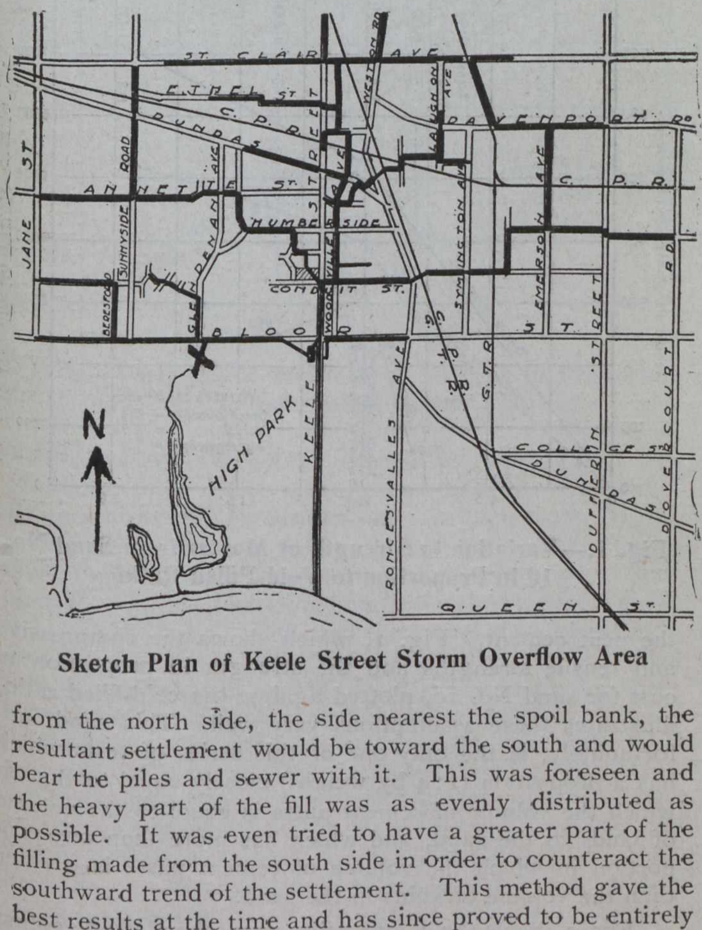
The sides of the ravine rose 95 ft. above the bottom, and as it was proposed to continue Bloor Street over the fill, which was only 60 ft. deep, cuts had to be made through the top of each bank in order to ease the grade for the future street. The top of the fill was 60 ft. wide and a slope of 1½ to 1 was provided on each side. This 60-ft. fill buried the sewers completely under 20 ft. of sand and later when the fill had settled sufficiently gullies were built in order that the storm water would be taken by them into the sewer instead of being allowed to wash out the sides of the fill.

The filling in this ravine had to be carefully done with a view to the effects which the settlement of the fill would have on the sewers. As we have mentioned, the lower 400 ft. of Clendenan Avenue sewer is in the ravine and so had to be filled in as well as Bloor Street. The completed fill, therefore, had a much greater volume on the north side of Bloor Street than on the south. In addition to this fact, the natural grade of the bottom of the ravine is towards the south, southeast. It may reasonably be supposed then, that, should all the fill be made



Sketch Plan of Keele Street Storm Overflow Area

from the north side, the side nearest the spoil bank, the resultant settlement would be toward the south and would bear the piles and sewer with it. This was foreseen and the heavy part of the fill was as evenly distributed as possible. It was even tried to have a greater part of the filling made from the south side in order to counteract the southward trend of the settlement. This method gave the best results at the time and has since proved to be entirely satisfactory.

This piece of work was interesting on account of the peculiar conditions under which it was carried out, because of which, problems arose different from those met with in the usual course of sewer construction. Whereas, in the usual sewer the problems have to do with stationary dead weights and the nature of the ground traversed, here the problems dealt with were those of shifting dead weights and the strengths of the substructures. The handling of material alone required an unusual organization on account of the fact that work was done at such a height above the ground, and because of the location of the work in a ravine where the approaches were difficult. In addition to this, in the ordinary sewer work, the problems are present and tangible, and may be largely dealt with as they are encountered, whereas here the problems were largely of the future and had to be estimated and the solutions planned in advance.

ECONOMICAL PROPORTIONS FOR PORTLAND CEMENT MORTARS AND CONCRETES*

By J. A. Kitts

A MORTAR is a mixture of sand, cement and water in various proportions. The question of scientific interest is: What determines the mixture of maximum efficiency?

Sands vary in physical, chemical and mechanical structure, causing a variation in the specific gravity and percentage of voids, and these latter cause a variation in the weight per cubic foot or aggregate specific gravity. An important consideration in the study of a large number of mortars from a large number of aggregates is that of comparison. A study of the characteristics of various sands will show that mortars are not comparable either in arbitrary weight proportions or in arbitrary volumetric proportions. What, then, determines the conditions for comparison of the mortar from one sand with that of another?

An analysis of the results indicated in Prof. M. O. Withey's paper on "Tests of Mortars Made from Wisconsin Aggregates," throws considerable light on the two preceding questions. In these tests mortars were made in 1 : 2, 1 : 3, 1 : 4 and 1 : 5 weight proportions and the following tests made: Unit tensile strength; unit compressive strength; leakage of water through specimens 2 ins. thick with pressures of 10 and 40 lbs. per square inch; density; yield; and compressive strength in proportion to cost. Tables I. and II. show the physical and mechanical characteristics of eleven of the sands used in these tests.

Tables III. and IV. show the variations of the volumetric and void conditions common to simple weight proportioning.

Table III. is computed by the following equation:

$$\frac{\text{Agg. Volume Sand}}{\text{Agg. Volume Cement}} = \frac{\text{Wt. Proportion Sand}}{\text{Wt. Proportion Cement}} \times \frac{\text{Agg. Sp. Gr. Cement}}{\text{Agg. Sp. Gr. Sand}}. \quad (1)$$

$$\text{Aggregate Specific Gravity} = (1 - \text{Proportion of Voids}) \times \text{Specific Gravity.} \quad (2)$$

$$= \frac{\text{Weight, in lbs. per cu. ft.}}{62.5}$$

$$= 110/62.5 = 1.76 \text{ for cement.}$$

Table IV. is computed by the following equation:

$$\frac{\text{Vol. of Cement Paste}}{\text{Vol. of Voids in Sand}} = \frac{\text{Agg. Sp. Gr. of Sand}}{\text{Agg. Sp. Gr. of Cement} \times \text{Wt. Proportion of Sand} \times \text{Voids in Sand}} \quad (3)$$

Table III. shows that the volumetric proportions corresponding to the 1 : 2 weight proportions vary from 1 : 1.77 to 1 : 2.41, the 1 : 3 weight from 1 : 2.65 to 1 : 3.62 volume, 1 : 4 weight from 1 : 3.54 to 1 : 4.82 volume, and

*Abstracted from paper read before the American Society for Testing Materials.