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\*An asterisk precedes the references which are especially noteworthy.

## APPENDIX I

**METHOD SUGGESTED FOR THE ANALYSIS OF LIMESTONES, RAW MIXTURES, AND PORTLAND CEMENTS BY THE COMMITTEE ON UNIFORMITY IN TECHNICAL ANALYSIS OF THE AMERICAN CHEMICAL SOCIETY, WITH THE ADVICE OF W. F. HILLEBRAND.**

**Solution:** One-half gram of the finely powdered substance is to be weighed out and, if a limestone or unburned mixture, strongly ignited in a covered platinum crucible over a strong blast for 15 minutes, or longer if the blast is not powerful enough to effect complete conversion to a cement in this time. It is then transferred to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, moistened with enough water to prevent lumping, and 5 to 10 c. c. of strong HCl added and digested, with the aid of gentle heat and agitation, until solution is completed. Solution may be aided by light pressure with the flattened end of a glass rod.\* The solution is then evaporated to dryness, as far as this may be possible on the steam bath.

**Silica:** The residue, without further heating, is treated at first with 5 to 10 c. c. of strong HCl which is then diluted to half strength or less, or upon the residue may be poured at once a larger volume of acid of half strength. The dish is then covered and digestion allowed to go on for 10 minutes on the bath, after which the solution is filtered and the separated silica washed thoroughly with water. The filtrate is again evaporated to dryness, the residue, without further heating, taken up with acid and water and the small amount of silica it contains separated on another filter paper. The papers containing the residue are transferred wet to a weighed platinum crucible, dried, ignited, first over a Bunsen burner until the carbon of the filter is completely consumed, and finally over the blast for 1 minute and checked by a further blasting for 10 minutes or to constant weight. The silica, if great accuracy is desired, is treated in the crucible with about 10 c. c. of HCl and four drops of  $H_2SO_4$  and evaporated over a low flame to complete dryness. The small residue is finally blasted, for a minute or two, cooled and weighed. The difference

\*If anything remains undecomposed it should be separated, fused with a little  $Na_2CO_3$ , dissolved and added to the original solution. Of course a small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

between this weight and the weight previously obtained gives the amount of silica.\*

$\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$ : The filtrate, about 250 c.c., from the second evaporation for  $\text{SiO}_2$ , is made alkaline with  $\text{NH}_4\text{OH}$  after adding  $\text{HCl}$ , if need be, to insure a total of 10 to 15 c.c. strong acid, and boiled to expel excess of  $\text{NH}_3$ , or until there is but a faint odor of it, and the precipitated iron and aluminum hydrates, after settling, are washed once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate is dissolved in hot dilute  $\text{HCl}$ , the solution passing into the beaker in which the precipitation was made. The aluminum and iron are then re-precipitated by  $\text{NH}_4\text{OH}$  boiled, and the second precipitate collected and washed on the same filter used in the first instance. The filter paper, with the precipitate, is then placed in a weighed platinum crucible, the paper burned off and the precipitate ignited and finally blasted 5 minutes, with care to prevent reduction, cooled and weighed as  $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ .†

$\text{Fe}_2\text{O}_3$ : The combined iron and aluminum oxides are fused in a platinum crucible at a very low temperature with about 3 to 4 grams of  $\text{KHSO}_4$ , or, better,  $\text{NaHSO}_4$ , the melt taken up with so much dilute  $\text{H}_2\text{SO}_4$  that there shall be no less than 5 grams absolute acid and enough water to effect solution on heating. The solution is then evaporated and eventually heated till acid fumes come off copiously. After cooling and redissolving in water the small amount of silica is filtered out, weighed, and corrected by  $\text{HFl}$  and  $\text{H}_2\text{SO}_4$ .‡ The filtrate is reduced by zinc, or preferably by hydrogen sulphide, boiling out the excess of the latter afterwards while passing  $\text{CO}_2$  through the flask, and titrated with permanganate.§ The strength of the permanganate solution should not be greater than .0040 gr.  $\text{Fe}_2\text{O}_3$  per c.c.

$\text{CaO}$ : To the combined filtrate from the  $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$  precipitate a few drops of  $\text{NH}_4\text{OH}$  are added, and the solution brought to boiling. To the boiling solution 20 c.c. of a saturated solution of ammonium oxalate is added, and the boiling continued until the precipitated  $\text{CaC}_2\text{O}_4$  assumes a well-defined granular form. It is then allowed to stand for 20 minutes,

\*For ordinary control work in the plant laboratory this correction may, perhaps, be neglected, the double evaporation never.

†This precipitate contains  $\text{TiO}_2$ ,  $\text{P}_2\text{O}_5$ ,  $\text{Mn}_2\text{O}_3$ .

‡This correction of  $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$  for silica should not be made when the  $\text{HFl}$  correction of the main silica has been omitted, unless that silica was obtained by only one evaporation and filtration. After two evaporations and filtrations 1 to 2 mg. of  $\text{SiO}_2$  are still to be found with the  $\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ .

§In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

or until the precipitate has settled, and then filtered and washed. The precipitate and filter are placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner. It is then ignited, redissolved in  $\text{HCl}$ , and the solution made up to 100 c.c. with water. Ammonia is added in slight excess, and the liquid is boiled. If a small amount of  $\text{Al}_2\text{O}_3$  separates, this is filtered out, weighed, and the amount added to that found in the first determination, when greater accuracy is desired. The lime is then re-precipitated by ammonium oxalate, allowed to stand until settled, filtered, and washed,\* weighed as oxide by ignition and blasting in a covered crucible to constant weight, or determined with dilute standard permanganate.†

$\text{MgO}$ : The combined filtrates from the calcium precipitates are acidified with  $\text{HCl}$ , and concentrated on the steam bath to about 150 c.c., 10 c.c. of saturated solution of  $\text{Na}(\text{NH}_4)\text{HPO}_4$  are added, and the solution boiled for several minutes. It is then removed from the flame and cooled by placing the beaker in ice water. After cooling,  $\text{NH}_4\text{OH}$  is added drop by drop with constant stirring until the crystalline ammonium-magnesium ortho-phosphate begins to form, and then in moderate excess, the stirring being continued for several minutes. It is then set aside for several hours in a cool atmosphere and filtered. The precipitate is redissolved in hot dilute  $\text{HCl}$ , the solution made up to about 100 c.c., 1 c.c. of a saturated solution of  $\text{Na}(\text{NH}_4)\text{HPO}_4$  added, and ammonia drop by drop, with constant stirring until the precipitate is again formed as described and the ammonia is in moderate excess. It is then allowed to stand for about 2 hours when it is filtered on a paper or a Gooch crucible, ignited, cooled and weighed as  $\text{Mg}_2\text{P}_2\text{O}_7$ .

$\text{K}_2\text{O}$  and  $\text{Na}_2\text{O}$ : For the determination of the alkalies, the well-known method of Prof. J. Lawrence Smith is to be followed, either with or without the addition of  $\text{CaCO}_3$  with  $\text{NH}_4\text{Cl}$ .

$\text{SO}_3$ : One gram of the substance is dissolved in 15 c.c. of  $\text{HCl}$ , filtered and residue washed thoroughly.‡

The solution is made up to 250 c.c. in a beaker and boiled. To the boiling solution 10 c.c. of a saturated solution of  $\text{BaCl}_2$  is added slowly drop by drop from a pipette and the boiling continued until the precipitate is well formed, or digestion on the steam bath may be substituted for the

\*The volume of wash water should not be too large. *Vide* Hillebrand.

†The accuracy of this method admits of criticism, but its convenience and rapidity demand its insertion.

‡Evaporation to dryness is unnecessary, unless gelatinous silica should have separated and should never be performed on a bath heated by gas. *Vide* Hillebrand.

boiling. It is then set aside over night, or for a few hours, filtered, ignited, and weighed as  $\text{BaSO}_4$ .

**Total Sulphur:** One gram of the material is weighed out in a large platinum crucible and fused with  $\text{Na}_2\text{CO}_3$  and a little  $\text{KNO}_3$ , being careful to avoid contamination from sulphur in the gases from source of heat. This may be done by fitting the crucible in a hole in an asbestos board. The melt is treated in the crucible with boiling water and the liquid poured into a tall, narrow beaker and more hot water added until the mass is disintegrated. The solution is then filtered. The filtrate contained in a No. 4 beaker is to be acidulated with  $\text{HCl}$  and made up to 250 c.c. with distilled water, boiled, the sulphur precipitated as  $\text{BaSO}_4$  and allowed to stand over night or for a few hours.

**Loss on Ignition:** Half a gram of cement is to be weighed out in a platinum crucible, placed in a hole in an asbestos board so that about  $\frac{3}{4}$  of the crucible projects below, and blasted 15 minutes, preferably with an inclined flame. The loss by weight, which is checked by a second blasting of 5 minutes, is the loss on ignition.

May, 1903:

Recent investigations have shown that large errors in results are often due to the use of impure distilled water and reagents. The analyst should, therefore, test his distilled water by evaporation and his reagents by appropriate tests before proceeding with his work.

## APPENDIX II

## FORMULAS FOR REINFORCED CONCRETE BEAMS\*

Direct working formulas suited to all ordinary cases of reinforced concrete design are presented in Chapter XXI. The analytical methods of deduction, however, are omitted there in order to make the book handier for every day use and are presented in this Appendix.

These formulas cover all the usual conditions occurring in practice and in theoretical treatment of beam design, as follows:

- (1) Rectangular beams with steel in bottom, assuming that concrete bears no tensile stress. (See page 751.)
- (2) T-shaped section of the beam, for use in combined beam and slab construction. (See p. 754.)
- (3) Beam with steel in both top and bottom, for use in connection with the design of a continuous beam at the supports and other special cases. (See p. 757.)
- (4) Beam with steel in bottom and concrete assumed to bear tensile stress, for theoretical use in determining accurate stresses at early stages of loading. (See p. 760.)
- (5) Beam with compressive stress varying as a parabola, to illustrate a method of computation occasionally used. (See p. 762)

The first three of these analyses are for common use and follow the recommendations of the Joint Committee on Concrete and Reinforced Concrete. This fact has necessitated no changes in the analyses in the first edition of this treatise except in the adoption of the new standard of notation.

As stated in Chapter XXI, the straight line theory,—that is, the theory in which the modulus of elasticity of concrete in compression is assumed to be constant within usual working limits,—is adopted as the standard and the concrete is assumed to bear no tension.

The various other rational formulas† which have been advanced by

\*The authors are indebted to Prof. Frank P. McKibben for the formulas in this Appendix which have been especially prepared by him for this Treatise.

†See Christophe's *Béton Armé* and Morel's *Ciments Armé*, 1902.