Eighty officials and employees of Morris Knowles, Inc., consulting engineers, Pittsburgh, Pa., attended the annual banquet of that organization, held recently at the University Club, Pittsburgh. Mr. Knowles made brief mention of the first dinner of the organization, held in 1914 with 10 present. Messrs. Garvin and McDowell, associates of the late R. Winthrop Pratt, of Cleveland, were then presented and made short addresses. One of the principal features of the evening was the announcement by Mr. Knowles of arrangements for the consolidation of the organization of Morris Knowles, Inc., with that of the late R. Winthrop Pratt. The various branch offices established by each organization will be continued. Although both firms have done important work in connection with water supply projects, sewerage systems and drainage, Mr. Pratt's organization specialized in garbage and sewage disposal plants, sewerage systems and water works, while Morris Knowles, Inc., developed special departments of town planning, industrial housing, flood prevention, valuation and rate-making, and appraisals. This consolidation results in a personnel of 130, and places the organization among the largest consulting engineering firms of the United States.

# DRAINAGE IN ROAD CONSTRUCTION\*

### BY G. R. MARSTON Engineer of Norfolk County, Ont.

I N road construction and maintenance, our first thoughts should be given to drainage. It is the first principle of road building. Many articles have been written in the scientific journals, and many papers read before road conventions, on drainage, but they have not yet penetrated deep enough into the minds of those in charge of roads, or else the latter have failed to impress this matter on those working on the roads. If drainage were carried out properly, there would be fewer mudholes in earth, sand-clay, gravel and water-bound macadam roads, and less foundation failure in bituminous macadam, asphaltic-concrete and brick roads, and fewer cracks in concrete roads. While there are road failures from other causes, poor drainage is the first cause. Water is the greatest natural enemy of all roads.

There is no set rule for draining a road. Each portion of the road will present its difficulties, and the road engineer's business is to overcome the difficulties and to devise the proper system to drain the road. The nature of the subsoil, the topographical features of the road itself, and those of the surrounding country, will be his chief guides.

### Three Types of Drainage

Three types of drainage for roads present themselves: (1) To keep the water out of them; (2) to keep the water from alongside of them; and (3) to keep the water from under them. The first two of these propositions is accomplished by what is known as surface drainage and the third by subdrainage. Surface drainage is always necessary; subdrainage is needed in soils having no natural underdrainage.

The crown of the road, the side ditches or gutters, pipes and culverts, are the means which are resorted to in order to procure surface drainage. The height of the crown of a road necessary to drain an earth road is best found by experience. The usual crown is about an inch to the foot of width from the centre of the road to the side ditches, and this is usually increased as the longitudinal grade of the road increases. As heavy traffic soon ruts earth roads, it is necessary to use the road drags frequently to prevent the formation of deep ruts or the surface water will follow the ruts and the roads will suffer from washouts and erosion.

The side ditch and gutters are intended to carry off the water shed from the road by the crowns, and to keep the water from outside of the right-of-way from flowing into the road. These ditches should be dug to as uniform a grade as possible, and should be in good alignment and sufficiently wide to carry off the water, and about 2 ft. deep below the outer edge of the graded portion of the road. These ditches will carry the water to the smaller creeks or outlet drains. If there is no apparent outlet, one must be procured either by consent or by the application of the Ditches and Watercourses Act.

It is important that these side ditches and gutters be properly maintained or they may become choked and cause serious damage. When roads are constructed along hill-sides, it is often necessary to dig what is known as a secondary drain. This drain should be well up the side of the hill so that it will intercept and dispose of the larger amount of water before it has a chance to reach the regular ditches.

#### Permanent Surfaces Prevent Rutting

The penetration of earth, gravel and macadam roads by water has not altogether been solved by crowning of the roads, and for this reason many municipalities are constructing roads with more permanent surfaces, such as bituminous and concrete surfaces, which prevent rutting and the consequent action of water. There is no doubt that with increasing traffic, which means more rutted roads, these more per-

\*Paper presented at the recent conference of county engineers and road superintendents of Ontario.