$$\text{Economy factor} = \frac{\text{Compressive Strength (lbs. per sq. in.)}}{\text{Cost of Mortar (dollars per cu. yd.)}}$$

$$= \frac{\text{Compressive Strength} \times \text{Yield}}{C_s + \frac{P_c X C_c}{P_s}} \quad (5)$$

in which P_c and P_s are the volumetric proportions of cement and sand, C_c and C_s are the costs, in dollars per cubic yard, of cement and sand, and the yield is based on the volume of the sand as unity.

This factor is plotted in Fig. 10 of Withey's paper previously referred to. The cost represents cost of materials only, cement being estimated at $1.50 per barrel and sand at $1.25 per cubic yard. In Fig. 3 these

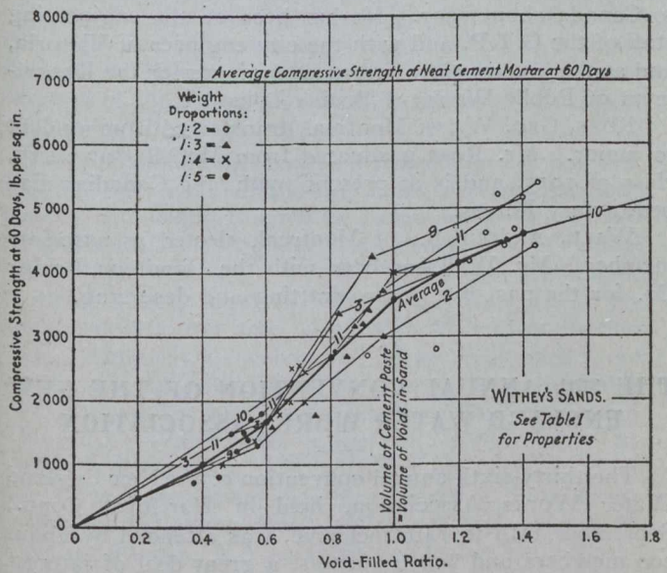

Fig. 2.—Variation in Strength of Mortars in Proportion to Void-Filled Ratios

factors for all 11 sands have been plotted against the void-filled ratio. The average compressive strength of the cement used in these tests was less than 7,000 lbs. per square inch at 60 days. The economy factor for the neat cement mortar would then be approximately 7,000 ÷ 10.14 = 690*. The highest economy factor shown on the curve of averages is 860. This and the curve of averages indicate that the economy factor decreases when the void-filled ratio is somewhat in excess of 1.5. The results of these tests, therefore, indicate that the most economical mixtures lie between proportions giving a void-filled ratio from 1 to 1.5.

As an illustration, Fig. 3 shows that the most economical proportion for sand No. 10 is that in which the volume of cement paste is equal to the volume of voids. From Fig. 1, it is seen that this proportion is 1 cement :3.58 sand by volume giving a tensile strength at 60 days of 525 lbs. per square inch, a compressive strength of 4,000 lbs. per square inch, and an economy factor slightly over 1,000.

The equations for economical mixtures, as indicated by this series of tests, may therefore be written:

$$\frac{\text{Volume of Sand}}{\text{Volume of Cement}} = \frac{1}{(1 \text{ to } 1.5) \times \text{Proportion of Voids in Sand}} \quad (6)$$

$$\frac{\text{Weight of Sand}}{\text{Weight of Cement}} = \frac{\text{Agg. Sp. Gr. of Sand}}{(1 \text{ to } 1.5) \times \text{Agg. Sp. Gr. of Cement} \times \text{Voids in Sand}} \quad (7)$$

If the properties of mortars from all sands vary with the variation of the void-filled ratio, the leakage, density and yield should show similar effects for all sands. Fig. 4 shows the leakage of the various mortars plotted against the void-filled ratio; and this is another proof that the void-filled ratio is the proper basis of comparison of the properties of mortars.

Conclusions Regarding Mortars

1. Sand-cement mortars are not comparable in simple weight proportions because of the wide variations in the corresponding volumetric proportions and the variations of the void-filled ratios.

2. Sand-cement mortars are not comparable in simple volumetric proportions because of the wide variations of the void-filled ratios.

3. The void-filled ratio has a general effect upon the strength, permeability and economy of a mortar and undoubtedly affects the density and yield.

4. An important function of the cement paste is to fill the voids in the sand.

5. Sand-cement mortars are properly comparable on the basis of the void-filled ratios.

6. The economical proportions for sand-cement mortars depend upon the void contents of the sands and may be expressed by Equations 6 and 7.

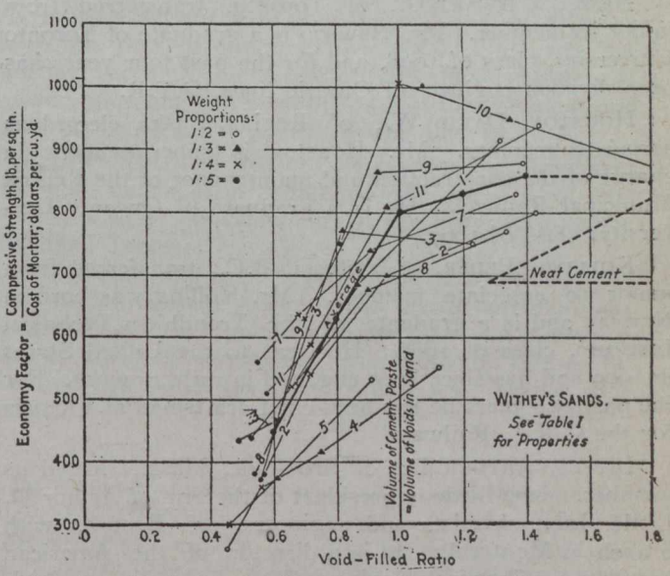

Fig. 3.—Variation in Economy Factor in Proportion to Void-Filled Ratio

7. The economy factor expresses the relative efficiency of mortars and may be determined by Equation 5.

8. The writer finds no general relation of silt content, uniformity coefficient, and absorption to the efficiency of sands.

(To be concluded in the next issue)

*It should be noted here that this value for the "economy factor" of neat cement mortar, as well as the other factors in Fig. 3, is based upon the assumption that one bag of cement gives 1 cu. ft. of cement paste. If, as has been done in this paper, it is assumed that it requires 110 lb. of cement to make 1 cu. ft. of neat cement paste, the cost of a cubic yard of cement mortar would be $11.85 instead of $10.14, giving an "economy factor" of 590.

It has been decided to carry out improvements of the Port of Antofagasta in Chili at a cost not exceeding £1,700,000.

It is stated that from boring operations made last year in the province of Novara, Italy, the existence of an important seam of coal has been found.