Proportioning the Materials of Mortars and Concretes by Surface Areas of Aggregates

Proper Mix For Any Desired Strength Can be Predetermined—Results of Tests Show That Strength of Mortars Depends Upon Consistency of Mix and Upon Quantity of Cement in Relation to Surface Areas of Aggregates—Paper Read at Atlantic City Convention of American Society for Testing Materials

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UNDERLYING the combination of inert aggregates with cement to form mortars and concretes, the fundamental principle is that the proportioning of the cement in relation to the aggregates shall be such as to develop the full strength of the inert materials or shall secure conditions of strength, hardness, impermeability or other desired physical properties. While the character of the aggregates and the amount of water used influence results to a marked degree the proper proportioning of the cement is a matter of the utmost consequence, since this is the only active, strength-producing material entering into the mixture.

The "surface-area" method of proportioning assumes as its basic principle that strength, hardness, etc., are primarily dependent upon the relation of the volume of cementing material to the surface areas of the aggregates.

This paper has for its object the following:—

1. To develop information relating to the average surface areas of sand and stone aggregates.

2. To describe the methods and materials used, the results obtained, and the phenomena observed in a series of experimental tests undertaken to develop the practical application and efficacy of this method.

From a careful consideration of the results obtained and of the phenomena observed, the following conclusions appear to be warranted:—

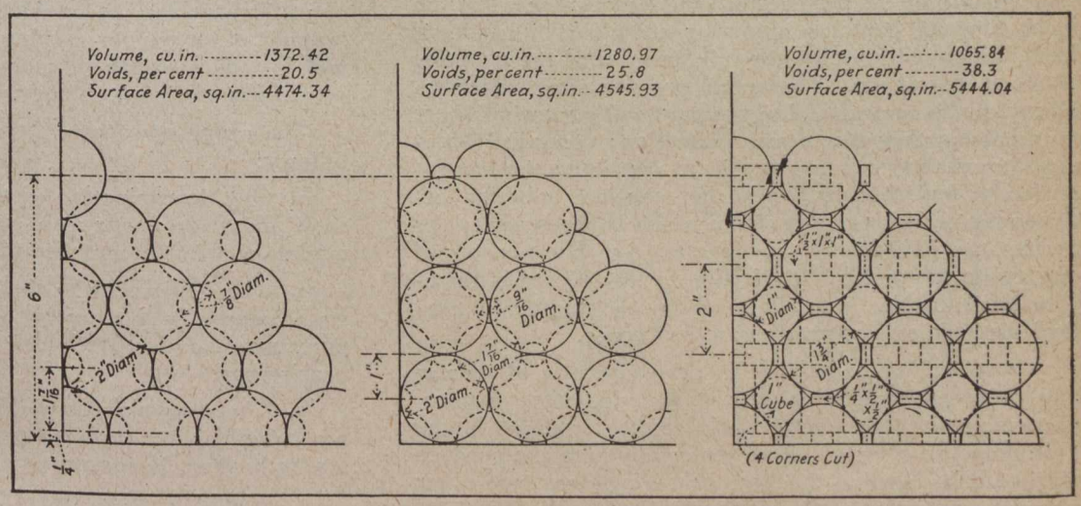

Fig. 1—Relation of Surface Area to Shape of Particles

Conclusions

1. The claim that the surface-area method of proportioning the cement content of mortars and of concretes is essentially scientific and rational is proven by the uniformity of results obtained in comparative strength tests of mortars and concretes and by the phenomena observed in these tests.

2. With a given uniform proportion of cement in relation to the surface areas involved, this method provides a definite and practical means of comparing the relative strength-producing qualities of aggregates of varying physical, chemical and mechanical properties.

3. This method provides a means for a more thorough investigation of the functions of sand and stone aggregates and for a more complete development of the true values of all the component materials of mortars and concretes.

4. Excess water in an over-saturated mortar or concrete mix exerts a decidedly weakening effect upon the cement matrix by producing a change in the physical structure of the matrix which tends to destroy the cohesion existing between the particles of cement and the adhesion existing between the cement and the aggregate.

5. In a normal consistency mortar the relation of the area of the particles of the sand aggregate to the cement content of the mix determines the strength of the mortar, provided the strength of the sand material is greater than that of the cement matrix. A similar condition applies to concrete mixes not over-saturated.

6. The strengths of mortars containing a given cement and sand but varying for the different mixes in the proportions of these ingredients, are directly proportional to the relation existing between the cement content and the surface area of the aggregate. It follows, therefore, that the strength of a mortar of given mix being known, the mix of a mortar having a desired strength can be pre-determined for the same materials.

7. The quantity of water required to produce "normal," uniform consistency mortars from a given cement combined in varying proportions with sands having the same origin but varying in their granulometric composition, is a function of the water required to reduce the cement to a "normal" paste and the surface area of the sand particles to be wetted.

8. The increase of volume due to the mingling of varying quantities of cement particles with a uniform quantity of a given sand bears no apparent relation to and is evidently not dependent upon the void in the sand.