ranges of mixes or grading of aggregates, but appears to be promising for use where only a limited range in the character of the concrete will be encountered.

The amount of water used in the batch exerts such a controlling influence that the quality of the concrete depends very largely on this factor. The quantity of water to be used depends on the following factors:

(1) The quantity of cement (mix).
(2) The normal consistency of the cement.
(3) The size and grading of the aggregate.
(4) The absorption of the aggregate.
(5) The moisture already present in the aggregate.
(6) The nature of the work; that is, the size of the members, the methods of handling, placing, finishing, etc.

The term "consistency" as used in this article refers to the physical condition of the fresh concrete with reference to viscosity or plasticity and not to the quantity of water. It has been found convenient to express the quantity of water used in the concrete in terms of the volume of the cement. This ratio has been found to be the best criterion of the strength of the concrete. The whole question of consistency has been studied, but it is not feasible to take up a detailed discussion of these studies in the present article.

The 6 by 12-in. compression cylinders were molded in metal forms made of 12-in. lengths of 6-in. inside diameter cold drawn steel tubing which had been split along one element by means of a thin slotter. The form was closed by a circumferential band. Each form stood on a machined, cast-iron base plate. A sheet of paraffined tissue paper was placed between the base plate and the cylinder form.

The concrete for the machine-mixed batches was taken from the receiving trough by means of a large scoop. In molding the cylinder the form was filled about one-third full and the concrete puddled with a ¾-in. steel bar about 21 ins. long. This process was continued until the form was filled. The top was levelled off with a bricklayer's trowel. About three to six hours after molding, a thin layer of neat cement paste (which was mixed at the same time or before the concrete) was spread over the top of the cylinder. A piece of plate glass and a sheet of paraffined paper was used to form a cap which made a smooth, square end for loading. The glass remained in place until the form was removed. This method of capping is much better than setting the specimens in plaster of paris or cement-plaster caps immediately before testing. It has the following advantages:

(1) The cap is just as strong and stiff as the concrete and forms an integral part of the specimen.

(2) The time and labor required is a small part of that necessary with the plaster method.

(3) The plate glass prevents evaporation of water during the period the concrete is in the form.

(4) The cylinder is ready for test at any time without further preparation.

The forms for the wear blocks were made in gangs of three. The forms were set on a sheet of building paper laid directly on the concrete floor. Each form was filled before puddling. The top was levelled off with a trowel. After a period of one to two hours the tops of the blocks were finished by hand with a wood float. Instead of capping, the blocks were covered with a sheet of wet building paper and about 3 ins. of damp sand. This method prevented loss of water while the blocks were in the forms.

All test pieces were allowed to remain in the metal forms over night. Upon removal of the forms they were stored in damp sand in the basement. The compression cylinders were not removed from the damp sand until immediately preceding their test. The wear blocks, however, were allowed to dry out in an open room for two days prior to testing.

The machine-mixed batches consisted of 15 to 17 specimens. The specimens were made and numbered in the same order in all cases. The material which was first discharged from the mixer was used to make Specimen 1; the material last discharged forms the last specimen from the batch. In assigning the test pieces to be tested at each age, the specimens were distributed throughout the batch. The exact distribution is stated in the tables giving the results of the tests in each series.

Methods of Testing

The compression tests of concrete were made in a 200,000-lb. Olsen universal testing machine. A spherical bearing block was used on top of the specimen. Stress-deformation measurements were made from which the modulus of elasticity of the concrete can be computed. These values are omitted from the present article.

Wear tests of concrete were made in the Talbot-Jones rattler. The test pieces consist of blocks 8 ins. square and 5 ins. in thickness. The blocks are arranged around the perimeter of the drum of the rattler, as shown in Fig. 1. Ten blocks constitute a test set. The ten-side polygon formed by the test blocks presents a nearly continuous surface. The outside diameter of the polygon thus formed is 36 ins. and the inside diameter 26 ins. During the test the front of the chamber is closed by means of a light steel plate. The abrasive charge consists of 200 lbs. of cast-iron balls (about 133 1⅞ ins. and 10 3¾ ins. in diameter). These balls conform to the requirements of the standard rattler test of paving brick of the American Society for Testing Materials.

The test consists of exposing the inner faces of the concrete blocks to the wearing action of the charge for 1,800 revolutions at the rate of 30 r.p.m. The machine was run for 90 revolutions in one direction, then reversed. Two sets of blocks are tested at once in the machine now in use. Each block was weighed upon removal from the form, upon removal from the damp sand, immediately before and after testing. The loss in weight during the test is used as a measure of the wear. This loss is reduced to an equivalent depth of wear in inches.

This method of making wear tests of concrete is believed to have the following advantages as compared with other methods which have been used or proposed for this purpose:

(1) The concrete is subjected to a treatment which approximates that of service.

(2) The test piece is of usual form and of sufficient size that representative concrete can be obtained.

(3) The test pieces are convenient to make, store and handle, and require a relatively small amount of concrete.

(4) The cost of tests is not excessive.

(5) The machine used is found in numerous testing laboratories.

(6) The wearing action takes place on the top or finished surface of the concrete. This makes it possible to study the effect of various surface treatments or finishes.

(7) Several tests may be made at the same time, thus enabling more representative results to be obtained.

(8) Tests may be made on sections of concrete cut from roads which have been in service.