Damsite and Dam Axis

1. Damsite

Two potential damsites have been considered for the Okkan Dam Irrigation Project before and during the feasibility stage. The one is located at about 400 m (0.25 miles) downstream of the confluence of the Okkan chaung and the Da chaung and the other is about 1.4 km (0.9 miles) far from the above site in downstream direction.

In order to obtain the basic data for the technical and economical evaluation, the topographical, geological and embankment materials investigations around the both damsites were carried out by Irrigation Department in 1976, 1977, 1980 and 1981.

From the above data, there is no significant difference as to the geological condition and embankment materials at the both damsites. However in the profile of dam axis, the embankment volume of dam body at the downstream site is fairly less quantitative than that of upstream one.

The results of comparative studies based on the above data are tabulated in Table 4D-1.

Table 4D-1 Evaluation for Potential Damsites

Evaluation Item	U/S Damsite	D/S Damsite
1. Catchment Area; x sq.km	223.0	225.0
2. Total storage capacity; x 10^6cu.m	240.0	240.0
3. Effective storage capacity; x 10^6cu.m	210.0	210.0
4. Area of full water surface; x 10^6sq.m	27.0	28.0
5. Dam height (from river bed); m	34.0	28.96
6. Length of dam crest; m	520.0	390.0
7. Chord-height ratio (6./5.)	15.3	13.5
8. Embankment volume; x 10^3cu.m	1,114	526
9. Direct construction cost; x 10^3Ks*/	77,626	36,653
10. Corresponding rate to water cost (9/3); Ks/cu.m	0.37	0.17

From the above evaluations, it seems that the downstream damsite is much more profitable than the upstream one from the viewpoints of technical and economical considerations, consequently the downstream damsite was proposed for the Okkan Dam Irrigation Project.

Moreover, the above profit will be increased by lowering the construction cost of diversion facilities, sub-dams at the right bank of reservoir rim and access facilities to the damsite.

2. Dam Axis

In deciding the dam axis, the following items have been duly considered to show the result in Drawing No.D-1001. In this case, the straight axis is adopted taking into account an idea of aseismatic design and easy construction.

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* Direct construction cost includes the costs for dam body, foundation, spillway, diversion facilities and outlet structures but does not include hydro-electric power plant. The cost has been derived from the data in the feasibility study of the South Nawin Irrigation Project.

- The dam height is approximately 30 m from the base of impervious zone.
- In order to make embankment volume minimized possible, the remaining hillock on the leftbank should be utilized at its best availability.
- It is preferable to locate the spillway on the rightbank ridge independently, considering the applicability of topographical condition and connection of existing river at the downstream of spillway.
- At the left abutment, it is desirable to locate the embankment within a portion where topography is transitting with the contour line running in near parallel against the dam axis.
- In the case that the dam axis is located at the right angle against the contour lines at the both abutment, the embankment volume is minimized.

Geology

1. General Geology

The damsite and its neighborhood are geologically composed of the following constituents:

Index	Age
Chaung Deposits	Holocene to Pleistocene
Alluvium terrace materials	
Deluvial soils	
Eluvial soils	
--------------- Unconformity	
Irrawaddy formation	Pliocene
--------------- Unconformity	
Obogon alternation	Miocene
Kyaukkok sandstone	Miocene to Oligocene

Each of the above-mentioned geological constituents is explained in the following paragraphs.

1.1. Chaung deposits

Chaung deposits are mainly composed of fine to medium grained sand which is concentratively deposited along the channels of chaungs and their tributaries. Small gravels and pebbles of sandstone and shale are found particularly in sand deposits. The chaung deposits are, in general, small and thin.

1.2. Alluvium terrace materials

Two layers of alluvium terrace materials (T_1 and T_2) are distributed at and around the damsite. One of the two (T_1) is composed of fine-grained sand, and is observed along almost all chaungs. The other (T_2) is composed of silty or clayey soils of yellowish-brown in color, and is limitedly distributed only at a higher elevation than that of T_1 such as at the borrow area No.1 and its neighborhood.

1.3. Deluvial soils

Deluvial soils generally spread between the above-mentioned alluvium terrace materials and the eluvial soils which are distributed near and on the peak of mountains. A layer of deluvium soils is thin or moderately thin. Its type varies from sandy soils to clayey soils depending upon the altering conditions of the bed rock. Borrow areas for earth materials of the dam have been located in distribution areas of the deluvial soils or terrace materials.

1.4. Eluvial soils

The veneer rock observed at the damsite has been formed by weathered sandy shale or sandstone. This rock can be observed everywhere near and on the mountain peaks around the damsite. Particularly, clayey or sandy soils around the dam contain the fragments of veneer rock.

1.5. Irrawaddy formation

The Irrawaddy formation is observed in the neighborhood of Chaung Zauk to San Yaw villages where the Okkan chaung starts to flow into the alluvial plain aparting from the hilly zone. This formation is lithogically represented by the gravel beds composed to quartz pebbles as well as by sandstone of brown to yellow in color, and is characterized by its iron oxide and clayey inclusion. The formation is loosely consolidated, and a light blow by hammer can be easily crush it. The Irrawaddy formation is considered usable for the concrete aggregate and filter zone of the dam.

1.6. Obogon alternation

The Obogon alternation is mainly composed of sandy shale, and is partially intercalated with sandstone. This alternation is well-exposed on the Okkan chaung bed at and around the damsite. The dam foundation will be located on this Obogon alternation in construction. The Obogon alternation is lithologically bluish-grey in color, and is well compacted as a whole.

The bed at the damsite has a dip and strike of N25° W60° - 65°W towards the downstream direction.

1.7. Kyaukkok Sandstone

The Kyaukkok foundation is observed both upstream and downstream of the damsite. The major constituent of this formation is sandstone though it is intercalated with a thin shale. The formation is a thick sandstone bed as a whole. It is so soft and a blow by hammer can easily crush it so far as its exposed portion on the river bed is concerned. Under the circumstances, further careful study and test will be requisite if this formation is used as rock materials of the dam.

2. Damsite Geology

The damsite is located about 1.8 km downstream of the confluence of the Okkan chaung with the Da chaung where the topographic conditions exhibit a striking contrast between the left bank and the right banks.

On the left bank a mountain ridge stands out from south to north so the Okkan chaung follows a winding course along the foot of this mountain ridge. The mountain ridge has been deeply eroded by streams, and shows the topography of the kern col and kern but. On the other hand, on the right bank a steep slope (about 1/1.0) of a mountain mass, which will be the dam abutment, closely faces the river bed.

The cord-height rate of the damsite at the elevation of 205 feet is to 13.5.

As regards geology of the damsite, drilling of four bore-holes with the total depth of 97.5 m and preparation of a geological map covering 9.7 km^2 have been completed.

Drilling of two bore-holes (BH-1 and BH-2) has been completed on the left abutment of the damsite. (BH-2 has been drilled on the saddle portion of the left abutment.) As a result, it has been verified that a depth of the weathered zone from the ground surface is 3.1 m at the both bore-holes, and a depth of the fresh zone is 5.8 m at BH-1 and 4.9 m at BH-2. As for the fresh zone, fresh and hard shale with thin sandstone layers has been sampled with the core recovery of 100 percent. But rocks of the weathered zone show the brown to buff color and a soft core condition.

The permeability test made at a depth of about 9.1 m in these bore-holes show a relatively low k value of 6×10^{-5} cm/s (k: coefficient of permeability) whereas the permeability test performed at the other elevations shows the impermeable value (k = nil). The groundwater level is nil at BH-1 and about 4.9 m depth at BH-2.

The bore-hole BH-3 has been drilled on the chaung bed. This bore-hole is recognized to be located directly on the fresh zone from the surface, in the other words, no weathered zone exist thereon. And the core recovery of all logs is 100 percent.

Results of the permeability test show the impermeable values of $k = 2 \times 10^{-5}$ cm/s between 3.1 - 9.1 m and k = nil below 9.1 m. The groundwater level is about 1.5 m deep from the chaung bed.

The borehole BH-4 was dug on the right abutment. As a result, it has been recognized that a depth of the weathered zone is 1.8 m, and that of the fresh zone is 8.2 m. The core recovery rate is 100 percent both at the weathered and fresh zones.

Results of the permeability test show the impermeable value of k = nil at varing depth. The groundwater level is about 17.7 m deep

The developed longitudinal section availed from bore-hole drillings is illustrated in Drawing D-1002.

In general, the foundation of impervious zone is studied from the two major angles, that is, its bearing capacity and permeability. From a view point of the bearing capacity, the top soil zone of sludge layer and the weathered zone are not favorable as soft core samples themselves suggest it , however, the fresh zone is judged to have a sufficient bearing capacity since hard and compact column cores have been almost continuously sampled with the core recovery rate of 100 percent.

From this judgement, it is concluded that the foundation of impervious zone has to be located on the above-mentioned fresh zone. (the permeability of fresh zone shows the semi-impermeable properties)

Moreover, judging from the geological conditions mentioned above, a two rows grouting treatment with the maximum depth of 18 m will be sufficient in order to improve the bearing capacity with uniformity and to obtain an impervious curtain in the dam bed-rocks and foundation of spillway crest.

Construction Material

1. Earth Materials

Alluvium terrace materials and deluvial soils are distributed along the Okkan chaung and the Migyaung chaung at upstream of the damsite. These materials are deemed usable as impervious earth materials of the dam. Therefore, totally nine borrow areas have been selected along the above-mentioned chaungs. Figure 3B-2 shows the location of these borrow areas.

In order to compute an available volume of impervious earth materials at the nine borrow areas, 5 trenches and 116 hand auger holes have been dug. As a result, totally 1,070,000 m^3 of such materials will be obtainable. For information, the total volume of the five large borrow areas amounts to 930,000 m^3. The details are tabulated below.

Borrow Area No.	Stripping	Useful Depth	Actual Yields (m^3)
B.A.1	2	10	229,000*
B.A.2	2	5	60,000
B.A.4	3	8	191,000*
B.A.5	4	8	25,000
B.A.6	2	8	17,000
B.A.7	2	10	285,000*
B.A.8	2	10	106,000*
B.A.9	2	10	40,000
B.A.10	2	10	119,000*

* Shows to the borrow area of large yields.

Soil tests have been conducted for five samples obtained at the test trenches and for 40 samples obtained from hand auger holes. Tables 3B-15 to 3B-17 and Figures 4D-1, 4D-2 and 4D-3 show the results.

As clearly seen in Figures 4D-1 and 4D-2 most materials at the borrow areas fall in the CL type in the Unified Soil Classification System, and they are low to medium plastic clayey materials. The gradat on curve of them indicates that they contain fine particles to a degree, however, the existence of fine particles will cause no severe problem in the dam construction so far as the dam is not too high.

Figure 4D-3 shows the relationship between moisture content and such factors as dry density, cohesion, internal friction angle and permeability.

Reportedly, the maximum dry density of earth materials ranges from 1.62 g/cm^3 to 1.76 g/cm^3. Here the materials can be classified into two groups depending upon their moisture content. One group has the optimum moisture content of 14.4 percent to 17.6 percent with the maximum dry density of 1.73 g/cm^3 to 1.76 g/cm^3 whereas the other has the optimum moisture content of 19.8 percent to 20.8 percent with the maximum dry density of 1.62 g/cm^3 to 1.68 g/cm^3. It is noted that the plastic index of the latter is, as a whole, higher than that of the former.

Furthermore, the materials have a cohesion of 0.3 to 0.48 kg/cm^2 and an internal friction angle of 15° to 28°. The latter attracts attentions to its high cohesion. It should be, however, pointed out that these two groups might be found to have related properties each other, when their comparison is made based upon additional test data in future.

A pending problem in respect to the soil mechanical tests is that the above-mentioned test results have been derived only from the materials having the optimum moisture content. Data on the differential of soil mechanical properties by moisture contents specially at the field moisture content will be indispensable in determination of the design values of a dam. For this purpose, the field moisture contents by seasons specially at the end of the monsoon season and the dry season should be measured, and soil mechanical properties at such moisture contents and at the moisture content of 95 percent should be obtained in addition to the moisture contents at the dry and wet sides from the optimum moisture content.

2. Sand and Gravel Materials

Sand and gravel materials suitable for the concrete aggregate, filter and drain of a fill dam are hardly obtainable near the damsite. Since the river sand is well sorted and relatively fine, it is deemed unsuitable for the said purposes.

The Irrawaddy formation observed at and around San Ywe, which is located about 10 km downstream of the damsite along the Okkan chaung, consists of quarts pebbles as well as by sandstone containing many fine particle materials. Judging from results of the gradation analysis test, these materials would be usable for the concrete aggregate, filter and drain of a fill dam.

Figure 4D-4 shows gradation curves of the river sand and Irrawaddy sand and gravel materials. Proper soil mechanical tests on these materials have not yet been made.

3. Rock Materials

In the initial stage of the study, sandstone of Kyaukkok formation located about 2.5 km away from the damsite was considered available as rock materials for the dam. However, the field investigation has revealed that the sandstone exposed on the river bed is soft and weathered to a considerable extent. It means that great earth works will be necessary for obtaining fresh rock, resulting in expensive rock materials.

Under the circumstances, a typical section of the dam body should be determined to minimize the use of rock materials, such as to use them only for the riprap and toe zone.

In this connection, a rock test of the bed rock at the dam site shows a compressive strength of 140 - 270 kg/cm^2 and a specific gravity of 2.35 - 2.40. From these results, the rock materials seem not quite favorable as the coarse concrete aggregate.

On the other hand, gravels in the above mentioned Irrawaddy formation could be used for the coarse concrete aggregate under the classification by screening plant. However, a rock test of gravel materials has not yet been made. Therefore, further studies will be required on the availability of the materials for this purpose.

FIGURE 4D-1 (I) PLASTICITY CHART

Project OKKAN DAM IRRIGATION PROJECT   Date of Testing 1978, 1980

Sampling Point ; Borrow Area 1~10

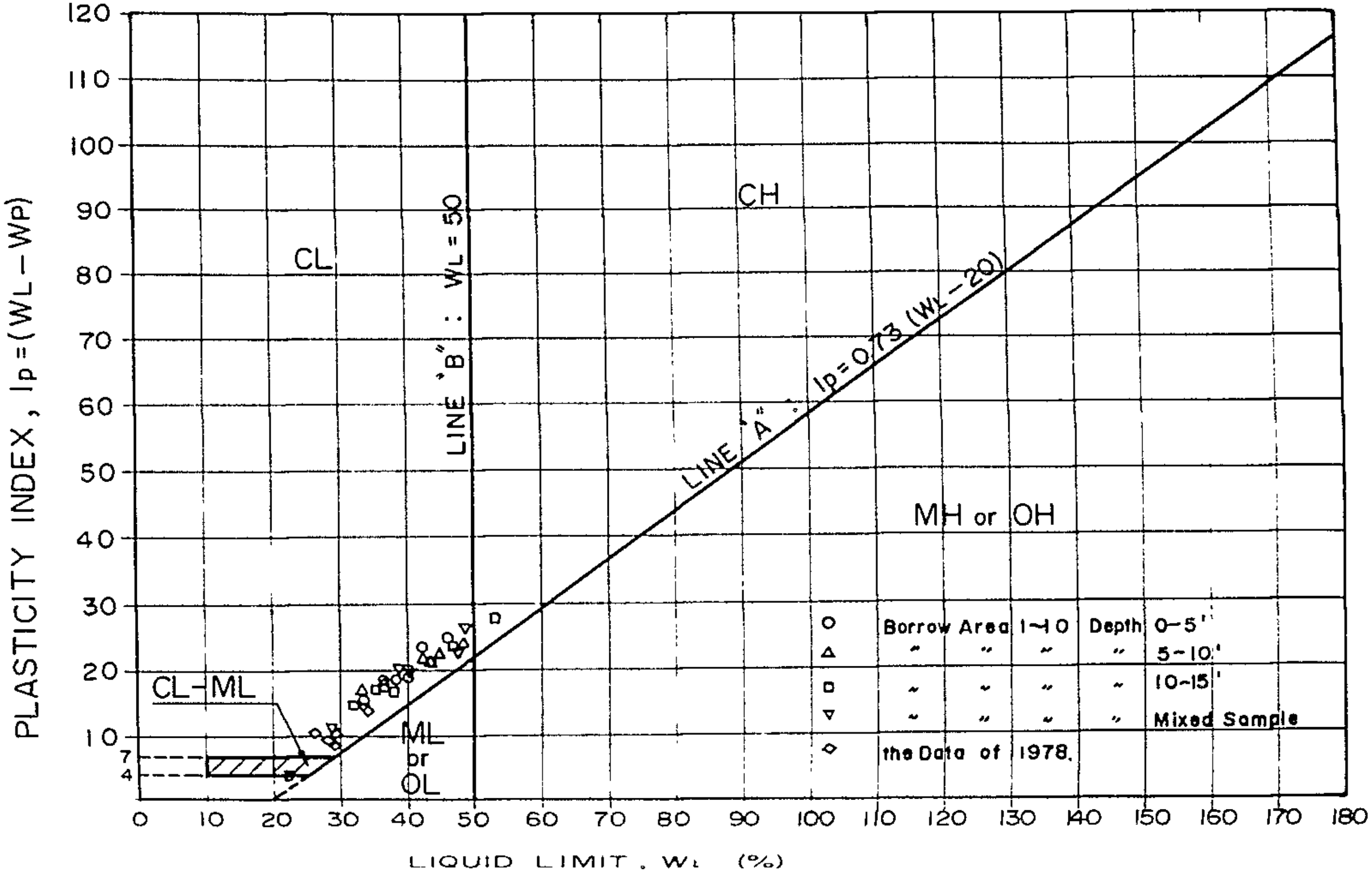


FIGURE 4D-1 (2) PLASTICITY CHART

Project OKKAN DAM IRRIGATION PROJECT   Date of Testing 1981

Sampling point ; Borrow Area 1, 4, 7, 8, 10.

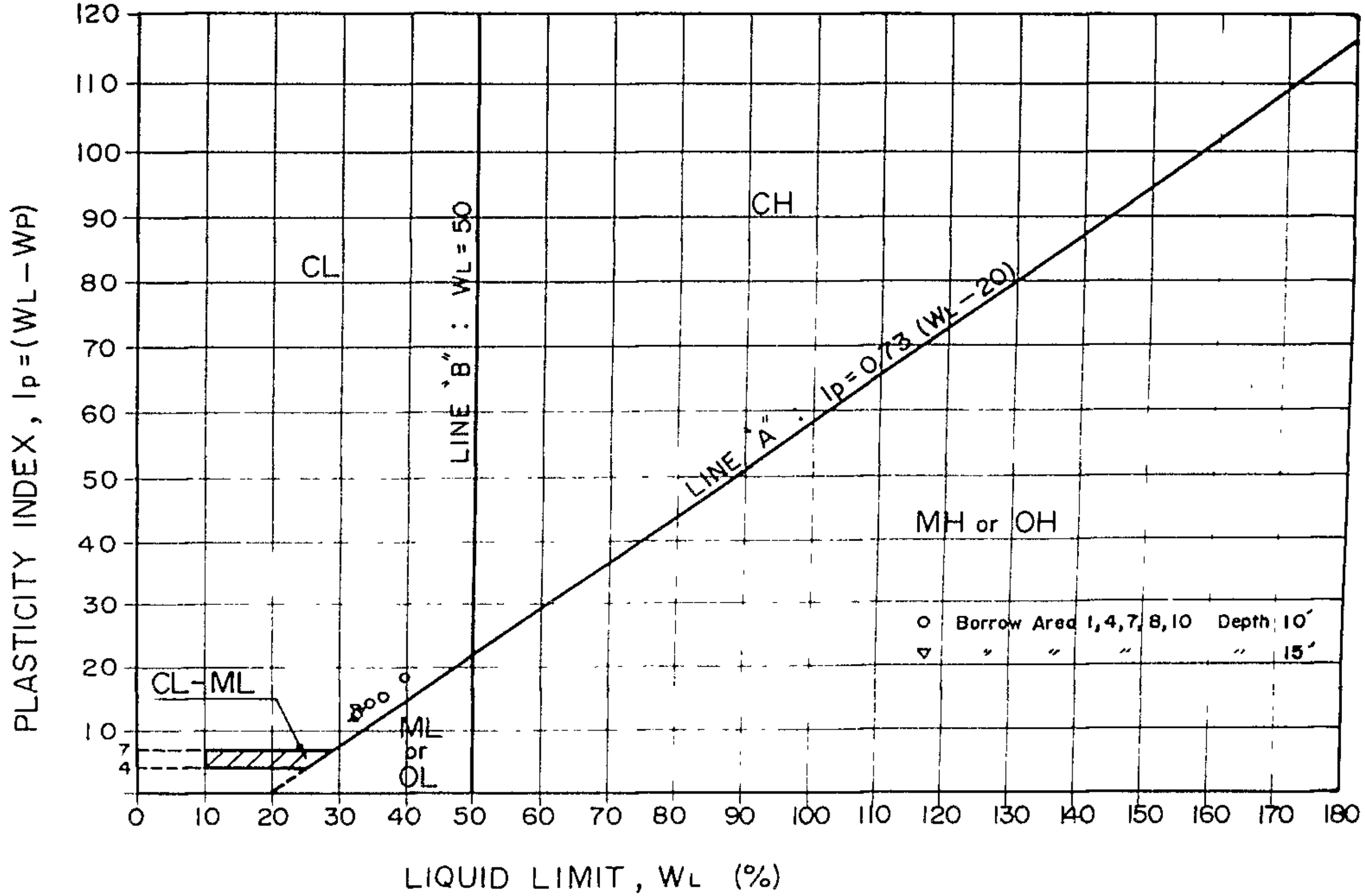


FIGURE 4D-2(1) GRAIN-SIZE ANALYSIS

Project OKKAN DAM IRRIGATION PROJECT

Date of Testing March 1978

Location of Project

Remarks ; Open Trench

Sampling point ; Borrow Area C,D,H,I,J (4,3,8,9,10)

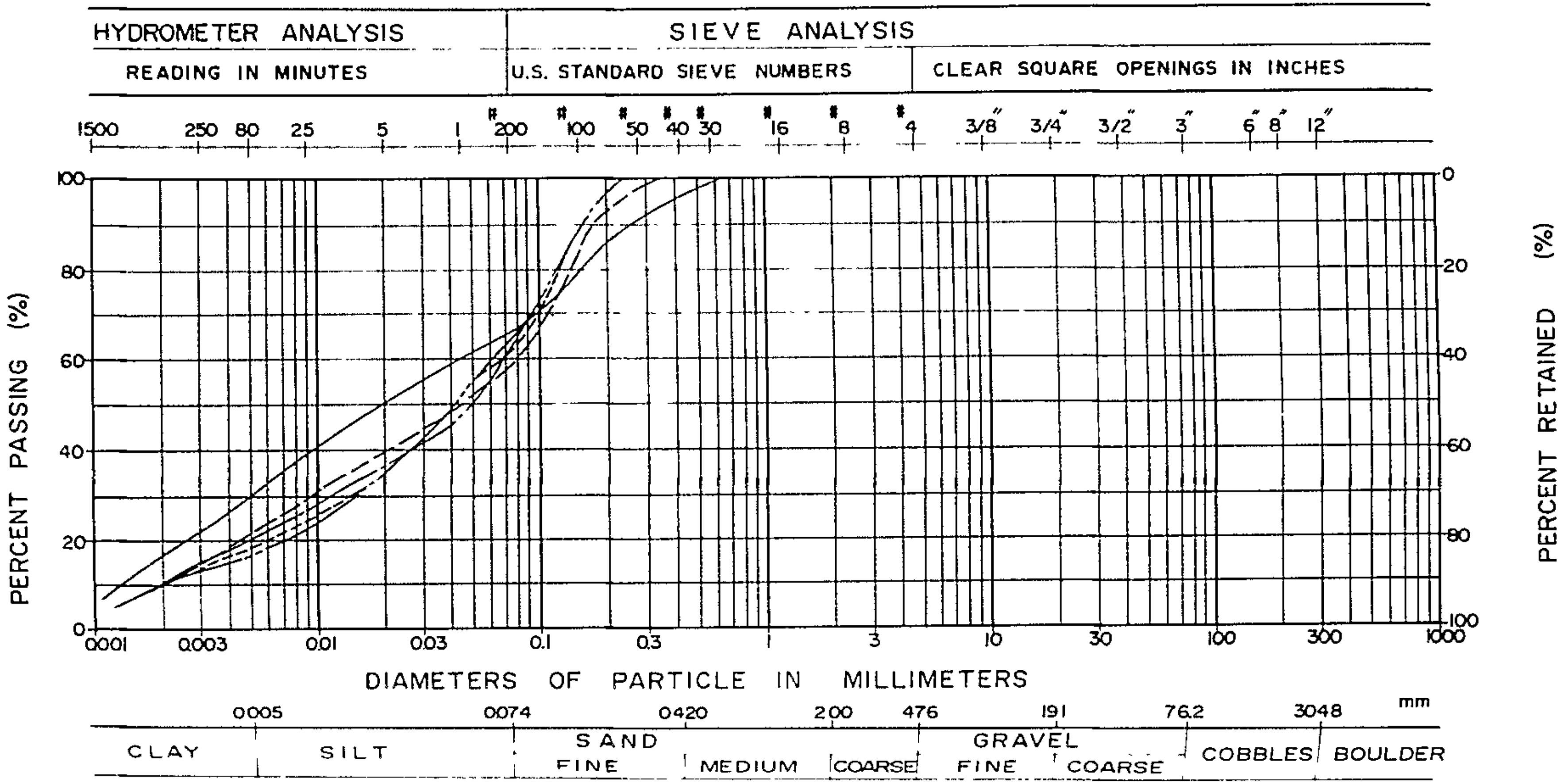


FIGURE 4D-2(2) GRAIN-SIZE ANALYSIS

Project OKKAN DAM IRRIGATION PROJECT

Location of Project

Sampling point ; Borrow Area 1~10

Date of Testing . March 1980

Remarks ;

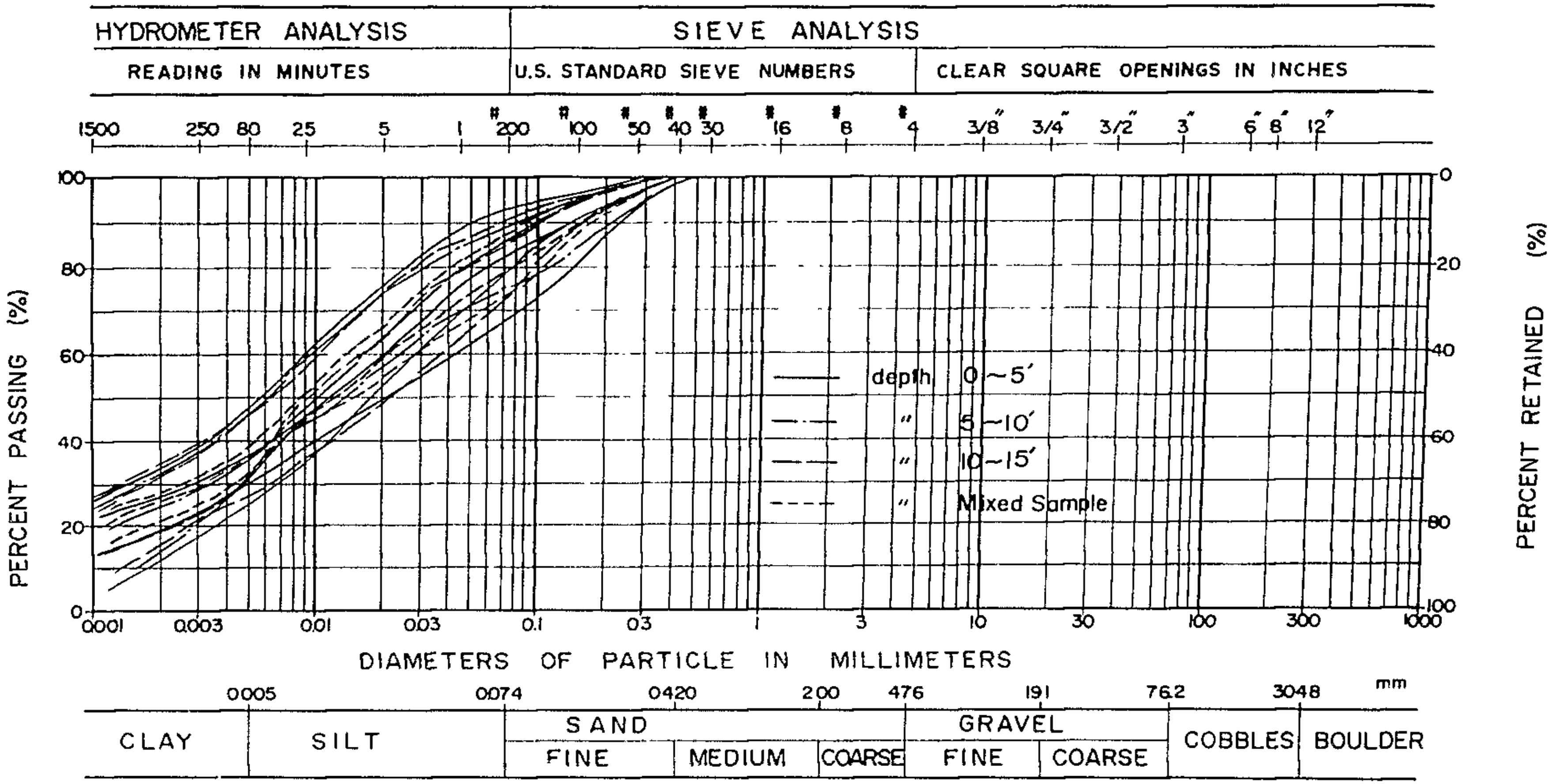


FIGURE 4D-2 (3) GRAIN-SIZE ANALYSIS

Project OKKAN DAM IRRIGATION PROJECT

Date of Testing February 1981

Location of Project

Remarks ;

Sampling point ; Borrow Area 1, 4, 7, 8, 10.

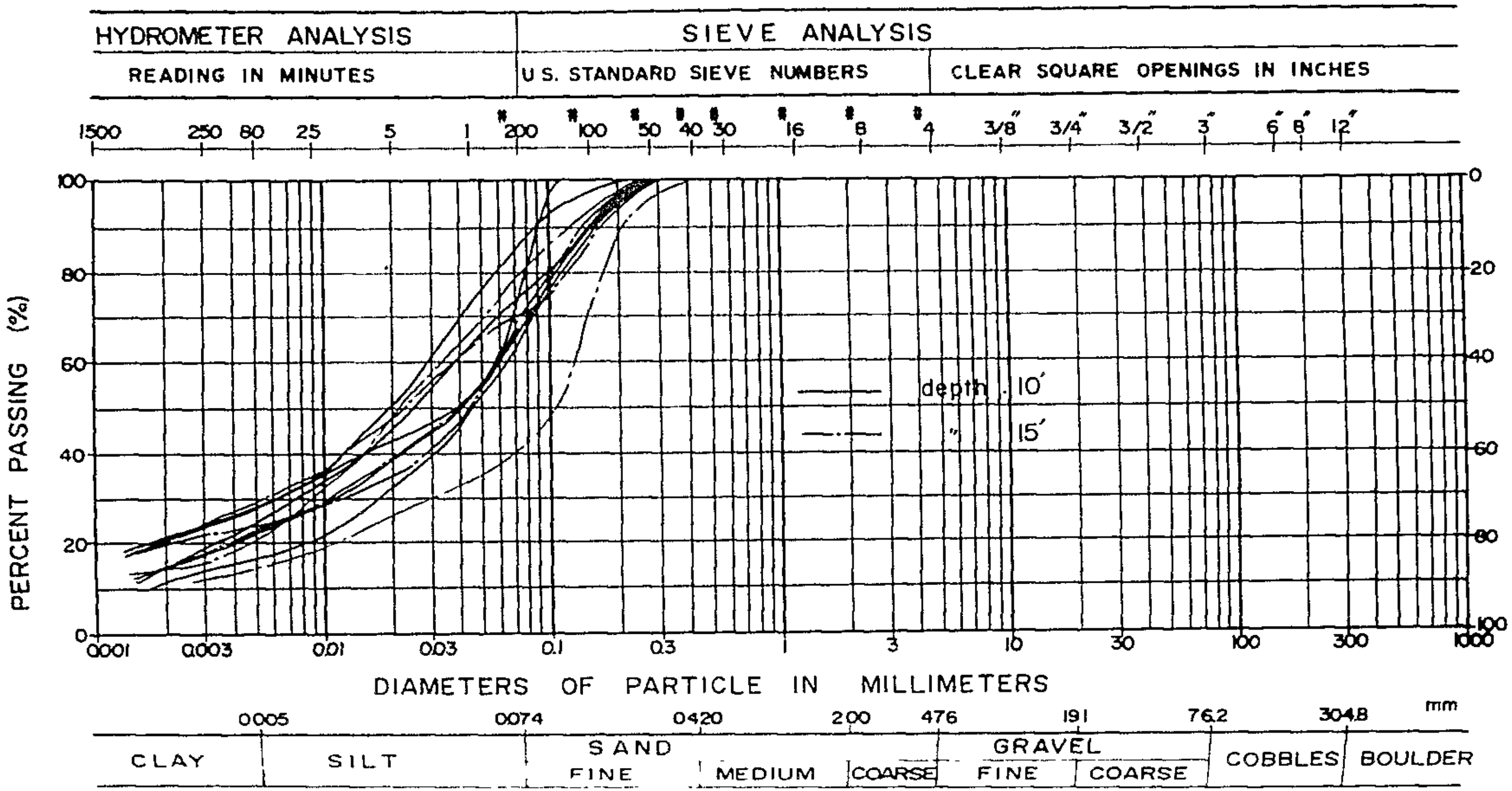


FIGURE 4D-3(I) RELATIONSHIP BETWEEN MOISTURE CONTENT/DRY DENSITY, COHESION, FRICTION ANGLE, PERMEABILITY

OKKAN DAM PROJECT

Sampling Point ; Borrow Area C,D,H,I,J (by Open Trench)

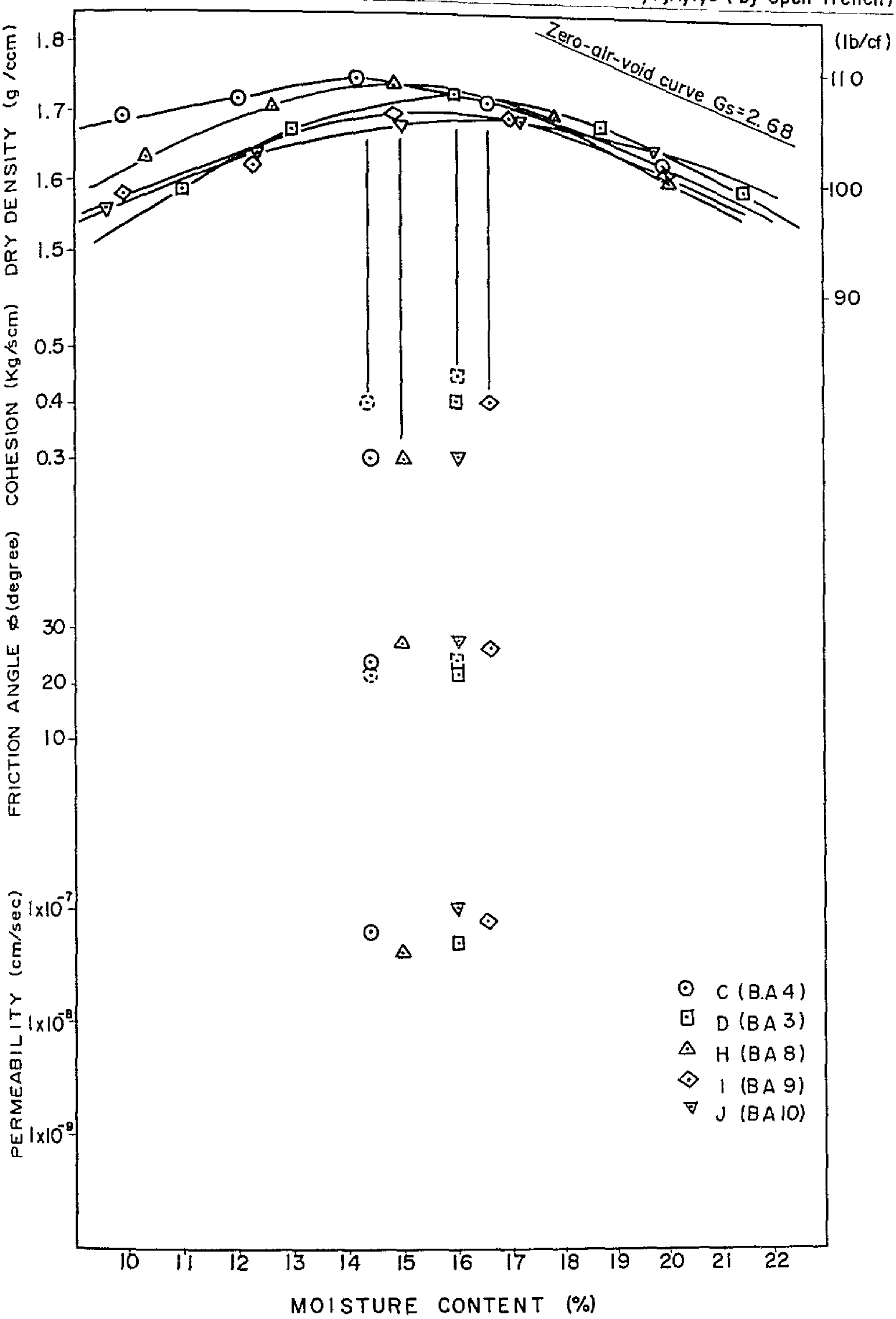


FIGURE 4D-3(2) RELATIONSHIP BETWEEN MOISTURE CONTENT/DRY DENSITY, COHESION, FRICTION ANGLE, PERMEABILITY

OKKAN DAM PROJECT

Sampling Point ; Borrow Area 1~10 (by Hand Auger)

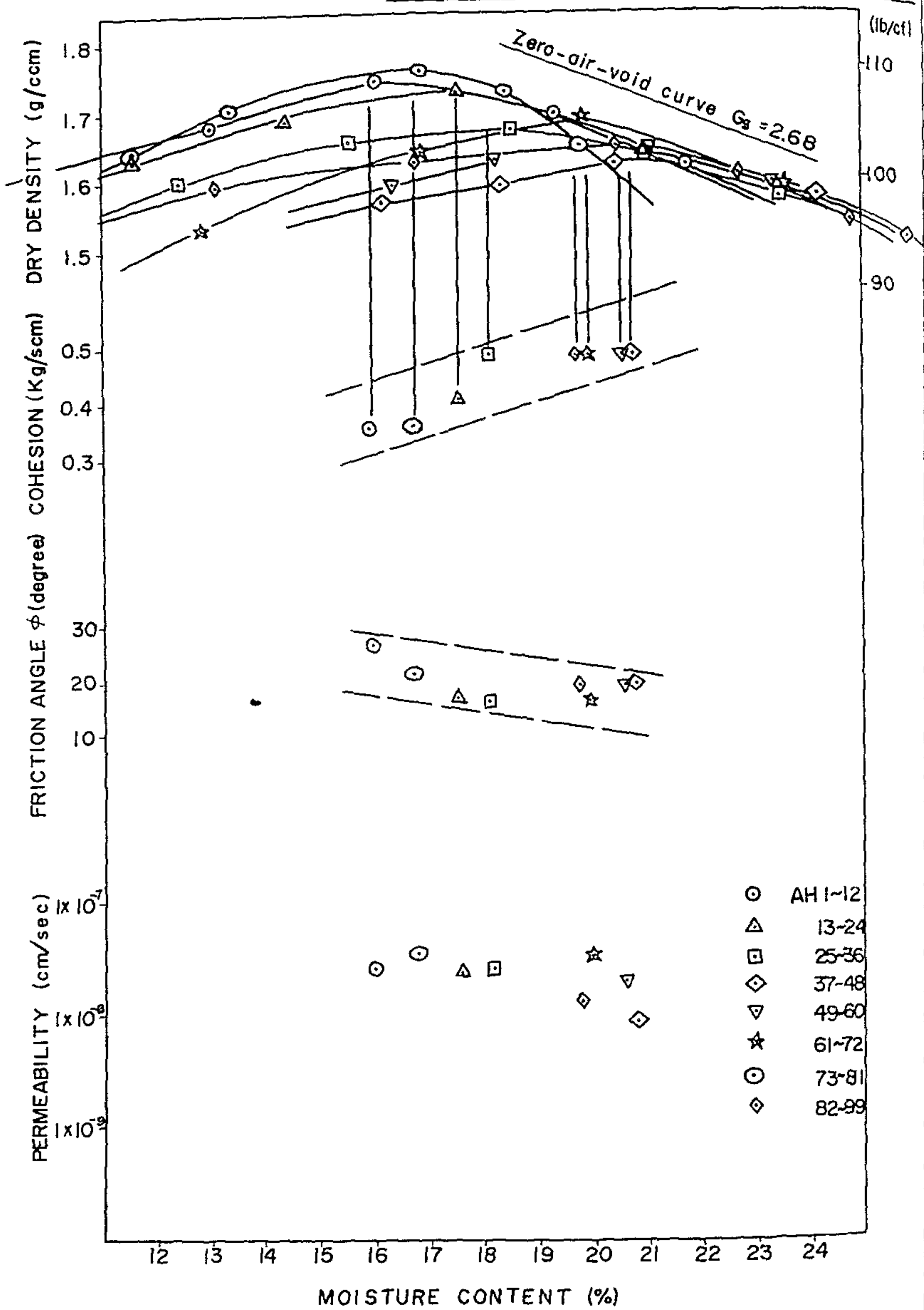


FIGURE 4D-4 (1) GRAIN-SIZE ANALYSIS

Project OKKAN DAM IRRIGATION PROJECT

Date of Testing . February 1981

Location of Project

Remarks ; River Deposits of the Okkan Chaung

Sampling point ; River Bed of the Okkan Chaung

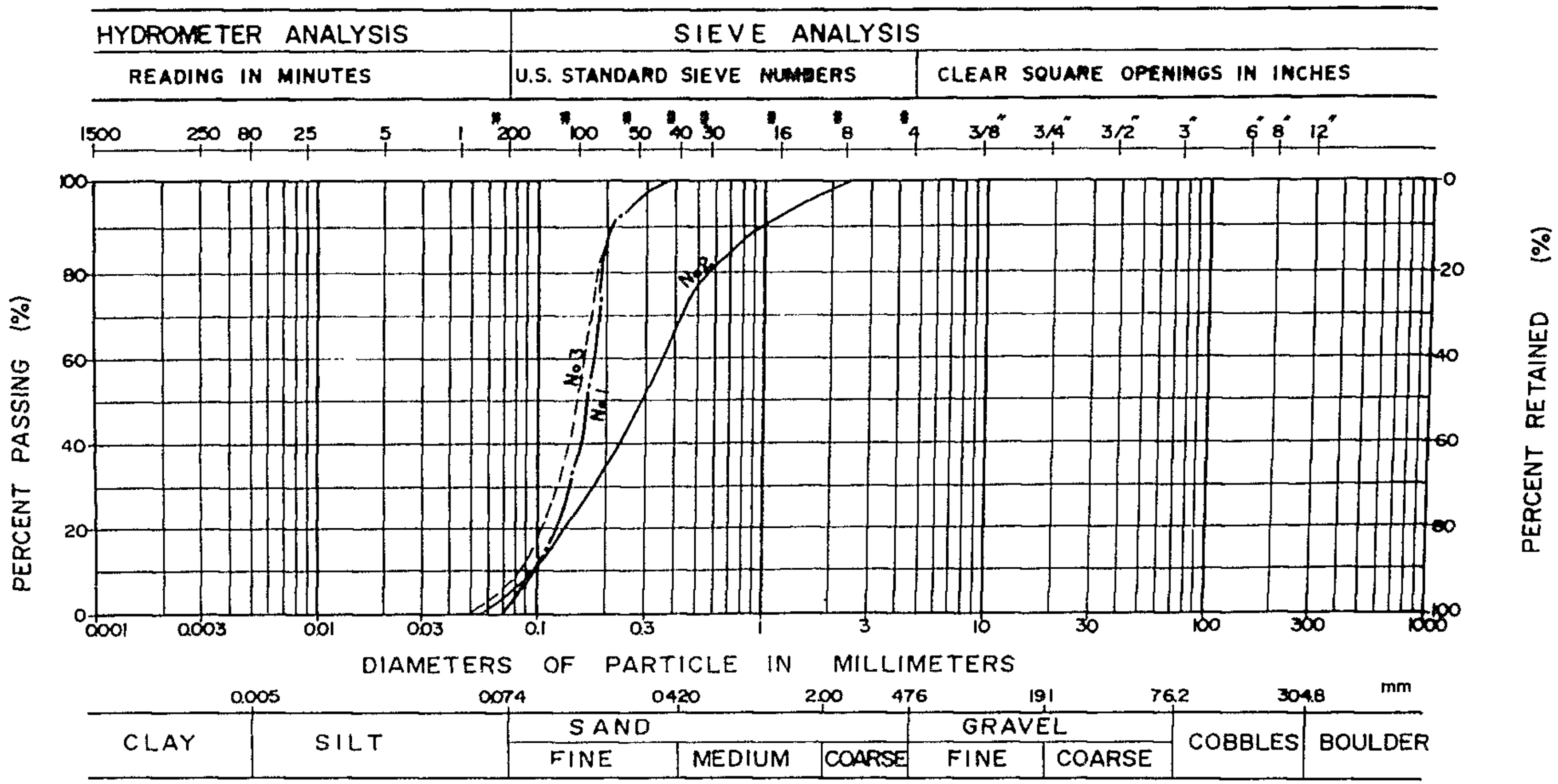


FIGURE 4D-4 (2) GRAIN-SIZE ANALYSIS

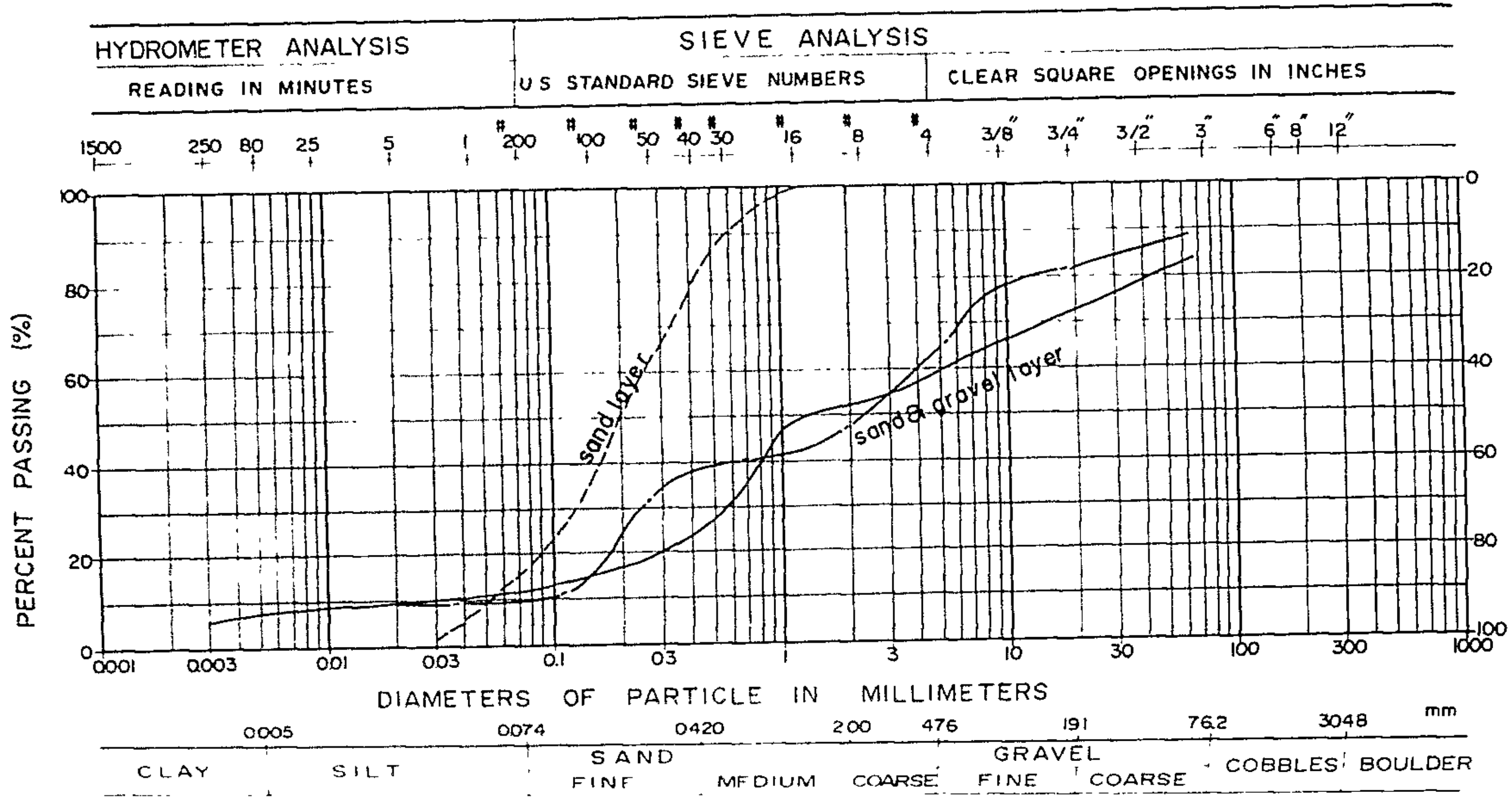
Project OKKAN DAM IRRIGATION PROJECT

Location of Project

Sampling point; near the NATSING GONE

Date of Testing February 1981

Remarks ; Filter Materials. (IRRAWADDY FORMATIONS)



Dam Type

In general, the dam type is classified into two types, concrete and fill. At the Okkan damsite, the most recommendable dam type is fill dam judging from the chord-height ratio, topographical condition, distribution of embankment materials available around the damsite and required bearing capacity and shearing strength of the dam foundation which shall be safe against normal and tangential component forces transmitted by the dam body.

As for the types of fill dams, a homogeneous type was given preference over zone and facing types taking into account about 30 m height of dam, available impervious materials sporadically distributed along the Okkan chaung and Migyaung chaung at the upstream of damsite which are classified as CL type under the Unified Soil Classification System, and previous and rock materials which are not easily available in the vicinity of the damsite.

Homogeneous dam body was mainly sub-divided into three zones considering the soil mechanic property of the embankment materials, resistance of piping, structural stability and execution of economical embankment. Zone 1 is located in the central part of dam body with impervious materials hauling from the borrow area. Zone 2 consists of a main part of the dam body with natural deposited materials at the borrow area and excavated material at the dam foundation and appurtenant structures sites, however, the excavated materials should be embanked at the downstream portion of Zone 2 in order to eliminate slaking effect of those materials against seepage water through Zone 1.

Zone 3 is placed at the downstream toe of the dam body as piping and uplift protection with rock material hauling from the quarry site.

At the surface of upstream slope of the dam body, the hand-placed riprap should be placed against the wave force due to wind.

Consequently, an earth-fill type of fill dam having central impervious zone with crest elevation at 205 feet (62.5 m) was selected as the most suitable type for the Okkan dam and the typical section is shown in Drawing No.D-1002.

Freeboard and Dam Crest Elevation

1. Freeboard

Freeboard is the difference between the crest elevation and the maximum water surface level in reservoir and is shown in the following equation in consideration of various factors according to the Design Criteria For Dams which was established by Japanese National Committee on Large Dams.

$$Hf \geqq (R \text{ or } he/2) + ht + hs$$

where, Hf; freeboard of dam

R; height of wave due to wind

he; height of wave due to earthquake

ht; rise of water level due to unexpected accident in operating spillway gates, for ungated type spillway ht may be taken to be zero

hs; addition of allowance according to type and importance of dam, standard value hs is 1.0 m adopted for fill dam

1.1. Height of Wave due to Wind

Height of wave due to the wind is considered to be caused by deep-water wave, and then, the height of significant wave is adopted based on S.M.B. (Sherdrup-Munk-Breschneider) method which is derived from factors such as fetch and wind speed. On the other hand, since uprushing height varies considerably with embankment slope and roughness of slope, height of significant wave should be adjusted adequately with Saville method to obtain height of wave due to the wind.

The calculation results with various slopes and fetches are shown in Figure 4D-5.

In order to obtain the height of wave due to wind in the Okkan damsite, the wind speed of 20 m per second in 10 minutes on an average is to be assumed taking into account the observed data of mean wind speed in Tharrawaddy.

1.2. Height of Wave due to Earthquake

The height of wave due to earthquake can be obtained by Sato's formula as follows;

$$he = \frac{k \cdot t}{2\pi} \sqrt{g \cdot Ho}$$

where, he; height of wave at upstream surface of the dam due to earthquake

k; horizontal seismicity and adopted by 0.15*

t; period of seismic waves and adopted by 1.0 second

g; gravitational acceleration

Ho; depth of reservoir water

1.3. Freeboard

Estimated freeboard of the Okkan dam is shown in the following table. The upstream surface of the Okkan dam is formed with hand-placed riprap by the materials obtained from quarry site, therefore, an intermediate value at the smooth slope and the rough slope in Figure 4D-5 was adopted as the height of wave due to wind.

Fetch (m)	R (m)	Ho (m)	he (m)	ht (m)	hs (m)	Freeboard (m)
4,500	0.97	23.0	0.36	0.00	1.00	1.97 (≑ 6.5 ft)

2. Dam Crest Elevation

According to the result of spillway studies, a rising height of water surface from the full water surface level due to release of

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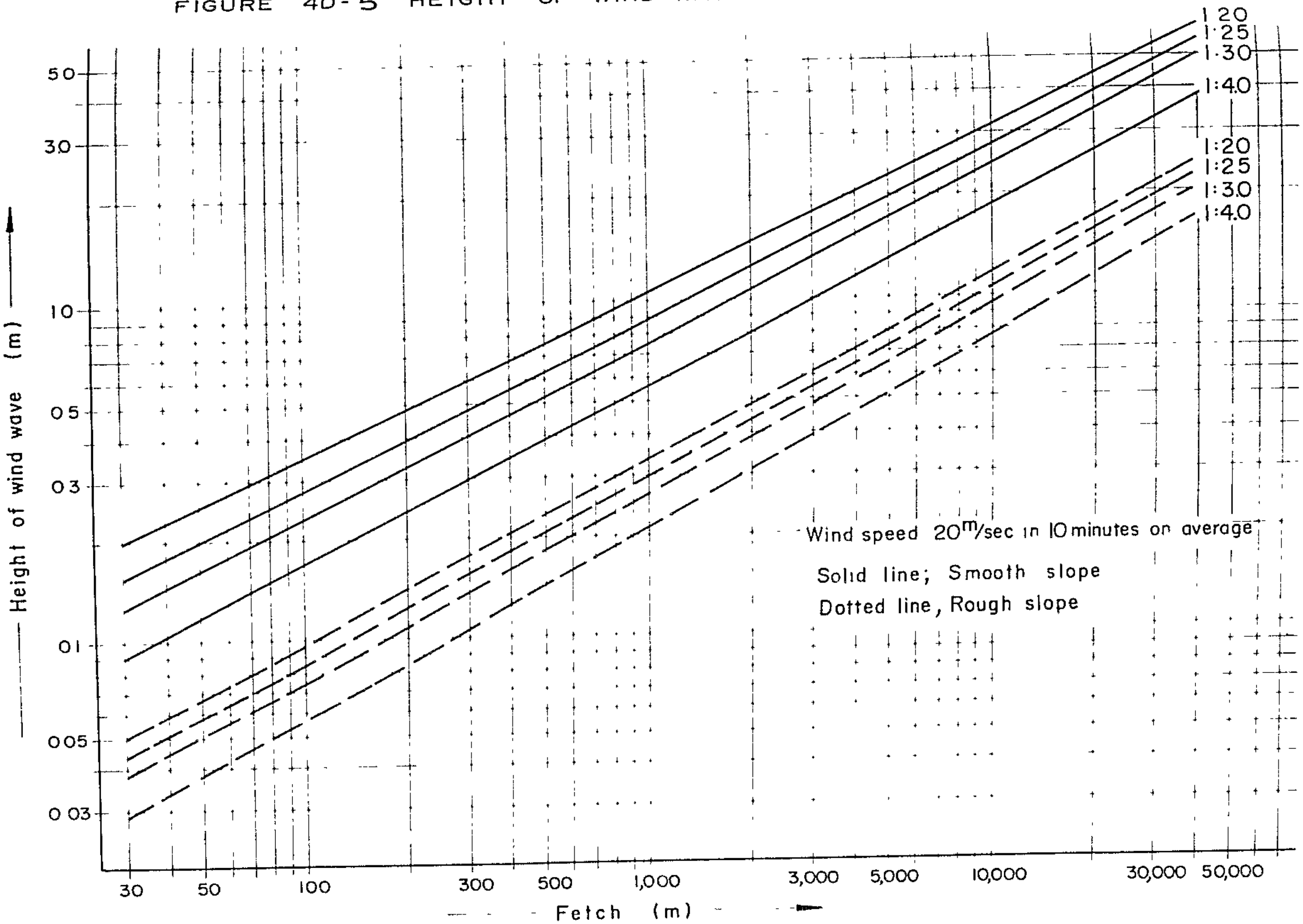
* Based on the Seismic Intensity Zonation Map by G.P. Gorshkov, it seems reasonable that the number of 0.15 will be adopted as a coefficient horizontal seismic force in designing the dam body and related structures.

FIGURE 4D-5 HEIGHT OF WIND WAVE (BY SMB & SAVILLE METHOD)



the design flood discharge at the spillway was decided to 1.10 m and its corresponding water surface elevation is tabulated as follows;

Water Level	Storage Capacity ($x\ 10^6 m^3$)	Water Surface Elevation (EL ft)	Area of Water Surface ($x\ 10^6 m^2$)
Full reservoir Storage	240.0	195.0	28.0
Max. reservoir Storage	268.8	198.6	30.0

From the above table, the crest elevation of Okkan dam without extra bank can be obtained by adding the freeboard to maximum water surface level in the reservoir as follows;

Dam crest elevation, EL 198.6 + 6.5 = EL 205.1 feet
≑ EL 205 feet

Stability Analysis of Dam Body

1. Design Values

The soil mechanic properties of embankment materials at the borrow area are almost same, however in detail, these materials have a little difference judging from the results of compaction test. It is desirable that the design values of embankment materials for the Okkan dam should be decided according to the results of soil tests, however some of them were assumed by the past data obtained in the similar materials in Japan due to the lack of dynamic tests in quality and quantity.

Design values of density and shearing strength to be used for the stability analysis of dam body vary with the moisture content and degree of compaction by the roller and these values of Zone 1, 2 and 3 are described as follows.

1.1. Zone 1. (Impervious) Materials

The excavation materials at the borrow area can be used as impervious fill. Since the embankment of impervious materials should be executed at about 90 percent in degree of saturation due to exclusion of the effect by seepage water from the reservoir, the dry density of impervious material is controlled more than 95 percent of the maximum dry density of compaction test.

From the above consideration, the design value of density and shearing strength is decided by the results of soil test executed by Irrigation Department in 1978, 1980 and 1981, and those values are shown in the following table. As for the shearing strength, the tests corresponding to various moisture contents and the triaxial compression test have not been executed; therefore the design values of shearing strength were decided from the direct shear test values considering the mechanism of testing equipment and execution of embankment at about 95 percent of the maximum dry density.

Density			Shearing strength		Permeability Coefficient (cm/sec)
γd 1/ (t/m³)	γt 2/ (t/m³)	γsat 3/ (t/m³)	ϕ 4/ (°)	C 5/ (t/m³)	
1.61	1.93	2.01	21°00'	4.0	4.0×10^{-6}

Notes; 1/ dry density, 2/ wet density, 3/ saturated density, 4/ angle of internal friction, 5/ cohesion

$$\gamma d = \frac{Gs}{(1 + e)}, \quad \gamma t = \gamma d\ (1 + \frac{M \cdot C}{100}), \quad \gamma sat = \frac{(Gs + e)}{(1 + e)}$$

$$e = \frac{GS - \gamma d}{\gamma d},$$ Gs; specific gravity, e; void ratio

M·C; moisture content

1.2. Zone 2 (Random) Materials

Zone 2 is embanked with excavated materials at the borrow area, spillway and appurtenant structure sites, however, most of them consist of hauling materials from the borrow area.

Since the excavated materials at the structures sites have a tendency to easily slake against seepage water from the reservoir, the utilization of these materials should be limited at the downstream side of Zone 2. The random zone may fairly be mixed with various materials ranging from fine clay materials to coarse excavated rock materials, however in global, it can be assumed that the soil mechanic properties of these materials are almost equal to the impervious one.

As for the design values of density and shearing strength, the same values of Zone 1 can be quoted for Zone 2, however for the permeability coefficient of Zone 2 should be increased considering the difference of compaction effect by tire roller.

1.3. Zone 3 (Rock) Materials

Since effective test has not been executed for determination of the design values of rock materials, the estimation is made based on the data obtained from the past tests in Japan, and the results are shown in the following table.

Gs 1/	e 2/	M·C 3/ (%)	Density: γd 4/ (t/m^3)	γt 5/ (t/m^3)	γsat 6/ (t/m^3)	Shearing strength: ϕ 7/ (°)	C 8/ (t/m^3)
2.37	0.5	5.0	1.58	1.66	1.91	42°00'	0.0

Notes; 1/, 2/, 3/ assumed values, 4/ dry density $\gamma d = GS(1 + e)$

5/ wet density $\gamma t = \gamma d\ (1 + \frac{M \cdot C}{100})$, 6/ saturated density

$\gamma sat = (Gs + e)/(1 + e)$, 7/ angle of internal friction,

8/ cohesion

Design values of the above-mentioned embankment materials for the Okkan dam are summarized in Table 4D-2.

Table 4D-2 Summary of Design Values for Embankment Materials on Okkan Dam

Material	Density: γd 4/ (t/m^3)	γt 5/ (t/m^3)	γsat 6/ (t/m^3)	Shearing Strength: ϕ 7/	C 8/ (t/m^3)	Permeability Coefficient (cum/sec)
Zone 1	1.61	1.93	2.01	21°00'	4.0	4.0×10^{-8}
Zone 2	1.61	1.93	2.01	21°00'	4.0	8.0×10^{-8}
Zone 3	1.58	1.66	1.91	42°00'	0.0	-

Note; The titles in the table are same in the paragraph of Zone 3 materials.

2. Phreatic Line (Seepage of Free Surface)

Since the seepage of free surface for the fill-type dam is rather difficult to obtain theoretically, an approximate formula which has been derived by Cassagrande was adopted for the full water level of the reservoir.

The permeability in horizontal and vertical directions of embanked impervious materials is quite different. In this case, the materials should be considered as an anisotropic medium with the permeability depending on the direction of flow. The ratio of vertical coefficient of permeability (Kv) to horizontal one (Kh) at the compacted impervious materials differs depending on the method of compaction. Generally, in case that compaction is made by tamping roller and tire roller, Kh may nearly be equal to 5 Kv and 20 Kv respectively.

The effect of an anisotropy in the permeability can be replaced by an equivalent shrinking of the coordinates. Namely, transformed section is obtained by shrinkage of horizontal dimension of coordinates by the ratio of $\sqrt{Kv/Kh}$. In the transformed section, the seepage of free surface can be obtained by using approximate formula at the full reservoir water surface.

The phreatic line in original section is shown in Figure 4D-6.

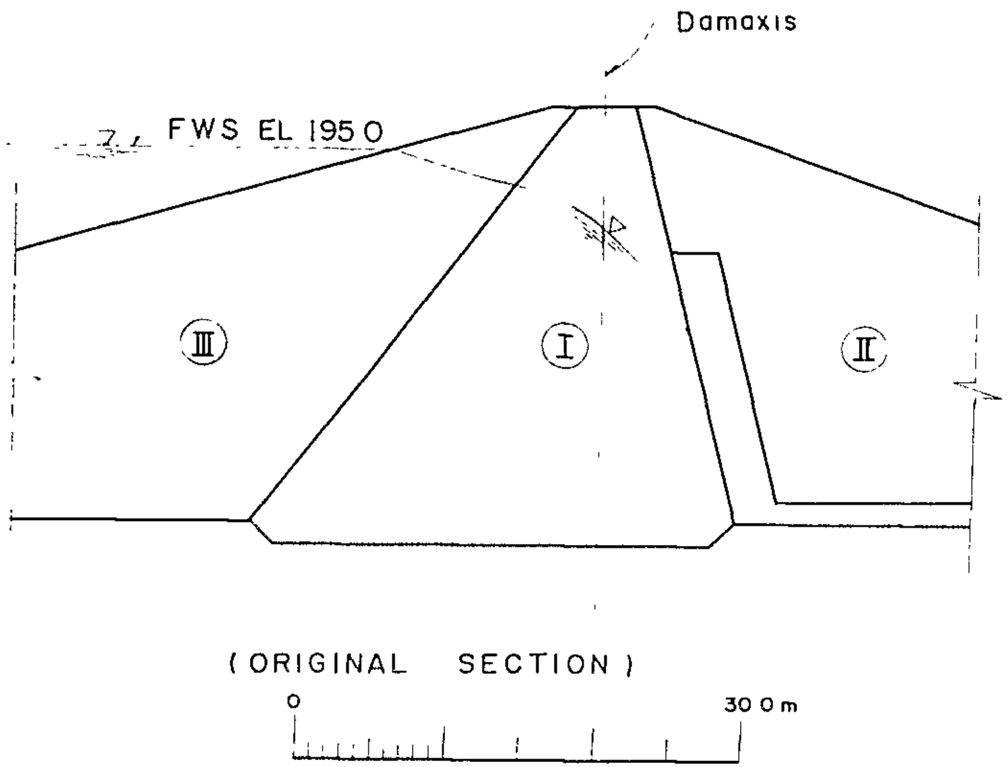
3. Stability Analysis against Sliding Failure

Stability of the dam body means that a soil mass with skelton stress and pore pressure can keep its equilibrium state in resisting to the external forces. Taking into account the above-mentioned condition, the stability analysis is made by effective stress method where the pore pressure was considered.

There are two situations for pore pressure; the one is due to unsteady flow in the course of embankment and immediately after completion of embankment, and the other is due to steady flow at full or rapid draw-down condition of the reservoir.

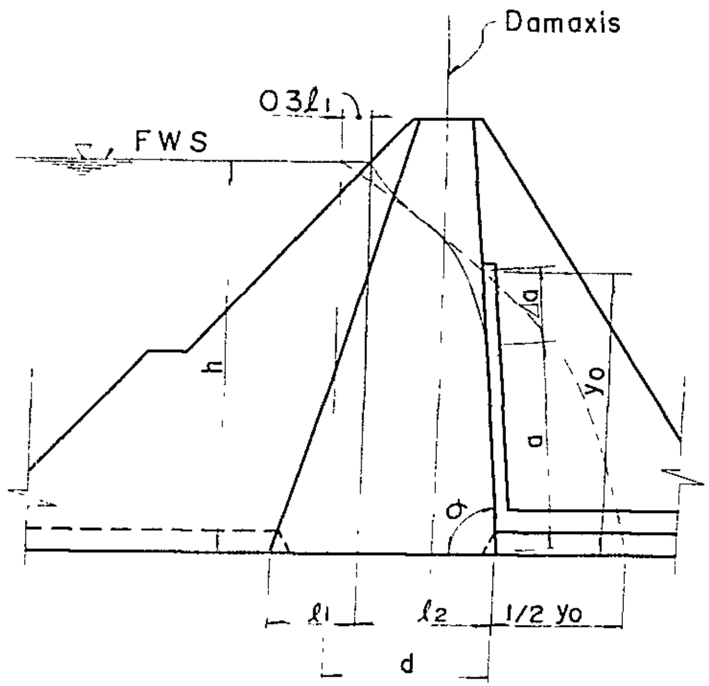
Since the shearing strength tests were carried out only by direct shear test, the sliding failure analysis for the dam body is made under the following cases in consideration of the pore pressure.

FIGURE 4D-.. SEEPAGE OF FREE SURFACE



(ORIGINAL SECTION)

Zone 1 , Kh = 5 Kv (Tamping roller)
Zone 2 ; Kh = 20Kv (Tire roller)



(TRANSFORMED SECTION)

$y_o = \sqrt{h^2 + d^2} - d$, $d = 1/3\,\ell_1 + \ell_2$

$X = \frac{y^2 - y_o^2}{2y_o}$, $a + \Delta a = \frac{y_o}{1 - \cos\alpha}$

$\frac{\Delta a}{a + \Delta a} = 0.2b$,

Case and reservoir condition	Slope	Core pressure
After completion, F.W.S.*	Up and downstream	Steady flow
Rapid drawdown, from F.W.S. to D.W.S.**	Upstream	Steady flow

Stability analysis is carried out by the slip circle method shown in Figure 4D-7 and the factor of safety is obtained by the following equation.

$$F.S = \frac{\Sigma[(N - U - Ne).\tan\phi + C\cdot\ell]}{\Sigma(T + Te)}$$

where, F.S; factor of safety

N; normal force acting on slip circle of each slice

U; pore pressure acting on slip circle of each slice

Ne; normal force of earthquake load acting on slip circle of each slice

ϕ; angle of internal friction of materials on slip circle of each slice

C; cohesion of materials on slip circle of each slice

ℓ; arc length of slip circle of each slice

T; tangential force acting on slip circle of each slice

Te; tangential force of earthquake load acting on slip circle of each slice

The factor of safety is in conformity with the Design Criteria for Dams established by Japanese National Committee on Large Dams, that is to say, it must not be less than 1.2 in any case. This value comes from the consideration that the dynamic property of the embankment materials in earthquake is not clarified and the limit design system is introduced to calculation process.

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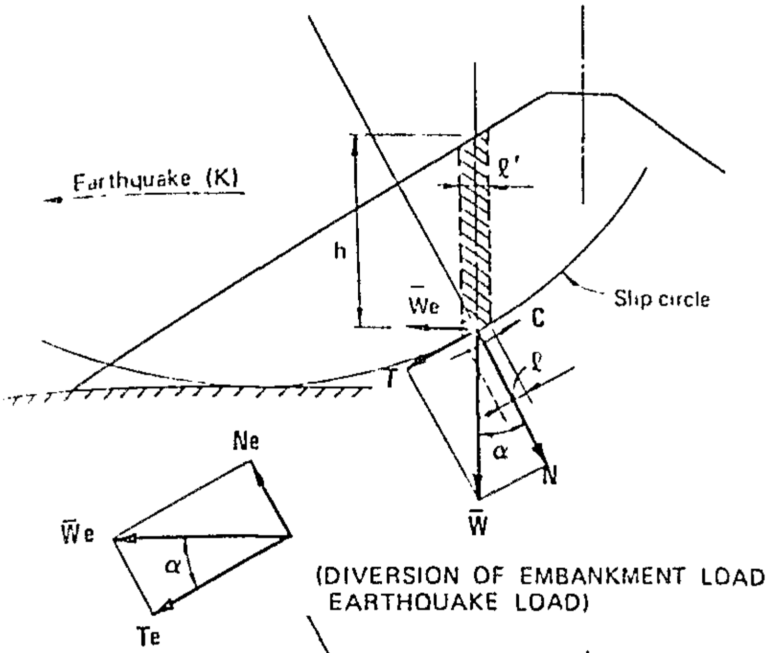
* Full water surface in reservoir and adopted by EL 195 feet.

** Dead water surface in reservoir and adopted by EL 155 feet.

FIGURE 4D-7 STABILITY ANALYSIS WITH SLIP CIRCLE METHOD



(DIVERSION OF EMBANKMENT LOAD AND EARTHQUAKE LOAD)

$\bar{W} = h \times \ell' \times \gamma$

ℓ': width of slice

γ : unit weight

$N = \bar{W} \times \cos\alpha$

$T = \bar{W} \times \sin\alpha$

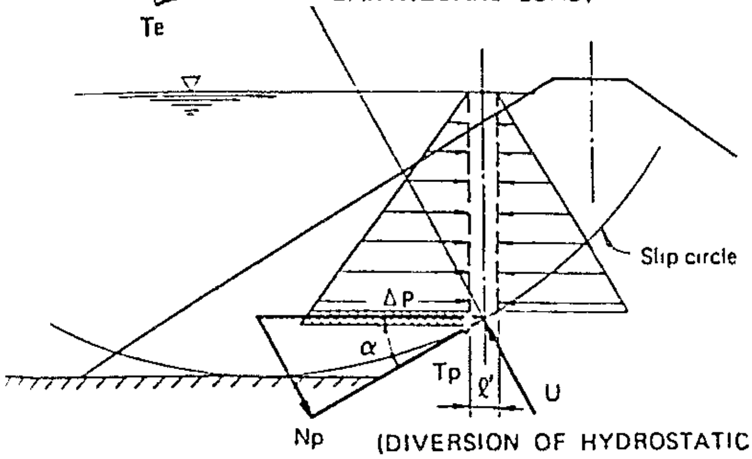
$\ell = \ell'/\cos\alpha$

$\bar{W}e = \bar{W} \times K$

K: seismic coefficient

$Ne = \bar{W}e \times \sin\alpha$

$Te = \bar{W}e \times \cos\alpha$



(DIVERSION OF HYDROSTATIC PRESSURE)

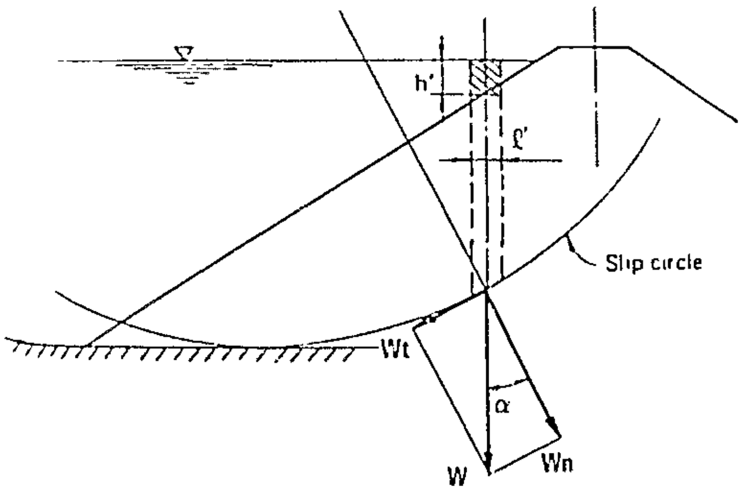
$Np = \Delta P \times \sin\alpha$

$Tp = \Delta P \times \cos\alpha$

ΔP: difference of hydrostatic pressure between both side of slice

ℓ': width of slice

U : pore pressure



(DIVERSION OF SURCHARGE WATER)

$W = h' \times \ell' \times \gamma'$

ℓ': width of slice

γ': unit weight of storage water

$Wn = W \times \cos\alpha$

$Wt = W \times \sin\alpha$

The calculation should be repeated for different circles until obtained in the smallest value of factor of safety as above-mentioned. This procedure is the work of trial and error, and the electronic computer is advantageously used with the flow chart as shown in Figure 4D-8.

The results of calculation are presented in Table 4D-2.

Table 4D-3 Factor of Safety for Dam Body

Reservoir condition	K3/	Slope	F.S4/	Pore Pressure
After completion with F.W.S1/	0.15	Upstream	1.229	Steady flow
	0.15	Downstream	1.365	Steady flow
Rapid drawdown from F.W.S to D.W.S2/	0.075	Upstream	1.716	Steady flow

Notes; 1/ full water surface level in reservoir and adopted by EL 195 feet

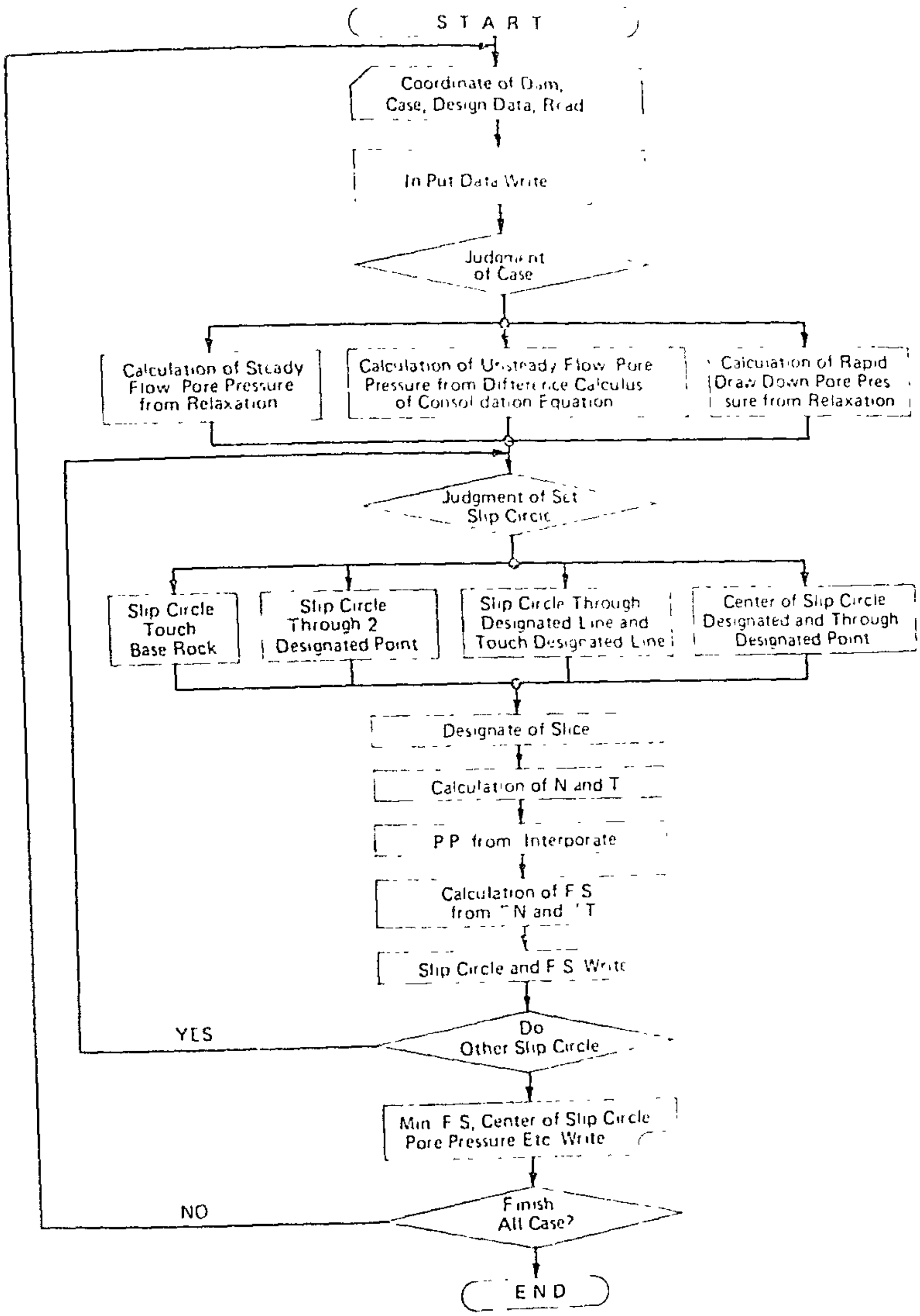
2/ dead water surface level in reservoir and adopted by EL 155 feet

3/ horizontal seismicity and adopted by 0.15 in usual case and 0.075 in special case.

4/ factor of safety

The above factor of safety is considered reasonable judging from the design of feasibility stage, the quality and quantity of soil tests, and the capacity of test equipment. Besides, the above factor of safety will be increased taking into account that the enlargement of crest width of coffer dam and stabilized fill executed by spoil bank at the upstream and downstream slopes of dam body respectively is effective.

FIGURE 4D-8 FLOW CHART OF STABILITY ANALYSIS BY COMPUTER



Since the dynamic tests for the embankment materials were limited in quality and quantity, it is recommendable to execute the triaxial compression tests with U-U* and C-U** conditions measuring the pore pressure.

It is desirable that the embanked devices such as per pressure gauges and multi-layer settlement measurements will be installed in the dam body due to control of the embankment speed; management of dam body in future.

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* U-U; unconsolidated-undrained test

** C-U; consolidated-undrained test

Spillway

1. Type and Alignment

In general, open-type spillway should be adopted to the fill dam from viewpoints of non resistance against overtopping from unexpected flood and hydraulic characteristics of itself. It is considered that the non-control type, i.g., overflow type without gate is more suitable to be adopted than the other type of spillway from the viewpoints of design flood discharge, topographical and geological conditions at the spillway site and the avoidance of risk by gate control.

As for the alignment of spillway, a skinny mountain ridge at the right bank is more profitable to be selected than the left abutment, considering the applicability of topographical feature and the weathering condition of the bed rock. The spillway is composed of three main elements such as center overflow type in control structure, chute type in discharge carrier and horizontal apron type in energy dissipator.

2. Design Flood Discharge

For the spillway design purpose, 1,000-year probability flood discharge was considered in conformity with Design Criteria for Dams in Japan*. The running discharge through the spillway in peak can be decreased from the design flood discharge due to storage effect above full water surface level in reservoir at the entrance of spillway.

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* According to Design Criteria for Dams which was established by Japanese National Committee on Large Dams, the design flood discharge for the spillway should be estimated by 20 percent more than that in 200-year probability flood discharge at the fill dam and this value is almost similar to 1000-year probability volume.

The calculation has been carried out by using the following formula considering the relationship between the flow-out capacity of spillway and the storage effect in reservoir provided by the dam with a 1,000-year probability flood flow into the reservoir.

$$1/2\ (I_1 + I_2)\cdot\Delta t + S_1 - 1/2\cdot O_1\cdot\Delta t = S_2 + 1/2\cdot O_2\ \Delta t$$

where, I_1; inflow discharge at t_1 hour in m^3/sec
I_2; inflow discharge at t_2 hour in m^3/sec
O_1; outflow discharge at t_1 hour in m^3/sec
O_2; outflow discharge at t_2 hour in m^3/sec
S_1; storage volume at t_1 hour in m^3
S_2; storage volume at t_2 hour in m^3
$\Delta t = t_2 - t_1,\ (t_2 < t_1)$

A rise of water surface level in the reservoir and flow-out discharge through the spillway due to various length of crest at the spillway are shown in Table 4D-2 and summarized in the following table in consideration of the storage effect in reservoir.

	Length of Crest at Spillway (m)			
	30.5	45.7	61.0	76.2
Water surface elevation (EL ft)	198.96	198.77	198.60	198.47
Flow-out discharge (m^3/sec)	87.03	121.09	150.62	177.93
Overflow depth* (m)	1.20	1.15	1.10	1.06

From the above table, it seems that the flow-out discharge of 150 m^3/sec is reasonable value as a design flood discharge for the spillway with length of crest about 61 m in consideration of the applicability and restriction of topographic feature and geological condition at the spillway site.

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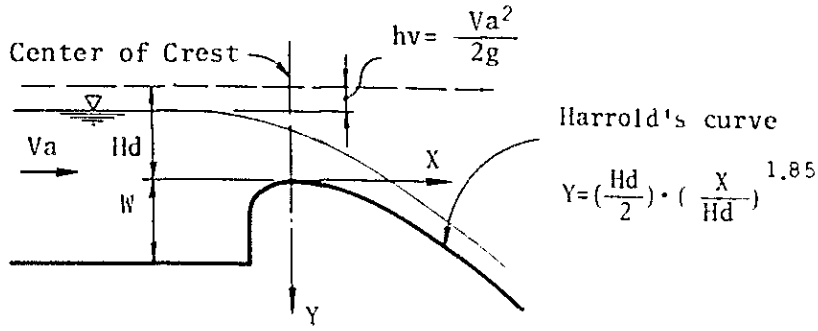
* Overflow depth = depth from water surface elevation - 195.0 feet

3. Hydraulic Design

The dimensions of weir in complete overflow condition have a close relation with a shape of weir. In case Harrold's standard type as shown in the following figure is adopted as the shape of overflow crest, coefficient of discharge and length of weir can be obtained from following equations.



$C = 2.200 - 0.0416\ (Hd/W)^{0.990} = 2.154$

$L = Q/CH^{3/2} = 60.36\ m \fallingdotseq 60.5\ m$

where, C; coefficient of discharge
Hd; overflow head at crest and adopted by 1.10 m
W; depth of entrance channel and adopted by 1.00 m
L; effective overflow width
Q; design flood discharge and adopted by 150 m^3/sec

Whe water depth of chute at the discharge carrier was roughly calculated in applying the following equation setting up a control point at 80.8 m downstream from the crest along the center of spillway.

$$(1 - \alpha)\ He = d + [Q^2/2gd^2 \cdot b^2]$$

where, He; difference elevation between the total head at control point and under consideratioin section
α; coefficient of friction loss and adopted by 0.15
d; water depth under consideration section
Q; design flood discharge through the spillway and adopted by 150 m^3/sec
g; gravitational acceleration
b; width of chute section and adopted by 15.0 m

The results of calculation of water depth at the chute are shown in the following table.

Distance* (m)	Bottom Elevation (EL ft)	Water Surface Elevation (EL ft)	Water Depth (m)	Velocity (m/sec)	Fr**
0.0	185.0	192.12	2.17	4.61	1.00
13.72	170.0	173.08	0.94	10.64	3.51
27.43	155.0	157.36	0.72	13.89	5.23
41.15	140.0	142.00	0.61	16.39	6.70
54.86	125.0	126.77	0.54	18.52	8.05
68.58	110.0	111.57	0.48	20.83	9.60
77.72	100.0	101.51	0.46	21.74	10.24

The running water through the chute posseses considerably high energy to bring about erosion and scouring at adjacent downstream of the dam body.

Judging from the velocity and Froude number of the running water, intensive hydraulic jump shall be occurred in the energy dissipator, therefore, the USBR (United States Department of Interior, Bureau of Reclamation) type II in providing chute and end sill in the stilling basin should be adopted. The conjugate depth in the stilling basin d_2 can be obtained by the following formula:

$$d_2 = 1/2\ d_1\ (\sqrt{1 + 8\ Fr^2} - 1),\quad Fr = V_1/\sqrt{g \cdot d_1}$$

where, d_2; conjugate depth in the stilling basin

d_1; water depth at the end of chute

Fr; Froude number

V_1; velocity at the end of chute

g; gravitational acceleration

---

* Distance is measured from the control point

** Froude number, $Fr = V/\sqrt{g \cdot d}$

The required length of stilling basin Ls can be obtained from relation curve between Ls/d_2 and Froude number, and adopted by Ls/d_2 is 4.3 for type II stilling basin.

The results of calculation for d_2 and Ls are shown in the following table.

Floor elevation (EL ft)	d_1 (m)	Fr	d_2 (m)	Ls (m)
100.0	0.46	10.24	6.44	27.69 ≑ 28.00

The freeboard of chute and stilling basin can be obtained from the following formula and the results of calculation are tabulated as follows:

Chute $\quad Fb = 0.1\ V\ d^{1/2}, \quad H = (d + Fb)/\cos\theta$

Stilling basin $\quad Fb = 0.1\ (V_1 + d_2), \quad H = (d_2 + Fb)$

where, Fb; freeboard of chute and stilling basin
V, d; velocity and water depth at the under consideration section
V_1; velocity at the end of chute
d_2; conjugate depth in the stilling basin
H; vertical height of side wall
θ; angle of bottom slope at the chute

Distance* (m)	Floor elevation (EL ft)	Chute		Stilling basin	
		Fb(m)	H(m)	Fb(m)	H(m)
0.0	185.0	0.68	3.00	-	-
13.72	170.0	1.03	2.08	-	-
27.43	155.0	1.18	2.00	-	-
41.15	140.0	1.28	1.99	-	-
54.86	125.0	1.36	2.00	-	-
68.58	110.0	1.44	2.02	-	-
77.72	100.0	-	-	2.82	9.26 ≑ 9.30

* Distance is measured from the control point

A profile along the center of spillway is shown in Drawing No.D-1003. Since the flow condition around control structure of the spillway is rather complicate, it is desirable to execute the hydraulic model test during the design stage.

4. Ultimate Flow-out Capacity

It is assumed that unexpected flood discharge would flow into the reservoir at quantity over the design flood discharge of spillway, the flow-out capacity of spillway can roughly be estimated from the following formula taking into account the storage effect of reservoir.

$$\Delta H = \frac{2}{3} \cdot \alpha \cdot \frac{Q}{Q_1} \cdot \frac{H}{1 + \frac{A \cdot H}{Q_1 \cdot T}}$$

where, ΔH; rise of water surface level due to unexpected flood discharge

α; rate of addition for unexpected flood discharge

H; design overflow depth

A; reservoir water surface area at time of design flood discharge

Q; 1,000-year probability flood discharge

Q_1; design flood discharge for the spillway

T; duration time of discharge over the design flood discharge and adopted by 2 hours

From the results of calculation, the relationship between the rising height of water surface and flow-out peak discharge for the Okkan dam is shown in the following table.

	α(rate of addition for unexpected flood discharge)					
	0.1	0.2	0.3	0.5	0.75	1.0
$(1+\alpha)$ Q(m^3/sec)	1,257.4	1,371.7	1,486.0	1,714.7	2,000.4	2,286.2
ΔH (m)	0.02	0.03	0.05	0.09	0.13	0.17

$Q_1 = 150\ m^3/sec$, $H = 1.10\ m$, $A = 30.5 \times 10^6 m^2$

Table 4D-4 (1) Flow-out Discharge for Spillway

FWL= 195.000 (FT) CREST LENGTH L=100.000 (FT)
V=+0000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	195.001	240008.0	20.783	0.000
20.00	195.003	240024.8	34.967	0.002
30.00	195.006	240050.0	49.150	0.005
40.00	195.010	240083.7	63.333	0.012
50.00	195.016	240126.0	77.517	0.022
60.00	195.022	240176.8	91.700	0.036
70.00	195.029	240232.3	93.617	0.055
80.00	195.036	240289.0	95.533	0.076
90.00	195.043	240346.9	97.450	0.100
100.00	195.051	240405.9	99.367	0.126
110.00	195.058	240466.0	101.283	0.155
120.00	195.066	240527.2	103.200	0.187
130.00	195.075	240597.0	129.883	0.225
140.00	195.085	240682.8	156.567	0.275
150.00	195.098	240784.6	183.250	0.339
160.00	195.113	240902.3	209.933	0.418
170.00	195.130	241036.0	236.617	0.514
180.00	195.148	241185.7	263.300	0.629
190.00	195.171	241367.1	342.650	0.779
200.00	195.199	241596.0	422.000	0.982
210.00	195.234	241872.4	501.350	1.248
220.00	195.275	242196.2	580.700	1.586
230.00	195.321	242567.4	660.050	2.004
240.00	195.373	242985.9	739.400	2.514
250.00	195.430	243443.5	791.483	3.113
260.00	195.491	243932.0	843.567	3.799
270.00	195.556	244451.3	895.650	4.575
280.00	195.625	245001.3	947.733	5.449
290.00	195.698	245582.0	999.817	6.426
300.00	195.774	246193.4	1051.900	7.510
310.00	195.853	246823.3	1063.967	8.684
320.00	195.932	247459.7	1076.033	9.927
330.00	196.013	248102.6	1088.100	11.238
340.00	196.094	248752.0	1100.167	12.616
350.00	196.176	249407.7	1112.233	14.060
360.00	196.259	250069.8	1124.300	15.570
370.00	196.342	250735.5	1127.433	17.140
380.00	196.425	251402.1	1130.567	18.761
390.00	196.509	252069.6	1133.700	20.433
400.00	196.592	252738.0	1136.833	22.153
410.00	196.676	253407.2	1139.967	23.922
420.00	196.760	254077.3	1143.100	25.738
430.00	196.843	254744.6	1134.500	27.589
440.00	196.926	255405.6	1125.900	29.465
450.00	197.008	256060.3	1117.300	31.364
460.00	197.089	256708.7	1108.700	33.282
470.00	197.169	257350.7	1100.100	35.219
480.00	197.248	257986.5	1091.500	37.173
490.00	197.326	258609.9	1062.850	39.122
500.00	197.402	259215.0	1034.200	41.046
510.00	197.475	259801.7	1005.550	42.940
520.00	197.546	260370.1	976.900	44.802
530.00	197.615	260920.2	948.250	46.629
540.00	197.681	261452.0	919.600	48.419
550.00	197.746	261964.5	887.300	50.165
560.00	197.807	262456.5	855.000	51.860
570.00	197.866	262928.2	822.700	53.502
580.00	197.922	263379.5	790.400	55.090
590.00	197.976	263810.6	758.100	56.621
600.00	198.028	264221.3	725.800	58.092
610.00	198.076	264611.7	693.367	59.503
620.00	198.123	264981.9	660.933	60.850
630.00	198.166	265331.8	628.500	62.133
640.00	198.208	265661.5	596.067	63.351
650.00	198.246	265971.1	563.633	64.500
660.00	198.283	266260.5	531.200	65.582
670.00	198.316	266531.2	503.583	66.599
680.00	198.348	266784.6	475.967	67.556
690.00	198.378	267021.3	448.350	68.453
700.00	198.405	267240.7	420.733	69.288
710.00	198.430	267443.0	393.117	70.062
720.00	198.454	267628.3	365.500	70.773
730.00	198.475	267802.3	356.650	71.442
740.00	198.496	267970.6	347.800	72.092
750.00	198.517	268133.2	338.950	72.721
760.00	198.536	268290.1	330.100	73.331
770.00	198.555	268441.3	321.250	73.919
780.00	198.573	268586.6	312.400	74.488
790.00	198.591	268727.2	305.150	75.037
800.00	198.608	268863.0	297.900	75.570
810.00	198.624	268994.0	290.650	76.085
820.00	198.640	269120.4	283.400	76.583
830.00	198.655	269242.2	276.150	77.064
840.00	198.670	269359.3	268.900	77.528
850.00	198.684	269472.4	263.517	77.976
860.00	198.698	269582.0	258.133	78.411
870.00	198.711	269688.1	252.750	78.833
880.00	198.724	269790.7	247.367	79.242
890.00	198.736	269889.6	241.983	79.638
900.00	198.748	269985.5	236.600	80.021
910.00	198.760	270078.1	232.517	80.392
920.00	198.771	270168.0	228.433	80.753
930.00	198.782	270255.3	224.350	81.104
940.00	198.792	270339.9	220.267	81.444
950.00	198.803	270421.9	216.183	81.774
960.00	198.813	270501.2	212.100	82.094
970.00	198.822	270577.7	207.167	82.403
980.00	198.831	270650.9	202.233	82.700
990.00	198.840	270721.1	197.300	82.984
1000.00	198.849	270788.1	192.367	83.256
1010.00	198.857	270852.0	187.433	83.515
1020.00	198.864	270912.8	182.500	83.762
1030.00	198.871	270970.6	177.950	83.997
1040.00	198.878	271025.6	173.400	84.221
1050.00	198.885	271077.6	168.850	84.433
1060.00	198.891	271126.9	164.300	84.633
1070.00	198.897	271173.2	159.750	84.823
1080.00	198.902	271216.8	155.200	85.000
1090.00	198.907	271258.1	152.833	85.169
1100.00	198.912	271298.0	150.467	85.332
1110.00	198.917	271336.3	148.100	85.489
1120.00	198.922	271373.1	145.733	85.640
1130.00	198.926	271408.4	143.367	85.784
1140.00	198.930	271442.2	141.000	85.923
1150.00	198.934	271475.5	142.050	86.060
1160.00	198.939	271509.4	143.100	86.198
1170.00	198.943	271543.8	144.150	86.340
1180.00	198.947	271578.8	145.200	86.483
1190.00	198.952	271514.3	146.250	86.629
1200.00	198.956	271650.3	147.300	86.777
1210.00	198.960	271681.2	129.417	86.905
1220.00	198.963	271701.3	111.533	86.987
1230.00	198.964	271710.6	93.650	87.026
1240.00	198.964	271709.2	75.767	87.020
1250.00	198.962	271697.1	57.883	86.970
1260.00	198.959	271674.3	40.000	86.877
1270.00	198.956	271645.5	37.417	86.758
1280.00	198.952	271615.1	34.833	86.633
1290.00	198.948	271583.3	32.250	86.502
1300.00	198.944	271550.0	29.667	86.366
1310.00	198.939	271515.3	27.083	86.223
1320.00	198.935	271479.0	24.500	86.074
1330.00	198.930	271441.5	22.433	85.921
1340.00	198.925	271402.9	20.367	85.762
1350.00	198.920	271363.1	18.300	85.599
1360.00	198.915	271322.1	16.233	85.432
1370.00	198.910	271280.0	14.167	85.259
1380.00	198.905	271236.8	12.100	85.083
1380.00	198.905	271236.8	12.100	85.083

PEAK OUTFLOW

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	OUTFLOW (M**3/SEC)
1233.70	198.964	271711.4	87.029

Table 4D-4 (2) Flow-out Discharge for Spillway

FWL= 195.000 (FT) CREST LENGTH L=150.000 (FT)
V=+0000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	195.001	240008.0	20.783	0.001
20.00	195.003	240024.8	34.967	0.003
30.00	195.006	240050.0	49.150	0.009
40.00	195.010	240083.7	63.333	0.018
50.00	195.016	240126.0	77.517	0.033
60.00	195.022	240176.7	91.700	0.054
70.00	195.029	240232.3	93.617	0.082
80.00	195.036	240289.0	95.533	0.114
90.00	195.043	240346.8	97.450	0.149
100.00	195.051	240405.7	99.367	0.189
110.00	195.058	240465.8	101.283	0.232
120.00	195.066	240527.0	103.200	0.280
130.00	195.075	240596.8	129.883	0.337
140.00	195.085	240682.5	156.567	0.412
150.00	195.098	240784.2	183.250	0.507
160.00	195.113	240901.8	209.933	0.626
170.00	195.129	241035.4	236.617	0.770
180.00	195.148	241194.8	263.300	0.942
190.00	195.171	241366.0	342.650	1.167
200.00	195.199	241594.7	422.000	1.472
210.00	195.234	241870.7	501.350	1.870
220.00	195.274	242194.1	580.700	2.375
230.00	195.321	242564.8	660.050	3.001
240.00	195.373	242982.6	739.400	3.764
250.00	195.430	243439.4	791.483	4.661
260.00	195.491	243926.8	843.567	5.687
270.00	195.556	244444.9	895.650	6.848
280.00	195.624	244993.4	947.733	8.155
290.00	195.697	245572.4	999.817	9.613
300.00	195.773	246181.7	1051.900	11.233
310.00	195.851	246809.2	1063.967	12.986
320.00	195.930	247442.8	1076.033	14.840
330.00	196.010	248082.6	1088.100	16.795
340.00	196.091	248728.4	1100.167	18.847
350.00	196.173	249380.2	1112.233	20.998
360.00	196.255	250037.9	1124.300	23.245
370.00	196.337	250698.8	1127.433	25.578
380.00	196.420	251360.1	1130.567	27.986
390.00	196.503	252021.8	1133.700	30.467
400.00	196.585	252684.0	1136.833	33.018
410.00	196.668	253346.4	1139.967	35.639
420.00	196.751	254009.1	1143.100	38.326
430.00	196.834	254668.6	1134.500	41.064
440.00	196.915	255321.2	1125.900	43.836
450.00	196.996	255967.1	1117.300	46.636
460.00	197.076	256606.0	1108.700	49.464
470.00	197.155	257238.1	1100.100	52.315
480.00	197.233	257863.3	1091.500	55.187
490.00	197.309	258475.7	1062.850	58.049
500.00	197.384	259069.1	1034.200	60.869
510.00	197.455	259643.6	1005.550	63.640
520.00	197.525	260199.4	976.900	66.360
530.00	197.592	260736.3	948.250	69.024
540.00	197.657	261254.4	919.600	71.627
550.00	197.719	261752.7	887.300	74.161
560.00	197.779	262230.1	855.000	76.617
570.00	197.836	262686.8	822.700	78.989
580.00	197.890	263122.6	790.400	81.277
590.00	197.942	263537.7	758.100	83.476
600.00	197.992	263932.1	725.800	85.583
610.00	198.038	264305.9	693.367	87.596
620.00	198.082	264659.0	660.933	89.512
630.00	198.124	264991.6	628.500	91.329
640.00	198.163	265303.6	596.067	93.045
650.00	198.199	265595.2	563.633	94.658
660.00	198.233	265866.4	531.200	96.167
670.00	198.265	266118.7	503.583	97.577
680.00	198.294	266353.6	475.967	98.897
690.00	198.321	266571.1	443.350	100.124
700.00	198.346	266771.4	420.733	101.259
710.00	198.369	266954.5	393.117	102.2
720.00	198.390	267120.4	365.500	103.2
730.00	198.409	267274.8	356.650	104.1
740.00	198.428	267423.4	347.800	104.9
750.00	198.446	267566.2	338.950	105.8
760.00	198.463	267703.2	330.100	106.5
770.00	198.479	267834.4	321.250	107.3
780.00	198.495	267959.9	312.400	108.0
790.00	198.510	268080.1	305.150	108.7
800.00	198.524	268195.5	297.900	109.4
810.00	198.538	268306.2	290.650	110.0
820.00	198.552	268412.2	283.400	110.7
830.00	198.564	268513.5	276.150	111.3
840.00	198.576	268610.0	269.900	111.8
850.00	198.588	268702.4	263.517	112.4
860.00	198.599	268791.3	258.133	112.9
870.00	198.610	268876.7	252.750	113.4
880.00	198.620	268958.5	247.367	113.9
890.00	198.630	269036.8	241.983	114.3
900.00	198.639	269111.6	236.600	114.8
910.00	198.648	269183.3	232.517	115.2
920.00	198.657	269252.4	228.433	115.6
930.00	198.665	269318.7	224.350	116.0
940.00	198.673	269382.3	220.267	116.4
950.00	198.680	269443.3	216.183	116.7
960.00	198.688	269501.6	212.100	117.1
970.00	198.695	269557.0	207.167	117.4
980.00	198.701	269609.2	202.233	117.7
990.00	198.707	269658.3	197.300	118.0
1000.00	198.713	269704.3	192.367	118.3
1010.00	198.718	269747.1	187.433	118.6
1020.00	198.723	269786.9	182.500	118.8
1030.00	198.728	269823.6	177.950	119.0
1040.00	198.732	269857.5	173.400	119.2
1050.00	198.736	269888.6	168.850	119.4
1060.00	198.740	269916.8	164.300	119.6
1070.00	198.743	269942.2	159.750	119.7
1080.00	198.746	269964.8	155.200	119.9
1090.00	198.748	269985.2	152.933	120.0
1100.00	198.751	270004.2	150.467	120.1
1110.00	198.753	270021.6	148.100	120.2
1120.00	198.755	270037.6	145.733	120.3
1130.00	198.757	270052.1	143.367	120.4
1140.00	198.758	270065.1	141.000	120.5
1150.00	198.760	270077.7	142.050	120.5
1160.00	198.761	270090.9	143.100	120.6
1170.00	198.763	270104.6	144.150	120.7
1180.00	198.765	270118.9	145.200	120.8
1190.00	198.767	270133.8	146.250	120.9
1200.00	198.769	270149.3	147.300	121.0
1210.00	198.770	270159.7	129.417	121.08
1220.00	198.770	270159.3	111.533	121.07
1230.00	198.769	270148.2	93.650	121.01
1240.00	198.766	270126.5	75.767	120.88
1250.00	198.762	270094.1	57.883	120.68
1260.00	198.756	270051.1	40.000	120.42
1270.00	198.750	270002.2	37.417	120.13
1280.00	198.744	269951.9	34.833	119.83
1290.00	198.738	269900.2	32.250	119.52
1300.00	198.731	269847.1	29.667	119.20
1310.00	198.724	269792.7	27.083	118.87
1320.00	198.717	269737.0	24.500	118.54
1330.00	198.710	269680.0	22.433	118.20
1340.00	198.703	269622.1	20.367	117.85
1350.00	198.695	269563.0	18.300	117.50
1360.00	198.688	269503.0	16.233	117.14
1370.00	198.680	269442.0	14.167	116.78
1380.00	198.672	269379.9	12.100	116.41
1380.00	198.672	269379.9	12.100	116.41

PEAK OUTFLOW

1214.65	198.770	270160.9		121.08

Table 4D-4 (3) Flow-out Discharge for Spillway

FWL= 195.000 (FT) CREST LENGTH L=200.000 (FT)
V=+0000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	195.001	240008.0	20.783	0.001
20.00	195.003	240024.8	34.967	0.004
30.00	195.006	240050.0	49.150	0.011
40.00	195.010	240083.7	63.333	0.024
50.00	195.016	240126.0	77.517	0.044
60.00	195.022	240176.7	91.700	0.072
70.00	195.029	240232.3	93.617	0.109
80.00	195.036	240288.9	95.533	0.151
90.00	195.043	240346.7	97.450	0.199
100.00	195.051	240405.6	99.367	0.252
110.00	195.058	240465.7	101.283	0.310
120.00	195.066	240526.8	103.200	0.373
130.00	195.075	240596.5	129.883	0.449
140.00	195.085	240682.1	156.567	0.549
150.00	195.098	240783.7	183.250	0.676
160.00	195.113	240901.3	209.933	0.834
170.00	195.129	241034.7	236.617	1.025
180.00	195.148	241184.0	263.300	1.255
190.00	195.171	241365.0	342.650	1.554
200.00	195.199	241593.4	422.000	1.960
210.00	195.234	241869.1	501.350	2.490
220.00	195.274	242192.0	580.700	3.162
230.00	195.320	242562.2	660.050	3.996
240.00	195.372	242979.3	739.400	5.011
250.00	195.429	243435.3	791.483	6.204
260.00	195.490	243921.7	843.567	7.567
270.00	195.555	244438.5	895.650	9.112
280.00	195.623	244985.6	947.733	10.847
290.00	195.695	245562.8	999.817	12.785
300.00	195.771	246170.0	1051.900	14.934
310.00	195.849	246795.1	1063.967	17.261
320.00	195.928	247426.0	1076.033	19.720
330.00	196.008	248062.7	1088.100	22.310
340.00	196.088	248705.0	1100.167	25.029
350.00	196.169	249352.8	1112.233	27.875
360.00	196.251	250006.2	1124.300	30.846
370.00	196.333	250662.3	1127.433	33.930
380.00	196.415	251318.4	1130.567	37.109
390.00	196.497	251974.4	1133.700	40.382
400.00	196.579	252630.3	1136.833	43.746
410.00	196.661	253286.1	1139.967	47.197
420.00	196.743	253941.6	1143.100	50.733
430.00	196.824	254593.4	1134.500	54.332
440.00	196.905	255237.8	1125.900	57.971
450.00	196.984	255874.9	1117.300	61.644
460.00	197.063	256504.6	1108.700	65.349
470.00	197.141	257126.9	1100.100	69.080
480.00	197.218	257741.8	1091.500	72.833
490.00	197.293	258343.3	1062.850	76.569
500.00	197.366	258925.3	1034.200	80.242
510.00	197.436	259483.0	1005.550	83.848
520.00	197.504	260031.3	976.900	87.379
530.00	197.569	260555.4	948.250	90.831
540.00	197.633	261060.2	919.600	94.198
550.00	197.693	261544.8	887.300	97.467
560.00	197.751	262008.0	855.000	100.628
570.00	197.806	262450.0	822.700	103.675
580.00	197.859	262870.6	790.400	106.604
590.00	197.909	263270.5	758.100	109.411
600.00	197.956	263649.2	725.600	112.093
610.00	198.001	264006.9	693.367	114.646
620.00	198.043	264343.7	660.933	117.067
630.00	198.082	264659.6	628.500	119.354
640.00	198.119	264954.7	596.067	121.503
650.00	198.154	265229.0	563.633	123.512
660.00	198.185	265482.8	531.200	125.381
670.00	198.215	265717.5	503.583	127.117
680.00	199.242	265934.6	475.967	128.730
690.00	196.267	266134.1	448.350	130.219
700.00	198.290	266316.3	420.733	131.583
710.00	198.310	266481.1	397.117	132.822
720.00	198.329	266628.7	365.500	133.933
730.00	198.346	266764.6	356.650	134.961
740.00	198.362	266894.7	347.800	135.946
750.00	198.377	267018.9	338.950	136.888
760.00	198.392	267137.2	330.100	137.788
770.00	198.406	267249.6	321.250	138.646
780.00	198.420	267356.3	312.400	139.461
790.00	198.432	267457.6	305.150	140.237
800.00	198.444	267554.2	297.900	140.977
810.00	198.456	267645.9	290.650	141.682
820.00	198.467	267732.9	283.400	142.351
830.00	198.477	267815.2	276.150	142.985
840.00	198.487	267892.7	268.900	143.583
850.00	198.496	267966.1	263.517	144.151
860.00	198.504	268036.0	258.133	144.691
870.00	198.513	268102.3	252.750	145.205
880.00	198.521	268165.0	247.367	145.691
890.00	198.528	268224.3	241.983	146.151
900.00	198.535	268280.0	236.600	146.585
910.00	198.542	268332.7	232.517	146.994
920.00	198.548	268382.7	228.433	147.383
930.00	198.554	268429.9	224.350	147.752
940.00	198.559	268474.6	220.267	148.100
950.00	198.565	268516.5	216.183	148.428
960.00	198.569	268555.9	212.100	148.735
970.00	198.574	268592.3	207.167	149.020
980.00	198.578	268625.7	202.233	149.280
990.00	198.582	268655.9	197.300	149.517
1000.00	198.585	268683.0	192.367	149.729
1010.00	198.588	268707.0	187.433	149.916
1020.00	198.591	268728.0	182.500	150.082
1030.00	198.593	268746.1	177.950	150.223
1040.00	198.595	268761.3	173.400	150.343
1050.00	198.597	268773.7	168.850	150.440
1060.00	198.598	268783.4	164.300	150.516
1070.00	198.599	268790.3	159.750	150.570
1080.00	198.599	268794.4	155.200	150.603
1090.00	198.600	268796.4	152.833	150.619
1100.00	198.600	268797.0	150.467	150.623
1110.00	198.600	268796.2	148.100	150.617
1120.00	198.599	268794.0	145.733	150.600
1130.00	198.599	268790.4	143.367	150.571
1140.00	198.598	268785.4	141.000	150.532
1150.00	198.597	268780.0	142.050	150.490
1160.00	198.597	268775.3	143.100	150.453
1170.00	198.596	268771.2	144.150	150.421
1180.00	198.596	268767.7	145.200	150.394
1190.00	198.596	268764.9	146.250	150.372
1200.00	198.595	268762.8	147.300	150.355
1210.00	198.594	268755.6	129.417	150.298
1220.00	198.592	268737.7	111.533	150.159
1230.00	198.589	268709.2	93.650	149.936
1240.00	198.584	268670.2	75.767	149.630
1250.00	198.578	268620.6	57.883	149.242
1260.00	198.570	268560.5	40.000	148.773
1270.00	198.562	268494.7	37.417	148.258
1280.00	198.553	268427.5	34.833	147.735
1290.00	198.545	268359.2	32.250	147.202
1300.00	198.536	268289.6	29.667	146.661
1310.00	198.527	268218.8	27.083	146.110
1320.00	198.518	268146.8	24.500	145.551
1330.00	198.509	268073.7	22.433	144.985
1340.00	198.500	267999.7	20.367	144.412
1350.00	198.491	267924.8	18.300	143.833
1360.00	198.481	267849.1	16.233	143.249
1370.00	198.472	267772.4	14.167	142.657
1380.00	198.462	267694.9	12.100	142.060
380.00	198.462	267694.9	12.100	142.060

PEAK OUTFLOW

1099.33	198.600	268797.0	150.624

Table 4D-4 (4) Flow-out Discharge for Spillway

FWL= 195.000 (FT) CREST LENGTH L=250.000 (FT)
V=+0000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	195.001	240008.0	20.783	0.001
20.00	195.003	240024.8	34.967	0.005
30.00	195.006	240050.0	49.150	0.014
40.00	195.010	240083.7	63.333	0.029
50.00	195.016	240126.0	77.517	0.054
60.00	195.022	240176.7	91.700	0.090
70.00	195.029	240232.2	93.617	0.136
80.00	195.036	240288.9	95.533	0.189
90.00	195.043	240346.6	97.450	0.249
100.00	195.051	240405.5	99.367	0.315
110.00	195.058	240465.5	101.283	0.387
120.00	195.066	240526.6	103.200	0.465
130.00	195.075	240596.2	129.883	0.561
140.00	195.085	240681.8	156.567	0.686
150.00	195.098	240783.3	183.250	0.844
160.00	195.113	240900.7	209.933	1.041
170.00	195.129	241034.0	236.617	1.281
180.00	195.148	241183.1	263.300	1.567
190.00	195.170	241363.9	342.650	1.940
200.00	195.199	241592.0	422.000	2.446
210.00	195.233	241867.4	501.350	3.108
220.00	195.274	242190.0	580.700	3.947
230.00	195.320	242559.6	660.050	4.987
240.00	195.372	242976.1	739.400	6.253
250.00	195.429	243431.2	791.483	7.741
260.00	195.490	243916.6	843.567	9.441
270.00	195.554	244432.1	895.650	11.365
280.00	195.622	244977.7	947.733	13.527
290.00	195.694	245553.2	999.817	15.940
300.00	195.770	246158.4	1051.900	18.615
310.00	195.848	246781.1	1063.967	21.510
320.00	195.926	247409.3	1076.033	24.567
330.00	196.005	248042.8	1088.100	27.785
340.00	196.085	248681.6	1100.167	31.160
350.00	196.166	249325.6	1112.233	34.691
360.00	196.247	249974.7	1124.300	38.376
370.00	196.328	250626.0	1127.433	42.196
380.00	196.410	251276.9	1130.567	46.132
390.00	196.491	251927.3	1133.700	50.181
400.00	196.572	252577.1	1136.833	54.337
410.00	196.653	253226.3	1139.967	58.598
420.00	196.734	253874.8	1143.100	62.961
430.00	196.815	254518.9	1134.500	67.396
440.00	196.894	255155.3	1125.900	71.875
450.00	196.973	255783.7	1117.300	76.393
460.00	197.051	256404.3	1108.700	80.943
470.00	197.127	257017.0	1100.100	85.520
480.00	197.203	257621.8	1091.500	90.120
490.00	197.277	258212.7	1062.850	94.690
500.00	197.348	258783.6	1034.200	99.178
510.00	197.417	259334.7	1005.550	103.575
520.00	197.483	259865.9	976.900	107.874
530.00	197.547	260377.5	948.250	112.068
540.00	197.609	260869.3	919.600	116.150
550.00	197.668	261340.5	887.300	120.106
560.00	197.724	261790.0	855.000	123.921
570.00	197.777	262217.8	822.700	127.589
580.00	197.828	262624.1	790.400	131.105
590.00	197.876	263009.0	758.100	134.465
600.00	197.922	263372.5	725.800	137.664
610.00	197.964	263714.7	693.367	140.699
620.00	198.004	264035.7	660.933	143.566
630.00	198.042	264335.5	628.500	146.261
640.00	198.077	264614.3	596.067	148.782
650.00	198.109	264872.3	563.633	151.127
660.00	198.139	265109.4	531.200	153.294
670.00	198.166	265327.2	503.583	155.293
680.00	198.191	265527.3	475.967	157.138
690.00	198.214	265709.8	448.350	158.826
700.00	198.234	265874.7	420.733	160.357
710.00	198.253	266022.2	393.117	161.73
720.00	198.269	266152.4	365.500	162.94
730.00	198.284	266270.9	356.650	164.05
740.00	198.298	266383.5	347.800	165.11
750.00	198.311	266490.2	338.950	166.11
760.00	198.324	266590.9	330.100	167.05
770.00	198.336	266685.8	321.250	167.95
780.00	198.347	266774.9	312.400	168.79
790.00	198.357	266858.6	305.150	169.59
800.00	198.367	266937.5	297.900	170.33
810.00	198.376	267011.7	290.650	171.04
820.00	198.385	267081.1	283.400	171.70
830.00	198.393	267145.7	276.150	172.31
840.00	198.401	267205.7	268.900	172.88
850.00	198.408	267261.5	263.517	173.42
860.00	198.414	267313.8	258.133	173.92
870.00	198.420	267362.6	252.750	174.38
880.00	198.426	267407.8	247.367	174.82
890.00	198.431	267449.6	241.983	175.22
900.00	198.436	267487.9	236.600	175.59
910.00	198.440	267523.2	232.517	175.92
920.00	198.444	267555.9	228.433	176.23
930.00	198.448	267585.9	224.350	176.52
940.00	198.452	267613.2	220.267	176.78
950.00	198.455	267638.0	216.183	177.02
960.00	198.458	267660.2	212.100	177.24
970.00	198.460	267679.6	207.167	177.42
980.00	198.462	267695.9	202.233	177.58
990.00	198.464	267709.2	197.300	177.71
1000.00	198.465	267719.4	192.367	177.81
1010.00	198.466	267726.7	187.433	177.88
1020.00	198.466	267730.9	182.500	177.92
1030.00	198.467	267732.3	177.950	177.93
1040.00	198.466	267730.9	173.400	177.92
1050.00	198.466	267726.8	168.850	177.89
1060.00	198.465	267720.1	164.300	177.81
1070.00	198.464	267710.6	159.750	177.72
1080.00	198.462	267698.5	155.200	177.60
1090.00	198.461	267684.4	152.833	177.47
1100.00	198.459	267668.9	150.467	177.32
1110.00	198.457	267652.2	148.100	177.16
1120.00	198.454	267634.1	145.733	176.99
1130.00	198.452	267614.6	143.367	176.80
1140.00	198.449	267593.9	141.000	176.60
1150.00	198.447	267572.9	142.050	176.40
1160.00	198.444	267552.7	143.100	176.20
1170.00	198.442	267533.2	144.150	176.02
1180.00	198.439	267514.5	145.200	175.84
1190.00	198.437	267496.4	146.250	175.65
1200.00	198.435	267479.2	147.300	175.50
1210.00	198.432	267456.9	129.417	175.29
1220.00	198.428	267424.1	111.533	174.97
1230.00	198.423	267380.8	93.650	174.55
1240.00	198.416	267327.0	75.767	174.04
1250.00	198.408	267262.9	57.883	173.43
1260.00	198.399	267166.4	40.000	172.72
1270.00	198.389	267108.2	37.417	171.96
1280.00	198.378	267026.9	34.833	171.19
1290.00	198.368	266944.5	32.250	170.40
1300.00	198.358	266861.1	29.667	169.61
1310.00	198.347	266776.6	27.083	168.81
1320.00	198.336	266691.0	24.500	168.00
1330.00	198.326	266604.6	22.433	167.19
1340.00	198.315	266517.3	20.367	166.37
1350.00	198.304	266429.3	18.300	165.54
1360.00	198.293	266340.6	16.233	164.71
1370.00	198.281	266251.2	14.167	163.67
1380.00	198.270	266161.0	12.100	163.02
1380.00	198.270	266161.0	12.100	163.02

PEAK OUTFLOW

1030.03	198.467	267732.3	177.93

It is learned from the above table that there would be no problem in point of overflowing the Okkan dam as a increase in the water surface is about 0.05 m, even if the unexpected flood with 10,000-year probability flows into the reservoir. In defining that the ultimate flow-out capacity of spillway is the discharge which flows out through the spillway when the maximum water surface reach is to the dam crest elevation, the ultimate flow-out discharge from the spillway would be estimated as follows and the figure means that the return period for the spillway would be indefinite.

Ultimate flow-out capacity, $Qv = 13,900\ m^3/sec$

(in case of $\Delta H = 1.95$ m)

Irrigation Outlet

1. Type and Alignment

The Okkan dam is constructed not only for irrigation but also for hydro-electric power, however, the storage capacity for hydro-electric power purpose is about 10 percent of total storage capacity, therefore storage water is used for both irrigation and hydro-electric power purposes. The storage water which will be released by the outlet facilities flows into the existing river. Another role of the outlet facilities is to make the rapid drawdown of the water level in the reservoir in case of emergency after completion of the dam.

The location of outlet facilities are selected along the "Wadi" on the left bank of the dam site considering the topographical and geological conditions, construction method and schedule of the dam.

A cylindrical column structure of drop inlet type of intake with trush-rack which is located near the upstream toe of dam body and an inner steel lining conveyance conduit with a bifurcation pipe are provided as the outlet facilities.

For the control equipment of irrigation demand, a corn valve is to be installed as it functions both for discharge control and energy dissipation at the end of irrigation conveyance conduit.

During the operation of the hydro-electric power plant, the water will be diverted through a bifurcation pipe to the plant and this released water will be used for irrigation purpose again.

2. Design Outlet Discharge

The outlet discharge from the reservoir varies with the water requirement of irrigation area in the seasons. From the results of reservoir operation study, the maximum outlet discharge of 22.5 m^3/sec has occurred at water level of 180 feet in the reservoir, however, at around the dead water level, most of outlet discharge may distinctly be less than the maximum discharge except extreme drought years. Since the water supply for the irrigation area in extreme drought year will be restricted on actual reservoir operation, it is reasonable that the amount of 80 percent of the maximum outlet discharge around the dead water level is adopted as the outlet discharge in hydraulic design of the irrigation outlet facilities.

3. Hydraulic Dimensions

The hydraulic dimension of conveyance conduit with circular shape can roughly be obtained on the basis of the allowable velocity in steel pipe.

Since the allowable maximum velocity in steel pipe is usually limited within 5.0 m/sec in ordinary case and within 3.5 m/sec in hydro-electric power purpose, the dimension of conduit was decided 2.4 m of inside diameter with circular shape, when the maximum outlet discharge flows through the irrigation outlet facilities.

Regarding the dimension of corn valve for irrigation demand, the total loss head through the irrigation outlet can roughly be estimated as follows:

$$H = f \cdot \frac{Q^2}{2gA^2} + \left(\frac{Q}{2.945 \cdot \phi^2}\right)^2, \qquad A = 0.7854D^2$$

where, H; total head and measured from water surface level at the end of conduit.

Q; design outlet discharge and adopted by 18.0 m^3/sec

g; gravitational acceleration

A; flow area of conduit and adopted by 4.524 m^2

f; coefficient of loss head at screen, entrance, bending, friction, bifurcation, contraction and butterfly valve and assumed by 4.0.

ϕ; inside diameter of corn valve (Howell Banger Valve) and assumed by 1.43 m

D; inside diameter of conduit and adopted by 2.4 m

When the downstream water surface elevation at the end of irrigation conduit is assumed at EL 115 feet, the effective head of He for irrigation outlet is as follows:

He = EL 155 - EL 115 = 40 feet (12.19 m)

On the other hand, total loss head of irrigation outlet is equal to 39.9 feet (12.16 m); therefore, the inside diameter of corn valve should be equaled to 1.43 m.

In order to repair and maintain hydro-power plant and corn valve for irrigation demand, the emergency butterfly valves should be installed in front of those facilities and to close each facilities as required.

Diversion Facilities

1. Type and Alignment

At the Okkan damsite, the diversion facilities are merely constructed for the purpose of bypassing the runoff flow in the river during the embankment period of the dam body. An open-type with no lining canal and coffer dam are provided as the diversion facilities from the viewpoints of the topographic feature, design flood discharge and construction schedule of the dam.

Since an open-type diversion system is adopted in this site, the locations of coffer dam and bypass canal are selected at about 130 m (about 430 feet) upstream from the dam axis and along the "Wadi" located at the left side of damsite respectively taking into account the construction schedule, economical construction of the dam and the topographical condition.

2. Design Flood Discharge

For the diversion facilities design purpose, 10-year probability flood discharge was considered in conformity with Design Criteria for Dams in Japan. Since the reservoir capacity provided by an upstream coffer dam is comparatively large, the storage effect with a 10-year probability flood flow into the reservoir will be expected.

The design flood discharge for the diversion facilities can be obtained as same estimation method with that of the design discharge on spillway. The results of calculation are shown in Table 4D-5 and summarized in the following table.

	Bottom width of open canal (m)			
	6.0	9.1	12.2	18.3
Water surface elevation (EL feet)	146.9	146.2	145.6	144.8
Flowout discharge (m^3/sec)	71.7	97.7	120.7	161.4

3. Hydraulic Design

The hydraulic calculation for the open canal has been executed to establish the relationship between the water depth and flow area with the design flood discharge runoff through the open canal. A requirement water depth at the open canal due to various bottom width can be estimated from the following Manning formula.

$$Q = A \cdot V,\ V = 1/n \cdot R^{2/3}\ I^{1/2},\quad A = 1/2\ (2b + 2h) \cdot h$$

where, Q; design flood discharge
A; flow area
V; velocity of flow
n; coefficient of roughness and adopted by 0.025
R; hydraulic radius
I; bottom slope in canal and adopted by 1 on 1.0
b; bottom width in canal
h; water depth

The results of calculation for various bottom width in canal are shown in the following table.

	Bottom width of open canal (m)			
	6.0	9.1	12.2	18.3
Flowout discharge (m^3/sec)	71.7	97.7	120.7	161.4
Water depth (m)	1.89	1.80	1.73	1.61
Velocity of flow (m/sec)	4.81	4.98	5.01	5.04

From the above table, it seems that the bottom width of 9.1 m in the open canal is reasonable value considering the topographical and geological conditions at the "Wadi" course, height of coffer dam and storage volume in the reservoir which will be used for the moisture control of embankment materials and mixing water of concrete.

4. Crest Elevation of Coffer Dam

The freeboard of coffer dam can be obtained as same estimation method of the freeboard on main dam. The result of calculation and adopted crest elevation of coffer dam is shown in the following table.

Fetch m	R* m	Freeboard** m	Water level EL ft	Crest elevation EL ft
1,900	0.6	1.6	146.2	151.5 ≒ 152

A smaller temporary downstream coffer dam with top of elevation 130 feet is also necessary in order to protect fully the construction site of the dam.

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* Wind speed is 20 m/sec and U/S slope of coffer dam is 1 on 3.5 with hand-placed riprap, therefore, an intermediate value at the smooth slope and rough slope in Figure 4D-1 was adopted as the height of wave due to wind.

** Freeboard can be obtained as follows; $Fb = R + hs$

Construction Method and Schedule

1. Workable Days for Dam Construction

It is known that construction of fill-type dam is quite affected by the meteorological and seasonal conditions especially by rainfall. Actual workable days for the embankment works varies with kind of embankment materials such as impervious, random and rock. In constructing of center core-type on filldam, it is usually required to embank various kind of the materials at the same elevation. Delay of impervious zone embankments which would easily be affected by weather might cause to delay the works for other zones of the dam embankments. Consequently planning of construction works should be made taking into consideration the workable days which would be affected by the seasonal conditions.

Workable days for the construction works as shown in Table 4D-5 were estimated based upon the rainfall data at Kyaukpyintha raingauge station located near the damsite for the period of three years from 1978 to 1980. From the above table, the workable days for impervious zone embankments at the damsite indicate 188 days per year in total, however there is only 15 workable days in the rainy season of four months from June to September. By these seasonal conditions, it has been scheduled during the rainy season that the works on dam embankments should temporarily suspended and the necessary maintenance services for the construction equipment be made.

From the above-mentioned work schedule, workable days for the impervious zone embankments may take 23 days per month on an average and 25 days for other zones of embankments, concrete placing and earth works.

The daily working hours are decided at eight hours for normal works and seven hours for equipment operation considering the adjustment of equipments before operation.

2. Construction Method

Prior to the dam construction in the first year, such preparatory works should be completed as provision of access roads to the damsite, construction roads to borrow areas and quarry site, and construction of office buildings and camping facilities and so forth.

The dam construction works will be commenced in the dry season of the first year with foundation excavation, grouting, and embankment of the dam body at a part of the river channel portion, after diverting the river flow of Okkan chaung by provision of coffer dam and open type by-pass canal along the "Wadi" channel. In parallel with the above works, excavation and concrete placing in parts of the proposed spillway will be carried out.

From October in the second year, when the rainy season (June - September) is over, foundation treatment and embankment works at the river channel portion shall be resumed and be completed at the end of the dry season of the third year. In parallel with these works, the construction of the spillway shall be completed excepting for the tailrace portion. On the other hand, construction works of the conduits and hydro-power plant shall be commenced at the "Wadi" channel portion in the same period as above.

From October in the third year, foundation excavation, grouting and embankment works will be started in the "Wadi" channel portion to be completed at the end of the dry season of the fourth year, while the construction of intake and discharge control structures of the outlet facilities as well as the hydro-power plant will be finished in the same period. And also, the tailrace of the spillway shall be constructed by the end of the dry season of the fourth year.

The above procedures of the dam construction will complete the whole works by June in the fourth year when the rainy season sets in and will allow to start storing water in the reservoir.

Table 4D-5 (1) Flow-out Discharge for Diversion Facilities

FWL= 135.000 (FT) CREST LENGTH L= 20.000 (FT)
V= 5000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	135.008	5004.6	11.083	0.001
20.00	135.022	5013.2	17.467	0.006
30.00	135.043	5025.6	23.850	0.015
40.00	135.070	5041.8	30.233	0.032
50.00	135.103	5061.8	36.617	0.058
60.00	135.143	5085.6	43.000	0.094
70.00	135.186	5111.6	43.850	0.140
80.00	135.230	5138.1	44.700	0.192
90.00	135.275	5165.0	45.550	0.251
100.00	135.321	5192.5	46.400	0.317
110.00	135.367	5220.3	47.250	0.388
120.00	135.414	5248.7	48.100	0.465
130.00	135.468	5280.8	60.067	0.558
140.00	135.534	5320.1	72.033	0.679
150.00	135.611	5366.5	84.000	0.832
160.00	135.700	5419.9	95.967	1.021
170.00	135.801	5480.4	107.933	1.249
180.00	135.913	5547.9	119.900	1.521
190.00	136.049	5629.6	155.533	1.874
200.00	136.221	5732.3	191.167	2.351
210.00	136.427	5856.2	226.800	2.971
220.00	136.668	6000.9	262.433	3.756
230.00	136.944	6166.6	298.067	4.726
240.00	137.255	6352.9	333.700	5.903
250.00	137.594	6556.2	357.100	7.282
260.00	137.955	6772.7	380.500	8.853
270.00	138.337	7002.2	403.900	10.627
280.00	138.741	7244.6	427.300	12.615
290.00	139.166	7499.8	450.700	14.826
300.00	139.613	7767.6	474.100	17.272
310.00	140.030	8042.6	479.500	19.673
320.00	140.228	8319.7	484.900	20.846
330.00	140.428	8599.4	490.300	22.052
340.00	140.630	8881.6	495.700	23.292
350.00	140.833	9166.3	501.100	24.566
360.00	141.038	9453.5	506.500	25.873
370.00	141.244	9741.9	507.917	27.208
380.00	141.450	10030.3	509.333	28.566
390.00	141.656	10318.8	510.750	29.945
400.00	141.862	10607.3	512.167	31.347
410.00	142.068	10895.8	513.583	32.769
420.00	142.274	11184.3	515.000	34.213
430.00	142.479	11471.1	511.133	35.669
440.00	142.682	11754.8	507.267	37.128
450.00	142.882	12035.3	503.400	38.590
460.00	143.080	12312.6	499.533	40.053
470.00	143.276	12586.7	495.667	41.518
480.00	143.470	12857.5	491.800	42.983
490.00	143.659	13122.5	478.950	44.432
500.00	143.842	13379.0	466.100	45.849
510.00	144.019	13626.8	453.250	47.233
520.00	144.190	13866.2	440.400	48.582
530.00	144.355	14097.0	427.550	49.896
540.00	144.514	14319.4	414.700	51.172
550.00	144.666	14532.7	400.183	52.407
560.00	144.812	14736.7	385.667	53.596
570.00	144.951	14931.2	371.150	54.738
580.00	145.083	15116.4	356.633	55.833
590.00	145.209	15292.2	342.117	56.880
600.00	145.328	15458.6	327.600	57.877
610.00	145.440	15615.8	313.033	58.823
620.00	145.545	15763.7	298.467	59.718
630.00	145.645	15902.3	283.900	60.561
640.00	145.737	16031.7	269.333	61.352
650.00	145.823	16151.9	254.767	62.089
660.00	145.902	16262.9	240.200	62.773
670.00	145.975	16365.4	227.800	63.407
680.00	146.043	16460.2	215.400	63.994
690.00	146.105	16547.1	203.000	64.535
700.00	146.162	16626.3	190.600	65.029
710.00	146.213	16697.8	178.200	65.475
720.00	146.258	16761.6	165.800	65.875
730.00	146.300	16820.2	161.833	66.243
740.00	146.340	16876.3	157.867	66.595
750.00	146.378	16929.8	153.900	66.932
760.00	146.415	16980.7	149.933	67.253
770.00	146.449	17029.0	145.967	67.558
780.00	146.482	17074.7	142.000	67.843
790.00	146.513	17118.2	138.750	68.123
800.00	146.543	17159.5	135.500	68.385
810.00	146.571	17198.7	132.250	68.635
820.00	146.597	17235.8	129.000	68.871
830.00	146.622	17270.9	125.750	69.094
840.00	146.646	17303.8	122.500	69.304
850.00	146.668	17335.0	120.083	69.502
860.00	146.689	17364.5	117.667	69.691
870.00	146.709	17392.5	115.250	69.870
880.00	146.728	17419.0	112.833	70.039
890.00	146.746	17443.9	110.417	70.193
900.00	146.762	17467.2	108.000	70.348
910.00	146.778	17489.2	106.167	70.489
920.00	146.793	17510.0	104.333	70.623
930.00	146.807	17529.7	102.500	70.749
940.00	146.820	17548.2	100.667	70.869
950.00	146.832	17565.4	98.833	70.979
960.00	146.844	17581.6	97.000	71.082
970.00	146.855	17596.4	94.767	71.178
980.00	146.864	17609.9	92.533	71.264
990.00	146.873	17621.9	90.300	71.342
1000.00	146.880	17632.6	88.067	71.411
1010.00	146.887	17641.9	85.833	71.471
1020.00	146.893	17649.9	83.600	71.522
1030.00	146.897	17656.5	81.550	71.565
1040.00	146.901	17661.8	79.500	71.599
1050.00	146.904	17666.0	77.450	71.626
1060.00	146.906	17668.8	75.400	71.644
1070.00	146.907	17670.5	73.350	71.655
1080.00	146.908	17670.9	71.300	71.657
1090.00	146.907	17670.3	70.250	71.654
1100.00	146.907	17669.2	69.200	71.647
1110.00	146.905	17667.4	68.150	71.635
1120.00	146.904	17665.0	67.100	71.620
1130.00	146.901	17662.0	66.050	71.600
1140.00	146.899	17658.3	65.000	71.577
1150.00	146.896	17654.5	65.467	71.552
1160.00	146.894	17651.0	65.933	71.530
1170.00	146.891	17647.8	66.400	71.509
1180.00	146.889	17644.9	66.867	71.490
1190.00	146.887	17642.3	67.333	71.473
1200.00	146.886	17639.9	67.800	71.459
1210.00	146.882	17635.3	59.783	71.429
1220.00	146.876	17626.0	51.767	71.368
1230.00	146.866	17611.8	43.750	71.277
1240.00	146.852	17592.9	35.733	71.156
1250.00	146.835	17569.3	27.717	71.006
1260.00	146.815	17541.0	19.700	70.822
1270.00	146.793	17510.0	18.550	70.623
1280.00	146.770	17478.5	17.400	70.421
1290.00	146.747	17446.4	16.250	70.215
1300.00	146.724	17413.7	15.100	70.006
1310.00	146.700	17380.5	13.950	69.794
1320.00	146.676	17346.7	12.800	69.578
1330.00	146.652	17312.4	11.867	69.359
1340.00	146.627	17277.7	10.933	69.138
1350.00	146.602	17242.6	10.000	68.914
1360.00	146.576	17207.0	9.067	68.688
1370.00	146.551	17171.0	8.133	68.460
1380.00	146.525	17134.6	7.200	68.228
1380.00	146.525	17134.6	7.200	68.229

PEAK OUTFLOW

1078.25	146.908	17670.9	71.658

Table 4D-5 (2) Flow-out Discharge for Diversion Facilities

FWL= 135.000 (FT) CREST LENGTH L= 30.000 (FT)
V= 5000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	135.008	5004.6	11.083	0.002
20.00	135.022	5013.2	17.467	0.008
30.00	135.043	5025.6	23.850	0.023
40.00	135.070	5041.8	30.233	0.048
50.00	135.103	5061.8	36.617	0.086
60.00	135.143	5085.6	43.000	0.141
70.00	135.186	5111.6	43.850	0.210
80.00	135.230	5138.0	44.700	0.288
90.00	135.275	5164.8	45.550	0.377
100.00	135.320	5192.2	46.400	0.474
110.00	135.367	5220.0	47.250	0.580
120.00	135.414	5248.2	48.100	0.696
130.00	135.467	5280.2	60.067	0.834
140.00	135.532	5319.3	72.033	1.015
150.00	135.609	5365.4	84.000	1.243
160.00	135.698	5418.6	95.967	1.524
170.00	135.798	5478.7	107.933	1.864
180.00	135.910	5545.9	119.900	2.269
190.00	136.045	5627.0	155.533	2.793
200.00	136.215	5729.1	191.167	3.503
210.00	136.420	5852.2	226.800	4.426
220.00	136.660	5996.0	262.433	5.592
230.00	136.934	6160.4	298.067	7.033
240.00	137.242	6345.2	333.700	8.778
250.00	137.578	6546.6	357.100	10.822
260.00	137.934	6760.7	380.500	13.145
270.00	138.312	6987.4	403.900	15.764
280.00	138.711	7226.4	427.300	18.693
290.00	139.129	7477.6	450.700	21.945
300.00	139.568	7740.9	474.100	25.533
310.00	140.007	8010.5	479.500	29.309
320.00	140.201	8281.7	484.900	31.026
330.00	140.397	8555.1	490.300	32.790
340.00	140.593	8830.7	495.700	34.600
350.00	140.792	9108.4	501.100	36.457
360.00	140.992	9388.3	506.500	38.361
370.00	141.192	9669.0	507.917	40.303
380.00	141.392	9949.4	509.333	42.274
390.00	141.592	10229.5	510.750	44.274
400.00	141.792	10509.2	512.167	46.302
410.00	141.992	10788.5	513.583	48.357
420.00	142.191	11067.4	515.000	50.439
430.00	142.389	11344.4	511.133	52.534
440.00	142.584	11617.8	507.267	54.631
450.00	142.777	11887.5	503.400	56.726
460.00	142.967	12153.8	499.533	58.819
470.00	143.155	12416.4	495.667	60.909
480.00	143.340	12675.5	491.800	62.994
490.00	143.520	12928.3	478.950	65.052
500.00	143.694	13172.1	466.100	67.057
510.00	143.862	13407.1	453.250	69.008
520.00	144.024	13633.2	440.400	70.903
530.00	144.179	13850.5	427.550	72.741
540.00	144.328	14059.0	414.700	74.518
550.00	144.470	14258.2	400.183	76.230
560.00	144.606	14447.7	385.667	77.871
570.00	144.734	14627.6	371.150	79.438
580.00	144.856	14797.8	356.633	80.931
590.00	144.970	14958.4	342.117	82.349
600.00	145.078	15109.5	327.600	83.690
610.00	145.179	15251.1	313.033	84.953
620.00	145.274	15383.2	298.467	86.137
630.00	145.361	15505.9	283.900	87.241
640.00	145.442	15619.2	269.333	88.266
650.00	145.517	15723.2	254.767	89.209
660.00	145.584	15817.9	240.200	90.071
670.00	145.646	15904.0	227.800	90.858
680.00	145.702	15982.2	215.400	91.574
690.00	145.752	16052.6	203.000	92.220
700.00	145.797	16115.1	190.600	92.796
710.00	145.836	16169.9	178.200	93.301
720.00	145.869	16217.0	165.800	93.736
730.00	145.899	16258.9	161.833	94.124
740.00	145.927	16298.3	157.867	94.488
750.00	145.954	16335.0	153.900	94.828
760.00	145.978	16369.1	149.933	95.145
770.00	146.001	16400.7	145.967	95.439
780.00	146.021	16429.8	142.000	95.709
790.00	146.040	16456.5	138.750	95.958
800.00	146.058	16481.1	135.500	96.187
810.00	146.074	16503.7	132.250	96.398
820.00	146.089	16524.2	129.000	96.589
830.00	146.102	16542.6	125.750	96.761
840.00	146.114	16558.9	122.500	96.914
850.00	146.124	16573.5	120.083	97.050
860.00	146.133	16586.6	117.667	97.172
870.00	146.142	16598.1	115.250	97.280
880.00	146.149	16608.1	112.833	97.374
890.00	146.155	16616.7	110.417	97.454
900.00	146.160	16623.7	108.000	97.519
910.00	146.164	16629.4	106.167	97.573
920.00	146.167	16634.0	104.333	97.616
930.00	146.170	16637.5	102.500	97.648
940.00	146.171	16639.8	100.667	97.671
950.00	146.172	16641.1	98.833	97.682
960.00	146.172	16641.2	97.000	97.684
970.00	146.172	16640.1	94.767	97.673
980.00	146.170	16637.7	92.533	97.651
990.00	146.167	16634.0	90.300	97.616
1000.00	146.164	16629.0	88.067	97.569
1010.00	146.159	16622.6	85.833	97.509
1020.00	146.154	16614.9	83.600	97.438
1030.00	146.147	16606.0	81.550	97.354
1040.00	146.140	16596.0	79.500	97.260
1050.00	146.132	16584.7	77.450	97.155
1060.00	146.123	16572.3	75.400	97.039
1070.00	146.113	16558.8	73.350	96.912
1080.00	146.103	16544.1	71.300	96.775
1090.00	146.092	16528.5	70.250	96.630
1100.00	146.080	16512.4	69.200	96.480
1110.00	146.068	16495.8	68.150	96.324
1120.00	146.056	16478.6	67.100	96.164
1130.00	146.043	16460.9	66.050	95.999
1140.00	146.030	16442.7	65.000	95.830
1150.00	146.017	16424.3	65.467	95.659
1160.00	146.005	16406.4	65.933	95.493
1170.00	145.992	16388.9	66.400	95.329
1180.00	145.980	16371.7	66.867	95.170
1190.00	145.968	16354.9	67.333	95.014
1200.00	145.956	16338.5	67.800	94.862
1210.00	145.943	16319.9	59.783	94.689
1220.00	145.926	16296.6	51.767	94.473
1230.00	145.906	16268.6	43.750	94.215
1240.00	145.883	16236.0	35.733	93.913
1250.00	145.856	16198.8	27.717	93.569
1260.00	145.826	16157.0	19.700	93.184
1270.00	145.795	16112.7	18.550	92.775
1280.00	145.763	16068.0	17.400	92.363
1290.00	145.731	16022.8	16.250	91.948
1300.00	145.698	15977.1	15.100	91.529
1310.00	145.665	15931.0	13.950	91.107
1320.00	145.632	15884.5	12.800	90.682
1330.00	145.598	15837.6	11.867	90.254
1340.00	145.565	15790.5	10.933	89.824
1350.00	145.531	15743.0	10.000	89.392
1360.00	145.497	15695.2	9.067	88.957
1370.00	145.462	15647.1	8.133	88.521
1380.00	145.428	15598.7	7.200	88.083
1380.00	145.428	15598.7	7.200	88.083

PEAK OUTFLOW

956.27	146.172	16641.3	97.684

Table 4D-5 (3) Flow-out Discharge for Diversion Facilities

FWL= 135.000 (FT) CREST LENGTH L= 40.000 (FT)
V= 5000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	135.008	5004.6	11.083	0.002
20.00	135.022	5013.2	17.467	0.011
30.00	135.043	5025.5	23.850	0.031
40.00	135.070	5041.8	30.233	0.064
50.00	135.103	5061.8	36.617	0.115
60.00	135.143	5085.6	43.000	0.188
70.00	135.186	5111.5	43.850	0.279
80.00	135.230	5137.8	44.700	0.384
90.00	135.274	5164.6	45.550	0.501
100.00	135.320	5191.9	46.400	0.631
110.00	135.366	5219.6	47.250	0.772
120.00	135.413	5247.7	48.100	0.925
130.00	135.466	5279.5	60.067	1.109
140.00	135.531	5318.4	72.033	1.348
150.00	135.607	5364.3	84.000	1.650
160.00	135.695	5417.2	95.967	2.022
170.00	135.795	5477.1	107.933	2.472
180.00	135.906	5543.8	119.900	3.008
190.00	136.041	5624.4	155.533	3.702
200.00	136.210	5726.0	191.167	4.640
210.00	136.414	5848.2	226.800	5.860
220.00	136.652	5991.1	262.433	7.401
230.00	136.924	6154.2	298.067	9.303
240.00	137.229	6337.5	333.700	11.604
250.00	137.562	6537.0	357.100	14.295
260.00	137.915	6748.8	380.500	17.351
270.00	138.288	6972.8	403.900	20.788
280.00	138.681	7208.5	427.300	24.624
290.00	139.093	7455.9	450.700	28.875
300.00	139.524	7714.6	474.100	33.557
310.00	139.965	7979.1	479.500	38.579
320.00	140.175	8244.5	484.900	41.051
330.00	140.366	8511.7	490.300	43.343
340.00	140.558	8780.8	495.700	45.693
350.00	140.751	9051.7	501.100	48.101
360.00	140.946	9324.4	506.500	50.565
370.00	141.141	9597.6	507.917	53.075
380.00	141.336	9870.2	509.333	55.619
390.00	141.530	10142.1	510.750	58.196
400.00	141.724	10413.3	512.167	60.804
410.00	141.917	10683.7	513.583	63.443
420.00	142.110	10953.4	515.000	66.112
430.00	142.301	11220.8	511.133	68.794
440.00	142.489	11484.2	507.267	71.471
450.00	142.674	11743.7	503.400	74.141
460.00	142.857	11999.3	499.533	76.803
470.00	143.036	12251.0	495.667	79.454
480.00	143.213	12498.8	491.800	82.093
490.00	143.386	12740.0	478.950	84.690
500.00	143.551	12971.9	466.100	87.212
510.00	143.710	13194.6	453.250	89.658
520.00	143.863	13408.2	440.400	92.024
530.00	144.009	13612.7	427.550	94.308
540.00	144.149	13808.1	414.700	96.508
550.00	144.281	13994.0	400.183	98.617
560.00	144.407	14170.0	385.667	100.628
570.00	144.526	14336.1	371.150	102.537
580.00	144.637	14492.3	356.633	104.345
590.00	144.742	14638.8	342.117	106.049
600.00	144.840	14775.6	327.600	107.649
610.00	144.931	14902.7	313.033	109.143
620.00	145.014	15020.3	298.467	110.530
630.00	145.092	15128.3	283.900	111.810
640.00	145.162	15226.8	269.333	112.981
650.00	145.226	15315.9	254.767	114.045
660.00	145.283	15395.7	240.200	114.999
670.00	145.333	15466.8	227.800	115.853
680.00	145.379	15530.0	215.400	116.613
690.00	145.418	15585.3	203.000	117.280
700.00	145.452	15632.9	190.600	117.854
710.00	145.480	15672.6	178.200	118.335
720.00	145.503	15704.7	165.800	118.724
730.00	145.523	15731.7	161.833	119.050
740.00	145.540	15756.1	157.867	119.346
750.00	145.556	15777.9	153.900	119.611
760.00	145.569	15797.2	149.933	119.846
770.00	145.581	15814.0	145.967	120.050
780.00	145.592	15828.3	142.000	120.224
790.00	145.600	15840.3	138.750	120.370
800.00	145.607	15850.4	135.500	120.492
810.00	145.613	15858.4	132.250	120.590
820.00	145.617	15864.4	129.000	120.663
830.00	145.620	15868.4	125.750	120.712
840.00	145.622	15870.4	122.500	120.736
850.00	145.622	15870.7	120.083	120.740
860.00	145.621	15869.6	117.667	120.727
870.00	145.619	15867.1	115.250	120.696
880.00	145.616	15863.1	112.833	120.647
890.00	145.613	15857.7	110.417	120.582
900.00	145.608	15850.9	108.000	120.499
910.00	145.602	15842.9	106.167	120.401
920.00	145.596	15833.8	104.333	120.291
930.00	145.588	15823.7	102.500	120.168
940.00	145.580	15812.6	100.667	120.033
950.00	145.572	15800.5	98.833	119.886
960.00	145.562	15787.3	97.000	119.727
970.00	145.552	15773.1	94.767	119.553
980.00	145.541	15757.6	92.533	119.366
990.00	145.529	15740.9	90.300	119.163
1000.00	145.516	15723.0	88.067	118.946
1010.00	145.503	15703.8	85.833	118.714
1020.00	145.488	15683.5	83.600	118.468
1030.00	145.473	15662.0	81.550	118.208
1040.00	145.457	15639.5	79.500	117.936
1050.00	145.440	15615.9	77.450	117.651
1060.00	145.422	15591.3	75.400	117.353
1070.00	145.404	15565.6	73.350	117.044
1080.00	145.385	15538.8	71.300	116.722
1090.00	145.365	15511.4	70.250	116.391
1100.00	145.345	15483.5	69.200	116.055
1110.00	145.325	15455.2	68.150	115.715
1120.00	145.305	15426.4	67.100	115.370
1130.00	145.284	15397.2	66.050	115.020
1140.00	145.263	15367.6	65.000	114.666
1150.00	145.241	15338.1	65.467	114.312
1160.00	145.221	15309.0	65.933	113.965
1170.00	145.200	15280.4	66.400	113.624
1180.00	145.180	15252.4	66.867	113.289
1190.00	145.161	15224.7	67.333	112.959
1200.00	145.141	15197.6	67.800	112.636
1210.00	145.120	15168.4	59.783	112.289
1220.00	145.096	15134.6	51.767	111.888
1230.00	145.069	15096.2	43.750	111.433
1240.00	145.038	15053.4	35.733	110.925
1250.00	145.004	15006.0	27.717	110.365
1260.00	144.967	14954.2	19.700	109.753
1270.00	144.929	14900.0	18.550	109.114
1280.00	144.890	14845.5	17.400	108.473
1290.00	144.851	14790.7	16.250	107.830
1300.00	144.811	14735.6	15.100	107.184
1310.00	144.772	14680.2	13.950	106.537
1320.00	144.732	14624.5	12.800	105.887
1330.00	144.692	14568.6	11.867	105.235
1340.00	144.652	14512.5	10.933	104.583
1350.00	144.612	14456.2	10.000	103.930
1360.00	144.571	14399.8	9.067	103.277
1370.00	144.531	14343.2	8.133	102.623
1380.00	144.490	14286.4	7.200	101.969
1380.00	144.490	14286.4	7.200	101.969

PEAK OUTFLOW

847.27	145.622	15870.8		120.741

Table 4D-5 (4) Flow-out Discharge for Diversion Facilities

FWL= 135.000 (FT) CREST LENGTH L= 60.000 (FT)
V= 5000.0 (1000M**3/SEC)

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
10.00	135.008	5004.6	11.083	0.003
20.00	135.022	5013.2	17.467	0.017
30.00	135.043	5025.5	23.850	0.046
40.00	135.070	5041.7	30.233	0.096
50.00	135.103	5061.7	36.617	0.172
60.00	135.142	5085.5	43.000	0.281
70.00	135.186	5111.3	43.850	0.418
80.00	135.229	5137.6	44.700	0.574
90.00	135.274	5164.3	45.550	0.749
100.00	135.319	5191.3	46.400	0.942
110.00	135.365	5218.8	47.250	1.152
120.00	135.411	5246.7	48.100	1.379
130.00	135.464	5278.2	60.067	1.651
140.00	135.528	5316.7	72.033	2.006
150.00	135.604	5362.2	84.000	2.453
160.00	135.691	5414.6	95.967	3.004
170.00	135.790	5473.8	107.933	3.670
180.00	135.899	5539.7	119.900	4.462
190.00	136.032	5619.4	155.533	5.485
200.00	136.200	5719.7	191.167	6.870
210.00	136.401	5840.5	226.800	8.670
220.00	136.636	5981.4	262.433	10.940
230.00	136.904	6142.2	298.067	13.736
240.00	137.204	6322.5	333.700	17.114
250.00	137.531	6518.3	357.100	21.053
260.00	137.876	6725.7	380.500	25.511
270.00	138.240	6944.2	403.900	30.508
280.00	138.623	7173.7	427.300	36.065
290.00	139.023	7413.6	450.700	42.199
300.00	139.440	7663.8	474.100	48.927
310.00	139.864	7918.4	479.500	56.108
320.00	140.123	8172.4	484.900	60.660
330.00	140.305	8427.6	490.300	63.926
340.00	140.489	8684.0	495.700	67.265
350.00	140.673	8941.7	501.100	70.677
360.00	140.858	9200.5	506.500	74.160
370.00	141.042	9459.3	507.917	77.698
380.00	141.226	9716.8	509.333	81.273
390.00	141.409	9972.9	510.750	84.882
400.00	141.591	10227.8	512.167	88.524
410.00	141.772	10481.3	513.583	92.197
420.00	141.952	10733.4	515.000	95.900
430.00	142.130	10982.6	511.133	99.606
440.00	142.305	11227.3	507.267	103.290
450.00	142.477	11467.4	503.400	106.949
460.00	142.645	11703.0	499.533	110.581
470.00	142.810	11934.1	495.667	114.182
480.00	142.972	12160.8	491.800	117.751
490.00	143.129	12380.3	478.950	121.243
500.00	143.279	12590.0	466.100	124.610
510.00	143.422	12790.1	453.250	127.851
520.00	143.558	12980.5	440.400	130.961
530.00	143.687	13161.4	427.550	133.939
540.00	143.809	13332.9	414.700	136.782
550.00	143.925	13494.5	400.183	139.479
560.00	144.033	13645.7	385.667	142.020
570.00	144.133	13786.8	371.150	144.404
580.00	144.227	13917.9	356.633	146.629
590.00	144.313	14038.9	342.117	148.695
600.00	144.393	14150.0	327.600	150.600
610.00	144.465	14251.3	313.033	152.343
620.00	144.531	14342.8	298.467	153.925
630.00	144.589	14424.7	283.900	155.345
640.00	144.641	14497.1	269.333	156.603
650.00	144.686	14560.0	254.767	157.700
660.00	144.724	14613.6	240.200	158.636
670.00	144.756	14658.6	227.800	159.423
680.00	144.783	14695.7	215.400	160.073
690.00	144.804	14725.0	203.000	160.587
700.00	144.819	14746.6	190.600	160.967
710.00	144.829	14760.5	178.200	161.212
720.00	144.834	14767.0	165.800	161.325
730.00	144.835	14768.5	161.833	161.352
740.00	144.834	14767.6	157.867	161.336
750.00	144.832	14764.3	153.900	161.279
760.00	144.828	14758.7	149.933	161.180
770.00	144.822	14750.8	145.967	161.042
780.00	144.815	14740.6	142.000	160.863
790.00	144.806	14728.4	138.750	160.648
800.00	144.796	14714.3	135.500	160.402
810.00	144.785	14698.5	132.250	160.124
820.00	144.772	14680.9	129.000	159.815
830.00	144.758	14661.5	125.750	159.476
840.00	144.743	14640.4	122.500	159.107
850.00	144.727	14617.9	120.083	158.712
860.00	144.710	14594.1	117.667	158.297
870.00	144.692	14569.1	115.250	157.861
880.00	144.674	14542.9	112.833	157.405
890.00	144.654	14515.6	110.417	156.928
900.00	144.634	14487.1	108.000	156.433
910.00	144.613	14457.7	106.167	155.920
920.00	144.591	14427.4	104.333	155.395
930.00	144.569	14396.4	102.500	154.857
940.00	144.546	14364.6	100.667	154.306
950.00	144.523	14332.0	98.833	153.742
960.00	144.499	14298.7	97.000	153.166
970.00	144.475	14264.5	94.767	152.576
980.00	144.450	14229.3	92.533	151.969
990.00	144.424	14193.2	90.300	151.347
1000.00	144.397	14156.1	88.067	150.709
1010.00	144.370	14118.0	85.833	150.055
1020.00	144.342	14079.0	83.600	149.387
1030.00	144.314	14039.1	81.550	148.704
1040.00	144.285	13998.4	79.500	148.008
1050.00	144.255	13956.9	77.450	147.300
1060.00	144.225	13914.6	75.400	146.579
1070.00	144.194	13871.5	73.350	145.846
1080.00	144.163	13827.6	71.300	145.100
1090.00	144.131	13783.3	70.250	144.348
1100.00	144.099	13738.7	69.200	143.594
1110.00	144.067	13694.0	68.150	142.839
1120.00	144.035	13649.1	67.100	142.082
1130.00	144.003	13604.0	66.050	141.323
1140.00	143.971	13558.8	65.000	140.562
1150.00	143.938	13513.8	65.467	139.808
1160.00	143.907	13469.5	65.933	139.067
1170.00	143.876	13426.0	66.400	138.340
1180.00	143.845	13383.2	66.867	137.626
1190.00	143.815	13341.1	67.333	136.924
1200.00	143.786	13299.7	67.800	136.236
1210.00	143.755	13256.4	59.783	135.518
1220.00	143.721	13208.8	51.767	134.729
1230.00	143.684	13156.9	43.750	133.870
1240.00	143.643	13100.7	35.733	132.943
1250.00	143.600	13040.3	27.717	131.949
1260.00	143.554	12975.6	19.700	130.888
1270.00	143.506	12908.9	18.550	129.795
1280.00	143.459	12842.1	17.400	128.705
1290.00	143.411	12775.3	16.250	127.618
1300.00	143.363	12708.5	15.100	126.533
1310.00	143.315	12641.6	13.950	125.450
1320.00	143.268	12574.7	12.800	124.370
1330.00	143.220	12507.8	11.867	123.293
1340.00	143.172	12441.0	10.933	122.221
1350.00	143.124	12374.2	10.000	121.153
1360.00	143.077	12307.6	9.067	120.090
1370.00	143.029	12241.0	8.133	119.031
1380.00	142.982	12174.5	7.200	117.976
1380.00	142.982	12174.5	7.200	117.976

PEAK OUTFLOW

TIME (MIN)	WATER LEVEL (FT)	CAPACITY (1000CM)	INFLOW (M**3/SEC)	OUTFLOW (M**3/SEC)
731.20	144.835	14768.5		161.352

3. Construction Schedule

Judging from the above-mentioned workable days and quantities of construction works, the construction works should be executed with heavy construction equipments. The construction schedule is planned after due consideration of various conditions such as river diversion system, proposed construction method and expected production rates of equipments and plants and the proposed construction schedule for the Okkan dam is shown in Figure 4D-9.

As net construction period, it takes about 2.8 years for the Okkan dam from the above-mentioned construction schedule.

Table 4D-6 Workable Days for Construction Works

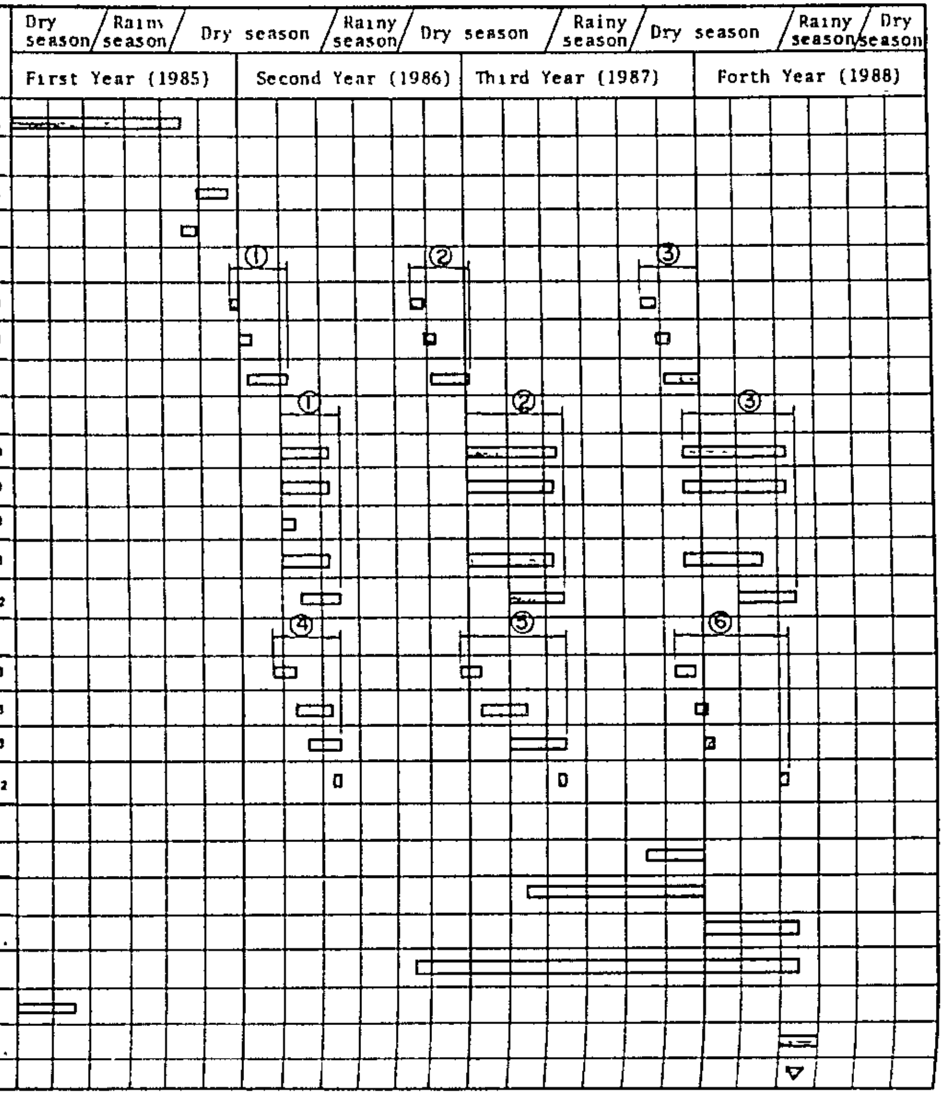
	Dry Season					Rainy Season				Dry Season			
Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Impervious	(31)	(27)	(30)	(29)	(20)	(4)	(4)	(2)	(5)	(18)	(28)	(31)	(229)
Material	25	25	25	25	20	0	0	0	0	18	25	25	188
material, concrete and earth works	25	25	25	25	25	0	0	0	0	25	25	25	200
	Construction period					Suspension period				Construction period			

Note; Workable days were computed by using the daily rainfall data observed at Kyaukpyintha raingauge station for three years (1978 - 1980), and the criteria for estimation of workable days on impervious materials embankment are as follows:

Daily rainfall	Suspended days
Less than 1.0 mm	Workable
1.1 to 10.0 mm	Non-workable on that day
10.1 to 30.0 mm	Non-workable two days
30.1 to 50.0 mm	Non-workable for three days
More than 50.1 mm	Non-workable for four days

FIGURE 4D-9 CONSTRUCTION SCHEDULE FOR OKKAN DAM

Description	Q'ty
1. Preparation Works	1 L.S.
2. Diversion Facilities	
Coffer Dam (Embankment)	47,200 m^3
Bypassing canal (Excavation)	20,000 m^3
3. Foundation Works	
Stripping	43,500 m^3
Core trench (Excavation)	53,400 m^3
Grouting	7,300 m
4. Dam Body	
Zone 1 (Impervious)	111,000 m^3
Zone 2 (Random)	368,000 m^3
Zone 3 (Rock)	2,500 m^3
Filter and drain	9,500 m^3
Riprap and sodding	34,300 m^2
5. Spillway	
Common excavation	32,600 m^3
Rock excavation	65,900 m^3
Concrete	5,900 m^3
Riprap	4,400 m^2
6. Outlet Facilities	
Drop intake (ϕ4.0m, H=11.0m)	1 L.S
Conduit (ϕ2.40m Steel Pipe)	220 m
Discharge control structure	1 L.S.
Hydro-electric power plant	1-2,340KW
Transmission line	33KV, 22.5km
7. Site Clearance	1 L.S.
8. Storing Water in Reservoir	



Notes. ① Lower portion of River Channel, ② Upper portion of River Channel, ③ 'Wadi' Channel
④ Weir and Chute portion ⑤ Chute and Stilling Basin portion ⑥ Tail Race portion