the decreasing diameter of the orifice, the curve showing a rapid decline near the limiting size of the orifice where the flow becomes irregular.

The differences in the surface condition of the grains, with the influence which this has upon the cohesion and the frictional coefficient, produce an important effect upon the velocity of flow. The content in moisture, the composition of the material, the hygroscopic properties, the angularity, and the uniformity of size are best judged, for purposes in practice, by the evident general quality of the material as a whole. In the case of lead shot, a material in which the influence of angularity of the grains is eliminated, a variation of 20 per cent. or more in the velocity results from the alteration of the surface with substances imparting a high and a low coefficient of friction.

An approximate constant to express the flow in terms of the orifice area, or the coarseness of material, can be used to gain a general idea of the discharge capacity of an orifice for a given material. Under the conditions of apportionment of sand materials by orifices in practice, prediction must be considered widely approximate. Results, moreover, are liable to marked deviation from changing quality of the material. In such application, differences in the specific gravity and the sand-head are of relatively small importance. The flow is seen to be actuated by the force acting upon the material distant but few diameters of the orifice from the orifice, and is thus affected only by the condition there existing. There is little serviceable analogy between the flow of fluid substances and of sand composed of solid grains.

An expression giving an idea of the flow to be expected would be sought for certain purposes from the trend of the curves. For such approximation, in which an accuracy of some 20 to 50 per cent. is obtained, based upon the size of the round orifice and the coarseness of the material, the following formula may be suggested:—

$$V = k \frac{d - cm}{\sqrt{d}}.$$

Here d is the diameter of the orifice in inches, m is the diameter of the particles in inches, V is the velocity of flow in feet per second, and k and c are constants to which are assigned respectively, in approximation, the numerical values 1 and 2.

The weight of sand discharged during each minute is correspondingly shown in the same degree of approximation by substituting the above value of V for the value v in the equation for round orifices, deriving the following equation:—

$$W = 20.43\, s\sqrt{d^3}\,(d - 2m).$$

Here W is the weight of sand discharged in avoirdupois pounds per minute, s is the specific gravity of the sand in the dry, loosely aggregated state, d is the diameter of the round orifice in inches, and m the diameter of the grains in inches.

An outline of the conclusions to be drawn from the tests described would be: (1) The increase in the velocity of flow with the increase in the diameter of the orifice; (2) the increase in the velocity of flow with the decrease in the diameter of the particles until the size of relatively fine material is reached; (3) the comparative unimportance of the variation in specific gravity of materials; (4) the relatively small influence of the variations in head; (5) the relatively small influence of the shape of the supplying reservoir; and (6) the influence of dampness and compacting qualities of the material, most marked in the fine sizes.

APPLICATION OF CONCRETE IN MODERN SANITATION.

CONCRETE has played its part in sanitation for many years with more or less success, according to the skill of the designer and the quality of the materials and workmanship. The tendency in recent years has been to employ concrete more and more, and this tendency in the future is sure to extend its use in directions where now it is scarcely applied. Its application to sanitation works in England was reviewed lately in a paper presented by Mr. Henry J. Tingle, M.Inst.C.E., to The Concrete Institute. The speaker traced the history of its adoption, its reception by the Local Government Board, and forecasted a very extensive use in future works. The following is a brief summary of his paper:—

Concrete has been, and is now, extensively used in the construction of reservoirs, sewage tanks, filters, aqueducts, and water towers. Full descriptions of these works are to be found in technical journals and volumes of proceedings of the various engineering societies. The same holds good for similar structures in reinforced concrete, though to a more limited extent.

Mass concrete has been largely used in the construction of sewers of 4 ft. diameter and upwards. It is moulded in the trench and supported by centering until set. Elliptical sewers are also constructed in this manner. In recent years reinforced concrete has been employed for sewers of both types, the mixture being sufficiently stiff to admit of ramming.

Concrete pipe has been extensively employed in main sewerage work in England for many years past, being supplied ready for use by firms who have taken up its manufacture. Such pipe, unless strongly reinforced, should be laid on a concrete bed not less than 6 in. in thickness, and the concrete brought up around the pipe as far as the springing. By the omission of this precaution failures have occurred. In pipes liable to internal pressure the concrete should entirely surround them.

These pipes often have ogee, rebated joints which are lined with cement and the inside pointed up.

Reinforced concrete pipes have been used for water mains at Swansea against heads of 246 ft. and 500 ft., at Norwich for sewage rising main head 131 ft., and at Clydebank for water head 390 ft., and are about to be laid at Leeds for water. They have been largely used on the continent and 119 miles of 10-in. to 49-in. water mains were in course of construction in Flanders at the outbreak of the war. They have also been largely used in Paris. Twenty years since, the municipality laid down one mile of 6-ft. diameter as a rising main for sewage head 115 ft., in a gallery alongside a steel riveted main of same diameter. It has been found that the steel main requires considerable maintenance, and the concrete tube none. Concrete pipes are constructed to form manholes, water tanks and cesspits. Sewers, reservoirs, manholes, etc., are constructed with moulded blocks of concrete which are supplied by various manufacturers.

As illustrating in greater detail the application of concrete to sanitation works the author described and illustrated the following examples: Failure and reconstruction of concrete-covered reservoir; temperature cracks in concrete reservoir wall; ejecter chamber in concrete with steel-plate lining; concrete mole forming sewage outfall into sea; circular hydrolytic tanks in reinforced concrete.