phate, and also that the capacity of resistance to the effects of the boiling water was strengthened in the same manner. So we find that in this particular case the addition of 3 per cent. sulphate of lime made the cement acceptable according to the prescribed standard of tests. If the cement then were accepted and used it may be subject to one of three causes for disintegration. If too new, or if over-limed, or if under-burnt, in either case the damaging effect of the free lime is only suspended, its time of action only retarded. If carbonate of lime had been added instead, the effects are the same, except that the disruptive elements in the cement may not show themselves for a year or more after being made, so slow is their development.

The detection of over-limed cements is often attempted by taking the increase in temperature during setting. This is a certain test provided the cement has not been "doctored," when the test fails, and the effect of the over-liming is retarded for weeks or perhaps months, but is almost sure to make the finished work unsound. In one case, where the temperature rose 23 degrees in five minutes the addition of only 2 per cent. of the sulphate so changed the action that the rise in temperature was only 1 degree in fifteen minutes. It seems then, certain that under present conditions of manufacture the rise in temperature and boiling water tests do not ensure a sound cement. Again, the tests for tensile strength show the progressive action of the sulphate of lime in imparting what may prove to be a meretricious strength to the cement, with a corresponding deception to the user.

In all the voluminous literature on cements, references to this branch of the subject are meager and unsatisfactory, some of them being positively erroneous. For instance, in a book on engineering construction by a well known engineer of reputation, and much used as a text book, the statement is made that sulphate of lime quickens the setting time of cements. The theory that plaster of Paris, being a quick setting material, imparts this property to what it is mixed with, seems plausible, but is denied by experiment. Why this is true seems so far to be unknown. The conclusion is also indicated that an unusually high tensile strength at an early period is a suspicious rather than a meritorious circumstance. In this connection, however, it should be remembered that almost all investigations in connection with cements have been and are being made by chemists in the employ of various cement manufacturing companies, and the information gained by each is carefully guarded by their employers as part of their stock in trade, not to be imparted to their rivals or customers. The benefits of the impartial and independent investigations of the properties of the constituents of asphalt pavements, as carried on by the city laboratories of Washington, Brooklyn and others, are well known and appreciated by the members of this society, and similar work and publications from the same sources on cement would be equally valuable. The competition among manufacturers to produce cements of high tensile strength has, I believe, deceived engineers into raising their requirements to correspond, until the danger line has been passed. One city has been raising the standard each year for a number of years, and parades this before the world as a virtue; but the manufacturer simply winks the other eye and produces a cement to correspond. The composition of cements and method of production are not now so different from ten years ago that a cement honestly and naturally made from the same rock and clay as then will now show double the tensile strength legitimately.

Authorities, what few there are, are much at variance about the amount of sulphate of lime permissible in Portland cements before injury is worked, one insisting on a limit of 1½ per cent., while another claims that 8 per cent. is allowable, with various other opinion in between, until the practicing engineer feels pretty much at sea in the matter. He is probably safe in adopting the minimum requirement, but with the risk of ruling out many good cements which overstep that limit, for it is possible that a safe amount in one cement might be injurious to another. But the worst feature is in the capacity of the sulphate to conceal bad qualities in cements totally disconnected with the sulphate itself. The question that confronts him is, where shall he take his stand, and what can he do to protect himself and his work? What benefit is it for him to undertake a tedious and possibly expensive quantitative analysis of each sample, if a permissible limit cannot be decided upon, beyond which rejection shall be obligatory? It might be suggested that the minimum proportion of sulphate of lime allowed should not be so great as to prevent "blowing" under the boiling water test, if the cement be so constituted as to fail under this test. This rule would seem to place the limit at about 2 per cent., and it might well be less.

If it would be possible to decide this point, and then prescribe one or more tests that would be adequate, easily performed and inexpensive, certainly a great stride forward would be made toward insuring good work of reliable duration. But as the matter now stands, such tests as it is now customary to prescribe in specifications, fail to assure the engineer sufficient guaranty that his work will endure the test of time and the elements. The idea of a rough and ready test for sulphate and carbonate of lime has taken form out of some of our laboratory experiments, and may briefly be stated as follows:

After first trying the boiling test (for if the cement fails under this it is rejected by the terms of the specifications anyway), dissolve a portion of the sample in diluted hydro-chloric acid, when, if carbonate of lime be present, a strong effervescence of carbonic acid gas will take place; and as the carbonate should never be present in any good cement, sufficient grounds for rejection are found at once. The solution should be perfect, though it need not be absolutely clear; and if there be a residue on the bottom of the glass there is a strong suspicion of adulteration. If, however, nothing suspicious be found so far, the solution may be filtered and boiled, and a small quantity of barium chloride added, which will, if sulphate of lime be present, cause a precipitate which can be taken as a measure of the sulphate for comparative purposes. In order to have a standard for comparison let a competent chemist take a sample of cement known to be reliable and accurately determine the percentage of calcic sulphate, if any, and then add enough to bring it up to the allowable limit, say 2 per cent. Then the quantity of the precipitate under barium chloride may be preserved by sealing the beaker; and if all future tests are made with the same quantity by weight of cement in the same size of beaker, a visual comparison can be made with the prepared standard close enough for practical purposes.

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