The tests grouped on this diagram are comparable by reason of being made from the same cement, similar materials, and subjected to the same conditions as to making, molding and curing. Each point is derived from the average tests of five specimens. Diagrams of other groups of tests comparable among themselves give similar results. A similar dia-gram published in the last (1918) edition of Johnson's "Materials of Construction," computed from data published in U.S. Bureau of Standards Technologic Paper No. 58, corroborates this assumption.

In order to compute proportions for equivalent strength, it is necessary to assume for each class of concrete that some mixture is satisfactory. For the three classes of concrete considered in this paper, the following mixtures were taken as the basis:-

Class I.-Proportion 1:41/2, gravel containing 42 per cent. sand.

Class II .- Proportion 1: 51/2, gravel containing 42 per cent. sand.



e = Absolute Volume of Cement and (1-d) = Volume of Air and Water Voids in a Unit Volume.

Class III .- Proportion 1:7, gravel containing 42 per cent. sand.

Taking each series of tests by itself, the probable proportions to use with the different percentages of sand in the aggregate, to yield concrete equivalent to the one having 42

To arrange the proportions for equivalent strength it is volumes of cement and aggregate that the ratio c/(1-d) will will, in each case, become equal to 0.455. The adjustment can be made by increasing or decreasing c and decreasing or increasing s+p, so that d will be unchanged, thus:-

Let c', s' and p' be the new values required for c, s and the p, respectively. As explained above, these values are the percentages of absolute volumes of the materials in a unit volume of freshly made concrete.

$$c'/(1-d) = c'/[1-(c'+s'+p')] = 0.455$$



FIG. 2.—RELATION BETWEEN PERCENTAGE OF SAND IN GRAVEL, AND THEORETICAL PROPORTIONS BY ABSOLUTE VOLUME, NECESSARY TO YIELD CONCRETE EQUIVALENT TO A GIVEN BASE MIXTURE

Therefore, to convert the mixture containing 33 per cent. of sand:-

$$\begin{array}{rcl} (1-0.763) &=& 0.455 \\ c' &=& 0.108 \\ d &=& c'+s'+p' \\ 0.763 &=& 0.108+(s'+p') \\ (s'+p') &=& 0.655 \end{array}$$

Accordingly the ratio of absolute volume of cement to absolute volume of total aggregate, required to make a proportion using the 33-per-cent. sand mixture equivalent to the 42-per-cent. sand mixture is 108: 655, or 1: 67.



To determine the amount of cement to use with a given pit-run gravel to yield a concrete equivalent to a given mixture of sand and gravel: Reduce the proportion of the standard mix to the basis of absolute 1. volume

Determine from curve decrease in parts of aggregate correspond-ing to increase in percentage of sand in aggregate. 2.

Change the absolute volume proportions thus found to the loose volume basis. 3. . volume basis. Formula for computing Item 2. $\tan \alpha = 3.6/62 = 0.058$ (See A B, Fig. 2) $y = x \tan \alpha = 0.058 x$