

THESIS

For The Degree of Civil Engineer

A STUDY OF THE SANDS OF VIRGINIA

By

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SANDS OF VIRGINIA.

It is the purpose of this paper to give the results of the study and investigation of the sand deposits in various parts of the State of Virginia. The chief stress is laid on those sands coming from points west of the Blue Ridge Mountains. The reasons for stressing the western and southwestern Virginia sands, as they will be called throughout this paper, will be brought out in the pages that follow.

The study and investigation of these sands was started in the spring of 1928 and has been carried on continually up to the present time, May 1929.

Results of this work have prompted a continued study of sand which it is impossible to complete during the school year 1928-29. However, it is the plan to continue this work during a part of the summer of 1929, taking it up as regular work in the fall of 1929 and carrying it on until January or February 1930, at which time a bulletin will be published setting forth results which may be found in this paper, together with other valuable information which it is hoped will be obtained in future research.

At the present time practically all of the building sand used in the State of Virginia comes from a sand deposit at Petersburg, Virginia. (By building sand it is to be understood that we mean sand used in concrete building construction).

Such a small amount of suitable building sand is available from any source in the State, other than Petersburg, that it has come to such a pass that specifications for concrete work frequently specify, "Petersburg sand (washed) or its equivalent".

During this investigation of different sands, it has been found hard to produce a sand that will absolutely satisfy A. S. T. M. (American Society for Testing Materials) specifications. Results of this work point to the possibility that these specifications might have certain limitations put on them which would allow the use of sand other than that from Petersburg.

The chief aim in finding a sand to replace that coming from Petersburg is due to the high freight rates which make the cost of this sand laid down on the job in this part of the State (southwest Virginia) practically four times the cost at the pits in Petersburg. The following figures will serve as an illustration of what might be overcome by producing sand in the western part of the State.

Petersburg washed sand \$0.50 per ton at Petersburg;  
Freight to Blacksburg \$1.50 per ton;  
Making a total cost of the sand \$2.00 per ton in Blacksburg.

This figure makes no allowance for cost of unloading the sand from the car and hauling it to the job. This means, then, that the sand costs the consumer \$3.00 to \$3.50 per cubic yard laid down on the job.

Should the results of this research cause the development of sand deposits in other parts of the State where the above freight rates would be greatly reduced, the final cost of concrete work would be reduced an appreciable amount.

At this point it might be well to give a definition of sand: The fine granular material one-fourth inch or less, resulting from the disintegration of rock or from the crushing of friable sand stone. Practically all sand has as its origin, rock, which has been disintegrated and broken down by physical agencies, leaving relatively small or fine particles which are known as sand. The kind of sand, of course, depends upon the kind of stone from which it comes. Most of the particles of sand are made up of quartz, the hardest and most resistant parts of the original stone.

Uses: Sand is used for many and varied purposes; however, its chief uses are in the making of concrete, plaster, moulding and glass. The most important use is probably in the making of concrete; at any rate, it has been the chief aim in this work to develop a good concrete sand.

Minor uses are such as blasting, sand for use on engines and cars to sand tracks, cushions for brick paving, brick mortar, etc.

Necessary Characteristics: The necessary characteristics of a good sand will be given in order for different kinds of work, as follows:

1. Concrete
2. Plaster
3. Moulding
4. Glass

Concrete Sand: Sand for concrete shall consist of hard, strong, durable and uncoated mineral or rock particles free from injurious amounts of alkalies, saline or other deleterious substances.

Hard durable particles are absolutely essential and may be easily overlooked in selecting a sand. It is not uncommon to bind sand made up of what appears to be good, sound particles, only to find upon careful investigation that the sand particles are made up of very minute bits of sand cemented together by clays or some other material which binds these particles together; even a sieve analysis will often fail to break these cemented parts down. Upon being subjected to water they will separate and break down into many small parts. The result is that the final sand will be much finer than allowance has been made for. It is quite possible that the final breaking down of the sand particle may not take place until after it has become coated with cement, mixed with the stone and placed in the forms. When such a condition exists the resultant concrete is greatly

## 3.

reduced in strength. The reduction in strength might be so great as to render the structure unsafe.

If we assume the breaking down of the particles to take place before the mixing is complete, so that all the fine particles become coated with the cement, the resultant concrete will be hard and stiff, necessitating extra work to handle. The final structure will be much more apt to crack from expansion and contraction due to the excess of surface area exposed by the fine particles.

It is not to be gathered from the foregoing that no fine material is required in a good concrete sand; quite the contrary is true. A certain amount of fine material is desirable to produce a good workable mix. The total amount or the per cent of fine material in the sand should be known and this amount kept fairly constant.

The best gradings of concrete sand are as follows:- (A. S. T. M. Specifications)

Two to thirty per cent of the sand should pass the 50-mesh sieve. (For further information, see sieve analysis given under Tentative Specifications.)

It is not uncommon for very fine sand to be bound or cemented together with certain organic substances which may or may not prove injurious to resultant concrete. The bond by such substances is not likely to exist in washed sands. On the other hand washing does not necessarily remove organic impurities which are undesirable in building sand. Certain tests will be given in the following pages which enable us to determine organic content in sand.

Organic impurities are undesirable in sand in that they tend to destroy the ideal condition in concrete, which is to have each particle of sand completely coated with cement, which in turn bonds it to the next particle of sand or stone. After this condition has been attained the concrete begins to grow in strength rapidly for about thirty days and at a somewhat slower rate for years.

Now let us assume that each one of the sand particles are completely coated with a fine film of some organic matter; this in turn being covered with a film of cement; the result is that we have a condition of which very little is known and of which accurate predictions are practically impossible to make. We do know that at any time the organic coating may peel off or separate from the sand, leaving the sand free from the desired coating of cement. The results of many tests show that it is unsafe to use a sand containing organic impurities.

It is not advisable to condemn a sand simply because the first tests for organic impurities are not satisfactory. The "Colormetric Test", which is the usual preliminary test, should only serve as a warning. It has been

discovered after using this test on many different sands that its results cannot be taken as conclusive. Often a sand will give a very poor color-metric test and on close investigation of the sand it has been found to contain practically no injurious organic matter. Discovery has been made of a few tiny particles of wood, leaves, grass or old roots of plants, which had fallen into the sand, and these alone were the cause of the poor test results. When organic material is present in such a form and in small quantities, it could have no detrimental effect on the strength of concrete. A thorough washing of the sand will often remove this material to such an extent that the result of test will be satisfactory.

Should washing fail to remedy this condition, it is advisable to have the sand sent to a testing laboratory for actual strength tests to be made before finally condemning it.

The presence of clay and silt in sand in quantities over about three to six per cent is undesirable. Practical field tests for determining the quantity of silt and clay will be given in the following pages.

Plaster sand: Sand should possess the same characteristics as those for good concrete work in order to produce good plaster.

Moulding sand: The principal requirements of a good moulding sand are:

resistance to fusion;  
hardness; and  
permeability.

An excess of lime (one per cent or more) will lower the resistance of the sand to fusion.

Permeability, or the ability of the sand to permit the passages of the gases formed in the moulds by the molten metal, is most essential. There must also be a bond or cohesion between the sand particles, or else the expansion due to the hot metal will cause the moulds to crack and break apart. A moulding sand must be durable, so that it may be used a number of times. The condition of the sand must be such that it is easily shaken from the moulds after cooling. This condition depends to a great extent on the ability of the sand to resist fusion. If the sand fuses readily, the result will be that the moulds blow all to pieces, or else it will be practically impossible to use the sand again due to the lumps and hard particles formed by the fusion.

The above properties are dependent on the amounts of the following substances in the sand:

- (1) Quartz:- The refractory body of the composition  
no bond.
- (2) Clay Substance:- The bonding body of the composition.
- (3) Feldspar or fluxing ingredient:- Not desirable,  
but present in some proportion  
in nearly all natural sands.

Limited quantities of moulding sand may be found in the Tidewater region of Virginia.

The following table gives an example of the chemical composition of a sand which is used for general casting work:

Silica - - - - -	85.04%
Alumina - - - - -	5.90
Ferric Oxide - - -	3.18
Lime - - - - -	0.06
Magnesia - - - - -	0.14
Potash - - - - -	1.65
Soda - - - - -	0.83
Titanic acid - - -	0.78
Water - - - - -	1.57
Moisture - - - - -	1.11

A chemical analysis is necessary, because the properties that are desirable of a moulding sand are dependent on the amounts of certain chemical compounds present in the sand.

Characteristics of a Good Glass Sand.

To be suitable for use in the making of glass a sand should be practically pure silica. Relatively small quantities of iron oxide render it unfit for use in this industry. Most of the glass used is plate glass, free from color. For this purpose, a sand containing more than about .06% iron oxide is not suitable. The brown color of most sand betrays at once the presence of iron in such quantities that there is little use of making a chemical analysis. The good glass sands are white or nearly white in appearance.

Unsatisfactory sands may sometimes be treated to reduce the percentage of iron oxide. Grinding and magnetic separation will often reduce the percentage of iron to such an amount that the sand can be used in making glass. This method is, however, too imperfect and costly to be of any use in sands containing enough iron oxide to give them a brown color.

The following is a typical analysis of a sand suitable for glass making, and is found in Southwest Virginia:

Silica - - - - -	96.99%
Alumina - - - - -	.01
Iron Oxide - - - - -	.02
Magnesia - - - - -	.07
Lime - - - - -	.80
Soda - - - - -	1.40
Potash - - - - -	.20
Water and Organic	<u>.31</u>
Total -	99.80%

### Sampling of Sand.

A. S. T. M. Serial Designation: D75-22

#### A. Non-Commercial Deposits.

Non-commercial as used here includes all undeveloped sand deposits and all deposits where the material is not washed or screened.

(a) The investigator should realize that few, if any, natural sand deposits are uniform, and when a sample is taken the quantity of material in the deposit similar to the sample shall be ascertained as nearly as possible.

(b) Where possible, samples of sand shall be taken when the sand is in the damp condition.

(c) If the deposit is worked as a bank or pit and has an open face, the sample shall be taken by channeling the open face so as to represent material that visual inspection indicates could be used. Care shall be taken to eliminate any overburden or stripping at the top or any that has fallen along the face from the top. It is necessary, especially in small deposits, to excavate test pits some distance back of and parallel to the face to determine the extent of the supply. The number and depth of these pits depends on the quantity of material that is to be taken from the deposit. Separate samples shall be taken from the face of the bank and from test pits. These shall be mixed in composite sample and the sample for test obtained by the quartering method.

(d) Deposits that have no open face shall be sampled by means of test pits. The number and depth of these shall depend on local conditions and the amount of material to be used from the source. A separate sample shall be taken from each pit and where visual examination indicates no radical difference in size of grain, color, etc., these shall be mixed in composite sample and the sample for testing obtained by the usual quartering method. Where visual inspection indicates a distinct difference in material from different pits, separate samples shall be taken for the test.

#### B. Commercial Sand Banks.

Samples of sand from commercial screening or washing plants shall be taken from the bins or storage piles preferably while the material is being loaded from these supplies. It is difficult to secure representative samples from stock piles and bins and, if conditions require sampling from these sources, the following is recommended:

Separate samples shall be taken from different parts of the stock pile, care being taken to avoid sampling segregated areas of coarse-grained material which are likely to exist at the base of the pile.

8.

In sampling from a bin, separate samples shall be taken from the top and the loading chute. At the latter place at least one-half cubic yard of material shall be run off and representative samples taken from it. These separate samples shall be well mixed in a composite sample and the sample for test obtained by the quartering method.

C. Quantity of Sand Samples.

Samples of sand shall contain at least twenty pounds of the material.

It is of utmost importance that great care be exercised in the taking of samples. A random sample taken from the foot of a stock pile where the larger material has collected in so far from representative of the sand that it is better to leave the sand untested. A thoroughly unsatisfactory sand may thus appear to be first class and vice versa. Samples taken when the sand is damp are more likely to contain fine and coarse particles in representative amounts.

Before tests are made on samples that have been hauled and shipped some distance, it is very important that the sample be well mixed and a sample for testing obtained by quartering. Otherwise the fine material may all be collected at the bottom of the container and a sample taken from the top is not representative.

Having given the general requirements of a sand suitable for concrete, plaster, moulding and glass the "Tentative Specifications for Concrete Sand" as set forth in "Design and Control of Concrete Mixtures"\* is as follows: (1) Sand shall be hard, durable and strong and shall conform to the requirements of these specifications.

"TENTATIVE SPECIFICATIONS

FOR

CONCRETE AGGREGATES

Serial Designation: C33-28T

Fine Aggregate"

"1. Fine aggregate shall consist of sand or other approved inert materials with similar characteristics, or a combination thereof, having hard, strong, durable particles and shall conform to the requirements of these specifications."

"2. (a) The maximum percentages of deleterious substances shall not exceed the following values:

	Per cent by weight
Removed by decantation . . .	3
Shale . . . . .	1
Coal . . . . .	1
Clay lumps . . . . .	1
Other local deleterious substances (such as alkali, mica, coated grains, soft and flaky particles) . . . .	

Note - It is recognized that under certain conditions maximum percentages of deleterious substances less than those shown in the table should be specified."

"(b) The sum of the percentages of shale, coal, clay lumps, soft fragments and other deleterious substances shall not exceed 5 per cent by weight."

"(c) All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified in Section 4."

"3. (a) Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves, shall conform to the following requirements:

10.

	Per Cent
Passing a 3/8 in. sieve . . . . .	100
Passing a No. 4 sieve . . . . .	(85) to (100)
Passing a No. 16 sieve . . . . .	(45) to (80)
Passing a No. 50 sieve . . . . .	(2) to (30)
Passing a No. 100 sieve . . . . .	(0) to (5)

NOTE-Figures in parentheses are suggested as limiting percentages, but they may be altered within these limits to suit local conditions."

"(b) In case the concrete resulting from a mixture of aggregates approaching the extreme limits for gradation is not of a workable character, or when finished does not exhibit a proper surface, due to an excess of particles approximately  $1/8$  to  $1/2$  in. in size, either a fine aggregate having a sufficiently greater percentage of fine material, or a coarse aggregate having a sufficiently smaller percentage of fine material, must be used."

"4. Fine aggregates, when subjected to the mortar strength test, shall have a tensile or compressive strength at the age of 7 and 28 days of not less than  $(100)^2$  per cent of that developed by mortar of the same proportions and consistency made of the same cement and standard Ottawa sand."

"STANDARD METHOD OF TEST  
FOR  
ORGANIC IMPURITIES IN SANDS FOR CONCRETE  
Serial Designation: C40-27"

"1. This method of test is an approximate method of determining the presence of injurious organic compounds in natural sands which are to be used in cement mortar or concrete. The principal value of the test is to furnish a warning that further tests of the sands are necessary before they are approved for use."

"2. A representative test sample of sand weighing about one pound shall be obtained by quartering or by the use of a sampler."

"3. (a) A 12-oz. graduated clear glass bottle shall be filled to the  $4\frac{1}{2}$ -oz. mark with the sand to be tested."

(b) A 3 per cent solution of sodium hydroxide in water shall be added until the volume of the sand and liquid indicated after shaking is 7 liquid ounces.

(c) The bottle shall be stoppered, shaken vigorously and then allowed to stand for 24 hours."

"4. A standard color solution shall be prepared by adding 2.5 cc. of a 2 per cent solution of tannic acid in 10 per cent alcohol to 97.5 cc. of a 3 per cent sodium hydroxide solution. This shall be placed in a 12-oz. bottle, stoppered, shaken vigorously, and allowed to stand for 24 hours."

"5. (a) After standing 24 hours, the color of the clear liquid above the sand shall be compared with the color of the standard color solution prepared at the same time and in accordance with the method described in Section 4, or with a glass of color similar to the color of the standard solution.

(b) Solutions darker in color than the standard color have a 'color value' higher than 250 parts per million in terms of tannic acid.

"STANDARD METHOD OF DECANTATION TEST FOR SAND

AND OTHER FINE AGGREGATES

Serial Designation: D136-28"

- "1. This method of test covers the determination of the total quantity of silt, loam, clay, etc., in sand and other fine aggregates.<sup>1</sup>"
- "2. The pan or vessel to be used in the determination shall be approximately 9 in. (230 mm.) in diameter and not less than 4 in. (102 mm.) in depth."
- "3. The sample must contain sufficient moisture to prevent segregation and shall be thoroughly mixed. A representative portion of the sample sufficient to yield approximately 500 g. of dried material shall then be dried to a constant weight at a temperature not exceeding 110°C. (230°F.)."
- "4. The dried material shall be placed in the pan and sufficient water added to cover the sample (about 225 cc.). The contents of the pan shall be agitated vigorously for 15 seconds, and then be allowed to settle for 15 seconds, after which the water shall be poured off, care being taken not to pour off any sand. This operation shall be repeated until the wash water is clear. As a precaution, the wash water shall be poured through a No. 200-mesh sieve and any material retained thereon returned to the washed sample. The washed sand shall be dried to a constant weight at a temperature not exceeding 110°C. (230°F.) and weighed."

- "5. The results shall be calculated from the formula:

$$\text{Percentage of silt, clay, loam, etc.} = \frac{\text{Original dry wt.-wt. after washing}}{\text{Original dry wt.}} \times 100$$

- "6. When check determinations are desired, the wash water shall be evaporated to dryness, the residue weighed, and the percentage calculated from the formula:

$$\text{Percentage of silt, loam, clay, etc.} = \frac{\text{Weight of residue}}{\text{Original dry weight}} \times 100$$

<sup>1</sup>This determination of the percentage of silt, clay, loam, etc., will include all water-soluble material present, the percentage of which may be determined separately if desired."

"STANDARD METHOD OF TEST FOR SIEVE ANALYSIS OF  
AGGREGATES FOR CONCRETE

Serial Designation:C41-24"

"1. A representative test sample of the aggregate shall be selected by quartering or by use of a sampler, which, after drying, will give not less than the following:

(a) Fine aggregate, 500 g."

"2. The sample shall be dried at not over 110° C. (230°F.) to constant weight."

"3. (a) The sieves shall be of square-mesh wire-cloth and shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sifting.

(b) The size of wire and sieve openings shall be as given in Table I."

"4. (a) The samples shall be separated into a series of sizes by means of the sieves specified in Section 3. Sifting shall be continued until not more than 1 per cent by weight of the sample passes any sieve during 1 minute.

(b) Each size shall be weighed on a balance or scale which is sensitive to 1/1000 of the weight of the test sample.

(c) The percentage by weight of the total sample which is finer than each of the sieves shall be computed."

"5. (a) The percentages in sieve analysis shall be reported to the nearest whole number.

(b) If more than 15 per cent of a fine aggregate is coarser than the No. 4 sieve or more than 15 per cent of a coarse aggregate is finer than the No. 4 sieve, the sieve analysis of the portions finer and coarser than this sieve shall be reported separately."

**Tensile or Mortar Strength:-** Mortar briquets, cylinders or prisms consisting of one part by weight of Portland Cement and three parts by weight of sand mixed and tested in accordance with "Standard Specifications and Tests for Portland Cement". These tests shall show a tensile or compressive strength at the age of seven days and twenty-eight days, not less than that of a 1:3 Standard Ottawa Sand Mortar of same consistency made with the same cement.

Specifications For Plaster Sand.

Sieve Analysis - Serial Designation: C66-27T.

Sand for lime plaster shall consist of hard, strong, durable, uncoated, mineral or rock particles free from alkaline, saline, or organic matter, in injurious quantities.

## Limits of Uniform Grading.

Retained on No. 8 sieve	-----	not more than 10%.
" " " 30 "	-----	not more than 80%.
		not less than 15%.
" " " 50 "	-----	not more than 95%.
		not less than 20%.
" " " 100 "	-----	not less than 95%.
Loss by decantation	-----	not more than 5%.

Sieve Analysis, Standard C41-28

Loss by Decantation Test, Standard D136-28.

Organic Impurities Test, Standard C40-27

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16.

In all tests here in and after given standard methods of A. S. T. M. specifications have been carefully followed.

All tests for strength were made from a standard 1:3 mortar. The cement used was of a standard brand conforming to A. S. T. M. specifications for soundness, fineness, time of set, specific gravity, etc. All tests were made from the same cements; all specimens made and tested by the same operator.

Storage was one day in moist closet, six days in water; age at test, seven days. Second test:- storage one day in moist closet, twenty-seven days in water; age at test, twenty-eight days.

According to specifications for a sand to be considered suitable for grade "A" concrete it must have a strength equal to or greater than two hundred and twenty-five pounds per square inch at the end of seven days and equal to or greater than three hundred and twenty-five pounds per square inch at the end of twenty-eight days.

The average strength at the end of twenty-eight days shall always be greater than that at the end of seven days.

The following table gives the county from which samples of sand have been secured and the number of samples from each. Tests recorded from here on shall be in the order given in this table.

Table No. 1

County from which sample was secured	from	: Number of samples
1. Standard Ottawa - Ottawa, Ill.		-----
2. Dinwiddie		1
3. Montgomery		1
4. Pulaski		5
5. Wythe		3
6. Augusta		1
7. Albemarle		1
8. Rockbridge		1

Tests of Standard Ottawa Sand.

Ottawa sand is a natural sand from Ottawa, Ill., screened to pass a No. 20 sieve and retained on a No. 30 sieve. This sand is considered standard when not more than 5 g. are retained on a No. 20 sieve and not more than 5 g. pass the No. 30 sieve after one minute of continuous sieving of a 100 g. sample.

Sieve Analysis.

A sieve analysis of the sand was run and it was found to come within the limits for standard sand specified above.

Loss By Decantation. ----- None.

Organic Impurities. ----- None.

Tensile Strength.

Six briquets were made using 250 g. cement and 750 g. Standard Ottawa Sand. These were cured under standard conditions and tested at seven days and twenty-eight days.

Test results.			
:	:	: 1	: 300
:	:	: 2	: 310
:	: 7	: 3	: 300
:	: days	: Average	: 303 303
:	:	: 1	: 327
:	:	: 2	: 355
:	: 28	: 3	: 330
:	: days	: Average	: 336
:	:	:	:
:	: Specification	: 7 days	: 225
:	: requirements	: 28 days	: 325

The above results show a higher 7 day strength than usual.

Name of Sand: ----Washed Petersburg.

Source of Sample: ----Dinwiddie County, Va.

This sand is dragged from a river bed and is typical water-deposited sand. It is well graded and contains a predominance of the larger particles. The silt and loam are commercially removed by washing before the sand is put on the market. The individual grains are round, hard, silicious material of a light brown color. In general, this sand has a very clean appearance and seems to be first class sand.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100 #
10	184	36.8	63.2
20	118	23.6	39.6
30	105	21.0	18.6 #
40	29	5.8	13.8
50	24	4.8	8.0 #
60	18	3.6	4.4
80	6.5	1.3	3.1
100	5.5	1.1	2.0
Pan	11	2.2	
<b>Total</b>	<b>500</b>	<b>100.0</b>	

# Concrete specifications

Loss by Decantation

Since this sand is thoroughly washed there is no loss by decantation.

Organic Impurities.

After 24 hours the liquid in this test showed practically no color whatever, indicating that this sample was free from organic matter and suitable, from this standpoint, for use in first class concrete.

Tensile Strength.

Weight of cement used.	:		:	233 g.	:
Wt. of sand used.	:		:	700 g.	:
Wt. of water used.	:		:	120 g.	:
	:	1	:	405	:
	:	7	:	380	:
	:	3	:	340	:
Test results:	:	Average	:	375	:
	:	1	:	540	:
	:	28	:	465	:
	:	3	:	435	:
	:	Average	:	480	:
Specification	:	7 days	:	225	:
requirements	:	28 days	:	325	:

Remarks.

This sample is in all ways excellent for use in Portland Cement concrete.

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Name of Sand: ----- Montgomery #1.

Source of Sample: ----- Montgomery County, Va.

This sand outcrops at many points on the side of a mountain and can be found at almost any point on the mountain by removing a small amount of overtopping. The mountain is covered with trees and underbrush and other vegetation which decays and contaminates the surface layer of the sand, builds up an overtopping, and slides down over the outcropping banks. The sand is very rusty in appearance, contains a great deal of fines, and appears to the casual observer to be nothing more than dirt. Nevertheless, it has been used locally in concrete for culverts, sidewalks, etc., and makes a satisfactory and pleasing appearing job.

The results shown in the following tests have been verified in the laboratory several times by the author and by other investigators.

An unwashed sample was used in making the tests here reported.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	0	0	100
20	13.9	2.8	97.2
30	26.6	5.3	94.7
40	94.2	18.8	81.2
50	81.0	16.2	83.8
60	241.3	48.3	51.7
80	8.3	1.7	98.3
100	13.6	2.7	97.3
Pan	21.0	4.2	95.8
Total	500 g.	100%	

Loss by Decantation.

Original dry weight of sample ----- 100 g.

Dry wt. of sample after washing --- 82.8 g.

$$\% \text{ clay \& silt} = \frac{100 - 82.8}{100} \times 100 = 17.2\%$$

That this sand is unusually dirty is shown by the large decantation loss (more than three times greater than the maximum allowable as per A. S. T. M. specifications). The amount of fines passing the No. 100 sieve amounted to only 4.2% whereas the loss by decantation was 17.2%. This great discrepancy is due to the fact that each grain of sand is heavily coated with very finely divided material which is removed by washing, but which is unaffected by the sieving.

Organic Impurities.

After 24 hours the sodium hydroxide solution showed a very dark color indicating high organic content. From the standpoint of this test the sand is unfit for use in concrete of any importance. Samples taken from different parts of the deposit varied considerably in organic impurities, but in every case the color was darker than the standard.

Tensile Strength.

Wt. of cement used.	:		:	233	
Wt. of sand used	:		:	700	
Wt. of water used	:		:	130	
	:	1	:	280	
	:	2	:	220	
Test	:	3	:	250	
results	:	Average	:		250
	:	1	:	340	
	:	2	:	340	
	:	3	:	390	
	:	Average	:		356
Specification:	7 days		:		225
requirements :	28 days		:		325

Remarks.

In spite of the high organic content and the excessive amount of fines, this sand gave a very good strength test. The organic matter is undoubtedly of such nature that it is not particularly detrimental to the strength of concrete made from this sand.

The location of this deposit is such that it is not feasible to wash this sand inasmuch as it is necessary to use a great quantity of water to accomplish the washing. For this reason no tests were made on a washed sample of this sand.

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Name of Sand: ----- Pulaski #1 (unwashed).

Source of sample: ----- Pulaski County, Va.

This sand comes from the disintegration of brown sandstone and is found intermingled with large lumps of easily crushed sandstone rock. The individual particles of the sand are dirty in appearance and the sandstone is fine-grained and contains no large or gravelly material.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	6.0	1.2	99.8
20	35.7	7.1	91.7
30	126.6	25.3	66.4
40	68.1	13.6	52.8
50	85.6	17.1	35.7
60	69.1	13.8	21.9
80	19.3	3.9	18.0
100	25.4	5.1	12.9
Pan	64.5	12.9	0
Total	500.3 g.	100%	

The percentages passing the No. 20 and No. 50 sieves are only slightly larger than allowed by the A. S. T. M. specifications. The percent passing the No. 100 sieve is considerable in excess of the maximum allowable, as per specifications. The average concrete foreman would label this sand too fine by visual inspection but, as is later pointed out, it can be made to comply with the Standard Specifications by commercial washing.

Loss by Decantation.

Original Dry Wt. of sample: ----- 500 g.

Dry Wt. after washing ----- 445.6 g.

$$\% \text{ of clay and silt} = \frac{500 - 445.6}{500} \times 100 = 10.8\%$$

This is about twice the usual allowable loss by decantation, as per A. S. T. M. specifications. Most of this fine material is free and does not coat the particles of the sand as was the case in the sample previously reported.

During the process of washing a large number of black particles were observed floating on the wash water. Examination proved these to be organic matter.

Name of Sand: ---- Pulaski #2 (unwashed)

Source of Sample: ---- Pulaski County, Va.

Like Pulaski #1 sand, this sample comes from disintegrated brown sandstone and contains many lumps of sandstone that crush easily. The stone is light in color with streaks of very rusty brown running thru it in no regular order. When this stone is crushed the resulting sand is of a fine-grained texture, light brown in color, and resembles very closely the sample #1 although it comes from a different locality.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	3.2	.6	99.4
20	17.5	3.5	95.8
30	182.8	36.6	59.2
40	103.7	20.7	38.5
50	89.4	17.9	20.6
60	41.9	8.4	12.2
80	17.4	3.4	8.8
100	13.9	2.8	6.0
Pan	30.2	6.0	0
Total	500 g	100%	

This analysis shows the sand to be within specifications as regards the No. 50 seive with a slight excess of material passing the No. 100 sieve. The sand is reasonably well graded with the coarser particles predominating.

Loss by Decantation

About the same condition of organic content was apparent in the washing as in Pulaski #1 sand. Considerable more water was required, however, to accomplish the result.

$$\% \text{ clay and silt} = \frac{500 - 462.6}{500} \times 100 = 7.4\%$$

Organic Impurities.

A test of a random sample gave much better results than Pulaski No. 1 sand but the solution was of a color slightly darker than the standard. A lump of the sandstone when crushed and tested, gave practically a perfect test. The organic matter present seems to be leaves and partially decayed weeds which indicates that they got into the sample by falling into the pit and were not eliminated by careful sampling. A commercial run of this sample would be free from organic impurities.

Tensile Strength.

Wt. of cement used.	:	200 g
Wt. of sand used.	:	600
Wt. of water used.	:	107
	:	1 : 260
	: 7 :	2 : 260
	: day :	3 : 290
Test results:	:	Average: 270
	: 28 :	1 : 355
	: day :	2 : 335
	:	3 : 335
	:	Average: 342
Specification:	7 days :	225
requirements :	28 days :	325

Remarks.

This sand is suitable for use in the best grade concrete and can be used in plaster and mortar for laying bricks. It is too dirty and impure to be of any value in the making of glass and the grains are too round for use in molding.

A specimen of this sand was washed thoroughly and retested. The results are recorded on the following page.

Pulaski #2 (washed sample)Sieve Analysis.

Sieve No.	Wt. retained	% retained	
4	0	0	100
10	3.3	.7	99.3
20	10.2	2.0	97.3
30	192.7	38.6	58.7
40	106.6	21.3	37.4
50	96.3	19.3	18.1
60	41.7	8.3	9.8
80	17.1	3.4	6.4
100	11.6	2.5	3.9
Pan	19.3	3.9	0
Total	498.3	100	

Washing reduces quite materially the amounts passing the No. 50 and the No. 100 sieves. The percentage of fine material passing the No. 100 is reduced from 6% to 3.9%.

Loss by decantation.

Silt and clay were removed by washing.

Organic impurities.

This sample of washed sand gave a very clear colorimetric test indicating that the organic matter present in the random sample of unwashed sand was the result of debris falling into the pit.

Tensile Strength.

The results of the tension test are doubtful as were those made on the washed sample of Pulaski #1 sand. The reason is the same, namely; low temperature of the water in the curing tanks when the briquets were first made. The tensile strength developed slowly under these conditions and the 7-day strength was consequently lowered.

Wt. of cement used.	:		233 g
Wt. of sand used.	:		700
Wt. of water used.	:		102
	:	1	230
	:	2	230
	:	3	215
Test results	:	Average	225
	:	1	370
	:	2	335
	:	3	350
	:	Average	352
Specification	:	7 days	225
requirements	:	28 days	325

Remarks.

The quality of this sand is undoubtedly improved by washing, but the slight increase in quality is more than offset by the increased cost of commercial washing, inasmuch as a great amount of water was necessary to accomplish the result. The per cent passing the No. 100 sieve and the loss by decantation of the unwashed sample are slightly higher than the limits suggested by the A. S. T. M. specifications, but are not high enough to condemn this sand for use in good grade concrete.

The organic matter would be absent in the unwashed sand if care is exercised in preventing overstripping from sliding down over the face of the deposit.

Name of Sand: Pulaski #3 (unwashed)

Source of Sample: Pulaski County, Va.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	44.7	8.9	92.1
20	33.8	6.8	85.3
30	145.8	29.2	56.1
40	86.9	17.4	38.7
50	91.4	18.3	20.4
60	44.5	8.9	11.5
80	7.9	1.6	9.9
100	14.2	2.8	7.1
Pan	35.6	7.1	0

# Original wt. 502 grams.

This analysis conforms very closely to standard specifications, with a percentage passing the No. 100 sieve slightly greater than the allowable. The sand particles retained on the No. 30 very closely resemble Standard Ottawa sand. The grains are white and rounded. A set of standard mortar briquets were made from sand retained on the No. 30 for the purpose of comparison with Standard Ottawa. The results of this test are later recorded.

Loss by Decantation.

Wt. of sample before washing ----- 500 g.

Wt. of sample after washing ----- 480.9 g.

$$\% \text{ of silt and clay} = \frac{500 - 480.9}{500} \times 100 = 3.8\%$$

This is well within the limit specified by the A. S. T. M. standard specifications.

Organic Impurities.

This sand occurs as white sandstone streaked with brown. This stone has a fine-grained texture and looks extremely clean. It crushes rather easily, but is not disintegrated to the degree that the No. 1 and No. 2 are. A crushed lump gave a perfect colormetric test indicating that the sample is free from organic matter and is suitable, from this standpoint, for use in the best grade of concrete.

Tensile Strength.

Wt. of cement used	:		233 g
Wt. of sand used.	:		700
Wt. of water used	:		116
	:	1	7
	:	2	day
	:	3	
Test	:		295
results	:	Average	275
	:		285
	:	1	28
	:	2	day
	:	3	
	:	Average	410
	:		510
	:		480
	:	Average	466
Specification:		7 days	225
requirements :		28 days	325

This sand shows great strength and is undoubtedly a splendid sand for the making of Portland Cement concrete, mortar for brick-laying, and lime plaster. The brown streaks of iron are too numerous to be effectively removed, thus rendering the sand suitable for the making of glass. The shape of the particles of this sand and the nature of the fines render it useless for molding.

The following table gives the results of a test for tensile strength made on briquets composed of 1 part cement, 3 parts of sand (retained on No. 30 sieve), and distilled water.

Tensile Strength: Pulaski #3, passing No. 20 sieve and retained on No. 30 sieve.

Wt. of cement used.	:	233 g
Wt. of sand used.	:	700
Wt. of water used.	:	116
: 7 :	1 :	250
: :	2 :	210
:day :	3 :	230
Test results :	Average :	230
: 28 :	1 :	415
:day :	2 :	380
: :	3 :	395
: :	Average :	397
Specification: 7 days	:	225
requirements : 28 days	:	325

The above results indicate that this specimen of sand approaches Standard Ottawa sand both as to appearance and as to strength.

Pulaski #3 (washed sample)

A Sample of Pulaski sand No. 3 was carefully washed and retested, with the following results:

Sieve Analysis.

Sieve No.	: Wt. retained	: % retained	: % passing
4	: 0	: 0	: 100
10	: 37.2	: 7.4	: 92.4
20	: 31.9	: 6.4	: 86.0
30	: 171.2	: 35.4	: 50.6
40	: 93.2	: 18.7	: 31.9
50	: 88.0	: 17.6	: 14.3
60	: 30.5	: 6.1	: 8.2
80	: 13.3	: 2.7	: 5.5
100	: 8.4	: 1.7	: 3.8
Pan	: 18.8	: 3.8	: 0
Total	: 498.5	: 99.8	:

Loss by Decantation.

Clay and silt removed by washing.

Organic impurities.

No retest for organic impurities was necessary inasmuch as the colormetric test of the unwashed sample gave perfect results.

Tensile Strength.

Wt. of cement used.	:		:	233 g
Wt. of sand used.	:		:	700
Wt. of water used.	:		:	110
	:	1	:	280
	:	7	:	280
	:	day	:	265
Test	:		:	
results	:	Average	:	275
	:	1	:	460
	:	28	:	440
	:	day	:	460
	:	Average	:	453
Specification:		7 days	:	225
requirements :		28 days	:	325

Remarks.

Washing has brought the per cent passing the No. 100 within the limit specified by the A. S. T. M. standards, but, since the strength is satisfactory and there is no organic matter present, it is not justified by cost. The excess of fines is not great enough to warrant the cost of reducing them by commercial washing.

31.

Name of Sand: Pulaski #4 (unwashed)

Source of Sample: --- Pulaski County, Va.

This sand comes from a deposit of white sandstone, fine-grained in texture and of a clean appearance. Fine streaks of brown, indicative of iron oxide, prevade this stone and thus contaminate it so that it would be impractical to purify the sand to such a state that it could be used in the manufacture of glass. This stone is hard and somewhat brittle, crushing readily and producing a very small quality of dust.

Sieve Analysis.

Sieve No.	:Wt. retained	: % retained	:% passing	:
4	: 0	: 0	: 100	:
10	: 18.9	: 3.7	: 96.0	:
20	: 93.8	: 18.0	: 78.0	:
30	: 135.1	: 26.0	: 52.0	:
40	: 83.8	: 16.1	: 35.9	:
50	: 96.2	: 18.2	: 17.7	:
60	: 51.8	: 10.0	: 7.7	:
80	: 17.5	: 3.3	: 4.4	:
100	: 10.9	: 2.1	: 2.3	:
Pan	: 12.3	: 2.3	: 0	:
Total	: 520.3 #	: 99.7%	:	:

# Original wt. of sample -- 521 g.

The above results indicate that this sand is well graded within the limits specified by the A. S. T. M. The sample used in making this test was crushed by hand by means of a mortar. The 2.3% passing the No. 100 sieve would not likely be increased to the maximum of five per cent by the ordinary commercial crusher.

Loss by Decantation.

There was no loss by washing, which proves the sand to be free from silt and clay.

Organic Impurities.

A sample of this sand placed in a 3% solution of sodium hydroxide showed practically no color at the end of 24 hours.

Tensile Strength.

Wt. of cement used	:		233
Wt. of sand used.	:		700
Wt. of water used.	:		110
	:	1	210
	:	7	220
	:	3	240
Test	:		
results	:	Average	224
	:	1	370
	:	2	360
	:	3	345
	:	Average	359
Specification:	:	7 days	225
requirements :	:	28 days	325

Remarks.

Since the foregoing tests show this sand to conform with standard specifications there is no need of testing a washed sample. This sand is well suited for use in concrete, lime plaster, and mortar for brick-laying. It is of little value as a glass sand or for molding.

Name of Sand: ---- Pulaski #5 (unwashed).

Source of Sample: -- Pulaski County, Va.

This sand is dug from a river bed and is typical water-deposited material. The individual particles are rounded and range in size from pebbles to fine dust. A great amount of the fine material appears to be mica.

Sieve Analysis.

Sieve No.	Wt. retained:	% retained	% passing
4	27.5	5.5	94.1
10	22.5	4.5	89.6
20	60.3	12.1	77.5
30	156.1	31.2	46.3
40	78.7	15.8	30.5
50	70.5	14.1	16.4
60	34.2	6.8	9.6
80	13.0	2.6	7.0
100	11.4	2.3	4.7
Pan	23.5	4.7	0
Total	497.7	99.6%	

Loss by Decantation.

Original dry Wt. of sample ----- 900 g.  
 Dry Wt. after washing ----- 885.5 g.

$$\% \text{ of clay and silt} = \frac{900 - 885.5}{900} \times 100 = 1.7\%$$

There is only a small amount of silt and clay in this sand and it can be removed by washing, only a small amount of water being necessary to accomplish this result. There is, however, very little to be gained by washing this sand commercially because of the small amount of fines present in the unwashed sample.

This sand has a high mica content, there being 17 grams of this material retained on the No. 200 sieve in the process of washing.

Organic Impurities.

This sample gave a poor organic test indicating that the sand is not good for important concrete work without further tests of tensile strength.

Tensile Strength.

Wt. of cement used.	:		:	233 g.
Wt. of sand used.	:		:	700 g.
Wt. of water used.	:		:	130
	:	1	:	220
	:	7	:	210
	:	day	:	210
Test	:		:	
results	:	Average	:	213
	:	28	:	320
	:	day	:	375
	:		:	385
	:	Average	:	360
Specification:	:	7 days	:	225
requirements :	:	28 days	:	325

Remarks.

This sand seems to be well graded from coarse to fine with the fine particles composed of mica and a small amount of clay and silt.

There is little to be gained by washing but in hope that this process might remove the organic matter a sample of this sand was washed and tested.

Pulaski No. 5 ----Washed Sample.

Loss by Decantation.

Silt and clay removed by washing.

Sieve Analysis.

Sieve No.	Wt. retained:	% retained	% passing
4	22.5	4.5	95.6
10	21.5	4.3	91.3
20	69.7	13.8	77.5
30	160.7	32.1	45.4
40	75.5	15.1	30.3
50	66.9	13.4	16.9
60	35.9	7.2	9.7
80	14.7	2.9	6.8
100	11.5	2.3	4.5
Pan	22.5	4.5	0
Total	500 g	100.1%	

Washing this sand had practically no effect on the sieve analysis.

Organic Impurities.

The colormetric test showed no appreciable change in organic content.

Tensile Strength.

Wt. of cement used.	:	233 g.
Wt. of sand used.	:	700
Wt. of water used.	:	130
	:	1
	:	7
	:	2
	:	3
Test	:	235
results	:	240
	:	245
	:	Average
	:	240
	:	28
	:	1
	:	315
	:	day
	:	2
	:	325
	:	3
	:	305
	:	Average
	:	315
Specification:	:	7 days
requirements :	:	225
	:	28 days
	:	325

Wythe County Sand.General.

Investigation shows that there is practically an unlimited supply of sand in Wythe County. The chief source of the supply comes from a mountain just outside of the town.

Samples were taken from a pit which had been opened to secure sand for local use. The results of tests made on these samples, three in number, will be set forth in the pages that follow. The samples shall be called Wythe No. 1 brown, 2 white, and 3 red.

This sand deposit has an overburden of about two to three feet of soil and leaves which can be removed with little expense.

There are some layers or seams of clay in the upper parts of the pit; these, however, thin out as the pit deepens, until they disappear at about twelve feet down.

The sand in the upper part of the pit is dark in color, gradually getting whiter as the depth increases until a practically white sand is produced at fifteen feet.

Near this sand pit there is a pit which contains a very red sand, resembling red lead paint in color. This sand shall be known as Wythe sand No. 3 red. The results of tests on this sand are given in the pages that follow.

Name of Sand: --- Wythe No. 1 (brown) (unwashed)

Source of sample --- Wythe County, Va.

Sieve Analysis.

Sieve No.	:Wt. retained	:	% retained	:	% passing	:
4	: 15.3	:	3.1	:	96.9	:
10	: 3.9	:	0.8	:	96.1	:
20	: 40.1	:	8.0	:	88.1	:
30	: 150.3	:	30.1	:	58.0	:
40	: 77.4	:	15.5	:	42.5	:
50	: 92.0	:	18.5	:	24.0	:
60	: 60.5	:	12.1	:	11.9	:
80	: 20.5	:	4.1	:	7.8	:
100	: 17.0	:	3.4	:	4.4	:
Pan	: 22.0	:	4.4	:	0	:
Total	: 499.0	:	100	:		:

Loss by Decantation.

Original dry wt. of sample -- 500 g.

Dry wt. of sample after washing -- 477 g.

$$\% \text{ of clay and silt} = \frac{500 - 477}{500} \times 100 = 4.6\%$$

Organic Impurities.

The test for organic impurities gave very poor results, showing that this sand has a high organic content. The organic matter present seems to be bits of decayed leaves and twigs and will hardly be detrimental to the strength of concrete made from actual tests of the tensile strength of a mortar made from this sand.

Tensile Strength.

Wt. of cement used.	:		:	233 g.
Wt. of sand used.	:		:	700
Wt. of water used.	:		:	105
	:	1	:	345
	:	7	:	305
	:	day	:	305
Test	:		:	
results	:	Average	:	318
	:	28	:	490
	:	day	:	590
	:		:	495
	:	3	:	
	:	Average	:	525
Specification:	:	7 days	:	225
requirements :	:	28 days	:	325

Remarks.

The tensile strength of this sand is not harmed by the organic matter present, as this test has shown. The material passing the No. 100 sieve is not in excess as shown by the sieve analysis.

This sand is excellent for lime plaster, mortar for laying bricks, and concrete work.

Wythe No. 1 --- (brown) washed sample.

Because of the similarity of results of tests on Wythe No. 1 and Wythe No. 2, washed samples, the results will not be recorded here but will be recorded under the heading of, "Wythe No. 2 (white) washed sample".

Name of Sand: -- Wythe No. 2 (white) (unwashed)

Source of Sample: -- Wythe County, Va.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	1.4	.3	98.7
20	35.5	7.1	91.6
30	173.7	34.7	56.9
40	72.1	14.4	42.5
50	84.5	16.9	25.6
60	46.2	9.2	16.4
80	25.8	5.2	11.2
100	18.1	3.6	7.6
Pan	37.9	7.6	0
Total	495.2	99%	

Loss by Decantation.

Original dry wt. of sample --- 500 g.

Dry wt. of sample after washing -- 478.3

$$\% \text{ of clay and silt} = \frac{500 - 478.3}{500} \times 100 = 4.3\%$$

Organic Impurities.

The colorimetric test showed unusually dark color indicating high organic content. Close examination shows that the organic matter is present in small grains and appears to be coal. Most of this organic matter is retained on the No. 30 sieve. It is likely that this test is not indicative of the suitability of this sand for use in concrete. The nature of the impurity is such that it should not materially effect the strength of cement concrete made from the sand.

Tensile Strength.

Wt. of cement used.	:		:	200 g
Wt. of sand used.	:		:	600
Wt. of water used.	:		:	90
	:	1	:	260
	:	7	:	300
	:	day	:	288
Test	:		:	
results	:	Average	:	283
	:	28 ; 1	:	395
	:	day ; 2	:	535
	:	3	:	460
	:	Average	:	463
Specification:		7 days	:	225
requirements :		28 days	:	325

Wythe No. 2 (white) --- washed sample

Sieve Analysis.

Sieve No.	:	Wt. retained	:	% retained	:	% passing	:
4	:	0	:	0	:	100	:
10	:	1.1	:	0.2	:	99.8	:
20	:	41.2	:	8.7	:	91.1	:
30	:	156.1	:	33.2	:	57.9	:
40	:	69.5	:	14.9	:	43.0	:
50	:	76.4	:	16.2	:	26.8	:
60	:	55.6	:	11.8	:	15.0	:
80	:	21.1	:	4.5	:	10.5	:
100	:	19.2	:	4.1	:	6.4	:
Pan	:	33.0	:	7.0	:	0.6	:
Total	:	473.2#	:	100.6%	:		:

# Original wt. of sample 473 g.

Loss by Decantation.

Silt and clay removed by washing.

Organic Impurities.

The colormetric test showed a very pale straw color indicating that washing had removed the greater part of the organic matter present in the unwashed sand. Apparently this organic matter is finely divided and is clinging to the grains of sand to some extent. This assumption is borne out by the fact that there was very little difference in the quantity of fine material in the unwashed and washed samples, as shown by the sieve analysis. A great deal of water was required to accomplish the washing.

Tensile Strength.

Wt. of cement used.	:		:	233	
Wt. of sand used.	:		:	700	
Wt. of water used.	:		:	105	
	:	1	:	210	
	:	7	:	210	
	:	day:	:	185	
Test	:	:	:		
results	:	Average	:		202
	:	28	:	355	
	:	day:	:	355	
	:	3	:	395	
	:	Average	:		369
Specification:	:	7 days	:		225
requirements :	:	28 days	:		325

Remarks.

The 7-day results in the above tension test are likely in error due to low temperature in the curing tanks during the early part of the curing of the briquets. Nevertheless, there is very little to be gained by washing the sand as the unwashed sample shows unusual strength.

Name of Sand: --- Wythe No. 3 (red) (unwashed)

Source of Sample --- Wythe County, Va.

Sieve Analysis.

Sieve No.	: Wt. retained	: % retained	: % passing	:
4	: 0	: 0	: 100	:
10	: 2.1	: .4	: 99.6	:
20	: 7.4	: 1.5	: 98.1	:
30	: 171.4	: 34.3	: 63.8	:
40	: 108.6	: 21.7	: 42.1	:
50	: 92.8	: 18.6	: 23.5	:
60	: 47.9	: 9.6	: 13.9	:
80	: 7.6	: 1.5	: 12.4	:
100	: 17.6	: 3.5	: 8.9	:
Pan	: 44.6	: 8.9	: 0	:
Total	: 500 g	: 100%	:	:

Loss by decantation.

Original dry wt. ----- 500 g.

Dry wt. after washing ----- 410.8

$$\% \text{ of clay and silt} = \frac{500 - 410.8}{500} \times 100 = 17.8\%$$

Practically all the red material washed from the sand and left it a white color similar to Wythe No. 2 (white). Twice as many grams of fine material passed the No. 200 sieve in washing as passed the No. 100 sieve in the sieve analysis. This was due to the fact that the red material was finely divided and coated each particle of sand. This coating was not removed by the sieve analysis but was removed by washing. Chemical analysis showed the coloring matter to be an iron compound.

The large amount of water required to wash this sand renders it practically useless for commercial purposes.

Organic Impurities.

This sand gave a very clear test proving the absence of injurious quantities of organic matter.

Tensile Strength.

Wt. of cement used.	:		200 g
Wt. of sand used.	:		600
Wt. of water used.	:		118
	:	1	285
	:	7	290
	:	day	280
Test	:		
results	:	Average	285
	:	28	425
	:	day	470
	:	3	435
	:	Average	443
Specification:	:	7 days	225
requirements :	:	28 days	325

Remarks.

In spite of the excess of fine material in this sand it makes an extremely strong mortar. It is suitable for use in lime plaster, mortar for laying brick, and Portland Cement concrete, although the extreme red color would probably be objectionable in plaster and mortar.

Name of Sand: -- Augusta #1

Source of Sample: --- Augusta County, Va.

This sand occurs as a large river bottom deposit covering many acres. The pit from which the sample was obtained was located near a stream and in an open field free from overgrowth. The supply is practically unlimited and is located near an all-weather road. This sand appears very fine in texture, is brown in color, and contains a great deal of very fine material.

Sieve Analysis.

Sieve No.	:Wt. retained	: % retained	:% passing	:
4	: 0	: 0	: 100	:
10	: 0	: 0	: 100	:
20	: 0	: 0	: 100	:
30	: 9.3	: 1.9	: 98.1	:
40	: 46.4	: 9.3	: 88.8	:
50	: 219.2	: 43.8	: 45.0	:
60	: 104.8	: 21.0	: 24.0	:
80	: 7.1	: 1.4	: 22.6	:
100	: 28.5	: 5.7	: 16.9	:
Pan	: 84.5	: 16.9	:	:
<b>Total</b>	<b>: 499.5 g</b>	<b>: 100 %</b>	<b>:</b>	<b>:</b>

This sand is extremely fine with a very great excess passing the No. 100 sieve.

Loss by Decantation.

Original dry wt. of sample ----- 500 g.

Dry wt. after washing ----- 463.8 g.

$$\% \text{ of clay and silt} = \frac{500 - 463.8}{500} \times 100 = 7.2\%$$

Organic Impurities.

The colormetric test of this sand showed a very dark color indicative of high organic content.

Tensile Strength.

Wt. of cement used.	:		:	233 g.
Wt. of sand used.	:		:	700
Wt. of water used.	:		:	120
	:	1	:	185
	:	2	:	210
	:	3	:	200
Test	:		:	
results	:	Average	:	199
	:	1	:	350
	:	2	:	330
	:	3	:	330
	:	Average	:	337
Specification:	:	7 days	:	225
requirements :	:	28 days	:	325

Remarks.

This sand is too fine and too uncertain in strength to be of value in Portland Cement concrete. It is used locally in lime plaster with reasonable success, but is not to be highly recommended for this purpose. It contains too much iron oxide to be of any use in the making of glass and does not possess the necessary characteristics for a molding sand.

An abundance of water nearby makes washing feasible, but the product would not be increased in value materially.

Name of Sand: ---- Albemarle #1.

Source of Sample: --- Albemarle County, Va.

This sand is dragged from a river and contains a small percentage of gravel between the sizes;  $\frac{3}{4}$  inch and  $\frac{3}{8}$  inch. The sand appears to be well graded from coarse to fine with the coarse particles predominating. The individual grains, rounded by water transportation, are dark brown in color and are composed of hard silicious material.

The sample used in making the following tests was passed thru a  $\frac{3}{8}$  inch sieve in order to remove the pebbles.

Sieve Analysis.

Sieve No.	: Wt. retained	: % retained	: % passing
4	: 0	: 0	: 100
10	: 50.1	: 10.0	: 90.0
20	: 119.9	: 24.0	: 68.0
30	: 170.9	: 34.2	: 31.8
40	: 67.6	: 13.5	: 18.3
50	: 42.3	: 8.5	: 9.8
60	: 19.6	: 3.9	: 5.9
80	: 9.1	: 1.8	: 4.1
100	: 6.3	: 1.3	: 2.8
Pan	: 14.0	: 2.8	: 0
Total	: 499.7 g	: 100 %	:

The above analysis shows this sand to be very well grades within the limits required by the A. S. T. M. Std. specifications.

Loss By Decantation.

Original dry wt. of sample ----- 500 g.

Wt. of sample after washing (dry) 493.5

$$\% \text{ of clay and silt} = \frac{500 - 493.5}{500} \times 100 = 1.3\%$$

Organic Impurities.

There seems to be considerable organic matter present in this sand in the form of partially decayed leaves. The colorimetric test was unusually black. A sample of this sand was thoroughly washed and tested for organic content. The result was equally as poor as the first, although washing removed some of the organic matter that was apparent to the naked eye.

The organic matter present in this sand is probably of a harmless nature as the tensile strength results below show a strength equal to that of unquestionable sands accepted as standard throughout the state.

Tensile Strength.

Wt. of cement used.	:		233
Wt. of sand used.	:		700
Wt. of water used.	:		109
	:	1	400
	:	7	375
	:	day	3
	:		430
Test	:		
results	:	Average	411
	:	28	1
	:	day	2
	:		3
	:		475
	:	Average	450
Specification:	:	7 days	225
requirements :	:	28 days	325

Remarks.

This sand is being used to make first class concrete, but would have to be screened before it could be used in plaster or mortar. It is obviously unfit for glass or molding sand.

Name of Sand: ---- Rockbridge #1.

Source of Sample -- Rockbridge County, Va.

This sand comes from an open quarry from which sandstone is being taken for use in glass making. The stone that is streaked with brown bands of iron oxide is singled out and handled separately. The sandstone is very white and soft, disintegrating readily under the action of a hydraulic giant. It is crushed by means of a Chilean mill and carefully washed, coming out of the process a fine, white, unusually clean sand.

Sieve Analysis.

Sieve No.	Wt. retained	% retained	% passing
4	0	0	100
10	0	0	100
20	1.9	.4	99.6
30	38.7	7.7	91.6
40	78.3	15.7	76.2
50	188.8	37.8	38.4
60	96.9	19.4	19.4
80	39.4	7.9	11.5
100	35.0	7.0	4.5
Pan	22.5	4.5	0
Total	501.5 g	100 %	

Loss by Decantation.

No loss by decantation as this sand is commercially washed.

Organic Impurities.

This sand gave a very clear colormetric test. The absence of organic matter is likely due to the fact that the sand comes from clean sandstone and is carefully washed.

Tensile Strength.

Wt. of cement used.	:		:	233
Wt. of sand used.	:		:	700
Wt. of water used.	:		:	105
	:	1	:	210
	:	7	:	200
	:	day	:	230
Test	:		:	
results	:	Average	:	213
	:	28	:	350
	:	day	:	335
	:	3	:	325
	:	Average	:	337
Specification:	:	7 days	:	225
requirements :	:	28 days	:	325

Remarks.

This is a good clean sand from which concrete of fair strength can be made. It is a little too fine for this purpose, however, but is very suitable for use in mortar and plaster or for sand-blasting.

Name of Sand: -- Glass and Molding Sands.

Source of Samples: -- Rockbridge County, Va.

The following results are from commercial samples of sand and sand-clay mixtures obtained in Rockbridge County, Va.. All Chemical and physical tests were made in accordance with tentative methods of the American Foundrymen's Assn. and microscopic tests were made to determine the shape of the individual grains of sand.

Sample #1.

A clear white sand containing very few particles of carbonaceous material.

Chemical Analysis:

Loss on ignition	---	.09%
SiO <sub>2</sub>	-----	99.53%
Fe <sub>2</sub> O <sub>3</sub>	-----	.41%
CaO	-----	.06%
Total	----	100.18%

Sieve Analysis.

Sieve No.	% retained	Description of grain
10	0.00	
20	0.00	
30	1.08	rounded
40	16.68	well-rounded
50	42.76	rounded
60	22.28	well-rounded
80	7.46	sub-angular
100	5.64	" "
200	2.88	angular
Pan	0.40	angular
Total	99.28%	

This material, a sand well suited for glass manufacture, is an ideal steel molding sand, since the grains are nearly all the same size and the larger percentage of them rounded, though sharp enough to make a permeable mold. None of the grains held any foreign material on their surface.

Sample #2.

Molding sand with clay bond.

Chemical Analysis.

Moisture	-----	0.42%
Loss on ignition	---	2.62%
SiO <sub>2</sub>	-----	77.45%
Fe <sub>2</sub> O <sub>3</sub>	-----	3.23%
Al <sub>2</sub> O <sub>3</sub>	-----	11.07%
CaO	-----	0.63%
MgO	-----	.94%
Na <sub>2</sub> O plus K <sub>2</sub> O	-----	3.54% (by difference)
		100.00%

By Washing:

Clay substance - 14.85%

By Computation:

Clay substance - 10.06%

Feldspar ----- 40.10%

Quartz ----- 50.02%

Total 100.18%

Sieve Analysis.

Sieve No.	: % retained	: Description of grain	:
10	: 0.00%	:	:
20	: 0.00%	:	:
30	: .35	: rounded	:
40	: .12	: "	:
50	: .33	: "	:
60	: .61	: "	:
80	: .31	: "	:
100	: .74	: "	:
200	: 20.07	: "	:
Pan	: 78.01	: sub-angular	:
Total	: 100.54%	:	:

The above sieve analysis was made of a sample of sand from which the clay had been washed.

Sample No. 3

Molding sand with clay bond.

Chemical Analysis.

Moisture-----	.31%	
Loss on ignition	2.15	
SiO <sub>2</sub> -----	80.68	
Fe <sub>2</sub> O <sub>3</sub> -----	3.45	
Al <sub>2</sub> O <sub>3</sub> -----	9.55	
CaO -----	.55	
MgO -----	.83	
Na <sub>2</sub> O plus K <sub>2</sub> O -	2.48	(by difference)
	<u>100.00%</u>	

## By Washing:

Clay substance ----- 16.08%

## By Computation:

Clay substance ----- 12.31%

Feldspar ----- 23.75%

Quartz ----- 59.48%

100.54%Sieve Analysis

Clay removed by washing.

Sieve No.	: % retained	: Description of grain
10	: 0.00%	:
20	: 0.00%	:
30	: .33	: Sub-angular
40	: .29	: " "
50	: .45	: " "
60	: 1.02	: " "
80	: .54	: " "
100	: 9.59	: " "
200	: 41.37	: " "
Pan	: 47.01	: " "
Total	: 100.62%	:

Sample #4.

A clear silica sand containing very little carbonaceous material.

Chemical Analysis.

Loss on ignition----- .18%

SiO<sub>2</sub> -----99.34%

FeO ----- .69%

CaO----- .00

100.50%

This material, a sand well suited for glass manufacture, is also an ideal steel molding sand. It is very pure, has no fluxing material, and the grains are nearly all the same shape and well shaped. None of the grains held any foreign material on their surface.

Sieve Analysis.

Sieve No.	% retained	Description of grains
10	0.00%	
20	0.00%	
30	.68	sub-angular
40	15.72	" "
50	54.88	rounded
60	16.80	"
80	5.52	"
100	2.84	sub-angular
200	2.64	angular
Pan	.40	"
<b>Total</b>	<b>99.48%</b>	

Sample #5.

Molding sand with clay bond.

Chemical Analysis.

Moisture	-----	1.08%
Loss on ignition		4.58%
SiO <sub>2</sub>	-----	77.82
Fe <sub>2</sub> O <sub>3</sub>	-----	2.70
Al <sub>2</sub> O <sub>3</sub>	-----	12.35
CaO	-----	.23
MgO	-----	.64
Na <sub>2</sub> O --- K <sub>2</sub> O	--	.06 (by difference)
		<u>100.00%</u>

## By computation.

Clay substances	28.56%
Feldspar	----- 5.82%
Quartz	----- 61.00%
Hematite, etc.	- 4.71%
	<u>100.09%</u>

Sieve Analysis.

Sieve No.	: % retained	: Description of grains	:
10	: 0.00%	:	:
20	: 0.00%	:	:
30	: 0.00%	:	:
40	: .25	: sub-angular	:
50	: .33	: " "	:
60	: .54	: " "	:
80	: .78	: " "	:
100	: 13.54	: " "	:
200	: 21.16	: " "	:
Pan	: 63.85	: " "	:
Total	: 100.45%	:	:

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