A Compact Rotary Sieve and the Importance of Dry Sieving in Physical Soil Analysis

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A Compact Rotary Sieve and the Importance of Dry Sieving in Physical Soil Analysis[1]

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ABSTRACT

Specifications are given for a more compact, lightweight rotary sieve that can be transported and handled more conveniently than the two-sectional units previously developed to determine the size distribution and mechanical stability of dry soil aggregates. The state and mechanical stability of the dry aggregates is a closer index of field structure than the state of the primary aggregates determined by wet sieving. In addition to the primary and the dry aggregates, the surface crust and the highly water-dispersible materials among the dry aggregates also markedly reflect the physical structure of soil as it exists in the field.

THERE IS A CONTINUING and increasing demand for more detailed specifications of a rotary sieve used to determine the size distribution and the mechanical stability of dry soil aggregates. The demand has been primarily for a compact, lightweight sieve that can be transported and handled more conveniently than the two-sectional units described previously (2, 4). Such a compact rotary sieve is described here. It has 5 individual cylindrical sieves, 4 of which have openings the same as in the original sieve (4). The compact sieve is not available commercially; therefore, users must construct their own.

Construction

The construction of the 5 cylindrical sieves is basically the same as of the improved rotary sieve machine described previously (2). The present set of sieves is bolted together to form one unit as shown in figure 1, A diagrammatic cross-sectional view of the sieve, drawn to scale, is shown in figure 2. Designation of the parts and their description is similar to that in reference (2).

The essential parts common to all rotary sieves can be observed from figure 2. They are: A circular flange *A* composed of a metal plate 1/8-inch thick and 18 inches in outer diameter, the upper portion *B*, the perforated area *C*, and the lower portion *D*. Dimensions of each of these parts, diameter of sieve openings, and other specifications are given in table 1. Sieves with larger or smaller openings can be used, but if larger, the diameter of the cylindrical sieves would have to be increased so the space between the cylinders is sufficient for soil aggregates to slide through.

Openings in sieves 1 and 2 are square perforations in the galvanized sheet metal of which the cylinders are composed. Openings of sieve 1 can be cut with a sharp wood chisel the same width as the openings. Openings of sieve 2 can be cut with a square punch with its tip shaped concavely. A block of hardwood under the sheet metal facilitates cutting.

Openings in sieves 3, 4, and 5 are composed of brass wire screening soldered to the sheet metal and suitably reinforced. The reinforcement consists of narrow metal strips riveted to the outside of the screening and to the upper and lower portions of the cylinder. Such reinforcement is required only for sieves 4 and 5.

The brass wire screening has openings conforming to the sieve series of the United States Bureau of Standards. The screening is available commercially. Sieves 3, 4, and 5 are composed of No. 10 (2000μ openings, 0.035 wire), No. 20 (840μ openings, 0.016 wire), and No. 40 (420μ openings, 0.011 wire) screening, respectively.

A nest of 5 sieves is made by stacking the cylinders one outside the other and bolting flange *A* of each cylinder to a circular hub board *E* (figure 2). The hub board is composed of plywood ½-inch thick and is fastened to a cylindrical hub *F*. The hub rides on two 2-inch diameter idling V-pulleys G with centers 4 inches apart. An inverted V-track *H* fastened around the outside of the rotating hub rides on the pulleys and keeps the sieve cylinders in place. Another V-track *H'* fastened on the outside of the cylindrical hub acts as a seat for a drive belt. The whole unit can be removed merely by disengaging the drive belt.

Spacing of cylindrical sieves is determined on the upper end by the position of the holes in flange *A* through which bolts are inserted. Spacers (not shown in figure 2) are used on the lower end. The spacers are composed of 4 to 8 stove bolts of appropriate length passed through the wall of the larger cylinder and butted against the next smaller one. Nuts tightened against the larger cylinder keep the bolts in place. To replace a cylinder it is necessary to loosen the nuts.

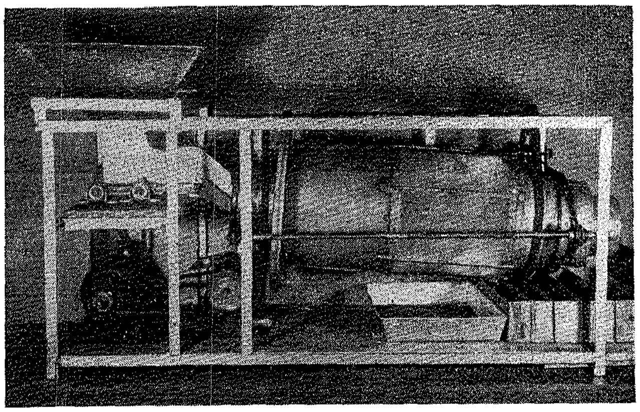

Figure 1—A compact rotary sieve ready for use.

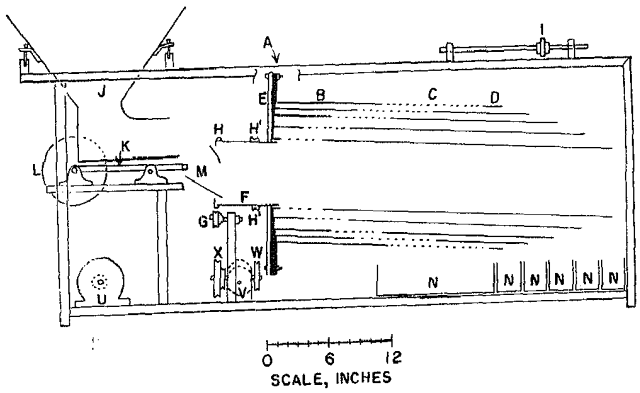

Figure 2—Diagrammatic cross-sectional view of the compact rotary sieve shown in figure 1.

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Table 1—Specifications of concentric cylindrical sieves of a rotary sieve apparatus.

Sieve no.	Diameter of square sieve openings	Diameter of cylinder	Length of cylinder			
			Upper portion	Perforated portion	Lower portion	Total portion
	mm.	inches	inches	inches	inches	inches
1	19.2	6	1/2	3 3/4	27 1/4	32 1/2
2	6.4	8 1/2	3	4	22 1/2	29 1/2
3	2.0	10	5 1/2	5	16 1/2	27
4	0.84	11 1/4	8	7	9 1/2	24 1/2
5	0.42	12 1/2	10 1/2	10	1 1/2	22

The cylindrical sieves are sloped 4 degrees from the horizontal as in the original apparatus (4). The upper end of the nest of sieves rides on two idling pulleys *G*, and the lower end is suspended on a belt that runs around the outside of any one of the cylindrical sieves and over an idler pulley *I* on top of the apparatus. Two other belts are strung around the cylinder and over idling pulleys (not shown in figure 2) on each side of the apparatus to prevent any side swing that might occur. The pulleys can be slid on a horizontal shaft to any desired position and are held in place by a pair of collars. Belts are removable. Belts of different lengths are available for use, depending on the diameter of the rotary cylinder on which they ride.

A sample of soil to be sieved is placed in hopper *J*. The hopper has an open bottom. The cross-sectional dimension of this opening is 3½ inches square. The opening fits against a horizontal conveyor belt *K* which carries a stream of soil into the apparatus. The speed of the conveyor is 5 inches per minute so that the volume of soil-flow into the apparatus is about 60 cubic inches per minute. The conveyor is driven by a shaft of 1-inch diameter connected to a drive pulley *L*.

The soil slides through chute *M* and inside the hub section *F*. From there it slides through the rotating sieves, is separated into various size fractions, and is deposited in trays at *N*. The speed of rotation of sieves is 7 rpm.

Chute *M* is mounted on a hinge so it can be raised to facilitate insertion and removal of the hub section *F* and the nest of sieves. A spring (not shown in figure 2) holds chute *M* in proper position.

Power is supplied from an electric motor *U* to a 50:1 speed reducer *V*. Pulley *W* drives the upper sieve section along a tract *H'*. Pulley *X* drives the conveyor pulley *L* through a pair of intermediary pulleys fastened to a horizontal shaft not shown in figure 2.

The hopper opening is large enough to provide a uniform flow of soil containing virtually any amount of crop residue and any proportion of clods up to 2 inches or more in diameter. Clods much larger than 2 inches are picked up by hand and weighed.

A small amount of dust is usually carried away by air currents during sieving. It is important that the soil sample be weighed prior to sieving to determine the amount of dust lost, if any. This amount could be added to the amount of the finest sieve fraction.

Sampling and Preparing Soil for Sieving

Sampling is best done when the soil is reasonably dry to avoid as much as possible the breakup of or the change in structure. A flat, preferably square-cornered, spade is pushed under a body of soil and the soil is lifted, placed in a suitable tray, and brought in for thorough drying. The depth of sampling varies, depending on a particular study. In connection with wind erosion studies, many samples are taken to approximately 1-inch depth. In some studies, layers of soil are sampled such as 0 to 1 inch, 1 to 3 inches, and 3 to 6 inches. The soil is dried at 70° C. prior to analysis. Results of analyses on soils dried at 70° C. and at room temperature were found to be about the same, however.

Table 2—Materials required for sieves.

Sieve no.	Circular plates*		24-gauge sheet metal for†		Brass screening‡
	Outside diameter	Opening diameter	Upper end	Lower end	
	inches	inches	inches	inches	inches
1	18	6	33 1/4 by 19 5/8	(all one piece)	None
2	18	7 1/2	30 1/4 by 27 1/2	(all one piece)	None
3	18	9	6 by 32 1/4	16 3/4 by 32 1/4	6 by 32 1/4
4	18	10 1/2	8 1/2 by 36 1/4	9 3/4 by 36 1/4	8 by 36 1/4
5	18	11 3/4	11 by 40	1 3/4 by 40	11 by 40

* Flange A of improved apparatus (2). Tempered aluminum plate, 1/8-inch thick to be bolted to hub board E.

† Three-fourths inch allowed for folding at joints, 1/4 inch for folded edge at lower end of cylinder, and 1/2 inch for flange at the upper end. This flange is riveted to the circular plate (flange A of reference 2).

‡ One-half inch is allowed for overlap of screen on metal.

Sieving Technique

Sieving is simple and rapid. The soil is placed in the hopper of the sieve. Sieving is automatic. The various soil fractions are weighed after the soil has gone through the sieve. During the weighing of one sample the machine is busy sieving the next. Sieving of each sample is repeated at least once to obtain some idea of the relative resistance of the soil to breakdown by mechanical forces such as tillage or abrasion by wind erosion. This is called mechanical stability. The size distribution and mechanical stability of the aggregates are thus determined simultaneously.

Advantages and Disadvantages of the Rotary Sieve

Some advantages of the rotary sieve over the flat sieve methods are as follows: (*a*) it is more consistent than any other method of dry sieving so far devised; (*b*) it is not subject to a variable personal factor; (*c*) it gives fairly consistent results irrespective of the size of soil sample used; (*d*) on the whole, it causes less breakdown of clods; (*e*) it virtually eliminates clogging of the fine sieves as is usually the case with the flat sieve methods; and (*f*) it is well suited for resieving the soil any number of times to determine its mechanical stability.

One disadvantage of the rotary sieve is that sieves of different openings are not readily interchangeable. The construction of the rotary sieve is more complicated than of the flat sieves. The number of sieves used influences the degree of aggregate breakdown. It is necessary, therefore, to have a standard size and number of sieves in all comparable tests.

Importance of Dry Sieving in Physical Analysis of Soil

Methods of aggregate analysis fall into two distinct classes, those that aim at determining the size distribution of the aggregates actually present in the field, and those that aim at determining the size distribution of the water-stable aggregates.

Many soils suffer frequent wettings. Pigulevsky (1913), Pavlov (1926), and Tuilin (1928), as quoted by Russell (7), were some of the first to suggest that much more useful information would be found by sieving the soil in water rather than in air. These suggestions were apparently based on the assumption that wetting of the soil as occurs in the field tends largely to break up the field aggregates to individual water-stable aggregates. The technique of sieving in water has been modified by a large number of workers and has been used extensively as a method of soil aggregate analysis.

The early assumption that dry aggregates are "transient" under field conditions apparently has helped to develop a conception among some workers that the status of the water-stable aggregates as conventionally determined by sieving, elutriation, or sedimentation in water is a proper index of soil structure. However, soil structure as it exists in the field is a complex condition. Therefore, no single method can be used to evaluate it completely. The primary, or water-stable, aggregates represent one phase of the soil structure; and the clods, secondary, field, or dry aggregates, as they are variously called, represent another phase. Neither of them separately nor together represent all phases of structure in the field. Two other major phases are the surface crust and the highly water-dispersible materials among the clods (3).

Mazurak (5, 6) asserted that the secondary aggregates, the same as any other structural aggregates, are transient only in degree. He concluded that the secondary aggregates as determined by dry sieving are the same as those obtained in water at zero shaking time, provided the aggregates for analysis in water are wetted under vacuum. Chepil (3) confirmed that only within the immediate soil surface where these aggregates are subjected to impacts of rainfall does considerable breakdown of secondary aggregates occur. Therefore the state of the secondary aggregates, as determined by dry sieving, is a closer index of field structure than the state of the primary aggregates. Wittsell,[3] for example, found that dry sieving with the compact rotary sieve detected smaller soil physical differences between crop rotations and field plot fertilizer treatments than wet sieving, clod crushing strength, mechanical stability of clods as determined by repeated dry sieving, or aggregate porosity determinations. In cases where soil physical differences were smallest, the size distribution of dry aggregates determined by dry sieving was the only soil property that was significantly different between plot treatments.

[3]Wittsell, L. E. A study of methods for measuring soil physical conditions. M.S. thesis, Kansas State University, Manhattan, 1959.

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