VARIOUS TYPES OF SAND IN LEBANON AND THEIR EFFECT ON THE STRENGTH OF CONCRETE AND MORTAR

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AND THEIR EFFECT
ON THE STRENGTH OF CONCRETE AND
MORTAR

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ABSTRACT

This thesis presents a study of the various types of sands of Lebanon and their effect on the compressive strength of concrete and mortar. To eliminate the effect of the coarse aggregate, mortar cubes were chosen for the study.

Geographical and geological surveys of the main natural sand sources in Lebanon were carried out. Twenty two natural sources were chosen to be tested as representative samples of the sands used for concrete and mortar mixing. In addition two samples of crusher sand were picked up from two different plants for study and comparison with the natural sand deposits.

These sand samples were tested for gradation, as well as for the presence of injurious organic impurities, acids, alkalies, chlorides, and calcium carbonates.

The compressive strengths of the mortar cubes using each of the various sands was determined, and based on the results specific recommendations aiming at producing higher compressive strengths using Lebanese sand were given.

CHAPTER ONE

INTRODUCTION

1.1 AGGREGATE DEFINITION : -

The principal structure and the main body of concrete is the aggregate; which consists of fine and coarse material. The 1940 Joint Committee for Standard Specifications for Concrete and Reinforeed Concrete Specifies that "Fine Aggregate shall consist of natural sand, sand prepared from the product obtained by crushing stone, gravel, or air cooled blast furnace slag; or, subject to the approval of the Engineer, other inert materials having similar characteristics."

The same committee specifies that "Coarse aggregate shall consist of crushed stone, gravèl, air-cooled blast furnace slag, or, subject to the approval of the Engineer,other inert materials having similar characteristics."

1.2 AGGREGATE CLASSIFICATION AND FUNCTIONS

Concrete consists mainly of a binding medium in which particles of an inert mineral filler are embedded. A combination of cement and water provides the binding medium while the aggregates of different sizes are the filler.

The functions of the aggregates in general are; to act as a cheap filler for the cementing material, to provide a mass able of resisting the loads applied on the concrete as well as moisture percolation, abrasion and weather action, and to decrease any changes in the volume of the concrete due to the setting and hardening process.

Aggregates are of two groups. All particles passing the 1/4 - in. sieve are called fine aggregates. Particles retained on this sieve are called coarse aggregates.

The coarse aggregate is mainly to give bulk to the concrete.

The fine aggregate is mainly to help in producing uniformity and workability of the concrete. It also helps the cement paste to hold in suspension particles of the coarse aggregate.

The fine aggregate plays a great role in determining the workability of concrete. The main elements in this respect being the gradation and the amount of the fine aggregate used, as well as the shape and surface characteristics of the fine aggregate particles. Particles with rough surfaces and angular shapes require more water than particles with smooth surfaces and rounded shapes to give the same concrete workability if other elements are kept the same.

1.3 MATERIALS USED AS FINE AGGREGATES:

There are two groups of fine aggregates. The first is rock fragments formed from weathering. This can take place by disintegration or glacial action. The second is prepared by crushing natural rocks and screening the product into the required sizes.

Sand deposits exist where streams have for a long period transported and collected the products of weathering of rocks. Usually there is a variety of particle sizes in these deposits.

A knowledge of the minerals and rocks from which the fine aggregates are obtained helps in determining the properties of these aggregates. The structure, mineral composition and texture of the rock affect aggregate suitability.

1.4 INJURIOUS MINERALS : -

Some minerals are usually injurious to fine aggregates when present in appreciable amounts. These are Mica, Pyrite and Tremolite.

Mica may decrease the durability of sand stone and cause structural weakness.

Pyrite may introduce weak and chemically undesirable products when it decomposes into iron sulfate, and limonite, and sulfuric acid is formed. Tremolite is a variety of amphibole with pale green and white colors which is sometimespresent in limestones. It decomposes into clay with a greenish-yellow color when exposed to weather.

1.5 SAND AS A FINE AGGREGATE : -

Natural sands are the most widely used fine aggregates. The qualities of natural sands usually vary greatly depending on the rocks from which they are derived. They are mostly the result of weathering of rocks which are broken down due to alternate freezing and thawing, or eroded as a result of water and wind.

Sands are generally either calcareous when large quantities of calcium carbonate are present, or siliceous when it has mainly quartz or silicates. A mixture of the two is frequently found in sands. Siliceous sands are considered the best for concrete. The minerals mostly present in sand are quartz and silica. Quartz may come from sandstone which itself consists mainly of quartz grains. The kind of the cementing material in sandstone affects the soundness of using the sand derived from this sandstone in concrete. Usually the cementing materials are iron oxide, calcium carbonate, or clay. The best sands are obtained when the cementing material is iron oxide. When the cementing material is calcium carbonate it easily dissolves in natural water due to the presence of carbon dioxide in water. Such sands should not be used in concrete for structures in which impermeability is needed such as water reservoirs. Clay cementingmaterials are weak and result in the sand being crushed easily. Clay also absorbs water forming a paste thus breaking the contact between sand grains and the cement. The concrete formed in such cases is very weak although at first sight the sand appears to be well graded and good quality concrete would hence be expected. Some sands have particles coming from fossil materials instead of mineral particles. These should be avoided because the concrete formed from such sands has a weak crushing strength and is highly pervious.

1.6 LOCATION OF NATURAL SANDS :

Natural sands are mainly present in stream deposits, dunes deposited by wind, glacial deposits, alluvial fans, and seashores.

STREAM DEPOSITS :-

Stream deposits are found on stream banks. They are usually strong and well graded because of the abrading action of the stream. Stream deposits are the most desirable among fine aggregates.

WIND DEPOSITS : -

These are sands drifted by wind and piled up as dunes. These deposits are mainly quartz. They are durable but fine and uniform. Because of fineness and uniformity it is recommended to mix these deposits with coarser sands when used for concrete.

GLACIAL DEPOSITS :-

Glacial deposits are only found in northerly latitudes or at high altitudes. Glacial deposits of hills and ridges are not recommended as aggregate because they have a heterogeneous character with a combination of strong and weak materials.

Fluvial glacial deposits which have undergone stream action and which occur in stream beds are better as aggregates because the weak materials would have been removed.

ALLUVIAL FANS :-

These deposits are formed as a result of intermittent torrential flodds. Sands of these deposits are usually angular and poorly graded.

SEASHORE DEPOSITS :-

Sands deposited on the seashore are usually fine and in most cases poorly graded. However it is satisfactory for concrete specially when mixed with sand of coarser particles. It is recommended to take the sand from as far as possible from seawater where the rain would have washed the salt.

CHAPTER TWO

SAND FORMATIONS IN LEBANON

Location And Use.

2. 1. General :

Sand formations in Lebanon include mainly seashore deposits, disintegrated sandstone deposits, stream deposits, and alluvial fans. Seashore deposits and disintegrated sandstones are more predominant than the others. Seashore sand deposits exist along most of Lebanon's cost. Disintegrated sandstone deposits are present in many areas of Mount Lebanon. Pine trees usually indicate the presence of sandstone. Stream deposits are present on several lebanese river banks sach as Nahr - Ibrahim and AL-ASSI. The sand existing in Bir-Hassan and the airport areas to the south of Beirut is believed to be an example of alluvial fans.

The geological map included in this chapter(1) shows the main sand formations in Lebanon. Because of scale limitations only those formations covering large areas could be shown..

2.2 Sources of Sand for Various Lebanese "Mouhafazats" And Provinces :

The information included here is a result of investigation done with engineers and contrators from various Lebanese provinces. It is to be noted that using seashore sand as an aggregate in concrete is prohibited by law. Any such use is done illegally. The sources mentioned here are the main ones only. Several additional small sources supply each of the mentioned provinces.

../..

(1) Figure 2

A. Beirut : -

The main present source of sand for Beirut is the alluvial deposits of redsand near Beirut's International Airport. Awzai' and Saint-Michel seashore sands are also used in limitted quantities because of legal aspects mentioned above.

B. Mount Lebanon : -

The main sand sources for Mount Lebanon are the many disintegrated sandstone deposits existing all over this "Mouhaffaza". Seashore and river deposits are used to a lesser extent.

The Chouf province uses the sand from Barouk and to a lesser extent from the sandy beach north of Saida such as the Bain-Militaire sand.

Aley province uses mainly the sand from Ghaboun.

Among the main sources for the Metn are Dowar and Mar-Shaya.

Kesrwan uses disintegrated sandstone deposits from various locations in the province. Jbeil province uses the sand from Ghabat, Nahr-Ibrahim and Jbeil.

C. South Lebanon : -

Tyr province uses the seashore sands of Ras El-Ain and Burghliah. Bint-Jbeil uses the sand from Ras El-Ain.

../..

Saida and Nabatieh province use the sand from the Bain-Militaire near Saida.

Jezzine province uses the sand of Dahr El-Ramleh. Marjayoun province takes its sand from Shwaya.

D. North Lebanon :-

Batroun and Koura obtain their sand from the cost such as from Nahr-Ibrahim and Jbeil.
Akkar gets the sand from Akkar Al-Alatika.
Zgharta and Tripoli get their sand from the cost north of Tripoli.

E. Beka'a :-

Zahleh province uses the sand of Ain-Hazir. Baalbeck and Hirmil use the sand of Al-Assi.

2.3 Location Of Main Sand Sources :-

The determination of the main natural sand sources in Lebanon and the location of each was a result of investigation done with engineers, contractors and inhabitants of various provinces. Twenty two sources were chosen to be the main sources covering most of Lebanon. Samples were obtained from each of these sources to be tested as fine aggregates for concrete. The location and nature of each of these sour sources is hereby listed with the area each one serves :

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No. 1 : RAS-EL-AIN : Seashore sand deposits around 10 kilometers south of Tyr adjacent to the Tyr-Nakoura road. It serves the southern part of Tyr province including Tyr itself and other main villages as Jwaya and Kana.

No. 2 : BAIN MILITAIRE :

Seashore sand deposits near the northern entrance of Saida (Sidon). It serves Saida and the surrounding villages as Nabatieh.

No. 3 : HASBAYA - SHWAYA :

Disintegrated sandstone deposits at Shwaya, 85 kilometers from Saida in the South-East direction. It is 10 Kms. from Hasbaya. It serves Hasbaya, Marji'uoun and the neighbouring villages.

No. 4 : MAR-SHAYA: Disintegrated sandstone deposits between Broummana &Ba'abdat. It serves the Broummana-Beitmeri part of the Metn.

No. 5 : DOWAR : Disintegrated Sandstone deposits in the Dowar village which is adjacent to Dhour Chouer. It serves the Dhour Chouer-Bois De Boulonge part of Metn.

No. 6 : HASBAYA-SHWAYA :

Another source of the same location as No3. and serving the same area but having different characteristics.

../..

No. 7 : DAHR EL-RAMLEH : Disintegrated sandstone deposits 35 kilometers east of Saida on the road from Saida to Jezzine. It serves Jezzine, Room and the surrounding villages.

No. 8: BURGHLIAH: Seashore sand deposits 3 kilometers to the north of Tyr, adjacent to the Beirut-Tyr road. It serves villages to the north east of Tyr such as Abbassiah and Ma'raka.

No. 9 : AL-GHABAT: Disintegrated sandstone deposits in Qartaba. Around 60 km. North-East of Beirut on the road to Afqa. It serves Qartaba and the surrounding villages.

No. 10 : JBEIL: Seashore sand deposits around one kilometer to the south of Jbeil. It serves Jbeil and the surrounding villages and to a lesser extent it serves Tripoli also.

No. 11: AL-MASHROUH: Seashore sand deposits about 4 kilometers to the south of the Lebanese northern borders near the main costal road. It serves Tripoli and Zghorta.

No. 12 : ABBOUDIEH: Seashore sand deposits about 6 kilometers to the south of the Lebanese northern borders near the costal road. It serves Tripoli and Zghorta.

No. 13 : AWZAI' : Seashore deposits around 10 Kilometers south of Beirut adjacent to the Awzai' road between Beirut and Khaldé. It serves Beirut and the surrounding area.

No. 14 : AIR PORT : Alluvial fans deposits adjacent to the Beirut Airport road around 2 Kilometers before the Airport. It is the main existing present source of sand for Beirut and the surrounding area.

No. 15 : SAINT-MICHEL : Seashore deposits at a knoun beach in the south of Beirut. It serves Beirut and the surrounding area.

No. 16 : NAHR-IBRAHIM : River deposits which were driven by the river to the sea and the sea has driven them back to the shore around 35 kilometers to the north of Beirut. It has served many villages in Mount Lebanon as well as Beirut.

No. 17 : DBAYEH : Seashore deposits around 20 Kilometers to the north of Beirut. It serves Beirut as well as some villages in Mount Lebanon.

No. 18 : AIN-HAZIR: Disintegrated sands tone deposits 5 kilometers to the south of Zahleh. It serves Zahleh and the surrounding villages.

../..

No.19: AKKAR AL-ATIKA:

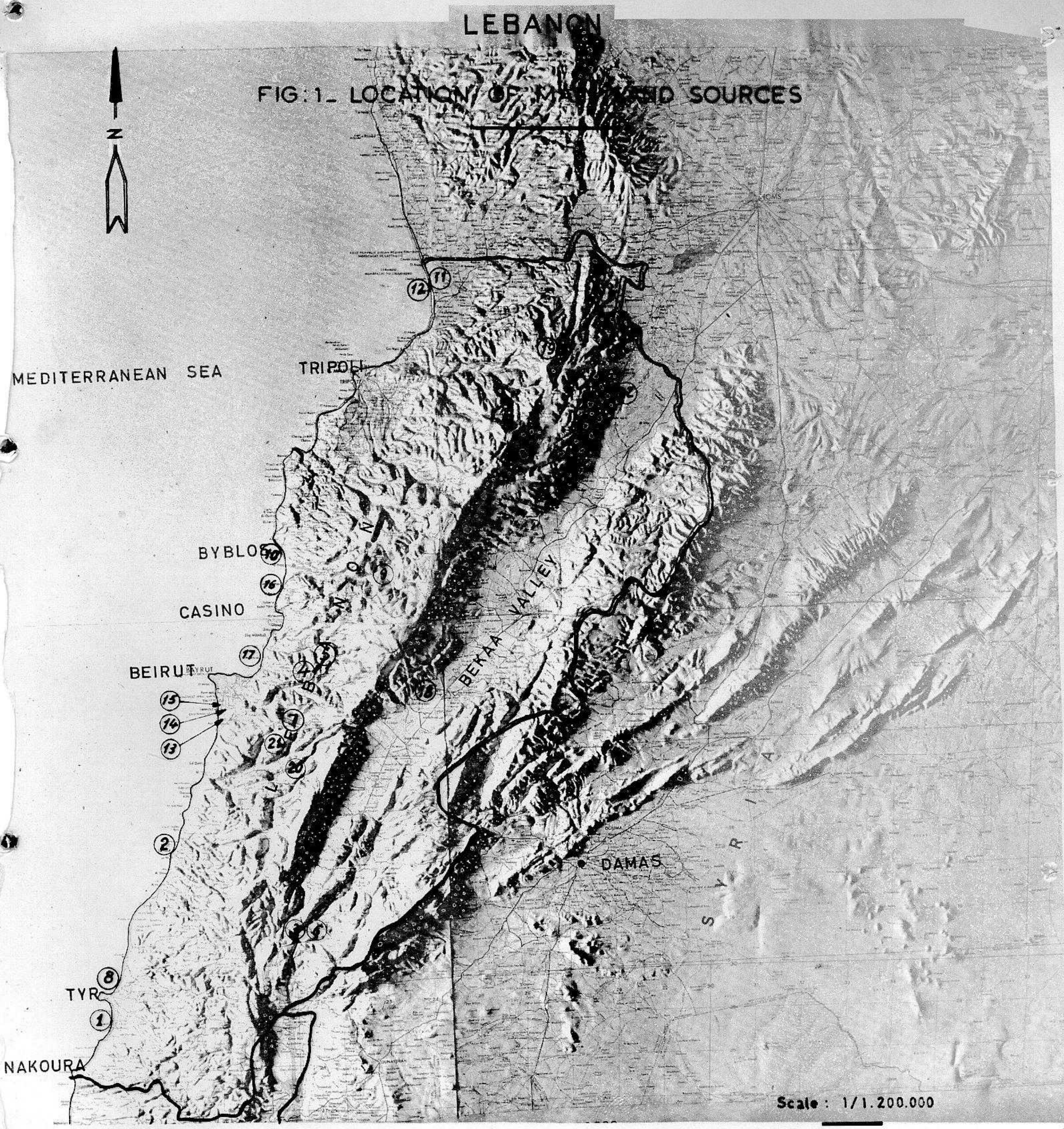
Disintegrated sandstone deposits around 50 kilometers to the east of Tripoli serving Akkar region.

No.20: BAROUK : Disintegrated sandstone deposits one kilometer to the east of the Barouk river source and around 45 kilometers from Beirut.

No.21: GHABOUN: Disintegrated sandstone deposits around 8 kilometers from Aley in the south east direction. It serves the Aley-Bhamdoun area.

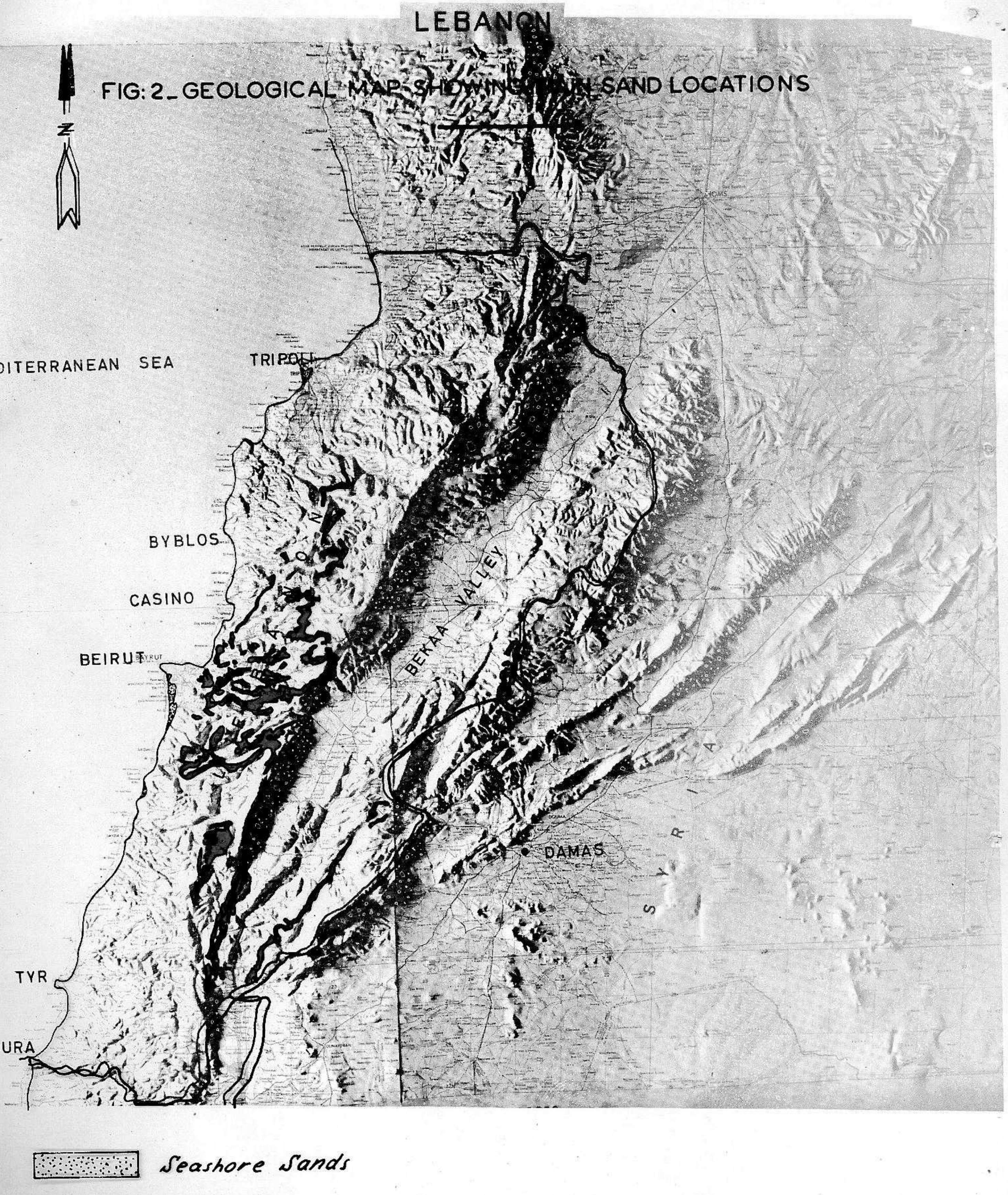
No.22: AL-ASSI: River deposits 2 kilometers to the east of Hirmil village and around 150 kilometers from Beirut. It serves the Ba'albeck-Hirmil Region.

FIG.3



1 _ RAS-EL-AIN
2 _ BAIN MILITAIRE _ SAÏDA
3 _ HASBAYA _ SHWAYA
4 _ MAR SHAYA
5 _ DOWAR
6 _ HASBAYA _ SHWAYA
7 _ DAHR-EL-RAMLEH
8 _ BURGHLLAH
9 _ EL-GHABAT
10 _ JBEIL
11 _ AL-MASHROUH
12 _ ABOUDIEH
13 _ AWZAI
14 _ AIRPORT
15 _ SAINT _ MICHEL
16 _ NAHR _ IBRAHIM
17 _ DBAYEH
18 _ AIN-HAZIR
19 _ AKKAR
20 _ BAROUK
21 _ GHABOUN
22 _ AL-A'SSI - HERMEL

FIG. 3



The Information in the map was taken from the geological maps of M. Louis Dubertret.
Small sand sources do not show on this map.

Scale : 1/1.200.000

CHAPTER THREE

STANDARD SPECIFICATIONS FOR SAND AS A FINE AGGREGATE IN CONCRETE

3.1. INTRODUCTION :

In Judging the adequacy of the various sand samples as fine aggregates in concrete the recommendations of the A.S.T.M. were used in addition to the comparative compressive strength of the various mortar cubes. If these recommendations were to be followed blindly most of the sand sources in Lebanon would have to be rejected. Practical aspects of economy and availability were hence considered in judging the adequacy of the sand sources.

3.2 THE A.S.T.M. RECOMMENDATIONS :

A- GRADING :

(1) Sieve Analysis :-

Sand, as a fine aggregate in concrete, should be graded within the following limits :

Sieve	percentage passing
3/8 - in (9.525m.m)	100
No. 4 (4.749m.m)	95 to 100
No. 8 (2.379m.m)	80 to 100
No. 16 (1.191m.m)	50 to 85
No. 30 (0.589m.m)	25 to 60
No. 50 (0.297m.m)	10 to 30
No. 100 (0.149m.m)	2 to 10

(2) No more than 45 percent of the sand may be retained between any two consecutive sieves of the series mentioned in part (1).

(3) The fineness modulus of the sand should be included between 2.3 and 3.1. The fineness modulus is the summation of the percentages retained on the sieves between No. 4 and No. 100 of the series shown in part (1) divided by 100.

B - DELETERIOUS SUBSTANCES :

(1) Materials finer than No. 200 sieve should not exceed five percent by weight in the case of natural sand and seven percent in the case of manufactured sand. This is reduced to three and five percent respectively in case the concrete is subject to abrasion.

(2) Sand, as a fine aggregate, must be free of excessive organic impurities, acids, alkalies, sulphates and chlorides. If when tested for organic impurities it produces a color darker than the standard, the sand must be rejected.

CHAPTER FOUR

PROCEDURES OF TESTS AND EXPERIMENTS

A - SIEVE ANALYSIS :-

The purpose of the sieve analysis test was to determine the particle size distribution of the sand. The tests were conducted according to the procedure specified by the A.S.T.M. C 136-63

B - TEST FOR CLAY LUMPS AND MATERIAL FINER THAN No. 200 SIEVE :-

This test was conducted according to the procedure specified in A.S.T.M. C 117-62.

C - TEST FOR ORGANIC IMPURITIES :-

This test was conducted according to the procedure specified in A.S.T.M. C 40-60.

D - TEST FOR CALCIUM CARBONATE :-

50 grams of dry sand of each sample were placed in a dry bottle. Hydrochloric acid was added to it till effervescence stoped. The residue was dried and weighed

again. The difference in weight is the amount of calcium carbonate present.

E- QUALITATIVE TESTS FOR ACIDS, ALKALIES, CHLORIDES AND SULPHATES:-

One hundred grams of sand were added to a bottle containing 100 c.c. of distilled water, shaked and left for 24 hours. It was then shaked, allowed to settle and the water was filtered off.

1. Acids and Alkalies :-

Litmus paper was used to detect the presence of acids and alkalies. Acids would turn blue litmus into red while alkalies would turn red litmus into blue.

2. Sulphates :-

A small amount of 10% HCl solution was added to the filtered water and few drops of 10% barium chloride solution were also added. The presence of sulphates would be indicated by a white precipitate being formed.

3. Chlorides : -

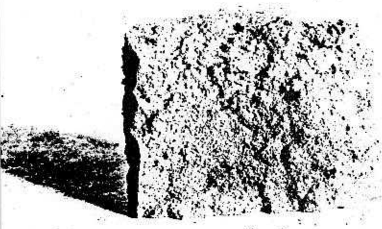
A small amount of 10% nitric acid solution was added to the filtered water and few drops of 10% silver nitrate solution were then added. Chlorides were indicated by the formation of a thick white precipitate.

F - TEST FOR COMPRESSIVE STRENGTH OF MORTAR :-

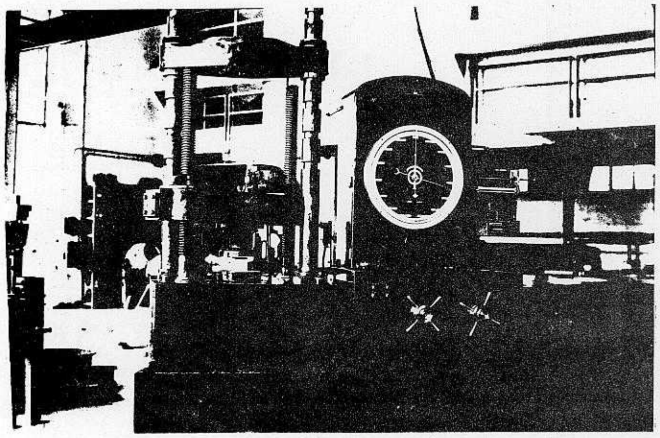
Mortar was chosen to test the compressive strength rather than concrete to eliminate the effect of coarse aggregate. The tests were conducted according to British Standards B.S.12 : 1958. Tests were performed at mortar ages of 3 days, 7 days and 28 days. Three cubes were tested each time.

G - DETERMINATION OF THE SHAPE OF SAND GRAINS : -

This study of the shape of sand grains was done by means of a microscope of magnifying power 45.

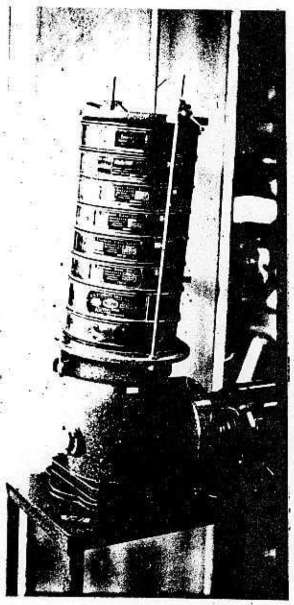


a) Failure Surface Of a Mortar Cube

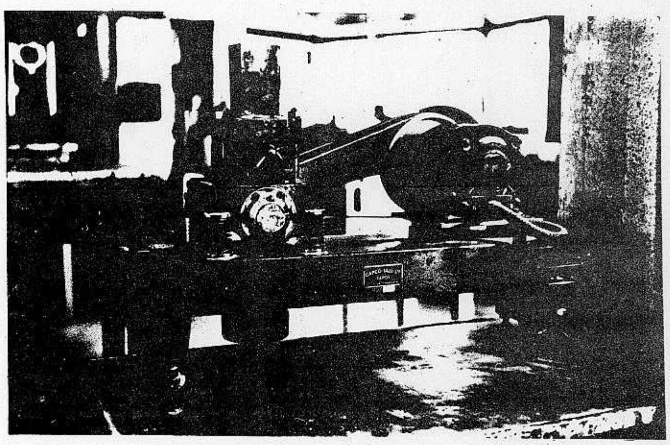


(d) Machine For Testing Compressive Strength. (clause 58. B.S.1881)

FIG_4_



b) Sieve Series A.S.T.M_E.11_



(c) Vibrating Machine B.S.12:1958

CHAPTER FIVE

DISCUSSION AND ANALYSIS OF TEST RESULTS

A. INTRODUCTION

The tests performed aimed at studying the gradation of each type of sand, the presence of deleterious substances, the shapes of the sand grains, and a comparative study of the mortar properties (compressive strength) of each. The results obtained encouraged further tests discussed later. Specific comments and recommendations for each source of sand are discussed in chapter six.

B - GRADATION

River deposits were found to be the best graded among Lebanese natural sands. They are coarser than the other sources. Both types tested, Nahr Ibrahim and Al-Assi had a fineness modulus higher than that specified by the A.S.T.M.

Seashore deposits, disintegrated sandstone deposits, and alluvial fans are generally fine and poorly graded. Most of their particles have diameters between 0.149m.m. and 0.589m.m. Their fineness moduli are less than the A S.T.M. specified limits (2.3-3.1). Many of these sands had more than 45 percent of their particles retained between two consecutive sieves of the series used. For sample No. 8 this was between sieve No. 16 and sieve No. 30. For samples No. 1, No. 2, No. 7, No. 13, No. 15 & No. 17 this was between sieve No. 30 and sieve No. 50. For samples No. 9, No. 10, No. 12, No. 13 & No. 14 this was between sieve No. 50 and sieve No. 100.

Crushers sand had a high percentage of of fines (20-25%) passing sieve No. 200.

SAMPLE No.	Fineness Modulus	SAMPLE No.	Fineness Modulus
1	1.89	12	1.13
2	1.54	13	1.50
3	1.32	14	1.36
4	1.24	15	1.64
5	1.40	16	3.61
6	1.25	17	1.74
7	1.55	18	1.57
8	2.88	19	0.88
9	1.55	20	1.33
10	1.50	21	1.34
11	2.91	22	3.71

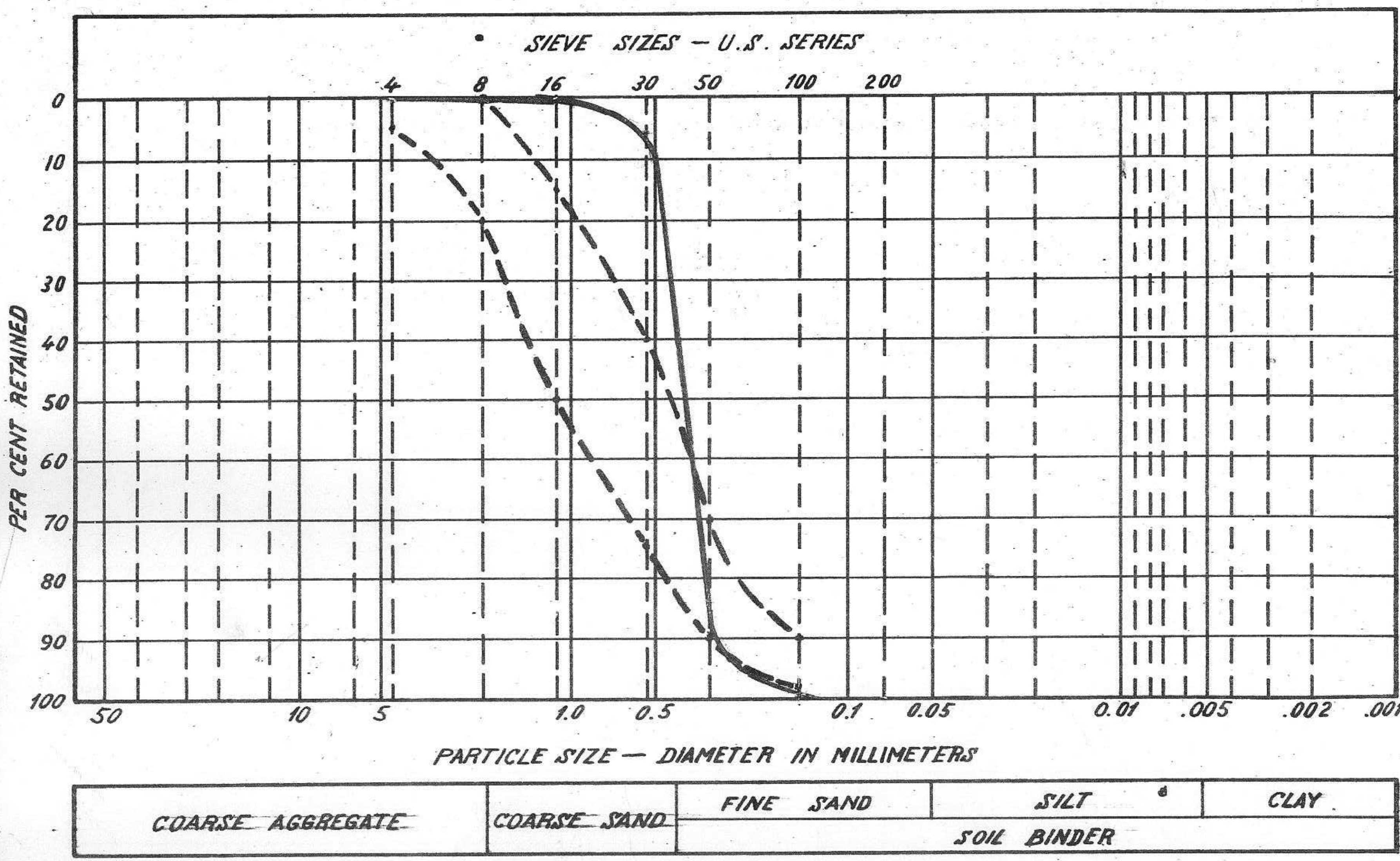


FIG. 5 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE
——— SAMPLE NO. 1
- - - - A.S.T.M. Specified Limits For Fine Aggregate

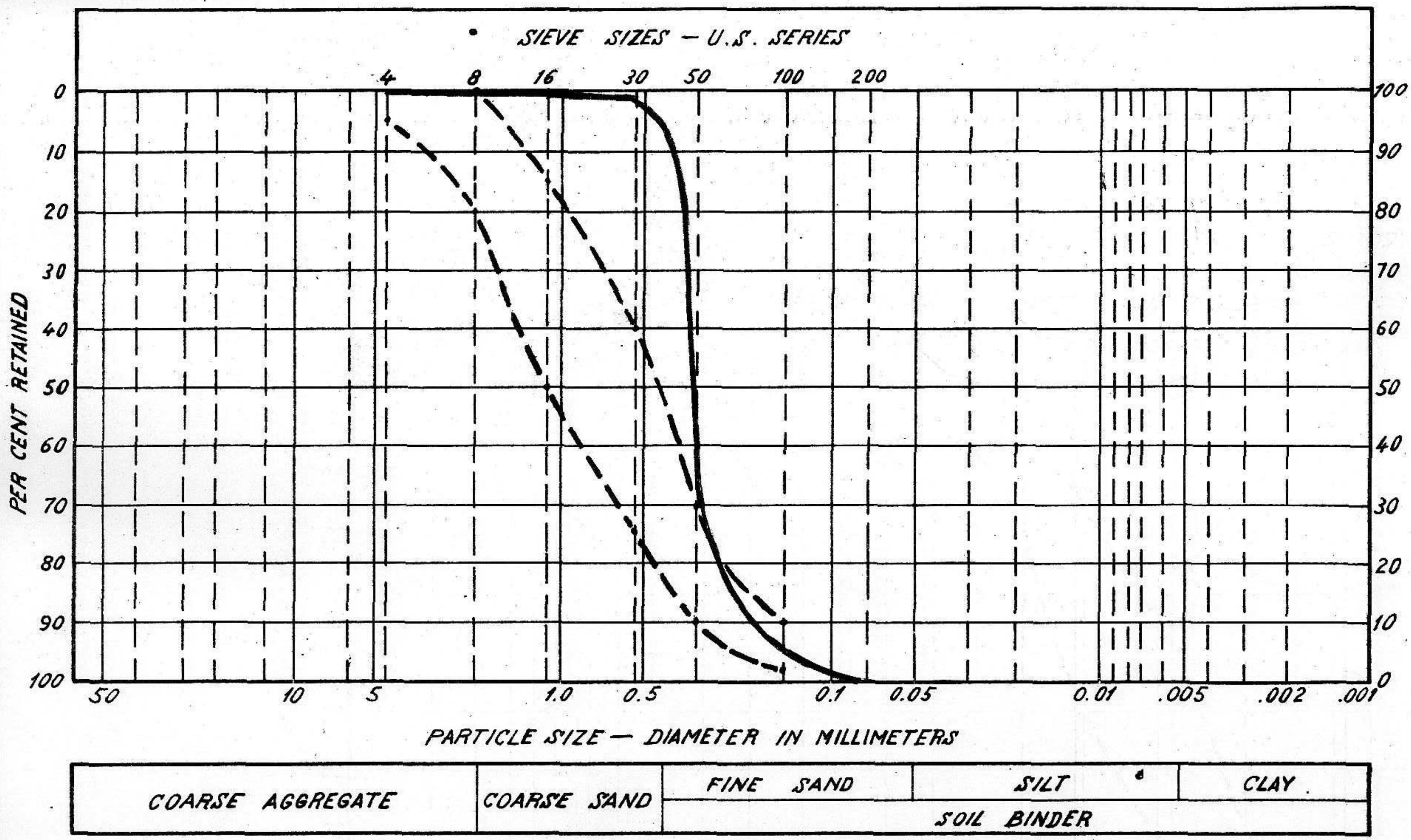


FIG. 6 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 2

– – – – A.S.T.M. Specified Limits For Fine Aggregate

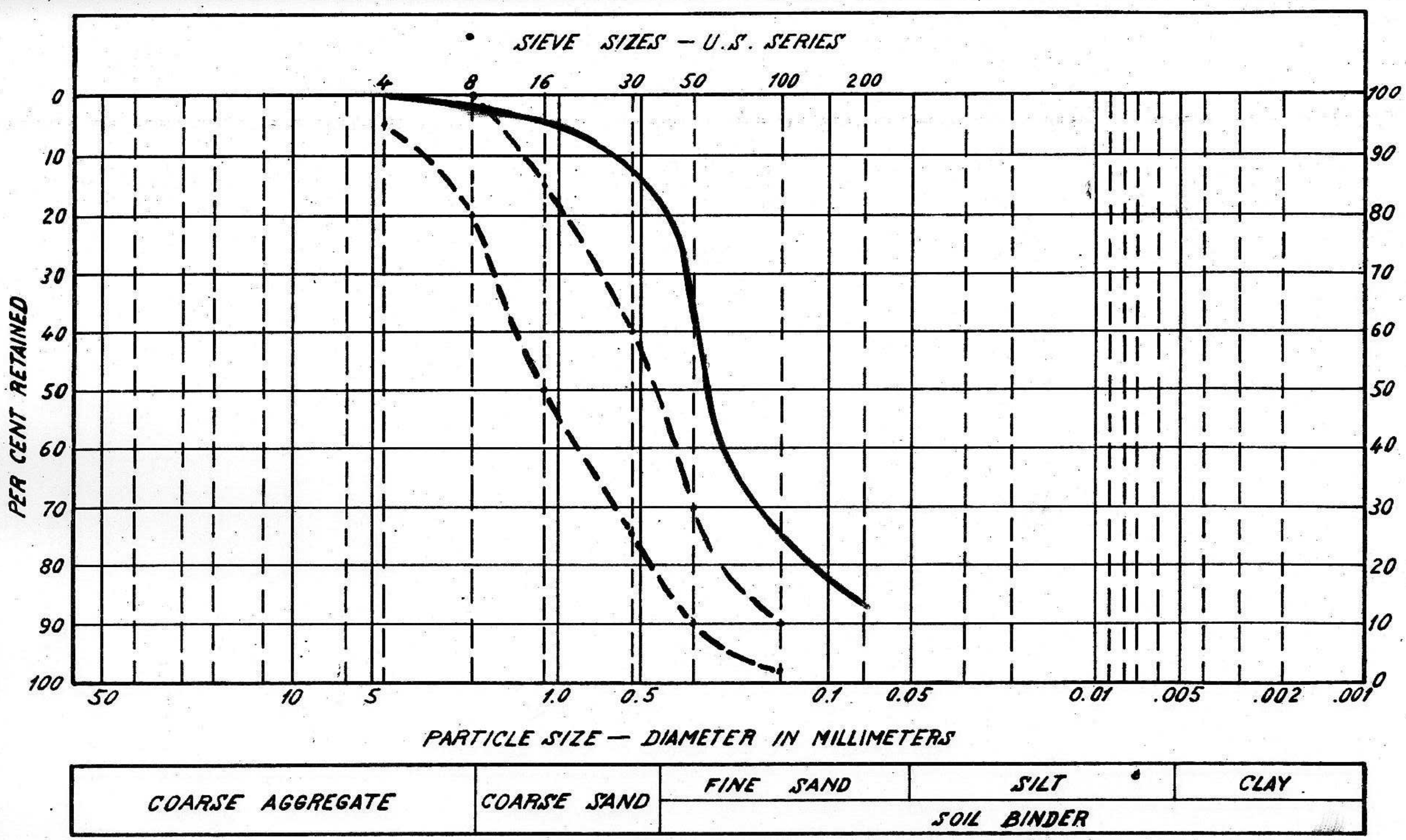


FIG. 7 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 3

- - - - A.S.T.M. Specified Limits For Fine Aggregate

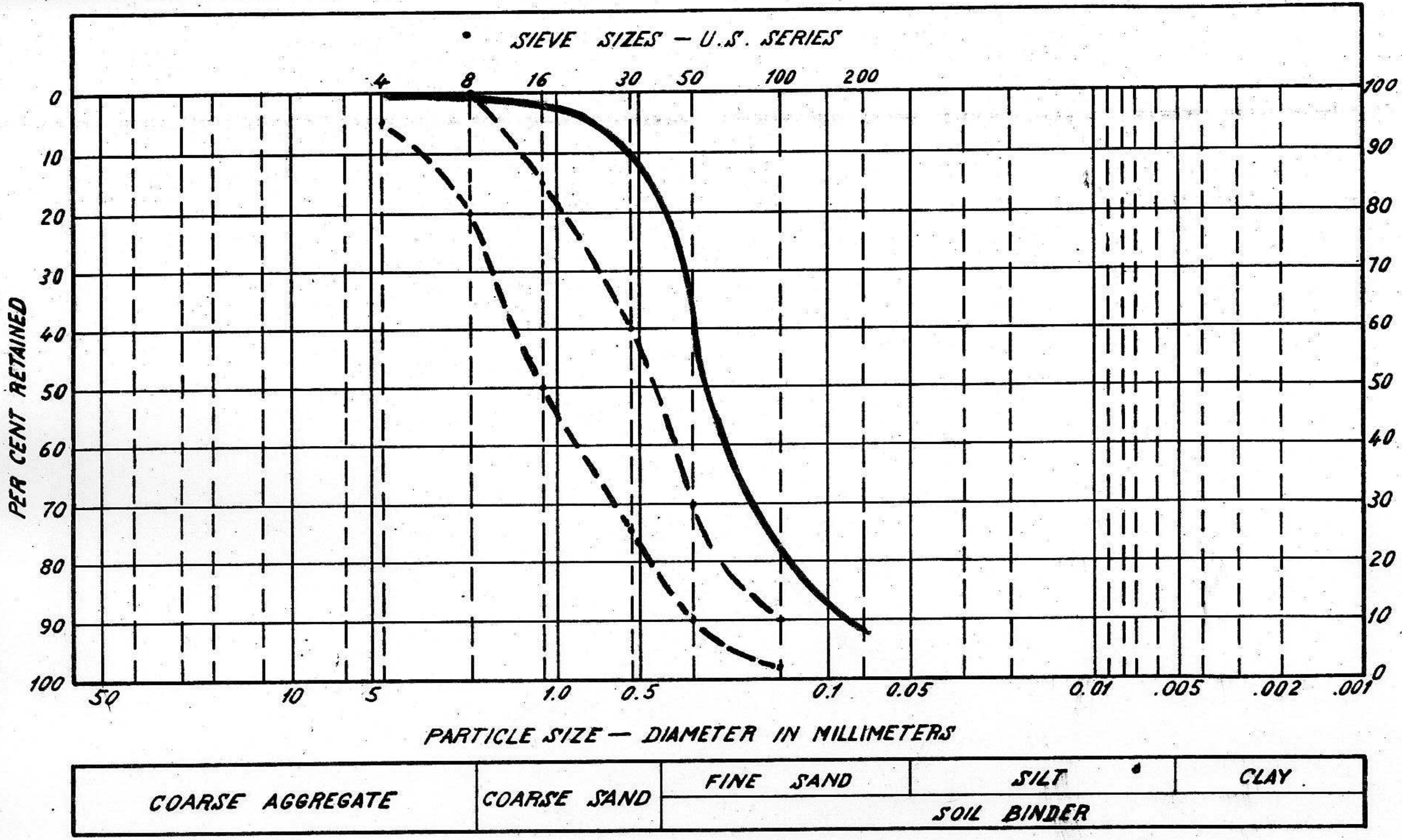


FIG. 8 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 4

- - - - A.S.T.M. Specified Limits For Fine Aggregate

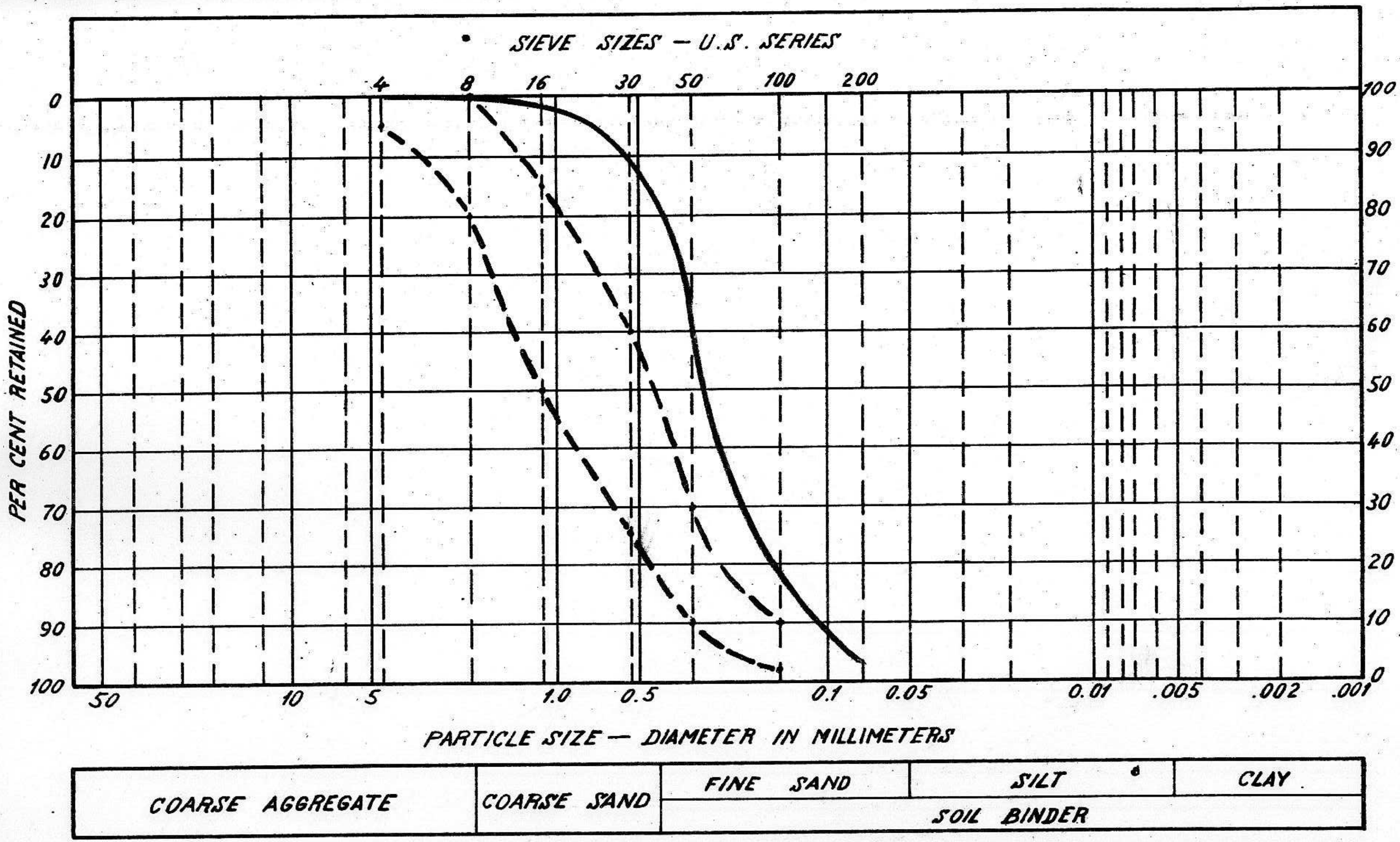


FIG. 9 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 5

- - - - A.S.T.M. Specified Limits For Fine Aggregate

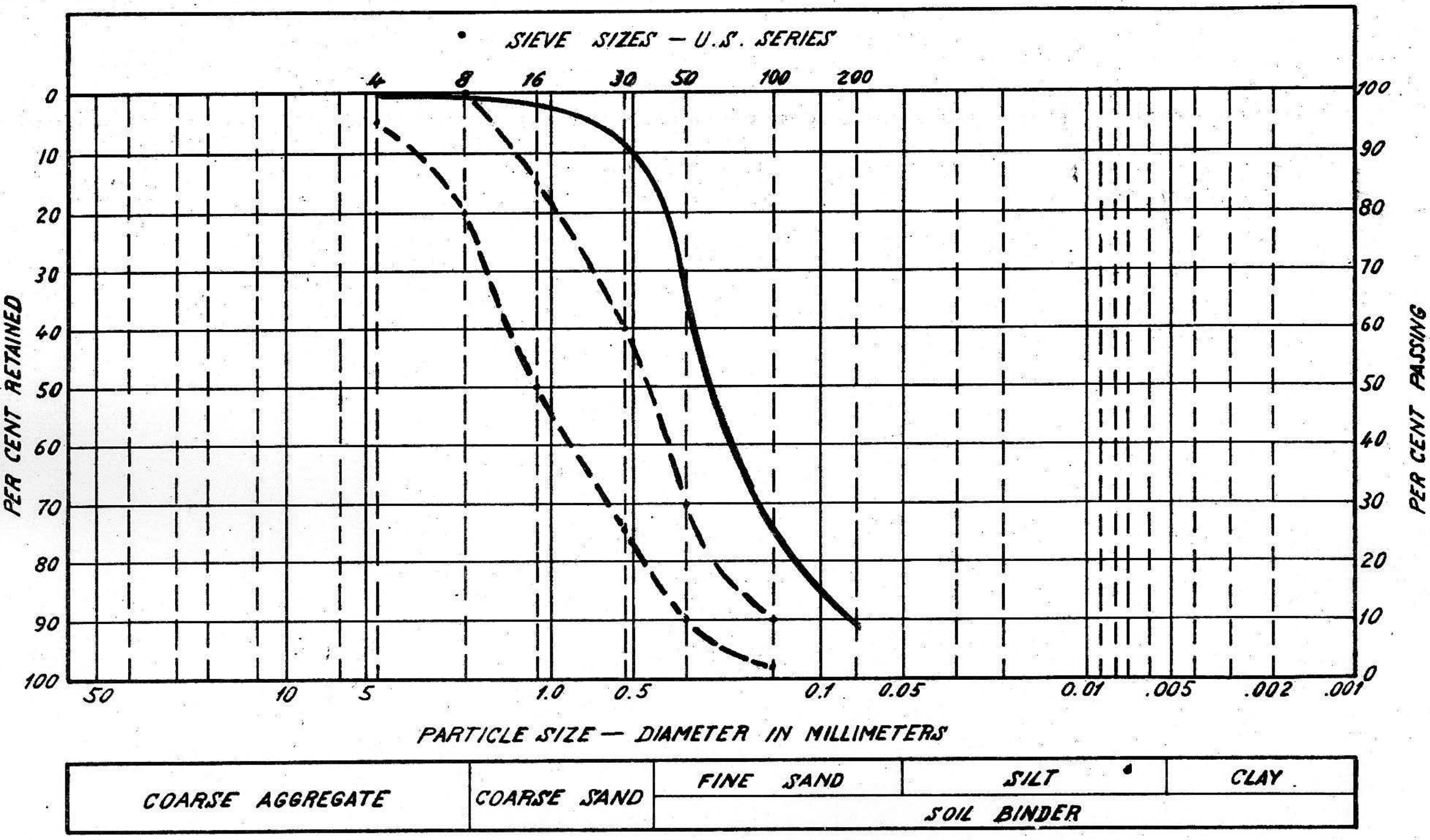


FIG. 10 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE
——— SAMPLE NO. 6
- - - - A.S.T.M. Specified Limits For Fine Aggregate

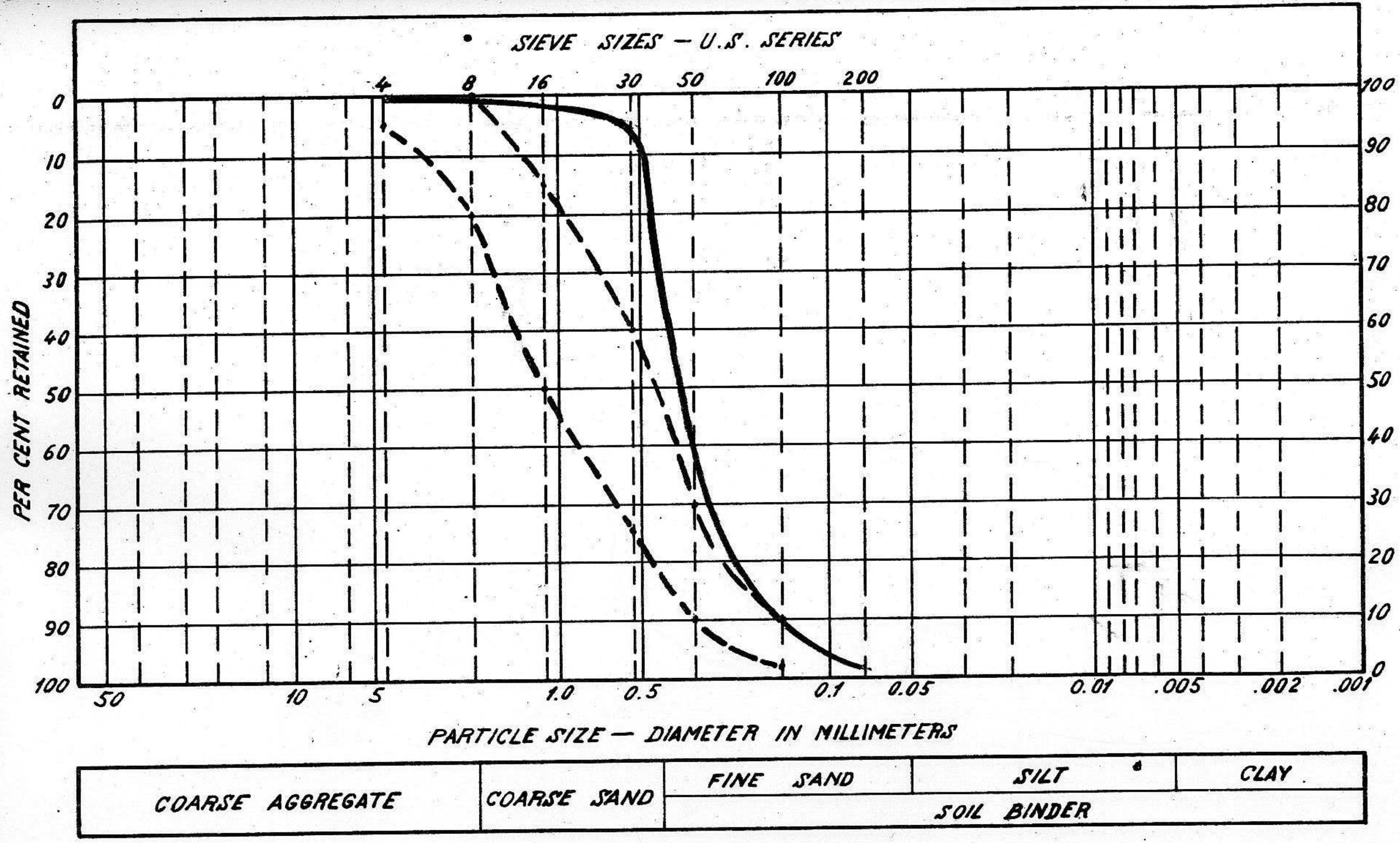


FIG. II MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 7

- - - - A.S.T.M. Specified Limits For Fine Aggregate

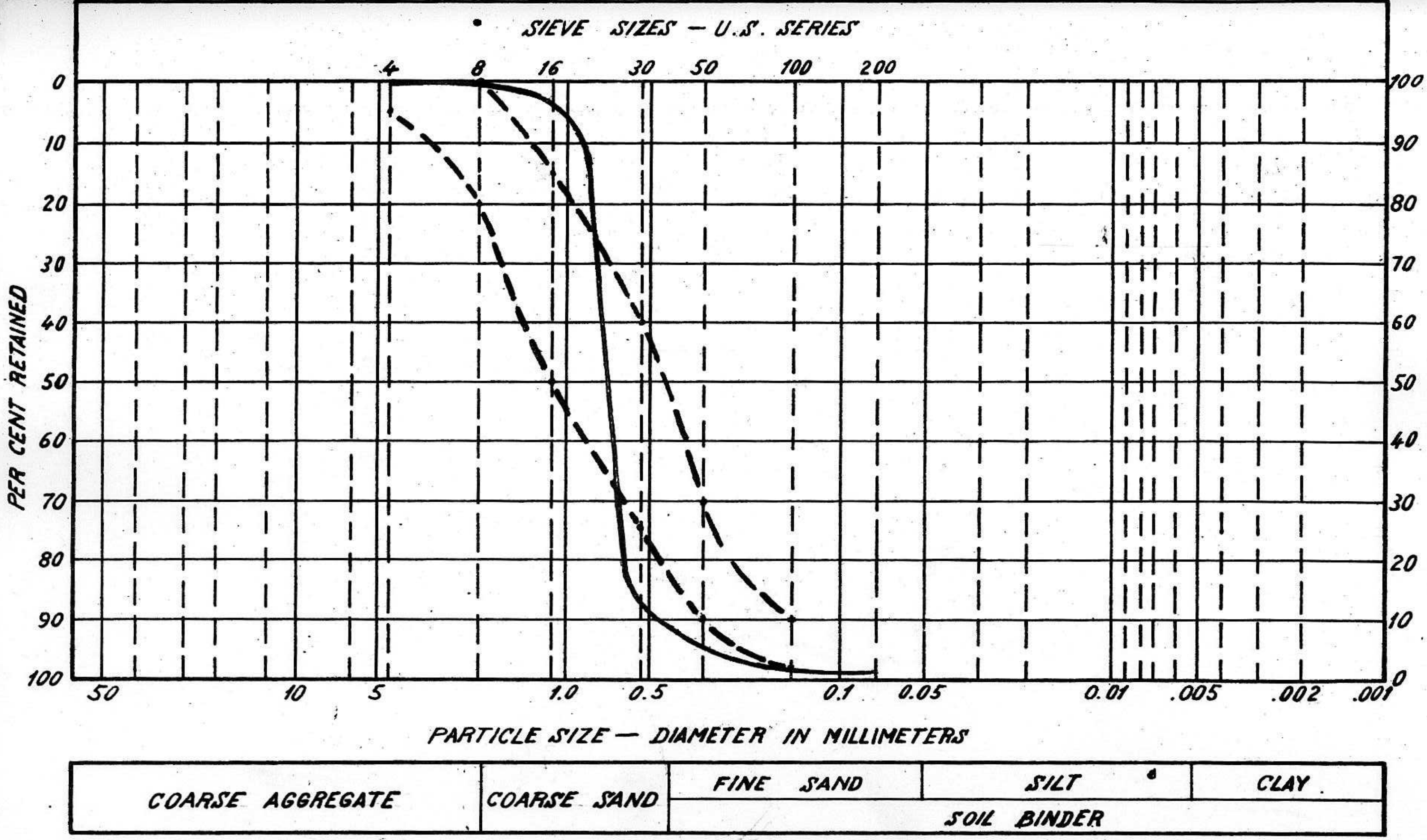


FIG. 12 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 8

- - - - A.S.T.M. Specified Limits For Fine Aggregate

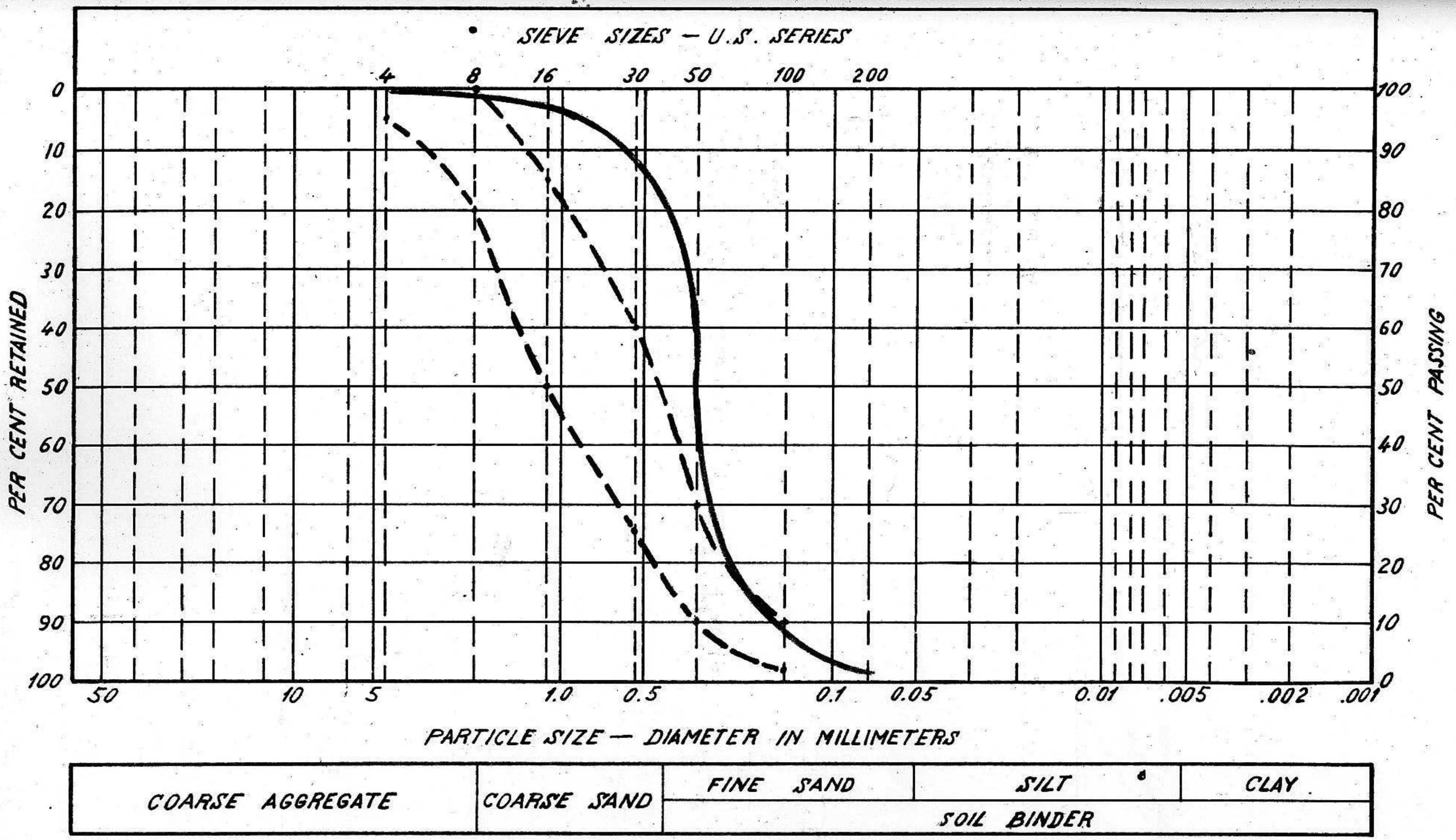


FIG. 13 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 9

- - - - A.S.T.M. Specified Limits For Fine Aggregate

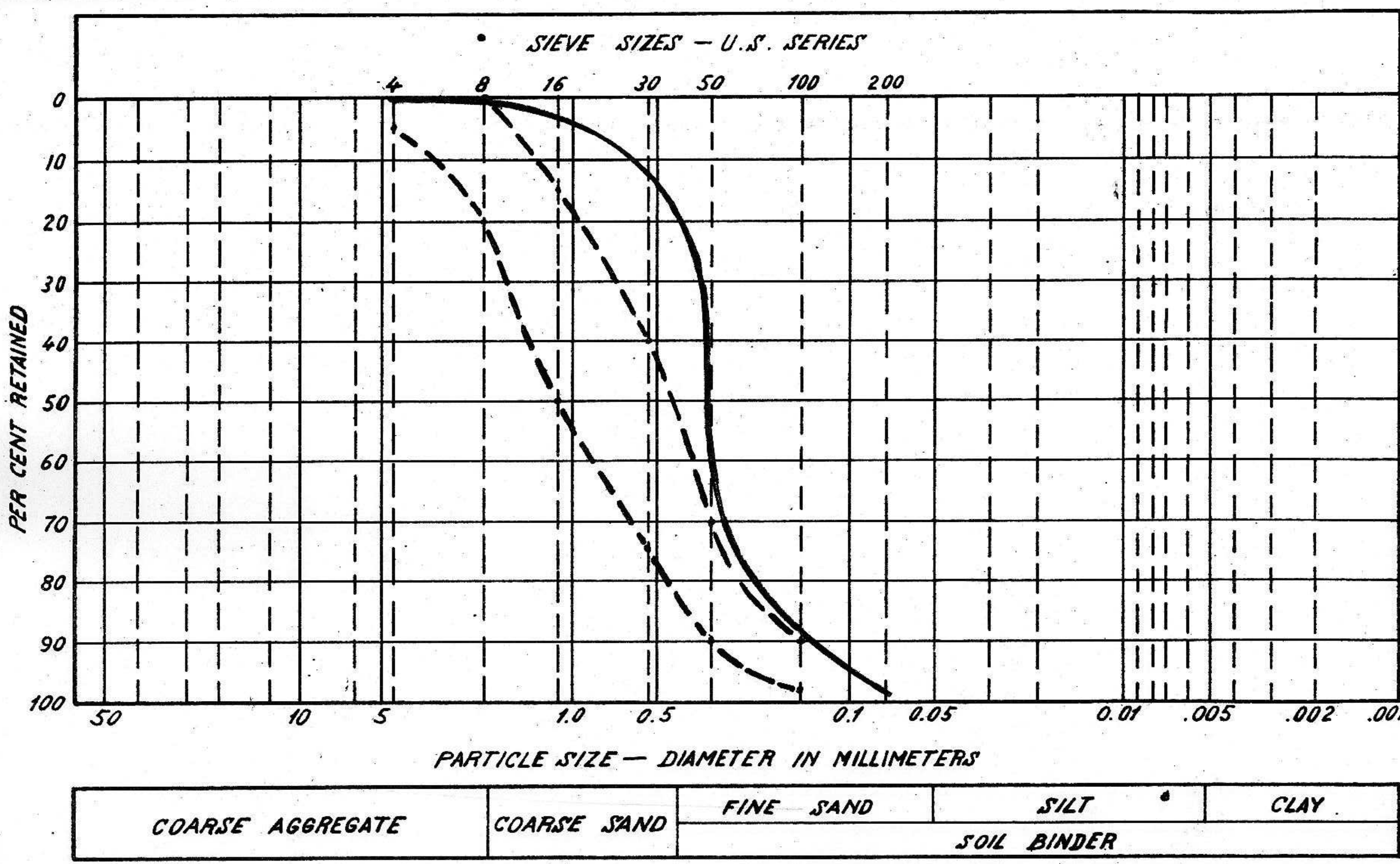


FIG. 14 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 10

- - - - A.S.T.M. Specified Limits For Fine Aggregate

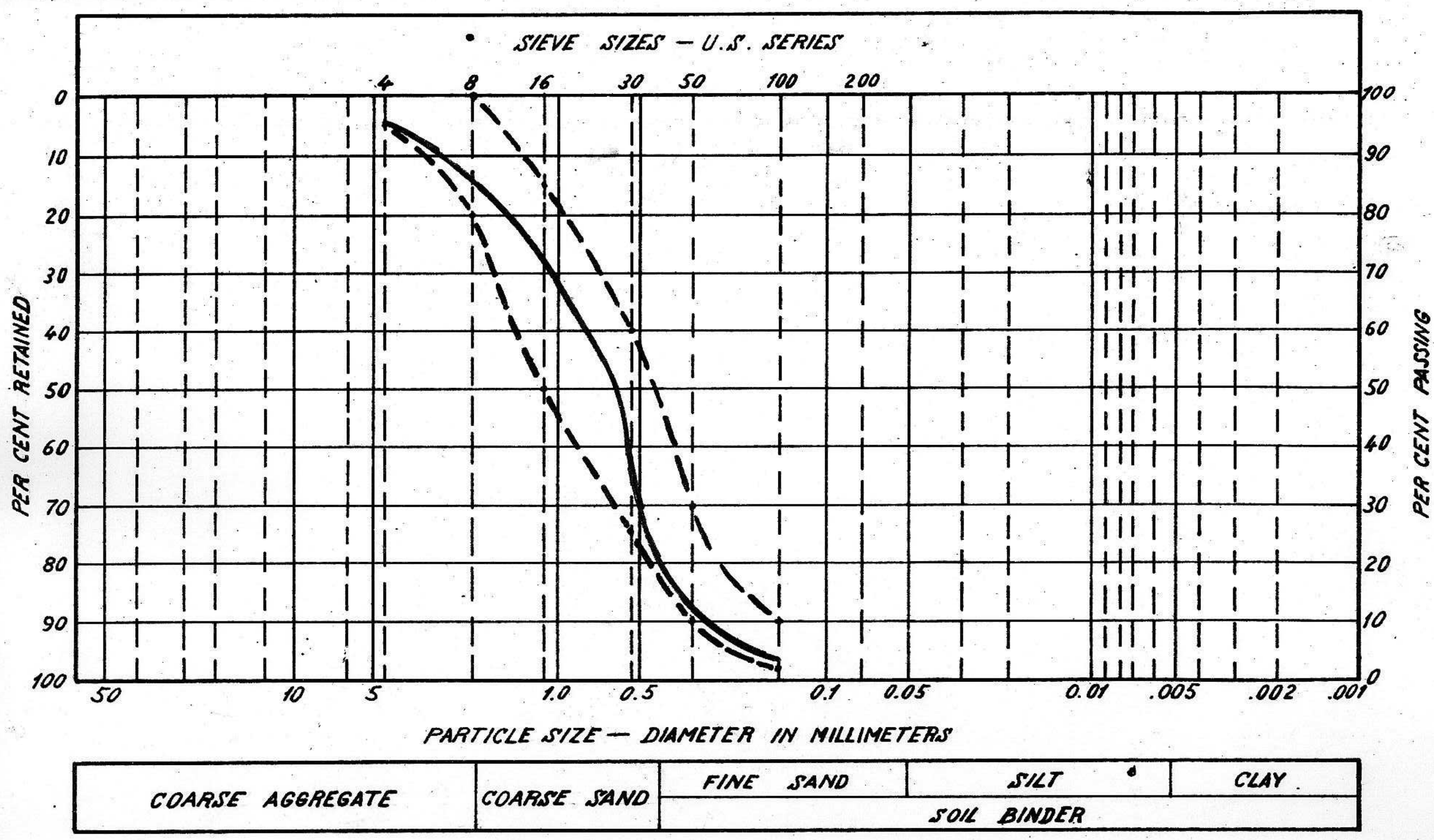


FIG. 15 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE
——— SAMPLE NO. 11
- - - - A.S.T.M. Specified Limits For Fine Aggregate

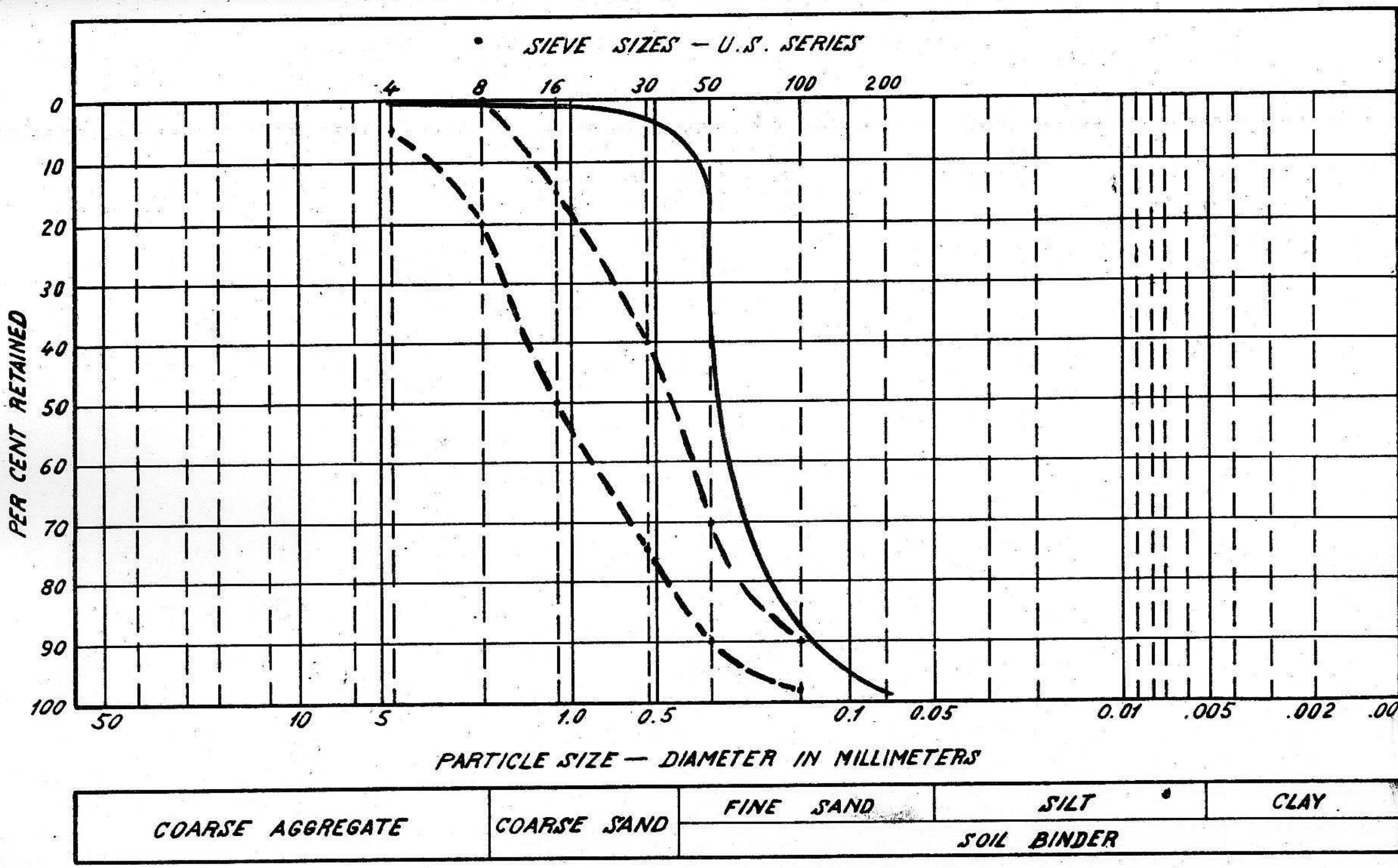


FIG. 16 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 12

- - - - A.S.T.M. Specified Limits For Fine Aggregate

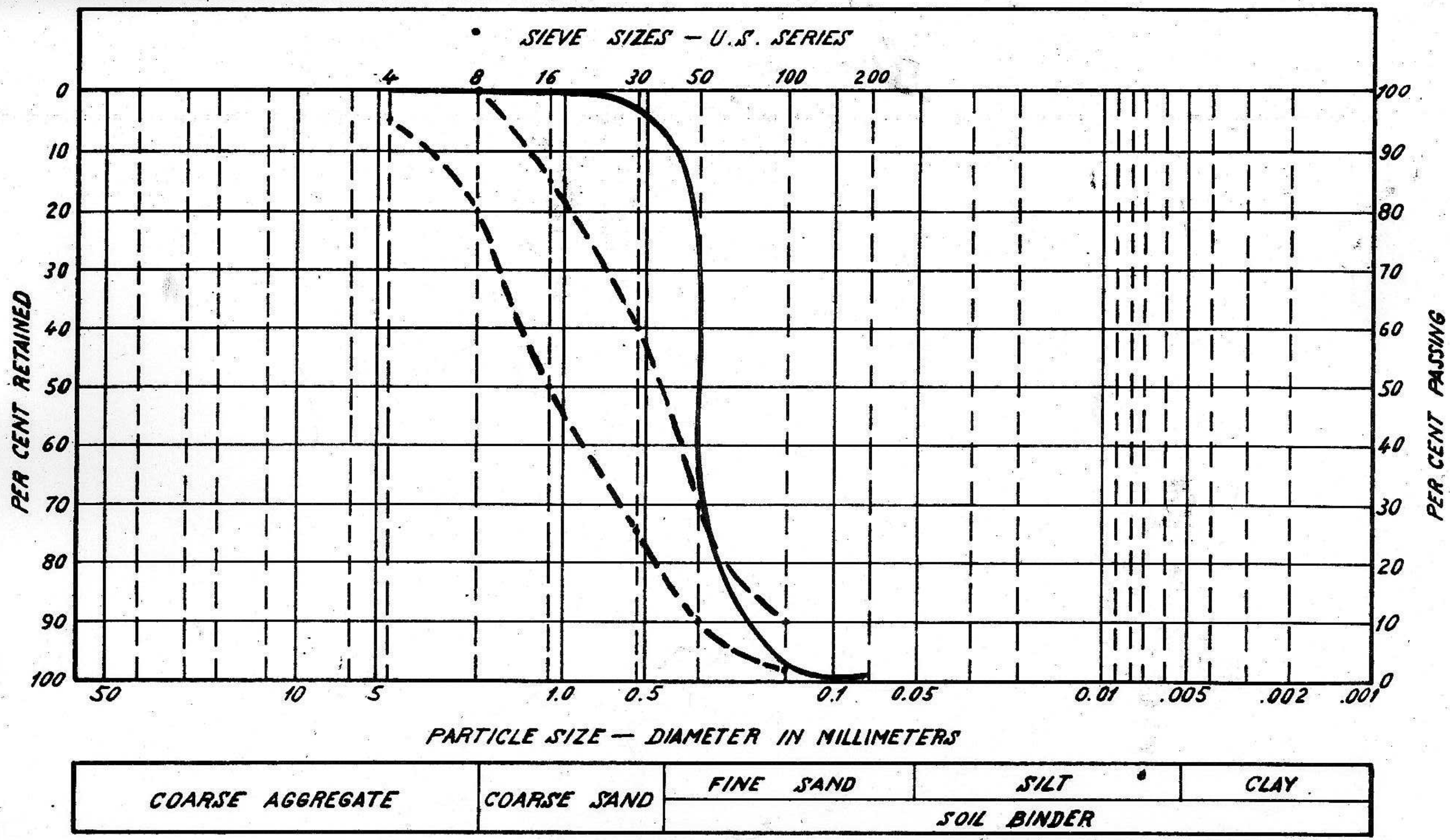


FIG. 17 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

—— SAMPLE NO. 13

- - - - A.S.T.M. Specified Limits For Fine Aggregate

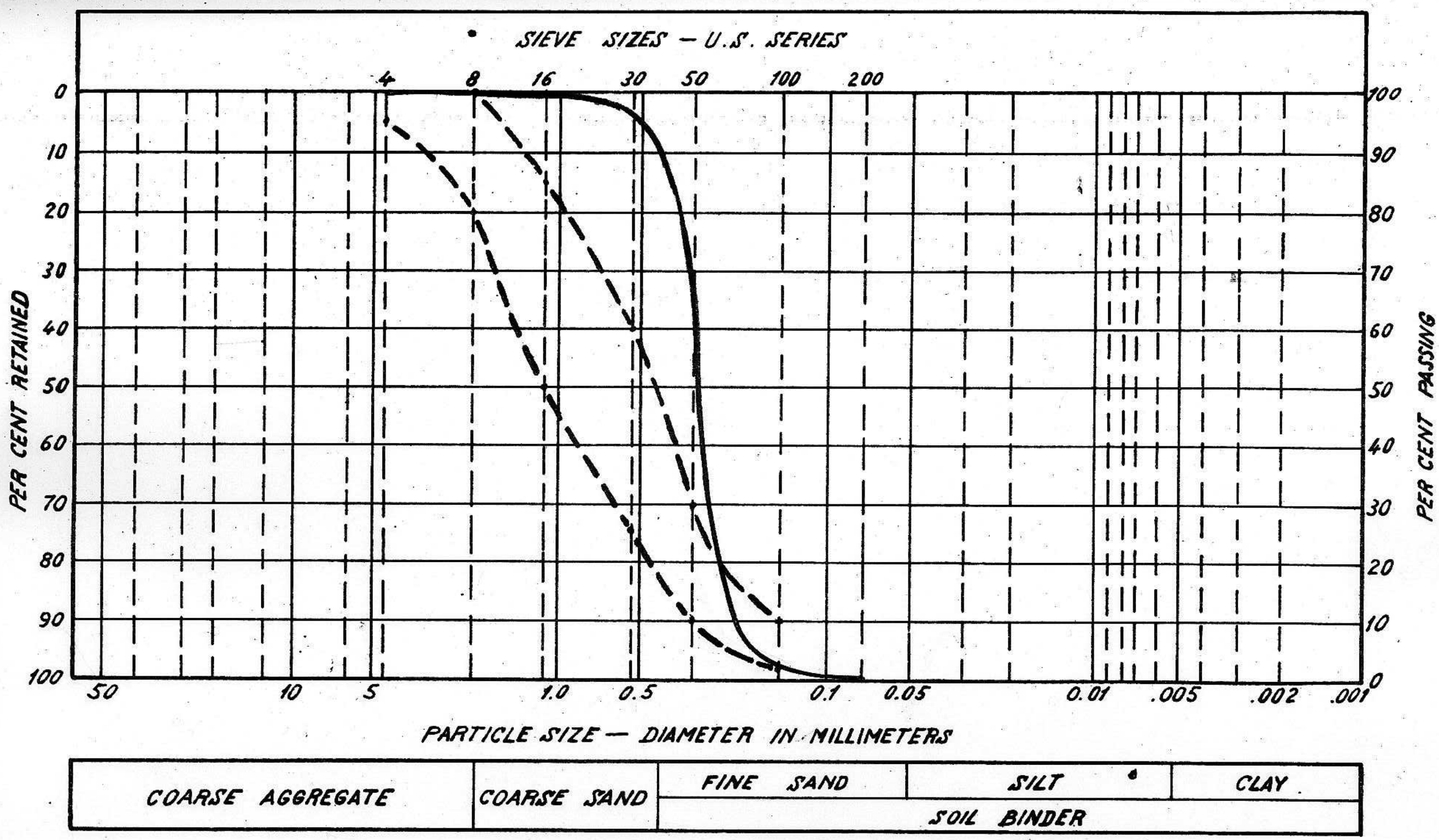


FIG. 18 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 14

- - - - A.S.T.M. Specified Limits For Fine Aggregate

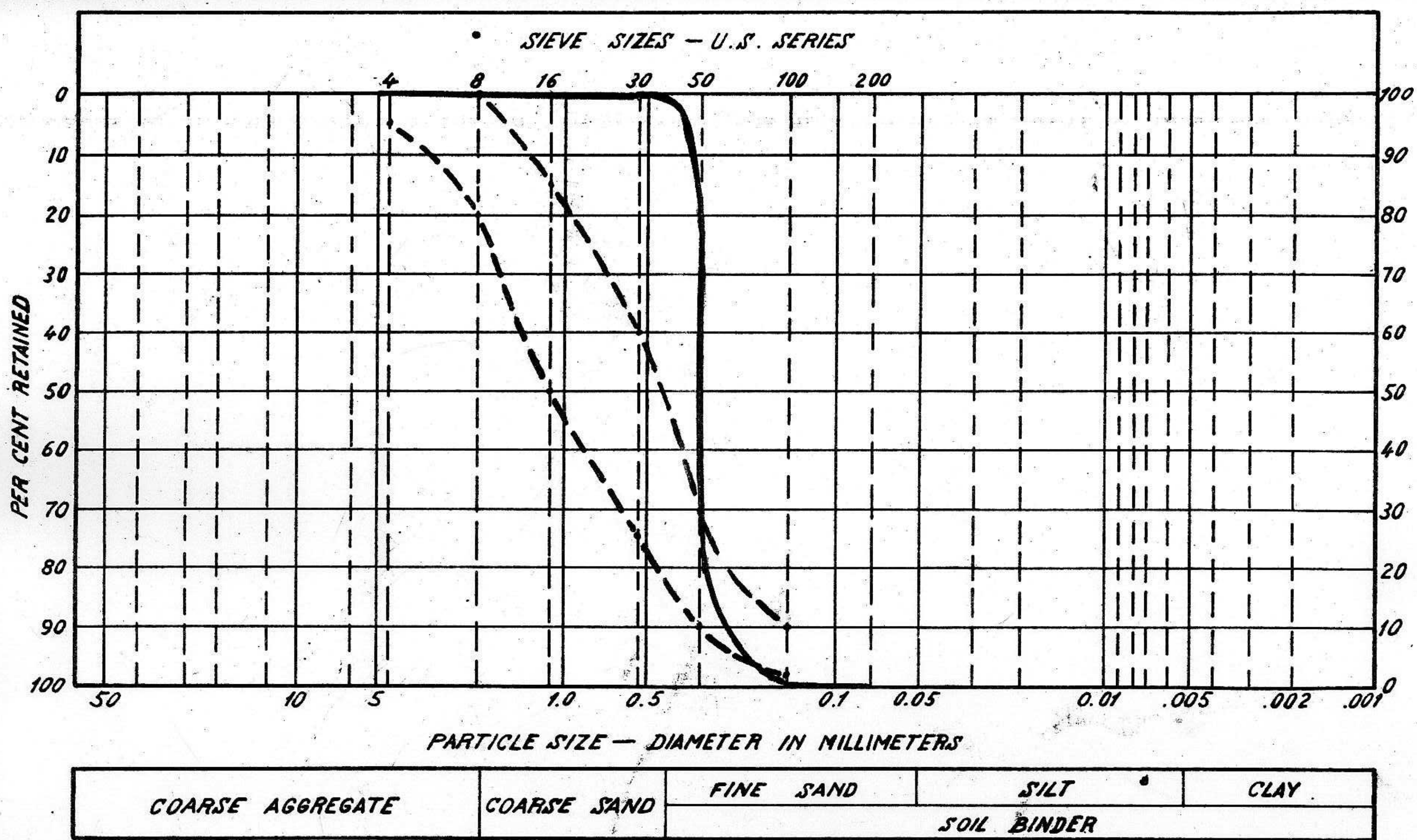


FIG. 19 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 15

- - - - A.S.T.M. Specified Limits For Fine Aggregate

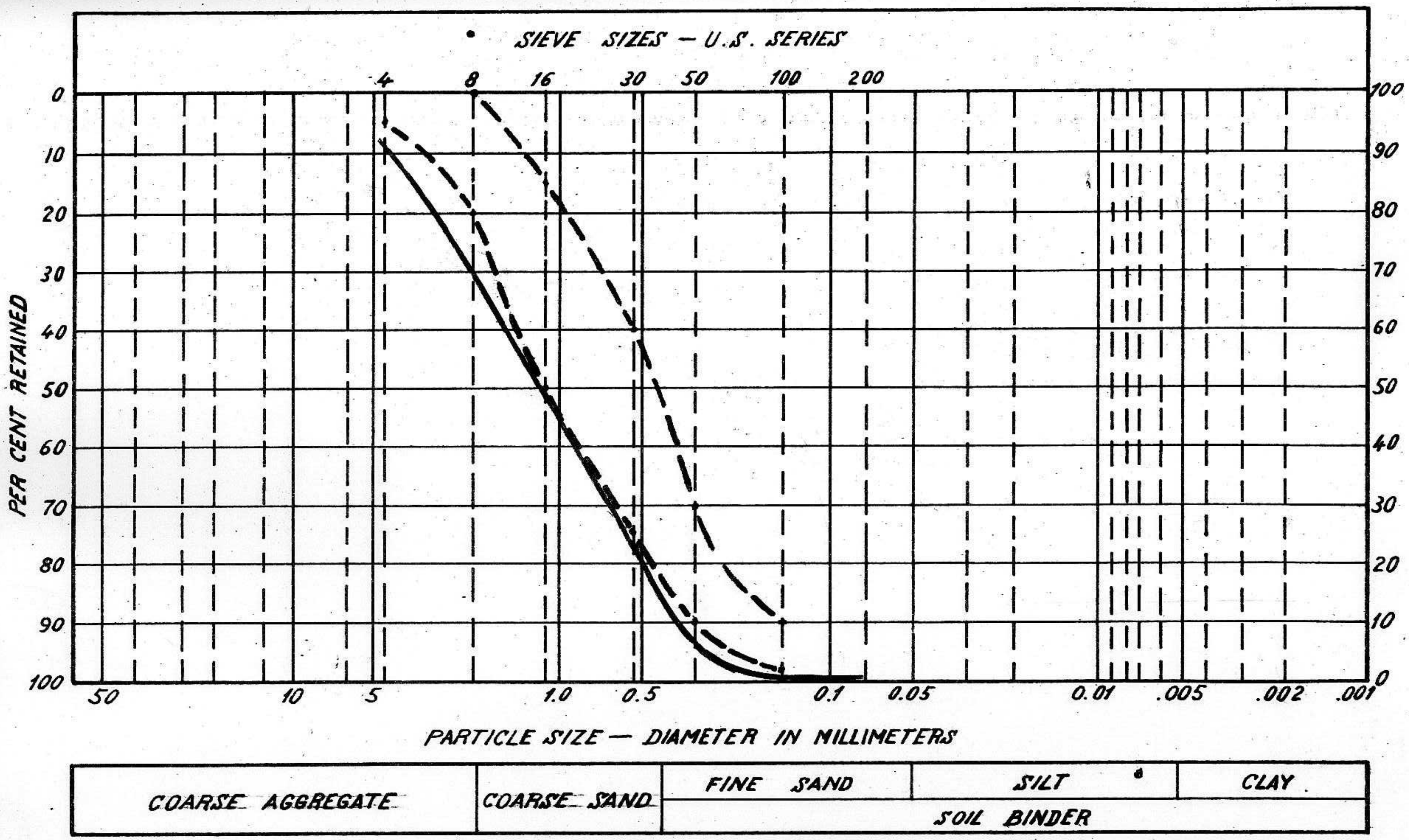


FIG. 20 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 16

- - - - A.S.T.M. Specified Limits For Fine Aggregate

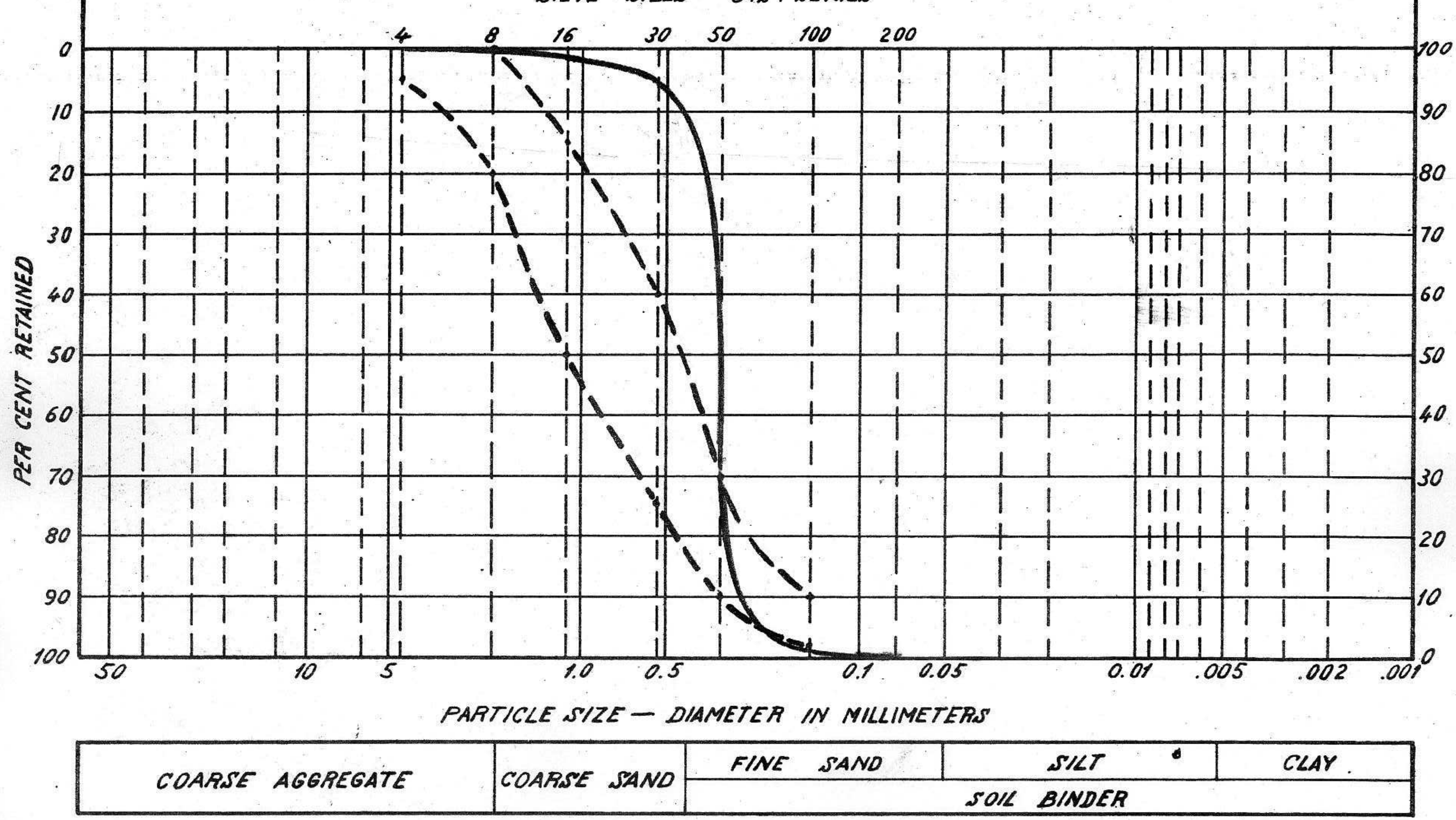


FIG. 21 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 17

- - - - A.S.T.M. Specified Limits For Fine Aggregate

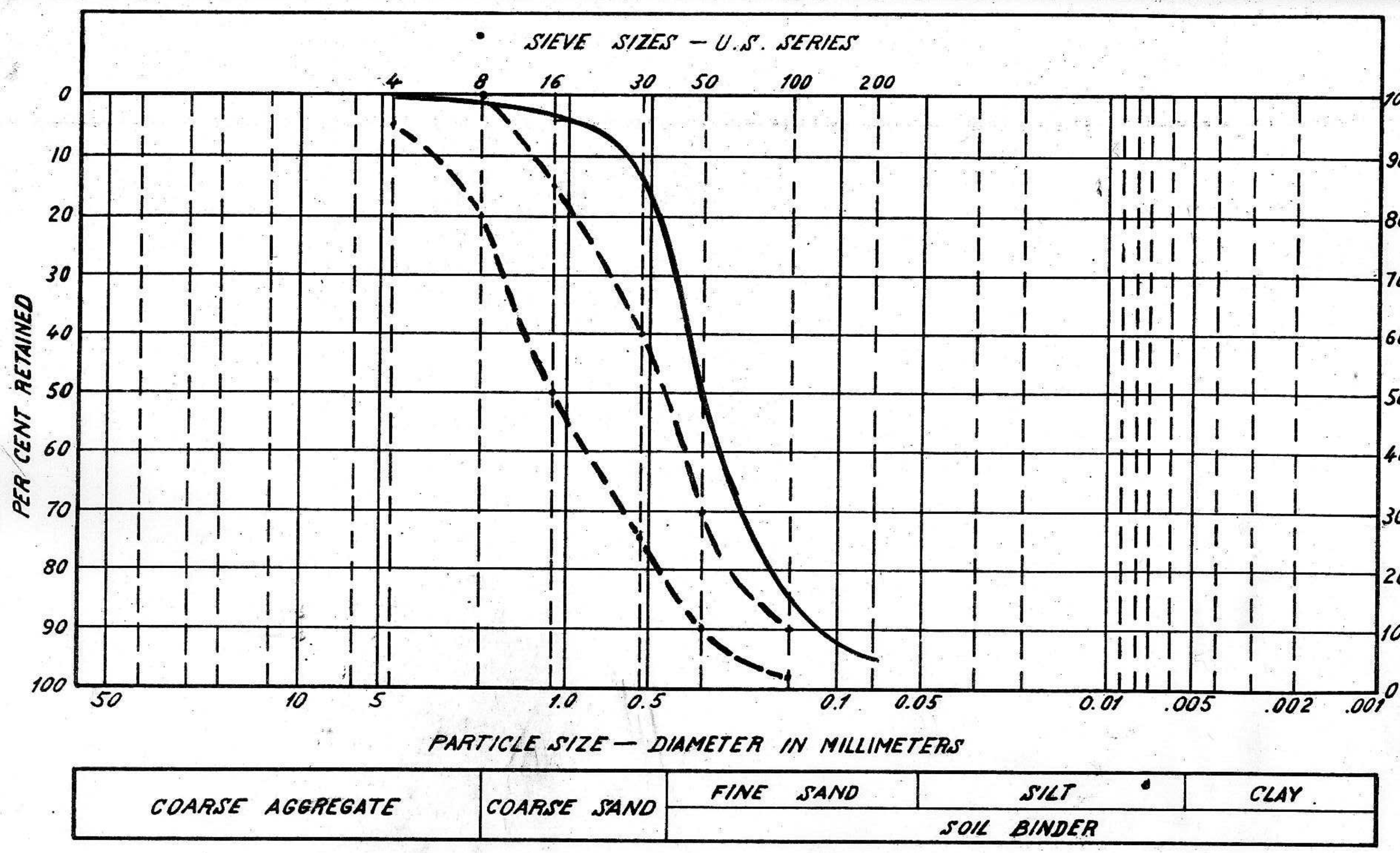


FIG. 22 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 18

- - - - A.S.T.M. Specified Limits For Fine Aggregate

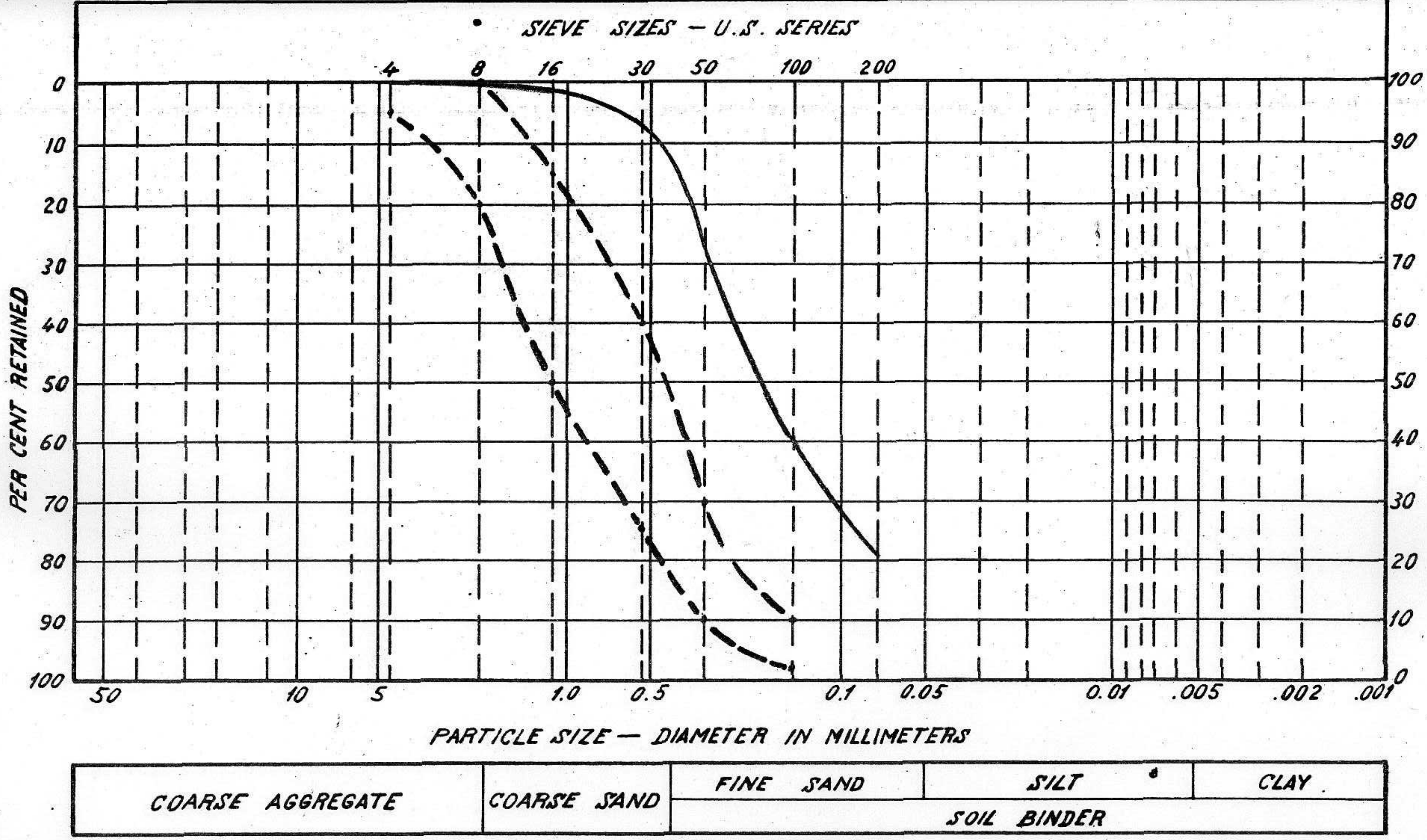


FIG. 23 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 19

- - - - A.S.T.M. Specified Limits For Fine Aggregate

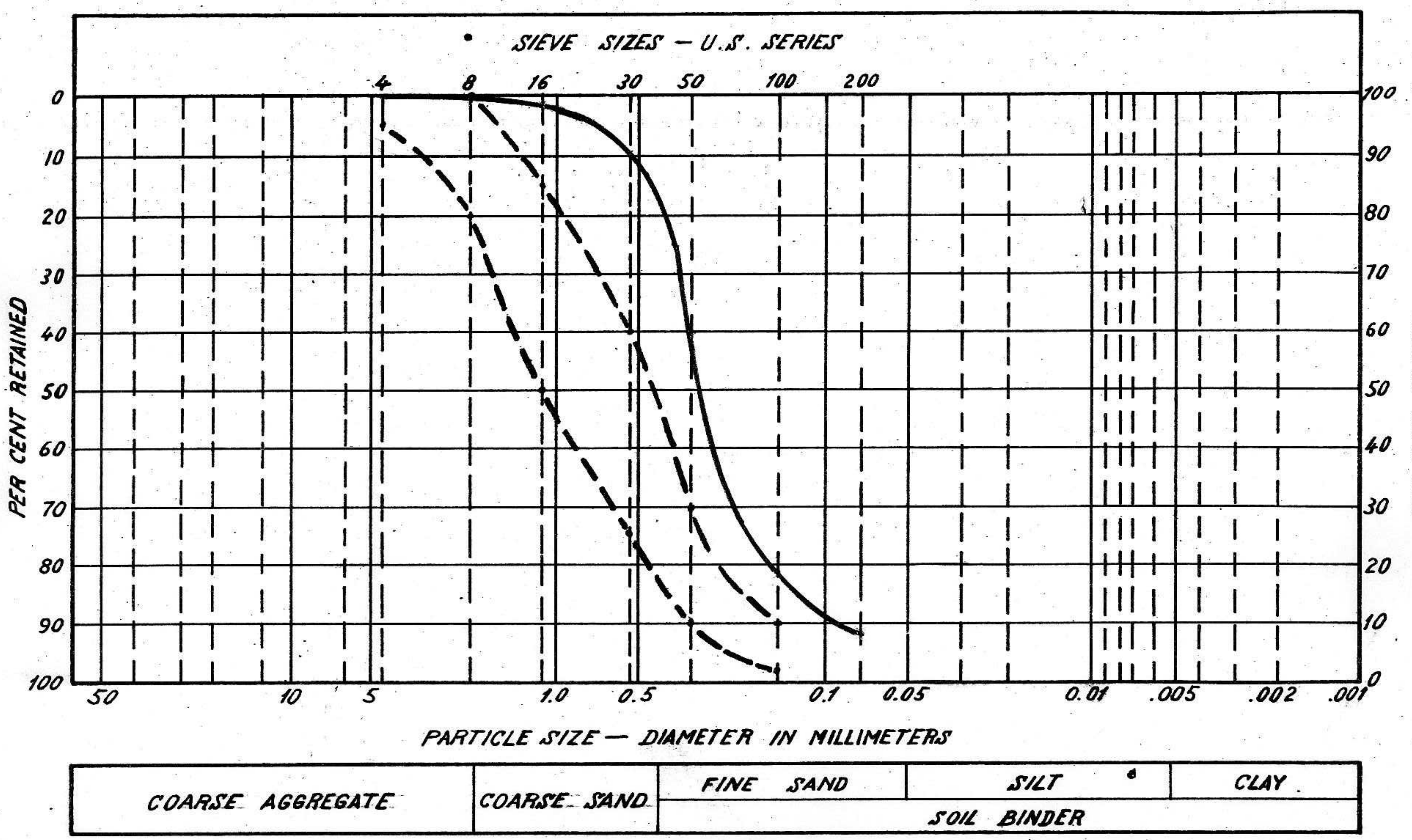


FIG. 24 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 20

- - - - A.S.T.M. Specified Limits For Fine Aggregate

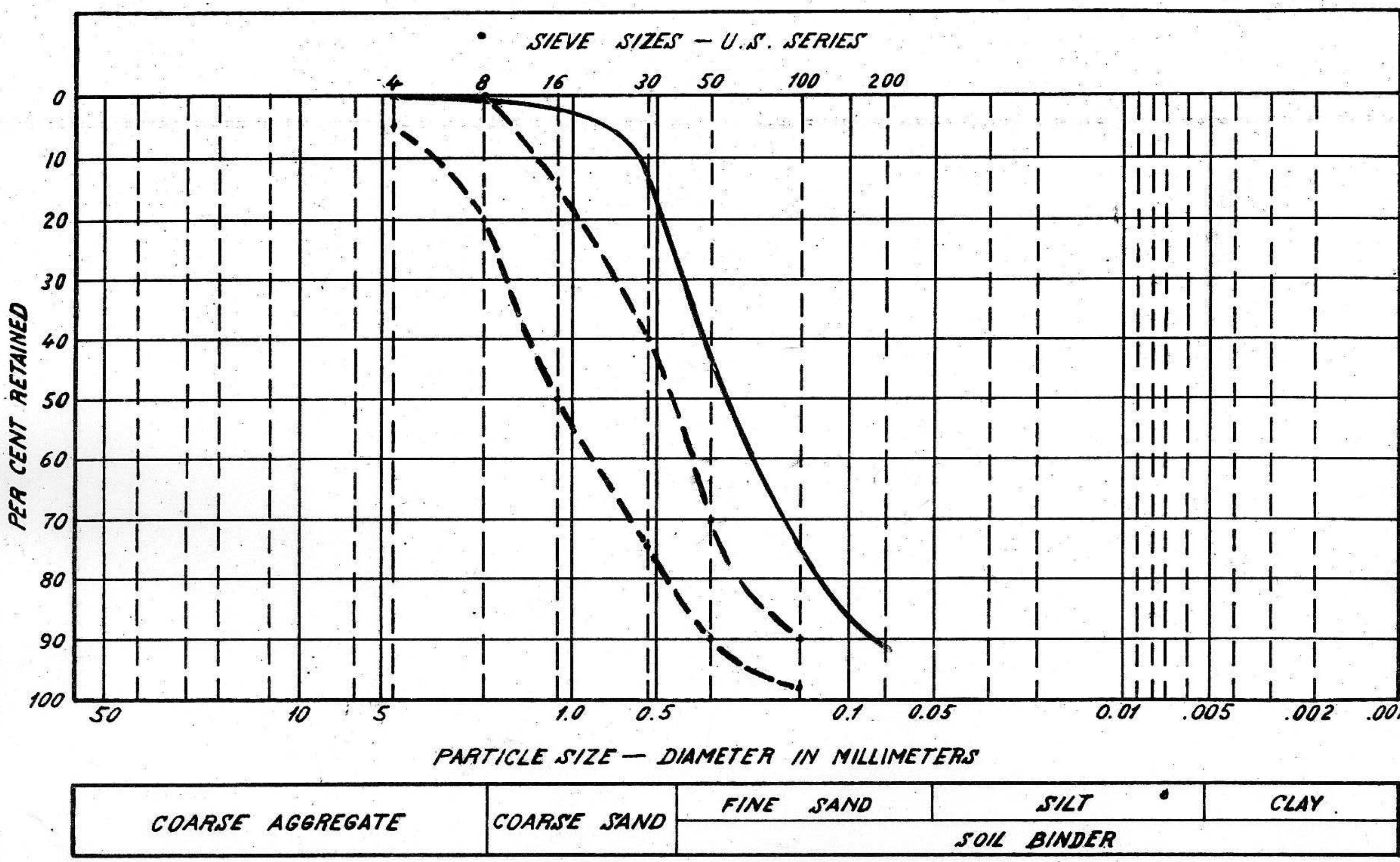


FIG. 25 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 21

- - - - A.S.T.M. Specified Limits For Fine Aggregate

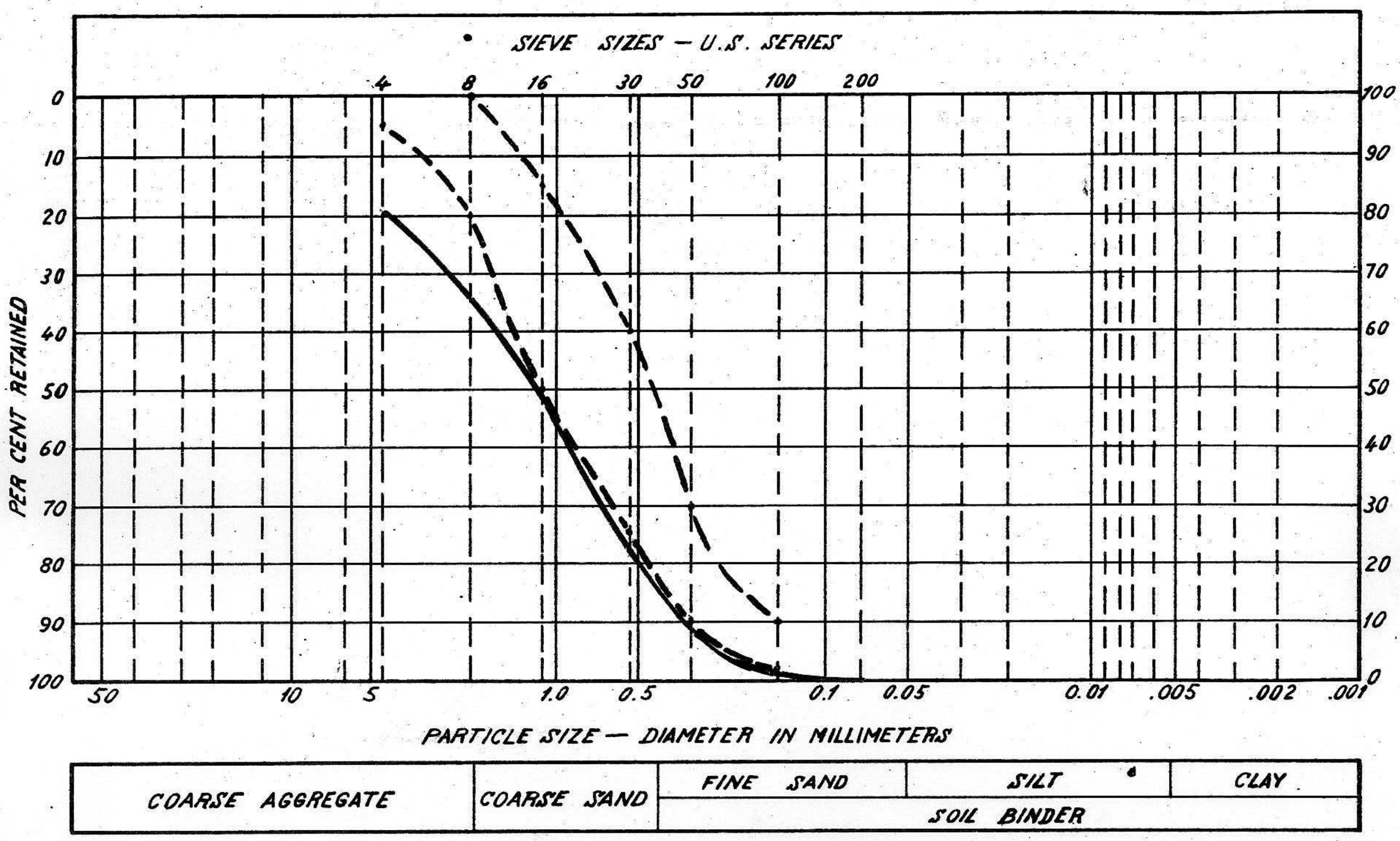


FIG. 26 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 22

- - - - A.S.T.M. Specified Limits For Fine Aggregate

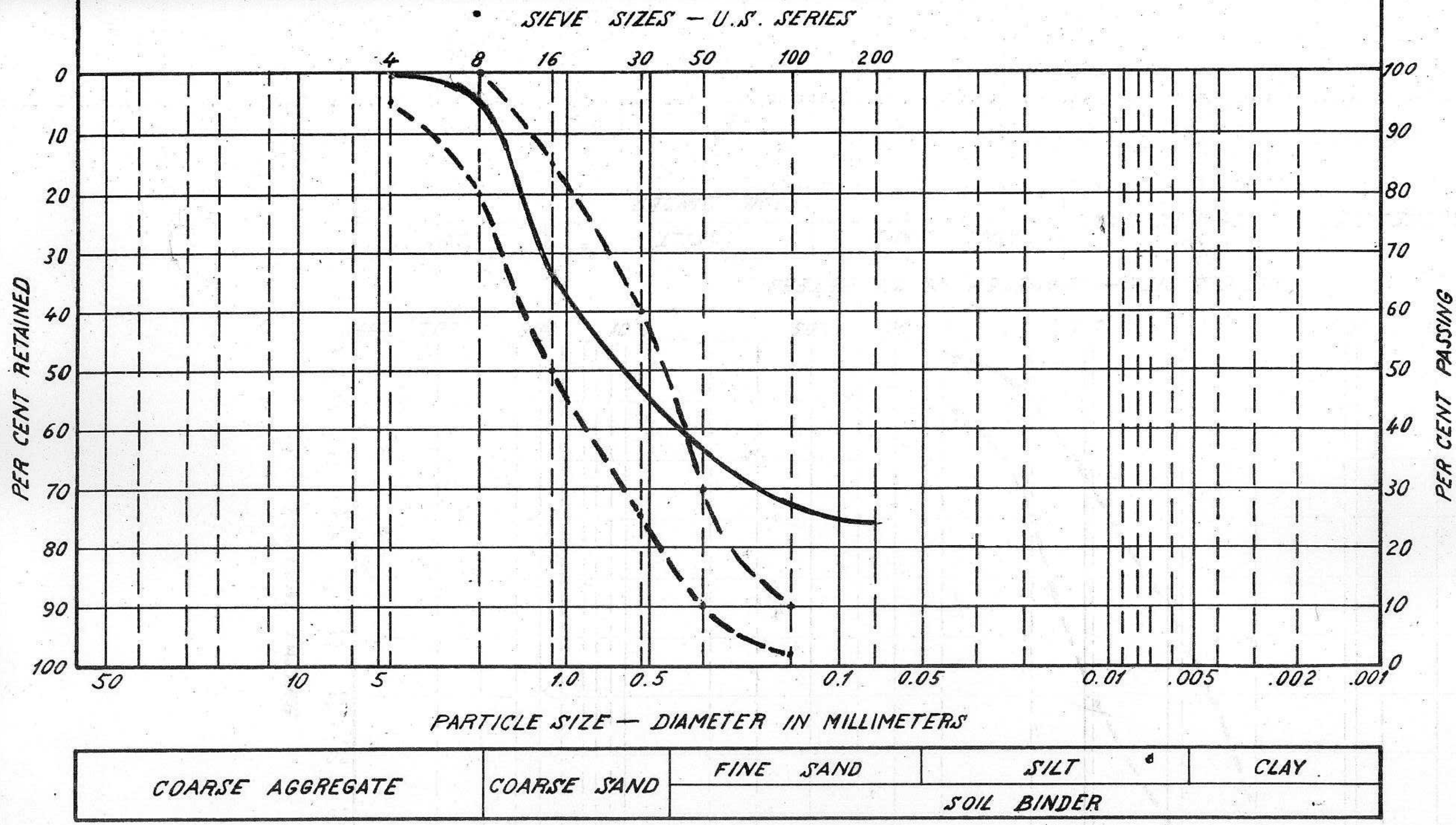


FIG. 27 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 23

– – – – A.S.T.M. Specified Limits For Fine Aggregate

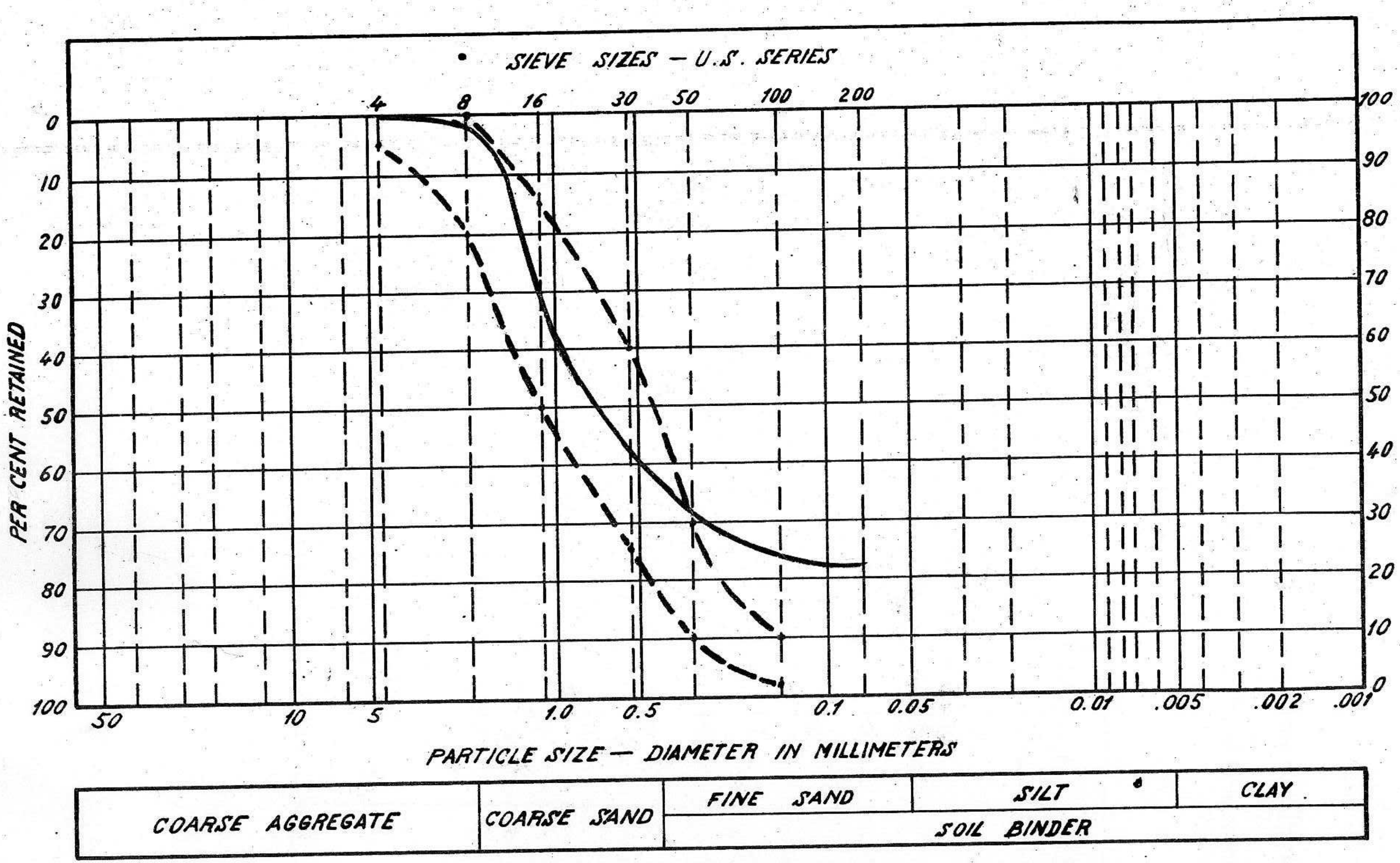


FIG. 28 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE NO. 24

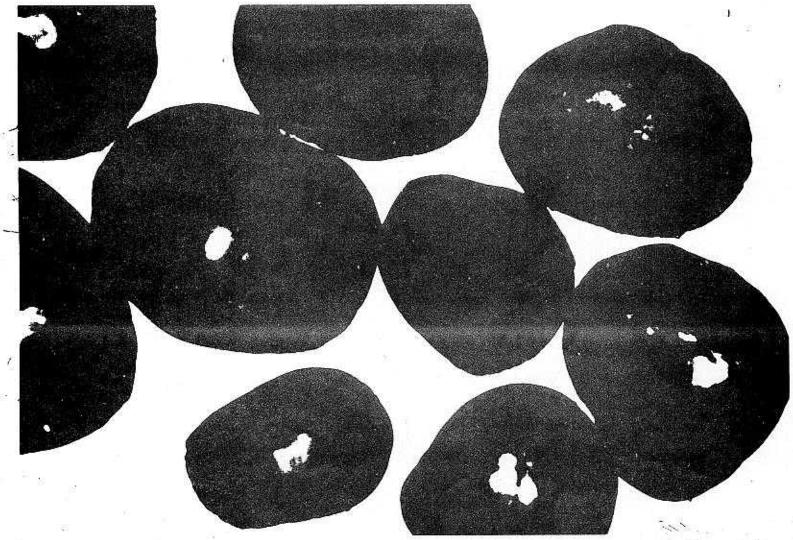
- - - - A.S.T.M. Specified Limits For Fine Aggregate

C - SHAPE OF SAND GRAINS

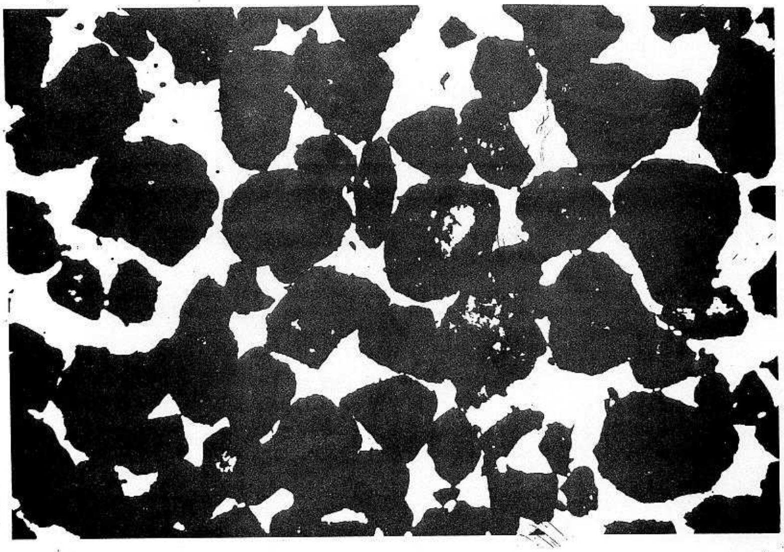
Seashore deposits, alluvial fans, and river deposits were found to have mainly rounded grains. Disintegrated sandstone deposits were found to have mainly angular grains.

SAMPLE No.	SHAPE OF GRAINS	SAMPLE No.	SHAPE OF GRAINS
1	Mostly Rounded	13	Rounded
2	Mostly Rounded	14	Mostly Rounded
3	Angular	15	Rounded
4	Angular	16	Rounded
5	Angular	17	Mostly Rounded
6	Angular	18	Angular
7	Angular	19	Angular
8	Mostly Angular	20	Angular
9	Mostly Angular	21	Angular
10	Mostly Rounded	22	Mostly Angular
11	Rounded		
12	Rounded		

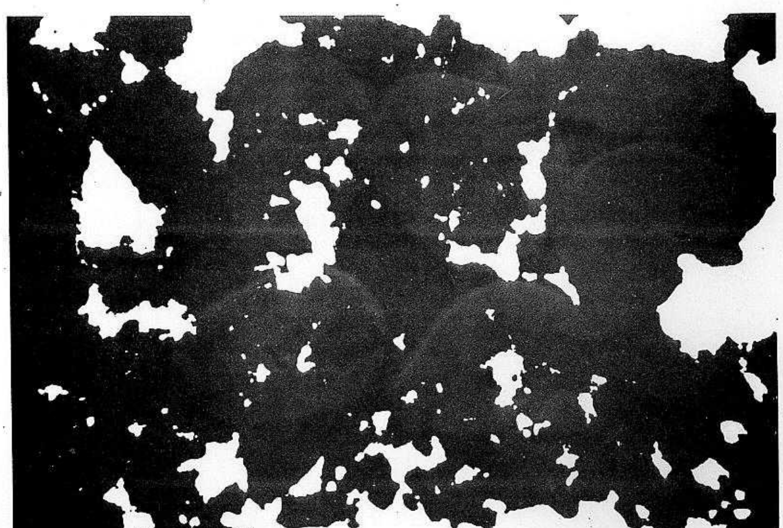
FIG_ 28 A



(a) Nahr_Ibrahim Sand
Rounded Grains
Magnified 45 Times



(b) Shwaya Sand
Angular Grains
Magnified 45 Times



(c) Crushers Sand
Magnified 45 Times
Fines Clearly adhering
To coarser Particles

D - <u>ORGANIC IMPURITIES, ACIDS, ALKALIES, SULPHATES, CHLORIDES AND CALCIUM CARBONATES</u> :

Most sand samples had an amount of organic impurities within specified limits. No. 7 and No. 10 slightly exceeded these limits, while No. 8 was found very rich with organic impurities. All samples were found free of acids, alkalies and sulphates. Chlorides were found present in the southern seashore deposits between Saida and Tyr only (No. 1 & No. 2). Calcium carbonate was found negligible in disintegrated sandstone deposits and in different percentages in other sources. Crushers sand and Burghliah sand were almost completely composed of calcium carbonate.

1. Acids (Qualitative Tests) :

   The tests for acids on all samples gave negative results.

2. Alkalies (Qualitative tests) :

   The tests for alkalies on all samples gave negative results.

3. Sulphates (Qualitative tests):

   The tests for sulphates on all samples gave negative results.

4. Chlorides (Qualitative Tests)

SAMPLE No.	RESULT OF TEST	SAMPLE No.	RESULT OF TEST
1	Positive	13	Negative
2	Positive	14	Negative
3	Negative	15	Negative
4	Negative	16	Negative
5	Negative	17	Negative
6	Negative	18	Negative
7	Negative	19	Negative
8	Negative	20	Negative
9	Negative	21	Negative
10	Negative	22	Negative
11	Negative	23	Negative
12	Negative	24	Negative

5. Organic Impurities

SAMPLE No.	COLOR COMPARISON WITH STANDARD SOLUTION	SAMPLE No.	COLOR COMPARISON WITH STANDARD SOLUTION
1	Lighter. (The solution was almost colorless)	13	Lighter
2	Lighter.	14	Lighter
3	Lighter.	15	Lighter
4	Lighter.	16	Lighter
5	Lighter. (The solution was almost colorless)	17	Lighter
6	Lighter	18	Lighter
7	Lighter	19	Lighter (The solution was almost colorless)
8	Darker (The solution was very dark in color)	20	Lighter
9	Lighter	21	Lighter
10	Slightly darker	22	Lighter
11	Lighter	23	Lighter
12	Slightly Lighter	24	Lighter

6. Calcium Carbonate :

SAMPLE No.	INITIAL WEIGHT GRS.	FINAL WEIGHT GRS.	WT. OF Ca Co3 GRS.	PERCENTAGE OF Ca Co 3
1	50	41.60	8.40	16.80
2	50	44.50	5.50	11.00
3	50	49.82	0.18	0.36
4	50	49.80	0.20	0.40
5	50	49.10	0.90	1.80
6	50	49.90	0.10	0.20
7	50	49.85	0.15	0.30
8	50	0.25	49.75	99.50
9	50	49.85	0.15	0.30
10	50	41.25	8.75	17.50
11	50.	41.10	8.90	17.80
12	50	46.30	3.70	7.40
13	50	46.20	3.80	7.60
14	50	43.60	6.40	12.80
15	50	46.30	3.70	7.40
16	50	46.62	3.38	6.76
17	50	45.60	4.40	8.80
18	50	49.30	0.70	1.40
19	50	49.00	1.00	2.00
20	50	49.90	0.10	0.20
21	50	49.85	0.15	0.30
22	50	38.40	1.60	3.20
23	50	0.20	49.80	99.60
24	50	0.22	49.78	99.56

E - MORTAR PROPERTIES (Compressive Strength)

The compressive strength of mortar was tested rather than concrete to eliminate the effect of coarse aggregate. Using British Standards and the same type of cement the only variable in the various tests was the sand.

Nahr Ibrahim sand gave the highest compressive strength to mortar. Mortar with seashore deposits as fine aggregate had in general a slightly higher compressive strength than that with disintegrated sandstones as fine aggregate. The gradation of the sand was noticed to have the most important effect on the compressive strength of mortar. The coarser and better graded the sand was, the higher was the compressive strength of mortar.

Burghliah sand (No. 8) and Abboudiah sand (No. 12) when used in mortar resulted in a 28 days compressive strength lower than the 3 days compressive strength. A repetition of tests for these two samples affirmed this fact.

SAMPLE No.	Compressive Strength P.S.I.		
	3 days	7 days	28 days
8	600	550	550
12	900	650	750

The series of chemical tests performed indicated that Burghliah sand (No. 8) was very rich in organic impurities. Careful study of this sand under the microscope indicated the presence of shell fragments that may dissolve by decomposing agents which reach them in the concrete or mortar.
In the absence of other factors, organic impurities and shell fragments were thought of as the cause of the low 28 days compressive strength of mortar using Burghliah sand.

A study of Abboudiah sand (No. 12) under the microscope indicated the presence of Basalt. Basalt is composed of Feldspar which is harmful in concrete and mortar. In the absence of other factors this was thought of as the cause of the low 28 days compressive strength of mortar using Abboudiah sand.

Mortar using washed crushers sand was found to have a lower compressive strength than when the crushers sand was used unwashed. It may be deduced that a small amount of fines is needed for gradation and workability purposes.

It was noticed while preparing most of the mortar cubes that the amount of water specified by the British Standards (B.S. 12 : 1958) was insufficient for the workability

../..

of the mix. This was because the sand used was generally fine.

An ideal gradation sand sample in accordance with A.S.T.M. specifications was prepared from Nahr Ibrahim sand to be used as a basis for comparing the compressive strength of the various mortars. The gradation was as follows :

Sieve No.	4	8	16	30	50	100	PAN
Percentage Retained on each sieve	5	10	20	20	25	15	5

The results for the compressive strength of mortar using the ideal gradation sand were :

No. of days	3	7	28
Compressive Strength P.S.I	4750	6000	9250

The following table shows the ratio of the 28 days compressive strength of mortar using each of the sand samples to that of mortar using the ideal gradation sand.

Sample No.	Ratio of 28 days mortar C.S. to that of ideal sand	Sample No.	Ratio of 28 days mortar C.S. to that of ideal sand
1	0.45	14	0.44
2	0.53	15	0.72
3	0.22	16	0.87
4	0.25	17	0.66
5	0.30	18	0.75
6	0.24	19	0.15
7	0.40	20	0.32
8	0.06	21	0.10
9	0.56	22	0.22
10	0.14	23	0.71
11	0.64	24	0.19
12	0.08	23(Washed)	0.31
13	0.56	24(Washed)	0.15

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 1

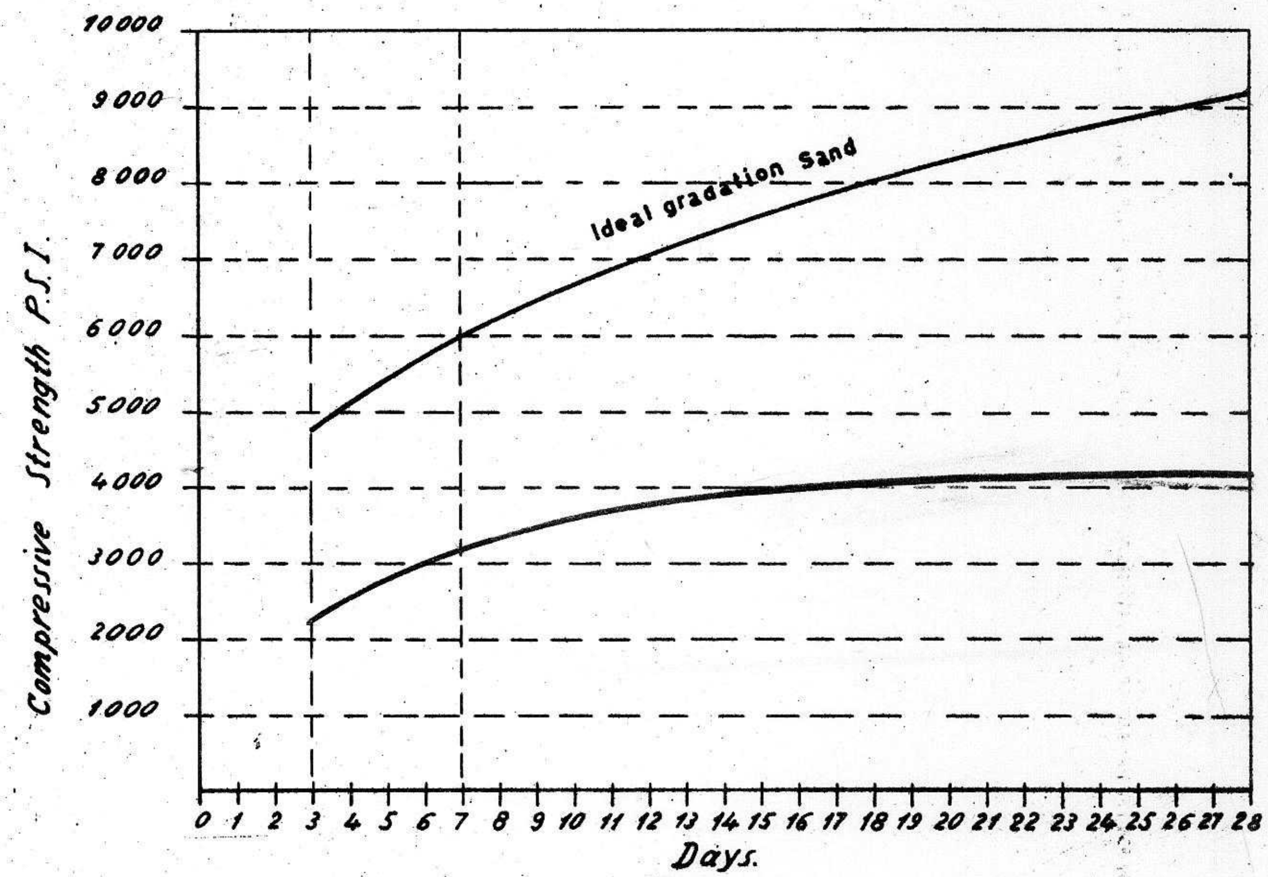


FIG 29

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 2

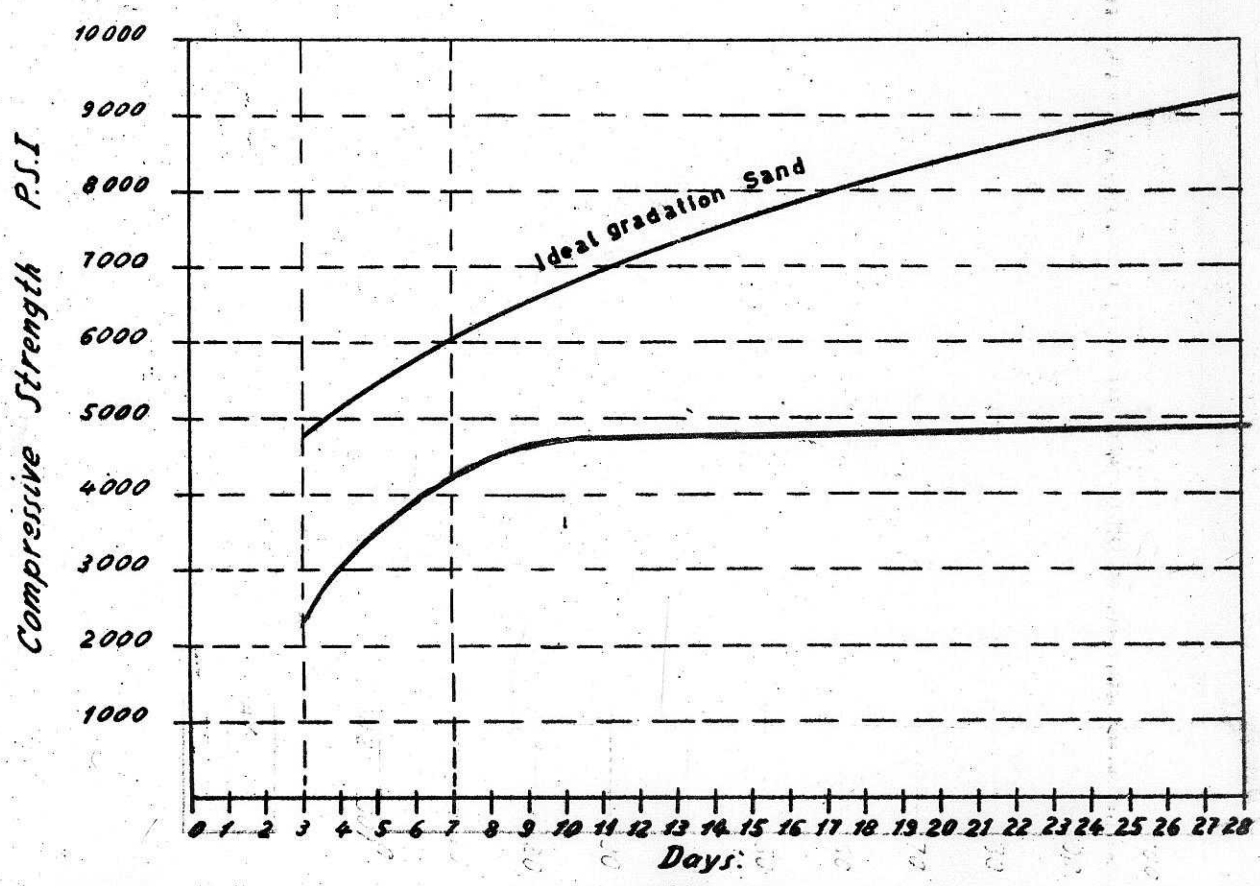


FIG. 30

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 3

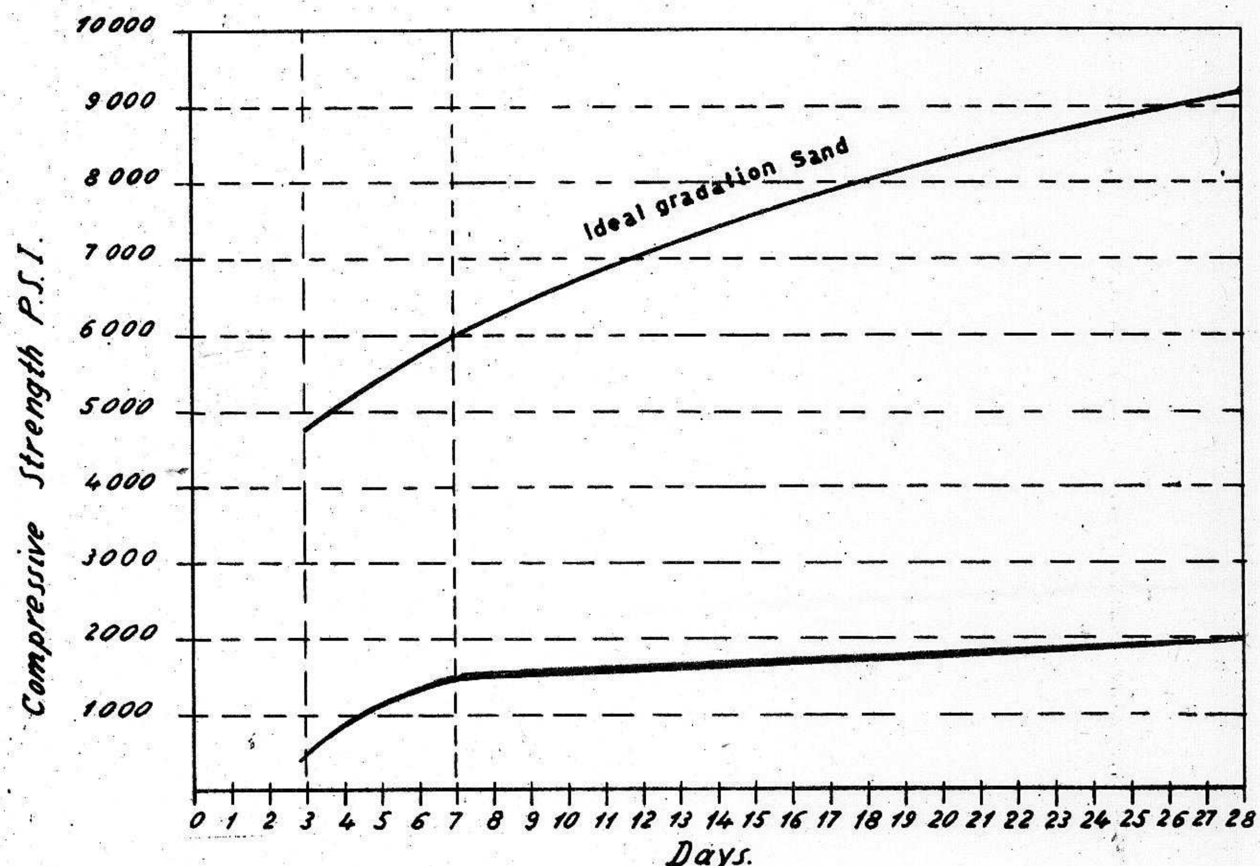


FIG 31

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 4

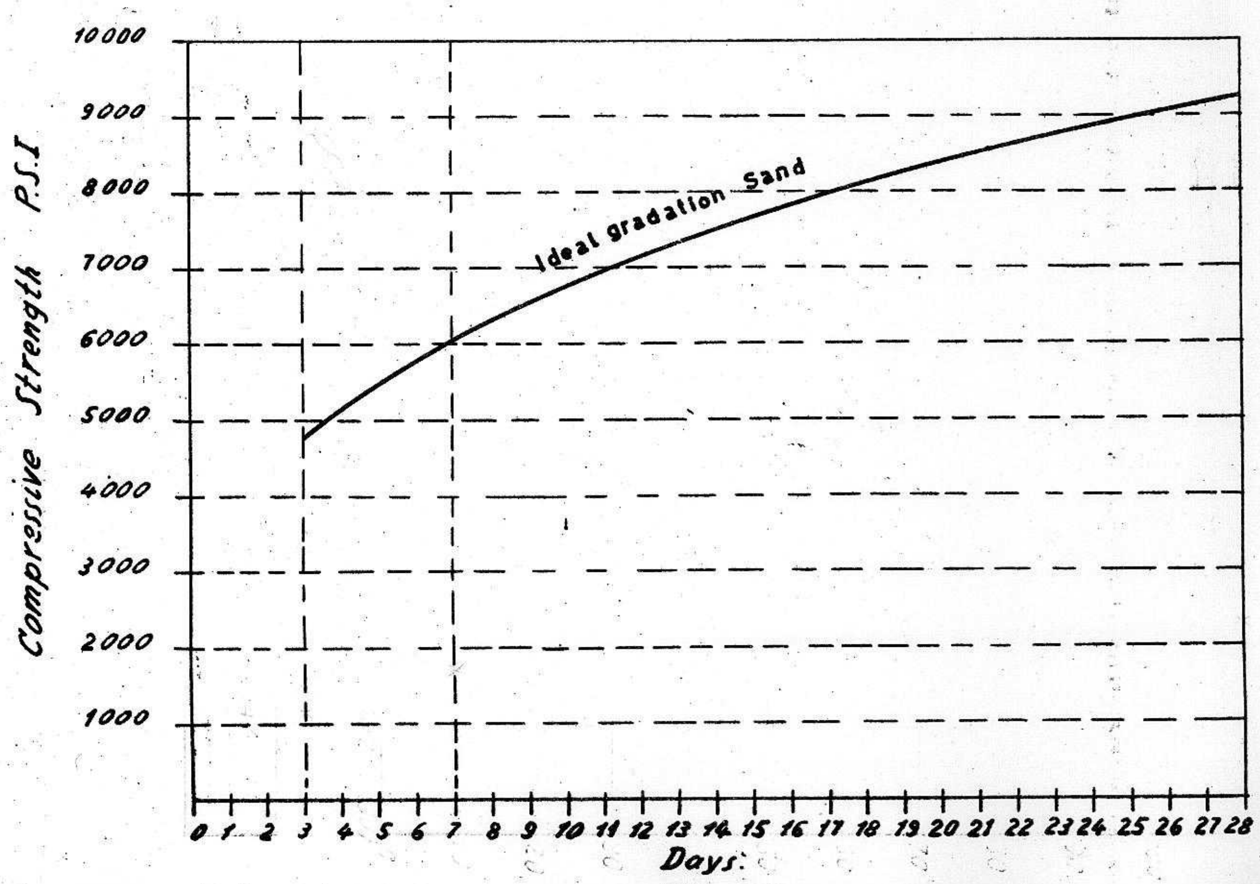


FIG. 32

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 5

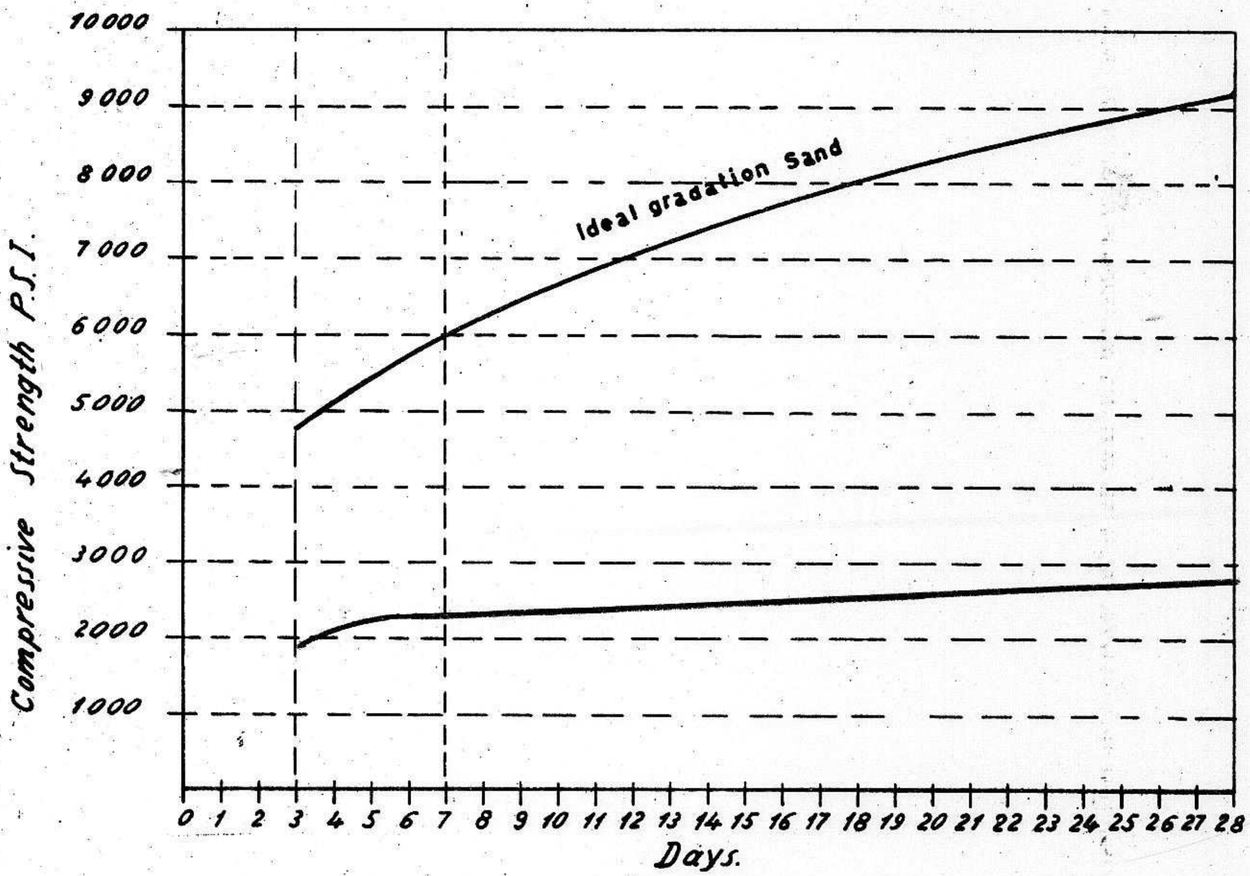


FIG 33

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 6

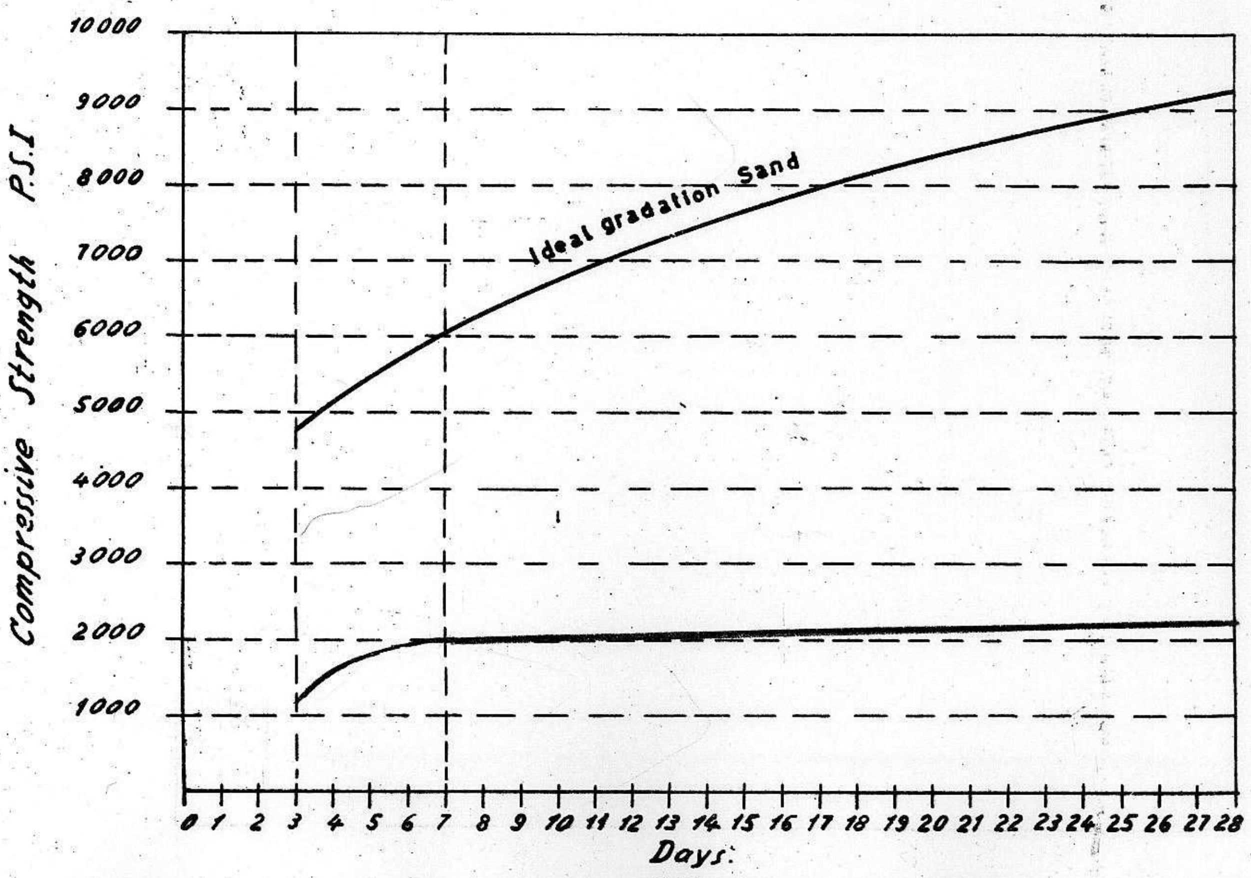


FIG. :34

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 7

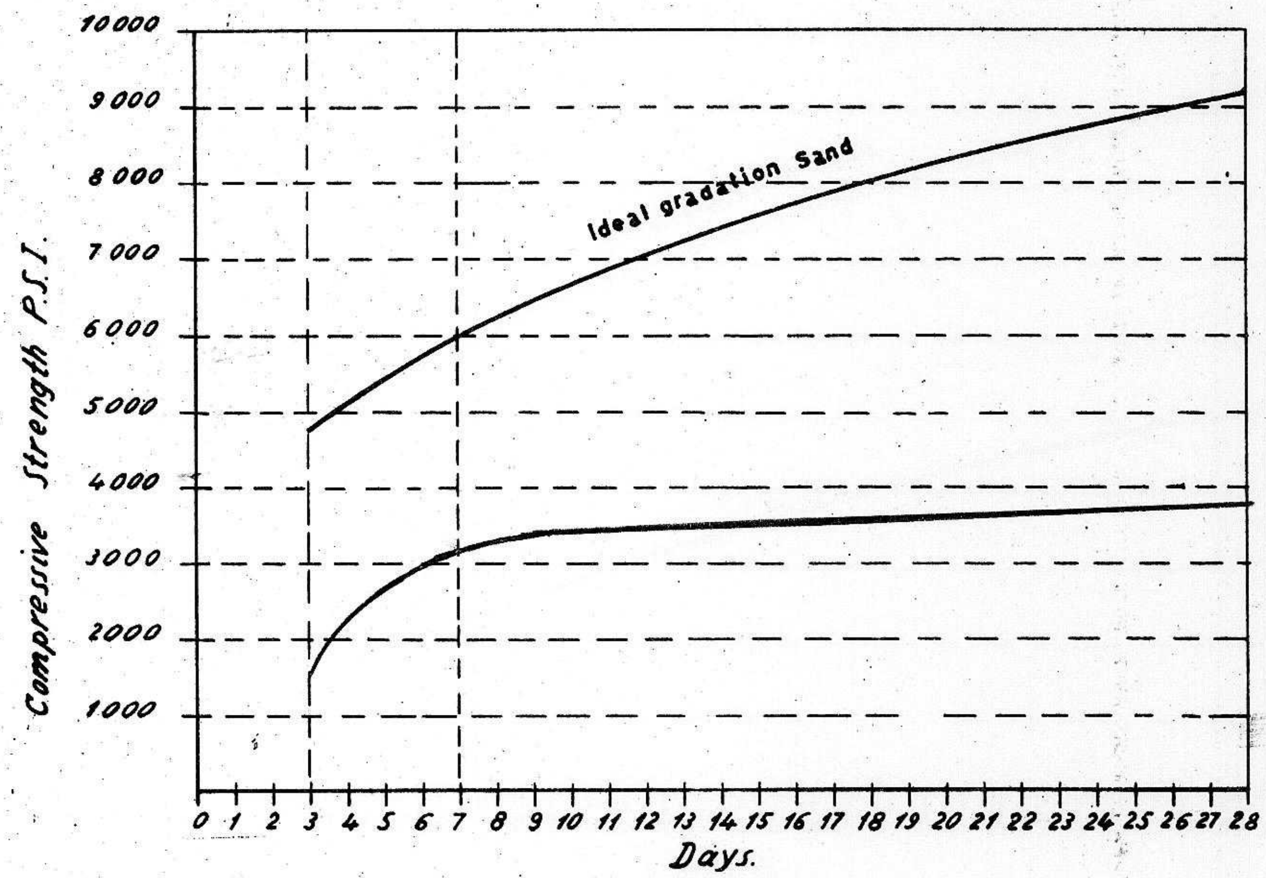


FIG 35

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 8

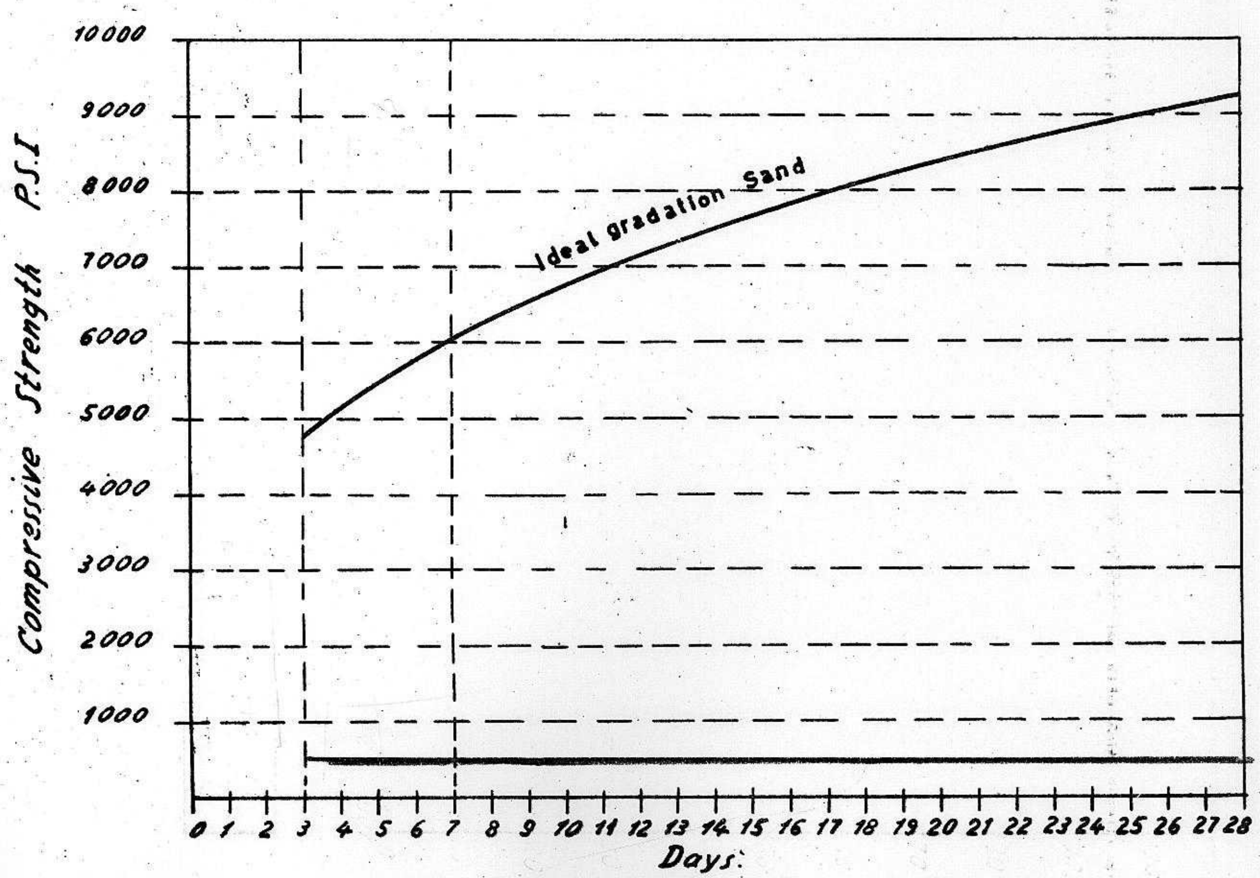


FIG. :36

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 9

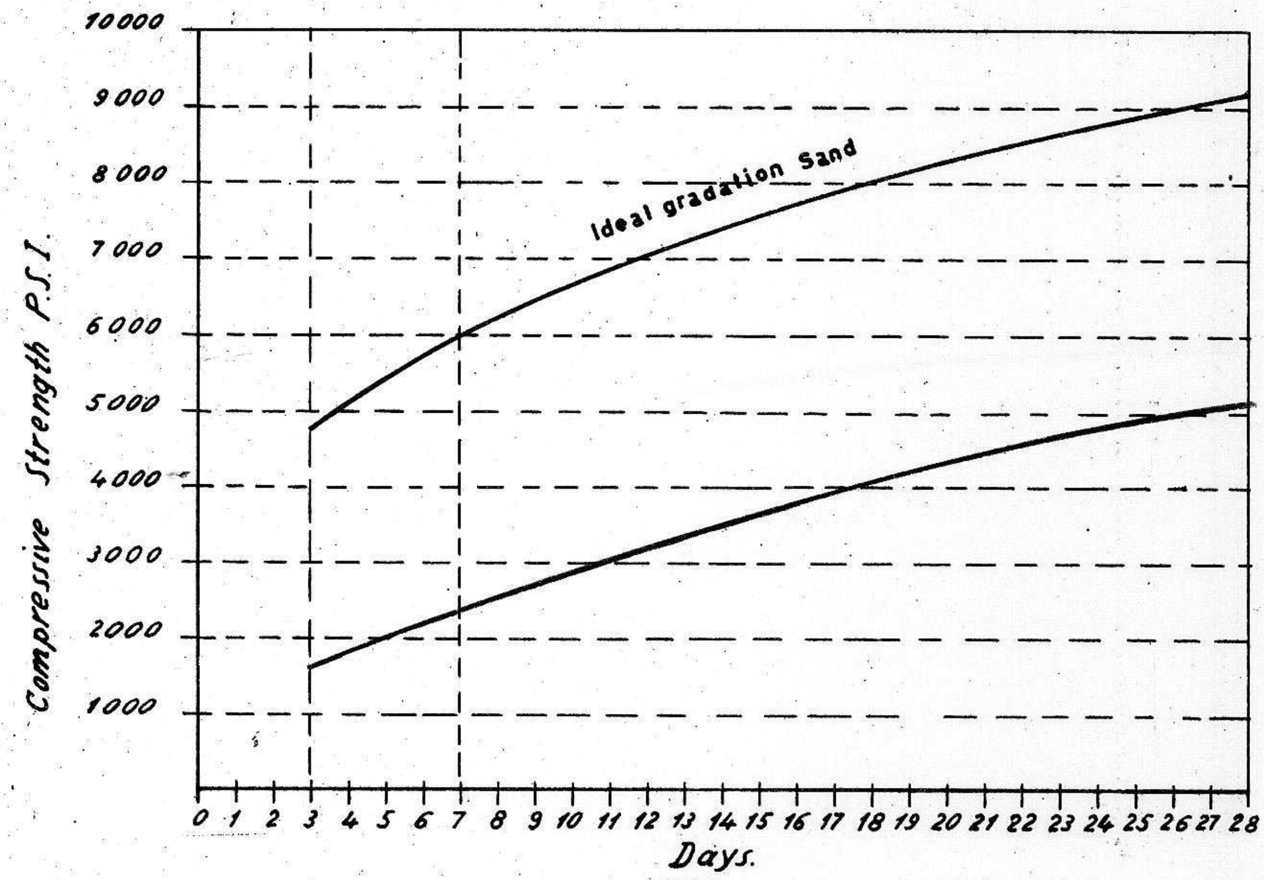


FIG 37

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 10

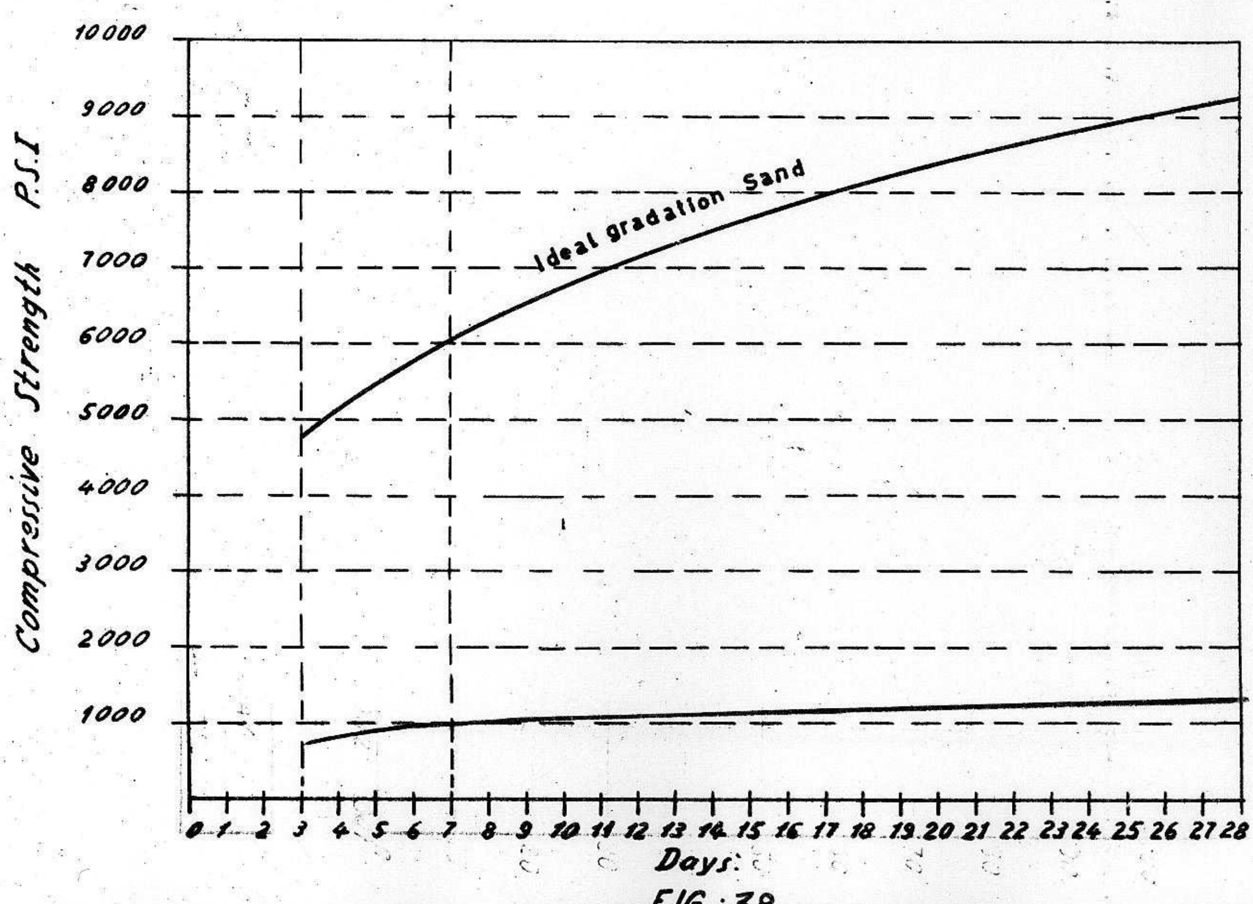


FIG. 38

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 11

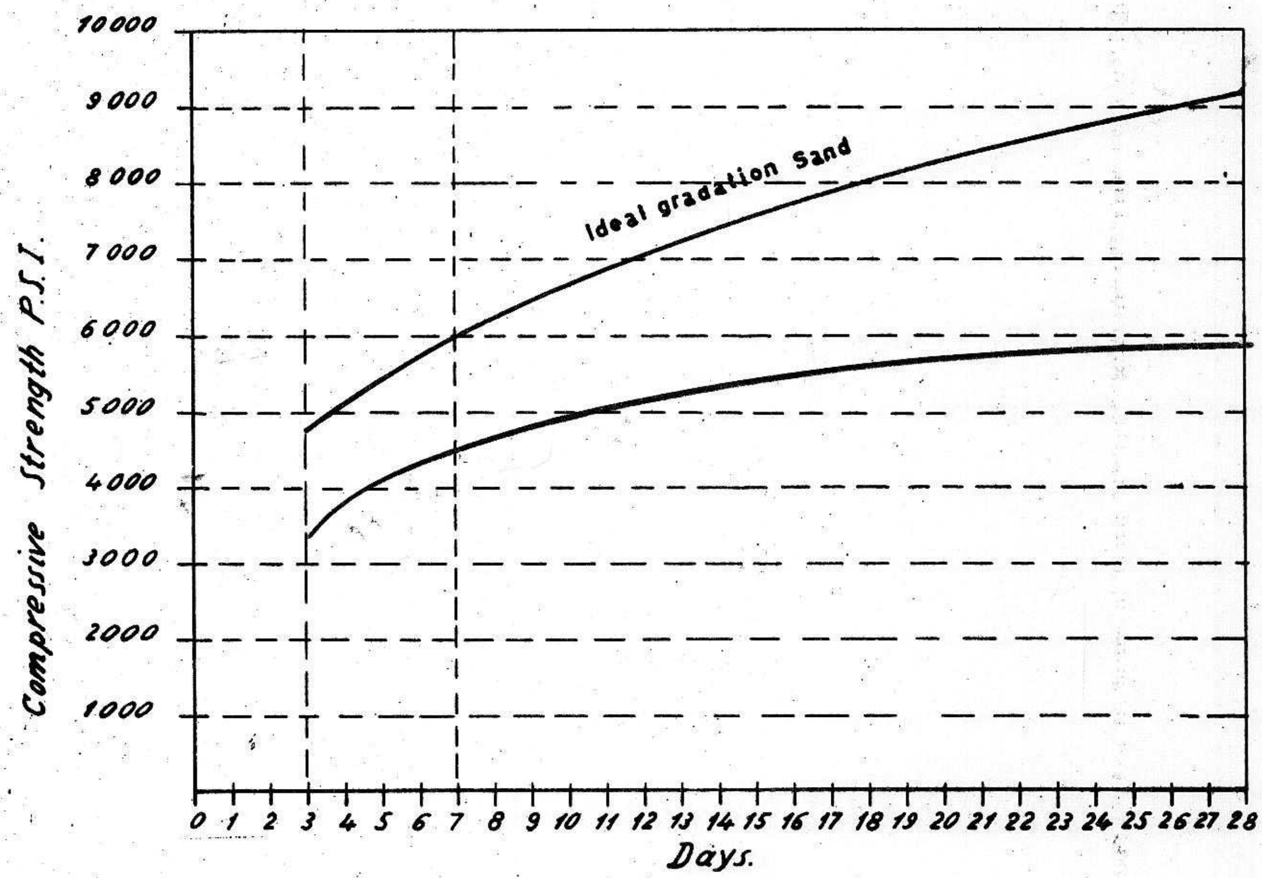


FIG 39

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 12

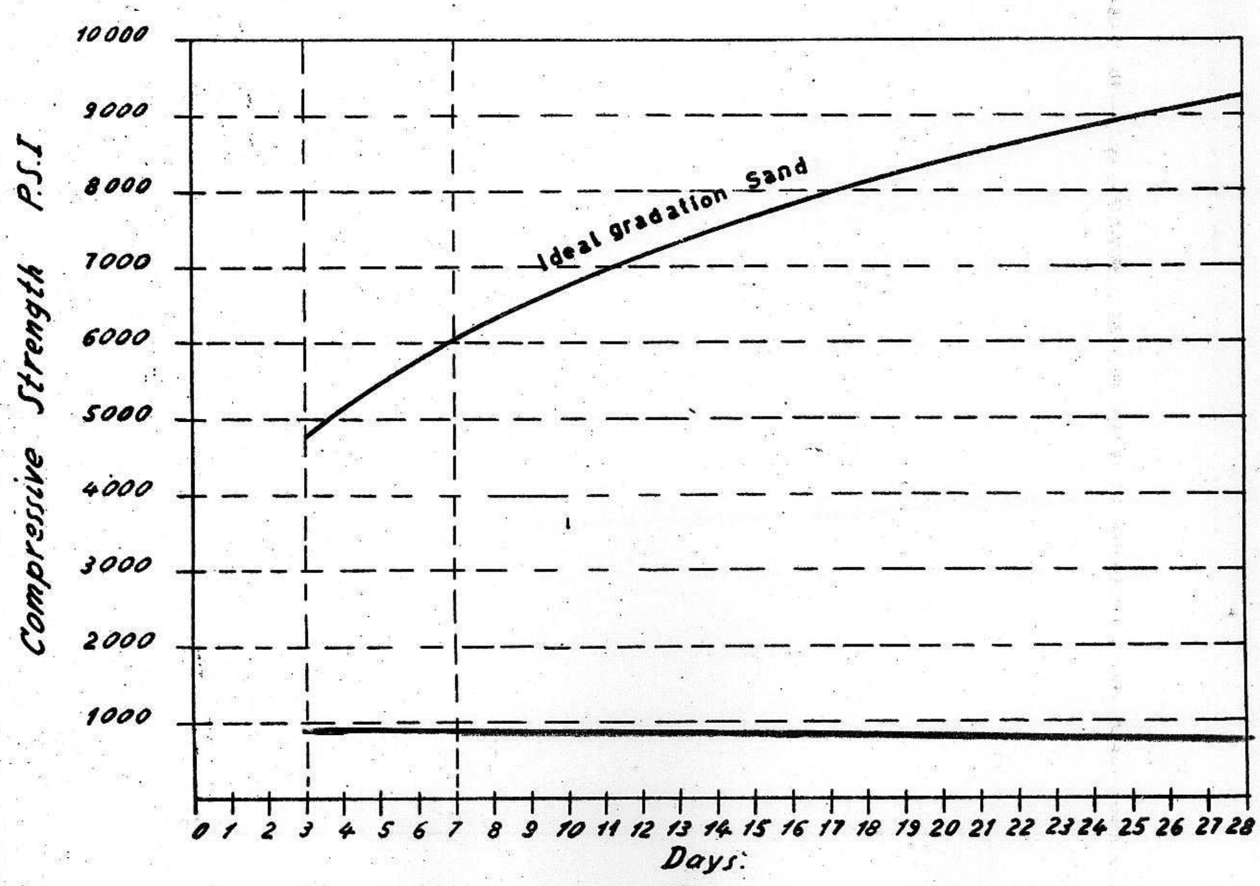


FIG.: 40

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 13

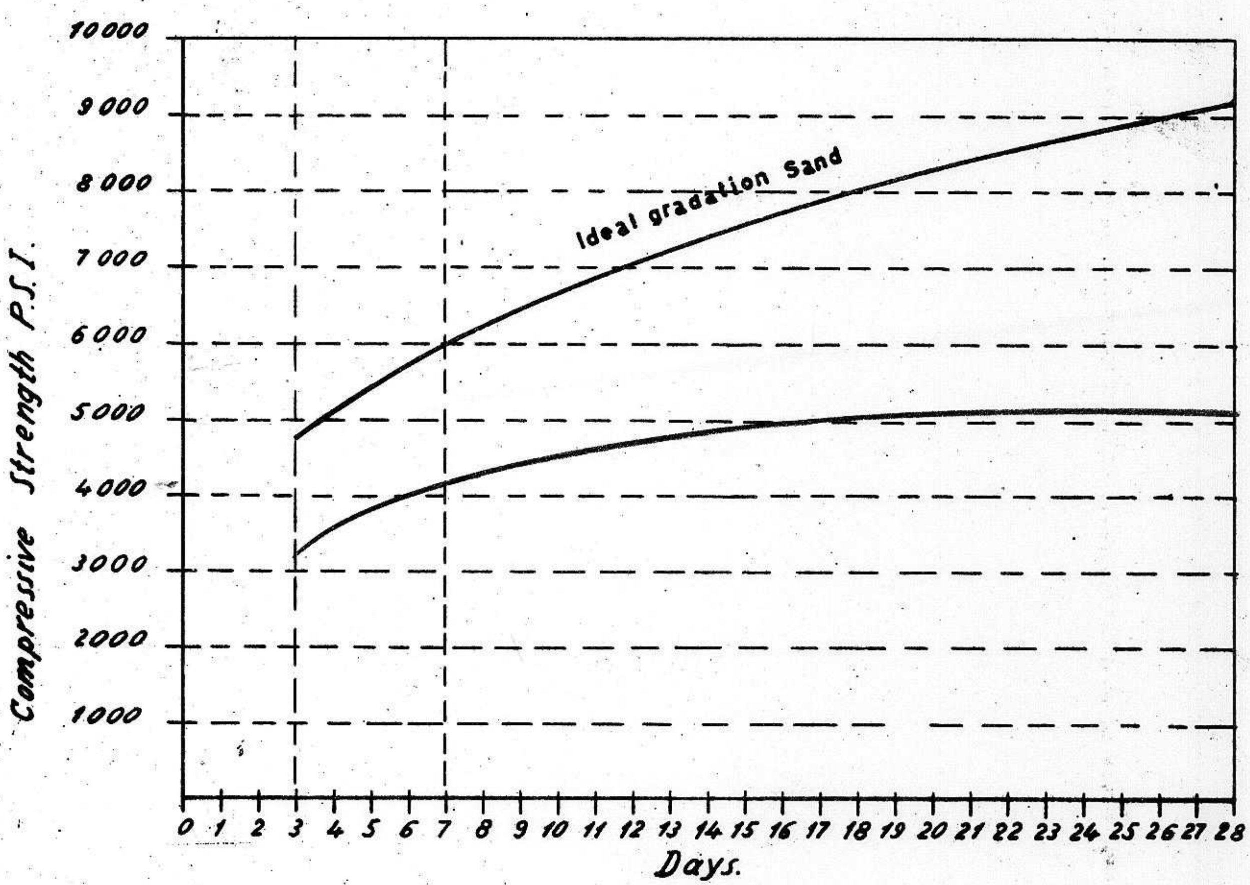


FIG 41

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 14

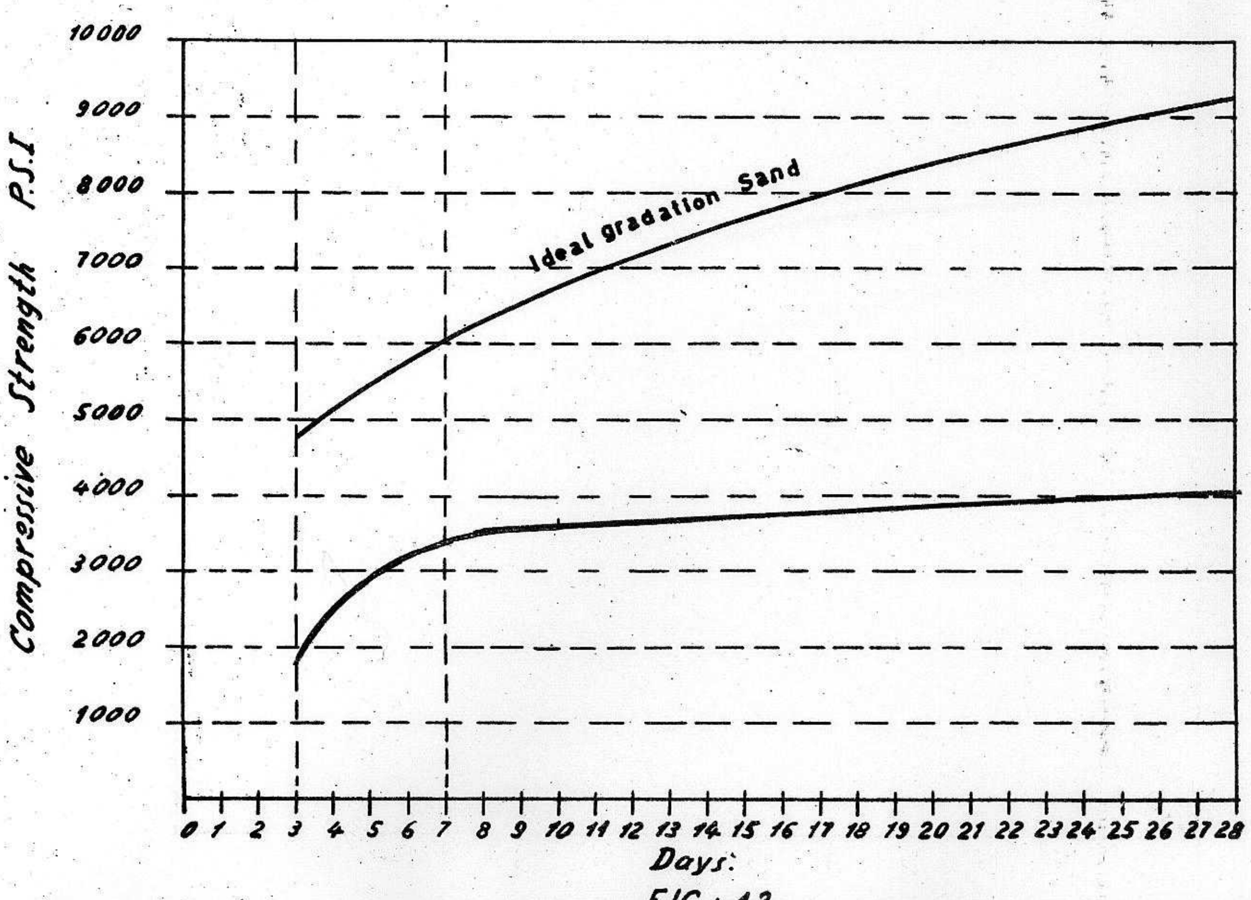


FIG.: 42

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 15

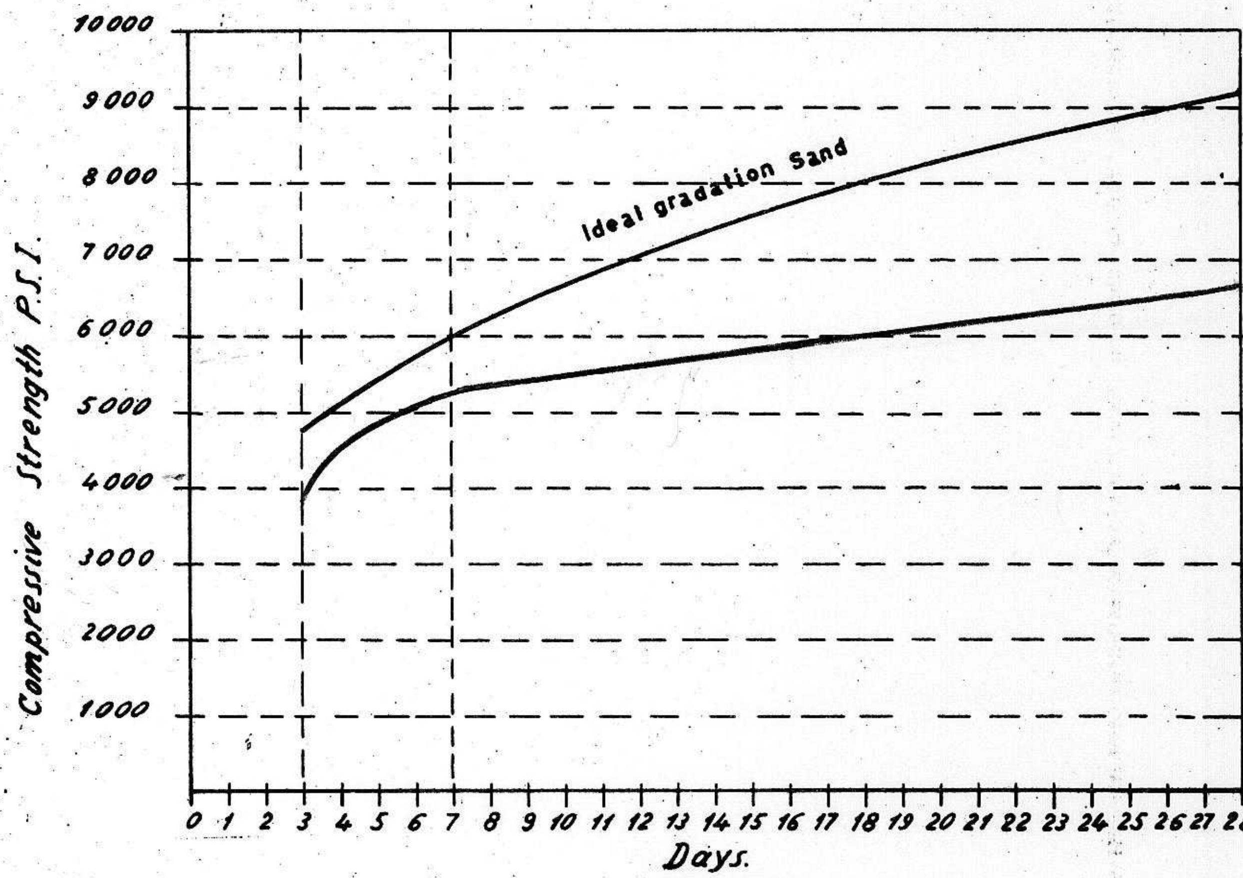


FIG 43

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 16

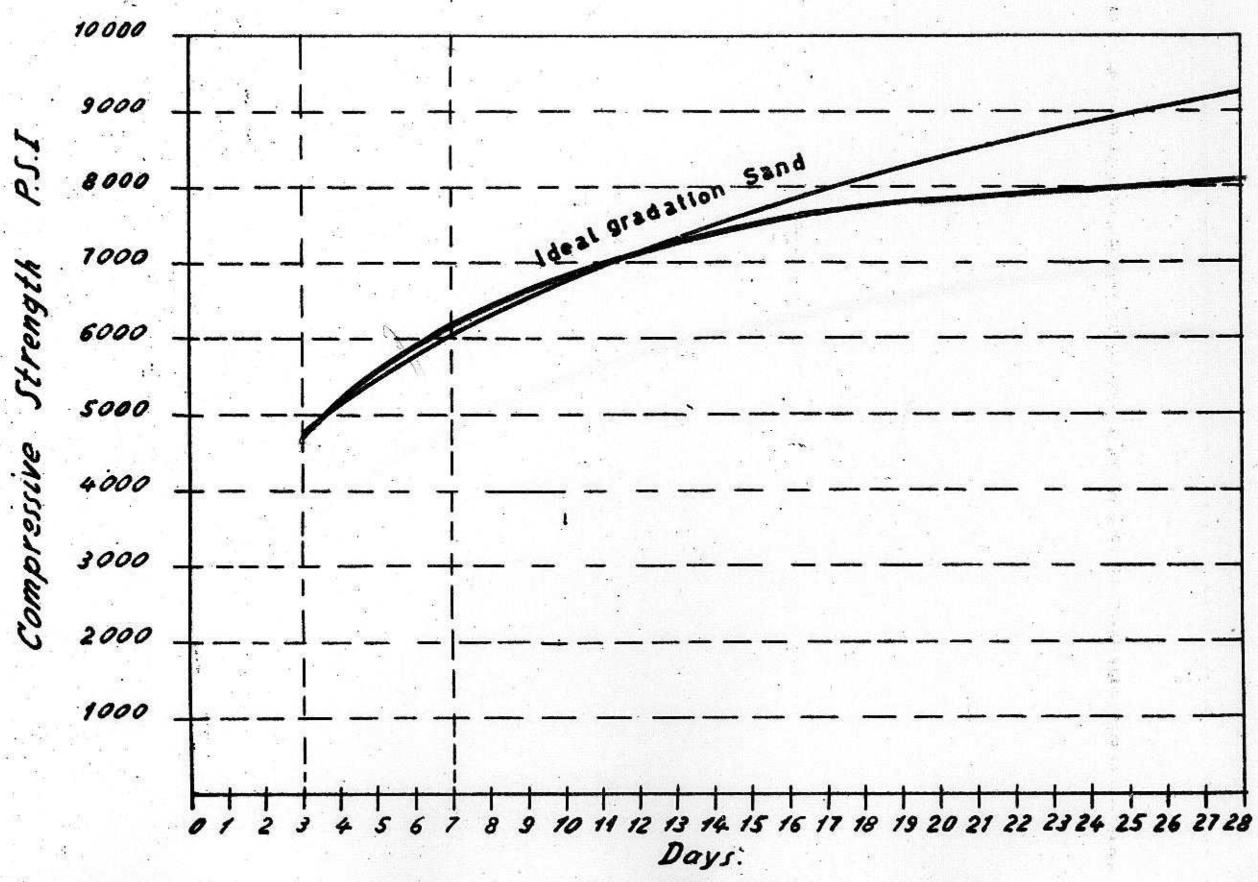


FIG.:44

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 17

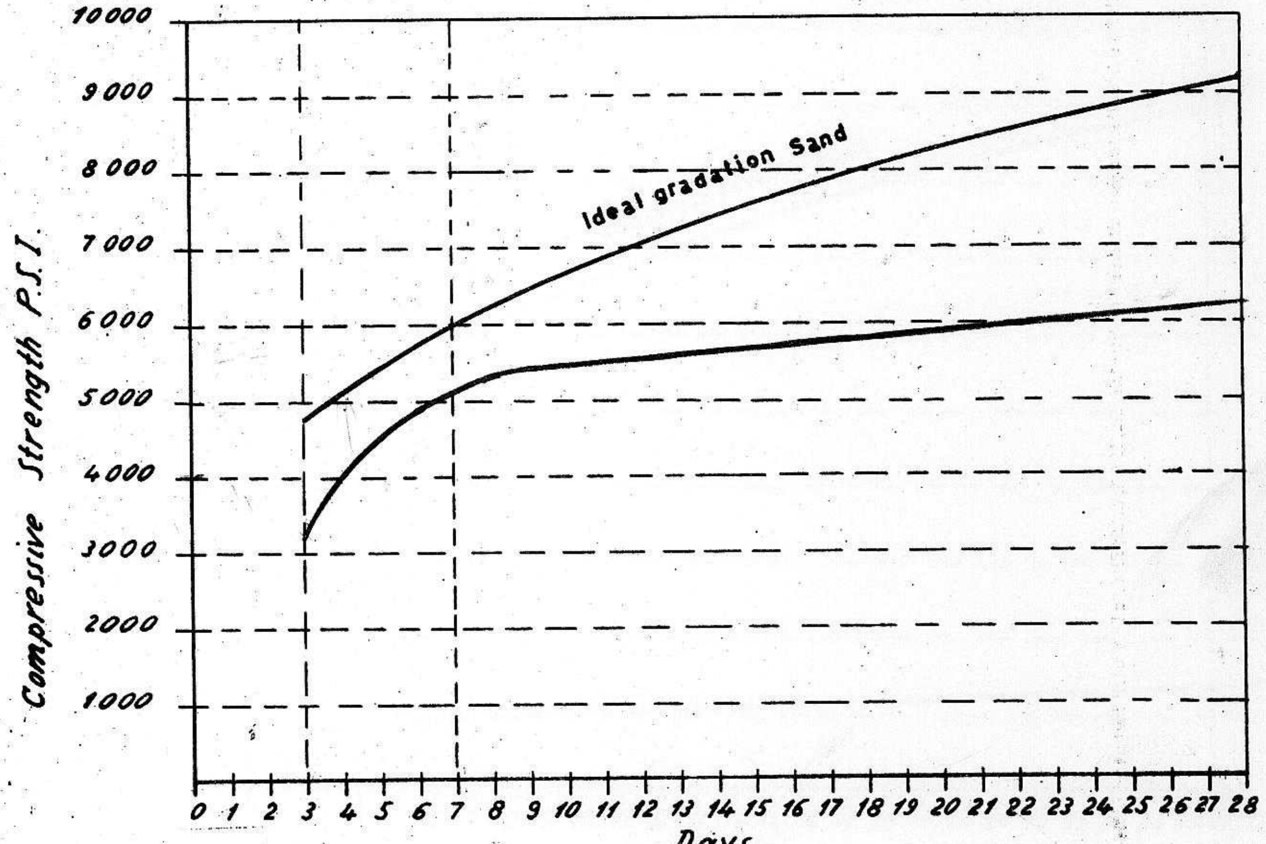


FIG 45

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 18

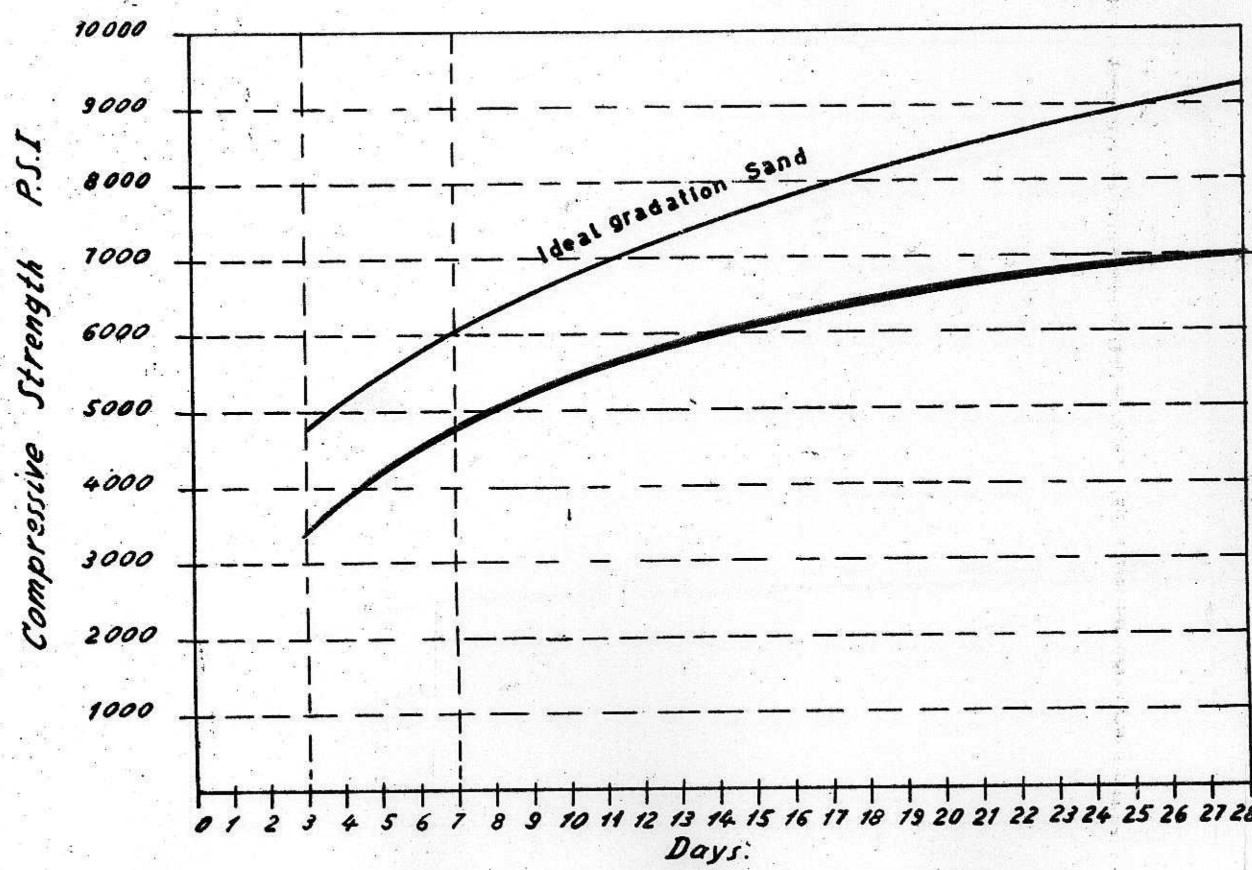


FIG.:46

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 19

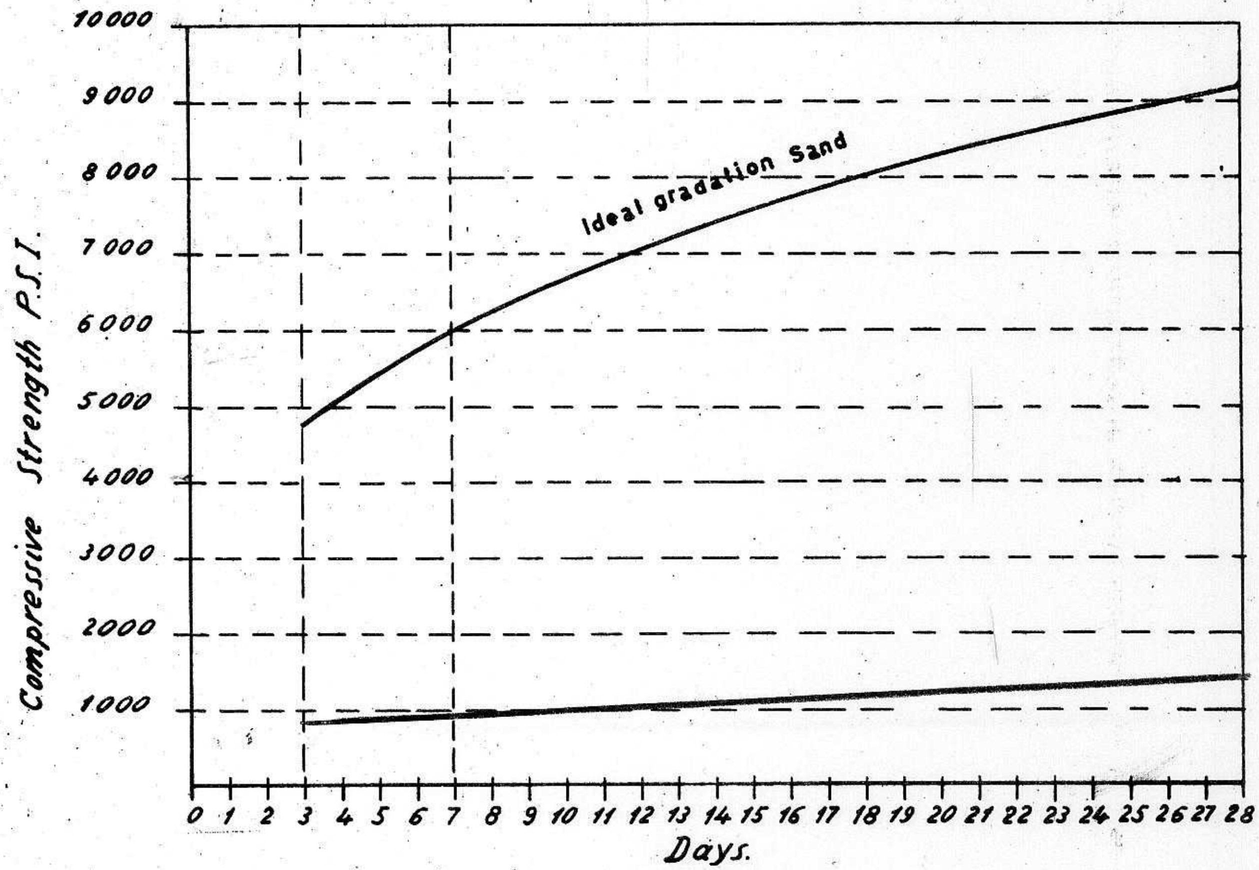


FIG 47

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 20

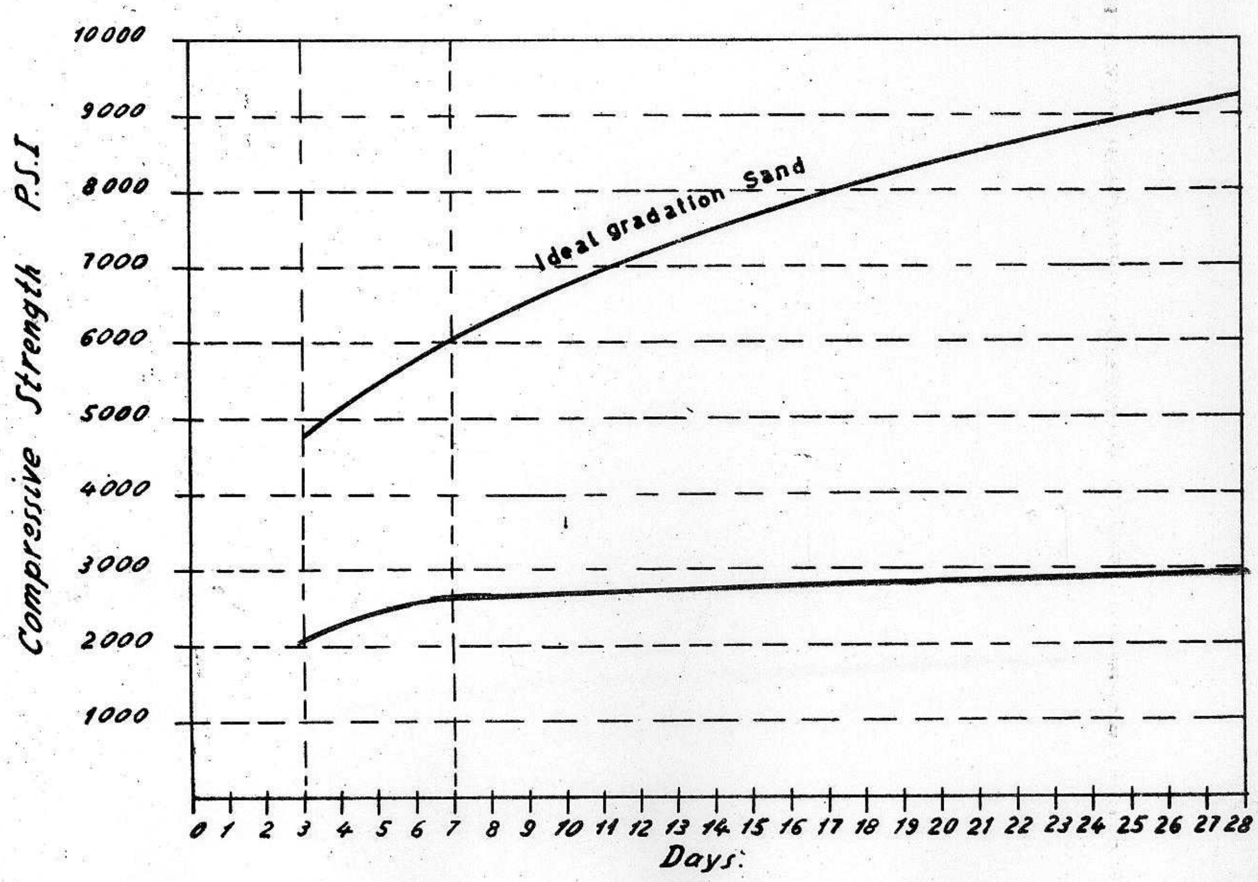


FIG. 48

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 21

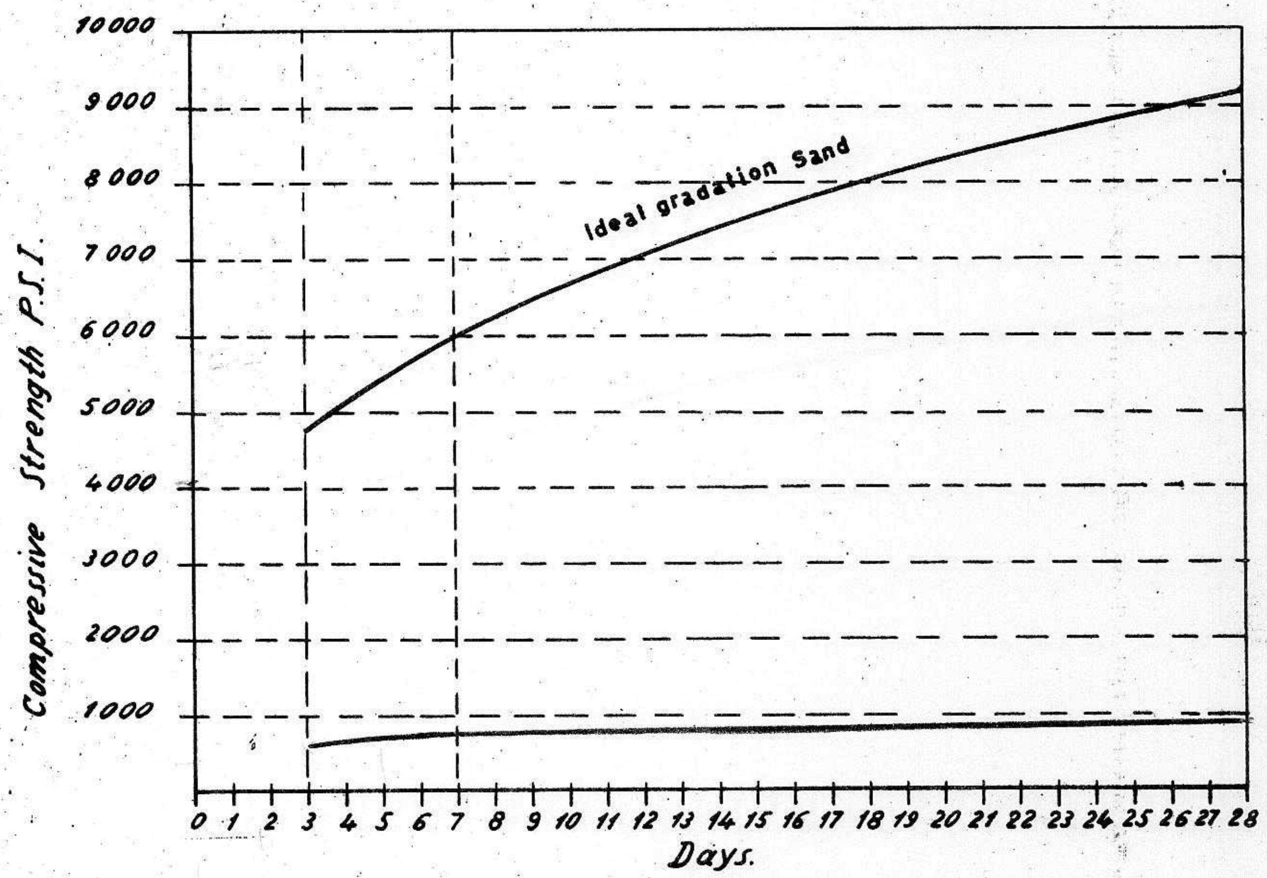


FIG 49

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 22

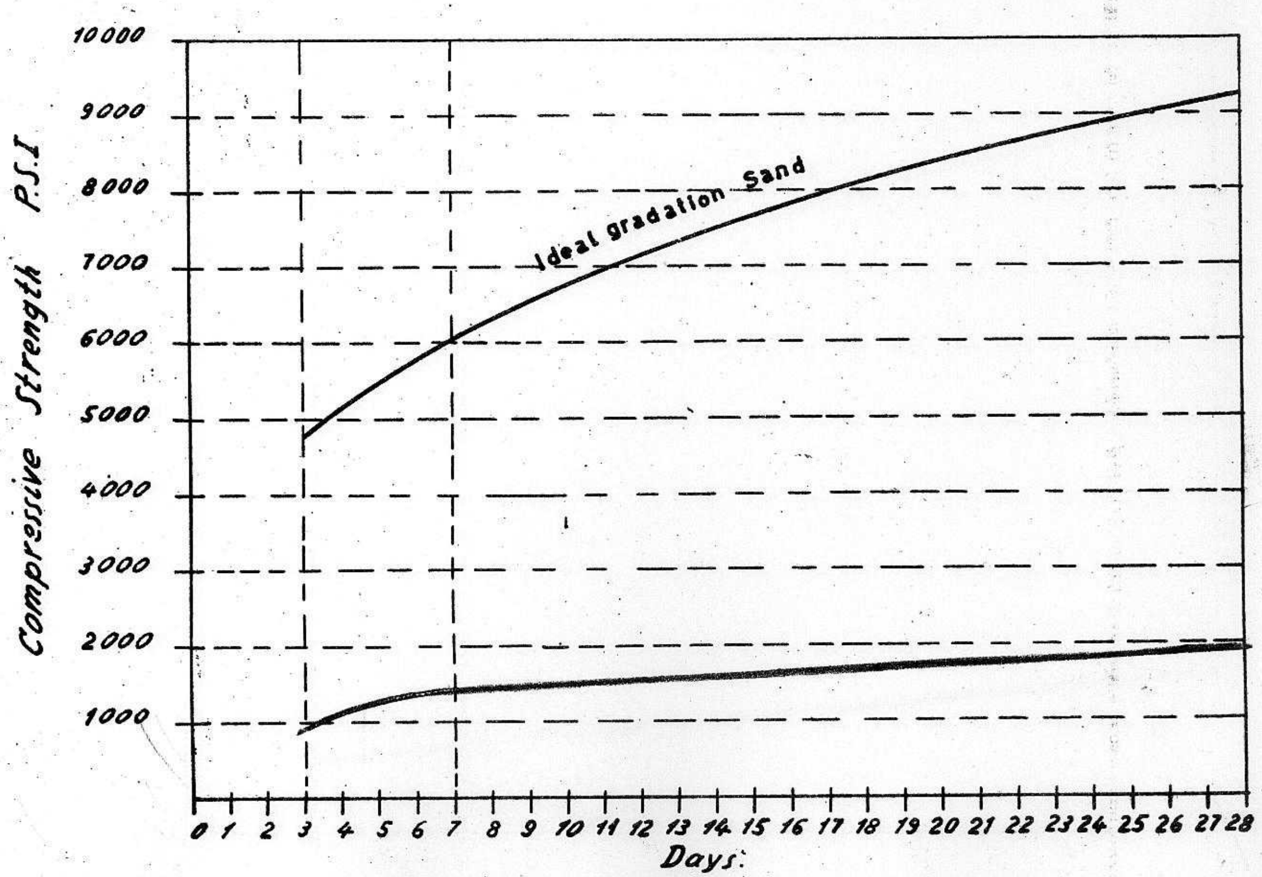


FIG.:50

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 23

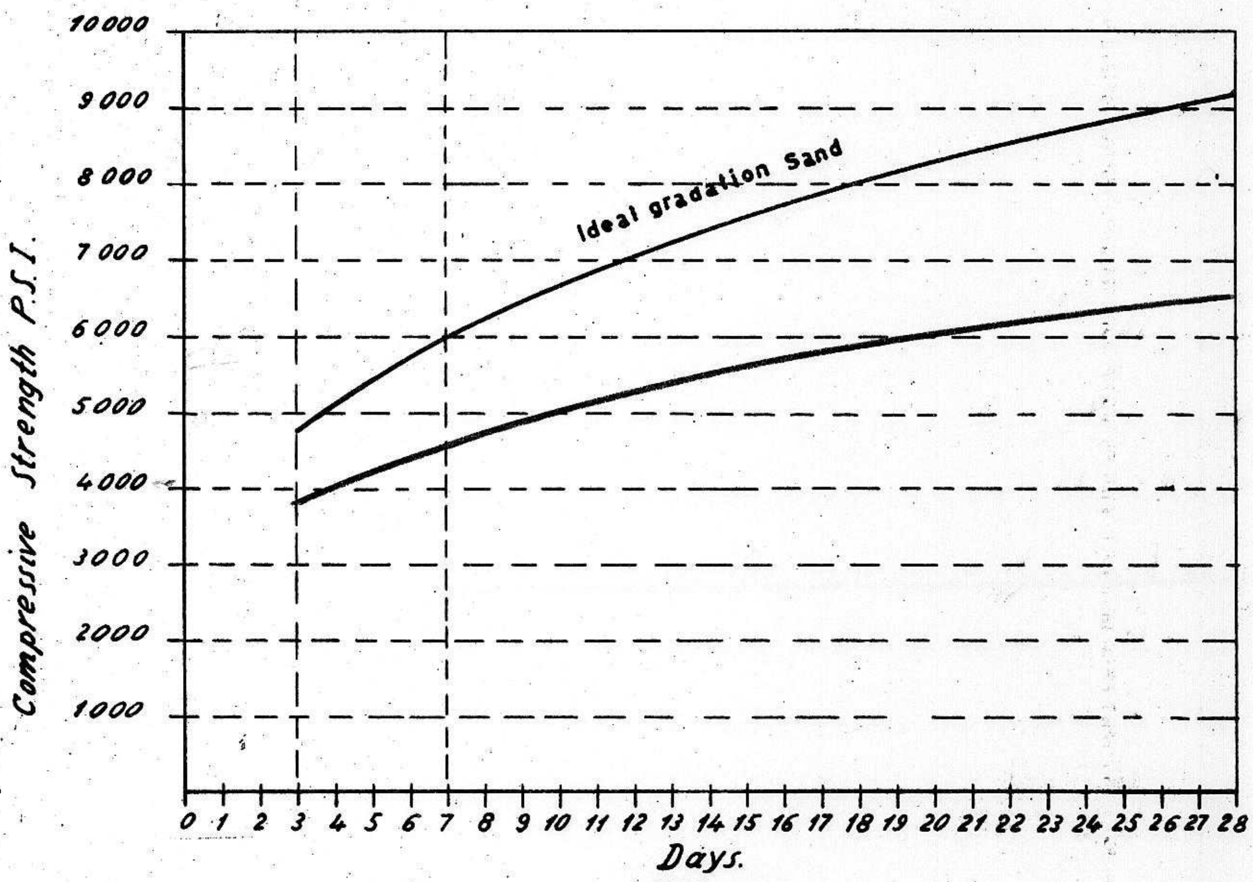


FIG 51

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 24

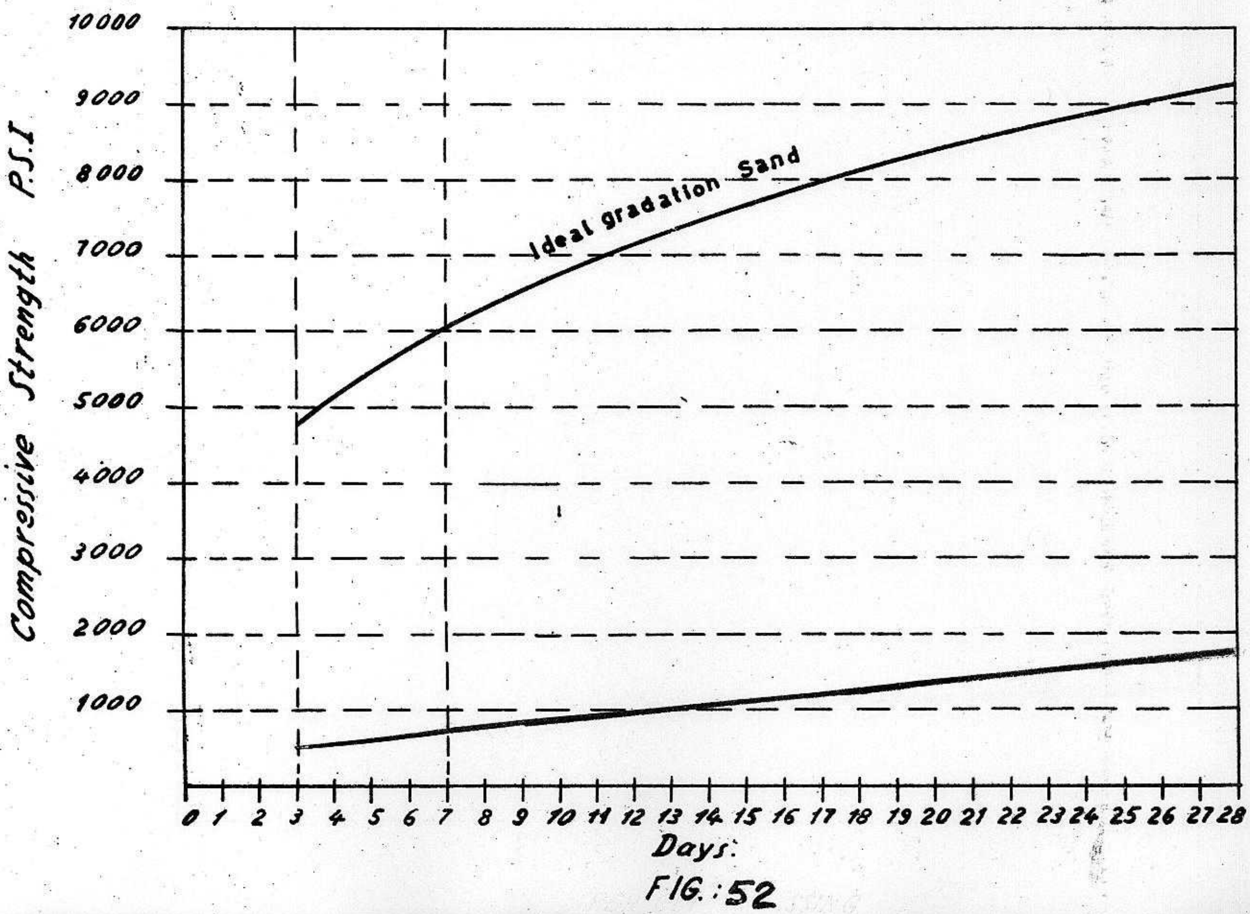


FIG.:52

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 23 (WASHED)

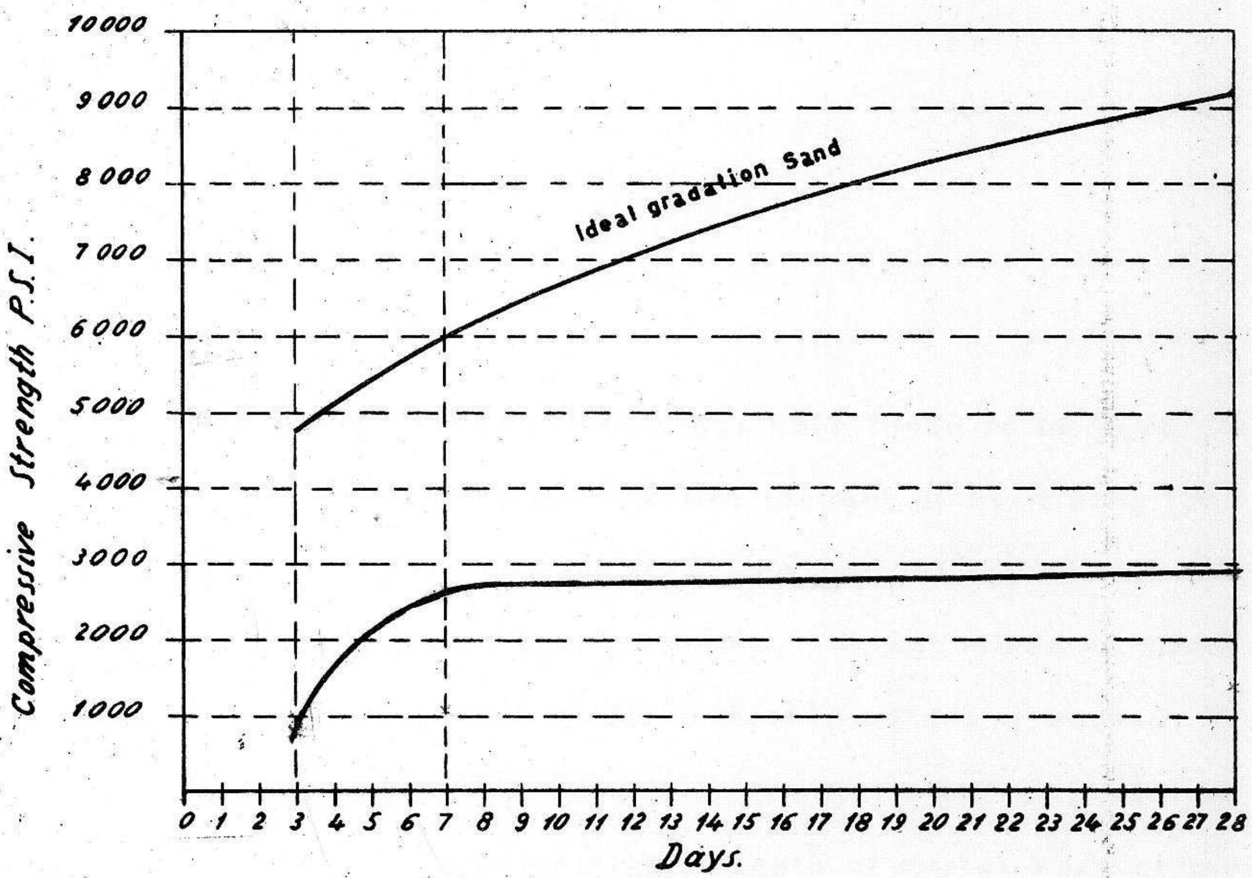


FIG 53

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. 24 (WASHED)

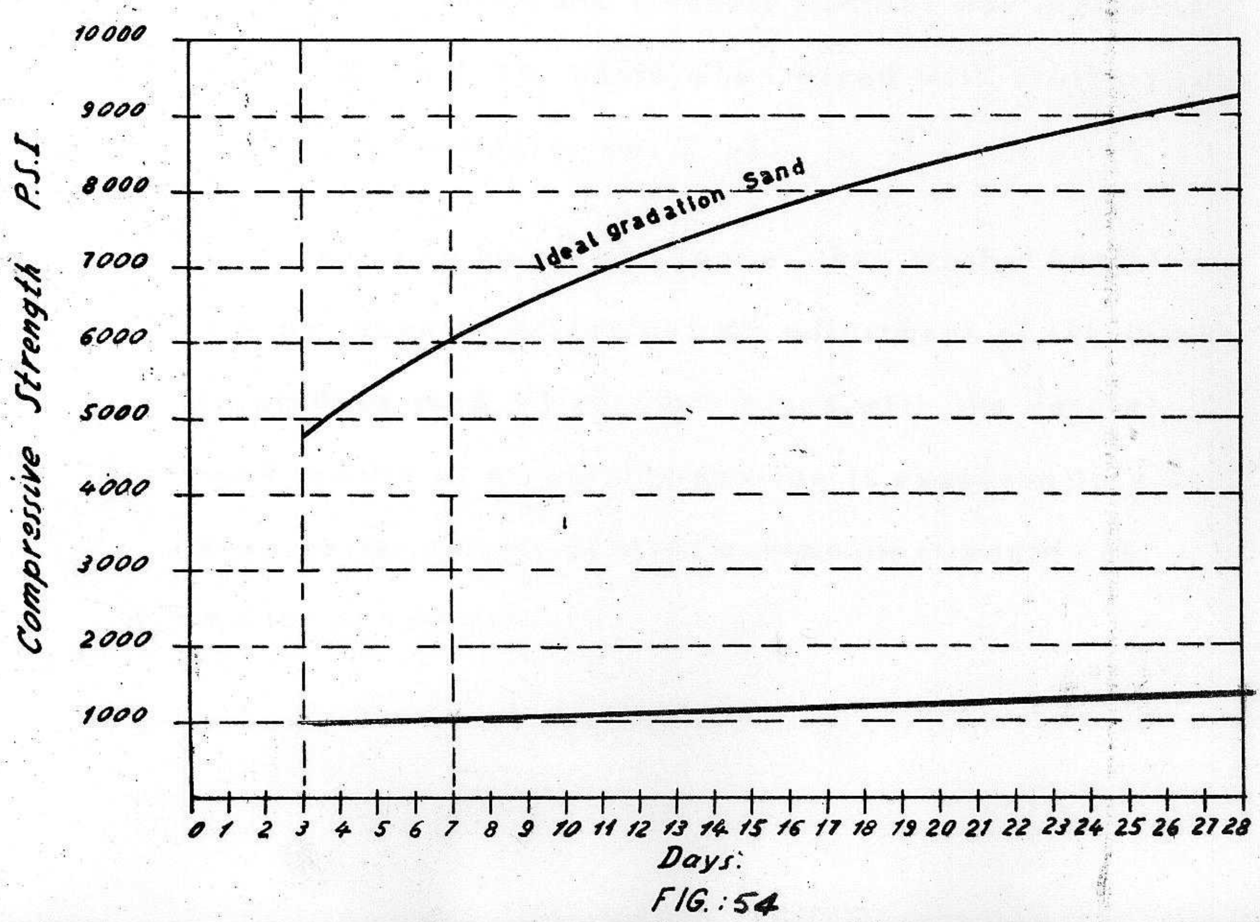


FIG.: 54

F - FURTHER TESTS :

1. Lebanese natural sands were found to be generally fine. Improved gradation was thought of by mixing the fine sand with coarser sand from natural sources or crushers. The airport sand (No. 14) was mixed in equal volumes with each of Nahr Ibrahim sand and washed crushers sand (No. 23). In both cases a better gradation and a higher compressive strength of mortar were obtained than when the airport sand was used alone. When mixed with Nahr Ibrahim the fineness modulus was increased from 1.36 to 2.34, while when mixed with crushers sand the fineness modulus was 2.13.

It is to be noted however that crusher sands have a wide range of gradation. An adjustment of the crusher to produce sand which when mixed with the natural sand results in an ideal gradation is expected to give even better results as far as the compressive strength of mortar or concrete.

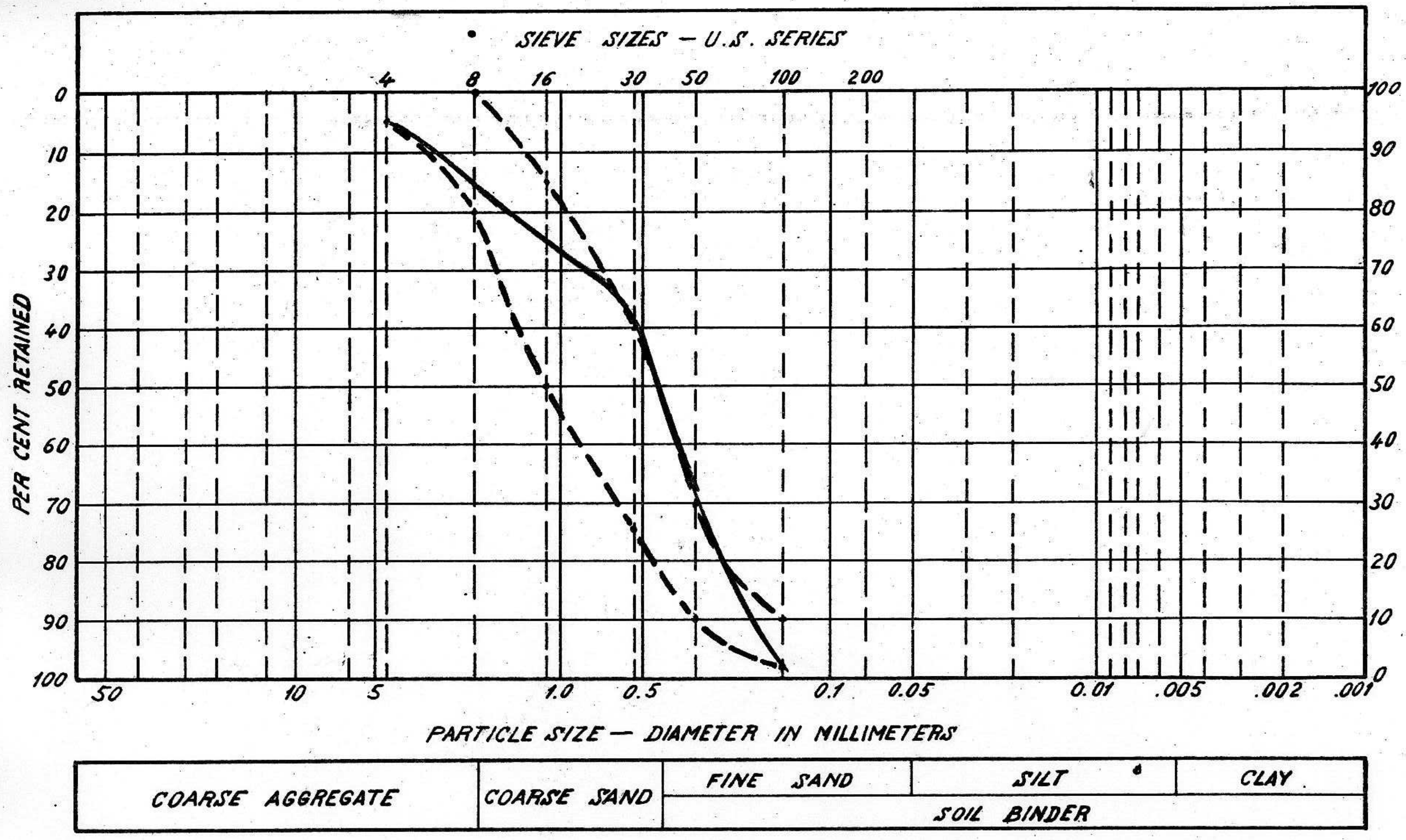


FIG. 55 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE : AIRPORT MIXED WITH NAHR IBRAHIM
- - - - A.S.T.M. Specified Limits For Fine Aggregate

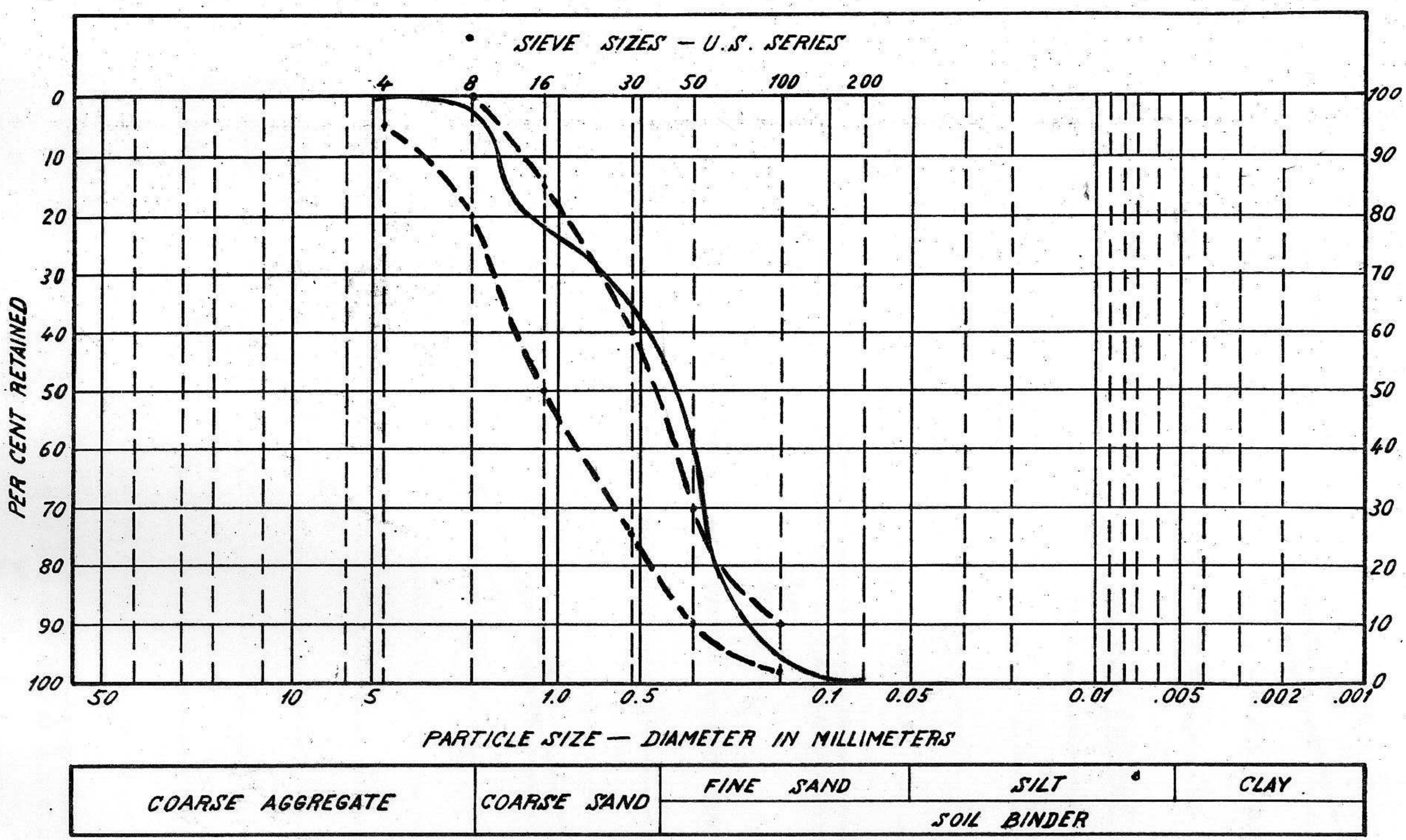


FIG. 56 MECHANICAL ANALYSIS
GRAIN SIZE ACCUMULATIVE CURVE

——— SAMPLE AIRPORT MIXED WITH WASHED CRUSHERS

- - - - A.S.T.M. Specified Limits For Fine Aggregate

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. AIRBORT MIXED WITH NAHR IBRAHIM

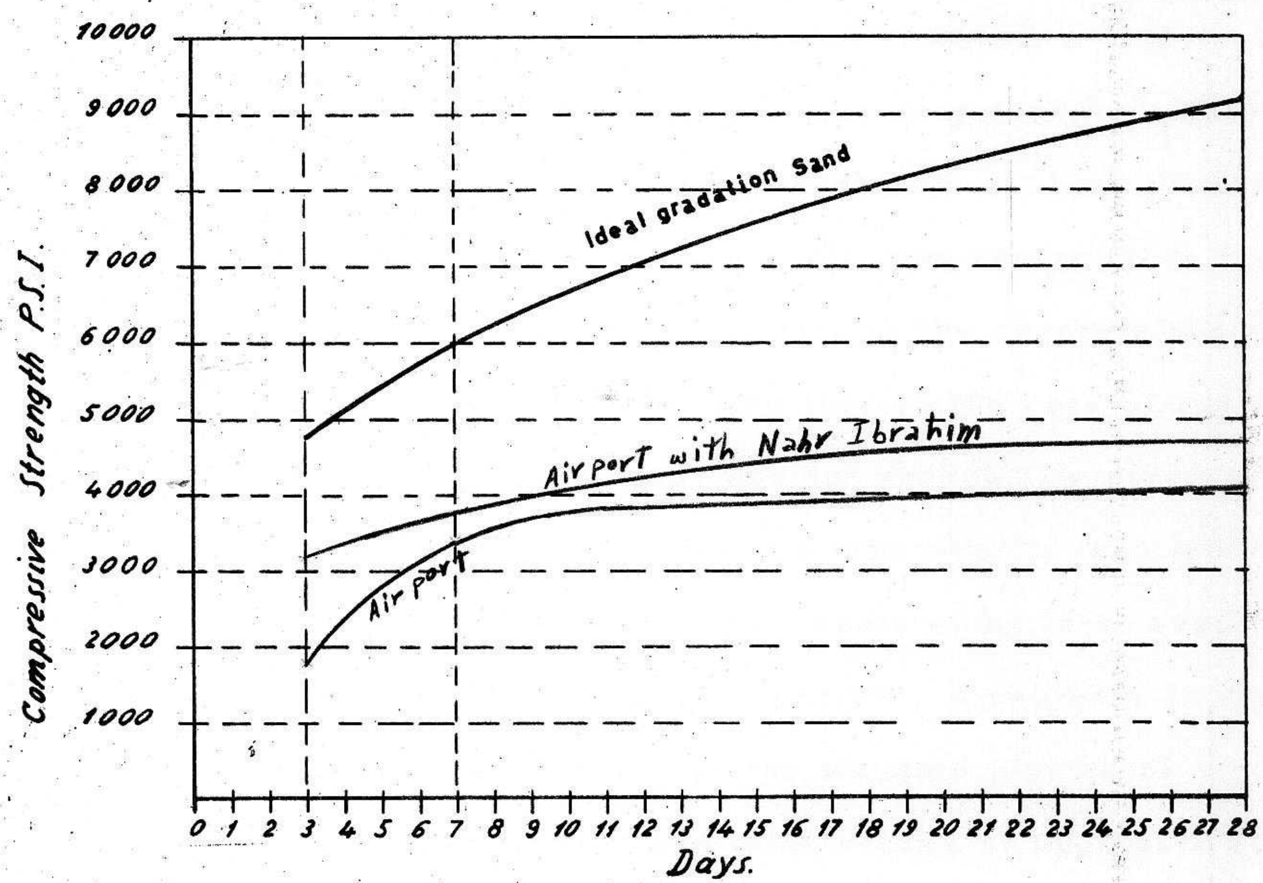


FIG 57

COMPRESSIVE STRENGTH OF MORTAR USING SAMPLE NO. AIRPORT MIXED WITH CRUSHERS

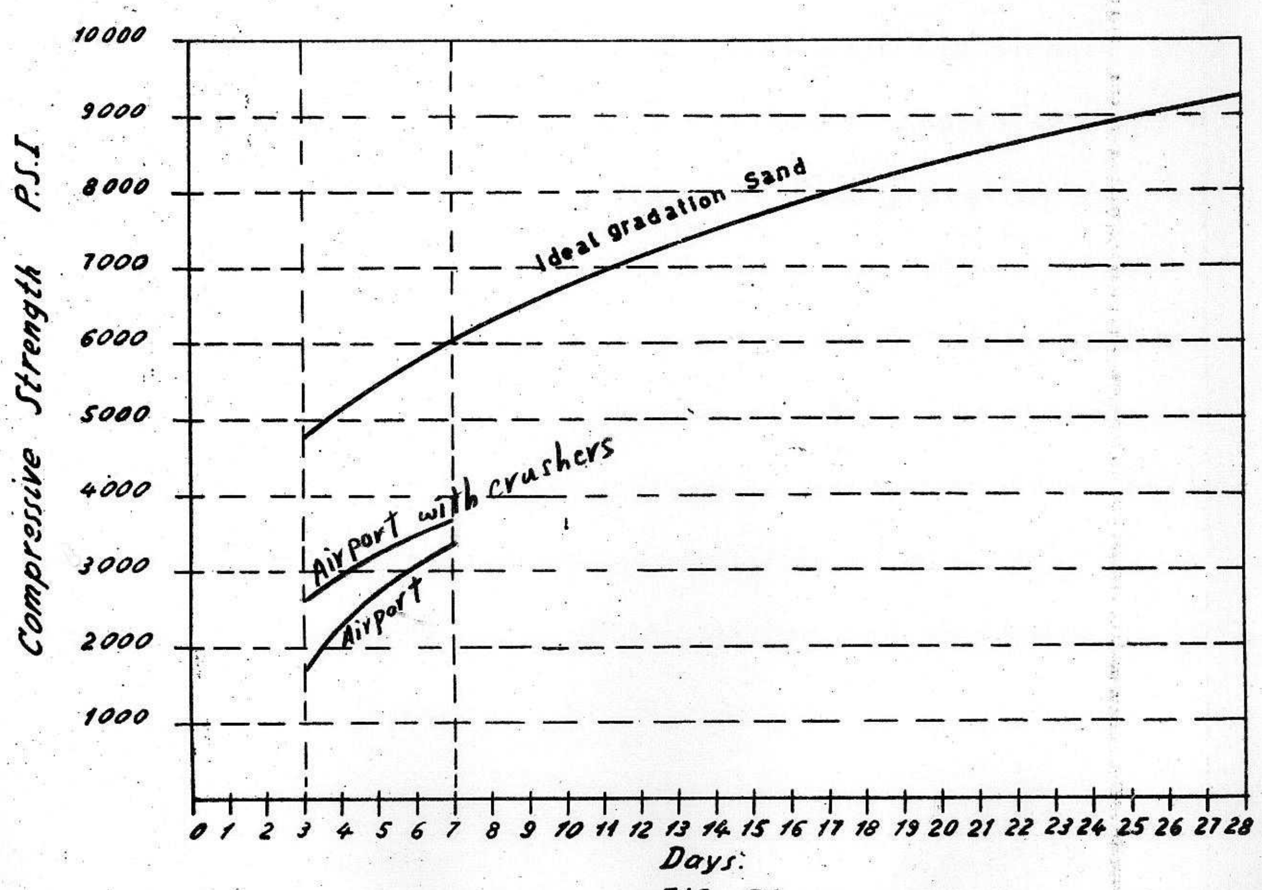


FIG.: 58

2. The surface area of concrete aggregates is mainly a factor of the surface area of sand. The surface area of gravel is negligible when compared with that of sand. Fine sands such as those predominant in Lebanon, have greater surface areas than coarse sands for the same volume. Thus for the same workability of the concrete mix more water is needed in the case of fine sand than in the case of coarse sand. Thus in the case of fine sand, and for workability purposes more water is present in the concrete mix than what is required for reactions of setting and hardening. The excess water later evaporates leaving voids and thus weakening the concrete. A decrease in the sand to gravel ratio in concrete than the standard pratice of 1 : 2 with the amount of cement and total volume of aggregate kept the same was thought of as a solution to the problem.

Trial mixes were prepared and tested with the airport sand and sieved gravel to insure the same gradation of coarse aggregate. Mixes of ratio (A) 1:2 and (B) 1:3 of sand to gravel by volume were chosen and the water - cement ratio was taken as 0.65. The results of the compressive strength for 3 & 7 days were not very different. This was explained by the fact that the amount of water used, which was just enough to make mix (A) workable and more than required for the workability of mix (B), was more than what is required for setting and hardening in both cases.

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Compressive strength.	3 days	7 days
Mix (A)	1610 P.S.I	2060 P.S.I.
Mix (B)	1720 P.S.I	2080 P.S.I.

The trial mixes were repeated with a water-cement ratio of 0.55. This was just enough for the workability of mix (B) and slightly insufficient for the workability of mix (A). The following results were obtained :

Compressive strength	3 days	7 days
Mix (A)	1440 P.S.I	2350 P.S.I
Mix (B)	2080 P.S.I	2900 P.S.I

These results show that when using an amount of water just enough for the workability of the concrete mix, the airport sand-gravel ratio of 1:3 would give a higher compressive strength of concrete than that of the standard practice of 1:2 ratio.
If similar tests were applied on other fine sands of Lebanon similar results would be expected.

CHAPTER SIX

SPECIFIC COMMENTS AND RECOMMENDATIONS FOR EACH SAND SOURCE

No. 1 RAS EL-AIN :

This sand is fine and poorly graded. 78 percent of it's particles have diameters between 0.297 m.m and 0.589m.m. It contains chlorides. The 28 days compressive strength of it's mortar mortar is 0.45 of the mortar using ideal gradation sand. It is recommended to mix it with a coarser sand from natural sources or crushers when used in concrete.

No. 2 BAIN MILITAIRE-SAIDA

This sand is almost clean from organic impurities. However it contains chlorides and is fine and poorly graded. 94 percent of it's particles have diameters between 0.149 m.m. and 0.589 m.m. It's 28 days compressive strength is 0.53 of the ideal. When used in concrete it is recommended to mix it with a coarser sand from natural sources or crushers.

No. 3 & No. 6

SHWAYA:

The two types of sand from this source are fine. The particles finer than No.200 sieve (0.074m.m) amount to 9-13 percent.

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The ratio of their compressive strengths to that of the ideal was 0.22 & 0.24 respectively. It is recommended to wash this sand before being used in concrete. It is also recommended to mix it with a coarser sand.

No. 4 MAR SHAYA:

This sand is fine and poorly graded.68 percent of it's particles have diameters between 0.149 m.m. and 0.589m.m. It's compressive strength is 0.25 of the ideal. It is recommended to mix it with a coarser sand from natural sources or crushers.

No. 5 DOWAR :

This sand is almost clean from organic impurities. It's compressive strength is 0.30 of the ideal. It is poorly graded. 71 percent of its particles have diameters between 0.149 m.m.and 0.589m.m. It is recommended to mix it with a coarser sand from natural sources or crushers.

No. 7 DAHR EL-RAMLEH

This sand has organic impurities. It's compressive strength is 0.40 of the ideal. It is fine and poorly

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graded. 53 percent of it's particles have diameters between 0.297 m.m. and 0.589 m.m. while 34 percent have diameters between 0.149 m.m and 0.297m.m. Although when used in mortar it resulted in an acceptable compressive strength, yet it is advisable not to use this sand for concrete if another source is available.

No. 8 BURGHLIAH

This sand is very rich in organic impurities. 99.5 percent of it is calcium carbonate. It is poorly graded. 85 percent of it's particles have diameters between 0.589 m.m. and 1.191 m.m. The 28 days compressive strength of it's mortar was only 0.06 of that of the ideal gradation sand and is even less than it's own 3 days compressive strength. It is highly recommended not to use this sand in concrete.

No.9 AL-GHABAT-QARTABA:

This sand is fine and poorly graded. 80 percent of it's particles have diameters between 0.149 m.m. and 0.589 m.m. When used in mortar fairly good results of compressive strength were obtained (0.56 of the ideal). It is recommended to mix it with a coarser sand before being used for concrete.

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No. 10 JBEIL

This sand has organic impurities. It is fine and poorly graded. When used in mortar a poor compressive strength was obtained (0.14 of the ideal). It is recommended not to use it for concrete.

No. 11 AL-MASHROUH:

This sand is well graded. It has a fineness modulus of 2.91. When used in mortar it resulted in a fairly high compressive strength (0.64 of the ideal).

No. 12 ABBOUDIEH

This sand is fine and poorly graded. 68 percent of it's particles have diameters between 0.149 m.m. and 0.297m.m. It's mortar had a very low compressive strength (0.08 of the ideal) which was even lower than the 3 days compressive strength. Basalt which is composed of the harmful feldspar is present in this sand. Abboudieh sand is not recommended for concrete.

No. 13 AWZAI':

This sand is fine and poorly graded. 98 percent of it's particles have diameters between 0.149 m.m. and 0.589 m.m. The mortar in which it was used as an aggregate had a fairly high compressive strength. (0.56 of the ideal). It is recommended to mix it with a coarser sand from natural sources or crushers before being used in concrete.

No.14 AIRPORT :

This sand is fine and poorly graded. 95 percent of it's particles have diameters between 0.149 m.m. and 0.589 m.m. It's 28 days compressive strength was 0.44 of the ideal. It is recommended to mix it with a coarser sand from natural sources or crushers before being used as an aggregate in concrete.

No.15 SAINT MICHEL

This sand is fine and poorly graded. 63 percent of it's particles have diameters between 0.297 m.m. and 0.589 m.m. It's mortar had a fairly high 28 days compressive strength (0.72 of the ideal). It is recommended to mix it with coarser sand from natural sources or crushers when used as an aggregate in concrete.

No. 16 NAHR IBRAHIM

This sand is slightly coarser than the A.S.T.M. limits. It has a fineness modulus of 3.61. However it is well graded. It gave the highest 28 days compressive strength to mortar (0.87 of the ideal) among all sources.

No. 17 DBAYEH:

This sand is fine and poorly graded. 63 percent of it's particles have diameters between 0.297 m.m. and 0.589 m.m. It's 28 days compressive strength was 0.66 of the ideal. It is recommended to mix it with coarser sands from natural sources or crushers when used in concrete.

No. 18 AIN HAZIR

This sand is better graded than other disintegrated sandstones but is finer than A.S.T.M. specifications. It's fineness modulus is 1.57. It's 28 days mortar compressive strength was fairly high (0.75 of the ideal).

No. 19 AKKAR AL-ATIKA

This sand is very fine. It's fineness modulus is 0.88. Twenty percent of it's particles are finer than sieve

No.200. It's 28 days compressive strength was 0.15 of the ideal. It is recommended to wash this sand well and mix it with a coarser sand of natural sources or crushers before being used in concrete.

No.20 BAROUK

This sand is fine and poorly graded. 8 percent of it's particles are finer than sieve No.200. It's 28 days compressive strength of mortar was 0.32 of the ideal. It is recommended to wash it and mix it with a coarser sand before being used in concrete.

No.21 GHABOUN

This sand is fine with 9 percent of it's particles finer than sieve No.200. It's 28 days compressive strength of mortar was only 0.10 of the ideal. It is recommended to wash this sand and mix it with a coarser sand from natural sources or crushers before being used in concrete.

No.22 AL-ASSI

This sand is coarser than the A.S.T.M. limits. It's fineness modulus is 3.71. It's 28 days compressive strength of mortar was 0.22 of the ideal.

CHAPTER SEVEN

GENERAL CONCLUSIONS AND RECOMMENDATIONS

A general feature in most Lebanese sands is their fineness and poor gradation. With few exceptions Lebanese sands were found to be free from injurious amounts of organic impurities or other deleterious substances. An improvement in the concrete aggregate should therefore aim at modifying the gradation of these fine sands by mixing them with coarser sands from natural sources or crushers. The natural coarse sands are mainly river deposits such as Nahr-Ibrahim and AL-Assi . The availability of these sands is limitted in addition to the fact that the use of some of them is prohibited by law. Thus crushers sand, washed to remove extra fines, must be used for mixing with the fine natural sands to improve the fine aggregate gradation. This must be done in different proportions depending on the characteristics of the natural sand and the crushers.

When crushers sand is used alone it must be washed to remove excess fines but not to the extent of removing all the fines because a small percentage helps the workability of the mortar or concrete mix.

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Lebanese sands due to their fineness require more water to make a concrete mix workable than what is needed for setting and hardening of the concrete. The excess water evaporates later leaving voids and thus weakening the concrete. A decrease in the sand to gravel ratio in concrete would decrease the total surface area of aggregate and thus the amount of water needed for workability. A ratio of airport sand to Gravel of 1 : 3 was found to give a higher compressive strength than the standard 1:2 ratio with the same workability conditions. Further research in the subject is recommended to find the best sand : Gravel gradation for each type of sand.

Mortars prepared with disintegrated sandstones had in general slightly lower compressive strengths than those with seashore sands. Yet, due to prohibition of the use of seashore sands it became much more expensive than the mountainous sandstones or the alluvial fans near the airport. It may thus be more economical to use disintegrated sandstone deposits as fine aggregate in concrete, with a modification in the proportions of the concrete ingredients to increase it's compressive strength rather than use the expensive seashore sands.

APPENDIX - A -

SIEVE ANALYSIS

SAMPLE NO. 1 SOURCE : RAS EL-AIN - TYR

ORIGINAL WEIGHT OF DRY SAMPLE : 1457 GRS

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	%COARSER
No. 4	4.749	1.05	0.07	99.93	0.07
No. 8	2.379	0.60	0.04	99.89	0.11
No. 16	1.191	2.95	0.20	99.69	0.31
No. 30	0.589	74.80	5.13	94.56	5.44
No. 50	0.297	1143.00	78.51	16.05	83.95
No. 100	0.149	230.10	15.80	0.25	99.75
No. 200	0.074	3.30	0.24	0.01	99.99
RETAINED IN PAN OR WASHED		0.20	0.01	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	189.63
TOTAL WT. RECOVERED		1456.00			
MANIPULATIVE LOSS		1.00			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100

FINENESS MODULUS = 1.89

Note: % RETAINED : Is the percentage retained on each individual sieve

SIEVE ANALYSIS

SAMPLE NO. 2 SOURCE : BAIN MILITAIRE - SAIDA

ORIGINAL WEIGHT OF DRY SAMPLE : 1540 GRS

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.15	0.01	99.99	0.01
No. 8	2.379	0.30	0.02	99.97	0.03
No. 16	1.191	1.35	0.09	99.88	0.12
No. 30	0.589	22.55	1.25	98.63	1.37
No. 50	0.297	892.05	56.00	42.63	57.37
No. 100	0.149	613.80	38.00	4.63	95.37
No. 200	0.074	7.60	4.61	0.02	99.98
RETAINED IN PAN OR WASHED		0.35	0.02	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4& No. 100	154.27
TOTAL WT. RECOVERED		1538.00			
MANIPULATIVE LOSS		2.00			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100

FINENESS MODULUS = 1.54

SIEVE ANALYSIS

SAMPLE NO. 3 SOURCE HASBAYA - SHWAYA

ORIGINAL WEIGHT OF DRY SAMPLE : 1792 GRS

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	16.45	0.92	99.08	0.92
No. 8	2.379	20.35	1.14	97.94	2.06
No. 16	1.191	38.25	2.14	95.80	4.20
No. 30	0.589	135.20	7.53	88.27	11.73
No. 50	0.297	493.75	27.65	60.62	39.38
No. 100	0.149	615.20	34.50	26.12	73.88
No. 200	0.074	243.75	13.62	12.50	87.50
RETAINED IN PAN OR WASHED		228.00	12.50	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	132.17
TOTAL WT. RECOVERED		1790.95			
MANIPULATIVE LOSS		1.05			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100

FINENESS MODULUS = 1.32

SIEVE ANALYSIS

SAMPLE NO. 4 SOURCE MAR - SHAYA

ORIGINAL WEIGHT OF DRY SAMPLE : 1767 GRS

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	5.95	0.34	99.66	0.34
No. 8	2.379	8.00	0.45	99.21	0.79
No. 16	1.191	25.70	1.45	97.76	2.24
No. 30	0.589	121.25	6.86	90.90	9.10
No. 50	0.297	436.20	24.72	66.18	33.82
No. 100	0.149	775.00	43.90	22.28	77.72
No. 200	0.074	283.80	16.06	6.22	93.78
RETAINED IN PAN OR WASHED		110.00	6.22	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100 124.01	
TOTAL WT. RECOVERED		1765.90			
MANIPULATIVE LOSS		1.10			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.24

SIEVE ANALYSIS

SAMPLE NO. 5 SOURCE DOWAR

ORIGINAL WEIGHT OF DRY SAMPLE : 1625 GRS

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.60	0.03	99.97	0.03
No. 8	2.379	3.70	0.22	99.75	0.25
No. 16	1.191	25.50	1.56	98.19	1.81
No. 30	0.589	152.20	9.36	88.83	11.17
No. 50	0.297	499.50	30.78	58.05	41.95
No. 100	0.149	655.40	40.38	17.67	82.33
No. 200	0.074	240.85	14.82	2.85	97.15
RETAINED IN PAN OR WASHED		46.40	2.85	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	140.51
TOTAL WT. RECOVERED		1624.15			
MANIPULATIVE LOSS		0.85			

FINENESS MODULUS : Summation of the percentages retained on sieves between No.4 & No. 100, divided by 100.

FINENESS MODULUS = 1.40

SIEVE ANALYSIS

SAMPLE No. 6 SOURCE HASBAY - SHWAYA

ORIGINAL WEIGHT OF DRY SAMPLE : 1892 GR.S

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	4.40	0.23	99.77	0.23
No. 8	2.379	7.20	0.39	99.38	0.62
No. 16	1.191	29.40	1.55	97.83	2.17
No. 30	0.589	129.75	6.83	91.00	9.00
No. 50	0.297	534.60	28.30	62.70	37.30
No. 100	0.149	729.10	38.60	24.10	75.90
No. 200	0.074	283.10	14.97	9.13	90.87
RETAINED IN PAN OR WASHED		173.00	9.13	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4&No. 100 125.22	
TOTAL WT. RECOVERED		1890.55			
MANIPULATIVE LOSS					

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4& No. 100, divided by 100.

FINENESS MODULUS = 1.25

SIEVE ANALYSIS

SAMPLE NO. 7 SOURCE DAHR EL-RAMLIEH

ORIGINAL WEIGHT OF DRY SAMPLE : 1837 GRS

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	2.40	0.13	99.87	0.13
No. 8	2.379	6.50	0.35	99.52	0.48
No. 16	1.191	12.30	0.66	98.86	1.14
No. 30	0.589	57.75	3.14	95.72	4.28
No. 50	0.297	982.05	53.52	42.20	57.80
No. 100	0.149	624.70	34.04	8.16	91.84
No. 200	0.074	135.00	7.35	0.81	99.19
RETAINED IN PAN OR WASHED		15.00	0.81	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100 155.67	
TOTAL WT. RECOVERED		1835.70			
MANIPULATIVE LOSS		1.30			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.55

SIEVE ANALYSIS

SAMPLE NO. 8 SOURCE BURGHLIAH

ORIGINAL WEIGHT OF DRY SAMPLE : 1818 GRS					
SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	3.65	0.20	99.80	0.20
No. 8	2.379	7.50	0.41	99.39	0.61
No. 16	1.191	57.45	3.16	96.23	3.77
No. 30	0.589	1545.00	85.06	11.17	88.83
No. 50	0.297	142.50	7.84	3.33	96.67
No. 100	0.149	23.10	1.27	2.06	97.94
No. 200	0.074	16.30	0.89	1.17	98.83
RETAINED IN PAN OR WASHED		21.35	1.17	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	288.02
TOTAL WT. RECOVERED		1816.85			
MANIPULATIVE LOSS					

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.88

SIEVE ANALYSIS

SAMPLE NO. 9 SOURCE GHABAT

ORIGINAL WEIGHT OF DRY SAMPLE : 1734 GRS					
SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSE
No. 4	4.749	9.65	0.55	99.45	0.55
No. 8	2.379[1]	16.25	0.93	98.52	1.48
No. 16	1.191	40.20	2.31	96.21	3.79
No. 30	0.589	136.25	7.86	88.35	11.65
No. 50	0.297	597.00	34.45	53.90	46.10
No. 100	0.149	791.60	45.70	8.20	91.80
No. 200	0.074	121.60	7.01	1.19	98.81
RETAINED IN PAN OR WASHED		20.65	1.19	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100 155.37	
TOTAL WT. RECOVERED		1733.20			
MANIPULATIVE LOSS		1.80			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.55

SIEVE ANALYSIS

SAMPLE NO. 10 SOURCE BYBLOS

ORIGINAL WEIGHT OF DRY SAMPLE : 1540 GRS

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	11.50	0.74	99.26	0.74
No. 8	2.379	7.55	0.49	98.77	1.23
No. 16	1.191	19.40	1.25	97.52	2.48
No. 30	0.589	157.45	10.22	87.30	12.70
No. 50	0.297	468.10	30.43	56.87	43.13
No. 100	0.149	719.10	46.74	10.13	89.87
No. 200	0.074	150.35	9.76	0.37	99.63
RETAINED IN PAN OR WASHED		5.75	0.37	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100 150.15	
TOTAL WT. RECOVERED		1539.20			
MANIPULATIVE LOSS		0.80			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.50

SIEVE ANALYSIS

SAMPLE NO. 11 SOURCE AL-MASHROUCH

ORIGINAL WEIGHT OF DRY SAMPLE : 1661 GRS

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	75.80	4.54	95.46	4.54
No. 8	2.379	165.25	9.95	85.51	14.49
No. 16	1.191	200.55	12.12	73.39	26.61
No. 30	0.589	560.60	33.70	39.69	60.31
No. 50	0.297	462.85	27.94	11.75	88.25
No. 100	0.149	156.80	9.50	2.25	97.75
No. 200	0.074	28.30	1.69	0.56	99.44
RETAINED IN PAN OR WASHED		9.35	0.56	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	291.95
TOTAL WT.RECOVERED		1659.50			
MANIPULATIVE LOSS		1.50			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.91

SIEVE ANALYSIS

SAMPLE NO. 12 SOURCE ABBOUDIEH

ORIGINAL WEIGHT OF DRY SAMPLE : 1786 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	1.60	0.08	99.92	0.08
No. 8	2.379	3.40	0.19	99.73	0.27
No. 16	1.191	3.30	0.18	99.55	0.45
No. 30	0.589	28.30	1.58	97.97	2.03
No. 50	0.297	343.90	19.30	78.67	21.33
No. 100	0.149	1215.00	68.10	10.57	89.43
No. 200	0.074	185.70	10.40	0.17	99.83
RETAINED IN PAN OR WASHED		3.15	0.17	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	113.59
TOTAL WT. RECOVERED		1784.35			
MANIPULATIVE LOSS		1.65			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100 .

FINENESS MODULUS = 1.13

SIEVE ANALYSIS

SAMPLE NO. 13 SOURCE AWZAI

ORIGINAL WEIGHT OF DRY SAMPLE : 1695 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.00	0.00	100.00	0.00
No. 8	2.379	0.00	0.00	100.00	0.00
No. 16	1.191	0.10	0.01	99.99	0.01
No. 30	0.589	10.95	0.64	99.35	0.65
No. 50	0.297	853.90	50.40	48.95	51.05
No. 100	0.149	810.15	47.85	1.10	98.90
No. 200	0.074	17.20	1.01	0.09	99.91
RETAINED IN PAN OR WASHED		1.60	0.09	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	150.61
TOTAL WT. RECOVERED		1693.90			
MANIPULATIVE LOSS		1.10			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.50

SIEVE ANALYSIS

SAMPLE NO. 14 SOURCE AIR PORT

ORIGINAL WEIGHT OF DRY SAMPLE : 1860 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.00	0.00	100.00	0.00
No. 8	2.379	5.30	0.29	99.71	0.29
No. 16	1.191	21.85	1.19	98.52	1.48
No. 30	0.589	21.45	1.17	97.35	2.65
No. 50	0.297	582.95	31.39	65.96	34.04
No. 100	0.149	1191.00	64.00	1.96	98.04
No. 200	0.074	33.75	1.81	0.15	99.85
RETAINED IN PAN OR WASHED		2.60	0.15	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	136.50
TOTAL WT. RECOVERED		1858.90			
MANIPULATIVE LOSS		1.10			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.36

SIEVE ANALYSIS

SAMPLE NO. 15 SOURCE SAINT - MICHEL

ORIGINAL WEIGHT OF DRY SAMPLE : 1450 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.00	0.00	100.00	0.00
No. 8	2.379	0.00	0.00	100.00	0.00
No. 16	1.191	0.00	0.00	100.00	0.00
No. 30	0.589	5.90	0.40	99.60	0.40
No. 50	0.297	922.75	63.68	35.92	64.08
No. 100	0.149	516.55	35.65	0.27	99.73
No. 200	0.074	3.85	0.26	0.01	99.99
RETAINED IN PAN OR WASHED		0.30	0.01	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4& No. 100 164.21	
TOTAL WT. RECOVERED		1449.35			
MANIPULATIVE LOSS		0.65			

FINENESS MODULUS :/ Summation of the percentages retained on sieves between No. 4& No. 100, divided by 100.

FINENESS MODULUS = 1.64

SIEVE ANALYSIS

SAMPLE No. 16 SOURCE NAHR - IBRAHIM

ORIGINAL WEIGHT OF DRY SAMPLE : 1110 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	%RETAINED	% FINER	% COARSER
No. 4	4.749	89.10	8.02	91.98	8.02
No. 8	2.379	246.20	22.20	69.78	30.22
No. 16	1.191	256.25	23.10	46.68	53.32
No. 30	0.589	261.25	23.58	23.10	76.90
No. 50	0.297	192.40	17.40	5.70	94.30
No. 100	0.149	53.50	4.82	0.88	99.12
No. 200	0.074	7.75	0.70	0.18	99.98
RETAINED IN PAN OR WASHED		2.00	0.18	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	361.88
TOTAL WT. RECOVERED		1108.45			
MANIPULATIVE LOSS		1.55			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4& No. 100, divided by 100.

FINENESS MODULUS = 3.61

SIEVE ANALYSIS

SAMPLE No. 17 SOURCE DBAYEH

ORIGINAL WEIGHT OF DRY SAMPLE : 1790 GRS.

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	%COARSER
No. 4	4.749	0.45	0.02	99.98	0.02
No. 8	2.379	0.20	0.01	99.97	0.03
No. 16	1.191	2.20	0.12	99.85	0.15
No. 30	0.589	99.15	5.54	94.31	5.69
No. 50	0.297	1133.90	63.40	30.91	69.09
No. 100	0.149	546.75	30.57	0.34	99.66
No. 200	0.074	5.75	0.32	0.02	99.98
RETAINED IN PAN OR WASHED		0.40	0.02	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	174.64
TOTAL WT. RECOVERED		1788.70			
MANIPULATIVE LOSS		1.30			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.74

SIEVE ANALYSIS

SAMPLE No. 18 SOURCE AIN-HAZIR

ORIGINAL WEIGHT OF DRY SAMPLE : 1942 GRS.

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	12.40	0.63	99.37	0.63
No. 8	2.379	13.90	0.71	98.66	1.34
No. 16	1.191	36.05	1.85	96.81	3.19
No. 30	0.589	208.05	10.72	86.09	13.91
No. 50	0.297	741.40	38.20	47.80	52.11
No. 100	0.149	667.35	34.40	13.49	86.51
No. 200	0.074	194.55	10.01	3.48	96.52
RETAINED IN PAN OR WASHED		67.70	3.48	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	157.69
TOTAL WT. RECOVERED		1941.40			
MANIPULATIVE LOSS		0.60			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4& No. 100, divided by 100.

FINENESS MODULUS = 1.57

SIEVE ANALYSIS

SAMPLE No. 19 SOURCE AKKAR AL-ATIKA

ORIGINAL WEIGHT OF DRY SAMPLE : 1825 GRS.

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.00	0.00	100.00	0.00
No. 8	2.379	0.00	0.00	100.00	0.00
No. 16	1.191	1.10	0.06	99.94	0.06
No. 30	0.589	60.25	3.30	96.64	3.36
No. 50	0.297	418.95	22.95	73.69	26.31
No. 100	0.149	582.95	31.95	41.74	58.26
No. 200	0.074	379.75	20.80	20.94	79.06
RETAINED IN PAN OR WASHED		382.00	20.94	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	87.99
TOTAL WT. RECOVERED		1824.95			
MANIPULATIVE LOSS					

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 0.88

SIEVE ANALYSIS

SAMPLE No. 20 SOURCE BAROUK

ORIGINAL WEIGHT OF DRY SAMPLE : 2410 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	2.80	0.11	99.89	0.11
No. 8	2.379	6.40	0.26	99.63	0:37
No. 16	1.191	19.65	0.81	98.82	1.18
No. 30	0.589	204.25	8.48	90.34	9.66
No. 50	0.297	735.55	30.55	59.79	40.21
No. 100	0.149	1008.55	41.90	17.89	82.11
No. 200	0.074	229.10	9.51	8.38	91.62
RETAINED IN PAN OR WASHED		202.00	8.38	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	133,64
TOTAL WT. RECOVERED		2408.30			
MANIPULATIVE LOSS		1.70			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.33

SIEVE ANALYSIS

SAMPLE No. 21 SOURCE GHABOUN

ORIGINAL WEIGHT OF DRY SAMPLE : 1740 GRS.

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	0.00	0.00		0.00
No. 8	2.379	2.15	0.12	99.88	0.17
No. 16	1.191	32.20	1.85	98.03	1.97
No. 30	0.589	185.80	10.67	87.36	12.64
No. 50	0.297	538.75	30.96	56.40	43.60
No. 100	0.149	563.45	32.40	24.00	76.00
No. 200	0.074	250.45	14.40	9.60	90.40
RETAINED IN PAN OR WASHED		167.10	9.60	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	134.33
TOTAL WT. RECOVERED		1739.90			
MANIPULATIVE LOSS		0.10			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 1.34

SIEVE ANALYSIS

SAMPLE No. 22 SOURCE AL-ASSI-HIRMIL

ORIGINAL WEIGHT OF DRY SAMPLE : 2420 GRS.					
SIEVE SIZE U.S.SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	458.60	18.90	81.10	18.90
No. 8	2.379	347.25	14.25	66.85	33.15
No. 16	1.191	445.05	18.70	48.15	51.85
No. 30	0.589	612.50	25.27	22.88	77.12
No. 50	0.297	362.80	14.90	7.98	92.02
No. 100	0.149	146.10	6.03	1.95	98.05
No. 200	0.074	33.50	1.38	0.57	99.43
RETAINED IN PAN OR WASHED		13.80	0.57	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	371.09
TOTAL WT. RECOVERED		2419.60			
MANIPULATIVE LOSS		0.40			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 3.71

SIEVE ANALYSIS

SAMPLE No. 23　　　SOURCE CRUSHERS

ORIGINAL WEIGHT OF DRY SAMPLE : 1320 GRS.

SIEVE SIZE U.S.SERIES	OPENING M.M.	WT.RETAINED GRAMS	%RETAINED	% FINER	% COARSER
No. 4	4.749	1.95	0.14	99.86	0.14
No. 8	2.379	44.85	3.40	96.46	4.54
No. 16	1.191	390.60	29.00	67.46	33.54
No. 30	0.589	225.30	17.10	49.36	50.64
No. 50	0.297	152.40	11.45	37.91	62.09
No. 100	0.149	117.20	8.87	29.04	70.96
No. 200	0.074	56.20	4.24	24.80	75.20
RETAINED IN PAN OR WASHED		330.00	24.80	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100 221.91	
TOTAL WT. RECOVERED		1318.50			
MANIPULATIVE LOSS		1.50			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.21

SIEVE ANALYSIS

SAMPLE No. 24 SOURCE CRUSHERS

ORIGINAL WEIGHT OF DRY SAMPLES: 1490 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	1.50	0.10	99.90	0.10
No. 8	2.379	37.35	2.51	97.39	2.61
No. 16	1.191	476.80	31.95	65.44	34.56
No. 30	0.589	314.65	21.35	44.09	55.91
No. 50	0.297	170.30	11.40	32.69	67.31
No. 100	0.149	107.90	7.24	25.45	74.55
No. 200	0.074	45.40	3.05	22.40	77.60
RETAINED IN PAN OR WASHED		335.00	22.40	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	235.04
TOTAL WT. RECOVERED		1488.90			
MANIPULATIVE LOSS		1.10			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.35

SIEVE ANALYSIS

NAHR IBRAHIM AND AIR PORT SAND MIXED IN EQUAL VOLUMES

ORIGINAL WEIGHT OF DRY SAMPLE : 1500 GRS.

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	60.20	4.01	95.99	4.01
No. 8	2.379	168.55	11.25	84.74	15.26
No. 16	1.191	183.50	12.24	72.50	27.50
No. 30	0.589	184.45	12.30	60.20	39.80
No. 50	0.297	366.00	24.40	35.80	64.20
No. 100	0.149	515.10	34.38	1.42	98.58
No. 200	0.075	18.75	1.25	0.17	99.83
RETAINED IN PAN OR WASHED		2.55	0.17	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	234.08
TOTAL WT. RECOVERED		149.10			
MANIPULATIVE LOSS		0.90			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.34

SIEVE ANALYSIS

AIRPORT SAND & WASHED CRUSHERS SAND No. 23 MIXED IN EQUAL VOLUMES

ORIGINAL WEIGHT OF DRY SAMPLE :

SIEVE SIZE U.S. SERIES	OPENING M.M.	WT. RETAINED GRAMS	% RETAINED	% FINER	% COARSER
No. 4	4.749	1.50	0.10	99.90	0.10
No. 8	2.379	36.18	2.41	97.49	2.51
No. 16	1.191	299.70	19.98	77.51	22.49
No. 30	0.589	179.75	11.98	65.53	34.47
No. 50	0.297	352.40	23.55	41.98	58.02
No. 100	0.149	572.10	38.12	3.86	96.14
No. 200	0.074	56.70	3.78	0.08	99.92
RETAINED IN PAN OR WASHED		1.20	0.08	SUM OF PERCENTAGES RETAINED ON SIEVES BETWEEN No. 4 & No. 100	213.73
TOTAL WT. RECOVERED		1499.55			
MANIPULATIVE LOSS		0.45			

FINENESS MODULUS : Summation of the percentages retained on sieves between No. 4 & No. 100, divided by 100.

FINENESS MODULUS = 2.13

APPENDIX - B -

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No 1 SOURCE RAS EL-AIN

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	17950	23750	31850
	2.	17150	25000	33200
	3.	17100	24200	31300
	Average	17400	24300	32100
COMPRESSIVE STRENGTH PSI		2250	3150	4150

SAMPLE No. 2 SOURCE BAIN MILITAIRE - SAIDA

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	19250	34250	39800
	2.	17750	32250	38200
	3.	19200	31850	36200
	Average	18750	32800	38050
COMPRESSIVE STRENGTH PSI		2400	4250	4900

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES.

SAMPLE NO. 3 SOURCE HASBAYA - SHWAYA

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	5250	11300	12950
	2.	4450	12200	18200
	3.	4650	11800	15350
	Average	4800	11750	15500
COMPRESSIVE STRENGTH PSI		600	1500	2000

SAMPLE No. 4 SOURCE MAR SHA'YA

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	8900	15250	19900
	2.	8350	11000	18350
	3.	8400	13450	16850
	Average	8550	13250	18350
COMPRESSIVE STRENGTH PSI		1100	1700	2350

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 5 SOURCE DOWAR

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	14200	16950	18900
	2.	13300	18600	24100
	3.	15650	18300	20550
	Average	14400	17950	21200
COMPRESSIVE STRENGTH PSI		1850	2300	2750

SAMPLE No. 6 SOURCE SHWAYA

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	8500	14250	17300
	2.	8950	17150	15750
	3.	9150	15100	18300
	Average	8850	15500	17150
COMPRESSIVE STRENGTH PSI		1150	2000	2200

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 7		SOURCE DAHR EL-RAMLIEH		
CRUSHING		3 days	7 days	28 days
LOAD	1.	11550	24800	30250
Lbs.	2.	11250	24900	31150
	3.	13500	25150	26300
	Average	12100	24950	29250
COMPRESSIVE STRENGTH PSI		1550	3200	3750

SAMPLE No. 8		SOURCE BURGHLIAH		
CRUSHING		3 days	7 days	28 days
LOAD	1.	5100	4900	4200
Lbs.	2.	4350	4000	4300
	3.	4800	3850	4150
	Average	4750	4250	4250
COMPRESSIVE STRENGTH PSI		600	550	550

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 9 SOURCE GHABAT

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	11500	16900	40050
	2.	12850	19200	41100
	3.	13750	18550	39650
	Average	12700	18200	40250
COMPRESSIVE STRENGTH PSI		1650	2350	5200

SAMPLE No. 10 SOURCE JBEIL

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	4750	7850	12600
	2.	6750	7450	10250
	3.	5950	7100	9150
	Average	5800	7450	10650
COMPRESSIVE STRENGTH PSI		750	950	1350

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 11 SOURCE MASHROUH

		3days	7 days	28 days
CRUSHING LOAD Lbs.	1.	25750	34250	47150
	2.	26850	36700	45250
	3.	26750	35650	44500
	Average	26450	35550	45650
COMPRESSIVE STRENGTH PSI		3400	4600	5900

SAMPLE No. 12 SOURCE ABBOUDIEH

		3days	7 days	28 days
CRUSHING LOAD Lbs.	1.	6750	5500	6500
	2.	7200	5200	6350
	3.	6950	4950	5100
	Average	6950	5200	5950
COMPRESSIVE STRENGTH PSI		900	650	750

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 13 SOURCE AWZAI'

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	22750	32350	39750
	2.	27400	31050	41250
	3.	24500	33300	40100
	Average	24900	32250	40350
COMPRESSIVE STRENGTH PSI		3200	4150	5200

SAMPLE No. 14 SOURCE AIR PORT

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	13800	25350	31950
	2.	13000	28100	31200
	3.	15050	26750	30900
	Average	13950	26750	31350
COMPRESSIVE STRENGTH PSI		1800	3450	4050

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 15 SOURCE SAINT MICHEL

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	27150	41350	51200
	2.	31500	40650	50650
	3.	31000	41600	51600
	Average	29900	41200	51150
COMPRESSIVE STRENGTH PSI		3850	5300	6650

SAMPLE No. 16 SOURCE NAHR IBRAHIM

CRUSHING LOAD Lbs.		3 days	7 days	28 days
	1.	36650	49500	61300
	2.	36550	48850	63000
	3.	36200	49100	63300
	Average	36500	49150	62550
COMPRESSIVE STRENGTH PSI		4700	6350	8050

COMPRESSIVE STRENGTH OF MORTAR USING WARIOUS SAND SAMPLES

SAMPLE No. 17 SOURCE DBAYE'

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	25550	39050	46750
	2.	25200	40500	48800
	3.	24850	38750	47100
	Average	25200	39450	47550
COMPRESSIVE STRENGTH PSI		3250	5100	6150

SAMPLE No. 18 SOURCE AIN HAZIR

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	27250	37100	54300
	2.	26700	38000	52900
	3.	28000	36800	54750
	Average	27300	37300	54000
COMPRESSIVE STRENGTH PSI		3500	4800	6950

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 19 SOURCE AKKAR AL-ATIKA

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	6800	7050	11050
	2.	6000	6750	10900
	3.	6450	7500	11000
	Average	6400	7100	11000
COMPRESSIVE STRENGTH PSI		850	900	1400

SAMPLE No. 20 SOURCE BAROUK

		3days	7 days	28 days
CRUSHING LOAD Lbs.	1.	15550	20750	22750
	2.	14600	21150	23100
	3.	16350	19650	22900
	Average	15500	20500	22900
COMPRESSIVE STRENGTH PSI		2000	2650	2950

COMPRESSIVE STRENGTH OF MORTAR USING VARIOUS SAND SAMPLES

SAMPLE No. 21 SOURCE GHABOUN

CRUSHING		3 days	7 days	28 days
LOAD	1.	5650	6100	7000
Lbs.	2.	6000	5500	8100
	3.	5200	5750	6550
	Average	5600	5800	7200
COMPRESSIVE STRENGTH PSI		700	750	950

SAMPLE No. 22 SOURCE AL-ASSI (HIRMIL)

CRUSHING		3 days	7 days	28 days
LOAD	1.	7300	10500	17200
Lbs.	2.	6600	11250	16100
	3.	8350	10950	14400
	Average	7450	10900	15900
COMPRESSIVE STRENGTH PSI		950	1400	2000

COMPRESSIVE STRENGTH OF MORTAR USING CRUSHERS SAND WITHOUT WASHING

SAMPLE No. 24 SOURCE CRUSHERS

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	4050	5950	13200
	2.	3900	5600	12900
	3.	4500	6350	14100
	Average	4150	5900	13400
COMPRESSIVE STRENGTH PSI		550	750	1750

SAMPLE No. 23 SOURCE CRUSHERS

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	25700	34600	52900
	2.	34200	37200	49000
	3.	28300	36150	50100
	Average	29400	36000	50750
COMPRESSIVE STRENGTH PSI		3800	4650	6550

COMPRESSIVE STRENGTH OF MORTAR USING WASHED CRUSHERS SAND

SAMPLE No. 24 SOURCE CRUSHERS

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	8000	8750	10000
	2.	7950	8050	12350
	3.	8100	8250	10 100
	Average	8000	8350	10 800
COMPRESSIVE STRENGTH PSI		1000	1050	1400

SAMPLE No. 23 SOURCE CRUSHERS

		3 days	7 days	28 days
CRUSHING LOAD Lbs.	1.	6200	26500	23700
	2.	5900	18650	21100
	3.	6100	20150	22150
	Average	6050	21750	22300
COMPRESSIVE STRENGTH PSI		800	2800	2900

COMPRESSIVE STRENGTH OF MORTAR USING MIXED SAND FROM TWO SOURCES

NAHR IBRAHIM AND AIRPORT SAND MIXED IN EQUAL VOLUMES				
CRUSHING LOAD Lbs		3 days	7 days	28 days
	1.	25200	28500	36150
	2.	24900	28650	35900
	3.	23750	28150	36450
	Average	24600	28450	36150
COMPRESSIVE STRENGTH PSI		3150	3650	4650

AIRPORT SAND AND WASHED CRUSHERS SAND No. 23 MIXED IN EQUAL VOLUMES			
CRUSHING LOAD Lbs.		3 days	7 days
	1.	19250	27150
	2.	21600	27400
	3.	21100	28050
	Average	20650	27550
COMPRESSIVE STRENGTH PSI		2650	3550

APPENDIX - C -

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