THE FLOW OF SANDS THROUGH ORIFICES.

IT is somewhat surprising that more data is not available respecting the flow of dry sands and like substances through orifices under varied conditions and different heads. Doubtless a study of the subject would result in some useful information. It would be desirable to know, for instance, (1) the rate of flow of dry sands and other substances under definite conditions; (2) the extent of the variation in flow under varying conditions; (3) the influence of the physical qualities of the substance, and (4) the form and size of required discharge-orifices to permit of unfailing flow or other desired results.

This has been a subject of investigation by Mr. Ernest A. Hersam, associate professor of metallurgy in the University of California. Mr. Hersam used three forms of appliance for measuring the flow: (1) with discharge-orifices of ½ inch or less in diam.; another with orifices greater than ½ inch diam., and a third of special design, used in certain small tests of limited application. A description of his work, appliances used, methods of accurate measurement, results acquired, and conclusions arrived at, form the basis of a paper presented last year to the Franklin Institute. The results of the tests are exceedingly interesting, but of considerable length, and we present only the deductions arrived at by Mr. Hersam at the close of his investigation:—

Conclusions.—The uniformity of flow of sands through discharge-orifices is influenced by the dampness, fineness, and general quality of the material. The momentary irregularity of flow is perceptible to the eye in the case of orifices that are small relative to the coarseness of the material. With long periods of observation, in the case either of large or of small orifices, a smaller but persistent variability is found to exist which is not materially diminished by greatly prolonging the time. The deviations from a uniform flow draw the attention to the manner of supplying the material to the orifice, the compacting, the head, the shape and size of the supplying receptacle, and the time during which the material is permitted to remain at rest before the flow begins. Uniformity is greatest in the case of substances least compacting under pressure, and under conditions of flow that loosen the material above and near the orifice. It is favored by thorough dryness, rounded particles, and a low sand-head. Observations deviate less than one part in six hundred in the case of river sand of .01 inch diameter, under a sand-head of three inches, flowing five minutes through round orifices of ¼ inch diameter; while under the same conditions, but with angular or damp material, deviations exceed one part in fifty.

The velocity of flow under the existing conditions of gravity is governed chiefly by the size of the orifice and the size of the grains. Other important influences are the shape and surface condition of the grains and the shape of the orifice. Other conditions to be mentioned exert a less marked influence.

The size of the grains influences the velocity of flow, causing, with the increase in size, a decrease in the velocity. There was observed in river sand a maximum velocity at which the ratio of the diameter of the grains to that of the orifice ranged from 1:15 to 1:30 approximately. With finer material the velocity quickly dropped from this maximum, while with coarser the drop was seen to be gradual, and, on the whole, more regular. The size of the grains is closely related to the shape and surface condition, one quality merging into another and requiring common consideration in the case of substances which require handling in practice.

The moisture content produces a retardation of the flow. The influence with increasing fineness and decreasing density becomes greater. The moisture in material which is positively dampened can alter the rate of flow many-fold, producing results out of all semblance to uniformity. As the material becomes progressively drier, the velocity of flow becomes greater and more uniform.

Angularity of the particles causes a diminution of velocity. The effect is less marked with fine material and with large orifices.

The uniformity of size of the grains is of influence upon the velocity. The velocity of a mixture of materials, with respect to the weight, approximates and slightly exceeds the mean of the velocities of the two sizes flowing separately. Thus the time occupied in the discharge of a given weight of material of mixed sizes is slightly less than that which would be required for the discharge of each sized constituent separately.

The material of which the orifice is constructed is shown to modify the velocity to a small extent.

The specific gravity of the flowing material is without relatively appreciable influence upon the velocity of flow under practical conditions.

The sandhead exerts a barely appreciable influence upon the velocity of flow. The influence is in the direction of a decreasing velocity with increasing head. With materials capable of becoming compressed or compacted, the retarding effect of the head becomes more pronounced. A consideration of the sand-head must thus include not only the height of the column and the specific gravity of the material, but the impact in gathering above the orifice, the dampness, coherence, and the angularity.

The contour at the surface of the material above the orifice exerts a minute influence upon the velocity. Thus when the surface is allowed to sink directly above the orifice, so as to form a pit, there is a slight increase in flow perceptible beyond that observed when the surface is level at the height corresponding to the bottom of the pit.

The shape of the receptacle supplying an orifice has but slight influence upon the velocity of flow where the bottom is flat around the orifice and the vertical column of material above the orifice remains unobstructed.

The effect of taper in orifices is an increase in flow where the enlarged opening of the orifice is presented to the descending material.

The length of discharge-orifices, or the thickness of the plate through which orifices are cut, is of scarcely appreciable effect as examined within the range of one inch.

The size of an orifice at the minimum required for an assured continuous flow must liberally exceed that found suitable for short intervals, to provide for the variability in quality of usual sands and the chance arrangement of particles in obstruction. The diameter of round orifices suitable for the steady flow of the sand materials tested ranges from five to twenty times the diameter of the particles, according with the size and quality of the material.

The horizontal, cross-sectional shape of the vertically discharging orifice influences the velocity of flow. The velocity is highest among the discharge-orifices tested having the greater ratio of area to periphery.

The area or size of the orifice affects the velocity. Thus the discharge is governed both by the area over which the given velocity is effective and by the velocity resulting from this area. The velocity decreases with