The securing of a mortar of maximum absolute density is not greatly to be desired since we can secure a higher density in many cases from sand alone, or aggregate alone than we obtain when cement is mixed with these materials. In comparing densities of mixtures it is essential that they be compared for the same cement content.

The difficulty of securing reliable results in density tests can be realized from the fact that for any given

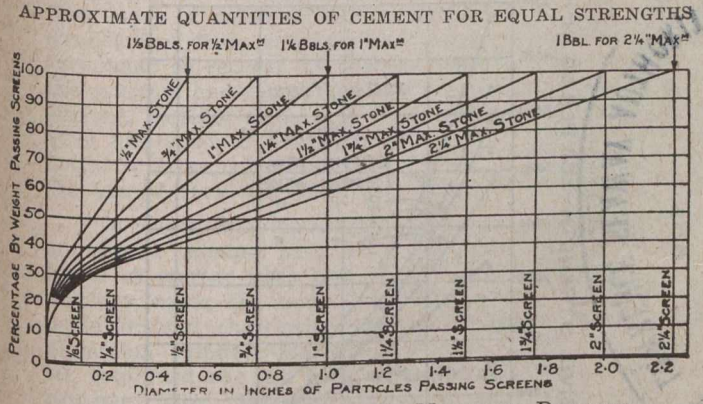

FIG. 1—FULLER'S CURVES FOR MAXIMUM DENSITY

mortars the amount of water used and the method of placing will greatly affect the position of the points on the density curve, the wetter mixes having a lower density. Cement will take up different percentages of water. The amount of water taken up by the sand also varies. If one attempts to make mixtures all of the same consistency, extreme difficulty is experienced in comparing the rich mixes with the very lean mixes. The absence of paste in a lean mix necessitates the addition of considerable water to make the mix workable, resulting in oversaturating both the cement and the sand, and when the mix settles a large quantity of

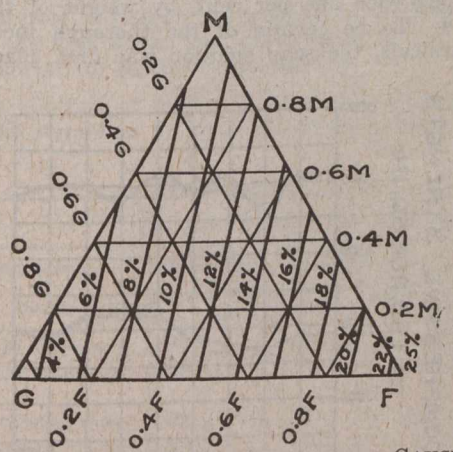

FIG. 2—PERCENTAGE OF WATER REQUIRED TO GAUGE GROUND QUARTZ SAND OF ALL GRANULOMETRIC COMPOSITIONS—FERET'S TRIANGLE

Large grains	G	passing	screen	of	5	meshes	per	linear	inch.
" "	"	retained on	"	"	15	"	"	"	"
Medium "	M	passing	"	"	15	"	"	"	"
" "	"	retained on	"	"	46	"	"	"	"
Fine "	F	passing	"	"	46	"	"	"	"

water is thrown off, but also a considerable quantity of water is held in the mix over what is actually needed to gauge the cement and sand, resulting in a reduction in the density of the mixture.

Figure 6 shows the mechanical analysis of sands used in Series I. of tests made in the water district's laboratory on concrete disintegration in alkali waters.

This series was made up with the object of finding what effect concentrated alkali solutions had on freshly made mortar and also after same mortar was steam treated.

A series of briquettes was made from sands of different grading and chemical nature in the form of 1:2 and 1:3 mortars. One set of these mortars was cured 24 hours in a moist closet and a second set was steamed 48 hours at 150°F. in a boiler for testing cement pats. After curing in the above manner, briquettes were placed in the following solutions: (1) Distilled water; (2) tap water; (3) 10% $MgSO_4$; (4) 10% Na_2SO_4. These briquettes were removed

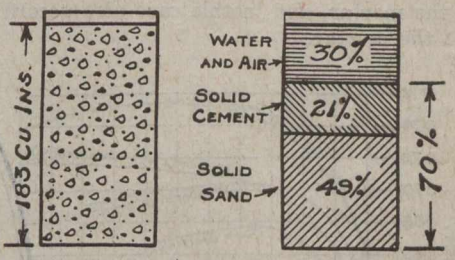

FIG. 3—TYPICAL CALCULATION FOR ABSOLUTE DENSITY OF A MORTAR (MORTAR 1:2)

Cement	4,500 lbs.	Wt. of mould	= 0 lbs. 7¾ oz.
Sand	9,000 "	Mould + mortar	= 14 lbs. 15 oz.
Water to gage mix	1,665 "	Mortar	= 14 lbs. 7¼ oz. = 14.454 lbs.
Total	15,165 lbs.		

MATERIAL IN THE MOULD

Cement	4.29 lbs.
Sand	8.57 "
Water	1.59 "
Total	14.45 lbs.

Specific gravity of sand = 2.65, 1 cu. ft. of solid sand = $62.4 \times 2.65 = 165$ lbs.

Specific gravity of cement = 3.10, 1 cu. ft. of solid cement = $62.4 \times 3.10 = 193$ lbs.

$$\text{Absolute vol. of sand} = \frac{8.57 \times 1728}{165} = 89.7 \text{ cu. ins.}$$

$$\text{Absolute vol. of cement} = \frac{4.29 \times 1728}{193} = \frac{38.4}{128} \text{ cu. ins.}$$

Actual vol. of set mortar = 183 cu. ins.

$$\text{Absolute density} = \frac{128}{183} = .700.$$

Absolute voids = 100—70 = 30 per cent. water + air.

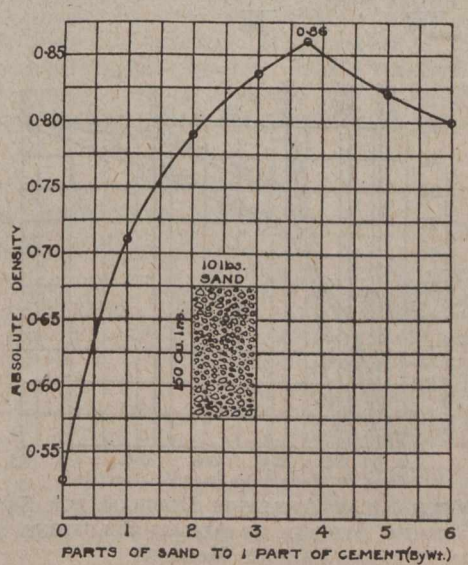

FIG. 4—THEORETICAL DENSITY OF MCCORKEL PIT SAND MORTARS

Voids by water settlement = 30 per cent.; 1 cu. ft. cement paste assumed to require 102 lbs. dry cement. This impossible curve is drawn only to illustrate the absurdity of proportioning a mortar by the "void-filling" theory.

VOID DETERMINATION

Weight of sand = 10 lbs.
Volume of sand after settlement = 150 cu. ins.

$$\text{Absolute volume of the sand} = \frac{10 \times 1728}{165} = 105 \text{ cu. ins.}$$

Absolute density 105/150 = 70 per cent.
Voids 100—70 = 30 per cent.
102 lbs. cement give 1,728 cu. ins. of paste.

$$\text{Cement to fill voids} = \frac{45 \times 102}{1728} = 2.66 \text{ lbs.}$$

Therefore voids should be filled at proportion of cement to sand 266 lbs. : 10 lbs., or 1 : 3.76.