In making field tests by the above described method of different samples of sand, use that which shows the least percentage of voids.

Wash 100 c.c. of the sand in 100 c.c. of water by shaking together in a bottle, decant water into a graduated glass tube; again wash sample as before and decant water into the glass tube, stand until settled and read amount of clay or loam.

Table 1.

100 C. C. Dry Sand Added to 100 C. C. Water.
(C.C. Stands for Cubic Centimeter.)

Water rose to	Sand Swelled in Volume to Following c.c.														
	100 Constant	101	102	103	104	105	106	107	108	109	110	111	112	113	114
	Percentage of working voids.														
150	50	50^{5}	50^{9}	51^{4}	51^{9}	52^{4}	52^{8}	53^{3}	53^{7}	54^{1}	54^{5}	55	55^{3}	55^{7}	56^{1}
151	49	49^{5}	50	50^{5}	51	51^{4}	51^{9}	52^{3}	52^{8}	53^{2}	53^{6}	54	54^{4}	54^{8}	55^{2}
152	48	48^{5}	49	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{9}	52^{3}	52^{7}	53^{1}	53^{6}	53^{9}	54^{3}
153	47	47^{5}	48	48^{5}	49	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{8}	52^{3}	52^{6}	53	53^{5}
154	46	46^{5}	47^{1}	47^{6}	48	48^{5}	49^{1}	49^{5}	50	50^{5}	50^{9}	51^{4}	51^{7}	52^{2}	52^{6}
155	45	45^{5}	46^{1}	46^{6}	47^{1}	47^{6}	48^{1}	48^{6}	49^{1}	49^{5}	50	50^{4}	50^{8}	51^{3}	51^{7}
156	44	44^{5}	45^{1}	45^{6}	46^{1}	46^{7}	47^{2}	47^{7}	48^{1}	48^{6}	49^{1}	49^{5}	50	50^{4}	50^{8}
157	43	43^{5}	44^{1}	44^{6}	45^{1}	45^{7}	46^{2}	46^{7}	47^{2}	47^{7}	48^{2}	48^{6}	49^{1}	49^{5}	50
158	42	42^{5}	43^{1}	43^{7}	44^{2}	44^{7}	45^{3}	45^{8}	46^{3}	46^{8}	47^{3}	47^{7}	48^{2}	48^{6}	49^{1}
159	41	41^{5}	42^{1}	42^{7}	43^{3}	43^{8}	44^{3}	44^{9}	45^{4}	45^{9}	46^{4}	46^{8}	47^{3}	47^{7}	48^{2}
160	40	40^{5}	41^{2}	41^{7}	42^{3}	42^{8}	43^{4}	43^{9}	44^{4}	44^{9}	45^{5}	45^{9}	46^{4}	46^{9}	47^{3}
161	39	39^{5}	40^{2}	40^{8}	41^{3}	41^{9}	42^{4}	43	43^{5}	44	44^{5}	45	45^{5}	46	46^{4}
162	38	38^{6}	39^{2}	39^{8}	40^{4}	40^{9}	41^{5}	42^{1}	42^{5}	43^{1}	43^{6}	44^{1}	44^{6}	45^{1}	45^{6}
163	37	37^{6}	38^{2}	38^{8}	39^{4}	40	40^{6}	41^{1}	41^{6}	42^{2}	42^{7}	43^{2}	43^{6}	44^{2}	44^{7}
164	36	36^{6}	37^{3}	37^{9}	38^{5}	39	39^{6}	40^{2}	40^{7}	41^{3}	41^{8}	42^{3}	42^{8}	43^{3}	43^{8}
165	35	35^{6}	36^{3}	36^{9}	37^{5}	38	38^{7}	39^{2}	39^{8}	40^{4}	40^{9}	41^{4}	41^{9}	42^{4}	42^{9}
166	34	34^{6}	35^{3}	35^{9}	36^{5}	37^{1}	37^{7}	38^{3}	38^{9}	39^{4}	40	40^{5}	41	41^{5}	42^{1}
167	33	33^{6}	34^{3}	34^{9}	35^{6}	36^{1}	36^{8}	37^{4}	38	38^{6}	39^{1}	39^{6}	40^{1}	40^{7}	41^{2}
168	32	32^{7}	33^{3}	34	34^{6}	35^{2}	35^{8}	36^{4}	37	37^{6}	38^{2}	38^{6}	39^{2}	39^{6}	40^{3}
169	31	31^{7}	32^{4}	33	33^{7}	34^{2}	34^{9}	35^{5}	36^{1}	36^{7}	37^{3}	37^{8}	38^{3}	38^{9}	39^{4}
170	30	30^{7}	31^{4}	32	32^{7}	33^{2}	33^{9}	34^{6}	35^{2}	35^{8}	36^{4}	36^{9}	37	38	38^{6}

That the reader may have confidence in the methods above described in ascertaining the characteristics of sand which will produce maximum density, some of the experiments made by Mr. Moyer and published in the pamphlet heretofore referred to, will be described.

The use of a graduated glass tube of 1½ inches to 2½ inches in diameter containing 200 to 250 c.c. might appear to some engineers as being unreliable on account of the small quantities tested and the probable variation of volume. Also the theory of capillary attraction prying apart the grains of sand of certain characteristics might seem to be unsound, but numerous tests seem to bear out this theory. At any rate

Table 2.

Proportion	100 c.c. Sand gave a Volume of Mortar of	Average 5 Briquettes Tensile Strength 7 days	28 days	Collected on Sieve.	%
1:1½	125 c.c	407	524		
				10	.003
1:1¾	120 c.c.	335	445		
				20	.004
1:2	120 c.c.	275	396		
				30	.01
1:2¼	115 c.c.	277	367		
				50	$.31^{4}$
1:2½	110 c.c.	255	334		
				Through	$.66^{9}$
1:2¾	110 c.c.	211	282		
1:3	110 c.c.	181	255		

$5\frac{6}{16}$ oz. Cement figured as = to 100 c.c. which is in same proportion as 94 lbs.=one cu. ft.

such peculiar characteristics have been noted by a number of engineers, but the writer has not yet run across any other theory which cannot be explained away. Some say that the head of the water used has different effects, that if a larger amount of water was used instead of 100 c.c., the results would be different. The writer, however, has not found this to be a fact and furthermore it would then be difficult to account for the sand which did not swell at all in volume.

Water must be clear, odorless and tasteless. If there is taste or odor, the water must be analyzed, the chemist to advise if there is sufficient percentage of any elements present to be injurious to Portland cement.

The most important ingredient in concrete is Portland cement, as it is this material which forms the bond. The other aggregates being usually stronger, upon the uniform strength of the cement depends the strength of the concrete.

Table 3.

% Voids in Sand.	PROPORTIONS. Figuring actual volume of 1 bbl. cement as packed by Mfgrs. to =3.8 cu. ft. and assuming 1 bag=1 cu. ft.	Proportions to use figuring 1 Bag cement=to 1 cu. ft. Figures are nearest the ¼.	% Voids in Sand.	PROPORTIONS. Figuring actual volume of 1 bbl. cement as packed by Mfgrs. to=3.8 cu. ft. and assuming 1 bag=1 cu. ft.	Proportions to use figuring 1 Bag cement=to 1 cu. ft. Figures are nearest the ¼.
	cu. ft.			cu. ft.	
25	1:3.76	1:3¾	38	1:2.47	1:2½
26	1:3.61	1:3½	39	1:2.41	1:2½
27	1:3.48	1:3½	40	1:2.35	1:2¼
28	1:3.35	1:3¼	41	1:2.29	1:2¼
29	1:3.24	1:3¼	42	1:2.23	1:2¼
30	1:3.13	1:3¼	43	1:2.18	1:2¼
31	1:3.03	1:3	44	1:2.13	1:2¼
32	1:2.93	1:3	45	1:2.09	1:2
33	1:2.85	1:2¾	46	1:2.04	1:2
34	1:2.76	1:2¾	47	1:2	1:2
35	1:2.66	1:2¾	48	1:1.96	1:2
36	1:2.61	1:2½	49	1:1.91	1:2
37	1:2.54	1:2½	50	1:1.88	1:1¾

The selection of stone, screenings, slag, cinders, sand or other ingredients can be determined often by sight or touch, or at least by simple tests. Portland cement tests require experts of some years' experience; the results of known laboratory tests are merely a guide from which deductions may be made only by the best scientific understanding available. Owing to the variable conditions surrounding such tests, the results cannot be absolute.

Each manufacturer exploits his particular brand as the best cement, some claiming extraordinary fine grinding the criterion, others larger bulk per barrel, others low lime content, others high lime content and hard burned clinkers, etc., etc., and all of them claim the strongest by test, which claims they support by various published test sheets.

Table 4.

Weight per Cubic Foot-lbs	Gravel (Pebbles) without Sand	Sandstone	Limestone medium soft	Limestone medium hard; Sandstone hard	Granite Blue stone Limestone hard	Granite hard Trap medium	Trap hard
75	54	50	52	54	—	—	—
80	51	47	49	51	52	—	—
85	48	43	45	48	50	51	—
90	45	40	42	45	47	48	50
95	42	37	39	41	44	46	47
100	39	33	36	38	41	43	45
105	36	30	33	35	38	40	42
110	33	26	29	32	35	37	39
115	30	—	26	29	32	34	36
120	27	—	—	26	29	31	34
125	—	—	—	—	26	28	31
130	—	—	—	—	—	26	28
135	—	—	—	—	—	—	25

There have been carried on a large number of experiments based largely on laboratory methods, which experiments tend to show that 3.8 cu. ft. to the barrel of Portland cement weighing 376 lbs. net, is approximately correct.