

these roads still follow the same old winding lines, although the obstructions may long since have disappeared. The roads now being built should be a permanent foundation for all future improvement and before grading is commenced should be carefully located in the centre of the allowance. If the boundaries or limits are not well defined by posts or fences a survey should be made by a competent engineer and the road properly located. The author quoted from the Surveys Act, providing for such alterations to concession and side roads, and from the Municipal Act, providing for the opening of roads at the jogs in the centres of double-front concessions.

Detours of the road should be made with curves as easy, and the driver's sight line as long, as circumstances will admit. With horse-drawn vehicles a fairly sharp curve is not objectionable, but the high speed of the motor vehicle makes a necessity of easy curves and long sight lines as an ordinary provision for the safety of the travelling public. Curves should have a radius of not less than 100 feet when practical and a sight line of not less than 125 feet. All sight-blocking obstructions should be removed.

After the location of the road has been established the next step will be to establish grade lines. The determination of the amount of grading to be done should depend largely upon the amount and nature of the traffic and the topographical conditions of the locality, but unfortunately the foremost consideration has too often to be the amount of funds available. It is generally agreed by engineers and roadmen that the maximum grade on main highways should not be more than 5%, but this may not always be found practicable. The maximum allowed by the regulations under the Highways Improvement Act is an 8% grade. It should, however, always be kept in view that to have our roads up to the standard adopted by both the United States and Canada the grades on main or trunk roads should not exceed 5%.

Steep grades increase the cost of transportation; no greater load can be moved over a highway than can be moved over the maximum grade. The cost of maintenance increases very rapidly with the increase of grade and is a very important consideration. It is roughly estimated that the destructive effect of heavy rains and spring freshets is four times as great on a 5% grade as on level ground and nine times as great on a 10% grade as on the level. It is not, however, on account of drainage considerations, desirable or economical to have a perfectly level road to obtain the best results. The minimum grade should be about one-half of one per cent.

On a stretch of road with a general ascending grade continuing to a higher elevation, descending grades should be avoided as much as possible, and vice versa where the tendency is a descending grade toward a lower level.

For the purpose of establishing grade lines, a line of levels should be taken along the centre of the road at regular intervals of, say, 100 feet. All heights of land and hollows should be noted with elevation and distance of same. A profile may then be plotted from the notes and the required grade line drawn, showing cuts and fills, with a view to having sufficient material from the cuts to do the necessary filling. For making the required calculations, cross-sections of cuts and fills may be necessary.

The author pointed out that where new grade lines of any considerable distance are required the engineering should be done by an experienced man with proper instruments. He described a home-made device that might be used for taking rough levels over short distances.

When the grade lines have been established on paper they should then be located on the ground by means of stakes with the elevations marked thereon, and at heavy cuts and fills cross-sections may be laid out. All necessary culverts having been previously constructed and underdrainage provided for, the work is now in shape for grading.

Relative to the latter, the author quoted a number of paragraphs from "Principles of Roadmaking," by Mr. W. A. McLean, Provincial Engineer of Highways, clearly setting forth the best methods of grading. A number of regulations governing grading, crowning, etc., were selected from the Department's manual and dwelt upon to some length.

The author's concluding remarks dealt with a few rules suggested from his own experience:

In deep fills the material should be laid in layers of about one foot in depth commencing the full width of the cross-section of the fill, in order to insure the minimum amount of settlement. Great care should be taken to have filling thoroughly settled and rolled with a heavy roller before surface metal is laid as the least settlement or softness in the foundation is fatal to the surfacing.

All subgrades should be brought to the proper grade and cross-section and rolled. All depressions that may appear during the rolling should be filled with earth and re-rolled until firm and solid so that when metal is applied sub-soil will not be forced up into the interstices of the stone.

Side ditches on long grades where a considerable flow of water may be collected, should be located an increased distance from the centre of the road, as the probable effect of the running water will be to deepen the ditches and eat into the sides of the road.

Through hollows, where the roadway is graded high, do not unnecessarily increase the height of roadway above the sides by taking filling from the sides. High, narrow roads and deep ditches are dangerous.

**DRAINAGE.** By J. A. P. Marshall, B.A.Sc., assistant engineer, Ontario Office of Public Highways.

The introduction of this paper referred to the important bearing of the climatic conditions of Canada upon the question of drainage in all types of road construction. Best results cannot be obtained in road building until water, the road's natural enemy, is properly looked after. If earth roads could be made practically impervious to water, and such sub-surface water removed, the condition would produce excellent roads. But the soil absorbs water so readily that it is scarcely possible to provide a means of shedding it completely. Moreover, in climates where the road surface is subjected to periodic freezing, thawing and rainfall, the effects of water are more serious. Hence the importance of drainage.

The author stated that drainage implied that: the road be crowned to shed water to open drains and gutters; the open drains have a constant fall to a good outlet; the water rising in the road from below be carried by deep or tile drains; and the surface of the road be kept smooth, free from ruts and hollows, so that water will not remain on the surface.

Removal of water is accomplished in two ways: (1) By surface drainage. (2) By sub-surface drainage.

**Surface Drainage.**—The drainage of the surface of a road is very important and is provided for by making the surface crowning and keeping it smooth. It is well to