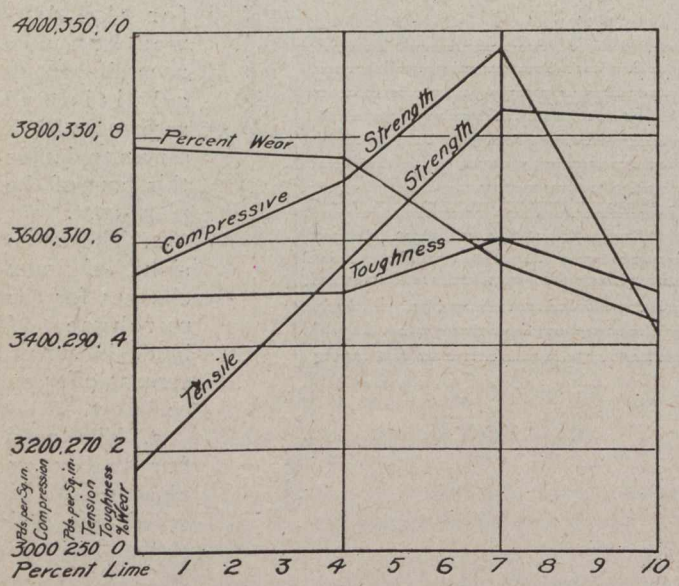
provision for but 16 or 18 hours' operation, upon the questionable hypothesis that the very low night flows can be neglected. In this respect the tank plants possess an advantage in the manner with which they can be left without attendance, though still in operation.

The finding of the report to the International Joint Commission is to the effect that the city of Niagara Falls, Ontario, can meet restriction upon the river discharge of crude sewage by the construction of Imhoff tank and disinfection treatment works at a first cost of $83,600 or less, and with annual labor and material charges of about $9,000.

HYDRATED LIME IN CONCRETE PAVEMENTS.

THE use of hydrated lime in the construction of concrete pavements is a subject in which many of *The Canadian Engineer* readers are concerned. In the annual report on highway improvement in Ontario, G. Cameron Parker, B.A.Sc., assistant engineer, Department of Highways, Ontario, presents a report from which the following extracts have been taken:

That the addition of hydrated lime to concrete results in an increase in the waterproofing properties of the material has been recognized for a number of years. The problem of rendering the walls of concrete tanks, reser-



Curves Showing Effect of Hydrated Lime in Portland Cement Mortar. (Mortar 1:2.)

voirs and foundations has been solved in many cases by the use of this material.

Laboratory tests have shown that concrete containing hydrated lime not only becomes impermeable but that none of the desirable properties are sacrificed. On the contrary, increases in tensile and compressive strength have been recorded along with greater facility in trowelling and surfacing. Ordinary sand mortar does not lend itself to the obtaining of a smooth finished surface. When such is required a coating of neat cement or fine sand mortar, a cement wash, or handrubbing with abrasive blocks is usually resorted to. The lime appears to act after the nature of a flux, rendering the mortar smooth and plastic and making it possible to work up to a fine surface. The formation of surface cracks is lessened by the addition of lime, which indicates that it reduces the coefficient of expansion of the material, due to change in temperature and moisture content, or causes it to be uniform throughout the mass.

While the chemical reactions taking place during the hardening of concrete are not fully understood, it is thought that the lime takes no part in them but acts solely as a void filler, making the concrete more dense and therefore stronger and less permeable. An examination of a piece of concrete mortar will show a certain percentage of fine voids. These are more pronounced where the mortar has been in contact with a piece of the coarse aggregate. By the aid of a microscope of even moderate power smaller voids may be seen throughout the mortar generally. If the material is subjected to the action of water it is to be expected that these voids will become filled. The resulting action on the concrete when the frost reaches these small, water-filled cavities will, to say the least, be deleterious. In warm weather when the danger from frost is not present the water may contain salts or other materials in solution which will have a disintegrating action. Thus, in all seasons the mass is exposed to danger so long as these capillary chambers exist.

It is, therefore, essential that the voids be filled, or reduced to a minimum. It is generally thought sufficient to have the material entering into the concrete so proportioned that the voids in the coarse aggregate are completely filled by the mortar, those in the fine aggregate being filled with cement, with a slight excess of the latter. Concrete so proportioned, properly wetted, mixed and tamped, is considered dense. Simple tests will show that no amount of mixing or tamping, or even the addition of an excess of cement will entirely eliminate the small voids. So long as they exist the mass will be subject to expansion and contraction to a greater degree than if they were filled with material. This is the purpose that is believed to be served by the hydrated lime. The results of tests in actual conditions, as well as those made in the laboratory, show that there is a decrease in the contraction of the material, that it is more impervious to water, and that with certain percentages of lime added there is a resulting increase in strength.

With these facts determined it was natural that favorable results should be expected from the use of hydrated lime in concrete pavements. When laid in this form, concrete is subjected to what is perhaps its most severe test. In addition to being under static and live loads, it is exposed to extreme climatic conditions. The temperature in the southern portion of Ontario commonly ranges from 95 degrees in summer to 20 degrees below zero during short periods in the winter months. In addition, the snow lies on the ground for at least three months of the year, attaining a depth of from 12 to 24 inches on the level. The average frost line is about three feet below the surface of the ground. When, together with these conditions, it is remembered that concrete in a pavement has a greater area of surface exposed, per cubic yard of material, than in any other class of work, the necessity of obtaining a thoroughly dense material with the minimum coefficient of expansion, is realized.

In the summer of 1913 a section of concrete road containing hydrated lime was laid by the Office of Public Roads and Highways near Sarnia, Ont. The road is 5,946 feet long, 16 feet wide and 7 inches thick, one-course construction being used. Gravel shoulders 4 feet wide, bound with limestone screenings, were laid on the sides. Expansion joints filled with paving pitch were placed at 30-foot intervals. The gravel used, was supplied from the St. Clair River at Point Edward.

The hydrated lime, which replaced 10 per cent. of the cement by volume, was mixed with the cement in a small