It is of interest to note that in Table No. II.,* Mr. Young has brought out very clearly the effect of the cement content as tending to vary the water-cement ratio, and has shown that for uniformly moist mixes this ratio is variable. His conclusions are in full accord with the consistency theory of the surface-area method.

The theoretical studies described by Mr. Young do not touch upon the effect of sandy dust (material passing a No. 100 sieve) in its relation to the water content of mortar and concrete mixtures. In the very limited concrete tests described in the writer's paper published in *The Canadian Engineer* in July, 1918, the dust content of the sand aggregate was treated as having the same surface area as an equal portion of material passing a No. 80 and retained upon a No. 100 sieve, and the cement content was proportioned accordingly. As regards the water content of the three con-

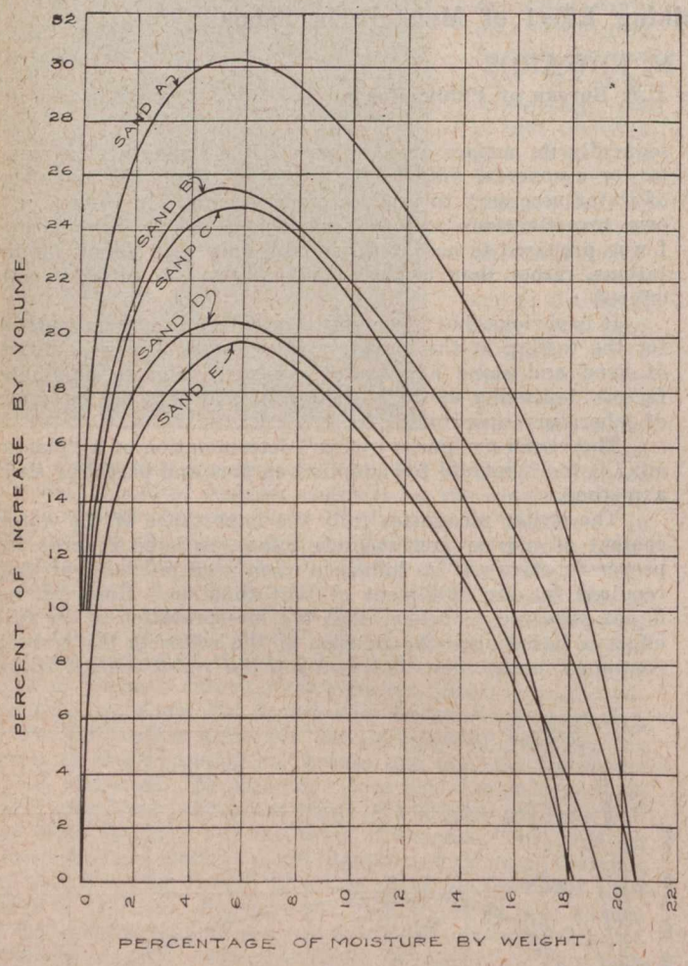

FIG. 3—BULKING EFFECT OF MOISTURE IN SANDS—VOLUME INCREASE IN RELATION TO MOISTURE CONTENT

crete mixes described, the paper referred to states that the water content of the mix was sufficient to produce a saturated, sticky, semi-plastic mortar showing no free water. In other words, the water content was determined by visual examination rather than by a specific rule. The speaker's investigations of the surface area method had not then extended to the development of a rule or formula for the determination of the water content of a uniformly moist concrete mix. However, the results of the tests appeared to be amply consistent to indicate the adaptability of the surface area method to concrete mixes, and for this reason alone they were included.

Tests made within the past six months with the object of obtaining information relating to the effect of sandy dust, have shown quite conclusively that the assumptions just referred to were entirely wrong in principle. Speaking briefly, these tests show that in proportioning the cement content, no allowance should be made for the surface area of dust material and that the water allowance for moistening the dust is nearly equal per unit of weight to that required per unit weight of cement. In other words, we must treat the dust as a "dilutant" or "extender" of the cement, rather than as a component part of the sand aggregate. Incidentally, it may be said that these tests have shown ample evidence of both the reliability and the advisability of the common practice of limiting the dust content, by weight, to approximately 5% of the sand aggregate.

*See *The Canadian Engineer*, issue of June 26th, 1919, p. 565.

Investigation of Various Aggregates

For a proposed concrete structure, the consideration of possible sources of supply of aggregates frequently involves the laboratory examination of the concrete-making qualities of two or more different aggregates varying in their granulometric composition and other physical properties. The field conditions attending the mixing, handling, placing and finishing of the concrete, as well as the ultimate strength, durability, etc., of the concrete producible from them, require that the relative merits of these aggregates be determined under conditions eliminating variations in the relative plasticity and the final strength of the cement matrix which performs the function of holding together the particles of the sand and stone aggregates. When the aggregate contains sandy dust it is important that allowance be made for the quantity of water required to moisten it.

Having determined under uniform conditions the relative concrete-making values of the materials, the question of their adaptability to the production of workable, plastic concrete mixes capable, in the "transitory" stage, of being formed with a reasonable amount of work into the various shapes required in its adaptation to the construction of bridges, buildings, roadways, etc., can be fully and systematically considered. The quantity of water required for absorption by the aggregate and for moistening its surfaces remaining constant, an increase in the water content over that used in the tests, produces a dilution of the cement paste which ultimately results in a weakening of the cement matrix. Unfortunately, many investigations have overlooked the basic importance of the cement matrix, and have evolved their investigations upon the assumption that the mobility of the mix is a primary rather than a secondary factor. The very nature of the component materials and the varied proportions in which they are used, render such an assumption untenable.

The determination of the effect upon the strength of mortars and concretes resulting from an increase in the water content has been the object of studies and tests made by several investigations, so that a considerable volume of information is now available. Doubtless the tests, formulas, etc., reported by Prof. Duff A. Abrams, Lewis Institute, Chicago, Ill., are the most complete, exhaustive and reliable.

Laboratory Testing of Concretes

Having discussed, at least to a limited degree, the fundamental requirements for the investigation of aggregates, it will not be amiss to indulge in a brief consideration of the conditions which are of vital importance to the laboratory testing of concretes and to the establishment of standard methods and practices. While several conditions of lesser importance might be enumerated, the three most important basic conditions entering into comparative tests are the following:—

1.—The water content of the mixes must be sufficient to permit the production, without loss of water, of uniformly sound, well-moulded specimens.

2.—The water content of each mix must be so proportioned as to produce for a given cement a uniformly strong cement matrix.

3.—The cement content of each mix must be so proportioned as to provide a uniform and equal quantity of matrix in relation to the surface area of the aggregates.

In a series of tests adapting the principles just mentioned to laboratory conditions, it has been found that concrete mixes containing a uniform broken stone aggregate,