Patented May 27, 1924. 1,495,510

UNITED STATES PATENT OFFICE.

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PROCESS OF MAKING CONCRETE.

No Drawing. Application filed February 15, 1922. Serial No. 536,803.

To all whom it may concern:

Be it known that I, GUSTAV E. ESCHER, a citizen of the United States, residing at Summit, county of Union, and State of New Jersey, have invented certain new and useful Improvements in Processes of Making Concrete, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to improvements in the art of making concrete.

As is well known to those skilled in the art, concrete is made by mixing sand, cement, broken stone or other aggregate and water. The greatest defect of concrete as a building material for the construction of concrete and reinforced concrete structures is its variation in compressive strength, or, in other words, the impossibility in regular practice of producing concrete in a succession of batches with a reasonable approach to uniformity of strength. As an illustration, concrete cylinders made from a series of presumably identical mixes of 1 part cement, 2 parts sand and 4 parts stone, with the same amount of added water, the cement, sand and stone for each mix, being of the same quality, gave, when tested by crushing in a testing machine, values running from about 1500 pounds per square inch to 2500 pounds per square inch, the variations of the individual samples being irregular between those limits. These tests represented the best that could be done under the prior practice, notwithstanding great care and every effort to produce uniform results. It is obvious that such variations in the strength of concrete necessitate the design and construction of concrete and reinforced concrete structures with a large factor of safety and therefore with more material and more expense for labor than would be necessary if only a fair average strength, for example, 2000 pounds per square inch compressive strength could always be obtained in practice.

It is known that the strength of such concrete depends upon several factors, as the strength of the stone, the grading of the stone, the fineness of the sand, the quality of the cement, the relative proportions of the mix, and also upon the ratio of the water to the cement. Many of these factors may be predetermined within reasonable limits. For example, the strength and grading of the stone may be determined in well known ways in advance of construction. Also, the average fineness of the sand to be used on a job may be ascertained by proper sampling and the test of the samples. So also cement may be obtained which will be sufficiently uniform in quality to meet the requirements of practice. And, heretofore, it seems to have been assumed that the relative proportions of the mix could be maintained constant in practice, but from my experience I believe that this has been impossible of attainment by prior methods of making concrete in regular practice. The reason for the failure to obtain and maintain a uniformity of mix in the different batches going into a structure is the variations in the amount of sand going into the various batches, as well as the fluctuations in the amount of water used. Such variation in the amount of sand, is brought about by what is known as the "bulking" of the sand. That is to say, sand as delivered and kept on the job in the usual way has different percentages of moisture in different parts of the pile and also packs down to different degrees in different places, so that a cubic foot, for example, taken at one time may not, and generally will not, contain the same amount of sand, figured as dry sand, as another cubic foot taken from another part of the same sand pile.

In practice it will be found that, starting with dry sand, and following with wet sand containing increasing amounts of moisture, the amount of sand, figured as dry sand, which a given volumetric measure will hold, first decreases with the increase of moisture up to a certain percentage of moisture content and then increases with further increase of moisture content. This variation in the amount of sand with the variation in moisture content is much more serious than is ordinarily realized. For example, at a certain stage of moisture content, a given measure may contain only about 83 to 85% of the sand, figured as dry sand, which it would contain if the sand were entirely dry.

If, however, the sand is thoroughly saturated with water, that is to say, inundated, it becomes possible to get substantially a cubic foot of sand, figured as dry sand, in a volumetric measure of one cubic foot.

In my new process of making concrete, I take advantage of the fact that by inun-

dating the sand when measuring it out for the mix, I can always obtain substantially the same amount of sand for each batch, thereby insuring a practical constancy in the amount of sand supplied to each batch. Furthermore, since it is possible to determine the percentage of voids in the sand, by testing a number of samples of the sand, and since this percentage is reasonably constant for a given lot of sand, it become possible, by measuring the sand in an inundated condition, not only to measure out uniformly the same amount of sand for the various batches of concrete, but also to know the amount of water which said sand carries into the batch, and to know that this water is practically constant in amount. By proceeding in this way, the two variables which seem to have been the chief causes of the variation in the strength of the concrete may be eliminated.

A further cause of variation in the strength of the concrete has been the absorptive power of the stone, that is, its ability to absorb water, and the variation in the amount of water which the stone has absorbed.

The absorptive power of the stone is quite variable from sample to sample, so that it is not easy in practice to determine with sufficient accuracy the average for a large amount of stone. Furthermore, the percentage of moisture already absorbed by the stone varies so much in the different portions, that no simple way exists in practice for determining the amount carried into a batch of the mix by a measured amount of the stone. To eliminate these variables, however, it is only necessary to wet the stone, thoroughly, some time in advance of using it and keep it well-wetted. In this way whatever may be the absorptive power of the stone it is thoroughly saturated and therefore cannot rob the cement of any of the water which is added with the sand.

In carrying out my process in practice, I wet the stone thoroughly some two or three hours before it is to be used and from time to time during operations wet it down as, for example, with a hose. The stone is measured by volume for each batch.

In carrying out my invention in the simplest way, the sand is measured as follows: A water tight receptacle having the desired volumetric content is supplied with a fixed or predetermined amount of water whose ratio to the volumetric content of the measure has about the same percentage value as the percentage of the voids in dry sand as determined by preliminary tests. In practice this usually runs about 30 to 37 per cent and is reasonably constant for a given lot of sand.

The receptacle for measuring the sand containing this given percentage of water is next supplied with sand, the sand being allowed to run into the receptacle in a stream. As the sand passes below the level of the water in the receptacle, it will be freed from any air clinging to it, agitation being used if found necessary, and when submerged will arrange itself in the receptacle in a well packed manner so that the density of the various lots measured in this way will be substantially constant. As the sand flows into the receptacle, it will elevate the water level, so that if the percentage of water added to the receptacle were identical with the percentage of voids, and if the sand were absolutely dry, the receptacle could be filled level full of sand and all the water would be absorbed in the sand. Since, however, in practice there is always considerable moisture in the sand which is supplied to the receptacle, it is obvious that when the receptacle is level full of sand there will be some surplus of water, this surplus being equal to the amount which was carried by the sand. This surplus will overflow the receptacle, leaving behind it that amount of water which just fills the voids in the sand. The sand, with its water, is now supplied to the mixer, the corresponding quantities of cement and wet stone are added, and the batch is mixed in the usual way. This is on the assumption that the amount of water added with the sand is sufficient to give a concrete of the desired plasticity. Where, however, a more plastic concrete than this is required, thereby requiring more water, the additional water necessary is determined, and thereafter this additional amount, accurately measured, is added to each batch of concrete. This water may be added to the batch either by a separate water-measuring device, or by using a volumetric measure for the sand whose capacity is greater than necessary for the amount of sand to be measured and which contains a mark or rib on its interior so that the sand can be run into the receptacle until it is seen to reach the mark or rib. With a measure of this kind, the excess capacity of the measure, above said mark, may be made equal to the additional water required in the mix. Hence, this additional water may be supplied to the receptacle, after the sand has been measured, it being understood, however, that the fixed percentage of water corresponding to the voids is first run into the receptacle, the sand then run in until the sand is seen to reach the given mark, and then the additional water run in on top of the sand until the receptacle is level full. Or the water may be supplied in excess and run off to the amount required.

It will be clear from the above that by always measuring the sand by volume in a submerged or inundated condition, a close approach to absolute accuracy of measure-

ment is obtained both of the sand and of the amount of water supplied with the sand, so that the proportions of mix of the various batches are so nearly uniform that the resulting concrete is all of practically the same strength, and by proper selection of the proportions this strength may be anything desired within the limits of strength obtainable in concrete. For example, in this way it becomes possible for an architect or engineer to determine, for example, that the concrete shall have a crushing strength of say 2500 pounds per square inch, design his structure accordingly and know that in regular practice he will be able to produce concrete of this strength uniformly throughout the structure, within a limit of about 3 per cent variation. In case a drier concrete is desired than would be produced by using sand all of which is saturated, under my process dry sand may be substituted for part of the saturated sand.

What is claimed is:

1. The process of making concrete, which comprises wetting the stone and allowing it to stand until it has absorbed all the water it will absorb, submerging the sand in water and measuring a predetermined volume of the sand while completely saturated and mixing this predetermined volume of sand and its accompanying water with the remaining ingredients of the mix, including a corresponding predetermined volume of the wet stone and a predetermined volume of cement.

2. The process of making concrete, which comprises wetting the stone and allowing it to stand until it has absorbed all the water it will absorb, submerging the sand in water and measuring a predetermined volume of the sand while completely saturated and mixing this predetermined volume of sand and its accompanying water with a corresponding predetermined volume of the wet stone, a predetermined additional volume of water, and a predetermined volume of cement.

3. In the process of making concrete, the step of measuring the sand for such concrete while the sand is in a completely saturated condition.

4. In the process of making concrete, the step of determining the amount of sand for each batch of the mix by always supplying a fixed amount of water to a water tight volumetric measure, this water being not less than sufficient to saturate the sand, allowing the sand to run into said water in the volumetric measure until the sand reaches a predetermined height in the measure, and then adding the sand so measured, with the water it contains, to the remaining ingredients of the mix.

5. In the process of making concrete the step of determining the amount of sand for each batch of the mix, which consists in supplying to a container, which when filled to a predetermined height will hold the desired measure of fully saturated sand, an amount of water greater than would be held by the said measure of fully saturated sand, then running the sand to be measured into the water in said container until the latter is filled with said sand up to said predetermined height, discharging all water above said predetermined height, and then adding the wet sand so measured to the remaining ingredients of the mix.

In testimony whereof, I have hereunto set my hand

GUSTAV E. ESCHER.