Mortar Proportioning, Mixing and Molding.—Proportioning the cement content of a mortar in relation to the surface area of the sand used is in no way directly comparable with the commonly used method of proportioning by volume the quantities of cement and sand. A "standard" 1:3 Ottawa sand mortar, as used in cement testing, was computed to contain 1 g. cement to 13 sq. ins. of surface area. This ratio or proportion was used in many of the tests.

The computed relation of the cement content to the surface areas of several sands assumed to be combined in mortars of 1:1½, 1:2, 1:2½, etc., mix by volume gave a suggestion as to the range of cement content to be used in tests intended to show the relation of strength to the surface area assumed to be covered per unit of weight of cement. This led to the adoption of the proportions, 1 g. cement to 10, 15, 20 and 25 sq. ins. of surface area for such tests.

All mixing of mortar and molding of test specimens was in accord with the Standard Specifications and Tests for Portland Cement and Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars of the Society for Testing Materials. The consistency of mix used was determined by special investigation. See "Mortar Consistency Tests."

Concrete Proportioning, Mixing and Placing.—The materials for concrete were proportioned as follows:

Cement, 21.12 lbs. per 1,000 sq. ft. of surface area of sand aggregate (1 g. cement to 15 sq. ins. area). For the portion of sand passing a No. 100 sieve the surface area was assumed to be the same as that of an equal portion of material passing a No. 80 and retained upon a No. 100 sieve.

Sand and stone aggregates, 1 part sand to 2 parts stone by volume.

In order to secure greater uniformity these volumes were reduced to a unit weight basis. These unit weights were as follows:

1 cu. ft. sand assumed at 100 lbs.
1 cu. ft. stone assumed at 87 lbs.
1 cu. ft. water assumed at 62.37 lbs.

The water content of the mix was sufficient to produce a saturated, sticky, semi-plastic mortar showing no free water.

It will be noted in the above that in the proportioning of the cement content of the mix no account was taken of the surface area of the stone aggregate. At the time of making the test specimens the approximate areas of broken stone and gravel aggregates had not been determined.

The concrete was mixed by hand. The cement and sand were first incorporated to form a mixture of uniform color. Water was then added to form a mortar, into which the broken stone, after it had been surface moistened, was shoveled and the mixing of the entire mass continued until the particles of stone aggregate were thoroughly coated with mortar.

In the puddling of the concrete in the forms special attention was given to the uniform distribution of the broken stone and mortar. Bars having a diameter of 5/16 to ⅜ in., flattened to form a comparatively thin blade-like end, were used to secure this distribution. Compacting and the exclusion of entrapped air were mainly accomplished by lightly tapping the exterior surface of the forms with a wooden mallet.

From the excess concrete remaining from each batch after the 6-in. cylinder forms were filled, an amount of mortar sufficient to fill twelve 2-in. cylinder molds was secured. The larger stone particles of the concrete were removed by screening upon a ⅜-in. screen.

The forms were removed from the test specimens 48 hours after filling. As soon as removed from the forms the concrete test specimens were marked for identification and placed in storage, where they were moistened three times per day by spraying, until required for testing. The mortar cylinders, upon their removal from the molds, were immersed in water.

Table V.—Grading of Test Sands

Sieve Passed and Retained on.	Percentage Retained on Sieve. Sand Letter.																
	A	B	C	D	E	F	G	H	I	J		L	M	N	O	P	Q
P 4 - R 8	15.0	25.0	5.0	25.0	0.0	10.0	30.0	0.0	0.0	8.0	10.0	15.0	8.0	14.0	11.0	11.0	9.5
P 8 - R 10	5.0	5.0	5.0	5.0	0.0	5.0	5.0	10.0	10.0	5.0	6.5	7.0	3.0	8.0	5.0	5.5	5.0
P 10 - R 20	25.0	23.0	15.0	15.0	0.0	18.0	30.0	25.0	25.0	22.0	16.0	22.0	11.5	21.0	16.0	18.0	19.0
P 20 - R 30	15.0	12.0	15.0	5.0	0.0	11.5	15 0	20.0	20.0	10.0	7.0	12.0	7.0	8.0	10.5	13.0	14.5
P 30 - R 40	15.0	15.0	15.0	5.0	0.0	18.0	10.0	15.0	15.0	14.0	16.5	14.0	10.5	12.5	15.5	16.0	20.5
P 40 - R 50	10.0	8.0	20.0	20.0	36.0	21.0	4.0	15.0	15.0	20.5	21.0	15.0	26.0	15.5	18.0	15.0	18.0
P 50 - R 80	10.0	8.0	20.0	20.0	52.0	15.0	4.0	10.0	10.0	20.0	21.5	13.0	32.0	19.0	20.0	15.5	12.0
P 80 - R 100	5.0	4.0	5.0	5.0	8.0	1.5	2.0	5.0	0.0	1.5	2.0	1.0	2.5	2.0	2.0	4.0	1.0
P 100	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	101.0	100.5	99.0	100.5	100.0	100.0	101.0	100.0

Mortar Consistency Tests

The marked influence of the consistency of the mix upon the ultimate strength of mortars renders it especially important that test mortars be made of uniform consistency. The importance of this investigation as a preliminary to the making of tests tending to prove or disprove the validity of the primary theory of the surface-area method of proportioning, is self-evident. Tests were therefore made with the object of developing a means of securing uniformity of consistency in accord with the secondary or consistency theory of this method of proportioning; that is, "The amount of water required to produce a normal, uniform consistency of mortar is a function of the cement and of the surface area of the sand aggregate to be wetted."

It is useless to even outline the preliminary tests made: suffice it to say that only trial or so-called "cut and fit" methods were found to be applicable. As a result of the preliminary tests it was found that "normal," uniform consistency mortars of varying cement content and of varying sand gradings were produced when the quantity of water used in the mix was made equal to (1) that required to reduce the cement to a normal consistency