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THE SELECTION AND PROPORTION OF AGGREGATES FOR CONCRETE.

In proportioning the ingredients for aggregates of large size it is first necessary to measure the voids existing in any given quantity of the largest particles, so as to determine the quantity of mortar necessary to fill these voids. After selecting the best stone or gravel economically obtained in the particular locality in which the work is to be done, the next thought is the grading of this material so as to obtain maximum density, thus reducing the voids and consequently the amount of mortar required to furnish the bond.

As the value of broken stone depends on several conditions, the following classification, read in the order in which they are stated, must be taken merely as a guide: Trap, quartz, gravel, limestone (hard), granite, marble, limestone (soft), slag, sandstone, slate, shale, and cinders. The importance of toughness and hardness, as related to strength, increases with the age of the concrete. For all classes of concrete, stone breaking in cubical form is far better than one breaking in flat layers, such as shale or slate, it being almost impossible to ram or tamp such stone into as dense and compact a mass as that breaking in cubical fracture.

The size of the stone aggregates depends on the purpose for which the concrete is used. For large masses of concrete 2½-inch stone is usually considered the maximum size, but for 12-inch walls and the ordinary cases of concrete construction ¾-inch stone will give satisfaction. In considering the selection of broken stone, Mr. Albert Moyer, in a publication dealing with this subject, written for the Vulcanite Portland Cement Company, states that he has found the use of screenings, quarry tailings, etc., a decided advantage when used with crushed stone, for the reason that voids are thus reduced, giving greater density and strength. When screenings are used as a proportion of the larger aggregates in concrete, the 1/100 in. or less dust, should not exceed 10% of the volume of screenings, which will pass a ¼ inch mesh, as the dust is apt to coat the stone so that the mortar does not come as readily in direct contact with the larger pieces of stone. If, through careful mixing, the mortar does happen to reach every portion of the surface of the larger aggregates, it is from necessity made less rich by the dust; therefore, dust and other particles which pass through a ¼ or ⅛ inch mesh should be screened out and used as part of the mortar.

Material which is foreign to the stone, such as vegetable mold, scale, or loam, which cling to the surface, will reduce the strength of the concrete. This again is largely a question of careful and thorough mixing. Numerous tests conducted during the last several years by competent engineers have shown that clay in small proportions, not over 15 per cent., when well mixed in the mortar, does not reduce the strength of the concrete; in fact, tests have shown that the strength has been increased. This applies particularly to the leaner mixtures. If carefully mixed, therefore, the clay will not cling to the stone, but will become part of the mortar.

Good sand cannot be easily defined, or an inflexible specification written, as sands of various properties may make equally good concrete. All things being equal, a coarse sand containing a large percentage of coarse particles is far superior to a fine sand in which few coarse particles are present.
The full strength of any cement cannot be developed with a sand, all the particles of which are fine, or so fine as to all pass through a 30 mesh sieve.

For field work the best test to determine the sand which will produce the greatest density is by means of the water void test properly applied and read.

The void test by use of water should be done in a graduated glass tube. Supply two glass tubes 1½ inches to 2½ inches in diameter, containing 200 cubic centimeters or over and marked by a graduated scale divided into cubic centimeters.

Dry the samples of sand to be tested by spreading a thin layer in a pan or over a piece of tin and heating same to a temperature of over 212° F. The reason for drying the sand is to arrive as nearly as possible at an accurate unit of measurement, so that the proportion of cement to sand, which will be described later, may be ascertained. When this sand is cool measure out in the graduated glass tube 100 c.c. of this dry sand; be careful to pour slowly into the tube, jarring the tube while pouring. Level off the top with a flat end stick so as to accurately read the measurement.

In the other glass tube, measure out 100 c.c. of water. Pour the dry sand slowly into the glass tube containing the water and note the height to which the water rises. Also note the number of c.c. of the sand. The sand will not always measure when wet exactly the number of c.c. as when dry, namely 100, as some sands, as previously stated, due to peculiar characteristics, swell in volume when moist or wet.

If 100 c.c. of solid matter had been placed in the glass tube the water would have risen to 200. Therefore, to ascertain the voids, deduct the number of c.c. to which the water has risen from 200. Sand as it comes from the bank or is measured by contractors is always damp or wet; it is assumed that it has swelled to its maximum volume.

If it is found that the sand has swelled in volume then the number of c.c. to which it has swelled over and above 100 must be considered.

As an illustration: 100 c.c. of Cheshire white quartzite, medium, was placed in 100 c.c. of water. It was found that white quartzite then measured 114 c.c., showing that it had increased in volume by 14 c.c., thus under working conditions increasing the voids. Therefore, if 114 c.c. of solid matter had been added to 100 c.c. of water, the latter would have risen to 214 c.c. It was found, however, that the water only rose 156 c.c., therefore there is 58 c.c. of voids in the 114 c.c. of sand; divide 58 by 114 and the result is 50 8/10% of voids.

Table 1 is a table giving the calculations for void percentages.