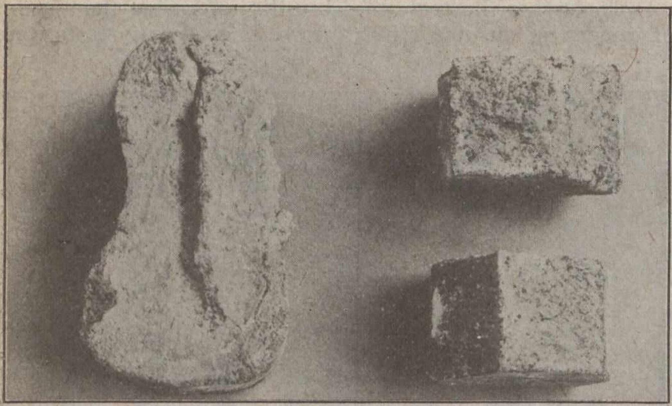
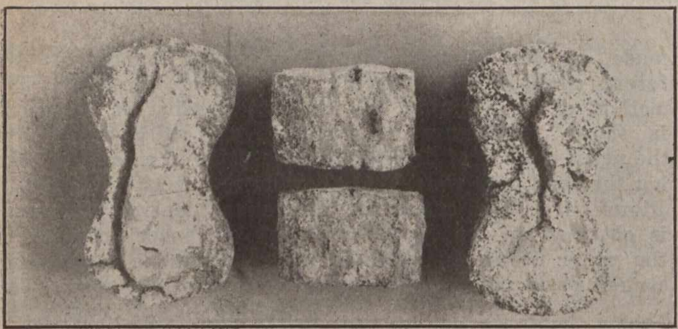
the sand. This water must necessarily occupy space in the set mortar. It is obvious therefore that the amount of cement paste which can be added to a sand without increasing the volume of the sand is very small, and in a case where we have present in the sand a



ACTION OF A 10% SOLUTION OF MAGNESIUM SULPHATE ON No. 12 MORTAR

1:3 mortar treated with 1 per cent. Al_2SO_4 and 1 per cent. soap. Cured 24 hours in moist closet.

considerable quantity of dust of a degree of fineness equal to that of cement, it is impossible to add any paste at all without increasing the volume of the sand. That there is no sharp and definite point at which the voids are just filled with cement paste would seem to be shown by actual



ACTION OF A 10% SOLUTION OF MAGNESIUM SULPHATE ON No. 14 MORTAR

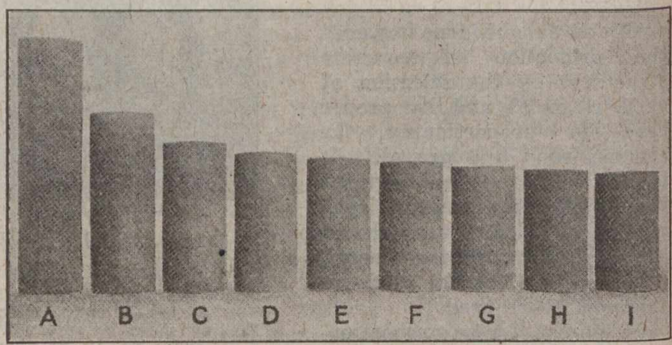
1:3 mortar treated with 1 per cent. Al_2SO_4 and 7 per cent. soap. Cured 24 hours in moist closet.

test; or if there is one, it is extremely hard to find, and even if found its position would depend on so many variables that it is not worth finding.

Figure 5 shows actual results of tests on the densities of mortars. Referring to the curve for mortars with the sand considered in Figure 1, that is McCorkell Pit sand, it will be seen that instead of the voids being filled at proportions 1:3.76 the density is approximately 71%, or the voids are 29%, so that by the addition of cement paste we have succeeded in reducing the voids by only one per cent. It is therefore impossible to do much void filling with this sand. On this same sketch the curves for sands of several other granulometric compositions are shown. The voids by water settlement in these sands were as below:—

Indian Bay sand 36%
Ottawa sand 36%
McCorkell Pit sand 30%
Lake Francis sand 32%

If we were to base the amount of cement used on the percentage voids in these sands, we would expect to be able to add more paste to the Indian Bay sand than to the Lake Francis material. But that exactly the opposite is the case is shown by the curves. The latter material is a very coarse sand and the former is a medium sand or plaster sand. Whether voids can be filled or not will therefore depend more on the actual size of the individual voids than on the total percentage voids in a sand. Taking an extreme case, in sands of extreme fineness the total percentage voids is high, but the voids are so minute that cement paste cannot be made to enter them. The result of the addition of cement paste to relatively fine sands is merely to replace a given bulk of the sand by the same bulk of paste and no void-filling results. The particles of void-filling material must also be smaller than the individual voids, but the finer the material the more water required to gauge it. The use of void-filling materials as such is very limited indeed and a very small amount of these void fillers actually serve the purpose for which they are intended. The fact



THE BULKING EFFECT OF MORTARS—EXPERIMENT BY CAPT. L. N. EDWARDS

Grams cement to sq. in. sand area:
(a) 1:5 (d) 1:20 (g) 1:35
(b) 1:10 (e) 1:25 (h) 1:40
(c) 1:15 (f) 1:30 (i) original sand

that these fine powders cannot be forced into the minute voids, but must be floated into space, greatly reduces their effectiveness. "The Bulking Effect of Mortars," republished from a paper by Capt. Edwards, of Toronto, bears out the density curves in Figures 5. As he points out in his Specimen (i) he has used only enough cement to hold the particles of sand in cylindrical form and the addition of a little more cement results in an increase in the volume of the mortar. He points out that there is no marked change in the increment of increase of volume due to the cement content exceeding the voids in the sand. The flatness of the curve from 1:2 to 1:6 proportions for all the sands in Figure 5, bears out his contention.

One hears a great deal of talk about securing mixtures of maximum density. But it is worthy of note that as the cement content of the mortars (Figure 5) is increased, the density decreases, cement itself having a very low density. 47% of the bulk of set neat cement being water and air.

STRENGTH TESTS: COMPOSITION OF MORTARS—TEST SERIES NO. 1
CEMENT, 1 G.: 13 SQUARE INCHES
(From article by Capt. L. N. Edwards)

Sand Letter	Surface per 1,000 gms. sq. in.=S	Water to Gauge the Sand $=\frac{S}{210}$	Cement By Wt. gms.	Cement By Vol. ccs. C	Water for Mortar ccs. =M	Ratio of Cement to Aggreg. by Wt.	$\frac{Water}{Cement}$ Ratio $=\frac{M}{C}$
A	5,857	28.0 ccs.	450.5	299	128	1: 2: 22	.428
B	5,106	24.4 "	392.0	260	111.5	1: 2: 55	.429
C	7,864	36.6 "	591.0	392	168.0	1: 1: 69	.429
D	6,758	32.2 "	520.0	345	148.0	1: 1: 92	.429
E	12,816	61.2 "	986.0	654	280.5	1: 1: 12	.429
F	6,769	32.3 "	521.0	345	148.0	1: 1: 92	.429
G	4,182	19.9 "	321.5	213	91.5	1: 3: 11	.430
H	6,565	31.3 "	505.0	335	143.5	1: 1: 98	.428
I	6,565	31.3 "	505.0	335	143.5	1: 1: 98	.428