than the rod or bolt to be driven. As a consequence, there is much discomfort to men driving them from the splashing that is usually unavoidable. The writer watched a gang of men driving short tie-rods at water line, easily, effectively and in comfort. In placing and starting the rods a raft of 12 in. by 12 in. timbers had been used to work from. After the rod had been started the men fastened one end of the raft loosely to the cribwork and used this fastening as a sort of hinge. One man on the raft pushed the free end away from the crib by a pole, and the rest by means of a rope pulled it back again, striking the bolt and driving it home. A more effective blow was delivered than could be done by a sledge, and it was more comfortable to the men.

CORRECTION OF ALIGNMENTS AND GRADES IN EXISTING HIGHWAYS.*

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THE importance of the alignments and grades is very apparent to all engineers who have had to do with the building of roads. When making a special study of this question I was impressed at first sight from the variety in the details of the many opinions expressed and the practices followed. But, after a careful examination of each particular case, I soon found that such variety has been mostly the result of the special circumstances in accordance with which the many aspects of the question have been dealt with and the various problems solved.

The methods used in the construction of roads vary to a certain extent according to the political, economical, commercial, topographical and climatic conditions of each country and the different periods of history. For instance, the famous Roman roads were, as a rule, laid out in approximately straight lines. Mountains, hills and valleys were crossed almost without any regard to topography. Hills were cut through and deep ravines filled in. But everybody will agree that the economical and political conditions of that time were quite different from those which we have to contend with to-day and it would be absurd to attempt to follow their example.

I will confine myself to a brief discussion of the question from the point of view of the construction of our trunk roads in the province of Quebec, setting aside the special conditions in mountainous country.

In the province of Quebec, as well as in all the other provinces, as those trunk roads have mostly to go across agricultural districts, settled many years ago, they have to follow the existing roads.

The engineer who has to secure the best alignments must always keep in mind that as those trunk roads are specially destined to promote agricultural development and the material welfare of the country through which they go, they will also have to bear an ever-increasing automobile traffic. Everybody knows that a great many of the automobile accidents are due to bad alignments. Of course, we cannot make our roads "fool-proof," but the country people and the careful tourist, unfamiliar with the road, have a right to protection against the speed lunatics who drive at from 40 to 60 miles per hour.

No hard and fast rules can be laid down about the alignments and grades. Although I will try to give the general principles which I have by experience found the most practical and important.

The curves should be planned to afford a sight distance; that is, the greatest distance at which the drivers of two approaching vehicles may see each other's machine—of not less than 250 feet. This is the most important rule. I might say that the whole question of alignment and grade is a question of the line of sight of unobstructed vision

Radius of Curvature.—In the province of Quebec, we have adopted the minimum radius of 300 feet wherever possible without incurring a prohibitive cost. If we have to shorten that radius to 150 feet and under, we put danger signs at 400 feet from the B.C. and the E.C.

The pavement itself should be widened in the curves and banked. For the widening, I found the following formulæ, given by Byrne, very useful:

$$R' = \sqrt{\left[R + \frac{W + w}{\frac{1}{2}}\right]^2 + l^2}$$

R' = minimum radius of outer curve.
R = radius of the inner curve of the road.
W = width of road on tangent.
w = total width of vehicles.
l = total length of vehicles, including teams.

For the banking of the curves, the following rules are advisable: On a curve of between 2,000 and 800 feet radius the outer side of the pavement should be 6 inches higher than the inside one; between 800 and 550 feet radius, 7 inches; between 550 and 400 feet, 8 inches; between 400 and 300 feet, 9 inches; and under 300 feet, 10 inches.

When a curve occurs on an ascent, the grade at that place must be diminished in order to compensate for the additional resistance of the curve. When it is necessary to make a radius of curvature less than 300 feet, we usually follow the principle of reducing the grade on the curve at the rate of one per cent. for every 50 feet that the radius has to be reduced; so that where we are locating a five per cent. grade and have to put in a curve with 200 feet radius, we give a three per cent. grade.

As a rule, there ought to be a tangent of about 100 feet between two curves. Quick reverse curves are disagreeable and dangerous with automobile traffic and are to be avoided.

To cross all obstacles as nearly as possible at right angles. The cost of skew structures increases nearly as the square of the secout of the obliquity.

The road on each side of an obstacle should be straight on a length of at least 50 feet when there is a possibility of doing so without incurring prohibitive expenses.

Do not overestimate the advantage of straightness. The curved road around a hill is often no longer than the straight road over it. In addition, a more or less sinuous course is an advantage from a maintenance standpoint, as on a winding road the wheel traffic has a tendency to spread over the entire surface.

Carry the road along the southern or western slope of ridges, if possible, so that it may be less exposed to storms and dry out more quickly after heavy rains and the melting of snow.

The difference in the length between a straight road and one which is slightly curved is very small. On the Montreal-Quebec Road, we have eliminated all the bad curves wherever possible and through that fact we have reduced the first 50 miles of roads from Montreal by only 400 feet. As a matter of fact, we generally follow the

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