may be equal or nearly so for two mixtures, the paste of the low area mix will be the wetter, so that the true *w/c* relations may be quite different. Further, as the flowabilities of the two are equally increased, the low area aggregate concrete will be the first to segregate and become difficult to handle.

For apparent economy the modified surface area theory as employed by Mr. Young necessitates the selection of such an aggregate as No. 3 or No. 4 above. The resulting concrete requires slightly more cement per cubic yard, has a lower compressive strength and is more difficult to place. Such a condition results since the basis of the modified method is the erroneous assumption that the most economical mixture is one having the lowest total surface area and which is near the border line of workability.

It is apparent that the making of strength tests does not enter into the procedure of this modified theory until after the "economical" mixture of aggregate is selected. After surface area is determined, which process will later be referred to, various ratios of cement to areas (100 sq. ft.) of aggregate are selected; concretes are then made up of equal consistencies, as determined by eye, and compressive strength for each mix determined. The strength values with calculated factors for areas and water-cement ratios are then plotted, and the limiting factors for various classes of concretes determined from the resulting curves.

Differs Little from Present Methods

That this method differs little from methods at present in use, except that the measured and calculated factors are given different names, is apparent from the following:—

In practice we have found that with Potomac river materials the proportion of 1 part sand to 2 parts aggregate is about the limit of coarseness which it is desirable to use. Less fine sand in the fine aggregate or a smaller ratio of sand to coarse aggregate results in harsh concretes, difficult to properly place, while with the same flowability a finer sand or more sand increases workability and results in less segregation in the wetter mixes. The above 1:2 combination is probably quite similar to that which Mr. Young would select as his "economical grading" if using our materials. In accordance with Mr. Young's next step in the process we will make up concretes having the same consistencies or flowabilities, with the following proportions of cement to aggregate: 1:1½:3, 1:2:4, 1:2½:5, 1:3:6 and 1:4:8.

Recent determinations indicate Potomac river materials to have the approximate areas of 1,830 sq. ft. per 100 lbs. and 86 sq. ft. per 100 lbs. respectively for the sand and gravel.

The following data will then result:—

Proportions,	1:1½:3	1:2:4	1:2½:5	1:3:6	1:4:8
Cement, lbs. per 100 sq. ft. . .	3.3	2.5	2.0	1.65	1.24
Per cent water by weight of cement, or *w/c*, ...	Increases as quantity of cement decreases.				
Strength, . . .	Decreases as quantity of cement decreases.				

It is seen from the above that a table similar to Mr. Young's Table 2 will result. Although we may not be accustomed to calculating and viewing our mix from the viewpoint of surface area and the cement-surface area relation, the relation is there and may be obtained by computation.

Although we may not be accustomed to calculating or expressing water in terms of quantity of cement, the relation is also there. Percentage of water by weight of cement is calculated as easily as water-cement ratio, but it is seen that both are incidental and a resultant, for any given flowability, of the predetermined grading and mix.

Our results may be plotted in the same manner as Mr. Young's Figs. 3 and 4, and we may likewise draw up Table 3.

In the field, the quantity of cement and mixing water may be varied as described by Mr. Young, and the strength of the resulting concrete may be checked in the same manner by molding samples of field concrete.

However, with our present knowledge of the advantage to be gained by using more fine aggregate (greater surface area) in our mix, we would not confine ourselves to such a low area combination as is required by the economical considerations of Mr. Young's modified method. Very likely we would reduce the above number of mixes and add a similar series in which the sand-gravel ratio would be 2½:3½ or even larger, or add more fines to the sand and maintain the same relative proportions.

Past tests show that the 2½:3½ or 2½:4 ratio mixes will have greater workability for the same flowability, and higher strengths, and will require less cement per cubic yard of concrete. While the surface area method limits the investigator to low area aggregates, the old volumetric trial method obtains identical results and permits the use of wide variation in gradations which are generally found to result in more satisfactory concretes.

As has been previously shown by other investigators, the method employed by Mr. Edwards and Mr. Young for determining surface areas is unnecessarily laborious. With any system of sand sieves constants can be calculated for approximate areas of unit weights of materials passing any one sieve and retained on the next size smaller. Since the assumption that all particles are spherical is at best only approximate, the areas calculated can be assumed to be proportional to the true areas and will serve the purpose fully as well. The counting of particles is tedious and time-consuming, and is not justified by the results obtained. For the Tyler system of sand sieves, the following series of constants greatly simplify this determination:—

Tyler sieves		Approximate surface
Passing	Retained on	area, ins. per 100 grams.
⅜	4	50
4	8	100
8	14	200
14	28	400
28	48	800
48	100	1.600
100		3,200

As to the material passing a 100 or 150-mesh sieve, it may be possible to ignore the dust in proportioning the cement, but any proposed water formula must give consideration to this size since its water requirement is only slightly less than that of an equal quantity of cement.

Good Supervision at Mixer

With regard to the results shown by Mr. Young in the table where comparison is made of the concrete used on two jobs, it is interesting to note that the use of the modified surface area method resulted in the old volumetric proportion of 1:2:4 for a concrete having a strength of 2,000 pounds. It is not clear why these strength results should show the merits or demerits of any method of proportioning. The writer is inclined to believe that they show the effect of good supervision at the mixer in the case of the "Hydro's" concrete and more careless work on the other job. The variations in strength found for the "outside" concrete are no greater than those commonly obtained when little supervision is given the loading of carts and the addition of mixing water. The uniform results on the "Hydro" work merely reflect better uniformity in the process of measuring aggregates and mixing water, and such improvement may be effected on any work regardless of the theory of proportioning.

In the case of Fig. 4, the writer agrees that the curve shown is representative of the variation in strength with increase in mixing water and change in cement content for this one graded aggregate, but if appreciable change is made in the aggregate grading, a series of such curves will be obtained, all falling within a band or zone whose width is greatly dependent upon the number of gradings employed. Reference to Tables 8, 9, 10, 11 and 12, also Table 5, of Technical Paper No. 58, Bureau of Standards, will show the wide ranges in strengths obtained with various gradings of aggregates when flowabilities are constant.

Mr. Young's statements relating to field practice and better supervision of the process of mixing concrete are