Bureau of Standards Criticizes Hydro's Method

Of Proportioning Concrete Materials—Engineer in Charge of Bureau's Concrete Research Work Says Mr. Young's Modified Surface Area Method Is Uneconomical and More Limited in Scope Than Old Volumetric Method

*In the January 1st issue there appeared an article by **Roderick B. Young** descriptive of the practical application of the surface area method of proportioning concrete materials. This method is being used, apparently with great success, at High Falls, on the Queenston-Chippawa work and in concreting penstocks at the Ontario Power Co.'s plant. **But G. M. Williams, who is in charge of concrete research work for the U.S. Bureau of Standards, declares that Mr. Young's method restricts the engineer and that it results in concretes lower in strength, harder to handle and less economical of cement than other concretes which might be produced from the same aggregate by use of the usual volumetric methods of proportioning. In the following letter to The Canadian Engineer, Mr. Williams discusses Mr. Young's article and claims that there is little in common between the Hydro's method of proportioning and the methods proposed by Prof. Abrams and Mr. Edwards.***—EDITOR.

STUDY of the article, "Practical Application of Surface Area Method," in the January 1st, 1920, issue of *The Canadian Engineer* indicates to the writer that neither the requirements of Prof. Abrams' fineness modulus theory, nor those of the surface area theory of Mr. Edwards, are met by the methods employed by Mr. Young. Further, it can be shown that the assumption made for the selection of the "economical" mixture is erroneous, and that the methods employed lead to results similar in practical application to those which may now be obtained by the common method of volumetric proportioning. The terms "surface area" and "water-cement ratio" as used are merely new terms for expressing the same qualities which are now determined in the volumetric method of proportioning.

The one term or factor which Mr. Young adopts from the "fineness modulus" theory is that of "water-cement ratio." This is, of course, equivalent to the term "per cent of mixing water by weight of cement." The one factor adopted from the "surface area" theory is the method of proportioning the cement according to surface area of aggregate. It is therefore seen that the "fineness modulus" expression and the water formula of Prof. Abrams are discarded, as has been the water formula proposed by Mr. Edwards.

Predetermines "Most Economical Grading"

Both of the foregoing proponents of new methods of proportioning included, in their theories, water formulas which, it was claimed, would result in equal consistencies and equal strengths for all workable mixtures. General laws were stated by which strength could be predicted for all normal concretes. The method employed by Mr. Young narrows the conclusion down to the possible value of any particular predetermined grading of an aggregate because of the limitation which he places on surface areas. Referring to a water formula which he has developed, but does not present, he states: "It is not general in its application and its constants have to be determined for each different class of material." However, as he states, a water formula is not necessary for the application of the method which he employs, since "the simplest way is for the operator to add water until, in his judgment, the mixture is of the required mobility" for what he calls normal consistency.

The first and greatest limitation which Mr. Young employs, and which removes his method from any possibility of being of general application to wide ranges of combinations, as was claimed for the methods proposed by Prof. Abrams and Mr. Edwards, is the determination at the outset, without the employment of strength tests, of the "most economical aggregate grading," which he states to be "the one containing the lowest surface areas per cubic foot of material which can be successfully handled and placed."

Whereas the surface area theory proposed by Mr. Edwards would admit of the use of wide variation in gradation (large differences in surface areas), Mr. Young at the beginning limits his aggregates to the "lowest areas which can be worked." Such a result is, of course, obtained by keeping the fine material in the sand or fine aggregate to a minimum. In usual concrete mixes, where the ratios of fine to coarse are as 1 to 2 (such as 1:2:4, 1:3:6, etc.) the area of the sand is usually more than 90% of the total area of both coarse and fine. Therefore, to obtain low areas it is necessary that the grading of the sand, the material whose variation most greatly influences workability and segregation, be made as coarse as possible and still permit of a workable mix.

Furthermore, the use of high area aggregates requires larger quantities of cement, which, if the same flowabilities are obtained, result in high strengths which are unnecessary and uneconomical. It is clear that this limitation to low area aggregates is essential for economy, and as a result the method employed is narrow and limited, rather than broad and general as that proposed by Mr. Edwards.

Results in Harsh Mixtures

It would be interesting to see the test data on which Mr. Young bases his conclusion that low surface areas are most economical. Tests made along this very line with which the writer is familiar do not bear out this basic assumption. It is found that the limitation of aggregates to low total areas results in harsh, "difficult-to-work" mixes whose strengths are lower than mixtures having higher surface areas. It is also found that the quantity of cement required per cubic yard of wet concrete is greater for such harsh, low area mixtures than for the high area mixtures.

The resulting concrete which Mr. Young's method provides, in reality results in false economy, since the concretes are more difficult to place, have lower compressive strengths and require a slightly greater quantity of cement. In other words, the use of low surface area aggregates is generally opposed to economy and strength. The concretes shown below were made with sands of varying degrees of fineness combined with the same gradation of coarse aggregate, all from the same source of supply:—

Aggregate Number	Surface Area Sq. Ins. Per 100 g. Aggregate	Surface Area Sq. Ins. Per Gram Cement	Pounds Cement for 1 Cu. Yd. Concrete	Compressive Strength, Lbs. Per Sq. In.
1	103	5.0	603	1,873
2	114	5.6	600	2,456
3	167	8.2	600	2,348
4	233	11.6	600	2,508
5	268	13.3	601	2,627
6	315	15.4	597	2,830
7	393	19.2	594	2,865

Proportions, 1:1½:3 by volume. Age, 28 days. Equal flowabilities for all.

These concretes are fully comparable since equal consistencies, or flowabilities, were obtained as measured on the "flow table." Concretes 1 and 2 were so harsh that they would be ruled out as unworkable; No. 3 was a somewhat harsh but workable concrete. The ease of working, or plasticity, increased with the amount of fine material in the sand, and it is seen that strengths were not reduced.

The tendency to seggregate when very fluid was less marked as the amount of fine material in sand or the surface area increased. It is also found, with flowabilities equal, that the cement paste in a high area mix contains a smaller proportion of water than in one having a low area. This condition no doubt partially accounts for the higher strengths of the mixes containing the higher quantities of fine aggregate. In such mixes, although the calculated *w/c* relation