

but will be found to be approximately 30 per cent. of the weight of the cement. It should have a temperature of 70 degrees Fahrenheit.

Soundness.—(1) A pat of neat cement $2\frac{1}{2}$ to 3 inches in diameter, $\frac{1}{2}$ -inch thick at centre, tapering to a thin edge, and allowed to take its final set in moist air, must withstand indefinite exposure in water or air at any ordinary temperature without checking, distortion, or softening. (1) The briquette used in testing shall be formed in moulds of the size and form now in customary use and recommended by the American Society of Civil Engineers, the stress to be applied at a uniform rate of 400 pounds per minute until fractured. (2) All briquettes of neat cement are to be made from paste of normal consistency in the following manner: The moulds should be filled with the paste as soon as it is thoroughly mixed and tempered, the material pressed in firmly with the fingers and smoothed off with a trowel without ramming; the material should be heaped up on the upper surface of the mould, and in smoothing off the trowel should be drawn over the mould in such a manner as to exert a moderate pressure upon the excess material. The mould should then be turned over and the operation repeated on the other side. (3) Briquettes for twenty-four-hour tests shall remain in moist air until final set has occurred, then be placed in water for the remainder of period. (4) Briquettes for seven and twenty-eight-day tests shall be allowed to set one day in moist air and remainder of period in water. (5) All briquettes are to remain in the water until they are placed in the testing machine. (6) Neat twenty-four-hour tests shall not show less than 60 pounds per square inch. Neat seven-day tests shall not show less than 100 pounds per square inch. Neat twenty-eight-day tests shall not show less than 150 pounds per square inch, nor less than 25 per cent. above the seven-day test.

The specific gravity, determined upon dried cement which has passed through a No. 100 sieve shall not be less than 2.50 nor more than 2.80. The specific gravity can be conveniently and accurately determined by the use of Le Chatelier's apparatus as recommended by the committee on uniform tests of cements.

If in the tests of any given brand of cement, any sudden, irregular or wide variation from its normal action is found, it should be withheld from use until more extended tests shall have demonstrated its reliability.

Owing to insufficient data, the committee was not prepared to specify a sand test in either class.

Portland Cement Concrete.

Cement shall be Portland, either American or foreign, which will meet the requirements of the standard specifications. Sand shall be clean, sharp and coarse, but preferably of grains varying in size. It shall be free from clay, loam, sticks and other impurities. Stone shall be found, hard and durable, crushed to sizes not exceeding two inches in any direction and freed from dust by screening. Gravel shall be composed of clean pebbles of hard and durable stone, of sizes not exceeding two inches in diameter, free from clay and other impurities except sand. When containing sand in any considerable quantity, the amount per unit of volume of gravel shall be determined accurately to admit of the proper proportion of sand being maintained in the concrete mixture. Water shall be clean and reasonably clear, free from sulphuric acid or strong alkalis.

Mixing by Hand.—(1) Tight platforms shall be provided of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed one cubic yard each, and smaller batches are preferable, based upon a multiple of the number of sacks to the barrel. (2) Spread the sand evenly upon the platform, then the cement upon the sand, and mix thoroughly until of an even color. Add all the water necessary to make a thin mortar and spread again; add the gravel if used, and finally the broken stone, both of which, if dry, should first be thoroughly wet down. Turn the mass with shovels or hoes until thoroughly incorporated and all the gravel and stone is covered with mortar; this will probably require the mass to be turned four times. (3) Another approved method, which may be permitted at the option of the engineer in charge, is to spread the sand, then the cement, then the gravel or broken stone; add water and mix thoroughly as above.

Mixing by Machine.—A machine mixer shall be used wherever the volume of work will justify the expense of installing the plant. The necessary requirements for the machine will be that a precise and regular proportioning of materials can be controlled and the product delivered be of the required consistency and thoroughly mixed. The concrete shall be of such consistency that when dumped in place it will not require much tamping. It shall be spaded down and tamped sufficiently to level off, and will then quake freely, like jelly. (1) Each course should be left somewhat rough to insure bonding with the next course above; and if it be already set, shall be thoroughly cleaned and dampened before the next course is placed upon it. The plane of courses shall be as nearly as possible at right angles to the line of pressure. (2) An uncompleted course shall be left with a vertical joint where the work is stopped. (3) The work should be carried up in sections of convenient length and completed without intermission.

EXPANSION JOINTS.—(1) In exposed work expansion joints shall be provided at intervals of thirty feet to fifty feet. A temporary vertical form or partition of plank shall be set up and the section behind completed as though it were the end of the structure. The partition will be removed, when the next section is begun and the new concrete placed against the old without mortar flushing. Locks shall be provided if directed or called for by the plans. (2) In reinforced or steel concrete the length of these sections may be materially increased at the option of the engineer. Concrete shall be placed immediately after mixing and any having an initial set shall be rejected. About one inch of mortar of the same proportions as used in the concrete may be placed next to the forms, immediately in advance of the concrete, or a shovel facing made, at the option of the engineer in charge.

FORMS.—(1) Forms shall be substantial and unyielding, properly braced or tied together by means of wire or rods. (2) The material used shall be of dressed lumber, secured to the studding or uprights in horizontal lines. (3) Planking once used in forms shall be cleaned before being used again. (4) The forms must not be removed within forty-eight hours after all the concrete in that section has been placed. In freezing weather they must remain until the concrete has had a sufficient time to become thoroughly set. (5) In dry but not freezing weather, the forms shall be drenched with water before the concrete is placed against them. (6) For backings, undressed lumber may be used for forms.

FINISHING.—(1) After the forms are removed, any small cavities or openings in the concrete shall be neatly filled with mortar if necessary. Any ridges due to cracks or joints in the lumber shall be rubbed down; the entire face shall then be washed with a thin grout, of the consistency of whitewash, mixed in the proportion of one part of cement to two parts of sand. The wash should be applied with a brush. (2) The tops of bridge seats, pedestals, copings, wing walls, etc., when not finished with natural stone coping, shall be finished with a smooth surface composed of one part cement to two parts of granite, or other suitable screenings, or sand applied in a layer 1 to $1\frac{1}{2}$ inches thick. This must be put in place with the last course of concrete. (3) In arch tops, a thin coat of mortar or grout shall be applied over the top to thoroughly seal the pores.

STRUCTURE.	PARTS BY VOLUME.			
	Cement.	Sand.	Gravel.	Broken Stone.

The proportion of the materials in the concrete shall be as specifically called for by the contract, or as set forth herein, upon the lines left for that purpose; the volume of cement to be based upon the actual cubic contents of one barrel of speci-

weight