

analyst the water in Elk Lake was found unsuitable for domestic purposes, and they purchased the entire supply from the Esquimalt Water Works Company. The consumption varied from $3\frac{1}{2}$ million Imperial gallons per twenty-four hours in the winter, to $5\frac{1}{2}$ millions in the summer.

During the year very satisfactory progress was made on the Sooke water supply. Up to the end of the year 15.7 miles of concrete flowline pipe were laid, leaving not quite twelve miles to complete the work. On the pressure pipe line $9\frac{3}{4}$ miles were completed, leaving less than a mile to complete. The Humpback reservoir has been filled with water from the drainage area around it, and also by tapping two mountain streams connecting them up to the flowline pipe at the manholes, and early this year they propose to obtain about two million gallons daily from this source. Upon the completion of the flowline, which should be some time in June, they will be able to put the whole system in use.

EARTH ROAD CONSTRUCTION AND MAINTENANCE.*

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A STUDY of actual road conditions in any of the western provinces or states will disclose the fact that over 90% of the public highways are, and must remain, earth roads, and for that reason the construction and maintenance of this class of roads is the most important work of the road engineer or other officer charged with administration of road affairs. With the possible exception of brick or concrete, almost any kind of road surfacing is of a temporary nature and must be replaced, but a properly located and constructed earth road grade is a permanent improvement.

The first point to take into consideration in planning a road system is location. Too many of our important roads are poorly located; in many cases on account of the tendency to follow the first trails, but usually the poor location is due to holding strictly to subdivision lines. In gently rolling and well drained country it is probably better to follow the section lines, but where heavy grades are encountered or other bad topographical conditions exist, a complete survey of the road situation should be made and a location determined upon without regard to property lines which will provide the most economical and satisfactory road for all times. The relatively unimportant road of to-day may be one of heavy travel in twenty or fifty years, and our responsibility is great in this respect; that we are probably determining the limits of travel for many years in advance.

In location, the factors to take into consideration are: Volume and direction of traffic, limiting grades, possibilities for adequate drainage and safety of the travelling public. The character of traffic is rapidly changing and the gradient becomes more of a limiting feature as the use of motor vehicles increases. If possible, roads should be so located that the maximum grade does not exceed 5%. The elimination of railroad grade crossings comes under the head of location and is very important as affecting the safety of the public. In a great many cases the necessity of making grade crossings can be avoided or the danger reduced by minor changes of location. With the advent of rapid motor travel there is also danger in abrupt change of road line and to avoid this the alignment of roads

should be so planned that a clear sight distance of 250 feet is provided at any point. These things should all be taken into consideration when laying out a road system and in general a good rule for road officials to adopt is to only apply construction funds on permanent locations.

Adequate drainage is the all-important feature of road work. A successful road plan must provide for the removal of water from the road surface and side ditches before it may saturate the subgrade, and to accomplish this it is necessary to have a sufficient crown on roadway with proper depth and fall in ditches. In the average soil a crown of ten inches on a 20-foot roadway is necessary and the depth of ditch below crown should be at least 2 feet at time of construction, but this may vary in accordance with the character of the soil. Surveys should always be made to determine upon lines and disposal of drainage, as the eye cannot be trusted in judging these points. Off-take ditches should be located where necessary and in any event the water must be removed from road ditches as quickly as possible. Frequently it is found necessary to construct roads through wet locations where drainage cannot be secured, and in such places the top of grade must be kept at least 3 feet above the water level. The most common neglect of drainage is found where grades are built up by borrowing the material from road ditches with blade graders. The wrong and usual method in such cases is to have the profile of road ditches conform to the surface of the ground, with the result that water stands in the depressions and saturates the grade. On this class of construction extra ditching should always be arranged for in order that continuous lines of drainage may be provided. In clay cuts it is not unusual to find great difficulty in draining the roadway shortly after the frost leaves the ground and after heavy rains. This condition can be remedied by the laying of farm drain tile or by rock-filled drains or other methods of subdrainage. The proper drainage of a road is of such great importance that it will be found economical in all cases to have surveys made and ditch grades established by an engineer, for the expense of this work is negligible as compared with the value of the information obtained.

The proper cross-section for earth roads depends upon the character of the soil and topography of the country, but as a general standard for average soil a crown of one inch per foot and a twenty-foot roadway is satisfactory. For main trunk roads 24-foot roadways should be provided, and on lateral roads where travel is very light 16 feet is an economical width. To establish a standard height of crown or depth of ditch for all roads is, however, an error, for local conditions require in many cases that two or three different sections be used within the same mile. A knowledge of the soil where improvement is to be made is necessary, as one will sometimes find that opposite conditions obtain on portions of the same job. For instance, in Hubbard County, Minnesota, one piece of road is through light soil which cannot be excavated to a greater depth than one foot without reaching a fine drifting sand, while on another portion of the road the soil appears to be heavy loam, but by excavating a foot and a half in depth we reach a first-class road gravel. Both of these sections were built by drawing the material up from the sides, but on the former a very low crown was held and wide, shallow ditches were dug, while on the latter a high grade was built up in order to dispose of the stripping and deep ditches were dug to obtain the surfacing material. On the sandy portion of this road we found that the top soil to a depth of eight inches to a foot would give almost as good a surface as gravel, but it required a great deal of dragging to bring it to proper

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