

maximum power for each diameter of pipe falls on the head line for 260 feet, or when the loss of head is $\frac{400}{2.85}$ equal to 140 feet.

It will be appreciated, of course, that no conduit would ever be designed for this maximum condition, as the losses of head are too large for economical operation unless water economy is of no object. In any case, conditions at this point are far too unstable to permit of any speed regulation. Probably, in an actual case, the maximum velocity to be used will give losses about one-third of that for maximum power.

REINFORCING PAVEMENT FOUNDATIONS.

The determination of the use of reinforcement in concrete pavement will depend upon the type of foundation and width of pavement. A paper by C. D. France, before the Indiana Engineering Society, gives some useful information respecting it. The writer states that reinforcement may be used in either single or two-course work, and is particularly designed to care for slight settlement of fills, and to guard against contraction cracks developing where the pavement is wide. In any road where a new fill of over 2 feet is made, and the material used is other than sand or gravel, the pavement should be reinforced, no matter what the width of the road. No amount of compacting by roller or puddling can effectively settle such a fill, so that no further movement of the foundation is probable after the placing of the pavement.

The type of reinforcement which is most economical in price and handling is wire fabric. The weight of material to use in this fabric has been the subject of much discussion and, although it may be well sometimes to consider each specific case, in general it may be said that reinforcing metal running parallel to the centre line of the pavement should have a cross-sectional area of 0.038 inches per foot of pavement width, and a cross-sectional area perpendicular to the centre line of the pavement of at least 0.049 inches per foot of pavement length. Reinforcing has been advocated in two-course work where it is spread upon the still plastic base, which, being slightly undulating, insures that no line of cleavage can possibly develop between the two courses, and, in addition, imparts greater strength and security to the pavement. In single-course work, reinforcing is placed about 3 inches from the surface.

PROGRESS ON SOOKE LAKE AQUEDUCT.

In *The Canadian Engineer* for July 23rd, 1914, the essential features were published relative to the project under way at Victoria to supply 16,000,000 gallons per day through 27.3 miles of reinforced concrete gravity pipe line and 10 miles of 36-inch steel pressure pipe, the supply to come from the Sooke Lake watershed. The work has progressed very favorably since that time. On October 8th the steel pressure main was successfully tested under a maximum pressure of 200 lbs. per square inch. Construction on the 42-inch concrete pipe line is well under way. It is to be noted that little success was achieved in the steam treatment used to hasten the setting of the pipe in the molds at first, and many of the sections had to be culled. Later on, however, the improvement of the steaming process gave much better results, and has proved a decided advantage in the construction of the pipe, and well worthy of note.

GRADES AND EXCAVATIONS.*

By A. D. Williams,
Chief Road Engineer, State of West Virginia.

IN the past two or three years stress has been laid upon the subject of permanent roads. Many articles have been written bearing upon the various kinds of surfaces, but the ever-important subject of grade and excavation has received only passing notice. Yet the only permanent thing about a road is its grade and location. The various kinds of surface will yield to the actions of the elements and pass the march of time, but the road once established will become more fixed as the years go by, adding improvements and new property lines to bind it firmly in place. This makes more important the engineering subject of our roads. The establishment of grades and location should be given the greatest consideration.

Minimum Grade.—The principal factor entering into the determination of a minimum grade is the question of sufficient drainage. Except on fills over 2 feet the minimum grade should not be less than $\frac{3}{10}$ of 1% and preferably not less than $\frac{5}{10}$ of 1%.

Maximum Grade.—There are a number of factors that enter into the maximum grade, but, before attempting to locate any road or to establish any grade the engineer should make a thorough study of the territory to be developed by the proposed road, giving due consideration to the following points:

- (1) What will be the present and future demands of the territory adjacent to the proposed improvement;
- (2) What are the possible developments in the territory from an industrial, agricultural, educational and social standpoint;
- (3) What part will the proposed road be of a general system of roads reaching to other communities and what will be the effect of the improvement on other sections;
- (4) The nature of traffic that the road will be called upon to take care of, making due allowance for development, considering the present and future tonnage;
- (5) The general direction in which the greatest amount of tonnage will be transported, the class of tonnage and the time necessary to move it in order to make it the most marketable;
- (6) The direction in which the ascending grade will be in comparison with the possible traffic demands;
- (7) The maximum load that a horse can pull based upon the length of grade and the time required to make the trip, from the standpoint of the horse and the time necessary to get the best results for the kind of material the country will produce;
- (8) Consideration should always be given to climatic conditions and to the season that the roads will be required to take care of the heaviest traffic, as well as a study of the foothold for horse-drawn vehicles. The possible amount of frozen or icy weather should be noted in determining a maximum grade;
- (9) The class of material over which the road is to be made and the cost of construction on the longer distance compared with the steeper grade and shorter distance have a certain bearing upon the subject, because the most important subject in connection with the cost of roads on grades is that of maintenance which increases very rapidly with the increase of grade. Roughly speaking, the destructive effect of violent and periodical storms

*From a paper read at Fourth American Road Congress, Atlanta, Ga., November 9 to 14, 1914.