In this connection it is of interest to note that the void in sand *F* was found to be 31.3 per cent. By the void method of proportioning the quantity of cement paste necessary to fill the void in 1,200 g. of sand bulking 41.29 cu. in. would be 12.92 cu. in., requiring 374.3 g. of dry cement. With no allowance for the separating of the sand particles, this corresponds approximately to a cement content, 1 g. cement to 22 sq. in. sand area by the surface area method.

Figs. 14 and 15 give no evidence of a marked change in the increment of increase of volume due to the cement content exceeding that of the void.

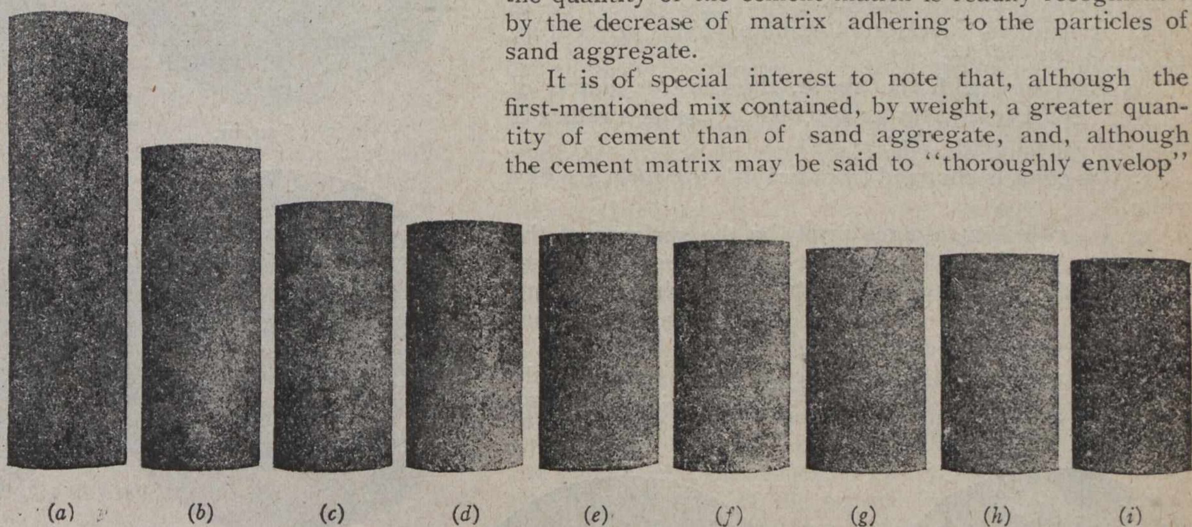

Fig. 14—Mortar Cylinders in which the Cement Content was Decreased

Observed Phenomena of Tests

Voids in Mortar. — Mortars produced under ordinary conditions invariably contain voids having two general sources of origin, namely: (1) Those due to globule-like accumulations of water which evaporate, leaving so-called water voids, and (2) those due to air adhering to the surfaces of the sand particles or to air entrained during the mixing of the component materials, producing air voids.

Fig. 16 shows a photomicrograph (× 75) of neat cement as it exists in standard briquettes. The effect of the surface tension of water is shown here by the great number of voids. This well-known attribute of water renders it impossible to secure, even in the richest mortars, an unbroken film of cementing material surrounding the particles of sand aggregate.

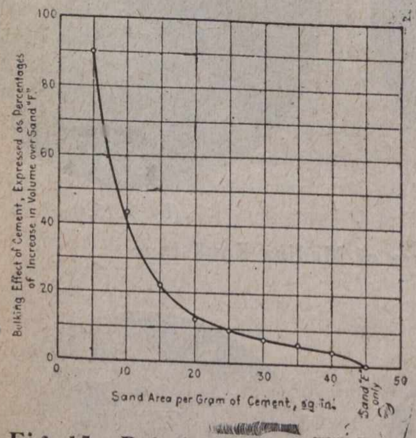

Fig. 15—Relation of Cement Content to Bulk of Mortars—Sand F.

Resistance to Impact. — Hardness, toughness, etc., were roughly tested under the impact of hammer blows, "knob" ends of briquettes and fragments of broken cylinders being used for this purpose. Mortars having an equal cement content in relation to the surface area of the sand aggregate showed a most remarkable uniformity when tested in this rather crude way.

Texture of Mortars.—A careful microscopic examination of the cement matrix of the mortars containing test sands *A* to *I*, inclusive, proportioned as indicated in Table VII., showed, in all cases, an equal uniformity of distribution. In a comparison of mortars containing a less proportion of cement in relation to the surface area of the aggregate this condition was found to be equally true.

Fig. 17 shows photomicrographs (× 20) of the fractured surfaces of mortars, proportioned 1 g. cement to 13 sq. in. sand area, in which the sands are of distinctly different granulometric composition.

Fig. 18 shows four photomicrographs (× 20) of fractured surfaces of mortars varying in their cement content as follows: 1 g. cement to 5, 15, 25 and 35 sq. in sand area. The specimens for photographing were taken from the mortar cylinders shown in Fig. 14. The decrease in the quantity of the cement matrix is readily recognizable by the decrease of matrix adhering to the particles of sand aggregate.

It is of special interest to note that, although the first-mentioned mix contained, by weight, a greater quantity of cement than of sand aggregate, and, although the cement matrix may be said to "thoroughly envelop" the particles of the aggregate, it nevertheless contains myriads of minute voids which are probably of water origin.

Fig. 19 shows photomicrographs (× 20, × 75) of Medina sandstone. The comparatively small amount of cementing material holding the particles of sand in place is of special interest.

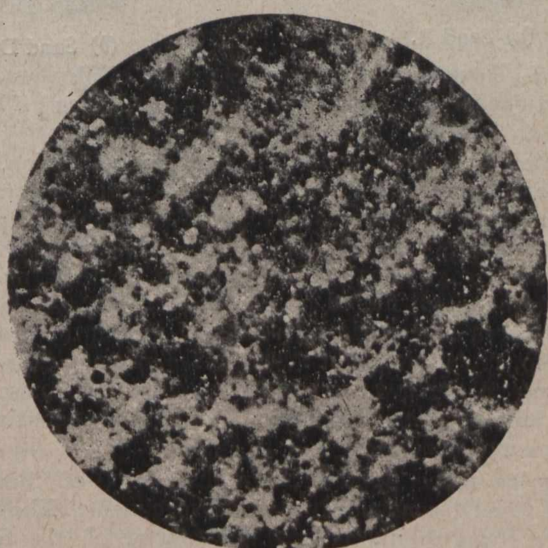

Fig. 16—Texture of Fractured Surface of Neat Cement Briquette (× 75)

Effect of Excess Water.—The proper function of the water content of a mortar mix is to combine with the cement in producing the pasty matrix which, when set, binds the particles of the aggregate into a uniformly strong, stone-like material. The addition of a comparatively small quantity of water in excess of that required for the fulfillment of its proper function produces a very marked effect upon the structure of the cement matrix.