APPENDIX VI-B
YARMOUK-JORDAN VALLEY PROJECT
MASTER PLAN REPORT

CONSTRUCTION MATERIALS

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INTRODUCTION

Field investigations were made at the following sites to determine the availability and suitability of local construction materials:

Yarmouk Diversion Site

Khalid Storage Site

Maqarin Storage Site

Zarqa Irrigation Site

East Ghor Canal Alignment

Each site was investigated for impervious and pervious borrow, concrete aggregate, riprap, and rock fill. The limits and volume of each source of material were determined, and representative samples were collected for testing.

Samples of concrete aggregate, quarry rock, rock fill, and cement from a local mill were tested by the Robert W. Hunt Company of Chicago, Illinois, U.S.A. Samples of impervious borrow were tested by Soil Testing Services, Inc., also of Chicago. Petrographic analyses of basalts from the Yarmouk Diversion Site were made by Dr. Howard A. Coombs, University of Washington, Seattle, Washington, U.S.A. Samples of water from various streams were tested by the Jordan Cement Factories, Amman, Jordan. The results of all these tests are given in Tables 1 to 12 and/or Drawings VI-B-2 to VI-B-6, of this report.

YARMOUK DIVERSION SITE

Borrow Material

Impervious Borrow

A suitable deposit of clay and clay loam occurs on a low floodplain terrace 1.4 kilometers downstream from the site immediately below the mouth of the Yarmouk Gorge. It is designated as area C on Drawing VI-B-1.

The deposit varies in depth from 1.5 to 4 meters and has a total volume of approximately 450,000 cubic meters.

The clay and clay loam was examined to determine its suitability as rolled fill material. It will be impervious when compacted forming a good core material and will be reasonably incompressible with little chance of swelling if properly compacted. However, those parts of the borrow which contain more than 40 percent clay may be subject to excessive swelling. Swelling takes place during saturation, reducing the density of the fill and resulting in a loss of strength.

The results of laboratory tests as shown on Drawing VI-B-2 indicate that a high degree of compaction of borrow is possible. The tested specimens exhibit good cohesion and internal friction indicating satisfactory shear strength.

Test results indicate that the material may be worked with the moisture content considerably above the optimum where design conditions do not require optimum strength and density.

The borrow may be used equally well for a core section or for an impervious blanket. It may also be used for a dam of uniform section.

However, in such case particular attention must be paid to toe drain and slope protection problems, and to selective placing of the material so that the more clayey portions of the borrow are placed in the center and the more sandy portions toward the outside.

Pervious Borrow

Pervious borrow may be obtained from alluvial gravel deposits along the river at or downstream from the site. These deposits are designated as areas A and B on Drawing VI-B-1.

The deposits at areas A and B have 20,000 and 110,000 cubic meters of material, respectively.

The gravel consists primarily of basalt with conspicuous but subordinate quantities of chalk and flint. It has a random gradation from 0.1 millimeters to 1 meter with more than 50 percent of the material by weight having diameters greater than 15 centimeters. Gradation curves of the material are shown on Drawing VI-B-2.

Filter Material

Sufficient filter and drain material can be screened from the above gravel. However, since more than 50 percent of the gravel by weight consists of particles greater than 15 centimeters in diameter, considerable segregation will be necessary to obtain proper gradation.

Riprap and Rock Fill

There is an ample source of basalt suitable for riprap and rock fill in both abutments at the site. The areas are designated as D and E on Drawing VI-B-1 and are fully described in Appendix VI-A, Damsite Geology, and illustrated on Drawings VI-A-2 and VI-A-3.

Concrete Aggregate

Natural Aggregate

The gravel described above and in Appendix VI-A, Damsite Geology, is not suitable for concrete aggregate. From 10 to 15 percent of the material consists of chalk and flint particles, the former being soft and friable and the latter deleterious. The basalt particles which comprise about 75 percent of the material are poorly graded and range from 0.1 millimeter to 1 meter in diameter. Segregation to obtain proper gradation would result in large quantities of waste material.

Manufactured Aggregate

Ample quantities of aggregate may be manufactured from three sources of basalt at the site. They include (1) the basalt boulders which make up about 50 to 75 percent of the alluvial gravels, (2) the basalt forming the cliffs on both abutments, and (3) the basalt talus on the left abutment. The basalt boulders are in areas designated A and B and the basalt cliffs in areas D and E on Drawing VI-B-1.

Petrographic analyses were made of samples taken from the basalt talus deposit on the left abutment. The results show that the basalt should be innocuous. The full text of the report is given in Table 1.

KHALID STORAGE SITE

Borrow Material

Impervious Borrow

A total of 15 areas, 10 on the right abutment and 5 on the left abutment, were investigated for impervious borrow. They are shown on Drawing VI-B-1 where they are designated as areas A through J, and I through V, on the right and left abutments, respectively.

The right abutment is the most likely source for material since the terraces are broad and extensive. Exploration to date indicates a total volume of 2,580,000 cubic meters of plastic, fat clay, ranging from 1 to 5 meters in thickness.

The left abutment has both terrace and plateau deposits. The terrace deposit (area I) varies in thickness from 1 to 3 meters and has an approximate volume of 500,000 cubic meters of plastic, fat clay similar to that encountered on the right abutment. Other areas (II-V) on top of the plateau south of the site have suitable deposits of similar material. They vary from 1 to 5 meters in thickness and exceed 2,450,000 cubic meters in volume.

The clay from the terraces was tested to determine its suitability as rolled fill material. The results of these tests are given on Drawing VI-B-3.

The clay will provide adequate water tightness to serve as impervious material. Although it may be somewhat compressible, it will be satisfactory for use as a central core in a rockfill or zoned earth dam and as an impervious blanket. However, due to its low frictional resistance the material is not recommended for use in an homogeneous earth dam nor as a blanket upon which shell material must rest.

The workability of soils with a high clay content is dependent upon the degree of consolidation of the material in situ and upon its natural water content. It is therefore recommended that any of this soil contemplated for use as borrow should be field tested for ease of excavating, placing, and rolling.

Pervious Borrow

Ample quantities of pervious borrow material may be obtained from alluvial gravel deposits at the site. The deposits are designated as areas K and O on Drawing VI-B-1.

The gravel is composed predominantly of basalt with some chalk (10 percent) and flint (5 percent). It has a random gradation from 0.1 millimeters to 40 centimeters with 30 to 40 percent of the material being sand. Gradation curves of the material are plotted on Drawing VI-B-3.

Filter Material

The random grading of the gravel at the site does not contain sufficient fines to be used as a first stage or composite filter material to protect the impervious materials from piping. A sample of the gravel was segregated into two gradations by sieving through a #4 sieve. Although the coarser fraction will be adequate to serve as a second stage filter or drain material, the finer fraction thus obtained does not meet the requirements for a first stage filter as the percentage of fines still remains low. However, as only one sample of the gravel was examined, further investigation and sampling is recommended. If further sampling does not disclose a larger percentage of fines than is now indicated, first stage filter material may be easily manufactured at the site by crushing the available gravels.

Riprap and Rock Fill

There is an ample source of material suitable for riprap and rock fill in the low-level basalt flow on the right abutment. The basalt is fully described in Appendix VI-A, Damsite Geology, and illustrated in Drawings VI-A-6, VI-A-7, and VI-A-8. The area is designated as L on Drawing VI-B-1.

Chunk samples of chalk were tested as shown in Table 4 for abrasion to determine its suitability for use as riprap or rock fill. The percentage of wear was 55 percent, thus exceeding by 5 percent the tolerable limit of 50 percent. The results substantiate field observations which indicated the rock was unsuitable for riprap or rock fill.

Concrete Aggregate

Natural Aggregate

The gravel described above and in Appendix VI-A, Damsite Geology, is considered to be unsuitable for concrete aggregate. About 10 to 15 percent of the material consists of particles of soft, friable chalk which range from sand-sized particles to a size 2 centimeters in diameter. Deleterious flint is also a common constituent of both sand and gravel size particles. Although the deleterious effects of the flint could possibly be neutralized by using a low-alkali cement, the removal of the chalk particles would be a costly operation.

The results of laboratory tests are shown on Tables 2 and 3 and the cumulative frequency curves are plotted on Drawing VI-B-3.

Although the results of the tests were within generally tolerable limits, the aggregate, for reasons stated above, is not considered to be suitable for the proposed structures.

Manufactured Aggregate

Ample quantities of aggregate may be manufactured from the low-level basalt flow on the right abutment. The basalt is designated as area L on Drawing VI-B-1, is described in Appendix VI-A, Damsite Geology, and is illustrated on Drawings VI-A-6, VI-A-7, and VI-A-8.

Petrographic analyses were not made of these basalts, but they are probably of the same composition as those described in Table 1 of this report for basalt samples collected at the Yarmouk Diversion Site. In all probability they are innocuous but they should be checked to confirm this opinion.

MAQARIN STORAGE SITE

Borrow Material

Impervious Borrow

Extensive investigations were conducted on the Jordan side of the site for sources of impervious borrow material. A high-level terrace on the centerline, indicated as area A on Drawing VI-B-1, is estimated from test pit data to contain approximately 1,200,000 cubic meters of a dark blackish-brown to salmon red, plastic, fat clay containing varying amounts of partially weathered basalt. The soil deposit varies in depth from 6 meters at the southern limit of the deposit to 1 meter at the northern limit where it is bounded by basalt outcrops.

A lower terrace at the foot of the talus slope, immediately upstream of the site, indicated as area B on Drawing VI-B-1, contains a soil deposit of medium grey to buff, moderately plastic, lean clay with angular fragments (20 percent) of limestone. The deposit is limited in extent, but the results from test-pit exploration indicate the depth to average over 6 meters and the total volume to be approximately 730,000 cubic meters.

Further exploration to find another source of impervious borrow material disclosed extensive areas, indicated as C on Drawing VI-B-1, on the rolling plateau south of the site. This soil deposit is shallow in most places with numerous exposures of limestone, particularly on the slopes. The soil is a reddish-brown, plastic, fat clay with angular fragments (15 percent) of limestone ranging up to 15 centimeters in diameter. The supply of this material is "unlimited."

Soils from the upper terrace (area A) and south plateau (area C) were tested to determine their suitability as a rolled fill material. Grain size analyses of the samples indicate that the materials are clay with high colloidal content and are similar in composition throughout the area.

Although the material is highly impervious, the absence of frictional resistance and the possibility of swelling (characteristic of colloidal soils) makes its use for a homogeneous dam or a blanket upon which shell material must rest undesirable. As the material will have little compressibility after proper compaction it may possibly be used as borrow for a central impervious core. However, its use as such should not be contemplated until further investigation has been made with respect to its workability and swelling properties.

Additional tests were carried out on representative samples from the lower terrace (area B). The soil from area B is more sandy and less clayey than the soil from areas A and C. Thus it will be more workable and have less tendency to swell when saturated. The material from area B will also be quite impervious and incompressible when adequately rolled, and it is the most desirable material for use as a central clay core.

Test data for the soils are shown on Drawing VI-B-4.

<u>Pervious Borrow</u>

The deposit of sand, cobbles, and boulders in the flood plain appears to be a likely source of pervious borrow. These areas are indicated as F and G on Drawing VI-B-1. The quantity available in the gravel bars extending from one kilometer upstream to approximately one kilometer downstream is estimated at 200,000 cubic meters. However, further investigation both upstream and downstream should disclose ample deposits to supply the required 700,000 cubic meters.

Filter Material

Unlimited areas of clean gravel, typical of the Yarmouk River deposits, are adjacent to the damsite. However, as a large percentage of these gravels have diameters greater than 7.5 centimeters, a screening plant will be necessary to obtain the various gradations of fine and coarse filter and drain material. Since the typical Yarmouk gravels contain about 30 percent by weight of material finer than a #4 sieve, there should be an adequate supply of all stages of filter required to protect the clay and clay loam soils contemplated for use as an embankment.

Riprap and Rock Fill

Ample quantities of basalt suitable for riprap and rock fill occur in the upper portion of each abutment. The areas are designated as E and D on Drawing VI-B-1.

Excavation of the basalt for road construction on the left abutment revealed that the basalt quarried into sizes suitable for riprap and rock fill.

Concrete Aggregate

Natural Aggregate

The gravels that fill the bottom of the Yarmouk Gorge at the Maqarin Storage Site are similar to those previously considered at the Yarmouk Diversion Site. Thus, for reasons already given, they are considered to be unsuitable for concrete aggregate.

The gravel deposits are designated as areas F and G on Drawing VI-B-1 and are described in Appendix VI-A, Damsite Geology.

Manufactured Aggregate

Ample quantities of basalt may be quarried for the manufacture of coarse and fine aggregate from the basalt flows that occupy the upper portion of each abutment. The areas are shown as D and E on Drawing VI-B-1.

Petrographic analyses were not made of these basalts, but they are probably innocuous. Megascopically, they are similar to those described in Table 1 of this report.

ZARQA IRRIGATION SITE

Borrow Material

Impervious Borrow Material

Extensively cultivated river terraces existing in the basin both upstream and downstream of the proposed axis of the dam and running to the foot of the knolls of Lisan Marl formation were investigated as a source of impervious material. The downstream terraces are under intensive agricultural development and therefore are not considered as available for borrow material. Those upstream are indicated as D and E on Drawing VI-B-1. The soil is a very uniform clay and has a high degree of compaction. The high clay content discourages its use in a homogeneous embankment section because of the difficulty in rolling when wet but indicates sufficient impermeability in situ to serve as an impervious blanket.

Investigation of the clays of the Lisan Marl formation revealed their suitability as impervious material. They are within economical range of the site and practically unlimited in volume. These areas are indicated as A and B on Drawing VI-B-1. The clays vary from silty to medium clay with some sand. The samples tested indicated sufficient impermeability and strength for use in the impervious core. The upstream blanket can also be made with this material and needs no special treatment except under the pervious rolled shell of the embankment.

Of the borrow areas investigated the clays of the Lisan Marl formation are recommended for the embankment and the upstream blanket.

Reference is made to Drawing VI-B-5 for details of testing data.

Pervious Borrow

The coarser fractions of the gravel in the river channel and extensive gravel bars appear to be suitable for pervious borrow material. The quantity available is considered ample, as determined by dozer trenches and test pits, for any possible design considerations. This area is indicated as E on Drawing VI-B-1. Reference is made to Drawing VI-B-5 for details of test data.

Filter Material

An ample supply of filter and drain material occurs as river sands and gravels at the Zarqa Irrigation Site. However, the material exists as a random mixture, grading from small boulders down to fine sand, rather than as segregated deposits. Therefore, it will be necessary to screen the random material at the site to obtain the various filter gradations. Samples of the random material were segregated by sieving through a #4 sieve to obtain a coarse and fine gradation. Grain size curves of the gradations thus produced indicate that the coarse aggregate will serve as a second stage filter and the fine aggregate will serve as a first stage filter. From the samples examined about 35% of the random material appears to be finer than a #4 sieve. Cumulative frequency curves(grain-size distribution curves) for this material are shown on Drawing VI-B-5.

Riprap and Rock Fill

Large quantities of limestone suitable for riprap are available on the left abutment. The limestone is described in Appendix VI-A, Damsite Geology, and designated as areas F and G on Drawing VI-B-1.

Concrete Aggregate

Natural Aggregate

A gravel bar suitable for a source of fine and coarse aggregate occurs between 200 and 900 meters upstream from the proposed axis of the dam. It is designated as area E on Drawing VI-B-1 and shown in more detail on Drawings VI-A-13 and VI-A-15.

The gravel bar has a total volume of 1,500,000 cubic meters and an average thickness of approximately 10 meters.

The gravel is composed of hard, clean, rounded particles of limestone, sandstone, and flint, the limestone being predominate. The flint is deleterious but the effects may be neutralized by using a low-alkali cement.

The gravel is sandy with particles ranging from 0.1 millimeter to 45 centimeters in diameter. It has ample quantities of both coarse and fine material but will require grading to meet specifications.

The results of laboratory tests are given in Table 5 and the cumulative frequency curves are plotted on Drawing VI-B-5.

Manufactured Aggregate

There are ample quantities of suitable limestone on the left abutment that may be quarried for the manufacture of fine and coarse aggregates.

EAST GHOR CANAL

Borrow Material

Impervious Borrow

Based on data from test pits and auger borings there are ample quantities of impervious borrow along the alignment of the canal. A large portion of impervious borrow may be obtained from the canal excavation, but where canal excavation is insufficient impervious borrow may be taken from areas immediately east of the alignment. Borrowing would be restricted to the east side to eliminate destruction of irrigable land lying to the west.

Generally the soil is a sandy clay and would make suitable compacted fill. The material is satisfactory as impervious blanket material and as a central core for zoned earthfill or rockfill structures. If used for homogeneous rolled fill dams the following general limitations must be applied:

1. For dikes not exceeding 10 meters in height, slopes not steeper than 2.0^h to 1.0^v shall be used.
2. For dikes greater than 10 meters but not exceeding 30 meters in height, slopes not steeper than 3.0^h to 1.0^v shall be used.

The strengths of the impervious borrow materials are based on the grain size curves shown on Drawing VI-B-6.

Pervious Borrow

There appears to be ample quantity of pervious material available, based on data from test pits, in both the canal excavation and along the minor wadis. The materials vary from well-graded sands and gravels to angular limestone debris ranging up to 15 centimeters in diameter.

Filter Material

Samples of river gravels from various locations along the canal alignment were examined for use as filter and drain material. Grain size curves of the random samples disclosed a percentage of fines insufficient for adequate filter protection of the clay loam soils contemplated for use in the embankment. However, the random samples were separated into a coarse and fine gradation by sieving through a U. S. Standard #4 sieve. The material passing the #4 sieve will serve adequately as a first stage filter for the clay loams, and the material retained on the #4 sieve will serve as a second stage filter. The four random samples examined indicated that about 30 percent by weight of the river gravels will serve as first stage filter material.

The random river gravels are reasonably well graded with particles ranging from 0.2 to 90 millimeters in diameter and should therefore have an average permeability of about 4800×10^{-4} cm/sec. This material will serve as excellent drain material and is so recommended. See Drawing VI-B-6 for grain-size distribution curves of pervious materials.

Riprap

Riprap for the flume section of the canal may be quarried from the basalt cliffs at the mouth of the Yarmouk Gorge or obtained from basalt talus deposits lying at the base of the cliffs.

Concrete Aggregate

Natural Aggregate

The wadis that drain the eastern highlands derive their debris from several stratigraphic units which are described in Volume II, Part 2. Thus, the composition of the gravel deposits along the wadis will be determined by the lithology of the bedrock outcropping in their respective drainage basins. This being the case, the wadis draining the northern area underlain by soft, friable chalks, including some flint, of the Belqa Series will have gravel deposits unsuitable for aggregate. On the other hand, those draining the southern area largely underlain by crystalline limestones and sandstones of the Ajlun Series and Zarqa Group may have gravel deposits suitable for aggregate - depending on factors other than composition. This condition was confirmed by field investigations and is illustrated by the results of laboratory tests on Samples 8, 9, and 10 shown in Tables 6, 7, and 8, respectively. Sample 10 was collected from Wadi Arab which drains the northern area. The chalk was found to be unsuitable for aggregate. Samples 8 and 9 were collected from wadis draining the southern area. The results of the tests are satisfactory.

It is important to note that most natural aggregates in the Jordan Valley area have appreciable quantities of flint. The flint is deleterious but the effects may be neutralized by using a low-alkali cement.

Manufactured Aggregate

Ample quantities of rock suitable for the manufacture of fine and coarse aggregate may be quarried from selected sites along the steep slopes that form the eastern border of the Ghor.

The basalt flows at the mouth of the Yarmouk Gorge provide an excellent source of material and have previously been recommended in this report as a source of aggregate for the Yarmouk Diversion Project. Petrographic analyses of these rocks are given in Table 1, the results showing that they should be innocuous.

The chalks of the Belqa Series that form the valley slopes from the Yarmouk Gorge to Wadi Yabis are not suitable for concrete aggregate. They are soft and friable and subject to cavitation.

The crystalline limestones of the Ajlun Series and Zarga Group that outcrop intermittently along the valley walls from Wadi Yabis to the Dead Sea are a good source for quarry rock for the manufacture of coarse and fine aggregate. These rocks are widespread and would provide a choice of several sites.

LOCAL SOURCE OF CEMENT

The only cement mill in Jordan is 21 kilometers northwest of Amman near the village of Fuhais. It is accessible from Amman, the nearest rail-head, by paved road.

At the present time, the plant has a maximum and a minimum output of 235 and 200 metric tons per day, respectively. Tentative plans call for installation of an additional kiln in 1955.

A portland cement which corresponds to Type I, ASTM Standards, is being produced at the present time. In the near future, a pozzolanic type of cement, Type IV, ASTM Standards, will be available.

Four samples were tested according to ASTM Standards by the Robert W. Hunt Company, Chicago, Illinois, U. S. A. The results of these tests are given in Tables 9, 10, and 11.

WATER ANALYSES

Chemical analyses were made on water samples collected from the following rivers and wadis:

Rivers

- Yarmouk
- Zarqa
- Jordan

Wadis

- Yabis
- Kufrinje
- Rajib
- Hisban
- Kafrein

The results of the analyses are given in Table 12. They show that the waters are relatively low in sulphate compounds of magnesium, sodium, and calcium and should not have deleterious effects on concrete structures.

PETROGRAPHIC REPORT ON AGGREGATE FOR CONCRETE

YARMOUK DIVERSION SITE

By

Howard A. Coombs
Consulting Geologist

Samples of basalt 300 meters upstream from proposed damsite located 1.5 kilometers upstream from the mouth of the gorge.

Report prepared according to A.S.T.M. Designation C295-52T, issued 1952.

Summary

The rock from the indicated locality on the Yarmouk River, Jordan, is all basalt. More specifically the rock is a very fresh, gray, vesicular, olivine basalt. The vesicules range from microscopic size in some samples up to those measuring several centimeters in length in other samples. A buff colored calcite has entered some of the vesicules as a secondary material and completely or partially filled a small percentage of the blow holes. One sample showed a face covered with calcite.

Under the microscope the rock is seen to be very fresh with practically no alteration products. One fact is clear that all the basalts are of the same composition and probably originated from the same source. All contain the identical minerals found in all the other samples. These are: plagioclase, olivine, augite, magnetite, ilmenite, calcite, and in one sample, a small amount of glass. The main variation in the

rocks is the volume and size of the vesicules present, and the condition of the groundmass. In the highly vesicular rocks the groundmass is finer and in one sample contained a little glass. In the less vesicular rocks the groundmass is coarser and the samples contain a greater concentration of olivine.

Three features worthy of note in connection with this material and its use as concrete aggregate are:

1. the presence of basaltic glass in one of the samples,
2. the high percentage of pore space in some of the samples because of vesicules, and
3. the presence of calcite as a secondary product partially filling the vesicules.

The basaltic glass is the only material observed in the thin sections that would ordinarily be considered deleterious. Although the amount is small it might be well to specify a cement containing less than 0.6 percent of total alkalis. If this material is quarried more of the marginal portions of the flow might be included where the percentage of glass would be greater. The above statements are not intended as a general opinion regarding the quality of the material. The A.S.T.M. Designation C295-52T specifically mentions that the report should not contain a general statement of opinion by the petrographer concerning the quality of the material. Detailed descriptions of the samples are given in the pages that follow.

Sample No. 1. Fresh gray basalt.

The rock is slightly vesicular showing vesicules averaging approximately 1 mm in diameter scattered so as not to average more than one vesicule per square centimeter of surface. A few smaller cavities exist in the rock and these are but a small fraction of the size of the vesicules. No weathering occurs on the surface of the rock sample sent in. The hand specimen is a uniform medium gray color in which the small lathe of feldspar can be determined by a hand lens.

The microscope reveals the rock to be an olivine basalt. The phenocrysts of olivine average approximately 1 mm in greatest dimension but the maximum approaches twice this figure. Augite is also present as phenocrysts but encloses plagioclase in a fashion typical of many diabases.

The most abundant mineral in the rock is plagioclase in the form of thin, tabular crystals. These average 0.5 mm in length and are very flat when viewed on edge. The largest ones can be seen in the hand specimen with a lens.

Between the rather felted texture of the plagioclase is a base or mesostasis of very fine material composed mainly of small augite granules, smaller feldspar crystals, magnetite and ilmenite grains. A small amount of pale brown glass occurs between some of the feldspars. This has an index of refraction of 1.564. Several patches of calcite were observed in the thin section. Calcite would be present in quantity of at least several percent.

A rough evaluation of the quantity of minerals present would be as follows: plagioclase 55%, olivine 17%, augite 10%, groundmass, including glass and magnetite 15%, and calcite 3%.

Sample No. 2. Fresh, gray basalt.

In hand specimen this rock is almost identical to Sample No. 1. The vesicules are about 1 mm in diameter and some partially or completely filled with calcite forming amygdules. No weathering or secondary products other than calcite are visible in the hand specimen. The small, green patches are clusters of olivine grains and not due to weathering.

Under the microscope the rock shows plagioclase laths, olivine, augite, and intergranular groundmass almost identical to Sample No. 1. The olivine and/or augite phenocrysts have a tendency to form clusters. A few olivine grains show slight alteration to antigorite or bowlingite. The groundmass is almost entirely crystalline. The small amount of pale brown glass observed in Sample No. 1 was not present in this slide. The mineral composition is practically identical to Sample No. 1.

Sample No. 3. Fresh, gray basalt.

The rock is very similar to Samples No. 1 and 2, except the vesicules are smaller. Some vesicules are partially filled with calcite. Again the olivine phenocrysts tend to form small clusters.

Under the microscope the chief difference between this rock and Sample No. 2 is the size of the vesicules. They are much smaller, perhaps half the size of the vesicules in the first two samples. However, this does not mean they are any less abundant. The total volume of vesicules would probably be the same in all three samples. The kind and quantity of minerals present is identical to Sample No. 2.

Sample No. 4. Fresh, gray vesicular basalt.

In color and general texture this rock is similar to the others. It differs in that it is obviously vesicular. The vesicules measure up to one cm. in length and most of them are coarse and irregular in shape. Portions of the surface are coated with a thin buff colored layer of calcite. Some of the large vesicules are partially filled with calcite.

Under the microscope the rock is identical to Samples No. 2 and 3. A little quartz was seen in a few of the vesicules but the total quantity would be less than 2%.

Sample No. 5. Fresh, gray, vesicular basalt.

The rock is identical to the others in general appearance but it is very vesicular both in regard to the number and size of the blow holes. Certain portions of the rock may have as much as 24% pore space. Some vesicules are completely filled with calcite but others have none. Most of the blow holes are empty.

Under the microscope the essential difference between this rock and the others is the condition of the groundmass. The high degree of vesicularity suggests the sample originally came from the top of the flow. The dark and dense groundmass bears out this suggestion. The plagioclase, olivine and augite are exactly like those in the other samples. The interstitial mineral between these crystals is so charged with fine magnetite and ilmenite dust that it is almost opaque. Under such conditions it is impossible to determine if glass is present in the groundmass.

Sample No. 6. Fresh, gray basalt.

Again the rock is identical to the others except in the degree of vesiculation. Sample No. 6 has vesicules but they are very small and inconspicuous. Another feature worthy of note is the almost complete lack of carbonate in the vesicules.

Under the microscope the visible minerals are plagioclase, olivine, augite, magnetite, and ilmenite with a groundmass of holocrystalline granules of augite, plagioclase, and opaque minerals. No glass was observed in the thin section. The holocrystalline nature of the rock together with the lack of large vesicules indicates the rock came from the central portion of a flow. Insofar as concrete aggregate is concerned, this type of the basalt is the most desirable.

Sample No. 7. Fresh, gray basalt.

The hand specimen shows but a few scattered vesicules in a very compact and even grained rock. In all other respects it resembles the previously described samples.

Under the microscope the thin section shows a higher percentage of olivine phenocrysts that may well total over 25% of the rock. The reason may be due to gravitative settling at the time the flow poured out. Calcium carbonate is present in some of the blow holes but would make less than 5% of the rock. Some of the olivine grains are rimmed with brown alteration products but the rock is not weathered or weakened by any secondary alteration. No glass was observed in the groundmass. It appears to be composed exclusively of smaller grains of the other minerals in the rocks.

Sample No. 8. Fresh, gray basalt.

Samples No. 7 and 8 are practically identical. They differ a little from the others in the lack of conspicuous vesicules.

Under the microscope the rock shows a higher concentration of olivine phenocrysts and in this respect it also resembles Sample No. 7. The plagioclase, augite, olivine, and opaque minerals are all remarkably fresh and unaltered. The groundmass is the coarsest of all the samples and is holocrystalline. No glass is present.

/s/ Howard A. Coombs

Howard A. Coombs
Consulting Geologist
Professor and Executive Officer
Department of Geology
University of Washington
Seattle 5, Washington

January 29, 1955

CONCRETE AGGREGATE

KHALID STORAGE SITE

Sample No. 14

Material Retained on a No. 4 Sieve
Percent, By Weight 62.13
Material Passing a No. 4 Sieve
Percent, By Weight 37.87

SIEVE ANALYSIS
(Grading of Aggregate By Weight)

U.S. Standard Sieve Size	Coarse Aggregate ** Cumulative Percent Retained	Coarse Aggregate ** Percent Passing	Fine Aggregate ** Cumulative Percent Retained	Fine Aggregate ** Percent Passing
3 1/2"	00	100		
3"	21	79		
2 1/2" *	38	62		
2" *	52	48		
1 1/2"	63	37		
1" *	75	25		
3/4"	80	20		
1/2" *	86	14		
3/8"	90	10		
No. 4	100	00	00	100
No. 8	100	00	19	81
No. 16	100	00	52	48
No. 30	100	00	79	21
No. 50	100	00	94	06
No. 100	100	00	98	02
Fineness Modulus	8.54		3.42	

*(Not included in Fineness Modulus calculations.)

** Sample separated on a No. 4 sieve into Coarse and Fine Aggregate classification prior to tests reported herein.

UNIT WEIGHT
(Lbs. Per Cu. Ft.)

	Rodded Weight Room Dry
Coarse Aggregate	115.6 (1851 Kg/M3)
Fine Aggregate	110.1 (1763 ")

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Coarse Aggregate 2.62
Fine Aggregate 2.66

ABSORPTION
(By Weight, Percent)

Coarse Aggregate 2.19
Fine Aggregate 4.20

ORGANIC IMPURITIES
(Color Value)

Fine Aggregate . . . . Plate No. 2

MATERIAL FINER THAN A NO. 200 SIEVE
(By Weight, Percent)

Coarse Aggregate 0.89
Fine Aggregate 1.02

ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

Grading . . . . "A"
Weight of Sample Before Test, Grams 5000
Weight of Sample After Test,
(Retained on a No. 12 Sieve), Grams 3219
Loss in Weight, Grams 1781
Percentage of Wear 35.62

SOUNDNESS OF COARSE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
2 1/2"	1 1/2"	63	3009	11.26	7.09
1 1/2"	3/4"	17	1720	9.33	1.59
3/4"	3/8"	10	1111	9.70	0.97
3/8"	No. 4	10	400	8.33	0.83
	Totals	100	6240		10.48

Qualitative Examination:

Sieve Size: Passing	Sieve Size: Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test — Pieces Affected: Split or Disintegrated	Pieces Affected: Chipped or Flaked	Pieces in Good Condition
2 1/2"	1 1/2"	37	2	12	23
1 1/2"	3/4"	46	3	11	32

SOUNDNESS OF FINE AGGREGATE
BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size: Passing	Sieve Size: Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
No. 100	—	1.6	—	—	—
No. 50	No. 100	4.8	—	—	—
No. 30	No. 50	14.2	100	7.1	1.01
No. 16	No. 30	27.0	100	8.3	2.24
No. 8	No. 16	33.6	100	9.6	3.23
No. 4	No. 8	18.8	100	10.2	1.92
3/8"	No. 4	—	—	—	—
	Totals	100.0	400		8.40

CONCRETE AGGREGATE

KHALID STORAGE SITE

Sample No. 15

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Sample, as received 2.82

ABRASION OF COARSE AGGREGATE
BY USE OF THE LOS ANGELES MACHINE

Grading . . . . "A"
Weight of Sample Before Test, Grams 5000
Weight of Sample After Test
(Retained on a No. 12 Sieve), Grams 4043
Loss in Weight, Grams 957
Percentage of Wear 19.14

SOUNDNESS OF COARSE AGGREGATE
BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
1 1/2"	3/4"	48	1731	5.90	2.83
3/4"	3/8"	32	1202	6.23	1.99
3/8"	No. 4	20	400	9.33	1.87
	Totals	100	3333		6.69

Qualitative Examination:

Sieve Size Passing	Sieve Size Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test: Pieces Affected: Split or Disintegrated	Pieces Affected: Chipped or Flaked	Pieces in Good Condition
1 1/2"	3/4"	61	2	7	52

CONCRETE AGGREGATE

KHALID STORAGE SITE

Sample No. 16

ABRASION OF COARSE AGGREGATE
BY USE OF THE LOS ANGELES MACHINE

Grading	"A"
Weight of Sample Before Test, Grams	5000
Weight of Sample After Test (Retained on a No. 12 Sieve), Grams	2247
Loss In Weight, Grams	2753
Percentage of Wear	55.06

CONCRETE AGGREGATE

ZARQA IRRIGATION SITE

Sample No. 13

Material Retained on a No. 4 Sieve
Percent, By Weight 64.89
Material Passing a No. 4 Sieve
Percent, By Weight 35.11

SIEVE ANALYSIS
(Grading of Aggregate By Weight)

U. S. Standard Sieve Size	Coarse Aggregate ** Cumulative Percent Retained	Coarse Aggregate ** Percent Passing	Fine Aggregate ** Cumulative Percent Retained	Fine Aggregate ** Percent Passing
3"	00	100		
2 1/2" *	04	96		
2" *	22	78		
1 1/2"	32	68		
1" *	53	47		
3/4"	66	34		
1/2" *	80	20		
3/8"	87	13		
No. 4	100	00	00	100
No. 8	100	00	10	90
No. 16	100	00	25	75
No. 30	100	00	45	55
No. 50	100	00	79	21
No. 100	100	00	95	05
Fineness Modulus	7.85		2.54	

* (Not included in Fineness Modulus calculations).

** Sample separated on a No. 4 sieve into Coarse and Fine Aggregate classification prior to tests reported herein.

UNIT WEIGHT
(Lbs. Per Cu. Ft.)

	Rodded Weight Room Dry
Coarse Aggregate	104.7 (1676 Kg/M3)
Fine Aggregate	105.2 (1684 ")

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Coarse Aggregate	2.61
Fine Aggregate	2.62

ABSORPTION
(By Weight, Percent)

Coarse Aggregate	1.73
Fine Aggregate	1.01

MATERIAL FINER THAN A NO. 200 SIEVE
(By Weight, Percent)

Coarse Aggregate	0.90
Fine Aggregate	4.40

ABRASION OF COARSE AGGREGATE
BY USE OF THE LOS ANGELES MACHINE

Grading	"A"
Weight of Sample Before Test, Grams	5000
Weight of Sample After Test, (Retained on a No. 12 Sieve), Grams	3735
Loss In Weight, Grams	1265
Percentage of Wear	25.30

SOUNDNESS OF COARSE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
1 1/2"	3/4"	66	1551	9.80	6.47
3/4"	3/8"	21	1100	7.00	1.47
3/8"	No. 4	13	300	4.33	0.56
	Totals	100	2951		8.50

Qualitative Examination:

Sieve Size Passing	Sieve Size Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test: Pieces Affected: Split or Disintegrated	Pieces Affected: Chipped or Flaked	Pieces in Good Condition
1 1/2"	3/4"	43	3	12	28

SOUNDNESS OF FINE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
No. 100	--	5.0	--	--	--
No. 50	No. 100	16.4	--	--	--
No. 30	No. 50	33.2	100	9.0	2.99
No. 16	No. 30	20.4	100	8.6	1.75
No. 8	No. 16	14.8	100	4.2	0.62
No. 4	No. 8	10.2	100	5.7	0.58
3/8"	No. 4	--	--	--	--
	Totals	100.0	400		5.94

CONCRETE AGGREGATE

EAST GHOR CANAL ALIGNMENT

Sample No. 8 (From Wadi Bust El Farras, on East Ghor Highway, at kilometer-post 65

Material Retained on a No. 4 Sieve
Percent, By Weight 83.02
Material Passing a No. 4 Sieve
Percent, By Weight 16.98

SIEVE ANALYSIS
(Grading of Aggregate By Weight)

U. S. Standard Sieve Size	Coarse Aggregate **		Fine Aggregate **	
	Cumulative Percent Retained	Percent Passing	Cumulative Percent Retained	Percent Passing
3 1/2"	00	100		
3"	09	91		
2 1/2" *	10	90		
2" *	19	81		
1 1/2"	31	69		
1" *	53	47		
3/4"	66	34		
1/2" *	81	19		
3/8"	90	10		
No. 4	100	00	00	100
No. 8	100	00	22	78
No. 16	100	00	32	68
No. 30	100	00	41	59
No. 50	100	00	74	26
No. 100	100	00	93	07
Fineness Modulus	7.96		2.62	

* (Not included in Fineness Modulus calculations).

** Sample separated on a No. 4 sieve into Coarse and Fine Aggregate classification prior to tests reported herein.

UNIT WEIGHT
(Lbs. Per Cu. Ft.)

	Rodded Weight Room Dry
Coarse Aggregate	101.50 (1625 Kg/M3)
Fine Aggregate	113.50 (1817 ")

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Coarse Aggregate	2.62
Fine Aggregate	2.60

ABSORPTION
(By Weight, Percent)

Coarse Aggregate	1.73
Fine Aggregate	2.04

ORGANIC IMPURITIES
(Color Value)

Fine Aggregate	Plate No. 2

MATERIAL FINER THAN A NO. 200 SIEVE
(By Weight, Percent)

Coarse Aggregate	0.80
Fine Aggregate	2.11

ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

Grading	"A"
Weight of Sample Before Test, Grams	5000
Weight of Sample After Test (Retained on a No. 12 Sieve), Grams	3500
Loss In Weight, Grams	1500
Percentage of Wear	30.00

SOUNDNESS OF COARSE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size: Passing	Sieve Size: Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
1 1/2"	3/4"	66	1698	9.67	6.38
3/4"	3/8"	24	1241	6.60	1.58
3/8"	No. 4	10	402	5.08	0.51
	Totals	100	3341		8.47

Qualitative Examination:

Sieve Size: Passing	Sieve Size: Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test: Pieces Affected: Split or Disintegrated	Chipped or Flaked	Pieces in Good Condition
1 1/2"	3/4"	54	3	15	36

SOUNDNESS OF FINE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size: Passing	Sieve Size: Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
No. 100	--	6.6	--	--	--
No. 50	No. 100	19.8	--	--	--
No. 30	No. 50	32.4	100	7.1	2.30
No. 16	No. 30	8.8	100	7.5	0.66
No. 8	No. 16	10.4	100	8.7	0.90
No. 4	No. 8	22.0	100	9.3	2.05
3/8"	No. 4	--	--	--	--
	Totals	100.0	400		5.91

CONCRETE AGGREGATE

EAST GHOR CANAL ALIGNMENT

Sample No. 9 (From Wadi Qarn on East Ghor Highway, at kilometer-post 105.

Material Retained on a No. 4 Sieve
Percent, By Weight. 70.89
Material Passing a No. 4 Sieve
Percent, By Weight. 29.11

SIEVE ANALYSIS
(Grading of Aggregate By Weight)

U. S. Standard Sieve Size	Coarse Aggregate ** Cumulative Percent Retained	Coarse Aggregate ** Percent Passing	Fine Aggregate ** Cumulative Percent Retained	Fine Aggregate ** Percent Passing
3 1/2"	00	100		
3"	08	92		
2 1/2" *	14	86		
2" *	21	79		
1 1/2"	31	69		
1" *	46	54		
3/4"	59	41		
1/2" *	74	26		
3/8"	84	16		
No. 4	100	00	00	100
No. 8	100	00	25	75
No. 16	100	00	53	47
No. 30	100	00	74	26
No. 50	100	00	87	13
No. 100	100	00	93	07
Fineness Modulus	7.82		3.32	

* (Not included in Fineness Modulus calculations).

** Sample separated on a No. 4 Sieve into Coarse and Fine Aggregate classification prior to test reported herein.

UNIT WEIGHT
(Lbs. Per Cu. Ft.)

	Rodded Weight Room Dry
Coarse Aggregate	98.50 (1577 Kg/M3)
Fine Aggregate	105.80 (1694 ")

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Coarse Aggregate.	2.58
Fine Aggregate.	2.53

ABSORPTION
(By Weight, Percent)

Coarse Aggregate	1.52
Fine Aggregate	3.09

ORGANIC IMPURITIES
(Color Value)

Fine Aggregate	Plate No. 3

MATERIAL FINER THAN A NO. 200 SIEVE
(By Weight, Percent)

Coarse Aggregate	1.12
Fine Aggregate	6.65

ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

Grading	"A"
Weight of Sample Before Test, Grams	5000
Weight of Sample After Test, (Retained on a No. 12 Sieve), Grams	3705
Loss In Weight, Grams	1295
Percentage of Wear	25.90

SOUNDNESS OF COARSE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
1 1/2"	3/4"	59	1687	5.19	3.06
3/4"	3/8"	25	1149	4.50	1.12
3/8"	No. 4	16	400	4.33	0.69
	Totals	100	3236		4.87

Qualitative Examination:

Sieve Size Passing	Sieve Size Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test: Pieces Affected — Split or Disintegrated	Pieces Affected — Chipped or Flaked	Pieces in Good Condition
1 1/2"	3/4"	49	2	16	31

SOUNDNESS OF FINE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
No. 100	--	6.8	--	--	--
No. 50	No. 100	6.4	--	--	--
No. 30	No. 50	13.2	100	3.9	0.51
No. 16	No. 30	20.8	100	4.3	0.89
No. 8	No. 16	27.4	100	5.5	1.51
No. 4	No. 8	25.4	100	6.2	1.57
3/8"	No. 4	--	--	--	--
	Totals	100.0	400		4.48

CONCRETE AGGREGATE

EAST GHOR CANAL ALIGNMENT

Sample No. 10 (From Wadi Arab, on East Ghor Highway, at kilometer-post 155.

Material Retained on a No. 4 Sieve
Percent, By Weight 64.35
Material Passing a No. 4 Sieve
Percent, By Weight 35.65

SIEVE ANALYSIS
(Grading of Aggregate By Weight)

U. S. Standard Sieve Size	Coarse Aggregate ** Cumulative Percent Retained	Coarse Aggregate ** Percent Passing	Fine Aggregate ** Cumulative Percent Retained	Fine Aggregate ** Percent Passing
3 1/2"	00	100		
3"	06	94		
2 1/2" *	11	89		
2" *	22	78		
1 1/2"	31	69		
1" *	53	47		
3/4"	69	31		
1/2" *	84	16		
3/8"	91	09		
No. 4	100	00	00	100
No. 8	100	00	12	88
No. 16	100	00	27	73
No. 30	100	00	44	56
No. 50	100	00	65	35
No. 100	100	00	82	18
Fineness Modulus	7.97		2.30	

* (Not included in Fineness Modulus calculations).

** Sample separated on a No. 4 Sieve into Coarse and Fine Aggregate classification prior to tests reported herein.

UNIT WEIGHT
(Lbs. Per Cu. Ft.)

	Rodded Weight Room Dry
Coarse Aggregate	93.5 (1497 Kg/M3)
Fine Aggregate	100.5 (1609 ")

BULK SPECIFIC GRAVITY
(Saturated Surface Dry Basis)

Coarse Aggregate	2.48
Fine Aggregate	2.44

ABSORPTION
(By Weight, Percent)

Coarse Aggregate	3.57
Fine Aggregate	5.48

ORGANIC IMPURITIES
(Color Value)

Fine Aggregate	Between Plate No. 3 and Plate No. 4

MATERIAL FINER THAN A NO. 200 SIEVE
(By Weight, Percent)

Coarse Aggregate	1.09
Fine Aggregate	9.73

ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

Grading	"A"
Weight of Sample Before Test, Grams	5000
Weight of Sample After Test (Retained on a No. 12 Sieve), Grams	3454
Loss in Weight, Grams	1546
Percentage of Wear	30.92

SOUNDNESS OF COARSE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
1 1/2"	3/4"	69	1703	16.30	11.25
3/4"	3/8"	.22	1212	15.67	3.45
3/8"	No. 4	09	401	14.33	1.29
	Totals	100	3316		15.99

Qualitative Examination:

Sieve Size Passing	Sieve Size Retained	Pieces in Test Fraction Before Test	Appearance of Material After Test: Pieces Affected: Split or Disintegrated	Pieces Affected: Chipped or Flaked	Pieces in Good Condition
1 1/2"	3/4"	47	5	16	26

SOUNDNESS OF FINE AGGREGATE BY USE OF SODIUM SULFATE (5-Cycles)

Quantitative Results:

Sieve Size Passing	Sieve Size Retained	Grading of Original Sample Percent	Weight of Test Fractions Before Test, Grams	Passing Finer Sieve After Test (Actual Percent Loss)	Weighted Average (Corrected Percent Loss)
No. 100	--	18.2	--	--	--
No. 50	No. 100	17.2	--	--	--
No. 30	No. 50	20.6	100	8.9	1.83
No. 16	No. 30	16.8	100	10.8	1.81
No. 8	No. 16	14.8	100	12.6	1.86
No. 4	No. 8	12.4	100	14.1	1.75
3/8"	No. 4	--	--	--	--
	Totals	100.0	400		7.25

TABULATION OF TEST RESULTS

OF CEMENT FROM

JORDAN CEMENT PLANT

near Amman, Jordan

Sample No. 1

Tested in accordance with methods prescribed in ASTM Designations C150-49 and C186-49

PHYSICAL TESTS

Fineness: Material Passing a No. 325 Sieve, By Weight, Percent	80.0
Fineness: Specific Surface Value, Sq. Cm. Per Gram	1632
Normal Consistency: Amount of Water Required By Weight, Percent	24.00
Soundness: Autoclave Expansion Percent	+7.01
Time of Setting: Gilmore Method	
Initial Set - Hours: Minutes	3:00
Final Set - Hours: Minutes	4:55

COMPRESSIVE STRENGTH
(On Standard 2-Inch Cubes)
(lbs.Per Sq.In.)

Age At Test	3-Days	7-Days
	2100 (147.6 Kg/cm^2)	3075 (216.2 Kg/cm^2)
	2250 (158.2 ")	2925 (205.7 ")
	2225 (155.4 ")	3050 (214.4 ")
Average -	2192 (154.1 ")	3017 (212.1 ")

Water used by Weight, Percent 57.50
Flow (Consistency), Percent 112.50

TENSILE STRENGTH
(On Standard Briquets)
(lbs.Per Sq.In.)

Age At Test	3-Days	7-Days
	340 (23.9 Kg/cm^2)	420 (29.5 Kg/cm^2)
	365 (26.4 ")	405 (28.5 ")
	330 (23.2 ")	440 (30.9 ")
Average -	345 (24.3 ")	422 (29.7 ")

Water used by Weight, Percent 10.50

CHEMICAL ANALYSIS

Magnesium Oxide (MgO), Percent	.79
Sulfur Trioxide (SO_3), Percent	2.10
Loss On Ignition, Percent	2.01
Iron Oxide (Fe_2O_3), Percent	2.72
Aluminum Oxide (Al_2O_3), Percent	6.00
Sodium Oxide (Na_2O), Percent	0.37
Potassium Oxide (K_2O), Percent	0.47
Alkalies (Summation Percentage Na_2O+0.648 Percent K_2O)	0.67
Calcium Oxide (CaO), Percent	66.00
Tricalcium Aluminate ($3CaO.Al_2O_3$) Percent	11.56
Insoluble Residue, Percent	0.19

TABULATION OF TEST RESULTS

OF CEMENT FROM

JORDAN CEMENT PLANT

near Amman, Jordan

Sample No. 2

Tested in accordance with methods prescribed in ASTM Designation C150-49, Type 1

PHYSICAL TESTS

Fineness: Material Passing a No. 325 Sieve, By Weight, Percent	81.20
Fineness: Specific Surface Value, Sq. Cm. Per Gram	1727
Normal Consistency: Amount of Water Required By Weight, Percent	25.00
Soundness: Autoclave Expansion Percent	+0.20
Time of Setting: Gilmore Method Initial Set - Hours: Minutes	3:05
Final Set - Hours: Minutes	5:00

COMPRESSIVE STRENGTH
(On Standard 2-Inch Cubes)
(Lbs.Per Sq.In.)

Age At Test	3-Days		7-Days	
	2150	(151.2 Kg/cm^2)	2750	(193.4 Kg/cm^2)
	2200	(154.7 ")	3150	(221.5 ")
	2250	(158.2 ")	3025	(212.7 ")
Average	2200	(154.7 ")	2975	(209.2 ")

Water used by Weight, Percent 55.71
Flow (Consistency), Percent 112.50

TENSILE STRENGTH
(On Standard Briquets)
(Lbs.Per Sq.In.)

Age At Test	3-Days		7-Days	
	355	(25.0 Kg/cm^2)	440	(30.9 Kg/cm^2)
	320	(22.5 ")	420	(29.5 ")
	340	(23.9 ")	435	(30.6 ")
Average	338	(23.8 ")	435	(30.6 ")

Water Used by Weight, Percent 10.70

CHEMICAL ANALYSIS

Aluminum Oxide (Al_2O_3), Percent	5.26
Ferric Oxide (Fe_2O_3), Percent	2.56
Magnesium Oxide (MgO), Percent	0.99
Sulfur Trioxide (SO_3), Percent	2.09
Sodium Oxide (Na_2O), Percent	0.22
Potassium Oxide (K_2O), Percent	0.67
Calcium Oxide (CaO), Percent	65.14
Loss On Ignition , Percent	2.33
Insoluble Residue, Percent	0.13
Tricalcium Aluminate ($3CaO.Al_2O_3$), Percent	9.61
Alkalies (Summation Percentage NaO+0.658 Percent K_2O), Percent	0.66

TABULATION OF TEST RESULTS

OF CEMENT FROM

JORDAN CEMENT PLANT

near Amman, Jordan

Samples No. 3 and 4

Tested in accordance with methods prescribed in ASTM Designations C150-49 and C186-49

PHYSICAL TESTS

	Sample 3	Sample 4	ASTM Stds.
Fineness: Material Passing a No. 325 Sieve, By Weight, Percent	80.6	84.1	
Fineness: Specific Surface Value Sq.Cm. Per Gram	1585	1751	1500 min.
Normal Consistency: Amount of Water Required By Weight, Percent	25.00	25.00	
Soundness: Autoclave Expansion, Percent	+0.19	+0.62	0.50 max.
Time of Setting: Gilmore Method			
Initial Set - Hours: Minutes	4:20	2:50	not less than 1:00
Final Set - Hours: Minutes	6:10	4:40	not more than 10

COMPRESSIVE STRENGTH
(On Standard 2-Inch Cubes)

Age At Test	Sample No. 3, 3-Days P.S.I.	Sample No. 3, 3-Days Kg/cm^2	Sample No. 3, 7-Days P.S.I.	Sample No. 3, 7-Days Kg/cm^2	Sample No. 4, 3-Days P.S.I.	Sample No. 4, 3-Days Kg/cm^2	Sample No. 4, 7-Days P.S.I.	Sample No. 4, 7-Days Kg/cm^2
	2325	163.5	2750	193.3	2100	147.6	2850	200.4
	2310	162.4	3250	228.5	2250	158.2	2650	186.3
	2200	154.7	3025	212.7	2075	145.9	2720	191.2
Average -	2278	160.2	3008	211.5	2142	150.6	2740	192.6
Water used by Weight, %			54.29				54.29	
Flow (Consistency), %			112.50				112.50	

TENSILE STRENGTH
(On Standard Briquets)

Age at Test	Sample No. 3, 3-Days P.S.I.	Sample No. 3, 3-Days Kg/cm^2	Sample No. 3, 7-Days P.S.I.	Sample No. 3, 7-Days Kg/cm^2	Sample No. 4, 3-Days P.S.I.	Sample No. 4, 3-Days Kg/cm^2	Sample No. 4, 7-Days P.S.I.	Sample No. 4, 7-Days Kg/cm^2
	345	24.3	440	30.9	350	24.6	435	30.6
	355	25.0	430	30.2	315	22.1	410	28.8
	320	22.5	455	32.0	325	22.9	420	29.5
Average -	340	23.9	442	31.1	330	23.2	422	29.7
Water used by Weight, %			10.70				10.70	

CHEMICAL ANALYSIS

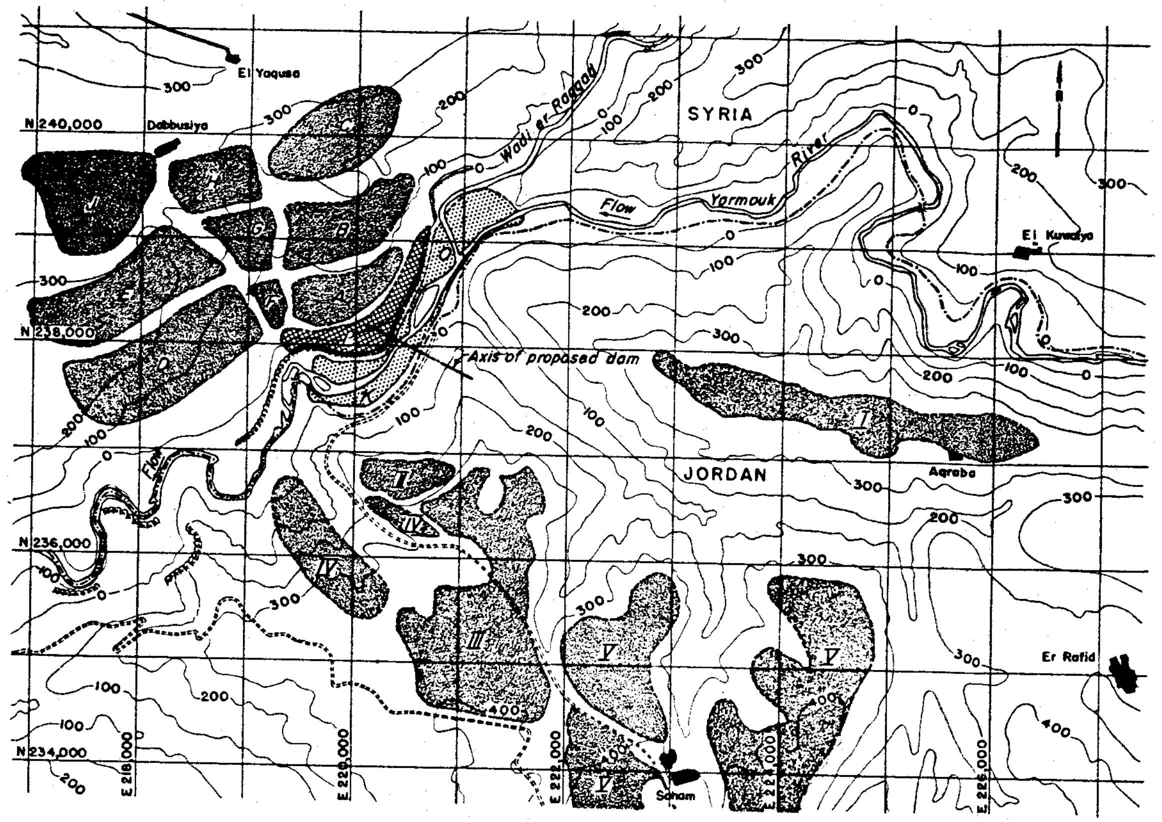
	Sample No. 3	Sample No. 4
Magnesium Oxide (MgO), Percent	0.91	1.06
Sulfur Trioxide (SO_3), Percent	2.12	2.71
Aluminum Oxide (Al_2O_3), Percent	6.11	6.89
Ferric Oxide (Fe_2O_3), Percent	2.67	2.77
Sodium Oxide (Na_2O), Percent	0.35	0.40
Potassium Oxide (K_2O), Percent	0.81	0.89
Calcium Oxide (CaO), Percent	64.94	64.48
Loss on Ignition, Percent	2.77	2.39
Insoluble Residue, Percent	0.12	1.14
Tricalcium Aluminate ($3CaO.Al_2O_3$), Percent	11.68	13.58
Alkalies (Summation Percentage (Na_2O+0.658 Percent K_2O), Percent	0.88	0.98

The above analyses indicate that Sample No. 3 complies with Type I and III cement. Sample No. 4 complies with Type III cement.

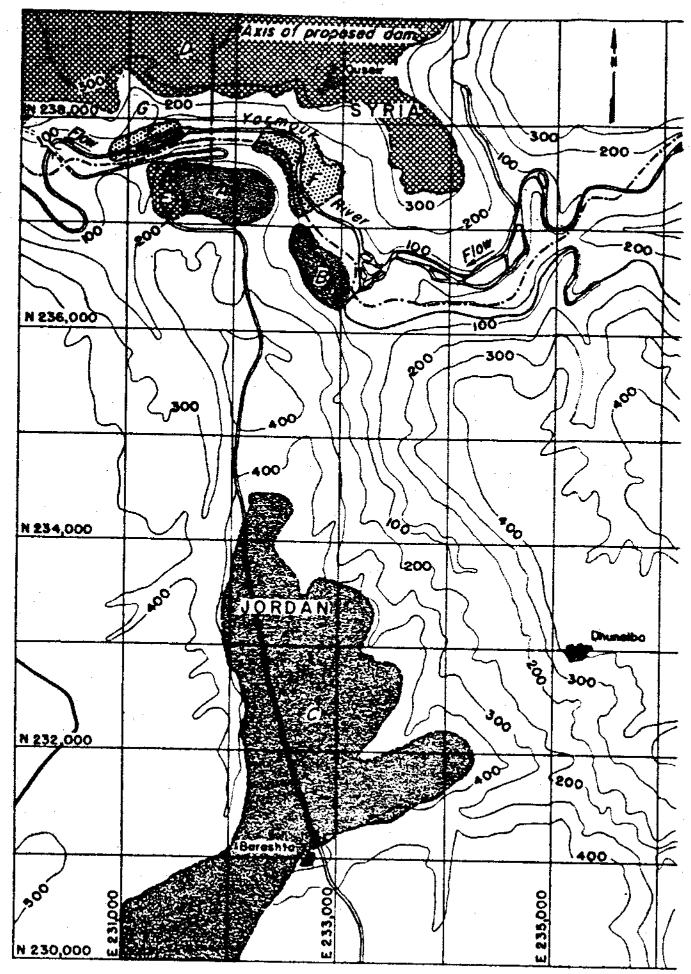
CHEMICAL ANALYSES OF WATER FROM

RIVERS AND WADIS

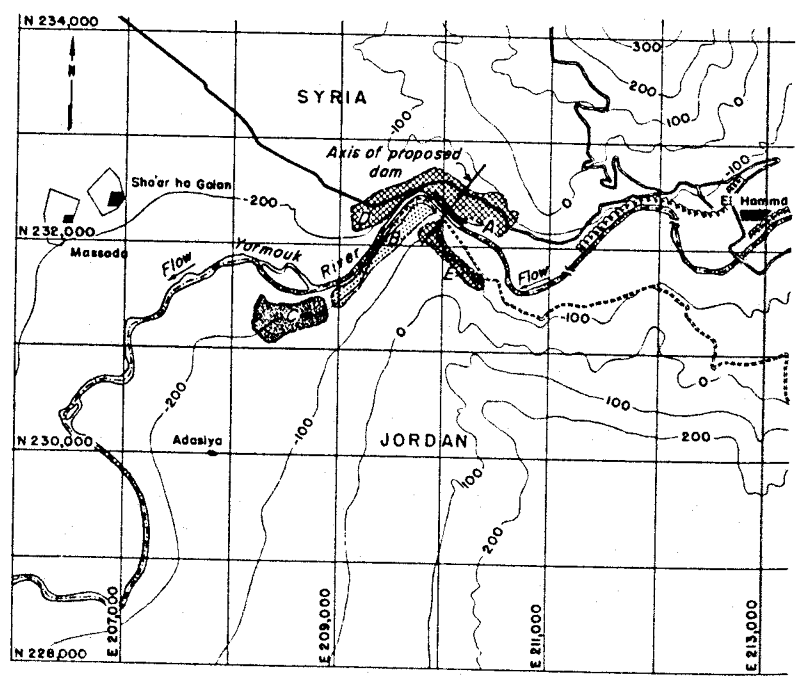
PPM	Jordan River	W/Yabis	W/Kufrinja	W/Rajib	Zarqa R.	Yarmouk R.	W/Hisban	W/Kafrein
Calcium	58	51	48	51	70	42	59	52
Magnesium	28	20	18	19	28	19	28	34
Sodium	130	18	11	10	55	50		
Bicarbonate	195	224	195	210	237	207		
Chloride	220	30	26	24	98	61		
Sulfate	60	6	8	12	44	32	38	79
Nitrate	12	20	15	15	40	10		
	—	—	—	—	—	—	—	—
TOTAL SOLIDS	703	369	321	341	572	421		
pH	7.5	7.5	7.5	7.4	7.4	7.7		



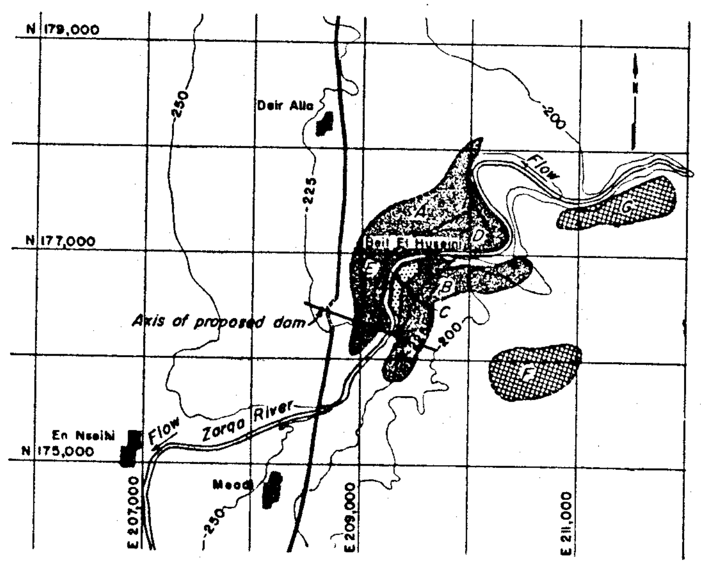
KHALID



MAQARIN



YARMOUK DIVERSION DAM



ZARQA IRRIGATION DAM

KHALID

IMPERVIOUS

Syrian side		Jordan side	
Area A	192,000 m^3	Area I	500,000 m^3
Area B	252,000 m^3	Area II	250,000 m^3
Area C	210,000 m^3	Area III	1,500,000 m^3
Area D	560,000 m^3	Area IV	900,000 m^3
Area E	600,000 m^3	Area V	unlimited
Area F	30,000 m^3		
Area G	80,000 m^3		
Area H	156,000 m^3		
Area J	500,000 m^3		
Total	2,580,000 m^3	Total	2,950,000 m^3

PERVIOUS Areas O & K Unlimited

ROCK FILL & RIPRAP Area L Unlimited

MAQARIN

IMPERVIOUS Area A 1,200,000 m^3; Area B 730,000 m^3; Area C unlimited

PERVIOUS Areas F & G Unlimited

ROCK FILL & RIPRAP Areas D & E Unlimited

YARMOUK DIVERSION DAM

IMPERVIOUS
Area C 450,000 m^3

PERVIOUS
Area A 20,000 m^3
Area B 110,000 m^3

ROCK FILL & RIPRAP Areas D & E Unlimited

ZARQA IRRIGATION DAM

IMPERVIOUS
Area A&B unlimited (Lisan Marl)
Area C&D unlimited (Alluvial soil)

PERVIOUS Area E Unlimited

ROCK FILL & RIPRAP Area F & G Unlimited

CONCRETE AGGREGATE Area E 1,500,000 m^3

LEGEND

- Impervious material
- Rock fill and riprap
- Pervious material
- International boundary
- Improved roads
- Unimproved roads
- Bridge
- Steep cliff
- Village

NOTES:

Coordinates refer to the Palestine Grid System
Elevations refer to mean sea level
All dimensions are in meters
For location of results of soil tests on foundation and construction materials see Drawings

Scale 0 — 1500 Meters

THE COOPERATIVE DEPARTMENT FOR
WATER RESOURCES DEVELOPMENT
HASHEMITE KINGDOM OF THE JORDAN

YARMOUK-JORDAN VALLEY | GENERAL

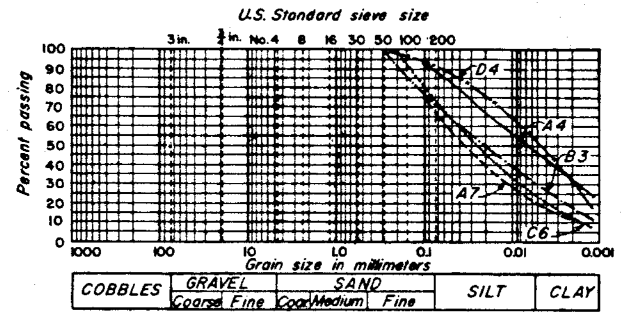
SOURCES OF CONSTRUCTION MATERIALS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR., INC.
CHICAGO, ILLINOIS | DATE | DWG. NO. VI-B-1

REV NO	DATE	NATURE OF REVISION	BY	CHKD	APPD

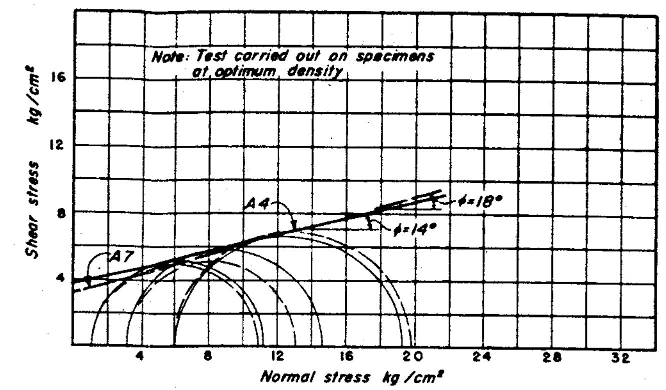
DATE	NO.	DISTRIBUTION
PRINTS		

	BY	DATE	CHKD	DATE
DSGN	RJF	[illegible]	[illegible]	[illegible]
DRN	AC	[illegible]	[illegible]	[illegible]
ENGR				
CH. ENGR	STAFF			

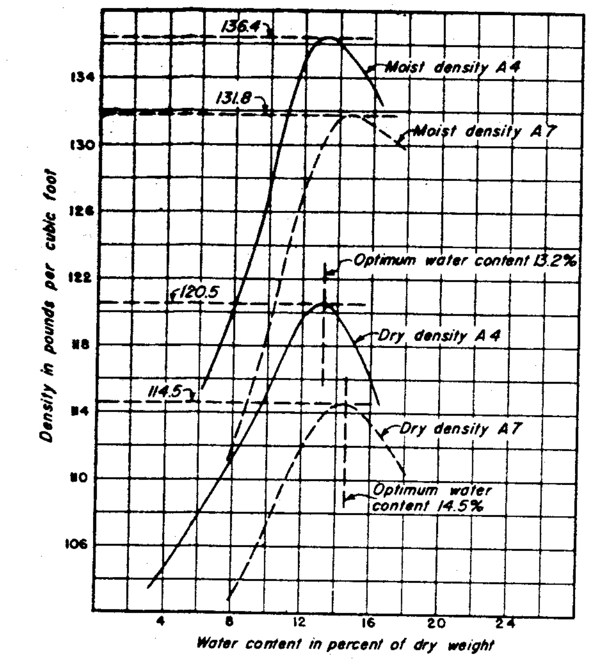


Pit No.	Line	LL%	PL%	PI%	Spec. grav.	Classification
D4	—·—				2.72	Clay
A4	——	33.4	18.1	15.3	2.71	Clay
B3	—··—				2.75	Clay loam
C6	········				2.79	Clay loam
A7	- - -	49.2	21.0	28.2	2.64	Clay loam

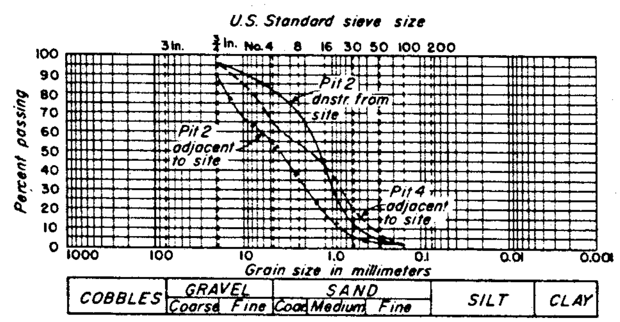
CLASSIFICATION TESTS
IMPERVIOUS MATERIAL



TRIAXIAL COMPRESSION TESTS
(Quick undrained)
IMPERVIOUS MATERIAL



MODIFIED PROCTOR TESTS
IMPERVIOUS MATERIAL



Area	Pit No.	Line	Description	Notes
Gravel bar dnstr. from site	2	——	Sandy gravel	50% to 70% by wt. of material >75.0mm.
Gravel bar adjacent to site	2	—×—	Sandy gravel	50% by wt. of material >75.0mm.
Gravel bar adjacent to site	4	- - -	Sandy gravel	

CLASSIFICATION TESTS
PERVIOUS AND FILTER MATERIAL

LEGEND

- Coar. – Coarse
- LL – Liquid limit
- PI – Plasticity index
- PL – Plastic limit

NOTES:

1. Pits D4, A4, B3, C6 and A7 are located in the low flood plain terrace
2. Pervious material from Pit 2 represents the fine fraction of the material in Pits 1 to 3 inclusive, located in the gravel bar downstream from the site. Pervious material from Pits 2 and 4 represents the fine fraction of material in Pits 1 to 5 inclusive, located in the gravel bar adjacent to site.
3. For location of site and terraces see Drawing

DATE	NO.	DISTRIBUTION
PRINTS		

	BY	DATE	CHKD	DATE
DSGN	GZD	3/1/55	BHK	3-31 1955
DWN	GZD	3/7/55	BHK	3-31 1955
ENGR.		PLAN	MECH.	ELECT.
CH. ENGR.		STAFF	CC.HY	

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD

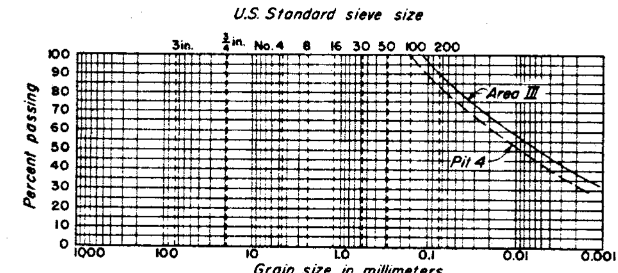
THE COOPERATIVE DEPARTMENT FOR
WATER RESOURCES DEVELOPMENT
HASHEMITE KINGDOM OF THE JORDAN

YARMOUK–JORDAN VALLEY | YARMOUK DIVERSION DAM

CONSTRUCTION MATERIALS
RESULTS OF SOIL TESTS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR., INC.

CHICAGO, ILLINOIS | DATE | DWG. NO. VI-B-2

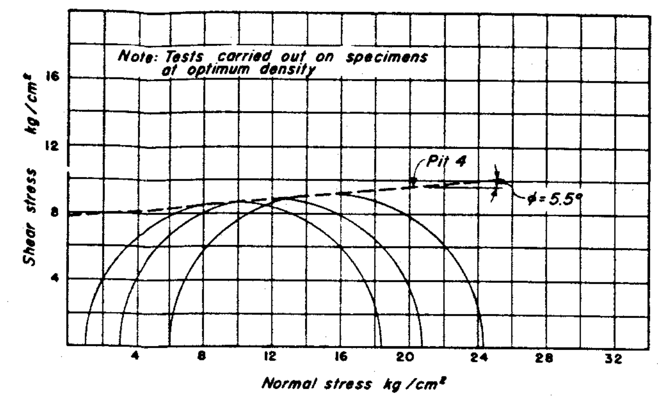


COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coar.	Medium	Fine		

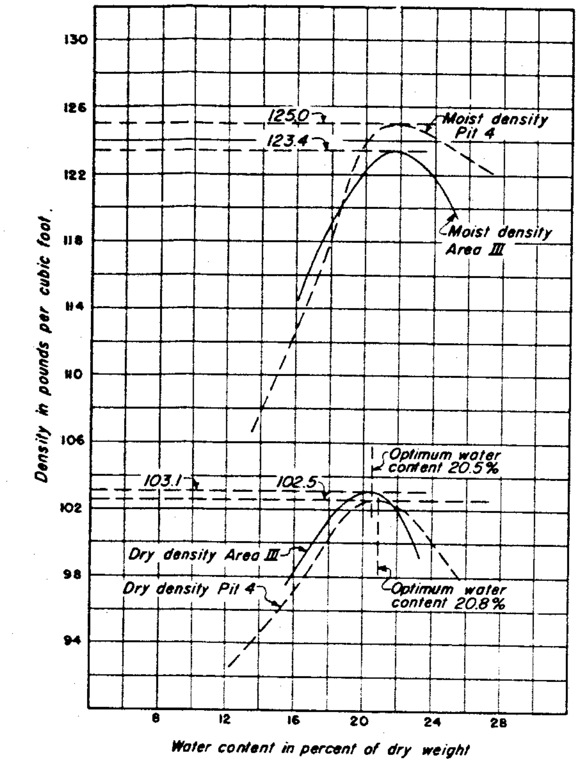
Pit No.	Line	Spec. grav.	Coefficient of permeability *	Classification
Area III	——	2.82	1.4×10^{-8} cm/sec.	Clay
Pit 4	- - -	2.75	4.12×10^{-8} cm/sec	Clay

* Coefficient of permeability determined for optimum density

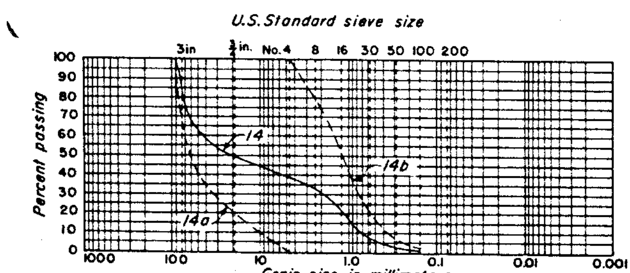
CLASSIFICATION TESTS
IMPERVIOUS MATERIAL



TRIAXIAL COMPRESSION TESTS
(Quick undrained)
IMPERVIOUS MATERIAL



MODIFIED PROCTOR TESTS
IMPERVIOUS MATERIAL



COBBLES	GRAVEL		SAND			SILT	CLAY
	Coar.	Fine	Coar.	Medium	Fine		

Sample No.	Description	
14	Sandy gravel from dozer pit in river	
14a	Proposed coarse filter (2nd stage)	derived from the segregation of Sample No. 14
14b	Propsed fine filter (1st stage)	

CLASSIFICATION TESTS
PERVIOUS AND FILTER MATERIAL

Pit No.	Specimen No.	Dm lb/cu ft	Dd lb/cu ft	W.C. %	Qu t/sq ft
Area III	1	117.8	99.2	18.8	5.72
Area III	2	123.9	102.8	20.8	4.92
Area III	3	120.3	97.0	24.0	2.71

UNCONFINED COMPRESSION TESTS
IMPERVIOUS MATERIAL

LEGEND
Coar. - Coarse
Dd - Density, dry
Dm - Density, moist
Qu - Unconfined compressive strength
WC - Water content

NOTES:
1. Pit 4 is located in the upstream terrace on the Jordan side of the site.
2. Area III is a terrace on the Jordan side about 2 kilometers of the site.
3. Sample No. 14 was obtained from a pit in the river bed within the area for the proposed Khalid dam.
4. For location of terraces see Drawing

DATE	NO	DISTRIBUTION
PRINTS		

REV NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD

THE COOPERATIVE DEPARTMENT FOR
WATER RESOURCES DEVELOPMENT
HASHEMITE KINGDOM OF THE JORDAN

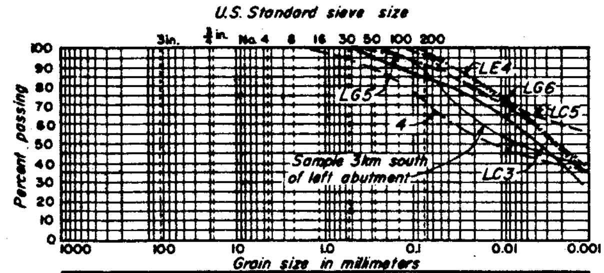
YARMOUK-JORDAN VALLEY | KHALID

CONSTRUCTION MATERIALS
RESULTS OF SOIL TESTS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR., INC.

CHICAGO, ILLINOIS | DATE | DWG. NO. VI-B-3

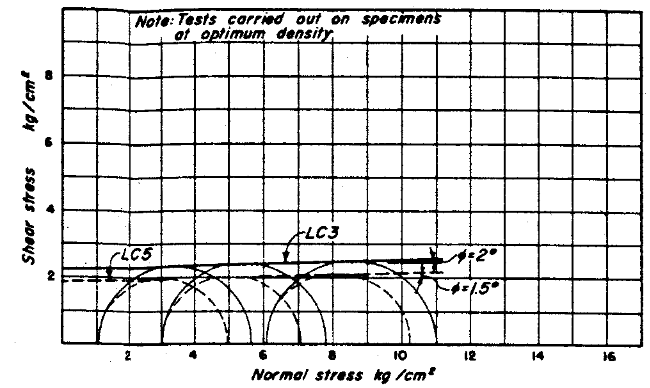
DRAWING VI-B-4



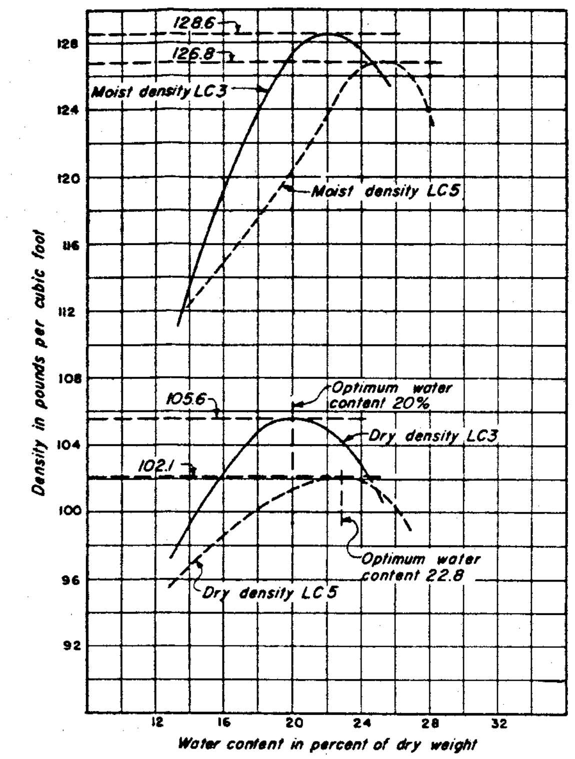
COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coar.	SAND Medium	SAND Fine	SILT	CLAY

Area	Pit No.	Line	LL %	PL %	PI %	Spec. Grav.	Classification
A	LE4	········				2.81	Clay
A	LG 6	— —				2.60	Clay
A	LC3	——	72.8	25.8	47.0	2.54	Clay
A	LC5	- - -	74.0	30.0	44.0	2.55	Clay
A	LG5	—·—·—				2.74	Clay
B	4	— - —				2.78	Clay
C	3km south	——				2.80	Clay

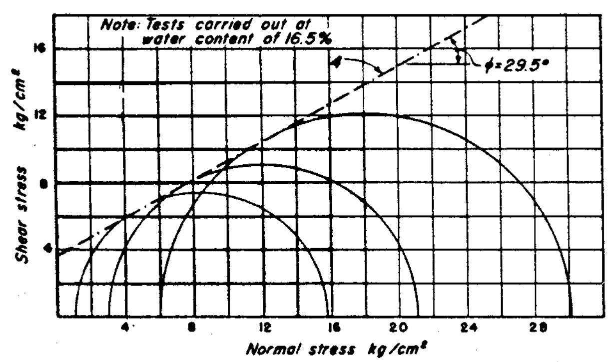
CLASSIFICATION TESTS
IMPERVIOUS MATERIAL
AREAS A, B & C



TRIAXIAL COMPRESSION TESTS
(Quick undrained)
IMPERVIOUS MATERIAL
AREA A



MODIFIED PROCTOR TESTS
IMPERVIOUS MATERIAL
AREA A



TRIAXIAL COMPRESSION TESTS
(Quick undrained)
IMPERVIOUS MATERIAL
AREA B

LEGEND
LL - Liquid limit
PI - Plasticity index
PL - Plastic limit

NOTE:
For location of Areas A, B and C see Drawing

DATE	NO.	DISTRIBUTION

PRINTS

	BY	DATE	CHKD	DATE
DRSN	GZD	3-1963	BHK	3-1963
DWN	GZD	3-1963	BHK	1963
ENGR		PLAN.	MECH.	ELECT.
CH. ENGR.		STRUCT.		CARD

REV NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD

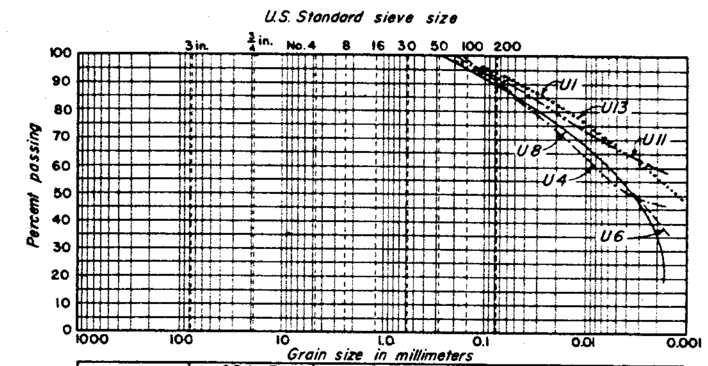
THE COOPERATIVE DEPARTMENT FOR
WATER RESOURCES DEVELOPMENT
HASHEMITE KINGDOM OF THE JORDAN

YARMOUK-JORDAN VALLEY | MAQARIN DAM

CONSTRUCTION MATERIALS
RESULTS OF SOIL TESTS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR., INC.

CHICAGO, ILLINOIS | DATE | DWG. NO. VI-B-4

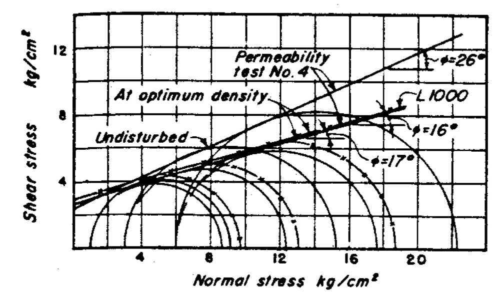


COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coar.	SAND Medium	SAND Fine	SILT	CLAY

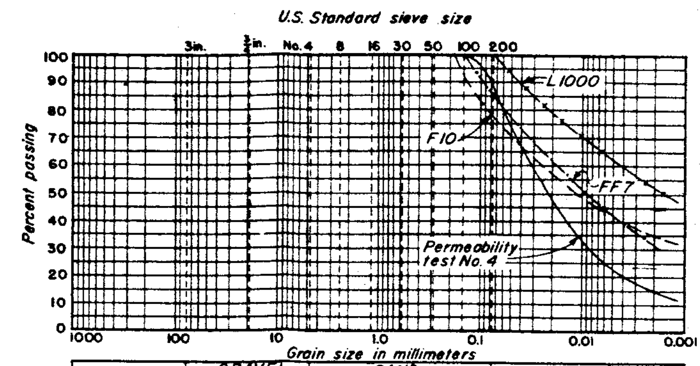
Hole No.	Samp. No.	Line	Nat. W.C.%	LL %	PL %	PI %	Dm lb/ft³	Dd lb/ft³	Qu t/ft²	Spec. Grav.	Depth m	Elevation m	Classification
AR4	U1	········	28.1	35.7	22.2	13.5	123.5	96.4	3.17	2.84	12.37	-265.87	Clay
AR4	U4	—·—	28.4	39.5	21.0	18.5	125.0	97.3	1.75	2.79	14.69	-270.59	Clay
AR4	U6	- - -	27.7	41.8	20.5	21.3	119.2	93.5	1.85	2.82	16.20	-273.60	Clay
AR4	U8	——	21.0	34.8	16.2	18.6	127.5	105.3	3.30	2.76	18.95	-279.05	Clay
AR4	U11	—x—	20.5	35.7	17.9	17.6	130.0	108.0	7.80	2.75	23.40	-288.00	Clay
AR4	U13	········	25.4	38.2	18.0	20.2	123.5	98.5	1.83	2.79	25.64	-292.44	Clay

Note: Samples U1 and U13 have similar grain size distribution.

CLASSIFICATION TESTS
FOUNDATION MATERIAL



TRIAXIAL COMPRESSION TESTS
(Quick undrained)
IMPERVIOUS MATERIAL

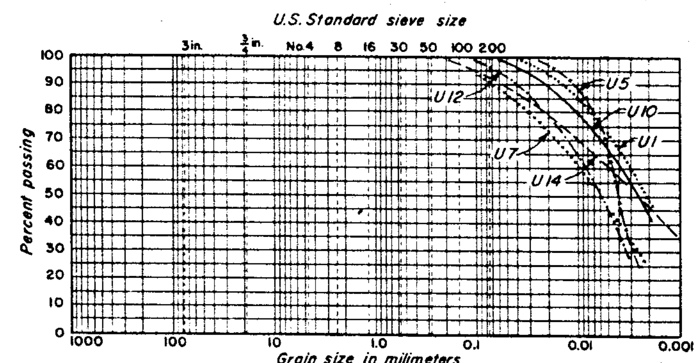


COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coar.	SAND Medium	SAND Fine	SILT	CLAY

Sample No.	Line	LL %	PL %	PI %	Spec. Grav.	Coefficient of permeability *	Classification
Pit L1000	—x—				2.85	8.4×10^{-8} cm/sec	Clay
FF7	—·—				2.81	7.81×10^{-8} cm/sec	Clay
F10	- - -				2.80	2.77×10^{-8} cm/sec	Clay
Permeability test No. 4	——	36.5	21.7	14.8	2.73		Silty clay loam

*Coefficient of permeability determined at optimum density

CLASSIFICATION TESTS
IMPERVIOUS MATERIAL

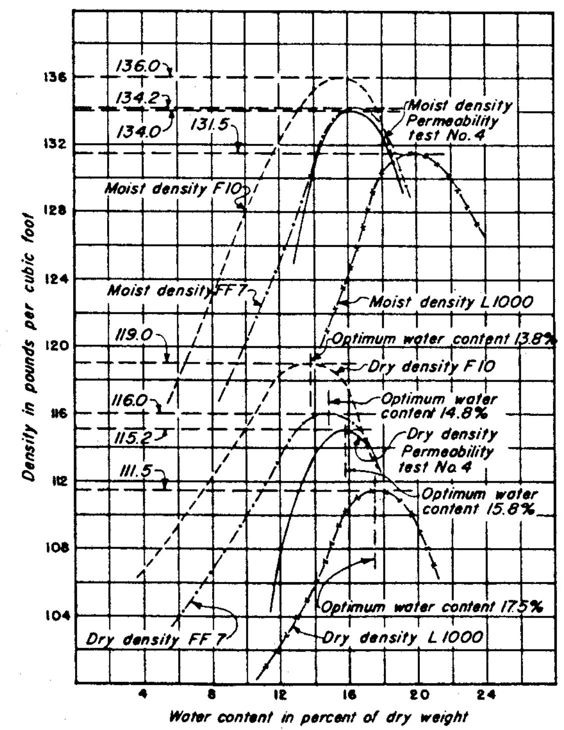


COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coar.	SAND Medium	SAND Fine	SILT	CLAY

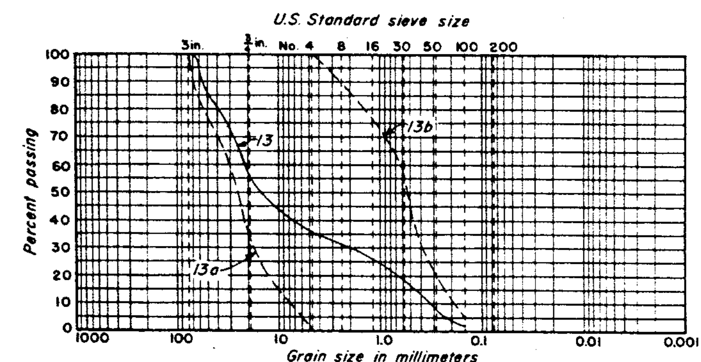
Hole No.	Samp. No.	Line	Nat. W.C.%	LL %	PL %	PI %	Dm lb/ft³	Dd lb/ft³	Qu t/ft²	Spec. Grav.	Depth m	Elevation m	Classification
AR1	U1	········	28.3	40.1	15.8	24.3	117.5	91.5	2.04	2.76	5.34	-238.04	Clay
AR1	U5	—x—	28.4	38.1	18.7	19.4	136.0	98.0	3.52	2.70	7.61	-242.61	Clay
AR1	U7	xxxx	26.4	30.6	18.2	12.4	112.5	88.9	2.14	2.76	9.29	-245.99	Clay
AR1	U10	——	30.6	28.0	16.5	11.5	118.5	90.8	2.10	2.89	11.56	-250.56	Clay
AR.1	U12	—·—	29.9	30.4	16.8	13.6	122.0	94.0	1.99	2.73	12.22	- 251.82	Clay
AR1	U14	- - -	39.6	46.2	20.9	25.3	117.0	83.9	1.50	2.85	13.25	-253.95	Clay

CLASSIFICATION TESTS
FOUNDATION MATERIAL

NOTES:
Hole AR1 is located on the right abutment
at centerline Sta. 0+112.0 see Drawing
Hole AR 4 is located on the right bank
at centerline Sta. 0+324.4 see Drawing
Pit L 1000 is located on the left bank approximately 1000meters
downstream from the centerline. Material obtained represents the Lisan Marl of Area B
Permeability test No. 4 is located in the knolls of the Lisan Marl, Area A.
Pits FF7 and F10 are located on terraces within the reservoir basin, Areas D and B.
Sample No. 14 was obtained from an unnumbered pit located in the gravel
of the streambed.
For location of Areas A, B and D see Drawing



MODIFIED PROCTOR TESTS
IMPERVIOUS MATERIAL



COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coar.	SAND Medium	SAND Fine	SILT	CLAY

Sample No.	Description		% by weight
13	Sandy gravel from streambed		100
13a	Proposed coarse filter (2 nd stage)	derived from segregation of Sample No. 13	65
13b	Proposed fine filter (1st stage)		35

CLASSIFICATION TESTS
PERVIOUS AND FILTER MATERIAL
AND CONCRETE AGGREGATE

LEGEND
Coar. – Coarse
Dd – Density, dry
Dm – Density, moist
LL – Liquid limit
PI – Plasticity index
PL – Plastic limit
Qu – Unconfined compressive strength
WC – Water content

THE COOPERATIVE DEPARTMENT FOR
WATER RESOURCES DEVELOPMENT
HASHEMITE KINGDOM OF THE JORDAN

YARMOUK–JORDAN VALLEY | ZARQA STORAGE DAM

FOUNDATION AND CONSTRUCTION
MATERIALS
RESULTS OF SOIL TESTS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR., INC.

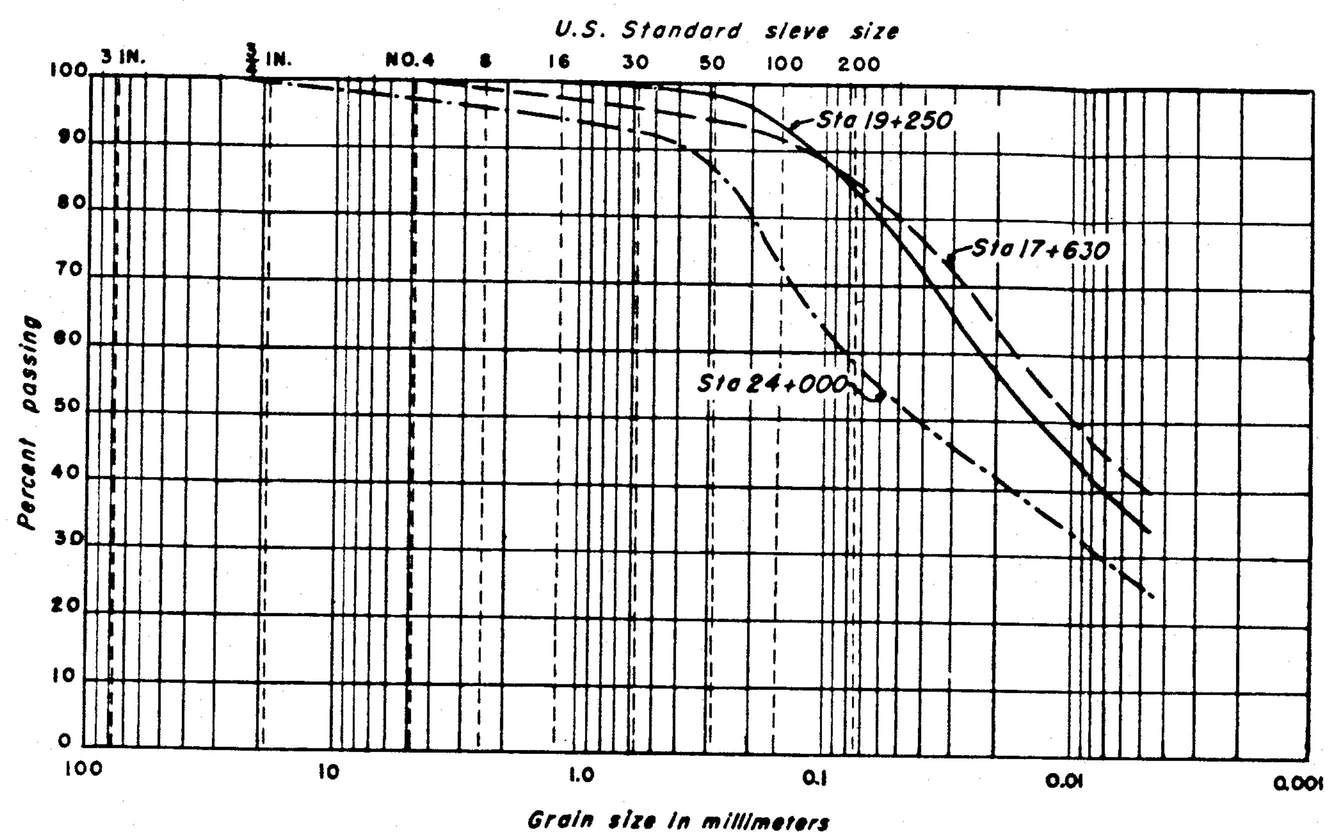
CHICAGO, ILLINOIS | DATE | DWG. NO VI-B-5

REV. NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD

DATE	NO	DISTRIBUTION

PRINTS

	BY	DATE	CHKD	DATE
DSGN	SZD		BHK	
DWN	SZD		BHK	
ENGR		PLAN	MECH	ELECT
CH. ENGR.		STAFF		

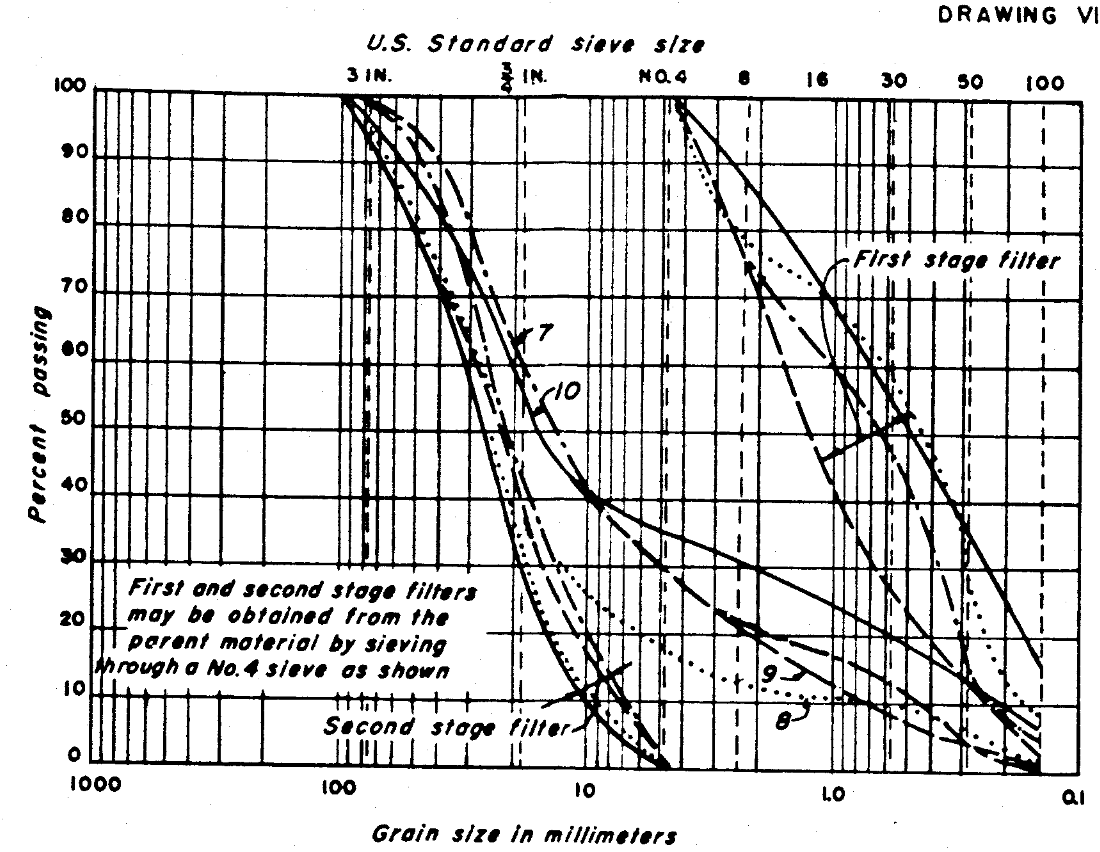


Cobbles	Gravel		Sand			Silt	Clay
	Coarse	Fine	Coarse	Medium	Fine		

IMPERVIOUS MATERIALS

Sample No.	Line	Classification	LL[x]	PL[x]	PI[x]	Remarks
Sta 17+630	— — —	Clay	41.5	20.6	20.9	Samples obtained from stationing along the proposed canal alignment
Sta 19+250	———	Clay	27.0	17.8	9.2	
Sta 24+000	—·—·—	Clay loam	32.9	19.4	13.5	

[x] LL = Liquid limit PL = Plastic limit PI = Plasticity index



Cobbles	Gravel		Sand		
	Coarse	Fine	Coarse	Medium	Fine

PERVIOUS MATERIALS

Sample No.	Line	Classification	LL	PL	PI	Remarks
7	—·—·—	Sandy gravel				
8	....	Sandy gravel				
9	— — —	Sandy gravel				
10	———	Sandy gravel				

YARMOUK-JORDAN VALLEY

EAST GHOR
CONSTRUCTION MATERIALS

HARZA ENGINEERING COMPANY
MICHAEL BAKER JR. INC.

DATE DWG.NO. VI-B-6