The following are the usual tests applied, and they are in some instances unreliable.

(*a*) For fineness by sifting and residue. The importance of having cement finely ground is generally acknowledged as a concomitant to a test for weight. Imperfect calcination or an excess of lime, or an incomplete light cement would, however, be more easily pulverized and would give a finer test from less grinding.

(*b*) For strength by breaking or a certain resistance to tensile strain. The test from briquettes after having been set seven days will be in favor of quick induration, which is in itself objectionable; extend the time to four weeks, the test will be found more reliable. If the cement is coarsely ground, considered comparatively, the tests will be equally good, yet coarsely ground cement is objectionable. Again, a small excess of lime will not affect the maximum strain in the machine, still the excess of lime may be injurious.

(*c*) For weight. Weight, specific gravity, and color are important elements. Until the same mode of ascertaining the weight is more generally adopted, or a more universal means is established so as not to be affected by the question as to whether the cement was more or less compact in the measure, the present means of testing will be unreliable for comparison.*

* Vide remarks of Mr. F. I. Brunwell, p. 136, 137, vol. 25 Trans. Inst. C. E.

(*d*) Immersion in water. By making two parts of cement paste, one to be put in water, the other to be set in the open air. If there is an undue quantity of clay, the cake put in water will assume a buff color. If there is too much chalk or if it is overburnt to the point of danger, cracks will be visible round the edge of the cake in the air. There must, however, be quite an excess of one or the other before these tests will be noticeable.

It has been frequently alleged by manufacturers and others that Portland cement can be made to pass all these tests and yet may have an excess of lime or sulphate of lime, and afterwards prove to be dangerous. However, enough is now known of the qualities of Portland cement, as well as its manufacture and behavior under different conditions, to direct the engineer in its application under the varying circumstances that may arise in the course of his practice. But it occurs to the author, as it has no doubt to several others, that in case of emergency a more practical and reliable test than any now available is necessary to enable the purchaser to arrive at least at a more approximate value of Portland cement, and here chemical tests suggest themselves. Mr. Henry Reid gives a chemical analysis for a good average Portland cement, capable of passing the following six tests, viz.,—weight 112 lbs. per imperial bushel, strength 300 lbs. tensile per sq. inch, texture 2500 atoms or a sieve (50 guage) to a square inch, hydraulicity, after six days immersion perfect without crack or fracture, color by an air sample grayish blue or steel grey. Such a quality of cement would produce with a moderate divergence of range the following analysis of the main ingredients:—

Lime	60.05
Magnesia	1.17
Alumina	10.84
Silica	24.31
Alkalies	1.54

Adopting the above or the best standard, the skilful chemist might determine practical tests for excesses or injurious ingredients, which are generally beyond the province of the otherwise actively employed engineer. For emergency, some more practical test than any at present available is required.

Passing over results 1 and 2, and taking 3 and 4 as factors determining measure of admixture, and adopting the theory of all good concrete, which is to coat every particle of stone and gravel with a film of the cement, the deduction from the theory would be that the more intimate the union the more perfect would be the concrete resulting from the combination, and since in a perfect Portland cement the admixture of lime and clay (3) with neat cement is stronger than an admixture with sand, it follows that the more cement is employed, the stronger and better the concrete.

Next taking result (4) cement mixed with an equal quantity of sand is $\frac{7}{8}$ of the strength of neat cement, with 2 parts $\frac{1}{2}$ the strength, with 3 parts of sand $\frac{1}{3}$ of the strength, and with 4 parts of sand $\frac{1}{4}$, but with 5 parts of sand it is about $\frac{1}{5}$ of the strength of neat cement. It would appear that the proportions are maintained up to the intermixture with four parts of sand, but very perceptibly loses with a greater or fifth measure, and this fourth intermixture is practically a proper limit. Fine concrete for external employment in this climate should not be more than three or four parts of gravel to one of cement. With this proportion a coat of solid lime will be deposited round each grain of sand and gravel. When freshly mixed each particle will be embedded in a saturated solution. If three to one and fine sharp sand is used,