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A FIELD TECHNIQUE FOR SIEVING COARSE GRANULAR MATERIAL

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Introduction

The technique described herein was developed so that a rapid and fairly accurate grain size analysis of coarse granular material between No. 4[1] and 3" (4.75 - 75 mm) could be carried out in the field. The method was first used in a granular resource inventory in the Mackenzie Valley, N.W.T. (Lawrence, 1972).

To obtain a representative grading curve for coarse grained material, the minimum sample weight required might be up to 45 kg. depending upon the maximum nominal size of the material (A.S.T.M. C136-71). It is not always practical to collect a sample of this weight for laboratory grain size analysis. An alternative quantitative procedure involves sieving a representative amount of material in the field, splitting and collecting a representative sample of the material passing the No. 4 sieve for further processing in a laboratory. The weight of this minus No. 4 portion would be 1-2 kg depending on test requirements; a more practical sample size.

Portability of the apparatus, and speed and accuracy of the testing procedure were the principal considerations in the development of this field technique.

Portability. It was necessary that the size and weight of the apparatus be small enough to fit easily into a small helicopter or be carried by one man while traversing difficult terrain.

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[1] All sieve sizes are U.S. Standard sieve specifications

Speed. A large number of widely separated deposits had to be assessed in a relatively short time. The length of time for a field sieving averaged 15 minutes, but this varied with size of material and environmental conditions.

Accuracy. Limits of accuracy were set at ±5.0%. Considering the size of the sample tested, the conditions under which the sample was tested and the alternatives (i.e., collecting very large samples or describing the sample subjectively as "very coarse" or "predominantly coarse"), these limits of accuracy did not detract from the purpose of the test – to provide preliminary quantitative information on granular material for construction purposes (A.S.T.M. D448-54).

APPARATUS

The apparatus consisted of four major components: a set of five nesting sieves, a set of five weighing pans; a spring scale and attachments, and 2 quartering canvases (Fig. 1).

The sieves were constructed from galvanized steel garbage tin lids, ranging in diameter from 16 to 20", so that they would nest (Grant, 1963, pp. 15-18). Three-inch and 1 1/2" square holes were cut in the two largest lids to conform to U.S. Standard sieve sizes 3/ and 1 1/2" respectively. Circles of 14" diameter were cut from the remaining three lids and wire mesh of 3/4", 3/8" and No. 4 (A.S.T.M. E11-70) were brazed into the circular openings to produce the three smaller sieve sizes.

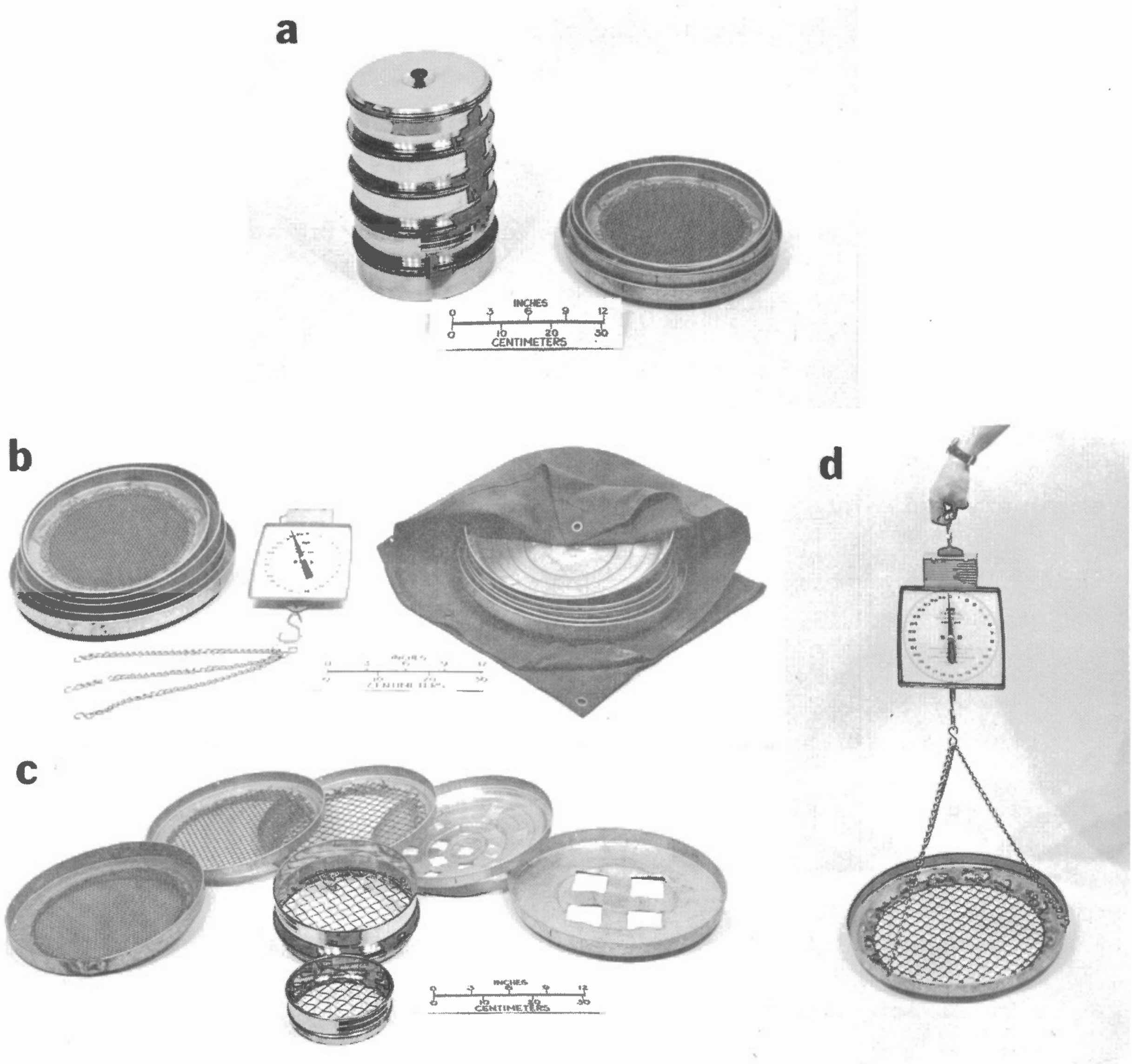

Figure 1.˙ (G.S.C. photos 202191, a, b, c, d)

a. Comparison of commercially available 12-inch diameter sieves and field sieves fabricated by the authors. The bulk and weight of the 12-inch diameter sieves preclude their use in the field.

b. Major components of field sieving equipment. Sieves, weighing pans, quatering canvas, spring scale and bridle.

c. Complete sieve bank (3", 1-1/2", 3/4", 3/8" and No. 4). For size comparison 12 and 8 inch diameter sieves are shown.

d. Weighing apparatus.

Weighing pans were constructed by removing the handles from a similar set of five garbage tin lids. Three equidistant holes were punched around the circumference of these lids so they could be suspended from the spring scale for weighing.

A spring scale (capacity 60 lbs., graduated in 0.1 lb. increments), fitted with a chain bridle, which could be easily attached to the weighing pans, was used for all weighing.

Two quartering canvases, with a grommet in each corner, served the following functions:

- a clean work surface
- a weighing container
- a sample quartering and splitting device
- a sample transport and pouring device
- a carrying container for sieves, pans and scale.

Miscellaneous equipment included a wire brush to clean the sieves and a cânvas bag to house the scale during transportation to keep it clean.

PROCEDURE

The flow diagram (Fig. 2) illustrates the sieving procedure. This procedure was modified from A.S.T.M. C136-71, D75-71 and E386-69.

A representative sample of appropriate weight was shovelled onto the first quartering canvas.

> "The estimated weight of the sample should be large enough to assure that the largest size particles are included in sufficient quantity so that the inclusion or exclusion of one particle will not affect the results beyond the limits of accuracy" (C. E. Proudly, 1948). The minimum sample weights set by A.S.T.M. are listed

> in Table 1 (A.S.T.M. D75-71 and A.S.T.M. C36-71). Experience shows that the C136-71 specification was always exceeded but the D75-71 specification was not exceeded except where the maximum particle size was less than 3/4".

Sieve pans required for the first sieving were then nested on the second quartering canvas in the order No. 4, 3/8", 3/4". The sample was transferred from the first canvas in small portions to the 3/4" sieve.

> The amount of material on a sieve at any time should not be more than 2 or 3 particle layers deep because larger amounts will retard sieving and prevent some particles from passing through the sieve.

The sieves were then shaken one at a time; the material passing being caught on each successively finer sieve. When the amount of material on a sieve exceeded the recommended amount, it was transferred to a weighing pan and retained until the whole sample had been processed. Material passing the No. 4 sieve was retained on the quartering canvas. The plus 3/4" material was transferred to a second bank of sieves (3", 1-1/2", 3/4") resting on the first quartering canvas and processed by the same technique. If material passed the 3/4" sieve during the second sieving it was recycled to the first bank of sieves.

When sieving was complete each fraction and weighing pan were weighed and then the weighed portion discarded. If only a small amount of material was retained on a sieve, the sieve and sample could be weighed directly, thus avoiding the transfer of material from sieve to weighing pan.

The minus No. 4 material was weighed using the quartering canvas as the weighing container by passing the balance hook through the grommets in each corner of the canvas. The minus No. 4 portion of the sample was then

FLOW DIAGRAM OF SIEVING PROCEDURE

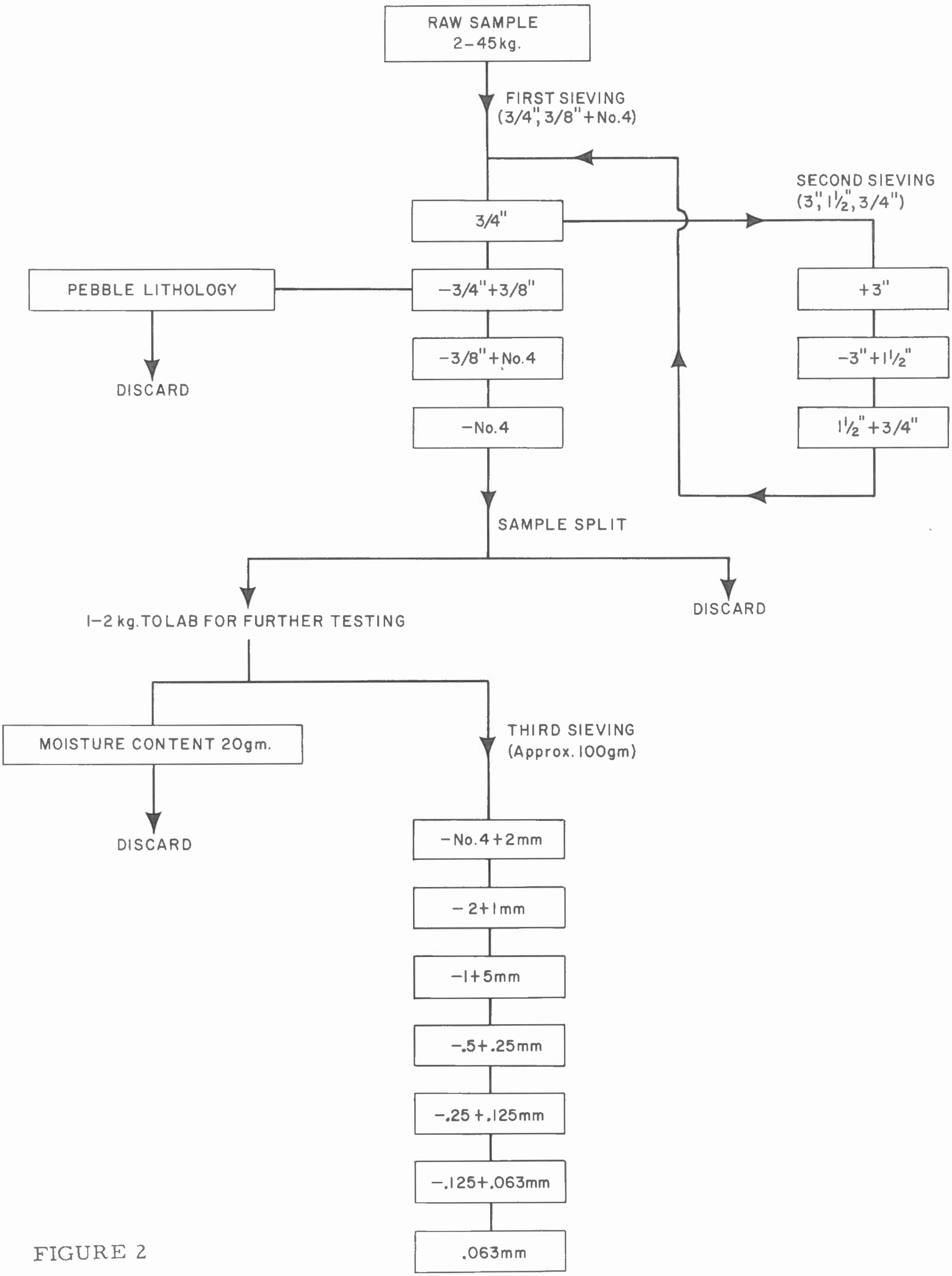

FIGURE 2

mixed and split on the canvas (A.S.T.M. C702-71T). A sample of approximately 2 kg was retained for further testing. The remaining portion of the sample was discarded and the quartering canvas weighed.

The 2 kg sample of minus No. 4 material was processed in a laboratory for moisture content and the grain size distribution.

Table 1

Recommended minimum sample sizes for assessment of coarse aggregate

Maximum size of particles USS (mm)	Minimum sample size lbs. (Kg.)	
	ASTM D75-71 and AASHO No. T2 aggregate for roads	ASTM C36-71 and AASHO No. T27 aggregate for concrete
3" (75)	330 (150)	100 (45)
1-1/2" (375)	165 (75)	35 (16)
3/4" (19)	55 (25)	20 (8)
3/8" (95)	25 (10)	5 (2)
No. 4 (4.75)	25 (10)	5 (2)

CALCULATIONS

Figure 3 is an example of the calculation sheet used to adapt the values obtained from field sieving (columns (1)[1] and (2)) to the laboratory sieving results (12), thereby determining the grain size distribution of the entire sample. The method and calculation sheet were modified from the standard soil mechanics grain size analysis, such as found in Lambe, 1951, and are explained fully in the Appendix.

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[1] These numbers refer to the columns or values in Figure 3.

FIGURE 3

SIEVE ANALYSIS

SIEVE SIZE			WEIGHT RETAINED					CUMULATIVE		CUMULATIVE %	
	OPENING	U.S.S	WET SOIL+ PAN 1	WET PAN 2	WET SOIL 3	WT. WATER 5	DRY SOIL 6	FIELD 7	LAB	RET. 9	PAS. 10
INCHES	3	3″									
INCHES	1 ½	1 ½″									
INCHES	¾	¾″									
INCHES	⅜	⅜″									
MILLIMETRES	4.76	4								15	14
MILLIMETRES	-4.76	-4									
MILLIMETRES	2.0	10					12		13	16	17
MILLIMETRES	1.0	18									
MILLIMETRES	0.5	35									
MILLIMETRES	0.25	60									
MILLIMETRES	0.125	120									
MILLIMETRES	0.063	230									
MILLIMETRES	-0.63	-230									

MOISTURE CONTENT
4

CONTAINER NO. ______

WT. TARE & WET SOIL ___ gm

WT. TARE & DRY SOIL ___ gm

WT. WATER ______ gm

WT. TARE ______ gm

WT. DRY SOIL ______ gm

WATER CONTENT (W)

______ %

STA. NO. ______

SA. NO. ______

UNIT ______

FIELD SIEVING
8

a) WT. WET SOIL

______ lbs

b) WT. DRY SOIL

______ lbs

LAB SIEVING
11

WT. DRY SOIL

______ gms.

The major modification to the standard calculations was the conversion of the wet soil weight to a dry soil weight. The field sample was sieved wet since it would have been impractical to dry it in the field. Since coarse granular material is relatively dry naturally, moisture in the sample did not hinder the sieving. A dry weight was necessary to adapt the field sievings with the laboratory sievings. To obtain this dry weight the moisture content of the sample was assumed to be distributed proportionally be weight throughout the entire sample. The moisture content was calculated in the laboratory on a portion of the minus No. 4 sieve fraction.

The weight of water in each sieve fraction was calculated as follows:

1. $$\text{weight of water} = \frac{\text{weight of wet soil retained}}{\text{total wet weight}} \times \text{total moisture content}$$

or $$(5) = \frac{(3)}{(8a)} \times (4)$$ (Nos. refer to boxes in Figure 3)

This weight was then subtracted from the wet soil weight of the same fraction size and standard calculations were followed from thereon.

IMPROVEMENTS

Field use showed that improvements could be made to both equipment and procedure. Although the modified garbage tin lids worked well, for a more permanent sieving apparatus, nesting sheet metal pans fitted with metal stone sieve plates, which can be obtained commercially, could be used. It was found that the nesting order should be reversed from that originally used. That is, the largest sieve size should be the smallest diameter pan. This would allow the sieves to nest in the order they are used for sieving.

The quartering canvases could be equipped with straps so when used as carrying cases for the pans and scale, they could be carried like a back pack or strapped to a pack board. This would improve the portability of the equipment when it had to be carried for great distances.

Other small refinements include the use of the metric system in field measurements and the use of a computer program to make the final calculations.

CONCLUSIONS

A rapid and fairly accurate technique for field sieving of relatively dry coarse granular material has been described. The apparatus is compact and light. A field sieving can be carried out by one or two men in fifteen to twenty minutes. A representative sieving of coarse granular material can be made without transporting large samples of material to a laboratory. Values from the field sieving can easily be tied in with laboratory sieving of finer material to obtain the grain size distribution of the entire sample.

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APPENDIX

Explanation of Calculation

(1)[1] weight of wet soil retained on each field sieve plus weight of the weighing pan

(2) weight of weighing pan

Only values (1) and (2) are determined in the field.

(3) weight of wet soil retained on each field sieve is determined by subtracting the pan weight from the weight of the wet soil retained plus pan

2. $$(3) = (1) - (2)$$

(4) standard calculation of moisture content determined from 20 gms of the minus No. 4 portion of the sample

(5) calculated weight of water contained in each size fraction (3" – No. 4). The field sample was sieved moist since it would have been impractical to dry it. To obtain a dry weight for each size fraction (3" – No. 4) it was assumed the moisture content calculated in (4) was distributed proportionally (by weight) throughout the entire sample. Therefore to calculate the weight of water in each size fraction (3" – No. 4):

$$\text{weight of water} = \frac{\text{weight of wet soil retained}}{\text{total wet weight}} \times \text{total moisture content}$$

3. $$(5) = \frac{(4)}{(8a)} \times (3)$$

(6) weight of dry soil retained on each sieve (3" – No. 4) is calculated by subtracting the weight of water in each sieve fraction from the weight of the wet soil in the same fraction

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[1] these numbers refer to the columns or values in Figure (3)

4. $$(6) = (3) - (5)$$

(7) cumulative weights of dry soil retained on sieves (3" – No. 4)

(8a) wet weight of soil obtained by summing values in (3)

(8b) dry weight of the total sample which is the cumulative weight of material passing the No. 4 sieve (7).

(9) cumulative per cent of the total sample retained on each sieve No. 4 or larger, calculated as the cumulative field weight divided by the dry weight of the total sample

5. $$(9) = \frac{(7)}{(8b)}$$

(10) cumulative per cent passing each sieve, calculated by subtracting the cumulative per cent retained from 100

6. $$(10) = 100 - (9)$$

(11) weight of dry soil passing No. 4 used in the laboratory sieving

(12) weight of dry soil retained on each sieve passing No. 4 as determined in the laboratory

(13) cumulative weights of dry soil retained by the laboratory sieving

(14) culative per cent passing No. 4

(15) cumulative per cent retained on No. 4

(16) cumulative per cent of the total sample retained on each sieve less than No. 4. It is calculated by adding the value of the cumulative laboratory weight divided by the dry weight of the laboratory sample multiplied by the cumulative per cent passing No. 4 to the cumulative per cent retained on No. 4 sieve.

7. $$(16) = \frac{(13)}{(11)} \times (14) + (15)$$

8. $$(17) = 100 - (14)$$

Either the values in (9) and (16) or the values in (10) and (17) can be plotted on an engineering grain size distribution curve.