REPORT ON THE DEFINITE PLAN

FOR

THE SAN MIGUEL-ALANGALANG RICE PRODUCTION CENTER IN THE PHILIPPINES

SEPTEMBER, 1968

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

The Overseas Technical Cooperation Agency sent the first preliminary survey team to the Philippines in September 1966, by way of cooperation with her in agricultural development. The team found it important to set up a rice producing center with an improved irrigation system. Then the Philippine Government requested for another survey team, which conducted investigations on the spot for 40 days from April 1967 in the Naujan district of Mindoro Island, San Miguel-Alangalang district of Leyte Island, and Titay Valley district of Mindanao Island, for a period of 40 days initiating in April 1967.

The Philippine Government, having made detailed examination of the report submitted by the second survey team, entered into an agreement with the Japanese Government, whereby a definite plan for the establishment of a Model Center for Rice Production in the Naujan district of Mindoro Island and the San Miguel-Alangalang district of Leyte Island was to be worked out. A team of 21 members was formed for this purpose, headed by Mr. Kensaku Takeda of the Ministry of Agriculture and Forestry. They made surveys in the above-mentioned two districts from 6 March 1968 thru 30 April 1968. Their work covered not only the designs of irrigation facilities, but also the designs of marketing facilities, such as rice processing and storage installations, with a view to establishing a model center for rice cultivation. Their report is now submitted herewith.

I confidently hope that this report will help increase the output of rice in the Philippines and contribute to the furtherance of friendship and economic relations between Japan and the Philippines.

I wish to take this opportunity to express my profound gratitude to Mr. Fernando Lopez, Vice President, Mr. Dioscoro L. Umari, Vice Minister of the Department of Agriculture and Natural Resources, and other authorities concerned in the Republic of the Philippines who extended full support and cooperation to the activities of the team, and the officials of the Japanese Embassy in Manila from whom the team members received kind assistance, and the Ministry of Foreign Affairs, the Ministry of Agriculture and Forestry, and the Japan Irrigation and Reclamation Consultants for their efforts rendered in connection with the dispatch of the team. I wish also to thank most sincerely the members of the team for their assiduous work in the Philippines and in Japan.

September 1968

S. Shibusawa

SHINICHI SHIBUSAWA
Director General
Overseas Technical Cooperation Agency
Government of Japan

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1. Existing Condition of the Project Area

1 Existing Condition

A) Location

The San Miguel Alangalang project area is located about 40 kilometers west of Tacloban City, Layte del Norte.

The project area stretches northward from the Tacloban - Carigara National Highway and is located along the Alangalang - San Miguel Provincial Highway, branching off from the National Highway at the bridge across the Mainit River.

The area can be divided into two sub-areas, the Alangalang area and the San Miguel area.

B) Topography

The project area is generally flat, but the land surface slants northward slightly. Elevations vary from 40 meters to 20 meters in the Alangalang area and from 20 meters to 10 meters in the San Miguel area.

The Mainit River, the main source of irrigation water for the project, flows in a northeast direction near its junction with the National Highway, and then curves to the east side out of the area. The Lukay creek, the largest among many creeks in the area, starts from the junction of the Mainit River and the National Highway and runs almost parallel with the river through the Alangalang area and joins the river again in the east of the San Miguel area. The project area consists of coconut groves, corn fields, and paddy fields.

II. Construction Plan

II. Construction Plan

A. Final Location

1 Boundary of Irrigation Area

The project has a total irrigable area of 1,086 ha., of which Alangalang area has 636 ha, and San Miguel 450 ha.

Alangalang Area:

The Alangalang project area is bounded on the south by the Alangalang Jaro National Highway, on the east by the Mainit River, on the west by the Arabunog Creek, and about 0.8 km. north of the Barrio Road to Bo. Borseth.

Three creeks, namely, the Libtong, Data, and Lukay Creeks, criss-cross the area forming valleys in the area.

San Miguel Area:

The San Miguel project area is bounded the south by the Lukay Creek, on the east by the Malipron Creek, on the north by the Sapiniton River and the west by Libtong Creek.

The Baran Creek passes across this area separating it into two.

On the northern part several small creeks crisscross the area.

2 Diversion Dams

The Mainit River and the Cabayongan River converge at a point 1.9 km. upstream of the Mainit National Highway Bridge. Then at a distance of 1.2 km. upstream of the same bridge, the Mainit River is again merged with the Old Mainit River.

The Old Mainit River deviates away from the Cabayongan River at approximately 3 km. upstread of the Bridge.

The Mainit River slopes at a grade of about 1 : 200. At the foot of the National Road Bridge, a self recording gauging station was established by the Hydrology Division of the Bureau of Public Works to record the water level of the Mainit River.

The discharges at the Bridge and at the confluence of the Old Mainit River are not practically different, so the discharge just downstream of the confluence is the same as the self-recorded data.

In the dry season, there is no difference in the discharge at the confluences.

In selecting the damsite, two sites can be considered. One is about 1.7 km. upstream of the Bridge and another is about 1.0 km. upstream from the Bridge. These damsites almost coincide with the sites contemplated by N.I.A. The lower damsite has a sufficient discharge to meet the requirement for the project area even during the dry season, but at the upper site the discharge decreases by one half during the same season.

The discharge at the upper site is not sufficient for the volume of water required in this project area. To obtain the necessary volume of water, a secondary dam to collect water from the Old Mainit River is considered.

Dam No. 1 functions as a diverter, by transporting the water of the Mainit River to the Old Mainit River. Then Dam No. 2 can convey the discharges of the rivers to the project area. As a result of comparative designs of the upper damsite system (including the connecting canal between the dams) and the lower damsite system, it has been found that the upper damsite system is more economical than the lower damsite system and also has advantageous conditions if water is to be collected for the irrigation of the area on the right bank of the Mainit River as planned by N.I.A.

For these reasons, the upper damsite has been adopted.

3 Irrigation Canals and Related Structures

a) Link Canal

The link canal is designed to conduct water taken in at Dam No. 1 to Dam No. 2. It is 600 m. long.

b) Main Canal

The main canal conducts water in the volume required for the whole project area from Dam No. 2 to the junction of the Alangalang area, and has a length of 1,140 m. Both canals will be concrete lined. The main canal has two structures, an elevated flume over a creek and an inverted siphon across the National Highway.

c) Check Gate

The source of irrigation water for the San Miguel project area is the Lukay Creek. The discharge of this creek is supplemented by the discharge of the Mainit River through a lateral of the Alangalang area. Water is taken in from the Lukay Creek by a check gate and distributed to the San Miguel project area.

d) Laterals

In the Alangalang area, three lateral canals, A, A1, and B, are considered to conduct water in the volume required for irrigable areas within the project area.

Lateral A is 6,505 m. long and will irrigate 385 ha., between the Arabunog Creek and the Libtong Creek.

Lateral A1 branches out from Lateral A and has a total length of 3,200 m. and will irrigate an area of 218 ha., between the Libtong Creek and the Lukay Creek. To the east of the Provincial Road between Alangalang and San Miguel, there is 72.0 ha. of paddy fields, which will be irrigated by Lateral B branching out from the main canal, with a length of 2,330 m.

Lateral A has two division works and an inverted siphon across the Provincial Road to Borseth.

Lateral B contains a division work and an inverted siphon across the Provincial Highway.

In the San Miguel area, three lateral canals, A, A-1, B, are considered for the purpose of irrigating different areas. Lateral A is 4,219.4 m. long and designed to irrigate 340 ha. between the Banran Creek and Miliporon Creek. Lateral A-1 branches out from Lateral A and has a total length 1,980.22 m. and will irrigate an area of 55.0 ha. on the west side of the Banran Creek and the Provincial Road between Alangalang and San Miguel Provincial Road. Lateral B branches out from Lateral A-1 and has a total length 1,583.21 m. to irrigate an area of 55.0 ha. which lies to the west of Alangalang San Miguel Provincial Road. Lateral A and Lateral A-1 have each a division work and Lateral B has an inverted siphon across the Provincial Highway.

e) Drainage Canal

One drainage canal, 1,100 m. long, is planned to drain water from the depression at the center of the San Miguel area. The outlet of this canal is the branch creek of the Maliporon Creek.

f) Feeder Roads

In the Alangalang area one feeder road, 5,847 m. long, will be laid along Lateral A from the National Road to Borseth. In the San Miguel area one feeder road will be laid for a length of 4,219.4 m. along Lateral A from the Check Gate.

g) Access Roads

In the Alangalang area three access roads are planned from the Provincial Road to the feeder road across the area. These three roads, Access Roads I, II and III, are spaced about 1 km. from each other.

Access Road I is 890 m. long, Road II is 1,243 m. and Road III 1,295 m. long.

In the San Miguel area three access roads are planned to cross the area from the Provincial Road to the feeder road. Access Road I is 780 m. long, Road II is 983 m. and Road III 1,744.25 m. long.

h) Operation, Maintenance and Extension Service Facilities

A building for operation, maintenance and extension service will be erected at Barrio Aliconob along the Provincial Highway.

Barrio Aliconob is situated at the center of this project area and is easily accessible from any place in the area. Since the damsite is about 6 km. from Barrio Aliconob, the gate keeper's quarters will be provided for operation.

B. Design

1. Water Requirement

a) Water Requirement in Depth

From data taken in the field, the average water requirement in depth is 16mm/day for the Alangalang area and 22m/day for the San Miguel area. The difference in water requirement in depth between the two areas is due to soil classification. Alangalang soil is palo-clay loam and San Miguel soil is San Miguel silt loam.

(note; field data on water requirement in depth is annexed)

b) Calculation of Water Requirement

Intake capacity is calculated on the basis of the following formula:

$$Qmax = \frac{(d_s \times a_s + d_c \times a_c) \times 10}{(1-r) \times (24hr \times 60mm \times 60sec)} \quad (m3/sec)$$

whereas

d_s ; water requirement in depth of silt loam 22mm/day

a_s ; area of silt loam 450 ha. (=0.90 total area)

d_c ; water requirement in depth of clay loam 16mm/day

a_c ; area of clay loam 636 ha. (=0.90 total area)

r ; water loss ratio 0.15

$$Qmax = \frac{(22 \times 450 + 16 \times 636) \times 10}{(1 - 0.15) \times 24 \times 60 \times 60} = 2.730m/sec$$

then Qmax consits of

Q_A = 1.386m/s (at Alangalang area)

Q_S = 1.344m/s (at San Miguel area)

The minimum discharge of the Mainit River will be sufficient to meet the computed water requirement of 2.73m/s for the entire project area as per attached five years' records.

2. Diversion Dams and Check Gate

According to survey, the maximum original ground height of the Alangalang area is approximately EL. 40 m. Total head losses, by intake, main canal, elevated flume, and main siphon are approximately 1.0 m. Therefore, the operating water surface of Dam No. 2 will be determined at EL. 41 m, by adding 1.0m. to the highest ground height of the Alangalang area.

Similarly, the operating water surface of Dam No. 1 is determined at EL.42.0 m., by adding 1.0m. to the operating water surface of Dam No. 2, since the total head losses by intake and the link canal are estimated at 1.0 m.

The width of the scouring sluice way is designed by assuming that the sluice way gates are operated at a discharge nearly equal to the ordinary flow of the Mainit River and the mean grain diameter of the river bed is 20 cm.

The Bligh method will be used for designing the apron and the riprap. The standards for designing the dams are as follows,

Roughness Coefficient of Mainit River	:	0.06
Roughness Coefficient of concrete	:	0.015
Safety factor for overturning	:	Should be inside the middle third of the base and the footing.
Safety factor of sliding	:	1.5
Coefficient of friction	:	0.5
Bearing stress of foundation	:	40 t/m^2
Unit compressive stress of concrete	:	80 kg/cm^2
Unit tensile stress of steel bar	:	1,400 kg/cm^2

b) Principal Dimensions of Diversion Dams

	Dam No. 1	Dam No. 2
Type of Dam	Overflow, gravity type	Overflow, gravity type
Dam length	76.0m	25.0m
Sluice way (including piers)	6.0m	5.0m
Fixed weir	70.0m	20.0m
Elevation of dam crest	42.10	41.10
Intake discharge	1.64	2.73
Operating water level	42.00	41.00
Maximum flood water level	44.50	43.00
Scouring sluice way		
Width	4.0m	3.0m
Bottom elevation	40.50	39.50
Bottom slope	1:50	1.50
Top elevation of operating platform	48.20	46.70
Type of gate	Roller gate	Roller gate
Gate size	1.6m x 4.0m	1.6m x 3.0m
Number of gate	1	1

c) Principal Dimensions of Check Gate

Item	Dimension
Type of intake	Overflow, gravity type
Dam length	20.5 m
Sluice Way (including pier)	4.0 m
Fixed Weir	16.5 m
Elevation of dam crest	19.5 m
Intake discharge	1.344 m/sec
Operating water level	19.45 m
Maximum flood water surface	20.80 m
Sluice way	
Width	3.0 m
Bottom elevation	17.70 m
Bottom slope	Level
Top of operating platform elevation	24.30 m
Type of gata	Roller gate
Gate size	1.8 x 3.0 m
Number of gate	1

3. Main Irrigation Canals

a) Principles and standards of design

The maximum allowable velocity in a lined canal is generally 1.20 meters per second. The height of linings above the water surface of lined canals is one sixth of the hydraulic depth and a minimum of 0.15 meter. However, the height of the bank above the water surface of lined canals is one third of the hydraulic depth, which is the same standard as in the case of unlined canals.

Berms used as operation and maintenance roads or feeder roads may range from 3.0 meters to 4.0 meters for canals with a capacity less than 3.0 cubic meter per second. Where there is no need for such operating and maintenance roads or feeder roads, the width of the embankment may be about 1.0 meter.

The Manning formula is commonly used for open canal flow.

The formula is as follows,

$$V = \frac{1}{n} I^{\frac{1}{2}} R$$

whereas, V = velocity of water in m/s

I = slope of energy gradient

R = hydraulic radius

n = coefficient of roughness

A roughness coefficient 'n' of 0.015 is generally used for lined canals. In the case of lined canals, the cost of lining makes up a large percentage of the total cost of construction; therefore, the section; therefore, the section with the least perimeter is the most economical. But, practically speaking, from experience, the steepest satisfactory side slope from both construction and maintenance considerations is 1 to 1.50 (vertical to horizontal).

Class 'c' concrete will be used for line canals.

Class 'A' concrete for flume will be reinforced.

The standards for the structural design of canal are as follows:

Unit compressive stress of concrete .... 80 kg/cm^2

Unit tensile stress of steel bar .... 1,400 kg/cm^2

Coefficient of earth pressure 0.333

b) Link Canal

The slightest increase in the annual flood level of the Mainit River will submerge and subject to the link canal to a great hydraulic pressure.

For this reason, it has been decided to adopt a rectangular reinforced concrete lined canal.

Table of Hydraulic Data

Name of canal	Section	Canal length	Design discharge	Velocity	Hydraulic depth	Hydraulic gradient
Link canal	Rectangle	593m	1.64m^3/s	1.117m/s	0.871 m	1/1,000

c) Main Canal

According to the design of the main canal, there is a section on the left bank of the Old Mainit River requiring deep excavation. During flood periods, the earth and water pressures against the sides of the main canal will be enormous. For this reason, a rectangular reinforced concrete lined canal is advisable for this section, from the station 18.0 to the station 760. Between the station 760 and 1,164, the main canal will have a trapezoid section lined with concrete.

Table of Hydraulic Data

Name of canal	Section	Canal length	Design discharge	Velocity	Hydraulic depth	Hydraulic gradient
Main canal	Rectangle	742.0m	2.73m^3/s	1.073m/s	1.157m	1/1,800
	Trapezoid	399.0m	2.73m^3/s	1.059m/s	1.112m	1/1,800

4. Laterals

a). Principles and standards of design

The laterals are designed as unlined canals except the sections where the discharge is large and deep excavation is needed. In unlined canals, the velocity of flow should be such as to prevent scouring and deposition of silt. The maximum velocity allowable, to prevent scouring, or the minimum velocity allowable to prevent silt deposition will depend upon soil characteristics and the depth of water. Velocities in unlined canals ordinarily vary from 0.30m/s to 0.70m/s, and the general limits of velocity on the bed of loamy slit are, according to experience, as follows:

TABLE Maximum allowable velocities of unlined canal.

Hydraulic Depth		Maximum Velocities
0	0.30	0.35
0.31	0.60	0.50
0.61	0.90	0.60
0.91	1.20	0.65

The free board of a canal is governed by the size, location, velocity, storm water inflow and soil characteristics of the canal. The minimum free board of an unlined canal is one third of the hydraulic depth and a minimum of 0.30 meter. Berms or bank top widths are matched with the standards of lined canals. The Manning formula is generally used for calculations about laterals, but a roughness coefficient 'n' of 0.025 is used for unlined canals.

Side slopes of 1 to 1.50 or 1 to 1.0 (vertical to horizontal) is generally used for unlined canals with ordinary conditions. Therefore, the side slopes have been determined according to the following standards:

TABLE Standards of side slope of unlined canals

Hydraulic depth		Side slope
0.30	0.70	1 : 1.0
0,71	1.00	1 : 1.5

b) Determination of Design Discharge

As mentioned in A. Final Location, the design discharges of each Lateral is calculated in proportion to the area it controls.

The design discharge for each lateral is as follows:

Table of design discharge for the Alangalang Project Area.

System of water supply	Name of Canal	Canal length	Irrig. control area	Total irrig. area	Percentage of area	Design discharge	Remarks
		m	ha	ha	%	m^3/s	
	VI	960.0	56.5	56.5	8.88	0.122	
	V	839.2	75.7	75.7	11.90	0.166	
Lateral A	IV	952.3	67.5	199.7	31.40	0.435	
	III	2,565.7	91.8	291.5	45.83	0.635	
	II	1,044.2	48.5	557.7	87.69	1.215	Include L-A_1
	I	143.6	6.4	636.0	100.0	2.730	Include L-A_1 and L-B
	Total	6,505.0	385.0				
	II	2,129.0	145.7	145.7	22.91	0.318	
Lateral A_1	I	1,151.0	72.0	217.7	34.23	0.474	
	Total	3,280.0	217.7				
	II	1,898.5	71.9	71.9	11.31	0.157	
Lateral B	I	431.5	0	71.9	11.31	1.501	To San Miguel 1.344 m^3/s
	Total	2,330.0	71.9				

Table of design discharge for the San Miguel Project Area:

System of water supply	Name of Canal	Canal length	Irrig. control area	Total irrig. area	Percentage of area	Design discharge	Remarks
		m	ha	ha	%	m3/s	
Lateral A	VI	1,192.5	115.8	115.8	25.73	0.346	
	IV	970.9	238.6	238.6	53.02	0.713	
	III	1,569.1	340.0	340.0	75.56	1.015	
	II	286.9	450.0	450.0	100.0	1.344	
	I	200.0	450.0	450.0	100.0	1.344	
	Total	4,219.4	450.0	450.0	100.00	1.344	
Lateral A_1	III	420.22	16.0	16.0	3.56	0.048	
	II	798.0	30.0	30.0	6.67	0.090	
	I	762.0	110.0	110.0	24.44	0.329	
	Total	1,980.22	110.0	110.0	24.44	0.329	
Lateral B	II	1,100.0	15.0	15.0	3.33	0.045	
	I	483.22	55.0	55.0	12.22	0.165	
	Total	1,583.22	55.0	55.0	12.22	0.165	

c) Decision of canal sections

The planned canal sections of each lateral has been decided as in the following table, in consideration of the hydraulically most efficient section.

Details of design are referred to in the Appendix.

Tables of canal sections

The Alangalang Project Area

Name of canal	Section	Lining	Side slope	Bottom width	Depth of canal	Design discharge
Lateral A-I	Trapezoid	Concrete lining	1:1.5	0.65^m	1.50^m	2.730m^3/s
" II	"	Unlined	"	0.60	1.30	1.215
" III	"	"	"	0.55	1.00	0.635
" IV	"	"	1:1	0.55	0.95	0.435
" V	"	"	"	0.40	0.75	0.166
" VI	"	"	"	0.40	0.70	0.122
Lateral A_1-I	"	"	"	0.55	1.00	0.474
" II	"	"	"	0.45	0.90	0.318
Lateral B-I	"	Concrete lining	1:1.5	0.45	0.95	1.501
" B-II	"	Unlined	1:1	0.45	0.70	0.157

The San Miguel Project Area

Name of canal	Section	Lining	Side slope	Bottom width	Canal hight	Canal slope	Discharge
LA-I	rectangle	Concrete lining		1.50	1.00	1/900	1.344
LA-II	trapezoid	Unlined	1:1.5	0.60	1.45	1/1,300	1.344
LA-III	"	"	1:1.5	0.55	1.30	1/1,100	1.015
LA-IV	"	"	1:1.5	0.45	1.10	1/900	0.713
LA-V	"	"	1:1.0	0.45	0.90	1/600	0.346
LA_1-I	"	"	1:1.0	0.45	0.95	1/600	0.389
LA_1-II	"	"	1:1.0	0.30	0.65	1/450	0.090
LA_1-III	"	"	1:1.0	0.30	0.55	1/450	0.048
LB-I	"	"	1:1.0	0.30	0.75	1/400	0.165
LB-II	"	"	1:1.0	0.30	0.55	1/250	0.045

5. Related Structures of Canals

a) Principles and standards of design

i) Division works

Three division works are to be erected in the Alangalang area. Division Works No. 1 and No. 2 are of the Parshall Flume type for water measurement. The Parshall Flume is suitable for a wide variety of conditions. For division work No. 3, the turnout type with a constant head orifice has been adopted, because the distributed discharge of Lateral B-II is far smaller than the feeder chute for the Lukay Creek and there is a sufficient head between Lateral B-I and Lateral B-II. Two division works are to be erected in the San Miguel area. Both of them are of the overflow weir type for drop and measuring purposes.

ii) Drops

A number of drops should be provided in each lateral to disssipate hydraulic energy.

The maximum vertical drop in water surface is about 1.0 meter for a discharge of about 2.0 m^3/s, except where downstream structures are lined or paved. A check structure is usually attached to the vertical drop, to prevent draw down and scour upstream and downstream and to measure the discharge of the lateral.

The Francis formula is generally used for the discharge at the check weir.

The formula is as follows;

$$Q = 1.84 (b - 0.2d)d^{3/2}$$

where, Q: design discharge

b: length of weir

d: overflow depth

(approach velocity head is disregarded.)

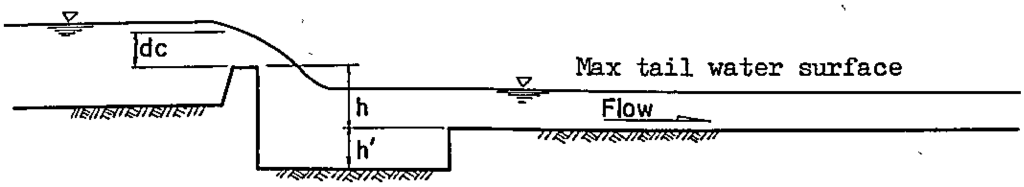
The following diagram shows the dimensions of the stilling pool. Its length should be designed with a margin of 0.15 meter over these dimensions.

The length of the stilling pool is obtained by the following formula.

$$L = \left[2.5 + 1.1\frac{dc}{h} + 0.7\left(\frac{dc}{h}\right)^3 \right] \sqrt{hd}$$

$$h' = \frac{dc}{2}$$

Stilling Pool Dimensions



iii) Waste Ways

Waste way channels are required to dispose of excess water in canals. They are needed in order to dispose of operational water or flood water that has entered the canal. Secondly, the waste way channel are necessary when the canals are emptied for maintenance. The general requirements for waste way canals are similar to those for irrigation channels, owing to various conditions.

Due to infrequent use of waste way channels in full capacity, the allowable velocity at full flow is usually greater than for an Irrigation channel of similar capacity. For these reasons, the allowable velocity, coefficient of roughness, and freeboard are decided as follows.

Allowable velocity for wasteway channel	V=0.80 m/s
Coefficient of roughness	n=0.025
Freeboard	F=0.15m

The overflow weirs and chutes are set on the top of banks.

The elevation of the crest is set equal to the normal water surface.

The wasteway is set at points where discharges differ. The length of the weir is determined by the difference of discharge between upstream and downstream. The overflow depth is assumed as 0.10 meter.

iv) Small Inverted Siphon

Two small inverted siphons are to be installed in the Alangalang area.

One is at the intersection of the Provincial Road with Lateral B-II, and the other at the point where Lateral A-V crosses the Barrio Road. They will be reinforced concrete pipes. The diameter of the pipe is determined by assuming that the velocity in the pipe is 1.5 times of the upstream velocity. One small inverted siphon is to be installed in the San Miguel area and is designed similarly to the siphons in the Alangalang area.

v) Turnouts

The turnouts on laterals are to be set at every point of intersection of laterals and the 1.0 meter contour line. But the turnout with a very small irrigation control area (less than 5.0 hectares) is joined to the nearest turnout. The diameter of the turnout pipe is decided for the standard velocity of 1.0 meter per second in the pipe. The water measurement structures and mechanical equipment are Constant Head Orifice, Openflow Meter, referred to as Sparlihg Meter, Parshall Flume and Weir. In this irrigation area, structure and equipment for the sole purpose of water measurement will not be provided from an economic point of view. But the discharge through the turnout can be estimated following the orifice formula by checking the scale of staff to be set up at the entrance of the orifice.

The Orifice formula is as follows:

$$Q = cA\sqrt{2gh}$$

where,

Q;	discharge of orifice turnout
H;	energy head at entrance
c;	coefficient of discharge
A;	water area

Valve of c=0.75 should be used for orifice.

b) List of Canal Structures

Name of canal	Canal Structures						
	Siphon	Flume	Division work	Drop	Culvert	Turnout	Wasteway
Link canal							
Main canal	1	1					1

Alangalang Area

Lateral A-I			1			1	
II			1	1	1	5	1
III				9	2	8	1
IV	1					3	1
V				3		8	1
VI				4		6	
Lateral AI-1				5	1	8	1
II				8	1	13	1
Lateral B-I	1		1				
II				7		7	1
Total	2	0	3	37	5	59	7

San Miguel Area

Name of canal	Canal Structures						
	Siphon	Flume	Division work	Drop	Culvert	Trunout	Wasteway
Lateral A-I							
II			1				1
III				2	2	10	1
IV				1		10	1
V				1	1	7	1
Lateral AI-I			1		1	4	1
II						3	1
III					1	3	1
Lateral B-I	1			1		5	1
II						1	1
Total	1	0	2	5	5	43	9

6. Feeder Raods and Access Roads

The feeder roads and the aceess roads are designed to be 3.5 meter wide, of which 2.5 meters are to be surfaced with graded gravel of 15 cm in thickness. Where the road surface is lower than the original ground level, side ditches are to be provided.

The list of Roads

Alangalang Area

Name of Road	Road length	Remarks
Feeder road	5,846.8 m	Main canal 1,141.0 m Lateral A 4,705.8 m
Access road I	890.0	
" II	1,243.0	
" III	1,295.0	
Total	9,274.8	

San Miguel Area

Name of Road	Road length	Remarks
Feeder road	4,219.4 m	
Access road I	780.0	
" II	983.0	
" III	1,744.25	
Total	7,726.65	

7. Bridges

Bridges are designed to 3.5 meters wide and constructed by timber. TL-6 loading is adopted, and the allowable stresses of timber are as follows:

Bending	90 kg/cm^2
Compression (cp ; i, ms)	70 "
Bearing	20 "
Horizontal shear	8 "

The List of Bridges

Name of Bridge	Name of Road	Number of Bridge	Span length	Width of Bridge	Remarks
Maintenance Bridge	Feeder Road	1	7.0 m	3.5 m	Alangalang
Farm Bridge	Access Road I	1	8.0	"	"
"	" II	2	"	"	"
"	" III	1	"	"	"
"	" II	1	4.0	"	San Miguel

(Note: TL-6 loading is the standard of the Japn Civil Engineering Institute, and is almost the same as the H-6 loading being used in U.S.B.R.)

C. COST ESTIMATES

Item	Unit	Quantity	Unit Price	Aggregate Price	Remarks
I. Civil Works				2,395,000	
1. Diversion Dam				655,900	
1-1 Dam No. 1				390,096	≑ 390,100
Excavation	cu.m.	3,545.09	12	42,541	
Fill and Bank	cu.m.	2,836.07	2	5,672	3,545.09x0.8
Borrow	cu.m.	7,698.86	3	23,097	
Class A Concrete	cu.m.	344.81	240	82,754	
6" Concrete	cu.m.	679.70	130	88,361	
Class B or 2" Conc.	cu.m.	8.48	105	890	
Class C Concrete	cu.m.	2.22	140	311	
Steel Sheet Piles	t.	76.50	1,000	76.500	
Steel Materials	t.	3.05	1,000	3,050	
Wooden Mattress	sq.m.	773.0	40	30,920	
Gates 1.6x4.0	unit	1		36,000	roller gate
" 1.0x2.0	unit	2			sluice gate
1-2 Dam No. 2				265,771	≑ 265,800
Excavation	cu.m.	3,327.46	12	39,930	
Fill and Bank	cu.m.	1,938.33	2	3,877	
Class A Concrete	cu.m.	449.58	240	107,899	
6" Concrete	cu.m.	220.20	130	28,626	
Class B or 2" Conc.	cu.m.	9.31	105	978	
Class C Concrete	cu.m.	2.24	140	314	
Steel Sheet Piles	t.	38.1	1,000	38,100	
Steel Materials	t.	3.111	1,000	3,111	
Wooden Mattress	sq.m.	173.40	40	6,936	
Gate 1.6x3.0	unit	1		36,000	roller gate
" 1.0x3.0	unit	2			sluice gate

(Con't)

Item	Unit	Quantity	Unit Price	Aggregate Price	Remarks
2. Irrigation Canal				1,217,400	
2-1 Link Canal				109,308	≑ 109,300
Excavation	cu.m.	1,478.78	2	2,958	
Fill and Bank	cu.m.	1,183.02	2	2,366	1,478.78x0.8
Borrow	cu.m.	2,168.94	3	6,507	
Class A Concrete	cu.m.	404.44	240	97,066	
Filter Drain	cu.m.	58.73	7	411	
2-2 Main Canal				253,959	≑ 254,000
Excavation	cu.m.	13,343.40	2	26,687	
Fill and Bank	cu.m.	5,862.18	2	11,724	
Class A Concrete	cu.m.	757.63	240	181,831	
Class C Concrete	cu.m.	215.46	140	30,164	
Filter Drain	cu.m.	71.06	7	497	
Gravel	cu.m.	436.50	7	3,056	
2-3 Check Gate				102,000	
Excavation	cu.m.	966.00	12	11,592	
Fill and Bank	cu.m.	662.00	2	1,324	
Class A Concrete	cu.m.	248.21	240	59,570	
6" Concrete	cu.m.	60.98	130	7,924	
Rubble Masonry	cu.m.	20.88	105	2,192	
Wooden Mattress	sq.m.	64.0	40	2,560	
Gates 3.0x1.8	unit	1			roller gate
" 2.0x1.0	unit	1		16,000	sluice gate
Steel Material	t.	0.508	1,000	508	
Filter Drain	cu.m.	3.93	7	28	
Joint Material etc.				302	

(Con't)

Item	Unit	Quantity	Unit Price	Aggregate Price	Remarks
2-4 Laterals and Canal Structure				752,100	
a. Alangalang				477,700	
(i) Lateral A				124,718	≑ 124,700
Excavation	cu.m.	5,528.52	2	11,057	
Fill and Bank	cu.m.	4,442.82	2	8,846	5,528.52x0.8
Borrow	cu.m.	25,173.44	3	75,520	
Class C Concrete	cu.m.	121.12	140	16,957	
Gravel	cu.m.	1,762.50	7	12,338	
(ii) Lateral A_1				19,770	≑ 19,800
Excavation	cu.m.	1,656.03	2	3,312	
Fill and Bank	cu.m.	1,324.82	2	2,650	1,656.03x0.8
Borrow	cu.m.	4,602.65	3	13,808	
(iii) Lateral B				33,050	≑ 33,100
Excavation	cu.m.	1,148.75	2	2,298	
Fill and Bank	cu.m.	919.00	2	1,838	1,148.75x0.8
Borrow	cu.m.	1,822.50	3	5,468	
Class C Concrete	cu.m.	167.47	140	23,446	
(iv) Siphon				34,493	≑ 34,500
Excavation	cu.m.	766.91	8	6,135	3 Places
Fill and Bank	cu.m.	464.41	2	929	
Class A Concrete	cu.m.	79.86	240	19,166	
Class B Concrete	cu.m.	3.99	105	4,190	
R.C Pipes ∅600	L.m.	24.29	40	972	
" ∅700	L.m.	15.00	54	810	
Wet Stone Masonry	sq.m.	26.87	70	1,881	
Screen	t.	0.41	1,000	410	

(Con't)

Item	Unit	Quantity	Unit Price	Aggregate Price	Remarks
(v) Division works				42,888	≑ 42,900
Class A Concrete	cu.m.	133.57	240	32,057	3 Places
Class B Concrete	cu.m.	0.14	105	15	
Gates 1.2x2.18	unit	2		5,000	
" 1.0x1.0	unit	2		3,600	
" 0.6x0.61	unit	1		1,000	
" 0.48x0.45	unit	1		900	
Riprap	sq.m.	78.99	4	316	
(vi) Drops				87,328	≑ 87,300
Class A Concrete	cu.m.	106.14	240	25,474	37 Places
Riprap	sq.m.	563.09	4	2,252	
Wet Stone Masonry	sq.m.	105.74	70	7,402	
Gates 1.7x1.8	unit	1	3,000	3,000	
" 1.3x06	unit	14	1,500	21,000	
" 1.1x0.55	unit	8	1,400	11,200	
" 0.9x0.35	unit	10	1,300	13,000	
" 0.7x0.35	unit	4	1,000	4,000	
(vii) Flume				6,398	≑ 6,400
Class A Concrete	cu.m.	26.66	240	6,398	
(viii) Waste Way				12,207	≑ 12,200
Class A Concrete	cu.m.	34.88	240	8,371	
Bank	cu.m.	901.65	2	1,803	
Wet Stone Masonry	sq.m.	290.40	70	2,033	
(ix) Turnout				64,444	≑ 64,000
Class A Concrete	cu.m.	91.87	240	22,049	59 Places
R. C. Pipes ϕ150	L.m.	63.20	6	379	
ϕ200	L.m.	57.90	7	405	
ϕ250	L.m.	26.30	9	237	

(Con't)

Item	Unit	Quantity	Unit Price	Aggregate Price	Remarks
R.C. Pipes ∅350	L.m.	5.30	14	74	
Gates	unit	59	700	41,300	
(x) Culvert				52,801	≑ 52,800
Class A Concrete	cu.m.	5.12	240	1,229	
Riprap	sq.m.	122.87	4	492	
R.C. Pipes ∅700	L.m.	80.0	54	4,320	
∅800	L.m.	80.0	70	5,600	
∅900	L.m.	240.0	90	21,600	
∅1,200	L.m.	120.0	163	19,560	
b. San Miguel				274,400	
(i) Lateral A				117,000	
Excavation	cu.m.	10,941.80	2	21,884	
Fill and Bank	cu.m.	8,753.4	2	17,507	10,941.8x0.8
Borrow	cu.m.	10,710.5	3	32,132	
Class A Concrete	cu.m.	137.49	240	32,998	
Filter Drain	cu.m.	33.47	7	234	
Gravel	cu.m.	1,582.28	7	11,076	
Weep hole, Joint Material etc.				1,169	
(ii) Lateral A_1				13,732	≑ 13,700
Excavation	cu.m.	632.0	2	1,264	
Fill and Bank	cu.m.	505.6	2	1,011	632.0x0.8
Borrow	cu.m.	3,818.98	3	11,457	

(Con't)

Items	Unit	Quantity	Unit Price	Aggregate Price	Remarks
(iii) Lateral B				9,902	≑ 9,900
Excavation	cu.m.	184.16	2	368	
Fill and Bank	cu.m.	147.33	2	295	184.16x0.8
Borrow	cu.m.	3,079.57	3	9,239	
(iv) Division works				19,300	2 Places
Class A Concrete	cu.m.	54.73	240	13,135	
Riprap	cu.m.	1.76	12	21	
Gates 2.0x0.85	unit	1		2,000	
1.0x0.55	untt	1		1,300	
1.0x0.6	unit	2	1,350	2,700	
Joint Material etc.				144	
(v) Siphon				7,800	1 Place
Excavation	cu.m.	289.04	8	2,312	
Fill and Bank	cu.m.	220.84	2	442	
Class A Concrete	cu.m.	13.34	240	3,202	
6" Concrete	cu.m.	8.07	130	1,049	
R.C. Pipe ∅450	L.m.	20.0	20	400	
Steel Ladder and Screen	t.	0.38	1,000	380	
Gumring etc.				15	
(vi) Drop (5 places)				19,754	≑ 19,800
Class A Concrete	cu.m.	52.28	240	12,547	
Riprap	cu.m.	36.98	12	443	
Gates 1.0x0.7	unit	2	2,200	4,400	
0.9x0.55	unit	1		1,300	
0.75x0.4	unit	1		1,000	
Timber	cu.m.	0.64	100	64	

(Con't)

Items	Unit	Quantity	Unit Price	Aggregate Price	Remarks
(vii) Waste Way (9 places)				40,677	≑ 40,700
Excavation	cu.m.	1,417.67	2	2,835	
Fill and Bank	cu.m.	380.41	2	761	
Borrow	cu.m.	346.36	3	1,039	
Wet Stone Masonry	sq.m.	513.97	70	36,042	
(viii) Turnout (43 places)				36,464	≑ 36,500
Class A Concrete	cu.m.	42.02	240	10,085	
R. C. Pipes ϕ150	L.m.	48.0	6	288	
ϕ200	L.m.	52.0	7	364	
ϕ250	L.m.	81.0	9	729	
ϕ350	L.m.	7.0	14	98	
Gates ϕ200	unit	28	500	14,000	
ϕ250	unit	14	700	9,800	
ϕ350	unit	1	1,100	1,100	
(ix) Culvert				9,717	≑ 9,700
Wet Stone Masonry	sq.m.	75.48	70	5,284	
Riprap	cu.m.	33.90	12	407	
R.C. Pipes ϕ900	L.m.	24.0	90	2,160	
ϕ800	L.m.	7.0	70	490	
ϕ700	L.m.	24.0	54	1,296	
ϕ400	L.m.	5.0	16	80	
3. Drainage Canal				14,033	≑ 14,000
Excavation	cu.m.	3,478.0	2	6,956	
Bank	cu.m.	1,728.0	2	3,456	
Drop (2 places)				3,621	
Class A Concrete	cu.m.	13.86	240	(3,326)	
Riprap	cu.m.	16.38	12	(197)	
Steel Material	t.	0.098	1,000	(98)	

(Con't)

Items	Unit	Quantity	Unit Price	Aggregate Price	Remarks
4. Right-of-Way and Damages				200,000	
5. Supervision		(1-4)x5%		103,000	
6. Contingencies		(1-4)x10%		205,000	
Total of Civil Works				2,395,000	≑ 2,395,000
II. Access Roads				46,300	≑ 46,000
a. Alangalang				19,984	≑ 20,000
(RI, RII, RIII)					
Excavation	cu.m.	1,685.30	2	3,371	
Fill and Bank	cu.m.	1,348.24	2	2,696	1,685.3x0.8
Borrow	cu.m.	337.06	3	1,011	
Gravel	cu.m.	1,285.51	7	8,999	
Bridge				3,907	
Timber	cu.m.	32.03	100	(3,203)	
Wooden Piles					
∅300x5.0m	unit	24	21	(504)	
∅250x3.0m	unit	8	25	(200)	
b. San Miguel				19,062	≑ 19,100
(RI, RII, RIII)					
Excavation	cu.m.	1,720.40	2	3,441	
Fill and Bank	cu.m.	1,149.1	2	2,298	
Borrow	cu.m.	578.8	3	1,736	
Gravel	cu.m.	1,315.22	7	9,207	
Culvert				1,639	
Wet Stone Masonry	sq.m.	14.42	70	(1,009)	
R.C. Pipe ∅1,000	L.m.	7.0	90	(630)	
Bridge				741	
Timber	cu.m.	5.51	100	(551)	

(Con't)

Items	Unit	Quantity	Unit Price	Aggregate Price	Remarks
Steel Material	t.	0.14	1,000	(140)	
Nail etc.				(50)	
c. Right-of-Way				5,000	
d. Supervision	5% of a,b,c			2,200	
III. Operation Maintenance and Extension Service Facilities				51,000	
1. Office Building and Garage	sq.m.	200.0	150	30,000	
2. Jeep, Motorcycles	unit	1 Jeep 3 motorcycles		11,000	
3. Gate Keeper's Quarter	sq.m.	30.0	100	3,000	
4. Office Equipment				5,000	
5. Water Supply System				2,000	
Total of I, II, III.				2,492,000	
IV. Landleveling, Diking and Farm Ditches					To be done by land-owners
1. Leveling & Diking	ha.	604.0		302,000	
2. Farm Dttches	ha.	482.0		25,000	
Total	ha.	1,086		327,000	
Total of I, II, III, IV				2,819,000	

D. Plan of Construction Work

1. Preparatory Work

A transportation road for the construction of the dams is to be laid first from the National Highway to Dam No. 1 by way of Dam No. 2. The road goes through the plain corn field between the National Highway and Dam No. 2.

The transportation road, from Dam No. 1 to Dam No. 2, runs along the Old Mainit River for about one hundred meters upstream.

In order to cross the Old Mainit River, a timber bridge is to be built. After crossing the river, the transportation road passes through the coconut fields and leads to Dam No. 1.

In the Alangalang-San Miguel area, there are many feeder roads available as transportation roads.

Warehouses, office buildings and other necessary facilities are to be erected near the damsites. After finishing Dam No. 1, Dam No. 2, Link Canal and Main Canal, these facilities are to be transfered to the Alangalang - San Miguel area.

2. Care of River and Cofferdam

Two cofferdam stages for the diversion of the Mainit River are to be used for the construction of Dam No. 1.

The first cofferdam is to be constructed to close half of the river on the left side. Within the first cofferdam, a sluice way, intake and some parts of the Fixed Weir are to be built. When the first coffer dam is constructed, it is necessary to excavate the existing center stream, in order to let the flood pass through.

Then the second cofferdam is to be built on the right side.

During the second cofferdam stage, the sluice way and some parts of the weir completed already, are to be used for letting the flood pass through.

The work on Dam No. 2 is to proceed in the same manner.

These cofferdams, shown as earth dikes in the drawing, are to be embanked by bulldozer or other machines.

3. Excavation

Excavation within the cofferdam is to be done by using a bulldozer or other machines in dry work.

The bulldozer, ditcher and other machines are to be used for excavation of the link canals, main canal and laterals.

4. Materials

Sand is obtained downstream of Dam No.1.

Coarse aggregate and stones for riprap can be collected at the damsite. Small hills scattered in the project area can be used as borrow pits.

E. CONSTRUCTION SCHEDULE

Work Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Preparation	—																							
Dam No. 1	—	—	—	—	—	—	—	—	—															
Dam No. 2										—	—	—	—	—										
Link Canal					—	—	—																	
Main Canal								—	—	—	—	—												
Check Gate											—	—	—	—	—									
Lateral													—	—	—	—	—	—	—	—				
Structure																	—	—	—	—				
Drainage Canal																					—	—	—	—
Access Road											—	—	—	—								—	—	—

F. SPECIFICATIONS

Specifications is contained in appendix

III. Operation and Maintenance of the System

Operation and Maintenance of the System

In this project, full consideration has been given to the securing of such volume of irrigation water as is required for double crop cultivation of paddy rice and to the installation of division works that will enable the smooth distribtuion of water to each farm.

In order to operate these facilities effectively, the State should directly control the main facilities and assign technical experts experienced in the operation and maintenance of such facilities to various posts. The control of water in the farms, a water users association should be organized by the beneficiary farmers for public control of water.

A. Operation and Maintenance Facilities

1. Operation office

For the convenience of the operation and maintenance of the irrigation facilities, the operation office is set-up at Bo, Aliconob, located in the center of the project area. In this office, an office for extension service (guidance of farm management) to be rendered by the State is attached.

2. Gate Keeper's Quarters

For the operation of Dam No. 1 and Dam No.2, gate keeper's quarters are set up at the site of Dam No. 1.

B. Operation and Maintenance Personnel

The Sate should assign the following personnel for the operation and maintenance of facilities.

One (1)	Watermaster
Two (2)	gate keepers
Five (5)	ditchtenders (one ditchtender covers 200 ha.)

C. Operation and Maintenance Expenses

The annual amount of expenses necessary for the operation and maintenance of the irrigation system total ₱ 24,664.00 (Twenty Four Thousand Six Hundred Sixty Four Pesos), which means ₱ 24.66 (Twenty Hundred Sixty Six Centavos) per hectare, (see the table below).

D. Operation and Maintenance Organization

The maintenance and operation of the irrigation system are performed by the local agency of the Government according to the system of N.I.A. For the effective distribution of water to each farm, a water users association should be organized with all beneficiary farmers as members, and the officials of this association should exercise control of water. As to the method of administering the water users association and the guidance and eduction of farmers in impartial distribution of water, a Japanese technical expert will give guidance in concrete terms at the pilot farm to be established together with the extension service (farm management).

Estimate of Operation and Maintenance Expenses for San Miguel-Alangalang Project (total net irrigable are of 1,068 hectares).

Item	Unit	Quantity	Unit Price ₱	Aggrigate Price ₱
Personnel Expenses				
Watermaster	Person	1		2,544
Gatekeeper	Persons	2	2,160	4,320
Ditchtender	persons	5	2,160	10,800
Sub Total				17,664
Goods and Supplies Expenses				5,000
Sundries				2,000
Total				24,664
Average Operation and Maintenance Cost per hectare				24.66

Note: Irrigation Facilities

Two (2) Diversion Dams

One (1) Main Canal

Six (6) Laterals

IV. Extension Service

(Guidance of Farm Management)

Extension Service (Guidance of Farm Management)

It is the thorough popularization of advanced technique of rice cultivation and farm management among the beneficiaries that is needed, together with the installation of irrigation facilities, for the realization of increased output of rice. The State must set up an office for farm management in the field and station competent technical experts to carry out the guidance and popularization of rice cultivation and farm management technique.

In putting into practice, full consideration should be given to the selection of species, determination of farming period, method of cultivation of species, determination of farming period, method of cultivation (fertilizer application, insect and pest control, farm work), and the securing of farming funds required in connection with the foregoing matters, and also the storage and sales of the products.

In order to carry them out effectively, it becomes necessary to organize the farmers.

The facilities and technical personnels required for extension service are as follows:

Office for extension service (farm management), attached to the Operation office of irrigation facilities.

Personnel for farm management guidance.

One (1)	Project director
One (1)	rice specialist
One (1)	credit and cooperative specialist
One (1)	extension specialist
One (1)	irrigation specialist

To carry out effectively the guidance of farm management, it is necessary to study sufficiently the traditional techniques and farmers' consciousness in the project area. From this point of view, it is necessary that to establish a pilot farm in the neighbourhood of the project area and preliminary farm management guidance is carried out before the start of the full extension service. The Government of Japan is making preparations to give assistance in the establishment of a pilot farm.

Estimated Annual Cost of Extension Service (Guidance of farm management)

Item	Unit	Quantity	Amount ₱
Personnel Cost	Person	1	4,404
Rive Specialist	Person	1	3,792
Credit and Cooperative Specialist	Person	1	3,792
Extension Specialist	Person	1	3,792
Irrigation Specialist	Person	1	3,792
Sub Total			19,572
Miscellaneous			5,000
Total			24,572

V. Economic Analysis

Economic Analysis

The economic efficiency of this project, computed by the ratio between the direct benefits obtained from the project and the direct expenses required for the project, is as follows:

		₱
A.	Estimated Initial Investment	
	1. Civil Works	2,395.000
	2. Access Roads	46,000
	3. Operation, Maintenance, and Extension Service Facilities	51,000
	Total	2,492,000
	4. Land Leveling, Diking, Farm Ditches	
	(Paid by Landowners)	
	Land leveling, Diking	302,000
	Farm Ditches	25,000
	Total	327,000
B.	Annual Cost	
	1. Maintenance and Operation of Irrigation System	24,664
	2. Farm Management Guidance	24,572
	3. Amortization of Investment 50 years, at 7% 2,492,000 x 0.07246 a/	180,570
	Total	229,806
C.	Annual Costs paid by Landowners	
	1. Maintenance and Operation of Farm Ditches (1.086 ha. x 10.00₱/ha)	10,860
	2. Redemption of Cost of Land leveling, Diking, Farm Ditches (327,000 x 0.09123) b/	29,832
	Total	40,692

D. Effects of Project

1. Present Output

		₱
	a. Gross income	474,548
	b. Production cost	329,088
	c. Net profit	145,460

2. Post-Project Output

	a. Gross income	2,953,920
	b. Production cost	1,924,044
	c. Net profit	1,029,876

3. Annual Increase of Net Profit due to Project

   (1,029,876 - 145,460) 884,416

4. Reduced Gain on account of Lag

   (by short-cut method)

   5 years, at 7%
   (884,416 x 0.71275) c/ 630,368

5. Net Profit after deducting Annual Cost

   (630,368 - 40,692) 589,676

E. Cost-Benefit Ratio

1.	Annual Net Profit	589,676
2.	Annual Cost	229,806
3.	Cost-Benefit Ratio	2.57

Note :

a/ $i = 0.07,\quad n = 50 \qquad \dfrac{i\,(1+i)^n}{(1+i)^{n-1}} = 0.07246$

b/ $i = 0.09,\quad n = 50 \qquad \dfrac{i\,(1+i)^n}{(1+i)^{n-1}} = 0.09123$

c/ $i = 0.07,\quad n = 5 \qquad \dfrac{1}{(1+i)^n} = 0.71275$

VI. Repayment Plan

Repayment Plan

The repayment plan, according to the terms of repayment of the fund for main facilities, namely, as annual interest of 7% and the repayment period of 25 years, and the terms of repayment of the fund for small ditches, landleveling, and diking, namely, an annual interest of 7%, and the repayment period of 10 years, is as follows.

A. Amount of Annual Repayment of Investment

1. Costs of Main Facilities

a. Amount of Investment

	₱
Civil works	2,340,000
Access roads	101,000
Operation, maintenances and extension service facilities	51,000
Total	2,492,000

b. Amount of Annual Repayment

Interest (i) 7%

Repayment period (n) 25 years

Rate of annual repayment $\frac{i\ (Hi)^n}{(H\ i)^{n-1}}$ = 0.08581

Amount of annual repayment (2,492,000 x 0.08581)	213,040
per ha.	196

2. Costs of Ditches, Landleveling, Diking

a. Amount of Investment	327,000

b. Amount of Annual Amortization

Interest (i) 9%

Repayment period (n) 10 years

Rate of annual repayment $\frac{i\ (1+i)^n}{(1+i)^{n-1}}$ = 0.15582

Amount of annual repayment (327,000 x 0.15582)	50,950
per ha.	47

3. Total Amount of Annual Repayment	263,990
per ha.	243

B. Possible Amount of Repayment

(Increased net profit or landowners)

1. Increased net profit due to project (see appendix)	884,416
2. Deducted Necessary Costs	
Costs of Operation and Maintenance of Irrigation Facilities	24,664
Costs of Operation and Maintenance of Ditches	10,860
Total	35,524
3. Balance of Annual Net Profit	848,892
per ha.	782

C. Examination of Possibility of Repayment

Ratio of Amount of Repayment to Net Profit

$$\frac{\text{Necessary amount of repayment}}{\text{Possible amount of repayment}} = \frac{263,990}{848,892} = 0.31$$

Notes:

1) In this computation, the time lag from the commencement of construction to the appearance of effects is not considered.

2) Personnel expenses for guidance of farm management is considered as Government expenses and are not included in the necessary expenses.

VII. Rice Processing Center

Rice Processing Center

(1) The location of the center

During the rainy season, collection of freshly harvested palay is not an easy matter, and the palay collected must be dried up quickly, otherwise it will suffer lossand damage. Therefore the location must convenient for collecting palay must be selected for the center. Moreover, this project area covers two manicipalities, namely San Figuel and Alangalang. Therefore, there is additional necessity to select a site convenient to both municipalities, so that the farmers of either municipality may have no complaint. For the above reasons, an intermediate point between these two municipalities, that is, the point where the Cavite-San Miguel Road branches off to Borseth seems appropriate. At this point, there is already a small old rice mill, but it is getting antiquated, and the new center may replace it.

The advantages of this location are described in detail below.

1. Convenience of the location
   a. From the procurement point of view, it is conveniently situated between the two municipalities.
   b. It is a convenient place for collection from the surrounding areas, while it has easy access to neighboring towns and the port city of Tacloban, since the Cavite-San Miguel Road is paved road and connected to the first class highway.
2. Soil characteristics — No boring as yet
3. Flood hazards — Since there is a rice mill, it may be assumed that there is no danger of flood in the rainy season, but is not certain as yet.
4. Existing facilities
   a. In and around the area, there are rice-cleaning machines of the small size Cono or Kiskisan type, but they all have a

small capacity.

b. In nearby Jaro and Palo, there are warehouses belonging to FACOMA with capacities of 500 cavs and 1,000 cavs respectively, and in Alangalang there is a warehouse with a capacity of 15,000 cavs. The last named is hardly being used at present. There was a suggestion that it may be put to use, but the room for its extension was found lacking as a result of investigation.
Moreover, from the view point of geographical conditions, the establishment of new facilities was considered advisable. There are warehouses in the neighborhood as stated above, but a considerable shortage of warehouse space is anticipated, if future increases of production is taken into account. Likewise, in the case of rice-cleaning facilities, a shortage was feld in this area, not to mention the economic antiquation of the existing facilities.

(Note) According to the "Survey of Warehouses by Committee composed by PNB, DBP, ACA and RCA as of July 1967", the shortage of warehouses in Leyte Province is as follows:

(in thousand sacks of 56 kg of cleaned rice)

Total required capacity of warehouse	775.0
Existing capacity of warehouses	353.4
Additional capacity required	421.6

(2) Standards of planning

According to the irrigation plan for this area, the planned area for rice cultivation is 1080 ha, and it is expected that the per hectare yield in the near future will be 3.5 tons of the 1st crop and 4 tons of the 2nd crop.

Therefore, the expected total annual production of palay is as follows:

1st crop	85,910 cavs	(3,780 tons)
2nd crop	98,180 cavs	(4,320 tons)
Total	184,090 cavs	(8,100 tons)

Based on the total annual production, the non-marketable quantities of palay have been calculated according to the following items:

1. Family consumption

   350 families x 5 persons x 5 cavs = 8,750 cavs/year

2. Seeds

   4 cavs x 1,080 ha = 4,320 cavs/year

3. Feeds

   8,750 cavs (total family consumption) x 0.06 = 525 cavs/year

4. Field losses

   184,090 cavs (total annual production) x 0.02 = 3,682 cavs/year

5. Payment in kind to part-time workers, etc.

   184,090 cavs (total annual production) x 0.10 = 18,409 cavs/year

Total 35,686 cavs/year

(Notes) Item-1. The number of families is the present actual number in the area. The present number of members per family is 4.5, but according to FAO reports, the population has been increasing 3.2% per year in this country, so it was assumed that it would increase to 5 in the near future. The average consumption of palay per capita is now 4.6 cavs per year, but it was assumed that with the increase of production, it would increase to 5 cavs per year.

Item-2. Generally, one cavan of palay is used as seeds per hectare, therefore 2 cavs are the minimum requirement for two crop cultivation. Considering the loss due to selection of good seeds and natural calamities, twice as much as the minimum requirement is to be reserved.

Item 3 to 5. These percentages follow the "Disposition of Palay Output in the Philippine, 1954/55 to 1964/65."

According to investigations made by RCA and other Government organs, 300 grains of palay per square meter are left on the paddy fields after harvesting and this quantity is equivalent to 6% of the harvest. Therefore the estimate of loss of 2% loss in the field is not considered an overestimate. The figure of 10% as payment in kind to part-time workers may seem too small in Layte. In this district, quite a number of seasonal migratory laborers are employed in addition to the labor force of the village and engaged in ear-picking harvesting.

The difference between the total annual production and the non-marketable quantity is the total expected storable volume, that is:

184,090 - 35,686 = 148,404 cavs

And the percentage of the salable volume as against the output is:

148,404   184,090 = 80.6%

Since the highest peak road harvest occurs volume of sales becomes larger during the 2nd crop season (98,180 cavs), the quantity of this season should be taken as a standard of planning. It is:

Storable volume = 98,180 x 0.806 = 79,133 cavs

A. Rice cleaning plan

According to investigations in the rice producing district of Central Luzon, the pattern of disposal of unhulled rice is as follows:

1) Sold in cleaned form 63%
2) Sold as palay 37%
3) Cleaning period . . . . 3 to 6 months

It is anticipated that when the increase of production has been attained as expected the project area, unhulled rice will be disposed of according to the pattern of Luzon.

1) Assuming the minimum cleaning period as three months, the maximum volume of rice cleaned in one season is,

79,133 x 0.63 = 49,770 cavs

Therefore, a cleaning capacity of 16,590 cavs per month and 553 cavs per day is required.

2) Assuming the maximum cleaning period as six months, the total per season volume of 49,770 cavs requires a cleaning capacity of 8,295 cavs per month, or 276 cavs per day.

Judging from the above-mentioned volume to be disposed of over a period of three to six months, a rice cleaning machine with a capacity of 300 cavs/ R hr, will suffice. The machine may be operated 12 hours per day for a 6 months' operation, requirement for 3 months running and 24 hours per day even if the period of operation is shortened to 3 months.

B. Drying plan

In this area, special consideration should be given to what method of drying is the most economical and rational to keep the loss of unhulled rice at a minimum and obtain a higher percentage of perfect grains after cleaning at a minimum cost, because the farmers bring in unhulled rice immediately after thrashing and it contains a high percentage of water. As a standard of planning, the harvest of the rainy season which is most difficult of drying, namely the storable volume of the 1st crop, was taken. It is 85.910 x 0.806 = 69.243 cavs.

(Note) According to the ten-years record (1957-1966) of the Tacloban meteorological station, November and December have the greatest amount of rainfall throughout the year, registering 12.6% and 12.3% respectively as against the average annual precipitation (10 year average: 2.014 mm). The duration of the harvesting season extends over 90 days. Harvesting is done by ear picking method, which requires a larger employed labor force. The duration of the rice planting season is also long. It is expected that the method of harvesting will be improved in future, and the period of turning in hulled rice has been assumed as 70 days. On this assumption, the daily tun in will be 69,243 ÷ 70 = 989 cavs. If the capacity of the dryers were to conform to the above daily volume, many dryers will be needed, the amount of investment will increase, and the days of operation of dryers, namely their utility, will decrease. Therefore, the use of holding bins should be considered. It will reduce the number of dryers required and will increase their utility.

By the combined use of holding bins and dryers, the volume of turn in at the peak time load will be reduced to half, and the volume to be processed immediately by the dryers will be 494 cavs/day, or approximately 1/2 of the above 989 cavs.

The advantages of this method are as follows;

1) Higher dryer utility factor
2) Lower dryer investment cost
3) Lower operation cost
4) Increased percentage of cleaned rice by minimizing cracking of grains
5) Higher flexibility in absorbing big overloads (wet crop harvest at any time)
6) Separate treatment of different varieties made easy.

However, if the moisture content of incoming unhulled rice is very large, dryer programming and bin scheduling should be suitably coordinated, taking into account of the possible deterioration of quality during storage and troubles during drying.

Assuming the day volume of drying at 494 cavs as above-mentioned, the number of dryers required is:

2 units with 150 cavs/12 hours capacity each.

or 1 unit with 300 cavs/12 hours capacity.

If either set is fully operated 24 hours, the volume of drying per day will be 600 cavs. In practice, however, the continuous 24 hour operation is not possible. Therefore, there should be a repetition of 24 hour operation and 8 hour break, with a cycle of 4 days. This method will make possible the drying of 1,800 cavs per cycle, that is 450 cavs per day. This volume is smaller than the required daily volume of 494 cavs by 44 cavs, but a deficit of this quantity does not warrant another dryer, and it can be taken care of by holding bins.

C. Storage requirement

There are three types or methods of grain storage which are in common practice.

1) Bag or pile storage
2) Bulk storage
3) Combined bag and bulk storage

For this project eenter, we have recommended the combined bag and bulk storage method. Several advantages by way of savings on container, low operating cost and minimal grain losses or spoilage can be realized aside from other advantages in connection with drying.

Based on the above-mentioned sales ratio of 63:37 between cleaned rice and palay, the ratio between bulk storage and bag storage as 60:40.

By this ratio, the total storage capacity requirement for the peak season (2nd crop) is as follows:

Capacity for bulk storage . . . . . . 47,400 cavs

Capacity for bag storage . . . . . . 31,600 cavs

1) Space requirement for bulk storage

Required bulk storage capacity 47,400 cavs (2,085,600 kg.)

The weight of one cubic metre of palay is about 364 kg.

If it is piled to a height of 5.5 meters.

Space required = $\frac{\text{Volume}}{\text{Height}} = \frac{2,085,600}{364} \times \frac{1}{5.5} = 1,041.7 = 1,042\ m^2$

If the depth of a bin is 6 metres, the total width of bins is $\frac{1,042}{6} = 173.6$ meters. If these bins are arranged, in a row on either side of the warehouse, the length of one row is $\frac{173.6}{2} =$ 86.8 = 87 meters.

2) Space requirement for bag storage

Bag storage capacity required ..... 31,600 cavs

Bag storage volume = Floor space x 7.0m(height) x 8(number of bags piled in a cubic meter) x 0.8(excluding 20% for passage)

Therefore, Floor space = $\frac{3,600}{7 \times 8 \times 0.8}$ = 705 square meters

If we assume the width of piling is 12 meters, the length required is

$$L = \frac{705}{12} = 58.7 = 59 \text{ meters}$$

3) Space requirement for rice cleaning machine and dryer.

140 square meters.

4) Space requirement for office and testing laboratory.

80 square meters.

This has been designed to be housed in the warehouse itself.

5) Space requirement for aisles and passages.

6,564 square meters

Therefore, the total required space is:

Bag storage	705 m
Bulk storage	1,046
Rice cleaning machines and dryerw	140
Office	80
Aisles and passages	656.4
Engine room	25
Total	2,652.4 m

According to the above space requirements, the building dimensions are 87 m x 30.2 m, to which 25 square meters for the engine room should be added. Therefore the total space becomes 2,652.4 square meters.

6) Space required for storage bins

For the efficient aeration of grains in bulk storage, we have fixed the allowable grain depth to about 17 feet or 5.18 meters. Assuming that the bin dimensions are 6 m (length), 6 m (width) and 5.5 m (height), the effective bin volume is 6x6x5.5 = 198 cubic meters. Bulk storage volume divided by the bin volume is the number of bins, that is

$$\frac{2,085,600}{364} \times \frac{1}{198} = \frac{5,729}{198} = 28.9 \text{ say } 28 \text{ bins}$$

These bins are placed in a row of 14 on either side of the warehouse.

D. Auxiliary machinery and tools

In the design of this rice processing center, several machinery and tools are provided as required. Their use will not only enable the effective quality control, but greatly increase the efficiency of the plant. Some of such equipment of importance are listed below, with explanations of their functions.

1) Aeration system ..... For the effective ventilation of the storage bin, with its four sides made of strong planks and with its lower part having two sheets of mesh wire nets, a portable blower and motor assembly will be provided and control humidity.

This equipment can also be utilized to eliminate pests by fumigant.

2) Cleaner ..... Unhulled rice will be first put into this machine to have foreign substance and unripe grains removed for greater efficiency of drying and easier cleaning process.

3) Automatic weigher ..... By weighing unhulled rice after precleaning and after drying, the amount of foreign substance removed and the amount stored can be accurately recorded.

4) Platform scale ..... It is needed for weighing each bag of unhulled rice received or about to be sold, or of cleaned rice.

5) Mobile pneumatic conveyer ..... It is needed for loading and unloading of grains and their transfer from bins to driers, and will considerably save labor.

6) Hygrometers and moisture meters ..... They are needed for ganging the humidity in the bins and the amount of moisture content of the stored grains.

7) Power plant ..... The project area is not supplied with electricity (Alangalang is serviced only at night). Therefore this center will be equipped with a power plant to operate machinery and to light up as required.

(3) Cost estimation and specifications

The management of this rice processing center will be entrusted to a non-governmental body. Accordingly, machinery and tools of domestic make will be used as much as possible to reduce the cost of equipment.

The cost estimation and specifications worked out are as follows;

Items	Specification	No. of units	Unit cost	Total cost
Warehouse building and office	Steel flawing warehouse Floor motor jointing Roof and wall galvanized steel plate.	1	177,000	177,000
Rice cleaning machine	Cono type machine 300 cavs/12 hr 70 hp Diesel engine	1	109,000	109,000
Dryer	Flat bed-batch type 150 cavs/12 hr including blower, motor, burner and control	2	18,000	36,000

Items	Specification	No. of unit	Unit cost	Total cost
Storage bins	Fabricated type made of wood, side walls are common to neighbouring bins. Width and depth 6m, height bin proper 5.5m, base 0.6m, bottom of bin proper has two sheets of mesh wire	28	-	143,500
Wooden pallet for bag storage	Each pallet made of 4 timbers 3"x3"x3'2" 3 planks 6'x12"x1"	319	36.61	11,700
Aeration system	3.5H.P., 3,400 CFM at 4" SWP	14	600	8,400
Cleaner	3.5 t/hr	1	11,000	11,000
Automatic weigher	0.55 t/cyc	1	11,000	11,000
Platform scale	1t 0.5t	2 2	1,000 700	2,000 1,400
Pneumatic conveyor	Portable type	1	10,000	10,000
Hygrometer	Probe type	14	100	1,400
Moisture meter	Resistance, capacitic or inductive type	2	1,300	2,600
Power plant and lighting	2x32 KW generators and necessary electric equipment, power house 10m x 13m x 4m (height)	1	-	100,760
Total				625,760

(Note) Other necessary machinery, tools and equipment, such as trucks, threshers, sewing machines, cement-block enclosures to treat chaffs, etc. are to be considered after the estimation of profitability and the study of marketing.

Data for the cost estimation and specifications.

1) Warehouse including office

a. Effective storage volume of warehouse

30.2m x 87m x 7m x (8 x 0.8) cavs = 117,707 cavs
(148% of storage volume required)

b. Unit cost per cavan = 1.34 (based on cost of construction of standard warehouse) cost = 117,707 x 1.34 = 157,727 plus 25% for installed cost of steel framing open-web outside Manila.

37,950 x 0.25 = 9,500

c. Engine room 25 m^2 per m^2 cost is ₱ 50 total cost ₱ 1,250

d. Therefore cost is 157,727 + 9,500 + 1,250 = 168,477 add 5% for contingency is ₱ 8,423

e. Total cost

168,477 + 8,423 = 176,900 177,000

2) Materials for a storage bin and its cost

a. Joists

volume $0.65m^3$ = 0.65 x 35.31 = 22.95 23 ft^3

B. F. = 23 x 12 = 276

cost per B.F. of yacal wood is 0.95

cost = 276 x 0.95 = 262

b. Flooring

volume $0.37m^3$ = 0.37 x 35.31 = 13.1 ft^3

B. F. = 13.1 x 12 = 157

cost per B.F. of apitong wood is 0.40

cost = 157 x 0.40 = 62.8 = 63

c. Plywood

53 pieces, cost of water proof plywood is 15

cost = 53 x 15 = 795

d. Posts

volume of posts including braces
6.02 m^3 = 6.02 x 35.31 = 212.6 ft^3

B. F. = 212.6 x 12 = 2,551

cost per B.F. of yacal rough is 0.93

cost = 2,551 x 0.93 = 2,372

e. Total cost per bin excluding mesh wire.

262 + 63 + 795 + 2,372 = 3,492

f. Bins

cost per wall = $\frac{3,492}{5}$ = 698

total number of walls = 84 + 30 = 114

total cost of bins excluding mesh wire = 698x114 = 79,572

g. Mesh wire

total floor area for bins is 1,008 m = 1,008x10,764 = 10,850 ft

cost of bronze mesh wire per feet of 1/16" x 3' is 3.20

cost = $\frac{10,850}{3}$ x 3.2 = 11,600

cost of ordinary mesh wire per ft of 1/2" x 1/2" x 3' is 1.50

cost = $\frac{10,850}{3}$ x 1.50 = 5,420

total cost is 11,600 + 5,420 = 17,020

h. Bolts and nails

estimated 16% of lumber costs

79,572 x 0.16 = 12,732

i. Labor charges

estimated 25% of total material costs

(79,572 + 17,020 + 12,732) x 0.25 = 27,331

j. Total cost for storage bins

lumber	79,572	
mesh wire	17,020	
bolts of nails	12,732	
labor charges	27,331	
Total	136,655	
5% contingency	6,832	
Grand Total	143,487	143,500

3) Aeration system

a. air rate 2.50 CFM/cav for moisture content of 18% to 12%

b. volume per bin, 1,480 cavs

c. allowable grain depth, 16'

d. static pressure requirement, 4"

e. horse power requirement = $Q \left(\frac{p + 0.25}{4,700} \right)$

$Q = 1,480 \times 2.5 = 3,700$ CFM, $p = 4"$

$H.P = 3,700 \times \frac{4 + 0.25}{4,700} = 3.34$ say 3.5

f. fan specification 3,700 CFM

static pressure 4 SWP

electric motor 3.5 H.P

cost per fan assembly = 600

number of unit = 14

total cost of aeration system = 600 x 14 = 8,400

4) Wooden pallets

each pallet made of 4 timbers (3" x 3" x 3'2") and 3 planks (6' x 12" x 1")

volume of 4 timbers = 0.75 ft = 9 B.F, unit cost = 0.93

cost = 9 x 0.93 = 8.37

volume of 3 planks = 6 x 3 = 18 B.F, unit cost = 0.95

cost = 18 x 0.95 = 17.10

total cost of lumber = 8.37 + 17.10 = 25.47

nails 15% of lumber cost = 3.82

total material cost = 25.47 + 3.82 = 29.29

labor charges, 25% of total material cost = 7.32

total cost per pallet = 36.61

number of pallets = 319

Therefore total cost of pallets = 36.61 x 319 = 11,678 = 11,700

5) Power plant

a. Lighting

floor area of warehouse 30 x 88 = 2,640m^2

2,640 x 10,764 = 28,416 ft^2

light bulb 500 watt = 24' x 24' = 576 ft = 580 ft^2

number of light bulb = $\frac{28,416}{580}$ = 48.9 = 50

total K.W = $\frac{500 \times 50}{1,000}$ = 25 K. W

H.P. = 25 x 1/ 0.746 = 33.5 H.P.

b. Dryer

total H.P. requirement / unit = 3/4 H.P.

total H.P. for dryer, 3/4 x 2 = 1.5 H.P.

c. Cleaner 2 H.P.

d. Aeration system

14 units, 3.5 H.P. per unit

total H.P. = 14 x 3.5 = 49 H.P.

Therefore, total H.P. is 86 H.P.

total K.W. is 86 x 0.746 = 64 K.W.

e. Generating cost

two units of 32 K.W. capacity necessary

cost of 1.5 K.W. is 2,000

cost of one unit = 2,000/1.5 x 3.2 = 42,600

cost of two units = 42,600 x 2 = 85,200

assuming 5% for electric equipment and maintenance

85,200 x 0.05 = 4,260

total cost is 85,200 + 4,260 = 89,460

f. Power plant house

dimension 10 m x 13 m = 130 m^2

cost per square meter, 50

cost for house = 130 x 50 = 6,500

g. Total power plant cost

89,460 + 6,500 = 95,960

plus 5% contingency, 4,798 = 4,800

total cost = 95,960 + 4,800 = 100,760

Economic background on the rice processing and storage center

Agriculture is characterized by large and irregular seasonal fluctuations in production, whereas the consumption of farm products is relatively uniform This situation makes it necessary to spread the seasonally concentrated outputs over a longer period of time.

One of the most important problems in the marketing of grains is the fact that the individual the farmers do not have the ability to store their produce effectively, and it prevents them from regulating the marketing of their produce and getting profits from high prices. Marketing is indeed the ultimate means of adjusting supply and demand.

In the case of the marketing of rice, an effective and appropriate method of storage, namely, the warehouse, should be worked out in order. to ensure proper returns for the producers and to leave a fair marketing margin for the dealers. In the light of the foregoing, the economy of the storage of unhulled rice will be considered.

A few economic advantages of a modern bulk storage method and a processing plant will be listed below.

1. The cost of bags or containers, which is basically a fixed cost, can be reduced;
2. Loss in terms of quality, arising from deterioration of rice, crushing and cracking of grains, can be prevented;
3. Efficiency and the plant operational rate are high;
4. Quality control is assured by the use of fumigants, regulation of humidity, and drying process.

However, in order to improve the storage facilities and processing method which are already realizing the above-mentioned advantages, an increase of investment is required. Aside from this, investment risk must be weighed against the returns to be derived. From various considerations, it follows that an economic judgment should be made, by assessing profitability and comparing it with the rate of profit of substitute plans. In making this judgment, advantages derived from the economy of operational expenses and the decrease of material losses, aside from other cost factors, should be kept in consideration.

Recommendation

The section on profitability and marketing, which is indispensable to the planning of facilities as above-mentioned, had to be curtailed, owing to the fact that the period of preparation needed for a full study of profitability in connection with the rice processing and storage center was extremely limited. It is, therefore, respectfully recommended that studies be continued on this section, that the team for such studies be composed of the respective counterparts of the two countries, and that an ample time be allowed for such studies.

APPENDIX

I. Bill of Quantities

A. Alangalang Area

BILL OF DIVERSION DAM'S QUANTITIES

	DAM NO. 1	DAM NO. 2	TOTAL
Class A concrete	344.81	449.58	794.39
Class B6 concrete	679.70	220.20	899.90
Class B2 concrete	8.48	9.31	17.79
Class C concrete	2.22	2.24	4.46
Form	1,747.38	1,869.61	3,616.99
Water stop	28.95	28.93	57.88
Elastic filler	17.78	15.30	33.08
Sheet pile	255	127	382
Reinforcement	24,301.94	30,793.63	55,095.57
Steel	3,050.06	3,110.58	6,160.64
Wooden mattress	773.00	173.40	946.40
Gates	1.6^{m}x4.0^{m}Roller Gate 1.0 x2.0 Sluice Gate	1.6^{m}x 3.0^{m}Roller Gate 1.0 x 3.0 Sluice Gate	
Excavation	3,545.09	3,327.46	6,882.55
Embankment	10,534.93	1,938.33	12,473.26
Others			

BILL OF CANAL'S QUANTITIES

Name of canal	Class A concrete	Class C concrete	Excavation	Embankment	Form	Reinforcement	Sand and gravel	Gravels
Link canal	404.44		1,478.78	3,351.96	3,099.93	13,661.97	58.73	
Main canal	757.63	215.46	13,343.40	5,862.18	6,854.78	10,552.68	71.06	436.50
Lateral A		121.12	5,528.52	29,596.26	742.45			1,762.50
Lateral A1			1,656.03	5,927.47				
Lateral B		167.47	1,148.75	2,741.50	1,546.23			
Total	1,162.07	504.05	23,151.48	47,479.37	12,243.39	24,214.65	129.99	2,199.00

BILL OF SIPHON'S QUANTITIES

		Main siphon	Small siphon No. 1	Small siphon No. 2	Total
Class "A" concrete		40.91	19.72	19.23	79.86m³
Form		196.41	108.92	95.13	400.46m²
Class"B" concrete		3.99			3.99m³
Rubber water stop B=150		24.20			24.20m
Reinforced concrete pipe	600			24.29	24.29m
	700		15.00		15.00m
Grouted rip rap			17.15	9.72	26.87m²
Trash rack		211.26	112.84	83.78	407.88kg
Excavation		272.28	241.30	253.33	766.91
Embankment		257.56	206.88	252.56	464.44
Reinf.	∅ 9	521.04			521.04
	∅ 13	810.23	916.20	853.45	2,579.88
	∅ 16	833.75			833.75
Total		2,165.02	916.20	853.45	3,934.67kg

BILL OF DIVISION WORK'S QUANTITIES

		Division work No.1	Division work No.2	Division work No.3	Total
Class "A" concrete		64.35	48.22	21.00	133.57
Class "B" concrete		0.09	0.05		0.14
Form		335.55	253.49	156.36	745.40
Water stop		15.87			15.87
Elastic filler		3.01			3.01
Rip rap		15.86	30.93	32.20	78.99
Reinf.	9	569.09	342.10	344.92	1,256.11
	13	2,865.99	1,723.29	473.97	5,063.25
	16			49.14	49.14
	19			543.41	543.41
	(Dawel bar) 9	30.60			30.60
Total		3,465.68	2,065.39	1,411.44	6,942.51

BILL OF DROP'S QUANTITIES

Type	Name	Drop	Concrete	Form	Reinforcement	Rip rap	Grouted rip rap	Plank	Gate
A	Lateral A - II	1,000	6.73	39.41	442.94	32.05		0.41	1.70 x 0.80 1 set
B	A - III	1,000	13.62	89.94	876.96	61.14		0.96	1.30 x 0.60 3 set
C	A - III	750	19.95	130.55	1,315.60	101.90		1.60	1.30 x 0.60 5 set
D	A - III	500	3.67	22.36	242.23	20.38		0.32	1.30 x 0.60 1 set
E	A - V	1,000	2.88	33.15	137.85	25.50	26.01	0.42	0.90 x 0.35 3 set
F	A - VI	800	3.36	38.44	176.40	30.92	25.36	0.52	0.70 x 0.35 4 set
G	A - I	1,000	17.20	120.84	1,119.72	73.92		1.28	1.30 x 0.60 4 set
H	A - I	500	3.46	21.67	226.93	18.48		0.32	1.30 x 0.60 1 set
I	A - II	1,000	23.28	170.94	1,487.64	100.08		1.68	1.10 x 0.55 6 set
J	A - II	500	6.26	42.02	406.34	33.36		0.56	1.10 x 0.55 2 set
K	B - II	1,000	3.84	43.52	172.96	42.44	34.48	0.60	0.90 x 0.35 4 set
L	B - II	500	1.89	21.84	88.98	22.92	19.89	0.36	0.90 x 0.35 3 set
	Total		106.14	774.68	6,694.55	563.09	105.74	9.03	Wooden gate 1.70 x 0.30 1 set 0.90 x 0.35 10 set 1.30 x 0.60 14 set 0.70 x 0.35 4 set 1.10 x 0.55 8 set

BILL OF FLUME'S QUANTITIES

	Flume	Open canal	Transition	Total
Class A concrete	10.03	12.45	4.18	26.66
Form	81.04	66.51	46.74	194.29
Reinforcement				1,232.45

BILL OF WASTEWAY'S QUANTITIES

	Class "A" concrete	Form	Reinforcement	Embankment	Grouted rip rap
Main wasteway	34.88m3	206.86m2	1,960.12kg		
Lateral wasteway No.1				46.55m3	74.32m2
" No.2				136.00	80.68
" No.3				216.00	24.58
" No.4				135.00	16.92
" No.5				122.40	38.75
" No.6				119.70	34.80
" No.7				126.00	20.35
Total	34.88m3	206.86m2	1,960.12kg	901.65m3	290.40m2

BILL OF TURNOUT'S QUANTITIES

Class A concrete		91.87
Reinforcement		4,003.91
Form		983.89
R.C. pipe	∅150	63.20
	∅200	57.90
	∅250	26.30
	∅350	5.30

BILL OF ACCESS ROAD'S QUANTITIES

	Road I	Road II	Road III	Total
Excavation	517.7	968.8	198.8	1,685.30
Embankment	712.0	2,939.9	2,630.2	6,582.1
Gravels	333.75	466.13	485.63	1,285.51

BILL OF BRIDGE'S QUANTITIES

	Maintenance bridge	Farm bridge	Total
Timber	12.12	12.89	25.01
Timber pile	18	14	32
Wooden board	5.38	1.64	7.02
Bolt	182	150	332

BILL OF CULVERT'S QUANTITIES

	Class A concrete	Form	Area of rip rap	Length of R.C. pipe			
				700	800	900	1,200
No. 1	1.47	15.03	33.18				12.0
No. 2	0.97	9.94	26.04			12.0	
No. 3	0.97	9.94	26.04			12.0	
No. 4	1.00	10.16	21.04		8.0		
No. 5	0.71	7.14	16.57	8.0			
Total	5.12	52.21	122.87	8.0	8.0	24.0	12.0

B. San Miguel Area

Bill of Quantity (San Miguel Area)

A. Irrigation Canal

1. Check Gate and Laterals (Except canal structures)

Items	Unit	Check Gate	Laterals		
			A	A1	B
Excavation	cu.m.	966.0	10,941.8	632.0	184.16
Bank	cu.m.	137.0	19,463.9	4,324.58	3,226.9
Fill	cu.m.	525.0			
Class A Concrete	cu.m.	248.21	137.49		
6" Concrete	cu.m.	60.98			
Rubble Masonry	cu.m.	20.88			
Form	sq.m.	702.78	914.19		
Reinforcement	kg.	8,495.22	3,840.15		
Wooden Mattress					
log	cu.m.	31.62			
Bolt	kg.	106.52			
Boulder	cu.m.	31.10			
Waterstop					
B = 150	m.	35.20			
B = 200	m.	13.90			
Pipe for handrail	kg.	167.10			
Steel ladder	kg.	36.01			
Elastic Filler t = 10	sq.m.	4.40	0.57		
Mastic Filler	cu.m.		0.01		
Drain	cu.m.	3.93	33.47		
Roller Gate 3.0 x 1.8	unit	1			
Sluice Gate 2.0 x 1.0	unit	1			
Weep hole	unit		146		

2. Division works and drops

Items	Unit	Division Works		Drops				Lateral
		No.1	No.2	No.1	No.2	No.3	No.4	A
Class A Concrete	cu.m.	38.58	16.15	15.53	15.53	13.45	7.77	
Form	sq.m.	249.37	124.04	69.14	69.14	50.40	35.45	
Reinforcement	kg.	2,064.39	604.54	643.85	643.85	592.62	412.81	
Water Stop B=150	m.	14.34						
Elastic Filler t=10	sq.m.	2.99						
Gate 2.0 x 0.8	unit	1						
1.0 x 0.55	unit	1						
1.0 x 0.6	unit		2					
1.0 x 0.7	unit			1	1			
0.9 x 0.55	unit					1		
0.75 x 0.4							1	
Riprap	cu.m.	1.76		8.2	8.2	7.35	5.48	7.75
Timber	cu.m.							0.64

3. Siphon, culverts and turnouts

Items	Unit	Siphon	Culverts					Turnouts
			Lateral A			Lateral A_1		
			I.P.5	No. 1 +686.9	I.P.12	N.O.0 +433.1	No. 1 +653.1	
Excavation	cu.m.	289.40						
Bank	cu.m.	21.39						
Fill	cu.m.	199.45						
Class A Concrete	cu.m.	13.34						
Class 6" Concrete	cu.m.	8.07						
Form	sq.m.	148.82						
Reinforcement	kg.	1,740.71						
Steel Material for Screen	kg.	336.78						
Steel Ladder	kg.	43.17						
Wet Stone Masonry	sq.m.		15.46	15.32	19.35	16.0	9.35	
Riprap	cu.m.		8.55	8.55	6.53	6.56	3.71	
R.C. Pipes ϕ150	L.m.							48.0
ϕ200	L.m.							52.0
ϕ250	L.m.							81.0
ϕ350								7.0
ϕ400	L.m.						5.0	
ϕ450	L.m.	20.0						
ϕ700	L.m.		12.0	12.0				
ϕ800	L.m.					7.0		
ϕ900	L.m.				9.0			
Gates ϕ200	unit							28
ϕ250	unit							14
ϕ350	unit							1

4. Wasteways

Items	Unit	Lateral A				Lateral A			Lateral B	
		N.O.1	N.O.2	N.O.3	N.O.4	N.O.1	N.O.2	N.O.3	N.O.1	N.O.2
Excavation	cu.m.		229.04	541.88		77.06	302.25	10.89		256.55
Bank	cu.m.		1.4			116.34	169.28	355.07		84.68
Wet Stone Masonry	sq.m.		87.54	101.10	107.07	28.62	16.94	13.89		12.96

B. Draingage Canal

Items	Unit	Drainage canal	Drop	
			N.O.1	N.O.2
Excavation	cu.m.	3,478.0		
Bank	cu.m.	1,728.0		
Class A Concrete	cu.m.		6.93	6.93
Form	sq.m.		62.92	62.92
Reinforcement	kg.		598.68	598.68
Riprap	cu.m.		8.19	8.19
Steel Material	kg.		49.2	49.2

C. Access Roads

Items	unit	Roads			Culvert	Budge
		I	II	III		
Excavation	cu.m.	469.6	614.1	636.7		
Bank	cu.m.	568.7	264.0	895.2		
Wet Stone Masonry	sq.m.				14.42	
Timber	cu.m.					5.51
Steel Material	kg.					139.92
R.C.Pipe ∅ 1,000	L.m.				7.0	

II. Specifications

A. General Specifications

Section 1 - Clearing, Grubbing and Powering

1. The entire right-of-way shall be cleared of all trees, stumps, brush, roots, vegetation, logs, rubbish and all other objectionable matter except the trees which the Engineer may order to be preserved. Such materials shall be burned or removed from the site of work or otherwise disposed of in a manner approved by the Engineer. All necessary precautions shall be taken in protecting the public and preventing damage to a third person.

2. No clearing will be done on any area where standing crop is present until such crop shall have been harvested, or unless the Contractor shall have secured a written permission from the Engineer to clear the area in question, preparatory to construction.

3. The ground surface under all embankments shall be grubbed and cleared of all organic materials, provided that where embankments shall sustain a water pressure head of 30 centimeters or more and/or for road foundation, the ground surface constituting the foundation of said embankments shall be plowed at least 15 centimeters deep, in addition to the grubbing and clearing above specified.

4. In case of disposing of any grasses or weeds by burning, the proper method of fire protection should be provided and shall be done with the permission of the Engineer.

5. After the date of completion of clearing and grubbing work, the work shall be inspected by the Engineer. Otherwise, the Contractor shall not be allowed to start next step of work.

Section 2 - Channel Excavation

1. Excavation shall be performed to the lines, grades, and dimensions shown on the plans or as established by the Engineer. The grades and sections shown, however, are subject to change before or during the progress of the work to vary the slopes and dimensions as shown on the plans. Changes of such character will not entitle the Contractor to additional compensation. The excavation shall be finished in a workmanlike manner to the prescribed lines, grades and dimensions as shown on the Plans or as prescribed by the Engineer. A maximum tolerance of ten centimeters for over excavation may be allowed. The Contractor shall repair all over excavation beyond the tolerable distance to the line and grade as shown in the Plans and to the satisfaction of the Engineer. The Contractor shall not be entitled to extra compensation for this repair.

2. Unexpected poor soil, embedded material, or embedded wood shall be removed.

3. When there is danger of spring water at the location of excavation and of collapse on the slope, the Contractor shall deal them by the indication of the Engineer.
   If the Contractor treats such conditions on his own judgement, he shall bear all cost due to failure.

4. All excavated materials moved from "Channel Excavation" which are suitable as filling materials as determined by the Engineer will be used for canal embankment, dikes, or as backfill for structures. All excess materials, or materials not suitable for filling purposes shall be deposited in waste areas designated by the Engineer.

Section 3 - Embankment

1. The canal embankments and dikes shall be constructed to the lines, grades and dimensions shown in the plans or as established by the Engineer, on properly prepared foundations approved by the Engineer. No brush, roots, sod, or other perishable or unsuitable materials, as determined by the Engineer, shall be placed in embankments.

2. Embankments may be filled by mechanical excavating and hauling equipment, by manual equipment, or by suitable machinery capable of performing both excavation and filling jobs.
   Embankments which are subject to a pressure head of less than 30 centimeters and filled by mechanical excavating and hauling equipment shall be done in horizontal layers, and the travel of the equipment over the embankment during construction operations shall be directed so as to distribute the compacting effect of its wheels to the best advantage. Embankments built by excavating machinery depositing the materials directly from the excavation shall be spread in horizontal layers having a thickness of approximately the depth of the materials as excavated by excavating machine. The deposited materials shall then be tamped to give it a reasonable degree of compaction. The finished embankment shall be given an allowance for shrinkage which shall be determined by the Engineer.
   When extra material is required, the Contractor shall put the foot of slope at the designated location, and shall carry top of embankment accordingly.

3. Embankments that will sustain a water pressure head of 30 centimeters or more, and/or to be used as road embankment, built by excavating and hauling equipment shall be spread in successive

horizontal layers not exceeding 20 centimeters in thickness after compaction and shall be kept as level as practicable.
Each layer shall be spread for the full width of the cross section and shall be compacted.
The moisture content of the material at the start of compaction shall be at or near the optimum moisture, as determined by the standard laboratory compaction test on soils (ASTM Designation: D698-42T). Embankment material which does not contain sufficient moisture for compaction in accordance with the above requirement shall be sprinkled with water as directed by the Engineer. Embankment material containing excess moisture shall be permitted to dry to the proper consistency before being compacted. After a layer has been spread for the full width of the cross section and brought to a satisfactory moisture content, it shall be compacted. The degree of compaction in each layer shall be determined by the standard field density test.
Each layer should attain the required percentage of compaction before the succeeding layer is allowed to be placed. The compaction requirements for different types of soil placed in embankments are as shown in the following tables.

Standard Compaction of Maximum Density obtained by AASHO method I-99-38 (lbs. per cu. ft.)	Maximum Compaction required percent of Maximum Density	
	for Roads	except Roads
90 - 99	100 %	80 %
100 - 109.9	95 %	80 %
110 - 119.9	95 %	80 %
120 - 129.9	90 %	80 %
130 and above	90 %	80 %

Section 4 - Borrow

1. Borrow pits shall be cleared and grubbed or stripped as directed to remove all unsuitable materials. Borrow pits shall be excavated to regular lines as staked and to a depth as directed by the Engineer. Borrow pits where practicable shall be excavated so that they will drain to the nearest natural outlet or to such outlet as directed by the Engineer.

2. If materials are taken from borrow pits adjacent to the canal embankment, or dikes, a berm of not less than five (5) meters shall be left between the outside toe of the embankment and the edge of the borrow pit, with the provisions for a side slope not steeper than 3:1 unless otherwise shown on the Plans or as directed by the Engineer.

   The surface of borrow pits shall be left in a reasonably smooth and even conditions, satisfactory to the Engineer.

Embankment made by manual tools shall be deposited loose, and spread in layers not exceeding 15 centimeters and sprinkled with water if necessary to obtain the desired moisture content and then hand tamped to produce the required degree of compaction equal to that produced by any method as specified above. Embankment will be built to the height designated by the Engineer to allow for settlement, and materials shall be deposited in embankments so that cobbles, gravel and boulders will be evenly mixed with other materials, and not nested in any position within or under the embankment.

4. Where canal embankment and dike are to be constructed across low, swampy ground or where the top soil is not satisfactory for foundation as determined by the Engineer, stripping of top soil of the foundation area will be ordered before construction of the embankment.

   Stripping and disposal of the stripped material is subsidiary work and will not be measured for payment. Provided, however, that when stripping to a depth beyond twenty (20) centimeters from the natural ground surface is ordered by the Engineer, the stripped materials below the twenty (20) centimeters free stripping depth will be paid for as "Channel Excavation".

5. If there is spring water or ground water in the site, the Contractor shall perform suitable drainage work at the instruction of the Engineer.

6. When making a new fill on the existing road, the Contractor shall place the fill after plowing the surface and then compact it carefully.

Section 5 - Structure Excavation

1. The foundation shall be excavated according to the outline of the footings, floors, bed of gravel blanket, filter drains, ripraps, and grouted riprap as shown on the Plans or as directed by the Engineer, and shall be of sufficient size to permit free movement of laborers.

2. On common excavation, the foundation bed upon which concrete, gravel blanket, filter drains, riprap, and grouted riprap are to be placed shall be finished accurately to the established lines and grades after a thorough compaction and trimming of the foundation with suitable tools and equipment.
   If at any point in common excavation, material is excavated beyond the lines and grades of any part of the structures, the over excavation shall be filled with the selected materials approved by the Engineer and shall be placed in layers of not more than 20 centimeters thick, moistened and thoroughly compacted by special rollers, mechanical tampers or by other approved methods.
   The cost of filling over excavation not ordered by the Engineer shall be for the account of the Contractor.

3. Diversion and care of the stream during construction.
   The Contractor shall construct and maintain all necessary cofferdams, channels, flumes and other temporary diversion and protection works during construction operation. He shall furnish all materials necessary therefor; and shall furnish, install, maintain, and operate all necessary pumping equipment needed for dewatering the various parts of the work as required in the construction.
   After having served their purpose all cofferdams or other protective works shall be removed from the stream channel and/or leveled

as prescribed by the Engineer, so that no interference whatsoever will result in the operation of the structure constructed or to the material flow of the stream. The Contractor shall be responsible for, and shall repair at his expense, any damage to the foundations or any other part of the work caused by floods, or failure of any part of the diversion and protection works.

4. If materials removed from "Structure Excavation" and/or "Channel Excavation" are used by the Contractor for the construction of cofferdams and other temporary protective works and are washed out and carried away by floods, or rendered unsuitable for "Structure Backfill" or "Embankment" by virtue of such use by the Contractor, these materials shall be replaced by the Contractor on his own account.

5. The cost of furnishing all labor, equipment, supplies, and materials for constructing cofferdams, channels, flumes, and other temporary diversion of the streams and protective works; and the cost of maintaining the work free from the action of water at all times as required, together with the removal of materials in the cofferdams, and of all other works shall be included in the unit price bid in the schedule for "Structure Excavation".

6. Foundation - All structures, where practicable, shall be constructed in open excavation and where necessary, the excavation shall be shored, braced or protected by cofferdams in accordance with approved methods.

7. All foundation shall be excavated to such depths as may be necessary to secure solid bearing for the structure. Whenever the safe bearing power of the soil as uncovered is less than that called for on the Plans, pilings, or appropriate spread footings will be used. The elevations of the bottoms of footings, as shown

on the Plans shall be considered as approximate, and the Administrator may order, in writing, such changes in dimensions and elevations of footings as may be necessary to secure a satisfactory foundation. Bearing tests, upon written order of the Engineer, shall be taken to determine the supporting power of the soil.

Cost of bearing test will be paid as "Extra Work".

8. In any case, after completion of the excavation which will be used as support for a structure at bottom foundation, and the other necessary items, the Contractor shall get the inspection of the Engineer, and shall not start the preceeding work before the approval.

Section 6 - Structure Backfill

1. All spaces to be filled shall be cleared of all rubbish and other objectionable matter.
   The excavation pit to be backfilled shall be dewatered. All mud and loose materials shall be removed before backfilling. The filling material with the proper moisture content determined by the Engineer shall be deposited loose in layers not exceeding 30 centimeters and then thoroughly compacted by ramming, rolling or by means of mechanical tampers, to obtain as compact a mass as possible.
   The time of commencement of the filling operation will be determined by the Engineer.

2. The refilling soil shall be compacted in thin layers separately until its density is more or less equivalent to the material ground and shall then be finished using proper moisture content.

3. During refilling and compaction, the Contractor shall take care not to apply lateral pressure to structures using a method of the work prescribed by the Engineer.

Section 7 - Selected Borrow

1. Subgrade

The subgrade shall be prepared in accordance with the applicable provisions of Section 2 and Section 3 of this Specification. Prior to placing the Selected Borrow, the previously constructed subgrade shall be cleared of all foreign substance. The surface shall be inspected by the Engineer for adequate compaction and surface tolerance. Ruts or soft, yielding spots that may appear in the subgrade, areas having inadequate compaction, and deviations of the surface from the requirements set forth in the Specification shall be finished in accordance with the provisions of Sec. 2 and Sec. 3.

2. Selected Borrow

Borrow pits shall be cleared and grubbed, where necessary, within the limits staked by the Engineer. Unsatisfactory overburden shall be stripped and disposed of as directed by the Engineer. The boundary of the borrow pit will be designated by the Engineer and the Contractor shall not excavate below the depth given, except with the consent of the Engineer. The depth of excavation throughout the area shall be uniform as practicable, and the side slopes shall be shaped to such slope as the Engineer may direct.

3. The materials shall be placed in position as indicated on the Plans or as directed by the Engineer, in accordance with the provisions of Section 3, "Embankment".

Section 8 - Base Course for Roadway
(Gravel Base Course)

1. Subgrade

The subgrade shall be prepared in accordance with the applicable provisions of Section 7 of this Specification prior to constructing the Gravel Base Course.

Out and fill of roadbed and ground is subject to each provision of the following:

(1) Working site shall be drained completely of rainwater and spring water and shall be protected from softening of roadbed soil by water.

(2) Spring water shall be drained out from the roadbed below the freezing line. If high water is probable at the raining season or melting snow period, report shall be submitted to the Engineer and he will specify procedure.

(3) When the kinds of soil of existing roadbed are humus, soft clay and other harmful soil, suitable treatments shall be resorted to at the Engineer's instruction.

(4) In case of executing subgrade work on the existing road ballast directly, the surface irregularity of road surface shall be corrected with unscreened gravel or material specified.

After shoulder, side ditch and other part to be burried are broken up and cleaned, it shall be burried with material specified and shall be compacted.

(5) Underground buried objects which are threatened with damage by compaction and additional fill shall be protected in accordance with the instruction of the Engineer previously.

2. Base Course

All Base Course material shall be placed on the prepared subgrade and compacted in layers. The depositing and spreading of the materials on the prepared subgrade, or on a preceeding completed layer, not to exceed 15 centimeters in thickness, shall commence at the point farthest from the point of loading, unless otherwise directed and shall progress continuously without breaks. The materials shall be deposited and spread in a uniform layer and without segregation of size, to such a loose depth that when compacted the layer shall have the required thickness.
Spreading shall be from spreader boxes or from moving vehicles, or be placed in windrow followed by spreading to required depth and width by means of blade grader.
When more than one layer is required, the construction procedure described below shall apply similarly to each layer. After the base course material has been spread, it shall be bladed to a smooth surface conforming to the cross section shown on the Plans. A grader weighing not less than 7 tons and having a blade of at least 2 meters in length, and a wheel base of not less than 2.0 meters shall be used for the blading.

3. Additional filler material for blending shall be spread in uniform layer over the loosely spread base course layer, in the amount set by the Engineer, and shall then be blended thoroughly into the layer by blade mixing.
The entire layer shall be bladed alternately to the center and back to the edges of the road until the mixture is uniform. When uniform, the mixture shall again be spread smoothly to the cross section shown on the Plans.
Additions of filler shall be such that the blend of added and original material placed shall meet grading and quality

requirements in all respects.

4. Rolling shall be done with rubber-tired rollers. The rollers shall have a minimum of four roller wheels with pneumatic tires. Tire pressure shall be maintained between 5.5 kilograms per square centimeters and 7 kilograms per square centimeters for maximum wheel load. The roller wheel shall be arranged in one line with a maximum center to center spacing of 82 centimeters, and the roller so designated that all wheels will carry approximately equal load when travelling over uneven ground. The roller shall be towed with a suitable type of tractor at a speed of three to eight kilometers per hour.

5. Immediately following the final spreading and smoothing, the rolling shall start longitudinally at the sides and proceed toward the center, overlapping on successive trips for at least one half of the width of the roller unit, until satisfactorily compacted. The rollers, unless otherwise directed, shall operate at a speed between 3 and 5 kilometers per hour.

6. The material shall be sprinkled with water during the blending, blading, rolling and tamping when ordered by the Engineer. The amount of water to be added at each application shall be set by the Engineer.

7. Filler shall be applied gradually to the surface and swept or otherwise worked in as rolling progresses until the entire course is a dense, compacted mass, true to grade and cross section as shown on the Plans.

8. Gravel Base Course shall be maintained by blading and rolling alternately as required or directed to insure the surface true to grade and cross section as whown on the Plans until final inspection and acceptance.

1. Classification and Proportioning of Concrete Mixture.

Concrete shall be proportioned to secure the strength and durability required for the part of the structure in which it is to be used. The following class or size of concrete are recognized in these specification:

Class or size of Max. Dia. of Aggregate	Minimum Compressive Strength at 28 days	Designated size of Aggregate
Class "C" or 3/4"	3,000	3/4" to No.4
Class "A" or 1-1/2"	3,000	1-1/2" to No.4
6"	2,000	6" to No.4

The concrete of the various classes or sizes given in the above table shall be designed so as to secure concrete having not less than the strength specified.

2. Proportions Based on a Constant Cement Factor

Subject to the adjustments provided for hereinafter, the weights of the fine and coarse aggregates per bag (94 pounds) of cement, the maximum size of coarse aggregate and the consistency for each class of concrete shall be as follows:

Class or size of Concrete	Minimum Cement bags/cm	Amount of Saturated Surface dry aggregate /bag(94 lbs)of cement		Max. Net Water Content per bag of Cement Kilos	Consistency in Slump Vibrated Inches
		Fine Kilos	Coarse Kilos		
"C" 3/4"	9.2	86	113	27.8	1-3
"A" 1-1/2"	8.5	77	145	27.8	1-3
6"	5.2	105	300	25.0	1-2

The weights of the fine and coarse aggregates given in the above table should be used only if the Contractor design mixture (with prior approval of the administrator) is not available.

The proportion by weight given in the table above are based on the maintenance of an approximately constant quantity of cement or aggregate having bulk specific gravities in saturated surface-dry condition of 2.65 plus or minus 0.05 for sand and gravel. For other specific gravities, the weights shall be corrected by multiplying the weights shown in the table by the ratio of the specific gravities of the aggregates used and those used in computing the table. The bulk specific gravity tests shall be made in accordance with Methods of Sampling and Testing of ASTM Designation; C-128 and C-127 respectively. Since the weights given in the table are computed for aggregates in a saturated dry-surface condition, the batch weights shall be corrected to conform with the moisture condition of the aggregates delivered to the measuring bin. Absorption test shall be made in accordance with Methods of Sampling and Testing ASTM Designation: C-128 and C-127 respectively.

3. Sampling of Fresh Concrete

The Engineer will take a reasonable number of strength test on the concrete to be made during the progress of the work. No less than four (4) standard cylinder specimens shall be made for each test. At least one set of samples shall be taken for each seventy-five (75) cubic meters of each class of concrete or fraction therefor, or for every pouring placed each day in one structure. Fresh concrete shall be taken in accordance with ASTM Designation C-31.

4. Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such consistency that it will flow around reinforcing steel, but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand.

The consistency shall be gauged by the ability of the equipment to properly place it and not by the difficulty in mixing or transporting. The slump as required should not be exceeded without the consent of the Engineer. Concrete as dry as it is practical to place with equipment specified shall be used.

5. Measurement of materials

Materials shall be measured by weighing, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose.

Each size of aggregate and cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within one percent of the desired amount. Cement in standard bag (94 lbs) needed not be weighed, but bulk cement shall be weighed. The mixing water shall be measured by volume or by weight. The water measuring device shall be susceptible to control and accurate to plus or minus 1/2 percent of the capacity of the tank. All measuring devices shall be subject to approval by the Engineer.

Measurement by wheelbarrow will not be permitted.

When sack or bag cement is used the quantities of aggregates for each batch shall be exactly sufficient for one or more full sack of cement and no batch requiring fractioned sack of cement will be permitted.

6. Storage of materials

Cement shall be stored, immediately upon arrival at the site of work, in substantial, weather proof bodega, with a floor raised from the ground sufficiently high to be free from dampness.

Aggregate shall be divided into classes, stored and transported and shall not be placed directly on the ground. In case of transporting with mechanical method, to prevent earth mixing, aggregate may be placed on the ground after approval by the Engineer.

For keeping the water content of fine aggregate uniform, storage area shall be divided into classes or provided with suitable drainage.

Fine aggregate shall be spread out by bulldozer for drying.

Finer particles of coarse aggregate shall not be allowed to segregate while in storing or transporting. For making the water content of coarse aggregate uniform, the coarse aggregate in storage shall be provided with suitable drainage.

Aggregate shall be provided with installations to avoid direct exposing to the sun as far as possible.

In case of storing reinforcement, the materials shall not be stored directly on the ground and shall be stored in the warehouse or covered with suitable means.

7. Mixing Concrete - General

Concrete shall be machine mixed at site.

Hand mixing shall be allowed only in case of emergency when there is machine breakage, and in the construction of small canal structures whose total volume of concrete is small. A written authority of the Engineer must be secured by the Contractor in both instances.

Mixing at Site - Concrete shall be thoroughly mixed in batch mixer of an approved size and type which will insure a uniform distribution of the materials throughout the mass.

The mixer shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used in each batch. Preferably, mechanical means shall be provided for rendering the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed within the specified minimum time.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials, composing a batch shall be deposited simultaneously in the mixer.

No mixer having a rated capacity of less than one bag batch shall be used nor shall a mixer be charged in excess of its rated capacity. During the period of mixing, the mixer shall be rotated with not less than fourteen nor more than twenty revolutions per minute after the introduction of the materials, including water into the mixer.

The minimum mixing time for each batch, after all materials and water are introduced in the mixer, shall be as follows:

Capacity of Mixer	Mixing Time
1/2 cubic yard or smaller	1-1/2 minutes
3/4 to 1-1/2 cubic yards	1-1/2 minutes
2 and 3 cubic yards	2 minutes
4 cubic yards	2-1/2 minutes

Excessive over mixing, requiring addition of water to preserve the required consistency, will not be permitted.
The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mixer.

8. Hand mixing of concrete

It is always needed to get the Engineer's approval in case of using hand mixing.
For hand mixing, a mixing platform of watertight iron plate and a mixing scoop are employed. As a rule, it will be as follows.
It needs above 4 times of dry mixing cement and sand, adding suitable amount of both, cutting over more than 3 times to make mortar, adding coarse materials with remained water to cut over above 4 times until getting uniform concrete.

9. Truck mixing

Truck mixers shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured at the proportioning plant before being charged into the drum.
Except as subsequently provided, the truck mixer shall be equipped with a tank for placing mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch in which case a tank shall not be required. Truck mixers must be provided with a device by which the mixing time can be readily verified by the Engineer.
The maximum size of batch in truck mixer shall not exceed the minimum rated capacity of the mixer as stated by the manufacturer

and stamped in metal mixer. Truck mixing shall be continued for not less than 50 revolutions after all ingredients, including the water, are in the drum. The mixing speed shall not be less than 4 RPM, nor more than 6 RPM. Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregates. When cement is charged into the mixer drum containing water on surface of wet aggregate and when the temperature is above 90°F, or when high early strength Portland Cement is used, the mixing limit shall be reduced to 15 minutes; the limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when the aggregates are sufficiently free from moisture, so that there will be no harmful effect on the cement.

10. Time of Hauling and Placing Mixed Concrete shall be placed in its final position in the form within forty-five minutes after the introduction of the mixing water to the cement and aggregates, or the cement to the aggregates.

11. Delivery

The rate of the delivery of concrete during concreting operation shall be such as to provide for the proper handling, placing, and furnishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The method of delivering and handling the concrete shall be such as will facilitate placing with the minimum of rehandling and without damage to the structure of the concrete.

12. Re-tempering

Concrete mixed which has developed initial set shall not be used; concrete which has partially hardened shall not be retempered or remixed.

13. Conveying and Placing Concrete

General approval of the Engineer shall be obtained before starting any concrete pour. Concrete placement will not be permitted when, in the opinion of the Engineer, condition prevents proper placement and consolidation.

Before concrete is placed all saw dust, chips, and other construction dabris and extraneous matters will be removed from the interior of forms, struts, stays, and braces, serving temporarily to hold the concrete in correct shape and alignments, pending the placing of concrete at their location, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary.

These temporary members shall be entirely removed from the forms and not buried in concrete.

Concrete shall be conveyed from mixer to forms, as rapidly as practicable, by methods which will prevent segregation, or loss of ingredients. There shall be no vertical drop greater than 1.50 meters except where suitable equipment is provided to prevent segregation and where specifically authorized by the Engineer.

Belt conveyors, clutch or similar continuously exposed flow, will not be permitted.

When placing operations would involve dropping the concrete more than 1-1/2 meters, it shall be deposited through sheet metals or other approved pipes. The pipes shall be kept full of concrete during placing and the lower ends of the pipes shall be kept buried in the newly placed concrete.

Concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting materials to segregate. Concrete shall be deposited as close as possible to the final position in the forms so that flow within the mass does not exceed two (2) meters and subsequent segregation is reduced to a minimum. Not more than three (3) cubic meters shall be deposited in pile for compaction. Near forms or embedded items or elsewhere as directed, the discharge shall be controlled so that the concrete may be effectively compacted into horizontal layers not exceeding fifty (50) centimeters in thickness within the maximum of lateral movement specified. Working sections to be placed and the steps of placing concrete in a working section shall be subject to the Engineer's approval.

As a rule, mixed concrete shall be placed immediately. In impossible circumstances to place concrete immediately, time from beginning or mixing to completion of placing shall not exceed one (1) hour. It is required to adjust the proportion, rate of placing concrete in order to prevent, as far as possible, water which will come up to the surfaces while placing and compacting of concrete. If there is surface water, it shall be removed by wiping with mops or sponges.

It shall be avoided to place concrete in the rain and it shall be stopped according to the Engineer's instruction. In case of rain-water standing on the concrete surface which has just been placed or washing the concrete surface, it is required to stop placing concrete. As to placing concrete, it may be necessary to lower placing the temperature of the concrete, avoiding the direct rays of the sun, etc. Concrete of poor quality, concrete which became hard in small quantities before placing, the misplaced concrete shall be rejected.

In this case, the expenses will be charged to the Contractors.

Where concrete is placed in a narrow form, it shall be placed through a flexible vertical chute. Where placing is done with thin bed boards and hand cars, concrete shall be placed while going back.

Where opening is provided in the form, a pocket shall be prepared under the opening and concrete shall be dropped in this vertically. Where concrete is placed on a slope, placing shall be started from the lower part of slope.

14. Concrete on Earth Foundation

All concrete shall be placed upon clean, damp surfaces free from standing or running water. Prior to placing concrete, the earth foundation shall be satisfactorily compacted in accordance with these specifications.

15. Lift in Concrete

Unless authorized or shown, lifts of mass concrete shall not exceed 1.5 meters in height, and a minimum of seventy-two (72) hours shall elapse between the placing of each successive lifts. Lifts of three (3) meters will be permitted in piers and walls. Height of lift specified herein will not apply where the use of slip form has been approved. All concrete when placed and vibrated shall be approximately horizontal layers not to exceed fifty (50) centimeters in thickness unless otherwise specifically authorized. The placement shall be carried in at such a rate that all concrete not yet to grade shall not have readied their initial set before additional concrete is placed thereon.

Slabs shall generally be placed in one lift unless the depth is so great that this procedure will produce objectionable results.

16. Consolidation of Concrete

Concrete shall be placed with the aid of mechanical vibrating equipment and supplemented by hand-spading and tampering.

The vibrating equipment shall be of the internal type and shall at all times be adequate in number of units and the power of each unit to consolidate properly all concrete.

The frequency of vibration shall not be less than 6,000 per minute. Form or surface vibrators shall not be used unless specifically approved in writing by the Engineer.

The duration of vibration shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. In consolidating each layer of concrete the vibrator shall be operated in a near vertical position and the vibrating head shall be allowed to penetrate under the action of its own weights and revibrate the concrete in the upper portion of the underlying layer. Vibrator shall not be used to make concrete flow in the form and to transport in the form.

17. Finishing of Concrete Lift Surfaces

The manipulation of the concrete adjacent to the surface of the lift in connection with completing lift placement shall be the minimum necessary to produce not only the degree of consolidation desired in the surface layer of concrete but also a surface with the desired roughness for bond with the next lift. Surface vibration or excessive surface working will not be permitted.

All unfinished top surface not covered by forms and which are not covered by additional concrete or backfill shall be carried slightly above grade, as directed, and struck off by board finish.

18. Placing Concrete Through Reinforcement

In placing concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs.

On the bottom of beams and slabs, where the congestion of steel near the forms makes placing difficult, a layer of mortar of the same cement sand ratio as used in the concrete shall be first deposited to cover the surface.

Forms:

1. General

Forms shall be used, whenever necessary to confine the concrete and shape it to the required lines, or insure the concrete against the contamination by foreign materials or sloughing from adjacent excavated surfaces. Forms shall have sufficient strength to with-stand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in correct position.

Forms shall be sufficiently tight to prevent loss of mortar from the concrete. Forms for exposed surfaces against which backfill is not to be placed shall be lined with a form grade plywood or sheet steel. Steel panel forms may also be used. The form linning shall be maintained in acceptable condition and replaced, when necessary, with new materials. Local defects such as clipped plywood or kinks in steal forms will not be permitted. All concrete surfaces exposed to public view shall be smooth and even in textures.

2. Form Ties

Embedded metal rods used for holding forms shall remain embedded and shall terminate not less than three (3) centimeters clear of the form-faces of concrete. Embedded fasteners on the ends of rods shall be such that their removal will leave holes of regular shape.

Embedded wire ties for holding forms will not be permitted in concrete walls to be subjected to water pressure or where the concrete surfaces through which the ties would extend will be permanently exposed. Wire ties may be used for holding forms for concrete walls where embankment is to be placed against both sides of the walls. Wire ties shall be cut off flush with the surface of the concrete after the forms are removed.

3. Clearing and Oiling of Forms

At the time concrete is placed in the forms, the surface of the forms shall be free from the encrustations of mortar, grout, or other foreign materials that would contaminate the concrete or interfare with the fulfilment of the specifications requirements relative to the finish of formed surfaces.

Before concrete is placed, the surface of the forms shall be oiled with a commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces.

4. Removal of Forms

Forms shall be removed as soon as possible to enable the earliest practicable repair of surface imperfections, but in no case shall they be removed before approval of the Engineer. Any needed repair or treatment shall be performed at once, and be followed immediately by the specified curing. Forms shall be removed with care so as to avoid injuring of the concrete and any concrete so damaged shall be repaired.

In field operation that are not controlled by beam or cylinder test, the removal of forms and supports shall be governed by the following.

Type of structure:	Time of removal after the last pouring
Arch, beam, girders, and slab:	14 days
Slab in close span of less than three (3) meters:	7 days
Side forms for beams, railings, paraport, Balustrade, and walls:	Not less than 12 hours and more than 48 hours

5. Curing and Protection

General - all concrete shall be moist cured for a period of not less than seven (7) days by any approved method or combination of methods applicable to local conditions, except that the curing period may be reduced to three (3) days for concrete made with high early strength cement. The Contractor shall have all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins.

Water curing - Concrete shall be kept wet by covering with an approved, water-saturated materials or a system of perforated pipes or mechanical sprinklers or by any other approved method which will keep all surfaces continuously (not periodically) wet. Where forms of tongue-and-groove lagging are used and left in place for curing, they shall be kept wet at all times to prevent opening at the joints and drying out of concrete. Water for curing shall be generally clean and free from an element which might cause objectionable staining or discoloration of the concrete.

Saturated sand curing - Horizontal construction joints and finished surfaces cured with sand shall be covered with a minimum thickness of five (5) centimeters of sand which shall be kept uniformly distributed and continuously saturated during the curing period applicable to the surface being cured.

Curing compound - Curing compound, in general, shall not be used. Curing compounds may be used in exceptional cases where it is demonstrated that water curing is not practicable, and then only when and as specified in writing.

In such cases, the curing compound shall be of the surface membrane type, and it shall be used only on surfaces to which additional concrete is not to be bonded.

Expansion, Contraction and Control Joints:

Expansion, Contraction and Control Joints shall be constructed at such points and of such dimensions as required or as shown on the construction plans or otherwise directed.

Except where indicated on the construction plans, no corner protection angles or other fixed metals, embedded in and bonded to the surface of the concrete, shall be continuous through an expansion or contraction joint.

Waterstop:

1. General

   Waterstop shown on the Plans shall be placed by the Contractor at the locations indicated or as directed by the Administrator. The Contractor shall take suitable precautions to support and protect the waterstop during the progress of the work. The Contractor shall furnish and place the waterstop and accessory fixtures unless otherwise specified in the Specifications.

2. Installation

   Waterstops of natural rubber, suitable synthetic rubber or a blend of natural and synthetic rubber shall be installed in joints as shown on the Plans or as otherwise directed. The location, dimensions, and method of installation shall be as shown in the Plans and as provided for in the Specification. Particular care shall be taken to see that waterstops are correctly positioned during installation to eliminate joint leakage. The bottom of each waterstop shall be sealed to other cutoff systems. All waterstops shall be installed so as to form a continuous watertight diaphragm in each joint. Adequate provisions shall be made to support and protect the waterstop during the progress of the work. Any waterstop punctured or damaged shall be replaced or repaired.

Maximum density and imperviousness of the concrete shall be insured by the thorough working of the concrete to be used in the vicinity of all joints. Suitable guards shall be provided to protect exposed projecting edges and ends of practically embedded waterstops from mechanical damage when concrete placement has been discontinued. Both field and factory splicing shall be done in accordance with the recommendation of the manufacturer of the waterstop.

Rubber waterstop shall be spliced by a hot valcanizing process and shall have a tensile strength of not less than 50 percent of the unvalcanized materials. Waterstop shall have a cross section as shown on the Plans.

The rubber will be a natural, synthetic, reclaimed, or a combination of these types, conforming to the applicable portion of ASTM D-735 Standard Specification.

Repair, Finishes and Finishing of Concrete:

The Contractor shall submit to the Administrator for approval all materials, procedures, operation, methods and equipment to be used in the repair, finishes, and finishing of concrete.

Repair of concrete shall be complete within 24 hours after removal of forms.

Reinforcements:

All splices in reinforcements shall be as shown in the Plans. Splices shall be in accordance with the provisions of ACI Code. Welding of reinforcing bars in lieu of lapping will be permitted when approved by the Administrator.

ASTM Specification shall be supplemented by requirements assuring satisfactory weldability in conformity with the AWSD 12.1-61. Welding shall be performed only by operator who had passed the qualification test to the satisfaction of the Engineer.

Reinforcement shall be secured in place by use of metal concrete supports, spacers, and ties.

Such supports shall be of sufficient strength to maintain the reinforcements in place throughout the concreting operation.

The support shall be used in such a manner that they will not be exposed or contribute in any way to the discoloration and deterioration of concrete.

Before assembling steel bars it is required to clean steel bars, to remove loose scale, oil, paint, dirt, etc., that disturb the adhesion of concrete.

Section 10 - Reinforced Concrete Pipe

1. Excavation

A trench shall be excavated to the depth and grade established by the Engineer, allowing the necessary camber. The bottom of the trench shall be shaped to conform to the shape of the pipe for at least 10 percent of its outside diameter. The width of the trench shall not be greater than necessary to permit satisfactory jointing and through taming of the bedding material under and around the pipe. The bedding surface shall provide a firm but slightly yielding foundation of uniform density throughout the entire length of the pipe. Recesses shall be excavated for any collar involved. Where rock or hardpan is encountered, the trench shall be excavated to a depth at least 15 centimeters below the grade established for the bottom of the pipe. This excess shall be refilled with earth backfill and thoroughly compacted. All soft unsound material underlying the proposed pipe shall be removed to the depth required by the Engineer in layers not exceeding 15 centimeters in depth and each layer shall be thoroughly compacted by tamping.

2. Placing Pipe

The pipe shall be laid carefully, hubs up-grade, ends fully and closely jointed, and true to the lines and grades given. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. Each section shall be securely attached to the adjoining sections by the method contemplated for the type of joint used. All joints, unless otherwise specified, shall be filled with stiff mortar composed of one part portland cement and one and one-half parts of sand. Cement, sand, and water shall conform to the requirements for those materials given for "Concrete". The morter shall be placed so as to form a durable, watertight joing. After each section of pipe is laid and before the succeeding section is laid, the lower portion of the hub shall be plastered thoroughly on the inside with mortar to such depth as to bring the inner surfaces of the abutting pipes flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap.

Any pipe which is not in true alignment or which shows any undue settlement after being laid, or is damaged, shall be taken up and relaid or replaced without extra compensation.

The spigot end of the pipe shall be placed concentrically with the bell and shall be held in position with wood or metal wedges. The filter material shall be carefully placed and compacted to form an even bedding, and so as not to disturb the pipe after being laid, and to hold it securely in position.

If the pipe is laid below the canal lining or a canal structure, the entire trench outside of the pipe shall be filled with filter material to the bottom of the canal concrete and shall then be covered with building paper to prevent it from becoming logged during the placing of concrete.

In the event the drawings indicate an abrupt change in grade, one length of pipe shall be cut near the center by use of concrete saw or chisel or as elected by the Contractor to the proper inclination for making the change in grade. The two cut sections can be turned and fit together and secured firmly in place from the elbow. Mortar shall be tamped into the joint until no voids exist.

Concrete structures jointing onto or connecting concrete pipe shall be poured after the pipe has been installed, thus assuring a tight bond between the structure and the pipe.

Concrete pipe shall be laid so that variation from grade is within ±2 cm, and so that variation from alinement is not more than 2 cm. per pipe section nor more than 5 cm. at any place.

3. Backfilling

After the pipe has been installed and the mortar joint sufficiently set, selected materials from excavation and borrow shall be placed alongside the pipes in layers not exceeding 15 centimeters in depth and shall be compacted thoroughly so that on each side of the pipe at least as wide as the external diameter of the pipe except insofar as undisturbed material obtrudes upon this area. Each layer, if dry, shall be moistened and then compacted by tamping with mechanical rammers, or by hand tamping with heavy iron tampers, the face of which shall not exceed 160 square centimeters in area, and of a weight not less than 20 kilograms. This method of filling and compacting shall be continued until the embankment has reached an elevation 20 centimeters above the top of the pipe. When the construction calls for placing high embankment over the pipes, special instructions regarding the method of backfilling shall be given by the Engineer.

Preparation and handling of concrete binder shall be governed by the Specifications for "Concrete", except the proportioning of the ingredients which is as specified above.

The stones shall be thoroughly wet before they are installed in place. The entire surface of each stone shall be thoroughly covered with the concrete binder. In general, one (1) cubic meter of rubble masonry will require one-half (1/2) cubic meter concrete binder.

Actual variation in this proportion will not entitle the Constructor to any price and adjustment.

The stone shall be well set so that no stone will project beyond the lines indicated on the Plans. The concrete binder shall be thoroughly worked into the space between stones so that no void is left within the rubble masonry. In case reinforcements are placed, no rubble stone shall be closer than four (4) inches to the nearest reinforcing bar. The masonry shall be cured by water curing for five (5) days.

When riprap is not laid on gravel blanket, the subgrade shall be excavated to the required elevation as shown on the Plans and then properly tamped and trimmed. On the prepared subgrade the stones for riprap shall be carefully laid to cause minimum displacement or disturbance of the bed. The stones shall be laid and arranged close to each other to offer minimum resistance to displacement due to the velocity of the stream.

Spalls or appropriate size filler stones shall then be placed to fill spaces between the stones for one-half (1/2) the thickness of the riprap as indicated on the Plans.

Section 13. - Filter Drain

The bed for the Filter Drain shall be excavated to the required elevation and dimension as shown on the Plans and then properly compacted as directed by the Engineer. The materials shall be dumped and spread on the prepared bed filter and each layer shall be compacted by a vibratory compactor to a degree approved by the Engineer. Placement of succeeding layers shall be allowed only after the Engineer has approved the placement and compaction of the preceding layer. Before laying the topmost layer of the Filter, perforated drain pipes for outlets shall be installed as shown on the Plans. Joints of drain pipes for outlets shall be tight in order to preclude entrance of cement grout when pouring concrete around the pipes. The pipes shall be sufficiently eraced to prevent any displacement during concrete pouring operation. When concrete is to be placed directly on the filter, the entire surface upon which concrete is to be placed shall be covered with a layer of reinforced building paper before concrete is placed.

Section 14 - Steel Gate Installation

The gate shall be installed and incooperated with the structure as indicated on the Plans and as per working drawings furnished by the Manufacturer. No anchor bolt embedded in concrete shall be disturbed at least seven (7) days after said anchor bolt had been installed. Trial runs of the gates shall be made by the Engineer prior to acceptance of the work.

If the steel gates are not furnished on time for their installation during the construction of the structure, necessary holes for the anchor bolts of the gates and lifting devices shall be provided in the concrete for their installation. The size and location of the holes will be determined by the Engineer and shall be furnished rough in order to provide the necessary bond with the new concrete filler when the anchor bolt is installed.

If additional holes for anchor bolts will be found necessary, said holes shall be drilled by the Contractor at his own account. No adjustment in the contract price will be made on account of these delays. All ferrous metal not in contact with concrete or not in sliding contact shall be painted. Wood shall not be painted unless specifically noted on the drawings.

Section 15 - Steel Sheet Piles

1. A trench well below the bottom of pile cap shall be excavated and where necessary, falsework to support the sheet piles shall be erected. Steel sheet piles shall be driven to the lines and grades, shown on the Plans, or as ordered by the Engineer in writing.
   Changes in grade elevations will not entitle the Contract or to additional compensation.

2. Driving the steel sheet piles shall be done with the drop or steam hammer or similar approved pile driving equipment.

3. Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by sufficient guys. Unless permitted by the Engineer in writing, the use of follower will not be allowed.

4. Driving cap shall be used and shall be strong cast steel. Compound type shall be used as far as possible. Steel wedge shall be driven into clearance between sheet-piles.
   Wooden driving cap shall be furnished always with spares and shall be replaced properly.

5. Weights of steel driving hammer shall be 2-3 times the weights of sheet pile to be driven, and one suitable to the condition of geology shall be employed. For preventing the damage of the top of sheet pile or inclination, drop of hammer shall be minimum and number of blows shall be increased.

6. The steel sheet piles shall be driven vertically to the full length, true to the lines and grades indicated on the Plans and they shall interlock with each other from the top to the bottom.

Steel sheet piles that deflect badly or refuse to penetrate further on account of obstructions in the subsoil shall not be forced. In such cases, the driving of the steel sheet piles down the line shall continue, leaving the obstinate pile or piles projecting above the rest. The obstruction shall thereafter be removed by excavation when all parts of the piling wall have been properly set. It is best to place the sheet piles in line and then work them down gradually rather than drive each pile down to the required grade in a single operation. Whenever necessary, suitable false work shall be provided to serve as guides in driving the sheet piles in proper position.

After driving the steel sheet piles and the butts cut-off, the trench shall be backfilled in a manner satisfactory to the Engineer.

7. Should it be found impractical to drive the steel sheet piles, open excavation shall be restored and the steel sheet piles shall then be placed in accordance with the Plans.

The steel sheet piles shall be braced to maintain their vertical position during the process of backfilling of the excavation trench. Backfilling shall be done simultaneously on both side and shall progress at the same rate. Materials for backfill and the degree of compaction will be determined by the Engineer.

Steel sheet piles installed in this manner shall be considered as driven. No allowance for extra compensation will be allowed when this method is employed.

Section 16 - Wooden Pile

1. Piles shall be a specified kind of straight timber which is good in quality having no large knots, dead knots, rotten knots and cracks. The timber, whose eccentricity is over 1/3 of its diameter from the line connecting the centers of its both ends, shall not be used.

2. Piles shall be made of green wood which will be skinned on the spot if possible. The point of a pile shall be shaved in square pyramid, and shall be shaved in obtuse angle where the geology is solid. The height of the part to be shaved shall be 1.5 - 2 times the diameter and the angle shall take a proper facing.
   In the case of using iron shoes, the iron shoes shall closely adhere to the pile at all the part.
   The head of pile shall be cut in a right angle to the center line of the pile and shall be finished into a right circular shape.
   If necessary, an iron ring or iron cap shall be used to prevent the pile head from being dented and cracked.

3. Piles shall be held in leading frame and driven in the right position.

4. Driving weight shall be standardized as 1.5 times the weight of pile.

5. In the case of using dropping weight for driving, the dropping height shall be limitted so that the head of pile may not be much damaged. When the bearing power is specified, the dropping height shall be determined on the instructions of the Engineer.

6. In driving, incessent corrections shall be made using supports, turn-buckle and jack in order to protect the displacement of pile. In case the pile head is broken, the Engineer's instructions shall be obtained.
When cracking or displacement of a pile occurs, such pile shall be redriven or added with another pile according to the instruction of the Engineer.

7. Joints of pile shall be cut as shown on the drawing to make a right angle to the centerline, to insure a close contact and the steel ring shall be attached tightly to the pile, so that eccentricity and bending resulting from the driving shock will be prevented.

8. In case the specified length of driving cannot be obtained, and the specified bearing power cannot be reached, the Contractor shall get the Engineer's instruction. In case the specified bearing power is obtained at a length shorter than the specified driving length, the above will apply.

9. When further driving becomes impossible and the head of pile shall have to be cut, a report thereof shall be made in writing.

10. Upon completion of the driving operation and with the Engineer's consent, the upper ends of piles shall be cut to keep level at the specified height but the cut-off portion shall not exceed 2% of its total length.

11. As to the bearing piles, penetration at finish driving shall be recorded and the record shall be submitted to the Engineer.
The inspection of bearing power of piles shall conform to the method specified by the Engineer.

12. Driving arrangement, start of driving, finish of driving and joint work shall be made in the presence of the Engineer. In the absence of his presence, order may be given when necessary to pull out or re-drive the piles.

Section 17 - Miscellaneous Metalwork

General

1. Structural steel sections shall be processed and fabricated by rivetting or welding as far as practicable in the shop. All the parts shall have no deformation or warp and so assembled as was designed.
   All parts shall be adquately braced to prevent deformation during shipping or placing.

2. Rivet holes shall be made by punching or drilling and after assemblage holes shall fit each with the other. All rivets shall be driven hot, using pressure tools, and heads shall be supported to prevent warp of the shank. All defective rivets shall be cut out and replaced

3. All welding at the shop shall be done by the shielded arc and suitable welding rods shall be used. For field welding gas may be used.
   All welders shall be thoroughly qualified for the welding operation.

4. The Contractor shall install or attach to or build into structures and shall clean and paint all Metalworks in a workmanlike manner as hereinafter specified or as directed by the Engineer. In the installation of metalworks, skilled mechanics shall be selected out for the work.
   The materials shall be carefully handled so that no part will be bent, broken, or otherwise damaged. Any damage occurring during the execution of work shall be repaired at the expense of the Contractor and the results of repairs shall be subjected to the inspection of the Engineer.

Metalworks to be embedded in the concrete shall be so embedded when the concrete is being placed, or if so shown on the drawing or directed by the Engineer as to leave recesses, they shall be filled with concrete after the metalworks are fitted.
Anchor bolts shall be placed when concrete is placed unless otherwise directed by the Engineer. Where it is impracticable to place anchors or anchor bolts required for the installation of railings or other comparatively light metal accessories before the concrete is placed, holes shall be made by drilling in the concrete after it has set thoroughly, and then expansion bolts or lead expansion anchors shall be installed. Metalworks to be embedded in the concrete shall be placed accurately and fixed in the correct position while concrete is being placed. The surfaces of all metalworks to be in contact with or embedded in the concrete shall be cleaned thoroughly of all rust, dirt, grease, loose scale, grout, mortar, and other foreign substance immediately before the concrete is placed.

Section 18 - Wooden Mattress

1. This section gives specifications regarding the wooden mattress to be placed as the fore-apron of the diversion dam, and the work shall be executed according to the Plans and the direction of the Engineer.

2. As regards the timber, green and flawless materials shall be used in order to prevent the parts which usually rise over and fall below the water surface from becoming rotted.

3. Stone material shall not be less than 30 centimeters in size and shall be placed stiffly so that the stones will not be detached from the mattress.

Section 19 - Sheathing Works

1. This section gives specifications regarding the boardings to be placed in sheathing wall and wooden drop, and the work shall be executed according to the Plans and the direction of the Engineer.

2. In execution of the work, green and flawless timber shall be used.

3. The work shall be executed after deciding the length of driving, spaces, the thickness of board, the length of bracing pile or anchor bar, if necessary, taking into consideration the length of the assumed sheathing line and the nature of the soil.

Section 20 - Wet Stone Masonry

Materials

1. Stone materials shall be so selected that they are solid and uniform, having no resistivity against weathering and no cracks or other defects. With regard to the borrow pit and quality, prior approval shall be obtained from the Engineer.

2. Stone materials shall have such surface and length as are specified by the Engineer, and their shape of face shall be rectangular with slightly convex face, and the rear area of the stone shall have more than 1/6 of the front area, and the depth of bearing area shall have more than 1/10 of the depth.

3. Dimensions of stone shall be based on the following table.

Length of side	Depth	Numbers per 1 m^2
24 cm	35 cm	16
30	45	10
60	60	5

Steps

4. After excavation, the supporting power of the soil of the base ground shall be subjected to the inspection of the Engineer.

5. The foundation shall be cut and leveled right angle against the masonry stone. When there is wide variety in the height of the foundation, bench-cut shall be applied in a regular form.

6. Base stone and crown stone shall be as large as possible.

Placing of stone masonry

7. Stone masonry shall be random masonry unless as otherwise specified. Stone masonry shall be started from the lowest part and stone shall be laid up keeping nearly the same height.

8. The Contractor shall arrange the height of valley of the stones in any row so as to be uniform as far as possible. Uneven valley of each stone row shall be adjusted by the size of stone. The height of stone masonry shall be adjusted in the upper three rows.

9. Stone masonry shall be laid so as not to be uneven or stick out from the surface of the slope.
Stone masonry shall have full bearing area and the lower stones shall be equally loaded with weight.

10. The laid-up stones shall be stabilized with back-up stones, and the back filling shall be applied when each row is set, and both lower bedding sides shall be filled with the specified mixed concrete. Next, all voids around stones shall be filled with concrete using bars, etc. and the concrete shall be placed each time nearly up to height of wall. In this case, a form shall be made in front of the back fill and the place shall be concreted. The form shall be taken off after the concrete has been hardened.

11. The work shall be carried out paying particular attention to the following items.

(1) Stone masonry shall be cleaned. If there is mud or dust, it shall be washed off with water.

(2) When face stone and back fill stone are dry, they shall be wetted by spraying water before placing concrete.

(3) The filled concrete shall be covered with straw mat, and always kept wet by spraying water.

(4) When placing jointing concrete to the concrete that has been cured over 6 hours, plaster shall be applied with thin mortar.

(5) Crown concrete work shall be carried out at the same time with the back fill concrete work, and a suitable drainage slope shall be made.

(6) The Contractor shall install a pipe to drain out spring water or static water at the back.

2. Special Specifications

Section 1. Irrigation Canal (Earth Canal)

Irrigation canal (earth canal) shall be constructed according to the following specifications:

1. The clearing work shall be carried out for the entire width required. If there is ground water which impedes clearing work in the site, suitable drainage facilities shall be simultaneously constructed.

2. As to the earth work, first set the top surface of canal berm as the standard line and then by excavation and embankment build the canal foundation.
   In this case, for the part of canal materials which contain gravel shall not be used for the embankment.
   The proper material fit for the formation of embankment must be used.
   For the embankment, the shoulder parts at both outside slopes shall be filled about 30 centimeters wide and then cut out as specified for finishing.

3. The base shall be excavated as specified canal sections and the excavated earth shall be dumped outside the berm slope.
   When permeable layers which include sand, gravel, etc. are found, the Engineer may order their replacements with good materials to the Contractor. In this case, the Engineer makes a decision on the selection of materials and thickness to be constructed.
   The excavation shall be performed by machinery but when imperfect portions done only by machinery are found, finishing shall be performed by hand work. The stones which appear on the slope shall be removed, and the holes left thereby shall be back filled with good earth.

If there is spring water on the slope, the slope shall be protected to prevent its collapsing.

In general, spring water shall be drawn from springing place to the inside or outside of the canal by mole drain.

4. The excavation for canal shall not be started unless the adaptabilities of the finished base are confirmed by the Engineer in charge. The Contractor shall in excavating the base keep a constant inspection of the dimension of canal sections with a ruler as the work progresses.

5. During the work, in order not to interfere with the general traffic temporary roads and temporary bridges shall be constructed as directed as directed by the Engineer in charge.

6. The above works shall conform thoroughly to the general specifications and for matters not specified in this specification they shall follow the direction of the Engineer in charge.

Section 2. Drainage Canal (Earth Canal)

Drainage canal (earth canal) shall be constructed according to the following specifications:

1. The clearing work shall be carried out for the entire width required. If there is a marshy ground which makes the operation of excavation equipment difficult, temporary drainage facilities shall be constructed for its drying.

2. The parts to be excavated shall be excavated and fill-up over the both banks and this part of banking shall be consolidated in conformity with the general specifications.

3. After the completion of filling-up of the earth to the specified height and the excavation of the specified depth, finishing of inside slope of canal and outside slope of the bank shall be performed by machinery or man power.

4. If there is a gushing water in excavated parts, adequate facilities shall be installed for drainage.

5. The items 5 and 6 of the Section 1, Irrigation Canal (Earth Canal) shall be applicable to the work under Section 2 - Drainage Canal.

Section 3. Concrete Lining for Canal

Earthwork

1. The clearing work of the entire width required shall be carried out as specified in the specifications for the irrigation canal.
2. The standard height of the finishing for the first canal shall be set at the bottom of top concrete lining.
3. Excavate the cross section to the size as specified. In this case, excavated earth will fill-up both sides of the canal, but be sure that it will not interfere for building concrete linings.
   Earth materials must be filled on the banks before finishing over the top concrete of lining. Remaining earth shall be dumped outside the slope.
   The formation of slopes shall be performed thoroughly and objectionable substance like stones shall be removed and holes left shall be backfilled. If there is any gushing water on the slope or bottom of the canal, build small ditches filled with gravel and either draw water to the bottom of canal or to outside the canal by a special facility installed.
   If the earth is of expendable clay, this shall be removed and replaced with good earth. The adaptability will be decided by the Engineer in charge.
4. After the concrete lining work is completed and prescribed days have elapsed, filling-up of the earth over the lining concrete must be performed.
   At this time the earth for the slope over the lining concrete shall be of specially selected impermeable nature and shall be sufficiently consolidated so as to prevent the seepage of rain into the back of concrete lining.

Placement of lining concrete:

Concrete

1. Class "C" concrete shall be used for lining concrete and the Engineer in charge will indicate its mixture to the Contractor. In general, the amount of gravel (5 - 10 mm) in proportioning class "C" concrete shall be reduced to about 5 percent by dividing the coarse aggregate into three kinds and the fine aggregate into two kinds.

2. Concrete shall be plastic and be able to be compacted sufficiently and have such a solidness as to stay on the slope. Slump shall be prepared with 5 or 6.5 centimeters.

Placing

Concrete shall be placed from the surface of slope and placing shall be performed by man power because the amount of lining is small.

Prior to the placing, perfectly formed base of surface of the slope shall be moistened sufficiently. It shall be moistened generally to about 15 centimeters so as not to be muddy, and then the wooden board even with the lining concrete in thickness shall be fixed on the up and down stream sides. The wooden board equal to the length of concrete shall be fixed also on the toe of the slope and the form for stopping shall be fixed also on the top of the slope.

The surface of the slope where weepholes installed shall be dug and placed by asphalt felt paper. Concrete shall be placed from the lower to the upper parts keeping the required thickness always.

Concrete shall be sufficiently compacted by beating concrete giving vibration with a wooden board with handle or a wooden stick. And then the surface shall be finished smooth faced by a trowel.

The trowel shall be used horizontally and not vertically to prevent the vertical trowel marks.

The wall shall be divided into sloped face of left and right, and shall not be executed continuously but on one side first and then the other. After concrete placement of both slope faces, invert face shall be finished.

In this case, after the base has been moistened, concrete shall be executed continuously. Curing of concrete shall be performed by the use of sealing compound. Kind of sealing compound will be decided by the Engineer in charge.

Weephole shall be inserted in the holes made by the stick with sharp edge after the completion of concrete placement, before being finished with the use of trowels, and shall be installed to contact sufficiently with concrete by compacting around the concrete.

The weephole valve shall be installed to open in the direction of downstream.

The contraction joint may not be necessary because the canal section is small and the faces of the slope are placed alternately by concrete, but as to invert face, the groove of 1.0 - 1.3 cm in width and 2.5 cm in depth shall be made at the same station as the construction joint of the slope during placing the concrete.

Covering with vinyl sheet or water-proof cloth may be ordered by the Engineer to prevent the collapse of the slope due to the saturation of rain, etc., before filling over the lining concrete.

Section 4. Diversion Dam

1. Temporary Coffering, Unwatering

Temporary cofferdam is the closure of earth and sand and the banking shall be executed within the scope and the cross section of the drawing. The temporary cofferdam shall be for half of the river. First Start from the left bank side and after finishing the sluice way and fixed dam partly, remove it and then start the coffering on the right bank side.

In coffering the left bank side existing gut shall be excavated as shown in the drawing and the cross section area of the stream shall be widened.

The cross section of temporary cofferdam shown in the drawing is the minimum.

In case of an increased water leakage, required cross section shall be made larger under the direction of the Engineer.

After the completion of work, cofferdam shall be removed as soon as possible as directed by the Engineer. During the work, unwatering inside the cofferdam shall be performed and pump and other equipment required for unwatering shall be prepared.

The capacity of equipment shall be sufficient to deal with the seepage water and rainfall and before installation the approval of the Engineer shall be obtained.

2. Excavation

The foundation shall be excavated roughly by the equipment of excavation and after excavating the greater part, the foundation shall be finished to the specified depth shown in the drawing by man power.

In case of excavating more than specified depth mistakenly, the parts of over excavation shall be filled with concrete without fail.

3. Concrete

As to concrete of diversion dam, the parts such as the piers of sluice way and intake which require reinforcement shall be placed with class "A" concrete, and class "B,6"" concrete shall be used for the other parts.

Before the placement of concrete for the main structure, waste concrete shall be placed to such a depth as shown in the Plans. Prior to placement of waste concrete, loose soil under the bottom slab shall be removed.

After the completion of placement of waste concrete, backfill to the elevation of waste concrete surface or other treatments shall be performed to prevent the discharge of earth material from the foundation as directed by the Engineer.

4. Gates

Gate of sluice way shall be steel roller gate and shall be made water-tight on three sides with rubber seals.

Gate of intake shall be steel sluice gate and watertight on four sides. Each gate leaf shall be sustained with sufficient strength and watertightness at design water pressure.

Seal plates and sills shall have a structure to distribute and carry over water pressures which act on gate, on concrete of piers safely and effectively. Seal plates shall be accurately installed inside the blockout of gate groove as shown in the Plans.

Miscellaneous metal shall have such a sufficient strength as to bear the shock at the time of lowering gate.

Hoists shall be operated by one man and man power shall be within 10 kilograms and hoists shall be furnished with installations for preventing abrupt drop and stopping gate to repair and check.

After completion of installation of gate, watertightness and operation of each part shall be inspected by the trial runs of the gates as instructed by the Engineer.

III. Data of Water Requirement in Depth taken in the Field

The soil of the project area is divided into Palo clay loam of the Alangalang area and San Manuel silt loam of the San Miguel area.

The water requirement in depth was measured at nine points.

The following data were taken:

Station	Soil	Measurement	Period
1	San Manuel Silt Loam	18mm - 22mm	March 26 - April 4
2	San Manuel Silt-Loam	20mm - 26mm	March 26 - April 4
3	San Manuel Silt Loam	16mm - 17mm	March 28 - April 4
4	Polo Clay Loam	10mm - 16mm	March 26 - April 4
5	" "	11mm - 15mm	March 28 - April 4
6	" "	8mm - 13mm	March 26 - April 4
7	" "	8mm - 15mm	March 26 - April 4
8	" "	16mm - 17mm	March 26 - April 4
9	" "	15mm - 18mm	March 28 - April 4

IV. Design Data and Typical Computation of Diversion Dams

Design data and typical computations of Diversion Dams.

(1) Scouring sluice way

(a) Standard discharge for flushing cobbles

One of the most important functions of sluice way is to keep the center of stream. In order to flush cobbles all through the year, the standard discharge of the dry season is considered. If the ratio of the discharges of the Mainit River and the Old Mainit River at their confluence is taken as 6 : 4, each discharge is as follows.

1960

Month	Mean Discharge Recorded	Discharge at Confluence		Remarks
		Mainit River	Old Mainit River	
Jan.	6.610 m^3/s	3.97 m^3/s	2.64 m^3/s	
Feb.	7.740	4.64	3.10	
Mar.	4.920	2.95	1.97	
Apr.	6.520	3.91	2.61	
May	5.350	3.21	2.14	
Jun.	4.800	2.88	1.92	
Jul.	4.470	2.68	1.79	
Aug.	3.890	2.33	1.56	
Sep.	3.760	2.26	1.50	
Oct.	12.070	7.24	4.83	
Nov.	8.720	5.23	3.49	
Dec.	9.110	5.47	3.64	

1961

Month	Mean Discharge Recorded	Discharge at Confluence		Remarks
		Mainit River	Old Mainit River	
Jan.	8.410 m^3/s	5.05 m^3/s	3.36 m^3/s	
Feb.	12.740	7.64	5.60	
Mar.	9.260	5.56	3.70	
Apr.	5.840	3.50	2.34	
May	5.790	3.47	2.32	
Jun.	4.110	2.67	1.44	
Jul.	3.160	1.90	1.26	
Aug.	3.180	1.91	1.27	
Sep.	2.560	1.54	1.02	
Oct.	3.320	1.99	1.33	
Nov.	7.160	4.30	2.86	
Dec.	8.340	5.00	3.34	

From these tables, the standard discharge for flushing cobbles of the Mainit River is determined at 4.0 m^3/sec. and that of Old Mainit River at 3.0 m^3/sec.

(b) Required velocity for flushing cobbles

The following formula gives the required velocity for flushing cobbles

$$Vc = 1.5\, C \sqrt{d}$$

where Vc : The required velocity for flushing cobbles. (m/sec)

C : Coefficient
3.2 - 3.9 cobble figure, a sphere to square.

d : The maximum cobble diameter (m).

(i) Dam No. 1

In this case, the coefficient C is taken as 3.2 and d as 0.2 m.

$$Vc = 1.5 \times 3.2 \sqrt{0.2}$$
$$= 2.146 \text{ m/sec.}$$

(ii) Dam No. 2

Coefficient, cobble diameter of Dam No. 2 are equal to those of Dam No. 1, Vc is the same

$$Vc = 2.146 \text{ m/sec.}$$

(c) Width of sluice way

Width of sluice way is decided to obtain required velocity.

So, width of sluice way depends on the following formula.

$$b = \frac{Q\ q}{Vc3}$$

where as b : Width of sluice way. (m)

Q : Designed discharge. (m)

V : Required velocity. (m/sec)

: acceleration of gravity. (m/sec^2)

(i) Dam No. 1

Q : 4.0 m^3/sec

: 9.8 m/sec^2

V : 2.146 m/sec

Therefore,

$$b = \frac{4.0\ 9.8}{2.146} = 4.0 \text{ (m)}$$

The width of sluice way is decided as 4.0 m.

(ii) Dam No. 2

Q = 3.0 m^3/sec

= 9.8 m/sec^2

Vc = 2.146 m/sec

Therefore,

$$b = \frac{3.0\ \ 9.8}{2.146} = 3.0 \text{ (m)}$$

The width of sluiceway is decided as 3.0 m.

(d) The floor slope of sluice way

The floor slope of sluice way should be steeper than the critical slope of standard discharge, in order to flush cobbles on the floor of sluice way, while the critical slope is expressed by

$$Ic \geqq \frac{n^2 \, g10/9}{q_c{}^{2/9}}$$

where as

- Ic : the critical slope
- n : coefficient of roughness 0.03
- g : acceleration of gravity (m/sec^2) 9.8
- q_c : discharge per unit width (m^3/sec/m)

For both dams,

q_c = 1.0 m^3/sec/m $\qquad$ $q_c{}^{2/9} = 1.0$

g = 12.629

Therefore,

$$I_c \geqq \frac{0.03^2 \times 12.629}{1.0} = \frac{1}{88}$$

The floor slope of sluice way is to be decided as 1 to 50 (vertical to horizontal) in Dam No. 1 and No. 2.

(e) Length of rear apron and rip rap

Bligh gives the length of rear apron and rip rap, respectively, as

$$l_1 = 0.9 \; c\sqrt{Ha}$$

$$L = 1.0 \; c\sqrt{Ha \times q}$$

$$l_2 = L - l_1$$

whereas

- l_1 : length of rear apron (m)
- l_2 : length of rip rap (m)
- L : total length of rear apron and rip rap (m)

c : Bligh's coefficient, coefficient characteristic of the materials of river bed

Ha : the drop, i.e. the height of the drop from the water level over the crest of the weir or over the top of the gates, down to the downstream water level.

q : the discharge per unit width of the weir or width of the sluice way

(i) Dam No. 1

$$Ha = 1.80m, \quad q = 10.0\ m^3/sec/m$$

Therefore,

$$l_1 = 0.9 \times 6 \times \sqrt{1.8} = 7.24\ (m)$$

$$L = 1.0 \times 6 \times \sqrt{1.8 \times 10.0} = 25.5\ (m)$$

Assuming that l_1 is 10.0 meters,

$$l_2 = 25.5 - 10.0 = 15.5\ (m)$$

(ii) Dam No. 2

$$Ha = 1.80m, \quad q = 6.0\ m^3/sec/m$$

Therefore,

$$l_1 = 0.9 \times 6 \times \sqrt{1.8} = 7.24\ (m)$$

$$L = 1.0 \times 6 \times \sqrt{1.8 \times 6.0} = 19.7\ (m)$$

Assuming that l_1 is 9.7 meters,

$$l_2 = 19.7 - 9.7 = 10.0\ (m)$$

(f) Calculation of creep length

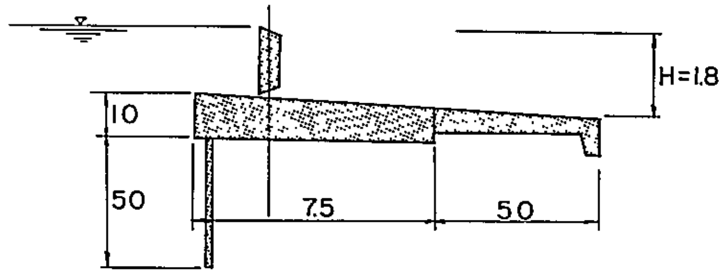
Minimum creep length required is expressed by

$$L \geqq c.H$$

There are two methods for the calculation of creep length

One is Bligh's method and the other is Lane's method.

(i) Dam No. 1



The required creep length by Bligh's method is

$$c.H = 6 \times 1.8 = 10.8$$

$$L = 1.0 + 5.0 \times 2 + 12.5 = 23.5 \text{ (m)}$$

therefore $L > c.H$

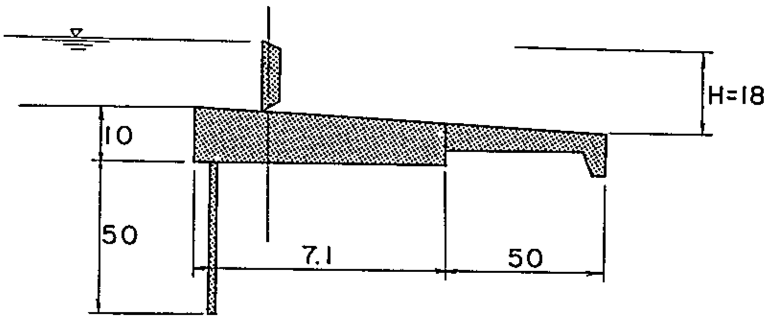
The required creep length by Lane's method is

$$c.H = 3 \times 1.8 = 5.4 \text{ (m)}$$

$$L = 1.0 + 5.0 \times 2 + 12.5 \times 1/3 = 15.2 \text{ (m)}$$

therefore $L > c.H$

(ii) Dam No. 2



The required creep length by Bligh's

$$c.H = 6 \times 1.8 = 10.8 \text{ (m)}$$

$$L = 1.0 + 5.0 \times 2 + 12.1 = 23.1 \text{ (m)}$$

therefore $L > c.H$

The required creep length by Lane's method is

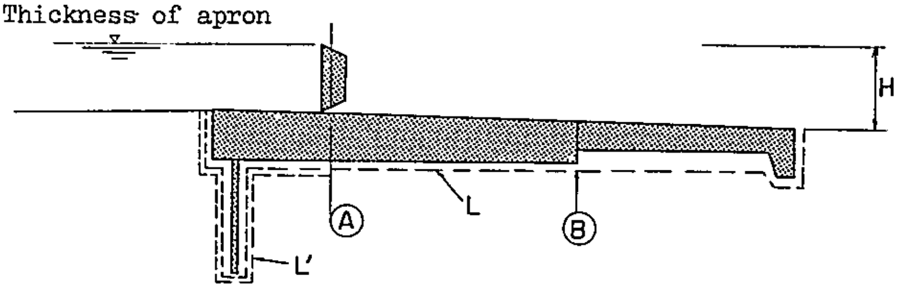
$$c.H = 3 \times 1.8 = 5.4$$

$$L = 1.0 + 5.0 \times 2 + 12.1 \quad 1/3 = 15.0$$

therefore $L \geqq c.H$

whereupon, the creep length of Dam No. 1, No. 2 is enough to prevent the dam footing from the percolation of ground water.

(g) Thickness of apron



Bligh recomends the thickness of apron as

$$t \geqq 4/3 \times \frac{H-h}{r-1}$$

whereas
- t : thickness of apron (m)
- r : specific gravity of concrete 2.4 t/m
- H : maximum drop (m)
- h : head loss to point Ⓐ or point Ⓑ (m)
  $h = H/L \times L'$
- L : creep length by Bligh's method (m)
- L': creep length to point Ⓐ or point Ⓑ by Bligh's method (m)

(i) Dam No. 1

h, t at the point Ⓐ, Ⓑ are respectively computed as follows

point Ⓐ

$$h = \frac{1.8}{23.5} \times 13.5 = 1.03$$

$$t = 4/3 \times \frac{1.8 - 1.03}{2.4 - 1} = 0.73$$

$$h = \frac{1.8}{23.5} \times 18.5 = 1.42$$

point B

$$t \geqq 4/3 \times \frac{1.8 - 1.42}{2.4 - 1} = 0.36$$

from which, the thickness of apron at the point A is decided to be 1.0 meter and at the point B, 0.6 meter.

(ii) Dam No. 2

The calculation of apron thickness of Dam No. 2 is the same as that of Dam No. 1, because the basis of design is the same.

(2) Fixed Weir

a) Elevation of Dam crest is 0.10 meter added to the operating water surface of Intake.

In Dam No.1, the operating water surface of the Intake is proposed as EL. 42.00.

Therefore, the elevation of the dam crest is decided as EL.42.10 and the elevation of the dam footing is as EL.40.00 from the result of survey.

In Dam No.2, the operating water surface of Intake is proposed as EL.41.00. Therefore, the elevation of the dam crest and the dam footing are respectively decided to be EL.41.10 and EL.39.00.

b) Decision of the Fixed Weir Section

The following formulae are recommended by Bligh in calculating the dam crest and the footing,

$$L = \frac{H + h}{r}$$

$$B = \frac{h}{r}$$

whereas, L : width of footing

B : width of dam crest

H : height of dam

h : maximum overflow depth
above the crest

r : specific gravity of
concrete 2.4

In Dam No.1, let H, h, and r, respectively 2.1, 2.4 and 2.4, then, according to the Bligh's formula,

$$L = 2.90 \text{ (m)}$$

$$B = 1.55 \text{ (m)}$$

The calculation of the section of Dam No. 2 is the same as that of Dam No.1, because the basis of design is the same.

(c) Length of rear apron and rip rap

Bligh gives the length of rear apron and rip rap, respectively, as

$$l_1 = 0.6 \times c \sqrt{Ha}$$

$$L = 0.66 \times c \sqrt{Ha\ q}$$

$$l_2 = L - l$$

whereas l_1 : length of rear apron (m)

l_2 : length of rip rap (m)

L : total length of rear apron and rip rap (m)

c : Bligh's coefficient, coefficient characteristic of the materials of river bed

Ha : the drop

q : the discharge per unit width of the weir or width of the sluice way

(i) Dam No. 1

Ha = 1.74 m , q = 6.0 m/sec/m

Therefore,

$$l_1 = 0.6 \times 6 \times \sqrt{1.74} = 4.75$$

$$L = 0.66 \times 6 \times \sqrt{1.74 \times 6.0} = 12.8$$

Assuming that l is 5.0 meters,

$$l_2 = 12.8 - 5.0 = 7.8 \text{ (m)}$$

(ii) Dam No. 2

Ha = 1.74 m , q = 3.0 m/sec/m

Therefore,

$$l_1 = 0.6 \times 6 \times \sqrt{1.74} = 4.75$$

$$L = 0.66 \times 6 \times \sqrt{1.74 \times 3.0} = 9.0$$

Assuming that l_1 is 5.0 meters,

$$l_2 = 9.0 - 5.0 = 4.0 \text{ (m)}$$

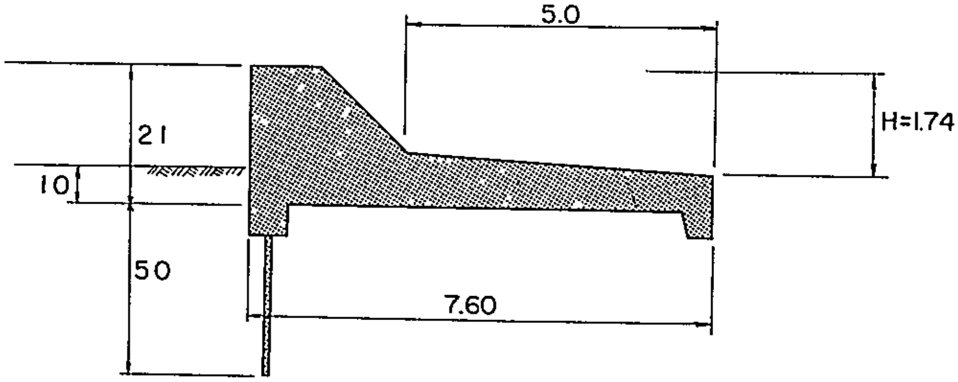
(d) Calculation of creep length

Minimum creep length required is expressed by formula.

$$L \geqq c \times H$$

There are two methods for the calculation of creep length. One is Bligh's method and the other is Lane's method.

(i) For both dams



① Bligh's method

The required creep length

$$c\,H = 6 \times 1.74 = 10.44 \text{ (m)}$$

$$L = 1.0 + 5.0 \times 2 + 7.6 = 18.60 \text{ (m)}$$

Therefore, $L > c\,H$

② Lane's method

The required creep length

$$c\,H = 3 \times 1.74 = 5.22 \text{ (m)}$$

$$L = 1.0 + 5.0 \times 2 + 7.60/3 = 13.53 \text{ (m)}$$

Therefore, $L > c \times H$

(3) Thickness of apron.

The formulae to calculate the thickness of apron are already mentioned in the calculation of the scouring sluice way.

(i) Dam No. 1

$$h = \frac{1.74}{18.6} \times 13.6 = 1.27$$

$$t = \frac{4}{3} \times \frac{1.74 - 1.27}{2.4 - 1} = 0.44$$

(ii) Dam No. 2

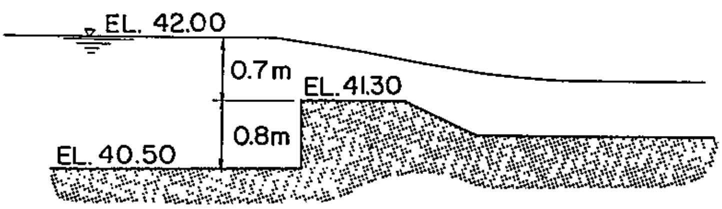
Figures for Dam No. 2 are equal to those for Dam No. 1, because the basis of design is the same.

(4) Intake

(a) Proposed capacity of Intake and Width of Intake

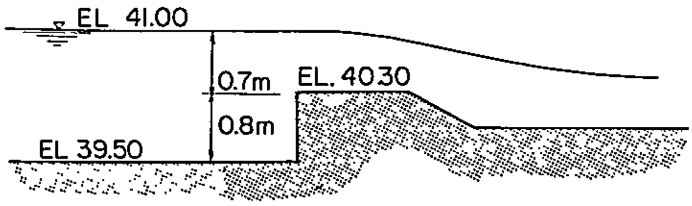
(i) Dam No. 1

Proposed water capacity of Intake	Q = 1.640 m/sec
Operating water level	EL. 42.00
Width of Intake	2.0 × 2 = 4.0 m
Breadth of Pier	0.6 m



(ii) Dam No. 2

Proposed water capacity of Intake	Q = 2.730 m/sec
Operating water level	EL. 41.00
Width of Intake	3.0 × 2 = 6.0 m
Breadth of Pier	0.6 m



(b) Hydraulic calculation

The drop of water surface at Intake is theoretically given as follows

$$4H = h_i + h_{sc} + h_s + h'_{sc} + h_f + h_t$$

where as $4H$: total drop

h_i : drop at entrance

h_{sc} : drop due to sudden reduction of hydraulic section

h_s : drop due to trash rack

h'_{sc} : drop due to gradual extension of hydraulic section

h_f : drop due to skin friction

h_t : drop due to gradual reduction of hydraulic section

The result of calculation is as follows:

(i) Dam No. 1

H = 0.127 (m) or, say 0.130 m

(ii) Dam No. 2

H = 0.115 (m) or, say 0.120 (m)

V. Design Data of Canals and Related Structures in Alangalang Area

TABLE OF HYDRAULIC CALCULATIONS

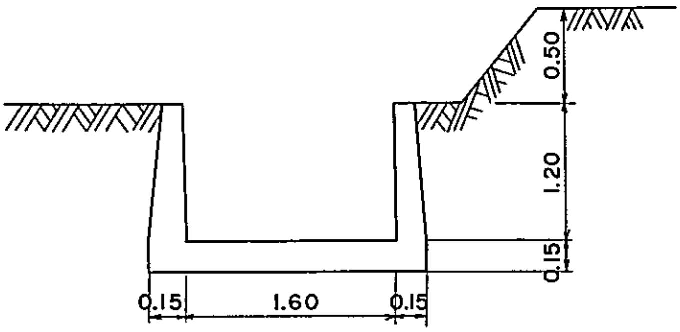
Name of canal	Hydraulic depth H	Coefficient of roughness n	Water area A	Wetted perimeter P	Hydraulic radius R	$R^{2/3}$	Hydraulic gradient I	$I^{1/2}$	Velocity V	Discharge Q
Link Canal	0.871	0.015	1.394	3.342	0.417	0.558	$\frac{1}{1,000}$	0.0316	1.177	1.641
Main Canal A	1.157	0.015	2.545	4.514	0.564	0.683	$\frac{1}{1,800}$	0.0236	1.073	2.731
Main Canal B	1.112	0.015	2.578	4.659	0.553	0.674	$\frac{1}{1,800}$	0.0236	1.059	2.730
Lateral A - I	1.112	0.015	2.578	4.659	0.553	0.674	$\frac{1}{1,800}$	0.0236	1.059	2.730
Lateral A - II	0.978	0.025	2.022	4.127	0.490	0.622	$\frac{1}{1,700}$	0.0242	0.602	1.215
Lateral A - III	0.713	0.025	1.155	3.121	0.370	0.515	$\frac{1}{1,400}$	0.0267	0.550	0.635
Lateral A - IV	0.643	0.025	0.769	2.368	0.324	0.472	$\frac{1}{1,100}$	0.0301	0.568	0.435
Lateral A - V	0.420	0.025	0.334	1.588	0.210	0.353	$\frac{1}{800}$	0.0354	0.497	0.170
Lateral A - VI	0.360	0.025	0.274	1.418	0.193	0.334	$\frac{1}{800}$	0.0354	0.450	0.130

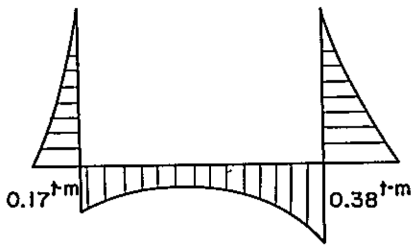
TABLE OF HYDRAULIC CALCULATIONS

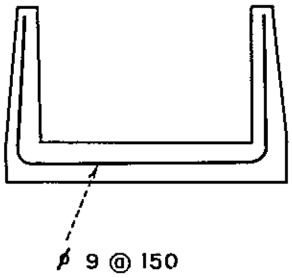
(Con't)

Name of canal	Hydraulic depth H	Coefficient of roughness n	Water area A	Wetted perimeter P	Hydraulic radius R	$R^{2/3}$	Hydraulic gradient I	$I^{1/2}$	Velocity V	Discharge Q
Lateral A1 - I	0.671	0.025	0.819	2.448	0.335	0.482	$\frac{1}{1,100}$	0.0316	0.580	0.474
Lateral A1 - II	0.604	0.025	0.637	2.158	0.294	0.443	$\frac{1}{1,250}$	0.0282	0.500	0.318
Lateral B - I	0.783	0.015	1.272	3.273	0.389	0.533	$\frac{1}{900}$	0.0333	1.183	1.501
Lateral B -II	0.394	0.025	0.333	1.564	0.213	0.357	$\frac{1}{900}$	0.0333	0.476	0.157

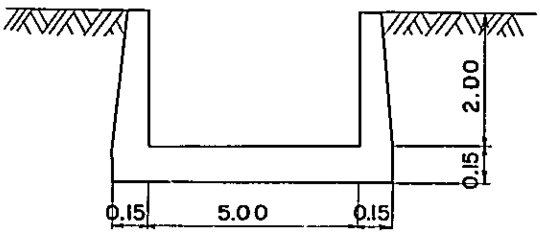
Proposed section, Bending moment and Reinforcement of Link Canal

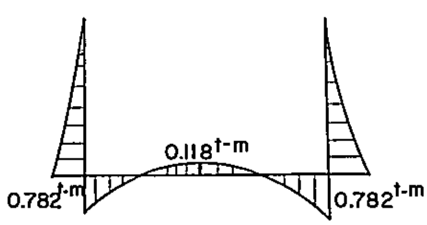


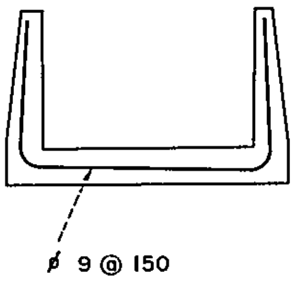




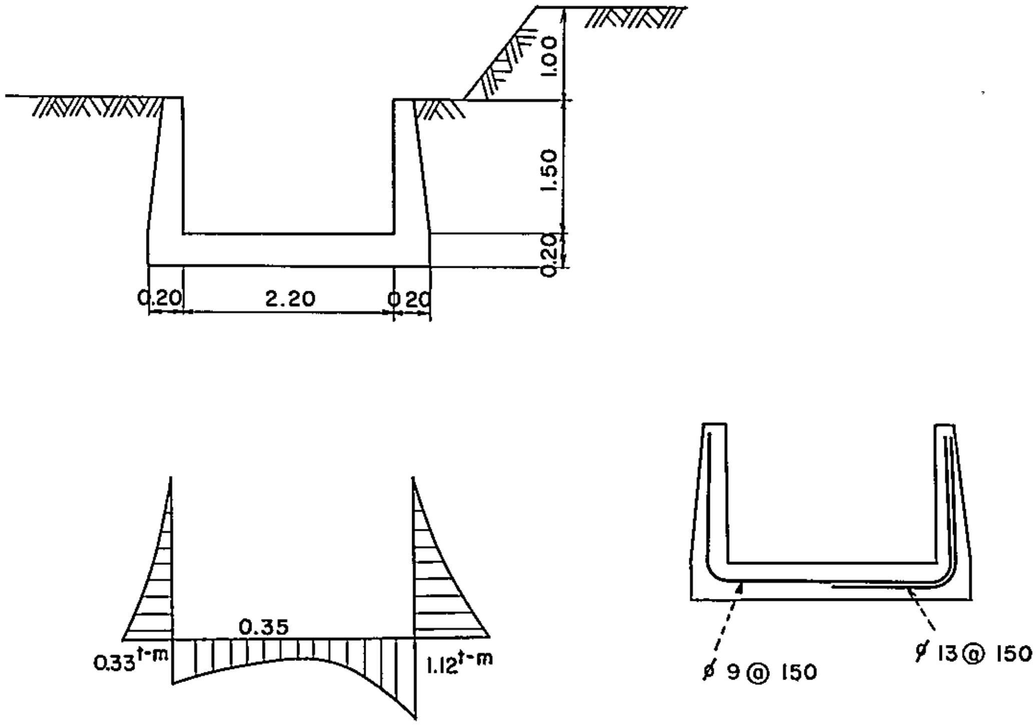
Proposed section, Bending moment and Reinforcement of Chute



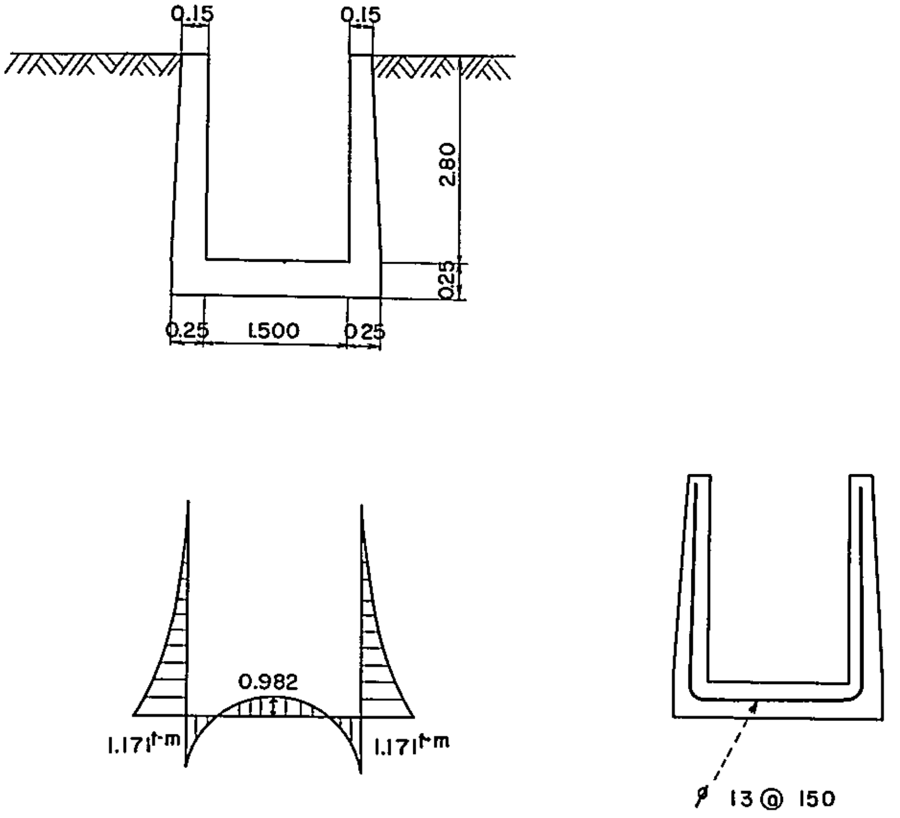




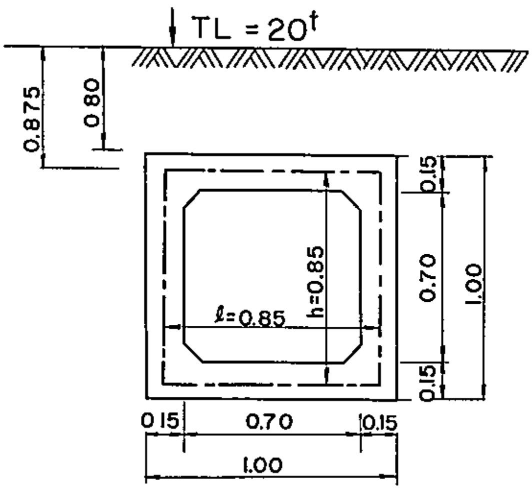
Proposed section, Bending moment and Reinforcement of Main Canal

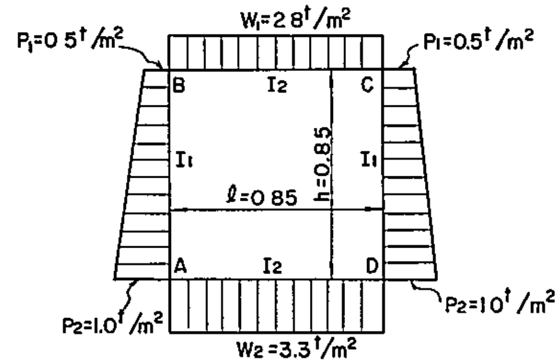


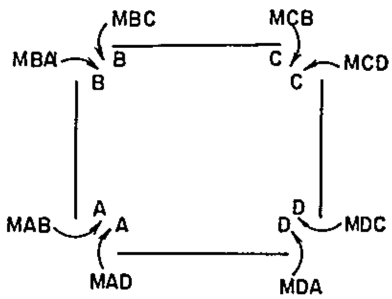
Proposed section, Bending moment and Reinforcement of Inlet or outlet of small syphon

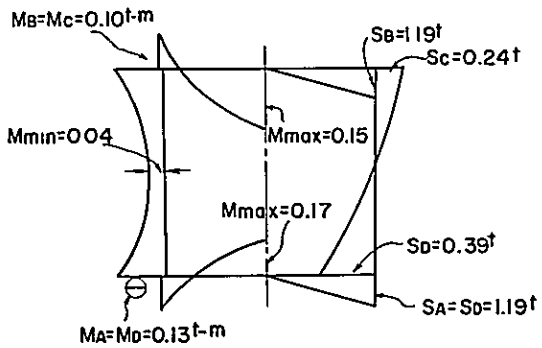


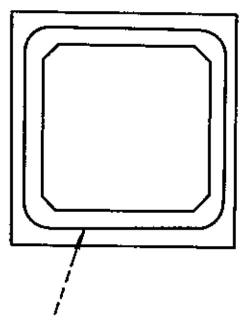
Proposed section, Loading, Bending moment, End moment, Shear strength and Reinforcement of Small Siphon Barrel



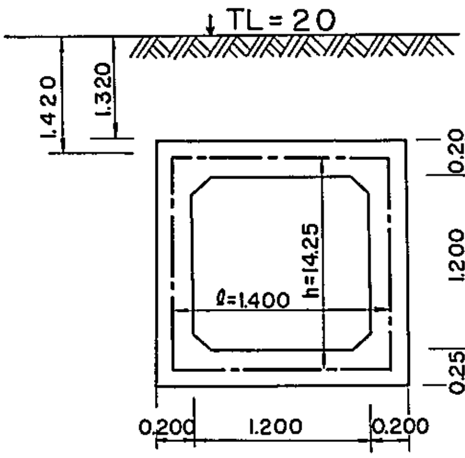


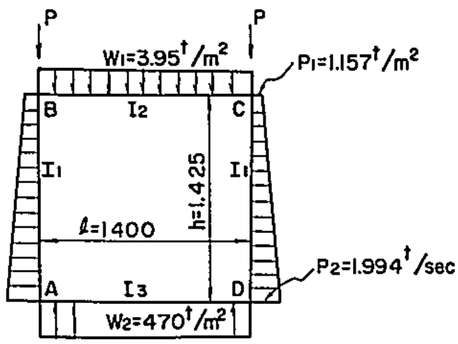


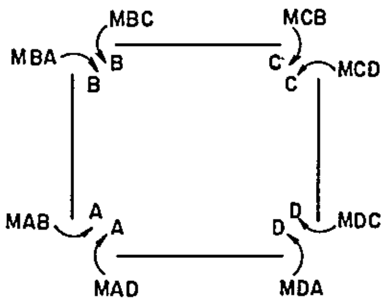


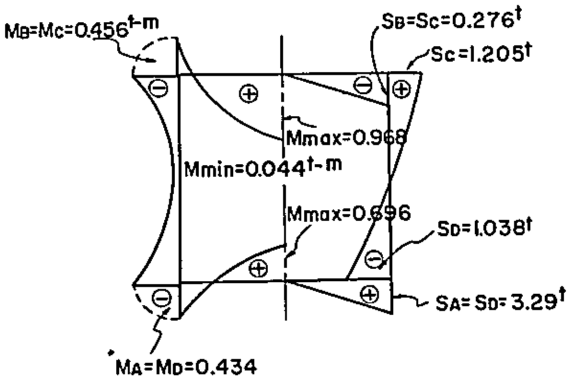


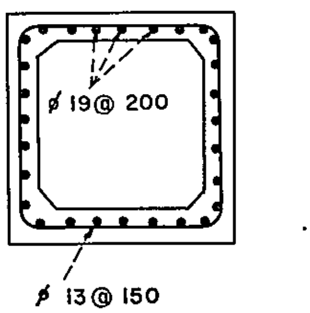
Proposed section, Loading, End moment, Shear strength, Reinforcement and Bending moment of Main Siphon.











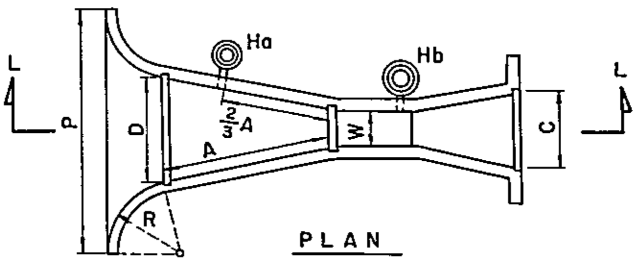
Division Works No. 1 and No. 2

The Parshall Flume consists basically of converging section, a throat, and a diverging section. The throat is inclined downward at a slope 9 vertical to 24 horizontal, while the diverging section has an inclination of the floor inversed, the slope being 1 vertical to 6 horizontal. The elevation of the floor downstream of the diversion section is 3 inches lower than the crest. The width of the throat ranges from 1 to 8 feet, and the lengths of the throat and of the diverging section are respectively 2 feet and 3 feet.

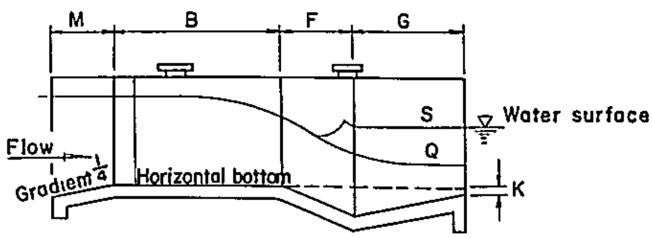
The flume is provided with two gauges : an upper gauge at two third point of the converging section and a lower gauge at the downstream end of the throat.

It is necessary to set these gauges with their zero point level with the crest.

The range of discharge of No. 1 is from 1.215 m^3/s to 1.501 m^3/s and of No. 2 is from 0.474 m^3/s to 0.635 m^3/s ; therefore dimensions of Parshall Flumes to be set at Division Works No. 1 and No. 2 are as follows.



PLAN



SECTION L-L

Dimension of Division Work No. 1

Mark	Dimension	Mark	Dimension
W	121.92	G	91.20
A	182.88	K	7.62
$\frac{2}{3}$ A	121.92	N	22.86
B	179.39	R	60.96
C	152.40	M	30.48
D	193.68	P	271.11
E	91.44	X	5.08
F	60.96	Y	7.62

Dimension of Division Work No. 2

Mark	Dimension	Mark	Dimension
W	60.96	G	91.20
A	152.40	K	7.62
$\frac{2}{3}$ A	101.60	N	22.86
B	149.47	R	50.48
C	91 44	M	38.10
D	120.65	P	195.44
E	91.44	X	5.08
F	60.96	Y	7.62

In addition to Parshall Flume, the division works are provided with two gates at head race, to control discharge of each lateral. So long as the reading of the lower gauge does not exceed 70% of the reading of the upper gauge, the discharge is free flow. Therefore, the discharge of free flow is obtained by the following table.

Table of free flow discharge for Parshall Flumes

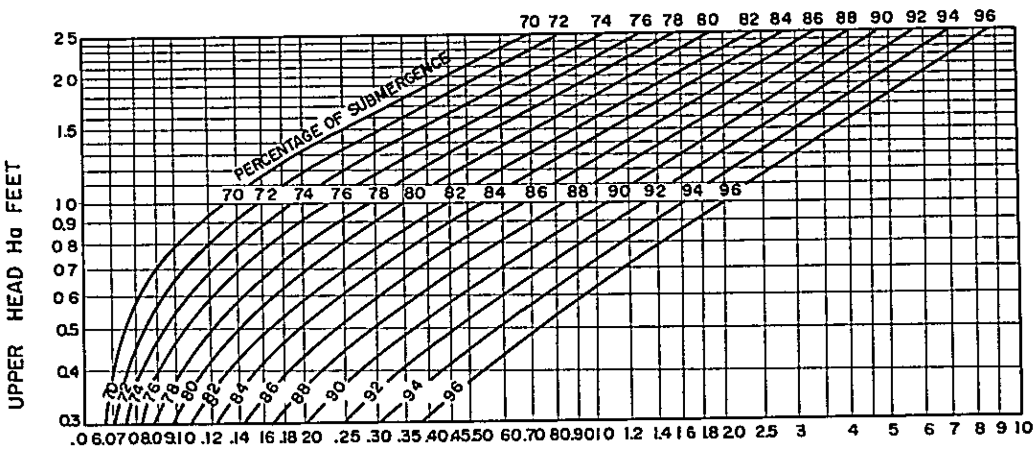
Division work No. 1				Division work No. 2			
Head		Discharge		Head		Discharge	
Feet	Meter	Cusec	m^3/s	Feet	Meter	Cusec	m^3/s
1.10	0.335	18.6	0.527	0.85	0.259	6.22	0.176
1.15	0.351	19.0	0.538	0.90	0.274	6.80	0.193
1.20	0.366	21.3	0.603	0.95	0.290	7.39	0.209
1.25	0.381	22.8	0.646	1.00	0.305	8.00	0.227
1.30	0.396	24.2	0.685	1.05	0.320	8.63	0.244
1.35	0.411	25.7	0.728	1.10	0.335	9.27	0.263
1.40	0.427	27.2	0.770	1.15	0.351	9.94	0.282
1.45	0.442	28.8	0.816	1.20	0.366	10.6	0.300
1.50	0.457	30.3	0.858	1.25	0.381	11.3	0.320
1.55	0.472	32.0	0.906	1.30	0.396	12.0	0.340
1.60	0.488	33.6	0.952	1.35	0.411	12.7	0.360
1.65	0.503	35.3	1.000	1.40	0.427	13.5	0.382
1.70	0.518	37.0	1.048	1.45	0.442	14.2	0.402
1.75	0.533	38.7	1.096	1.50	0.457	15.0	0.425
1.80	0.549	40.5	1.147	1.55	0.472	15.8	0.447
1.85	0.564	42.2	1.195	1.60	0.488	16.6	0.470
1.90	0.579	44.1	1.249	1.65	0.503	17.4	0.493
1.95	0.594	45.9	1.300	1.70	0.518	18.2	0.515
2.00	0.610	47.8	1.354	1.75	0.533	19.0	0.538
2.05	0.625	49.7	1.408	1.80	0.549	19.9	0.564
2.10	0.640	51.6	1.461	1.85	0.564	20.8	0.589
2.15	0.655	53.5	1.515	1.90	0.579	21.6	0.612
2.20	0.671	55.5	1.572	1.95	0.594	22.5	0.637
2.25	0.686	57.5	1.628	2.00	0.610	23.4	0.663
2.30	0.701	59.6	1.688	2.05	0.625	24.3	0.688
2.35	0.716	61.6	1.745	2.10	0.640	25.3	0.716
2.40	0.732	63.7	1.804	2.15	0.655	26.2	0.742
2.45	0.747	65.8	1.863	2.20	0.671	27.2	0.770

When the reading of the lower gauge is greater than 70 percent but less than 95 percent of the reading of the upper gauge, the discharge is submerged flow.

The correct amount of discharge can be obtained by subtracting from the free flow discharge in the above table the value read in the curves below multiplied by the K value in the following table.

TABLE OF FACTOR K

Width 'W'		Value of 'K'
Feet	Meter	
1.0	0.305	1.0
2.0	0.610	1.8
4.0	1.219	3.1
6.0	1.829	4.3
8.0	2.438	5.4



Hydraulic calculation of Wasteway Channel

The length of overflow weirs are calculated as follows.

$$Q = C\ B\ H^{3/2}$$

Where C : Coefficient of discharge (1.70)

H : Overflow depth

Q : Design discharge

B : Length of Weir

Manning formula should generally be used for wasteway channel.

The formula is as following

$$V = \frac{1}{n} I^{1/2} R^{2/3} \qquad Q = A \cdot V$$

Where V : Velocity in m/s

I : Slope of energy gradient

R : Hydraulic radius
(Water area divided by wetted perimeter)

n : Coefficient of roughness

The results of calculation are as shown in the following Table.

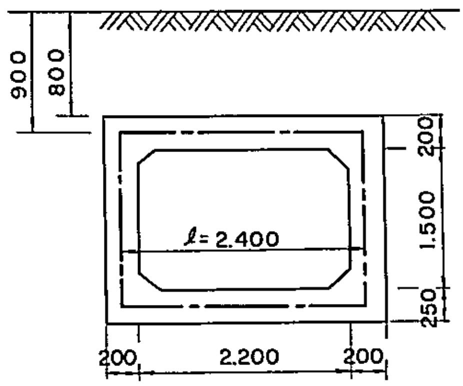
Table of Hydraulic Calculation of Weir Length

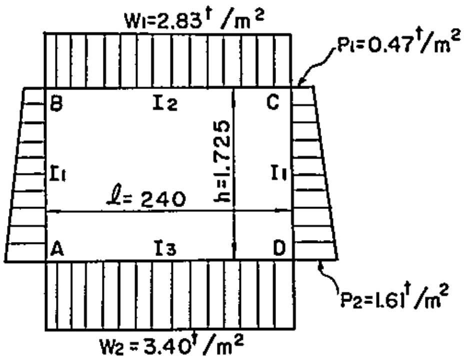
Name of wasteway	Design discharge	Overflow depth (H)	$H^{3/2}$	$B = \frac{Q}{1.70\ H^{3/2}}$
Wasteway No. 1	0.106	0.10	0.0316	2.00
Wasteway No. 2	0.200	0.10	0.0316	3.75
Wasteway No. 3	0.291	0.10	0.0316	5.50
Wasteway No. 4	0.144	0.10	0.0316	2.70
Wasteway No. 5	0.156	0.10	0.0316	2.90
Wasteway No. 6	0.318	0.10	0.0316	6.00
Wasteway No. 7	0.157	0.10	0.0316	3.00

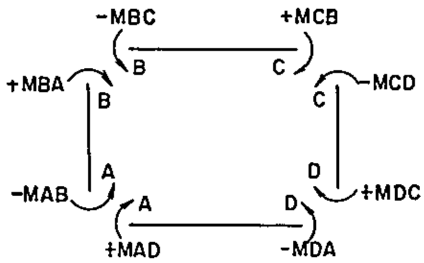
Table of Hydraulic Calculation of Wasteway Channel

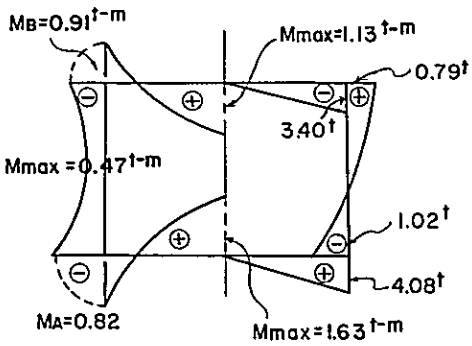
Name of wasteway	Assumed depth	Water area	Wetted perimeter	Hydraulic radius (R)	$R^{2/3}$	Hydraulic gradient (I)	$Q = A \frac{1}{n} I^{1/2} R^{2/3}$
Wasteway No. 1	0.24	0.142	1.029	0.138	0.266	0.005	0.107
Wasteway No. 2	0.37	0.266	1.396	0.190	0.331	0.003	0.204
Wasteway No. 3	0.32	0.214	1.255	0.171	0.308	0.004	0.125
Wasteway No. 4	0.26	0.159	1.059	0.147	0.278	0.005	0.125
Wasteway No. 5	0.31	0.205	1.227	0.167	0.303	0.004	0.157
Wasteway No. 6	0.49	0.461	1.836	0.251	0.398	0.002	0.328
Wasteway No. 7	0.32	0.214	1.255	0.171	0.308	0.004	0.167

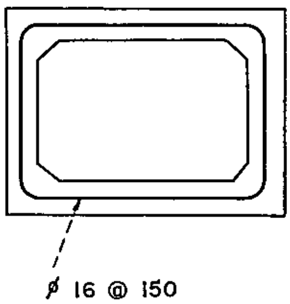
Proposed section, Loading, Bending moment, Fixed end moment, Shear Strength and Reinforcement of Culvert











VI. Design Data of Check Gate and Canals in San Miguel Area

A. Hydraulic Computation (for the San-Miguel Area)

I. Hydraulic Computation of Check Gate

I-1. Sluice way and fixed weir

Hydraulic features of Lukay Creek adjacent to the check gate are as follows.

S : 1/1,000

N : 0.07

V : 0.60 m/sec.

Q : 24.6 m^3/sec.

F.W.S : 20,800 m

I-1-1. Computation of sluice way

Overflow discharge after completion of sluice way is assumed as follows.

$$Qn = 7.00\ m^3/sec.$$

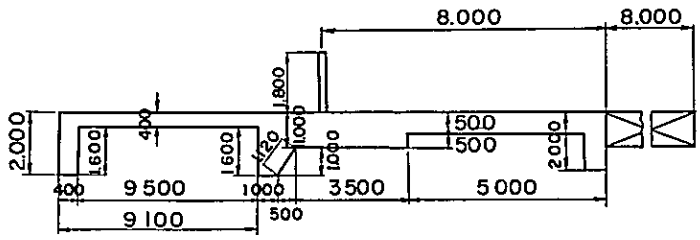
(a) Length of fore apron

Length of fore apron is computed on the basis of Bligh's formula.

$$\ell_1 = 0.6C\sqrt{Ha}$$

$$= 0.6 \times 12 \times \sqrt{1.8}$$

$$= 9.65\ m$$



Length of fore apron of sluice way is decided at 8.00 meters to align the ends with fore apron of fixed weir and the shortage of length is sufficiently supplemented by the creep length of rear apron.

(b) Computation of length of floor protection

Total length ℓ of apron length ℓ_1 and floor protection length ℓ_2 is as follows.

$$\ell = 0.67C\sqrt{Ha \times qn} = 0.67 \times 12 \times \sqrt{18 \times \frac{7.00}{3.00}}$$

$$= 16.00 \text{ m}$$

Where q_n : projected flood discharge of a unit width of sluice way.

Then $\ell_2 = 16.00 - 8.00 = 8.00$ m.

(c) Creep length

Minimum required creep length is computed by the following formula.

$$L = C.H = 12 \times 1.80 = 21.60 \text{ m}$$

on the other hand, $L - \ell = 21.60 - 8.00 = 13.60$ m.

The length of this difference is supplemented by the rear apron.

(i) Bligh's method

Creep length is as follows.

$$\Sigma L = 2.00+0.40+1.60+9.10+1.60+1.00+1.12+3.50+0.5+5.00$$

$$= 25.82 \text{ m.}$$

$$L = C.H = 12 \times 1.80 = 21.60 < 25.82 \text{ m.}$$

(ii) Lane's method

Weighted creep length is as follows.

$$L = \Sigma L_V + 1/3 \ \Sigma L_H$$

$$= (2.00+1.60+1.60+1.12+0.5) + 1/3(9.50+5.00+5.00)$$

$$= 13.32 \text{ m.}$$

Then, in either cases it is on safety side.

(d) Computation of thickness of fore apron.

$$t = \frac{4}{3} \times \frac{H - h}{r - 1}$$

where H : 1.80 m

L : 25.82 m

L' : Creep length to the end of fixed weir

2.00+0.40+1.60+9.10+1.6+1.00+1.12+3.50 = 20.32

h : $\frac{H}{L}$ L' = $\frac{1.80}{25.82} \times 20.32 = 1.41$ m

r : 2.4 concrete's specific gravity

then $t = \frac{4}{3} \times \frac{1.8-1.41}{2.4-1} = 0.37$ m

taking allowance, it's decided 0.50 m.

I-1-2. Computation of fixed weir

Overflow discharge after completion of fixed weir is assumed as follows.

Qm = 17.6 m^3/sec.

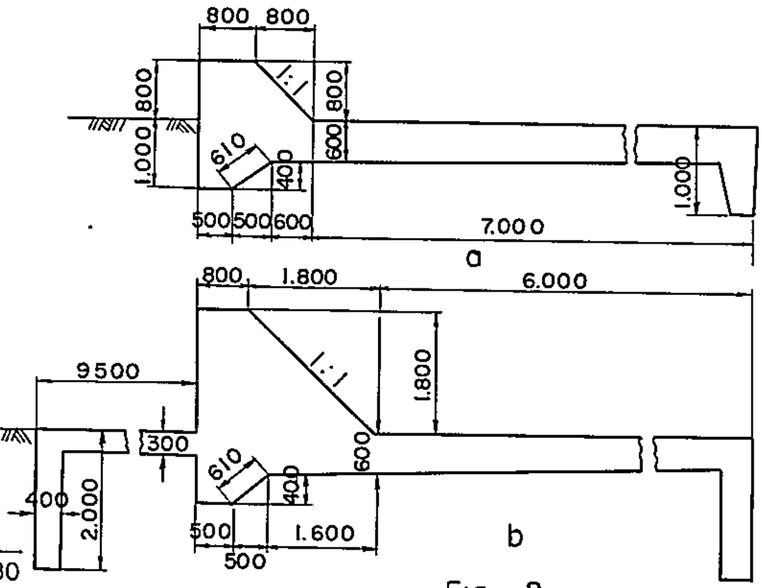


Fig – 2

(a) Length of fore apron

From Bligh's formula

$\ell_1 = 0.6\ C \sqrt{Ha}$

$= 0.6 \times 12 \times \sqrt{0.80}$

$= 6.41 = 7.00$ m

taking a little allowance, it's decided 7.00 m.

(b) Computation of length of floor protection.

From Bligh's formula

$$\ell \fallingdotseq 0.67\ C\sqrt{Ha.qm} = 0.67 \times 12 \times \sqrt{18 \times \frac{17.60}{16.50}} = 7.42 \text{ m}$$

where, qm : projected flood discharge of a unit width of fixed weir.

then $\ell_2 = \ell - \ell_1 = 7.42 - 7.00 = 0.42$ m.

The length of 0.42 m is neglected, but in case of type b in Fig. 2, the same length of floor protection of 8.00 m as sluice way is designed.

(c) Computation of creep length

Of types a and b, computation is made of type a, which is considered on the danger side.

Minimum required creep length is as follows.

$$L = C.H = 12 \times 0.8 = 9.60 \text{ m}$$

on the other hand, $L - \ell = 9.60 - 7.00 = 2.60$ m.

The length of this difference is supplemented by the cut off on up stream side.

(i) Bligh's method

Creep length is as follows.

$$L = 1.00 + 0.50 + 0.61 + 0.60 + 7.00 = 9.71 \text{ m.}$$

$$L = C.H = 12 \times 0.80 = 9.60 < 9.71 \text{ m}$$

(ii) Lane's methos

$$L = \Sigma L_V + 1/3 \Sigma L_H = (1.00+0.61) + 1/3\ (0.50+0.60+7.00)$$

$$= 4.31 \text{ m}$$

then in either case it is on safety side.

(d) Computation of thickness of fore apron

$$t = \frac{4}{3} \times \frac{H-h}{r-1}$$

where
H : 0.80 m
L : 9.71 m
L': 1.00 + 0.50 + 0.61 + 0.60 = 2.71 m
h : $\frac{H}{L} L' = \frac{0.80}{9.71} \times 2.71 = 0.223$ m
r : 2.40

then

$$t = \frac{4}{3} \times \frac{0.80-0.223}{2.4 - 1} = 0.548$$

taking allowance, it's decided at 0.60 m.

I-2. Intake

I-2-1. Conditions

1. Intake; intake of full supply discharge $Q = 1.344\ m^3/sec.$
2. Operating water level $EL = 19{,}450$ m
3. Width $B = \frac{1.344}{0.75 \times 0.90} = 2{,}00$ m
4. Entrance velocity $V = 0.900$ m/sec.
5. Bottom elevation $EL = 18{,}700$ m.

I-2-2. Drop of water surface at intake

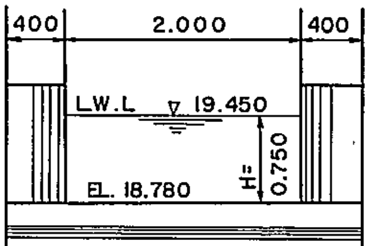


Fig - 1

(a) Drop of water surface by inlet : h_1

Inlet is assumed as the section in Fig. 1.

Approaching velocity is assumed as $V_1 = 0$, because the creek flow at inlet is static during drawing water.

$$h_1 = \frac{V_2^2}{2g}(1 + f_1)$$

$$= \frac{0.900^2}{2 \times 9.8}(1 + 0.2)$$

$$= 0.049 \text{ m.}$$

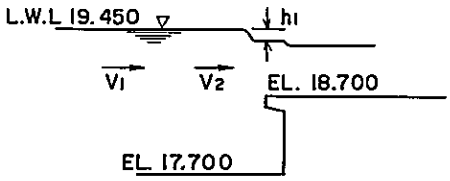


Fig - 2

f_1 : coefficient of inlet loss, for circular shape

$f_1 = 0.2$

then dropped water surface is

19.45 - 0.049 = 19,401 m.

(b) Drop of water surface by abrupt rise : h_2

$$h_2 = f_2 \frac{V_2^2}{2g} + \frac{V_2^2 - V_1^2}{2g}$$

$V_1 = \cdot 0$

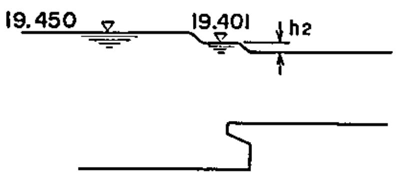


Fig - 3

f_2 : Coefficient of abrupt rise loss.

$f_2 = 0.5$ for angular shape

then $h_2 = f_2 \frac{V_2^2}{2g}$

$= 0.5 \times \frac{0.900^2}{19.6} = 0.021$

accordingly, dropped water surface is

19,401 - 0.021 = 19,380 m.

(c) Drop of water surface by trash screen : h_3

$$h_3 = \beta \sin\theta \left(\frac{t}{d}\right)^{4/3} \times \frac{V_1^2}{2g}$$

where β : coefficient by screen shape $\beta = 2.34$

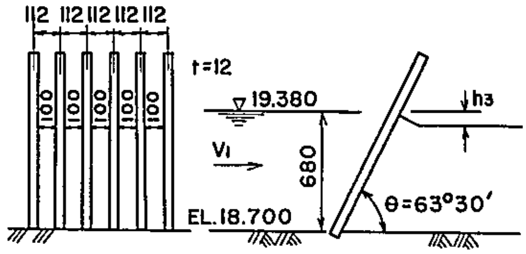


Fig − 4

θ : inclination angle of screen

$\theta = 63°30'$ $\sin\theta = 0.895$

t : thickness of screen flat bar

t = 12 mm

d : space of screen flat bar

d = 100 mm

V_1 : upstream's velocity of screen

$V_1 = \frac{1.344}{0.68 \times 2.00} = 0.988$ m/sec.

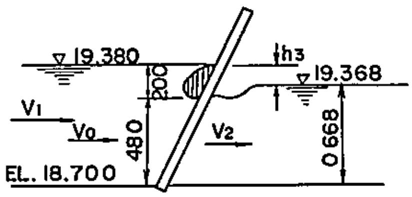
The value of V_1 applies where trash has not been caught.

If trash sticks to the screen bar for 20 cm in depth,

$V_o = \frac{V_1 H_1}{H_o}$

$= \frac{0.988 \times 0.680}{0.480}$

$= 1.400$ m/sec.



Fig−5

then

$$h_3 = 2.34 \times 0.895 \times \left(\frac{12}{100}\right)^{4/3} \times \frac{1.40^2}{19.6}$$

$$= 2.094 \times 0.0592 \times 0.1 = 0.012 \text{ m}$$

accordingly

dropped water surface is

19,380 - 0.012 = 19,368 m

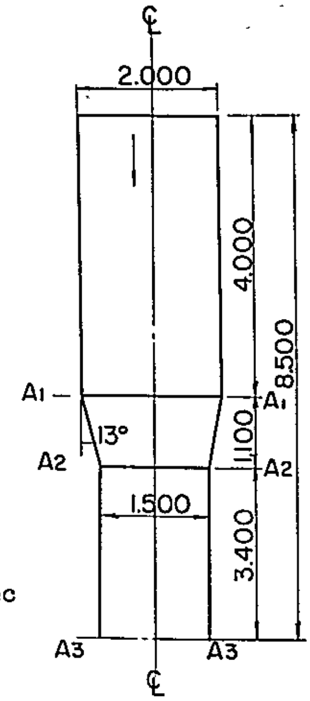


Fig.6

(d) Drop of water surface by abrupt contraction of section : h_4

$$h_4 = f_3 \frac{V_2^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$$

where, f_3 : $\frac{A2}{A1} = \frac{1,500 \times 0.768}{2.00 \times 0.668} = 0.83$

then $f_3 = 0.15$

V_2 : $V_2 = \frac{1.344}{1.50 \times 0.768} = 1.16$ m/sec

V_1 : 0.97 m/sec.

then $h_4 = 0.15 \times \frac{1.16^2}{19.6} + \frac{1.16^2 - 0.97^2}{19.6} = 0.031\text{m}$

Accordingly,

the water level of section A_2-A_2 is

19,368-0.031 = 19,337 m

(e) Drop of water surface by friction : h_5

$$h_5 = n^2 \frac{V^2}{R^{4/3}} L$$

$$= 0.015^2 \times \frac{1.16^2}{0.38^{4/3}} \times 8.50$$

$$= 0.008 \text{ m}$$

then

dropped water surface is

19,337 m - 0.008 m = 19,329 m.

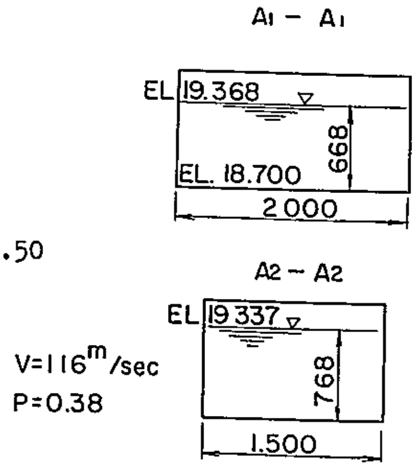


Fig. 7

(f) Total drop of water surface

Drop of water surface by inlet	h_1	= 0.049 m
" by abrupt rise	h_2	= 0.021
" by trash screen	h_3	= 0.012
" by abrupt contraction	h_4	= 0.031
" by friction	h_5	= 0.008
+)		
Sub-total		0.121
Others and allowance +)		0.029
Total		0.150

Then, beginning water level of

lateral A is,

19,450 - 0.150 = 19,300 m

and bottom elevation is

19,300 - 0.768 = 18,532 m

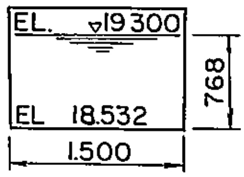


Fig. 8

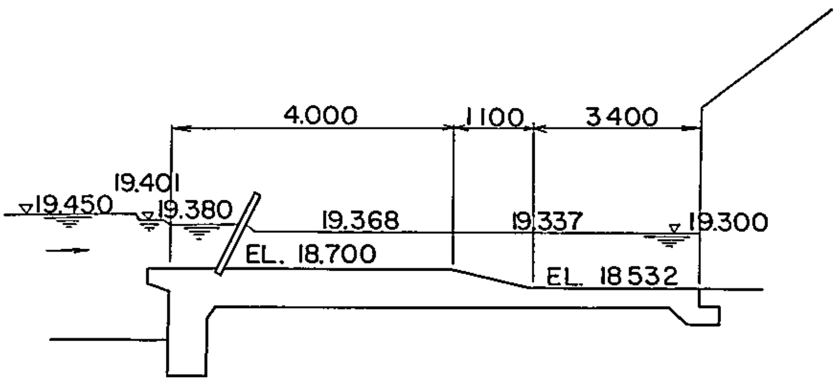


Fig. 9 General profile

I-3. Hydraulic Computation for Irrigation Canal

(a) Conditions for Design

Manning's formula $V = \frac{1}{n} I^{1/2} R^{2/3}$

Coefficient of roughness	Concrete lining canal	n = 0.015
	Earth canal	n = 0.025
Allowable maximum velocity	Concrete lining canal	V< 1.20 m/sec
	Earth canal	V< 0.70 m/sec

Coefficient of water depth and bottom width

of most effective cross-section.

(1) In case side slope = 1:00

Water depth $H = 0.707 \sqrt{A}$

Bottom width $B = 1.414 \sqrt{A}$

(2) In case side slope = 1 : 1.0 $H = 0.740 \sqrt{A}$

$B = 0.613 \sqrt{A}$

(3) In case side slope = 1 : 1.5 $H = 0.689 \sqrt{A}$

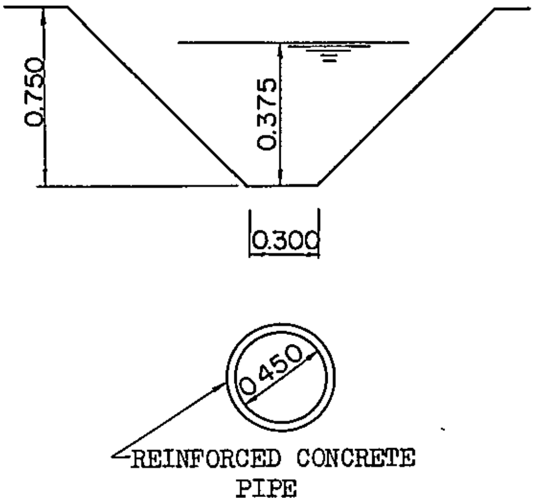
$B = 0.417 \sqrt{A}$

By the above coefficients, the width of the bottom and the depth of water of the hydraulically most advantageous section is obtained, and, by rounding off the figure of the width of the bottom, the slope was obtained. The figure of the slope was rounded off and the normal depth was obtained. The results so obtained are shown in the following table.
As to lateral B, bottom slope is found in accordance with the ground slope and is not found by the most effective cross section.

(b) Results of computations

Irrigation system	Name of canal	Section	Side slope	Discharge (Q) m³/sec	Bottom width (D) m	Water depth (H) m	Flow area (A) m²	Velocity (V) m/sec	Bottom slope (I)	Linning
A	I	Rectangular	1:0	1.344	1.50	0.768	1.152	1.167	1/900	Concrete Linning
	II	Trapizad	1:15	1.344	0.60	0.962	1.965	0.684	1/300	Earth canal
	III	"	1:15	1.015	0.55	0.834	1.502	0.676	1/1100	"
	IV	"	1:15	0.713	0.45	0.704	1.060	0.673	1/900	"
	V	"	1:1	0.346	0.45	0.525	0.512	0.676	1/600	"
A_1	I	"	1:1	0.329	0.45	0.513	0.494	0.666	1/600	"
	II	"	1:1	0.090	0.30	0.287	0.168	0.534	1/450	"
	III	"	1:1	0.048	0.30	0.208	0.106	0.454	1/450	"
B	I	"	1:1	0.165	0.30	0.375	0.253	0.652	1/400	"
	II	"	1:1	0.045	0.30	0.173	0.082	0.549	1/250	"

1.4. Hydraulic Computation of the inverted siphon of Lateral B across the national road.



$Q = 0.165$

$V_1 = 0.693$

$A_1 = 0.238$

$D = 0.450$

$$A_2 = \frac{\pi D^2}{4} \quad \frac{3.14 \times 0.450^2}{4} = 0.159$$

$$V_2 = \frac{Q}{A^2} = \frac{0.165}{0.159} = 1.038$$

Drop of water surface at inlet

$$h_i = f_i + \frac{(V_2^2 - V_1^2)}{2g}$$

$$\text{where} \quad f_i = 0.50 \times \frac{V_2^2}{2g} = 0.50 \times \frac{1038^2}{196} = 0.028$$

$$= 0.028 + \frac{(1.038^2 - 0.693^2)}{196} = 0.028 + 0.030 = 0.058$$

Screen loss $\quad h_s = 0.006$

Friction loss by pipe

$$h_f = f.\ L.\ \frac{V_2^2}{2g}$$

$$\text{where} \quad f = \frac{1245 \times n^2}{D^{4/3}} = \frac{1245 \times 0.016^2}{0.3448} = 0.092$$

$L = 20.00$ m

$$h_v = \frac{V_2^2}{2g} = \frac{1.038^2}{19.6} = 0.055$$

$$= 0.092 \times 20.00 \times 0.055 = 0.101$$

Drop of water surface at outlet

$$h_u = 1.0 \times \frac{V_2^2}{2g} = 1.0 \times \frac{1.038^2}{19.6} = 0.055$$

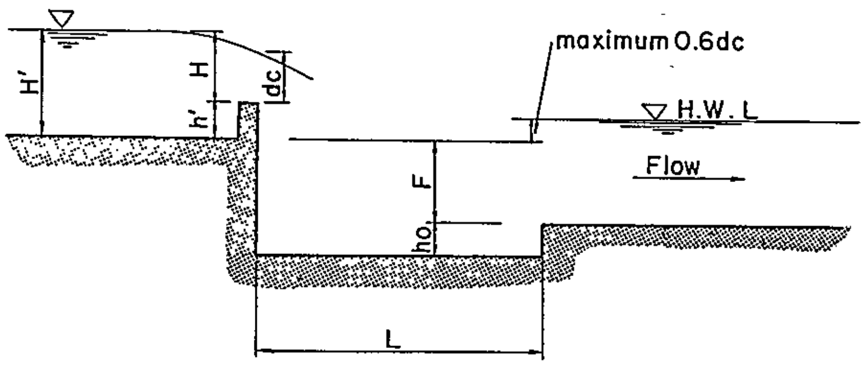
Total drop of water surface

$$\Sigma h = h_i + \text{screen} + h_f + h_v$$

$$= 0.058 + 0.006 + 0.101 + 0.055 = 0.220 \text{ m}$$

I-5. Hydraulic Computation of Drop of Irrigation Canal.

(a)



$$Q = C.\ B.\ H^{3/2}$$

C: Coefficient of overflow = 2.0

B: Width of overflow

H: Overflow depth

$$dc = \sqrt[3]{\frac{Q^2}{gB^2}}$$

dc: Critical water depth

Q: Discharge

B: Width of overflow

g: Acceleration of gravity = 9.8 m/sec^2

$$L = \left[2.5\times1.1\frac{dc}{F} + 0.7\left(\frac{dc}{F}\right)^3 \right]\sqrt{F\cdot dc}$$

L: Length of stilling basin

F: Difference between both bottom elevations in drop

$$ho \geqq \frac{dc}{2}$$

$$h' = H' - H$$

h': Height of weir not to prevent back water

H': Upstream water depth

H : Overflow depth

Computed results are as follows.

(b) Computed Results

Canal		Name of drop	Station	Discharge Q (m³/sec)	Weir width B (m)	Drop F (m)	H (m)	h' (m)	dc (m)	L (m)	ho (m)
Irrigation system	Name										
Lateral A	III	No.1 No.2	No.1 +206.9 No.1 +586.9	1.015	1.00	1.00	0.634	0.20	0.472	2.30	0.25
	IV	No.3	No.2 +646.9	0.713	0.90	1.00	0.539	0.165	0.400	2.05	0.25
	V	No.4	No.3 +46.9	0.346	0.75	1.00	0.375	0.150	0.279	1.70	0.15
Lateral	I	No.1	No.0 +520	0.165	0.50	0.70	0.282	0.093	0.223	2.50	0.300

I-6. Hydraulic Computation of Division Work

Division work serving also as drop work is computed as drop work.

Name of division work	Station	Divided discharge Q m³/sec	Weir Width B m	Drop F m	H m	h' m	dc m	L m	ho m	Remarks
No. 1	Lateral A I.P.4	1.015								Without head
		0.329	1.85	0.20	0.199	0.314	0.148	1.50	0.20	
No. 2	Lateral A_1 I.P.3	0.090	1.00	0.60	0.127	0.386	0.094	1.00	0.05	
		0.165	1.00	0.20	0.190	0.323	0.140	1.00	0.075	

I-7. Hydraulic Computation of Waste Way

Width of overflow weir $Q = C.B.H^{3/2}$ $C = 1.7$

Waste way $Q = A.V$ $V = \frac{1}{n} R^{2/3} I^{1/2}$ $n = 0.025$

$V \leqq 0.80$ m/sec

Waste way is computed by the same method as the hydraulic computation of irrigation canal.

Name	Q	Overflow Weir		Waste Way					Side slope
		H	B	A	P	R	I	V	
Lateral A No.1	m/sec 0.329	m 0.100	m 6.500	m^2	m	m		m/sec	
Lateral A No.2	0.302	0.100	6.000	0.398	1.706	0.233	$\frac{1}{400}$	0.759	1:1.0
Lateral A No.3	0.367	0.100	7.000	0.461	1.836	0.251	$\frac{1}{400}$	0.796	1:1.0
Lateral A No.4	0.346	0.100	6.500						
Lateral A_1 No.1	0.074	0.100	1.500	0.109	0.900	0.121	$\frac{1}{200}$	0.682	1:1.0
Lateral A_1 No.2	0.042	0.100	1.000	0.055	0.664	0.083	$\frac{1}{100}$	0.759	1:1.0
Lateral A_1 No.3	0.048	0.115	0.700	0.074	0.752	0.098	$\frac{1}{150}$	0.652	1:1.0
Lateral B No.1	0.105	0.100	3.500						
Lateral B No.2	0.045	0.113	0.700	0.066	0.716	0.092	$\frac{1}{150}$	0.682	1:1.0

II. Design of drainage canal

(a) Decision of canal section

1. Rainfall

Maximum daily precipitation probability

(from attached information)

Maximum daily precipitation on a 10 year probability basis is adopted.

2. Runoff coefficient is taken 60%

3. Duration of drainage is 2 days

4. Catchment area is 113.5 ha.

5. Determination of drainage discharge

$$- Q = \frac{113.5hu \times 0.249m \times 0.6}{60sec \times 60sec \times 24h \times 2day} = 0.984\ m^3/sec \quad 1.0\ m^3/sec.$$

6. Decision of canal section

By the same computation as in the case of irrigation canal, the section is as follows.

Name	Discharge	Section	Bottom width	Water depth	Bottom slope	Side slope	Velocity
Drai-nage canal	m^3/sec 1.00	Trapi-zoid	m 0.50	m 0.823	1/1100	1:1.5	m/sec. 0.691

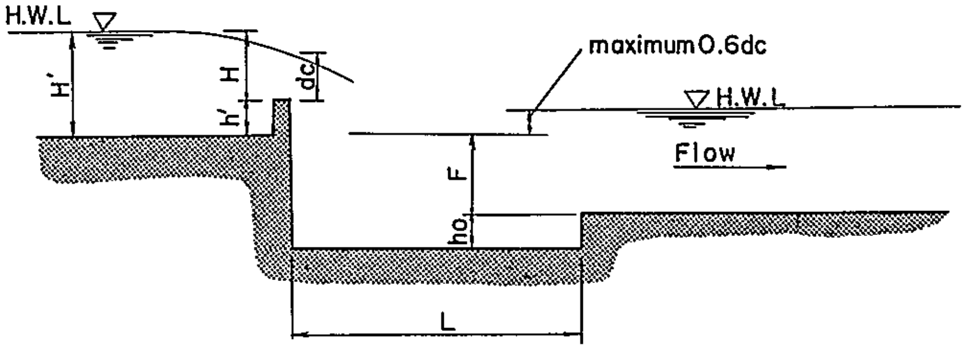
Coefficient of roughness: n = 0.025 for earth canal

(b) Hydraulic computation of drop work

The results from the same computation as in the case of irrigation canal are as follows.

Name of drop	Station	Discharge Q m^3/sec	Weir width B m	Drop of bottom F m	H m	h' m	dc m	L m	ho m
No.1	No.0 +100	1.00	1.00	0.80	0.73	0.10	0.468	2.20	0.25
No.2	No.0 +400	1.00	1.00	0.80	0.73	0.10	0.468	2.20	0.25

Method of computation



$$Q = C.B.H^{3/2} \qquad C : 20$$

$$dc = \sqrt{\frac{Q^2}{gb^2}} \qquad g : 9_q$$

$$L = \left[2.5 + 1.1 \frac{dc}{F} + 0.7 \left(\frac{dc}{F}\right)^3 \right] \sqrt{Fdc}$$

$$ho \geqq dc/2$$

$$h' = H' - H$$

VII. Present Condition of Agriculture in the Project Area

Present Condition of Agriculture in the Project Area

1. Area Coverage

The project in San Miguel-Alangalang covers the barrios and sitios of Cavite, Lourdes, Patong, Binutong, Lukay, Burseth, Aliconob, Bubunao, Hupit in Alangalang, and Lukay, Barian, Cargynato, Tanghas, Minogbinog, Malaguinabot, Malipuran, Cabatianuhan, Squatter, Guincianan in San Miguel, embracing an area of around 1,540 hectares. (Per engineering survey - 1,430 hectares.)

2. Number of Households

In Alangalang, there are 184 families operating farms within the project area, while 159 farming families are in the area of the San Miguel production center.

3. Landowners

A total of 174 landowners own land in the project area. Some 84 percent of them own less than 10 hectares.

4. Major Utilization of Land

Farmland constitutes 91 percent of the total area. Other land which is not used for productive purposes amounts to only 8 percent of the project area. Around 24 hectares are devoted to residential use, distributed in barrio residential quarters. Of all the barrios covered by the project, only the barrio of Burseth has a recognizable form of community.

With regard to the area distribution of the cropland, rice fields and corn fields account for 66 percent of the area.

5. Tenure, Number and Area of Farms

The number of farming families totals 343, and they are divided into (a) Full owners, 27 percent; (b) part owners, 1 percent, and (c) share tenants, 72 percent. The total area of the farmland is 1,398 hectares, of which 48 percent belongs to full owners and 52 percent to share tenants, and a small area is under partownership. The average area of the farm in the project area is 4.1 hectares. It is less in San Miguel than in Alangalang, where it is 4.4 hectares for each farming family.

6. Palay Production

The palay crop area in the San Miguel-Alangalang project totals 667 hectares. For the crop year 1966-67, the average yield per hectare for all crops was 20.9 cavans. By municipality, rice productivity in Alangalang is higher than in San Miguel. There is a yield difference of 6.4 cavans in the favored places in the Alangalang area.

7. Cost of Palay Production

The average cost of production of palay in the irrigated lowland in Leyte Del Norte amounts to 390 pesos per hectare. In the non-irrigated lowland, it is ₱291. The toal farm expenses for upland rice is at least ₱232 per hectare.

(Note: Higher productivity increases farm operation costs per unit area. Generally speaking, the additional expenses go to the care, harvesting and threshing of the crops. The share of harvester-thresher in Leyte del Norte ranges from 1/7 to 1/6 of the produce, paid in kind and valued at current market price.)

1. Number of landowners and size of land owned in the San Miguel-Alangalang area, Leyte, 1967.

Size of owner-ship in hectares	Number of landowners	Distribution (percent)	Area of land in hectares	Distribution (percent)
Under 5.0	115	66.1	210	13.6
5.0 - 9.9	31	17.8	202	13.1
10.0 - 24.9	18	10.3	273	17.7
25.0 - 49.9	4	2.3	124	18.1
50.0 - 99.9	2	1.2	117	7.6
100.0 - 199.9	4	2.3	614	39.9
200.0 and over	-	-	-	-
TOTAL	174	100.0	1,540	100.0

2. Number and area of farms by tenure, San Miguel-Alangalang Area, Leyte, 1967.

Tenure	Number of farms	Area of farmland in hectares
Full Owner	91	666
Part Owner	4	13
Share Tenant	248	719
TOTAL	343	1,398

2.1 Number and area of farms by tenure, by municipality, San Miguel-Alangalang Area, Leyte, 1967

Municipality	Number of farms				Area of farmland (Has.) 1/			
	Total	Full owner	Part owner	Share tenant	Total	Full owner	Part owner	Share tenant
San Miguel (percent)	159 (100.0)	41 (25.8)	2 (1.3)	116 (72.9)	595 (100.0)	203 (34.1)	7 (1.2)	385 (64.7)
Alangalang (parcent)	184 (100.0)	50 (27.2)	2 (1.1)	132 (71.70)	803 (100.0)	463 (57.7)	6 (0.7)	334 (41.6)
T O T A L (Percent)	343 (100.0)	91 (26.5)	4 (1.2)	248 (72.3)	1,398 (100.0)	666 (47.6)	13 (0.9)	719 (51.5)

1/ *Including home lots.*

2.2 Average area of farmland by tenure, by municipality, San Miguel-Alangalang Area, Leyte, 1967

Municipality	Average area of farmland (hectares)	Average area of farm in hectares by tenure		
		Full owner	Part owner	Share tenant
San Miguel	3.7	4.9	3.4	3.3
Alangalang	4.4	9.3	3.0	2.5
Average for Project Area	4.1	7.3	3.2	2.9

3. Area and percentage by major utilization of land, by municipality, San Miguel Alangalang Area, Leyte, 1967

Land Use	San Miguel		Alangalang		Total	
	Area (hectares)	Distribution (percent)	Area (hectares)	Distribution (Percent)	Area Has.	Dist. (%)
Homelot	8	1.3	16	1.7	24	1.5
Farmland	595	93.8	803	88.7	1,398	90.8
Other land	31	4.9	87	9.6	118	7.7
TOTAL	634	100.0	906	100.0	1,540	100.0

3.1 Area and percentage by crop, San Miguel Alangalang Area, Leyte, 1967

	Area (hectares)	Distribution (percent)
P a l a y	595	42.6
C o r n	327	23.4
Coconut	345	24.7
Fruit Trees	6	0.4
Vegetables and Root Crops	20	1.4
Other Crops	27	1.9
Uncultivated	78	5.6
T O T A L	1,398	100.0

4. Palay production by municipality San Miguel-Alangalang Area, Layte, 1967

Type of Crop	Area (hectares)	Production (sacks of 44 kilos)	Yield per hectare (sacks of 44 kilos)
San Miguel	356	6,370	17.9
Lowland First Crop a/	356	6,370	17.9
Lowland Second Crop c/	-	-	-
U p l a n d b/	-	-	-
Alangalang	311	7,550	24.3
Lowland First Crop a/	239	5,860	24.5
Lowland Second Crop c/	72	1,690	23.5
U p l a n d b/	-	-	-
T O T A L	667	13,920	20.9

a/ Non-irrigated.

b/ Corn was planted in upland area instead of palay.

c/ An area of 29 hectares normally utilized for lowland second crop was not planted during the crop year 1966-1967.

5. Average Cost of farm operations in Leyte del Norte

Farm operation and other expenses		Average cost of production per hectare 1/		
		Lowland irrigated	Lowland non-irrigated	Upland
		Pesos	Pesos	Pesos
	TOTAL FARM EXPENSES	499.60	291.06	232.65
I.	Farm Operations	218.34	127.71	148.93
	Seedbed preparation and care 2/	6.86	6.87	-
	Land preparation 3/	63.73	43.17	73.32
	Planting 4/	28.82	14.74	8.75
	Care of the crop 5/	35.10	3.54	31.80
	Harvesting 6/	78.41	53.85	31.69
	Stering 7/	5.42	5.54	3.37
II.	Other Operation Expenses 8/	29.98	24.92	20.72
III.	Fixed Cost 9/	251.28	138.43	63.00

1/ Personnel cost is based on the ratio of wages surveyed.

2/ Includes seed selection and care of seedbed.

3/ Includes clearing 1st and 2nd and plowing and harrowing.

4/ Includes pulling, bundling and hauling of seedlings, transplanting and replanting.

5/ Includes irrigation and drainage (where available), weeding, cultivation, fertilization and pest and disease control.

6/ Includes threshing.

7/ Includes drying and hauling.

8/ Includes costs of seeds, fertilizers, chemicals, irrigation fee (where applicable) and laborers' foot expenses.

9/ Includes depreciation (6%), land rent and land tax.

6. Weighted average yield per hectare by palay cropping pattern, Leyte del Norte and Mindoro Oriental, 1965-67.

Crop Type	1965-67 Average Yield per Hectare
	(sacks of 44 kgm)
Lowland (Average for 1st & 2nd)	32.5
Irrigated	41.3
Non-irrigated	28.4
Lowland 1st crop	35.0
Irrigated	42.9
Non-irrigated	31.1
Lowland 2nd crop	30.0
Irrigated	39.5
Non-irrigated	26.0
U p l a n d	16.4
AVERAGE (Lowland & Upland)	31.0

VIII. Increased Income due to the Project

Increased Income due to the Project.

Table 1. Major Utilization of Land and Net Irrigable Area in the Project Area, 1967.

C r o p	Area	Percentage Distribution	Not irrigable a/ area (Projected)
	Hectares		Hectares
1. Lowland rice	565.4	39.5	509.0
2. Upland rice	106.6	7.5	95.0
3. Corn b/	535.0	37.4	482.0
4. Coconut and other land	223.0	15.6	-
TOTAL	1,430.0	100.0	1,086.0

a/ Based on detailed design survey made in 1968.

b/ Including area devoted to Camote.

Table 2. Yields of Crops and Income in the Project Area, 1967

Crop	Area Harvested (hectares)	Yield a/ per Hectare cavans	Production cavans	Unit Price Pesos	Income Pesos
Existing Condition					
Palay					
Lowland 1st crop.					
a) Irrigated	84.0	42.9	3,604	16.00	57,664
b) Non-irrigated	481.4	31.1	14,972	16.00	239,552
Lowland 2nd crop					
a) Irrigated	67.2	39.5	2,654	16.00	42,464
b) Non-irrigated	48.1	26.0	1,251	16.00	20,016
Upland crop	106.6	16.4	1,748	16.00	27,968
Corn	535.0	11.6	6,206 sacks	14.00	86,884
TOTAL					474,548
PROJECT					
Palay					
Lowland 1st crop					
Irrigated	1,086.0	80.0	86,880	16.00	1,390,080
Lowland 2nd crop					
Irrigated	1,086.0	90.0	97,740	16.00	1,563,840
TOTAL					2,953,920
INCREASE					2,479,372

a/ Weighted average for three years for Leyte del Norte, 1965-67.

Table 3. Average Cost of Production per hectare of Lowland and Upland Palay by Cropping Pattern and Item of Cost, Existing Condition and Project, 1967

(Unit: Pesos)

	Existing Condition				Project	
	Lowland Crop (Irrigated)	Lowland Crop (non-irrig.)	Upland Crop	Corn	First Crop	Second Crop
Total Farm Expenses	390.43	291.06	232.65	170.33	856.83	914.85
I. Farm Operations	218.34	127.71	148.93	134.23	320.75	337.25
a) Seedbed Preparation & care	6.86	6.87	-	-	11.50	11.50
b) Land preparation	63.73	43.17	73.32	75.03	75.00	75.00
c) Planting	28.82	14.74	8.75	6.88	50.00	50.00
d) Care of the crop	35.10	3.54	31.80	23.30	52.25	52.25
e) Harvesting	78.41	53.85	31.69	20.02	120.00	135.00
f) Storing	5.42	5.54	3.37	-	12.00	13.50
II. Other Operating Expenses	29.98	24.92	20.72	10.59	321.90a/	346.90b/
III. Fixed Costs	142.11	138.43	67.00	25.51	214.18	230.70

a/, b/ Irrigation fee not included.

Table 4. Net Profit from Crops in Benefited Area, 1967

CROP	Area	Cost of Production (Per Hectare)	Cost of Production	Gross Income
	(Hectares)	(Pesos)	(Pesos)	(Pesos)
PRESENT				
1. Gross income from crop production				474,548
2. Less cost of production				
a) Low 1st crop				
(a) Irrigated	84.0	390.43	32,796	
(b) Non-irrigated	481.4	291.06	140,116	
b) Lowland 2nd crop				
(a) Irrigated	67.2	390.43	26,237	
(b) Non-irrigated	48.1	291.06	14,012	
c) Upland crop	106.6	232.65	24,800	
d) Corn	535.0	170.33	91,127	
				329,088
NET PROFIT	- - - - -	- - - - - - - -	- - - - -	145,460
PROJECTED				
1. Gross income from crop production				2,953,920
2. Less cost of production				
a) Lowland 1st crop	1,086.0	856.83	930,517	
b) Lowland 2nd crop	1,086.0	914.85	993,527	1,924,044
NET PROFIT	- - - - -	- - - - - - - -	- - - - -	1,029,876

Table 5. Total of Outputs of All Crops in the Benefited Area and Net Profit

I T E M	Gross Income	Production Cost	Net Profit
	P	P	P
Project	2,953,920	1,924,044	1,029,876
Existing condition	474,548	329,088	145,460
Increase	2,479,372	1,594,956	884,416

IX. Cost Benefit Ratio by N.I.A. Method

Cost Benefit Ratio by N.I.A. Method

a. Total Construction Cost (in Pesos)

(1)	Civil Works	2,395,000.00	
(2)	Access Roads	46,000.00	
(3)	Operation, Maintenance and Extension Service Facilities	51,000.00	
	Sub-Total	2,492,000.00	
(4)	Land levelling, Diking and Farm Ditches	327,000.00	
	T o t a l		2,819,000.00

b. Average Annuel Repayment of Peso Cost

(1) Bond Fund P2,492,000.00

Interest Payment 7%

25-year Repayment

a) 41% or Peso Cost P 1,021,720.00

(Redeemed in 15 years)

b) 59% of Peso Cost 1,470,280.00

(Refloated for a term of 10 years)

	Interest(7%)	Sinking Fund Annual Repayment a/	Total Repayment
1st-15th year	P 174,440.00	P 51,025.00	P 225,465.00
16th-25th year	102,920.00	122,452.00	225,372.00

a/ Accruing 4% interest earnings.

Average annual repayment of Peso cost

$$\frac{(P225,465)15 + (P225,372)10}{25} = P225,428.00$$

(2) Agricultural Loans, D.B.P.

Peso Cost	P 327,000.00		
Interest Payment	9%		
10 year Repayment in equal annual installment			
P327,000 × 0.15582 b/		P 50,953.00	
T o t a l			P 276,381.00

c. Total Annual Cost

a) Average annual repayment of Peso Cost	P 276,381.00	
b) Operation and Maintenance of Irrigation System	24,664.00	
c) Operation and Maintenance of Farm Ditches (1,086 has at P10.00/ha)	10,860.00	
d) Extension Service Cost	24,572.00	
T o t a l		P 336,477.00

d. Cost Benefit Ratio

Cost Benefit Ratio =

$$\frac{\text{Total Net Annual Profit c/}}{\text{Total Annual Cost}}$$

$$= \frac{P884,416}{P336,477} = 2.63$$

c/ See Appendix.

NOTE:

Sinking Fund

a) 1st-15th year, P1,021,720 $\sum_{n=0}^{n=14} (1 + i)^n \quad (n + 1) \quad 15$

= 51,025.00

$$n \quad \sum_{n=0}^{n=14} (1 + i)^n \quad (n + 1), \quad i = 0.04, \quad 1.33493$$

b) 16th-25th year, 1,470,280 $\sum_{n=0}^{n=9} (1 + i)^n \quad n \;, \; 1 \quad 10$

= 122,452.00

$$\sum_{n=0}^{n=9} (1 + i)^n \quad (n + 1) \quad i = 0.04, \quad 1.2007$$

b/ $\dfrac{i(1 + i)^n}{(1 + i) \; -1}$, n = 10, i = 0.09, 0,15582

X. List of Drawings

LIST OF DRAWINGS

LIST OF DRAWINGS FOR ALANGALANG AREA

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
D - 1	Diversion dams and Link canal	General location
D - 2	Diversion dam No. 1	Plan and profile
D - 3	Diversion dam No. 1 scouring sluice way	Sections
D - 4	Diversion dam No. 1 scouring sluice way	Reinforcement sheet (1)
D - 5	Diversion dam No. 1 scouring sluice way	Reinforcement sheet (2)
D - 6	Diversion dam No. 1 intake	Plan, profile and sections
D - 7	Diversion dam No. 1 intake	Reinforcement sheet
D - 8	Diversion dam No. 1	Details of hand rail and trash rack
D - 9	Diversion dam No. 1	Install assembly of gates
D - 10	Diversion dam No. 1 retaining wall	Reinforcement sheet
D - 11	Diversion dam No. 2	Plan and profile
D - 12	Diversion dam No. 2	Sections
D - 13	Diversion dam No. 2 scouring sluice way	Reinforcement sheet (1)
D - 14	Diversion dam No. 2 scouring sluice way	Reinforcement sheet (2)
D - 15	Diversion dam No. 2 intake	Plan, profile and sections
D - 16	Diversion dam No. 2 intake	Reinforcement sheet
D - 17	Diversion dam No. 2	Detail of hand rail and trash rack
D - 18	Diversion dam No. 2	Install assembly of gates
D - 19	Diversion dam No. 2 retaining wall	Reinforcement sheet (1)
D - 20	Diversion dam No. 2 retaining wall	Reinforcement sheet (2)

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
D - 21	Diversion dams	Plan of construction work
D - 22	Chute of link canal	Plan, profile and sections
D - 23	Link canal	Profile
D - 24	Main canal	Profile
D - 25	Link and main canal	Typical cross sections
D - 26	Elevated flume	Plan, profile and sections
D - 27	Elevated flume	Reinforcement sheet
D - 28	Main wasteway	Plan and sections
D - 29	Main wasteway	Reinforcement sheet
D - 30	Maintenance bridge	Plan, profile and sections
D - 31	Main siphon	Plan, profile and sections
D - 32	Main siphon	Reinforcement sheet
A - 1	Laterals	General location
A - 2	Lateral A	Profile (1)
A - 3	Lateral A	Profile (2)
A - 4	Lateral A	Profile (3)
A - 5	Lateral A	Profile (4)
A - 6	Lateral A	Profile (5)
A - 7	Lateral A1	Profile (1)
A - 8	Lateral A1	Profile (2)
A - 9	Lateral A1	Profile (3)
A - 10	Lateral B	Profile (1)
A - 11	Lateral B	Profile (2)
A - 12	Lateral A	Typical cross sections
A - 13	Lateral A1 and B	Typical cross sections
A - 14	Small siphon No. 1	Plan and sections
A - 15	Small siphon No. 2	Plan and sections
A - 16	Division work No. 1	Plan, profile and sections
A - 17	Division work No. 1	Sections

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
A - 18	Division work No. 2	Plan, profile and sections
A - 19	Division work No. 3	Plan and sections
A - 20	Division work No. 3	Reinforcement sheet
A - 21	Division work No. 3	Install assembly of gates
A - 22	Drop type A	Plan and sections
A - 23	Drop type B	Plan and sections
A - 24	Drop type C	Plan and sections
A - 25	Drop type D	Plan and sections
A - 26	Drop type E and F	Plan and sections
A - 27	Drop type G	Plan and sections
A - 28	Drop type H	Plan and sections
A - 29	Drop type I	Plan and sections
A - 30	Drop type J	Plan and sections
A - 31	Drop type K and L	Plan and sections
A - 32	Wasteway No. 1	Plan and sections
A - 33	Wasteway No. 2	Plan and sections
A - 34	Wasteway No. 3	Plan and sections
A - 35	Wasteway No. 4	Plan and sections
A - 36	Wasteway No. 5	Plan and sections
A - 37	Wasteway No. 6	Plan and sections
A - 38	Wasteway No. 7	Plan and sections
A - 39	Turnout type A and B	Plan, profile and sections
A - 40	Turnout type C	Plan, profile and sections
A - 41	Access road I	Profile
A - 42	Access road II	Profile
A - 43	Access road III	Profile
A - 44	Farm bridges	Plan, profile and details
A - 45	Culvert No.1,No.2 and No.3	Plan and profile
A - 46	Culvert No.4 and No.5	Plan and profile

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
A - 47	Housing of rice processing center	Plan and views
A - 48	Housing of rice processing center	Framing plan and elevation
A - 49	Housing of rice processing center	Details
A - 50	Generator room of rice processing center	Plan and views

LIST OF DRAWINGS FOR SAN MIGUEL AREA

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
S - 1	Laterals	General location
S - 2	Check gate	General plan and section
S - 3	Check gate fixed weir and wooden mattress	plan and section
S - 4	Check gate sluice way	Plan and section
S - 5	Check gate intake and retaining wall	Plan and section
S - 6	Check gate retaining wall and intake	Reinforcement sheet
S - 7	Check gate	Install assembly of gate
S - 8	Check gate	Excavation and embankment (1)
S - 9	Check gate	Excavation and embankment (2)
S - 10	Check gate	Excavation and embankment (3)
S - 11	Check gate	Temporary works
S - 12	Lateral A	Profile (1)
S - 13	Lateral A	Profile (2)
S - 14	Lateral A	Profile (3)
S - 15	Lateral A_1	Profile (1)
S - 16	Lateral A1	Profile (2)
S - 17	Lateral B	Profile (1)
S - 18	Lateral B	Profile (2)
S - 19	Lateral A, A1, B and drainage canal	Typical cross section
S - 20	Flume and transition	Plan, section and details
S - 21	Division work No. 1	Plan and section
S - 22	Division work No. 1	Reinforcement sheet

DRAWING NO.	NAME OF STRUCTURES	NAME OF DRAWING
S - 23	Division work No. 2	Plan and section
S - 24	Division work No. 2	Reinforcement sheet
S - 25	Lateral B siphon	Plan, section and details
S - 26	Lateral A drop No.1, No.2	Plan and section
S - 27	Lateral A drop No.1, No.2	Reinforcement sheet
S - 28	Lateral A drop No.3	Plan and section
S - 29	Lateral A drop No.3	Reinforcement sheet
S - 30	Lateral A drop No.4	Plan and section
S - 31	Lateral A drop No.4	Reinforcement sheet
S - 32	Lateral B drop	Plan and section
S - 33	Lateral A wasteway No. 1	Plan and section
S - 34	Lateral A wasteway No. 2	Plan and section
S - 35	Lateral A wasteway No. 3	Plan and section
S - 36	Lateral A wasteway No. 4	Plan and section
S - 37	Lateral A_1 wasteway No. 1	Plan and section
S - 38	Lateral A_1 wasteway No. 2	Plan and section
S - 39	Lateral A_1 wasteway No. 3	Plan and section
S - 40	Lateral B wasteway No. 1	Plan and section
S - 41	Lateral B wasteway No. 2	Plan and section
S - 42	Lateral A culvert No. 1	Plan and section
S - 43	Lateral A culvert No. 2	Plan and section
S - 44	Lateral A culvert No. 3	Plan and section
S - 45	Lateral A_1 culver No. 1 and No. 2	Plan and section
S - 46	Turnout	Plan and section
S - 47	Turnout	Install assembly of gates
S - 48	Drainage canal	Profile
S - 49	Drainage canal drop	Plan and section
S - 50	Drainage canal drop	Reinforcement sheet

DRAWING NO.	NAME OF STRUCTURE	NAME OF DRAWING
S - 51	Access road I	Profile
S - 52	Access road II	Profile
S - 53	Access road III	Profile (1)
S - 54	Access road III	Profile (2)
S - 55	Access road II bridge	Plan and section
S - 56	Access road I culvert	Plan and section