SERICULTURAL DEVELOPMENT PROJECT
IN
INDONESIA

FINALSTUDY REPORT
NO I

OCTOBER 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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Chapter 1. Introduction

1-1. Antecedents

In Indonesia, sericulture is a time-honoured industry brought up with enthusiasm. In 1971, the output of raw silk was 144 tons. But in the following years, heavy drought and pebrine raged; the year 1974 ended in a token output of 23 tons.

Tropical though Indonesia is, she has a good reason to have sericulture - the great blessings of climate.
Encouraged by this, the Indonesian Government mapped out a sericulture promotion program and established a sericultural department in the Forestry Experiment Station, with a view to increase the sericultural farmers' earnings through increased production of cocoons. Regretably enough, the program was stalled for want of except sericulturalists, and due to the lower techniques.

Against this backdrop, the Indonesian Government requested the Japanese Government to formulate a project for invigorating the sericultural industry.

At the request of the Indonesian Government, in March, 1974, a first mission, headed by Mr. M. Asino, visited Indonesia and conducted a preliminary survey. The diligence and eagerness of sericultural farmers and high potentials in sericultural industry reasoned the mission into concluding that the project should be implemented as early as possible.

As there were many problems left to be identified before implementation of the project, a long-term resident survey team, led by Dr. K. Aoki, was despatched for a period of one year from March 1975. They put together the various type of information, including statistical data, and carried out a fact-finding survey with energy.

As a result of close analysis of the findings and comments in the report submitted by the team, the Indonesian Government made a decision to go. Following this, the Japanese Government sent a project implementation planning team, directed by Mr. M. Kumamoto, in November 1975, in order to determine the place and scope of technical cooperation to be rendered by the Japanese Government.

As a result, South Sulawesi, which has turned out 80 to 90% of cocoons produced in Indonesia, was selected as a project site, and it was also determined to install a sericulture centre at Bili-Bili Vilage in the suburbs of the District of Ujung Pandang, a subcentre at the Soppeng Sericulture Station now in operation, and five pilot units in major sericultural areas, together with necessary mulberry farms, sericultural facilities and land lots.

In March 1976, Dr. K. Hazama, head of a Japanese mission, and Ir. Soedjono Soerjo, Secretary of the Directorate General of Forestry, agreed each with the other, and signed the Record of Discussion on the project implementation plan.

1-2. Purposes and objectives of the survey

The survey to be conducted this time pursuant to the Record of Discussion agreed upon between the Japanese Government and the Indonesian Government purposes to cover the following undertakings.

As regards the sericulture centre and subcentre, soil survey, meteorological survey and socio-economic survey, plane table surveying, and topographic surveying will be conducted in order to study whether mulberry fields and land lots are available in the proposed site as planned and where the mulberry fields should be located as classified by purpose, and also to make up a blueprint for the formation of mulberry fields. In addition, a profile surveying will be carried out to determine the sources of crinking water, utility water and irrigation water and their intake methods; to determine the routing of the aqueducts to the farm ponds and their water requirements; to plan the water quality survey; and finally to blueprint the water system.

As regards the sericultural facilities, a blueprint for land adjustment and a basic design drawing and a plat for buildings will be prepared. For the cold storage for silkworm egg speed and the nursery for male silk moths, blueprinting will be made. In addition, building appurtenances, including equipment and furnishings, will be stated in detail as to type, quantity, specifications and cost estimate.

Blueprints, land reclamation method, basic design drawings and other necessary data will be submitted to the Indonesian Government, and the Indonesian Government will make arrangements with Japanese exports and undertake the formation of multerry fields and the construction of buildings and water system.

Remarks: Formation of the survey team, itinerary, and Indonesian Personnel will be detailed in a separate survey report.

Chapter 2. Outline of the final design engineering

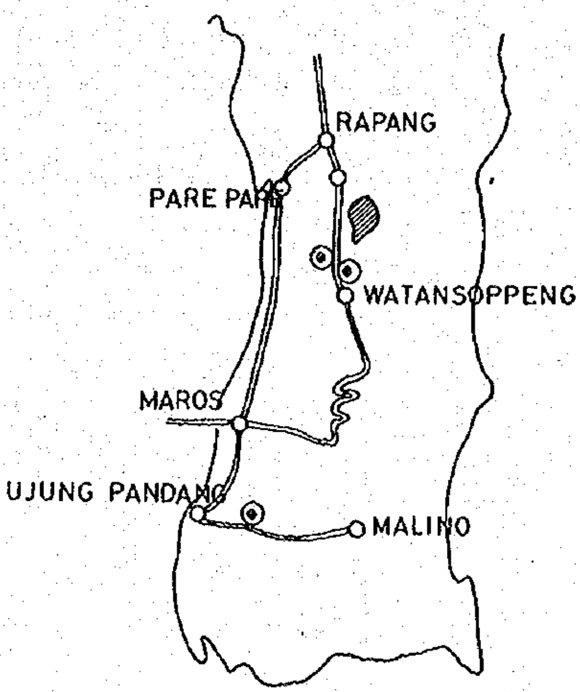
2-1. Siting

The sericulture centre and subcentre are the subjects of implementation design.

The sericulture center will be located at Bili-Bili Village, lying along Marino Road, some 30 km east of Ujung Pandang, the capital of South Sulawesi in Sulawesi Island.

The proposed site for the center is in a hilly area at an altitude of 150 to 215 m.

On the other hand, two subcentres will be located at Soppeng in South Sulawesi, about 180 km north of Ujung Pandang; one at the sericulture substation of the Forestry Experiment Station in Donri-Donri Village, and the other at Lalabata Riaja, about 10 km north of the substation.



1. Bili-Bili: Sericulture centre
2. Donri-Donri: Subcentre
3. Lalabata Riaja : Subcentre

Fig. 2-1 Location of sericulture centre and subcentres

2-2. Sericulture centre

The construction of the sericulture centre aims at establishing the sericultural technology in Indonesia.

The functions and activities there will include: establishment of technological norms for mulberry cultivation and silkworm nursery, production and distribution of original strain and mulberry cuttings, pest control of silkworm and mulberry, training of subcentre engineers, and short-term education of leading farmers.

The planned facilities are as follows.

Mulberry fields	: 8.0 ha
Aggregate floor space of buildings	: 3,510 m^2
Water system	: Pump station, conduit, and form Ponds pond

The candidate site for the sericulture centre is measured as follows.

Total area	: 8.8 ha
Effective area	: 7.33 ha
Mulberry fields	: 6.21 ha
Buildings	: 1.12 ha

The area of mulberry fields is 0.67 ha too short.

2-2-1 Design of farms

a) Scale and layout of farms

The site picked up for the sericulture centre is in a hilly area, and this topographical restriction prevents gathering the farms at one place.

Farm No. 1 is sited on a hill, 200 to 215 m above the sea level, major facilities are put together in it.

Farm No.2 is sited on the side of a hill having an altitude of 155 to 170 m, to operate mulberry fileds alone. The existing microwave road (asphalt pavement of 3.5 m wide) will be used for interconnecting the Farms No.1 and No.2.

Table 2-1. Area of Farm

	egg-production	testingfarm	glass land
Farm No.1	2.14ha	0.82ha	0.98ha
Farm No.2	1.12	0.90	0.25
Total	3.26	1.72	1.23

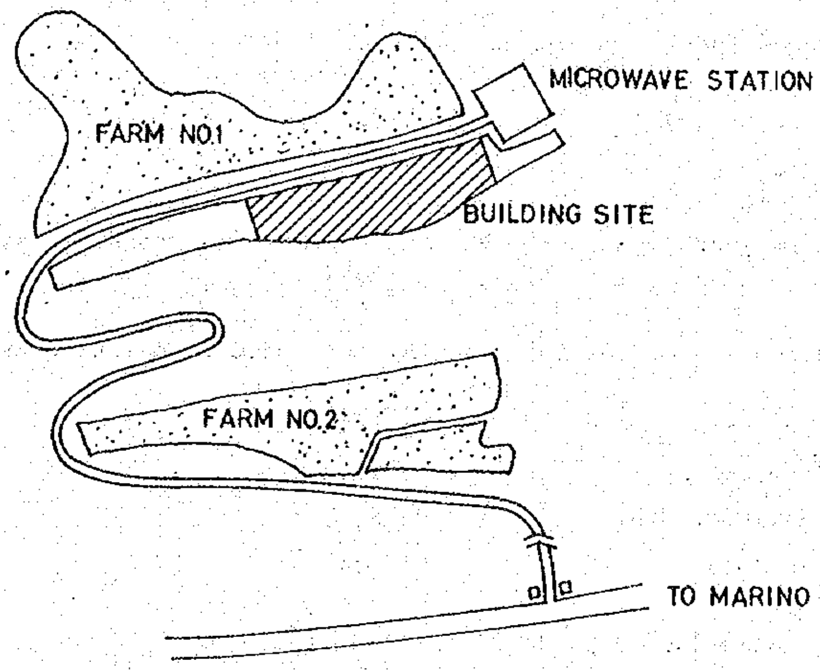


Fig. 2-2

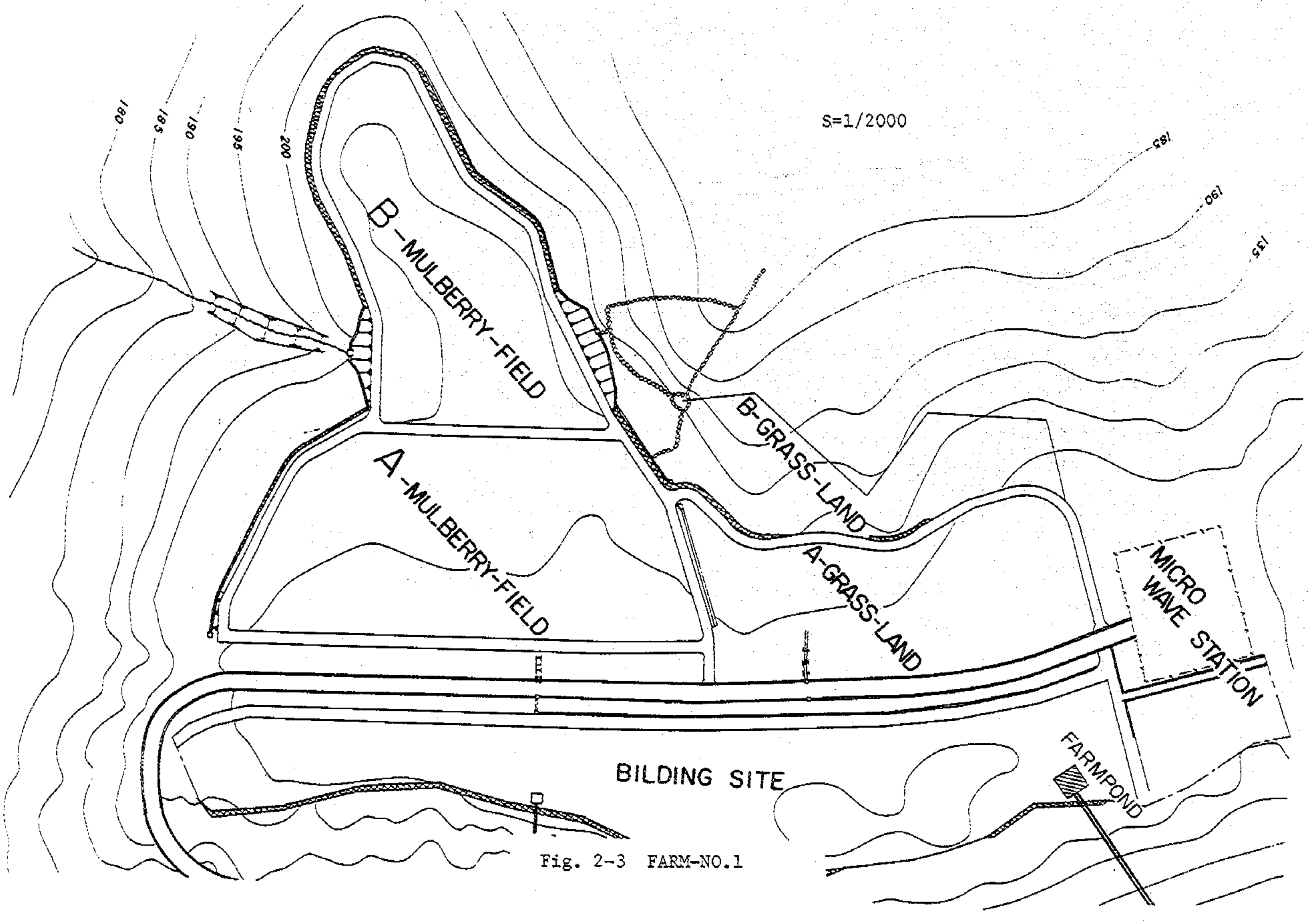


Fig. 2-3 FARM-NO.1

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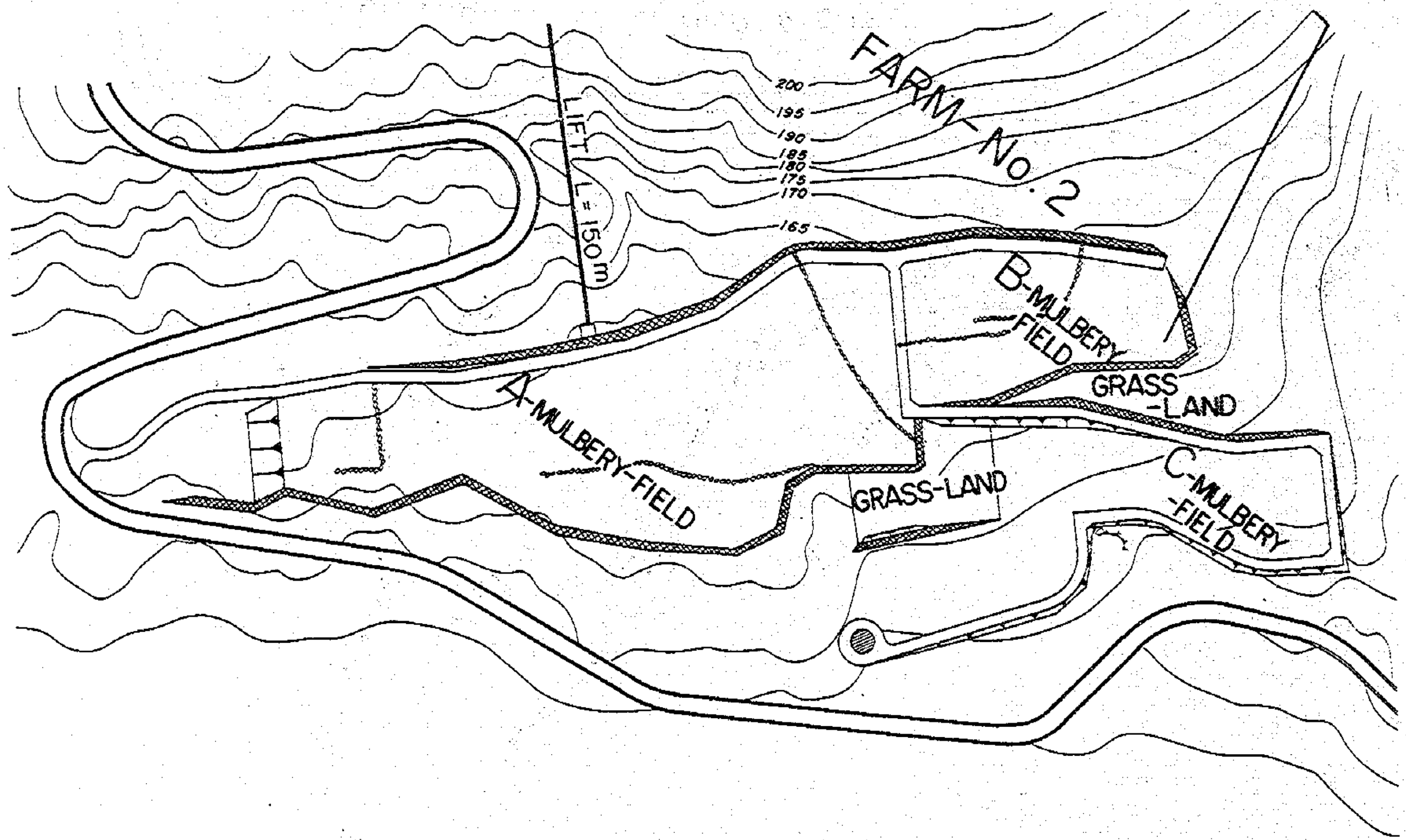


Fig. 2-4 FARM-NO.2

2-2-2 Size and Layout of Buildings

Table 2-2 shows the kinds and size of buildings and Fig. 2-2 their layout. The buildings to be constructed in Sericulture Centre and their size are shown in the following table.

Table 2-2 List of New Construction in Sericulture Centre

Building Name		Brief Description	Total Floor Area	Building Area
A	Main building	2-storied reinforced concrete building	848 m²	413
A'	Cocoon testing room	1-storied brick building	242	180
B	Rearing room for rearing method	- do -	456	192
C	Rearing room for egg production (1)	- do -	456	192
	" (2)	- do -	456	192
	Research room	- do -	86	46
D	Pathological rearing room	- do -	264	96
E	Pebrine inspection room	- do -	372	252
F	Silkworm egg refrigerator	- do - (prefabricated partition)	270	180
G	Artificial hatching room	- do -	48	24
H	Chemicals warehouse	- do -	-	4
I	Garage	- do -	-	60
J	Mulberry field maintenance building	- do -	165	117
K	Compost shed	- do -	264	200
L	Agricultural machine and tool warehouse	- do -	187	120
	Sericultural equipment pool	2 places	-	(40 m²)
Total				2,268

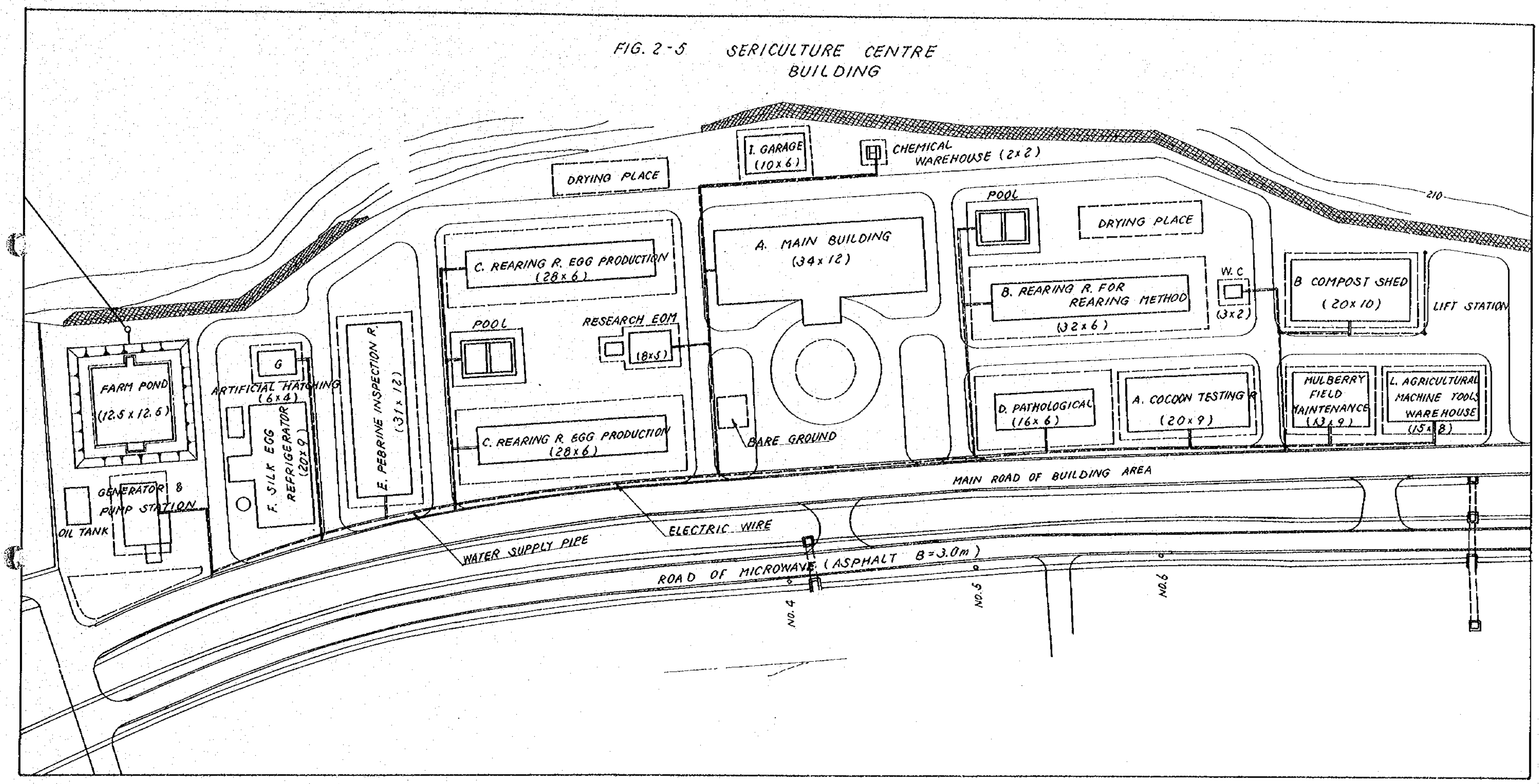


Fig. 2-5 Arrangement Plan for the Sericulture Centre

2-2-3 Design of Irrigation Facilities

In the capacity calculation of irrigation facilities, the irrigation area (mulberry field) was taken at 8.0 ha, the water supply hours from the water source to the farm pond at 24 hours, and the irrigation hours at 16 hours. Further, it was assumed that gun type sprinkler irrigation would be introduced.

The following table shows the quantity and specifications of irrigation facilities.

Table 2-3 List of Irrigation Facilities

Name of Facility	Structure/ Equipment	Quantity	Remarks
Inktake and conveyance facilities	Intake works	1 set	Structure: ϕ300mm porous pipe
	Pump	2 units	Port diameter: 65x80m/m Discharge : 0.51 m^3/min Total head : 172m Power plant : 50 PS diesel engine Type : Multi-stage horizontal centrifugal pump
	Pump house	33.12m^2	Structure: RC construction
	Water pipe	1368.37m	Type : Ductile cast iron pipe Diameter : ϕ 100
Irrigation facilities	Farm pond	300 m^3	Structure : RC construction
	Pressure pump	2 units	Port diameter: 80 mm Discharge : 0.744 m^3/min Total head : 51m Power plant : 15kW motor Type : Single-suction single-stage centrifugal pump
	Farm 1∿Farm 2 connecting pipeline	185.34m	Type : Ductile cast iron pipe Diameter: ϕ 100
	Water supply pipe	1376.8m	Type : Vinyl chloride pipe Diameter : ϕ 100
	Hydrant	20 places	Diameter : ϕ 75
	Sprinkler	2 sets	Type: No.70 (24 units per set)

2-2-4 Rough Cost Estimation and Construction Schedule

a) Construction Cost

Table 2-4 Construction Cost of Sericulture Centre Facilities

Type of Work/Facility	Main Components	Specification/ Standard	Quantity	Direct Construction Cost
1. Reclamation works	Mulberry field for silkworm egg production		3.26 ha	16,156,000
	Experimental mulberry field		1.72 ha	
	Grassland		1.23 ha	
	Building site		1.12 ha	
	Farm road	Gravel pavement, B = 4.0	1684.62 m	
		Asphalt pavement, B = 5.0	378.30 m	
	"	Gravel pavement, B = 3.0		
	Stone mansory	H=2.0m B=1.0m	1629.10 m	
	Drainage side ditch		1186.50 m	
2. Water source works	Intake works	Collecting conduit, ϕ 300		
		Draft tank(RC)	1 place	4,674,000
	Pump house	9.2m x 3.6m	33.12m^2	7,242,000
	Pump	ϕ80 x 65 m/m H172m, 50PS Multistage centrifugal pump	2 units	10,188,000
3. Water conveyance works	Water pipe	Ductile cast iron pipe, ϕ100	1368.37 m	15,480,000
	Aqueduct	Steel pipe	5 places	
4. Irrigation facilities	Farm pond	12.5x12.5x2.4	375 m^3	11,668,000
	Pressure pump	Single stage centrifugal pump, ϕ100	2 units	
	Connecting pipeline	Ductile cast iron pipe, ϕ100	185.34 m	9,521,000
	Water supply pipe	Vinyl chloride pipe, ϕ100	1376.80 m	

Type of Work/Facility	Main Components	Specification/ Standard	Quantity	Direct Construction Cost
	Hydrant	ϕ75	20 places	
	Sprinkler set	Type No. 70, 24 units/set	24 sets	
5. Sericultural buildings	13 buildings		2.268m^2	232,273,000
6. Appurtenant facilities	Pump and generator house	10m x 6m	60m^2	13,776,000
	Cable		1 set	96,034,000
	Water supply pump and tank	0.75 kW centrifugal pump	1 unit	
	Water supply and drainage pipe	Vinyl chloride pipe	1 set	
	Generator	(incl. fuel tank)		
	For pressure pump	40 KVA	2 units	
	For cold storage	65 KVA	2 units	
	For lighting and electric heating	40 KVA	1 unit	
	Electric wiring work		1 set	
Total direct construction cost				417,012,000
Overhead cost				86,434,000
Total construction cost				503,446,000

b) Construction Schedule

The construction schedule is shown in Table 2 - 5 .

Table 2-5 Construction Schedule of the Sericultural-Centre

Items	1st Year	2nd Year	3rd Year	Remarks
1 Land Preparation				
Muberry field	3.0HA	4.0HA		1st year bulloozer is rentaled
Glassland			1.0HA	
Building site		1.0HA		After 2nd year bul. will be provided from Japan
2 Pump Staion				
Intaice work		L=31M ϕ300		ry season only
Pump house (2 places)		1,000M^2		included installation of pumps
3 Pipe laying				
Foundation				Aqueouct 5 places support 82 places
Pipe laying		L=1,390M		buried 989M surface 326M
4 Buildings	- - - -	- - - -	- - - →	1st : Mulberry field maintenance room 2nd : Silkworm egg refrigerator room

Note 1st year 76' 10 ∿ 77' 3 2nd year 77' 4 ∿ 78' 3 3rd year 78' 4 ∿ 79' 3

Buildings of centre will be disgned and constructed by indonesian side therfore, the schedule of buildings is not clear.

2-3. Sericulture subcentre

The subcentre mainly undertakes the production of silkworm egg, and also performs testing and investigations for the purpose of adapting to specific areas the standard techniques established by the sericulture centre.

It also assigned to guide and manage the pilot unit, educate and train the leaders and sericultural farmers.

The planned facilities are as follows.

Mulberry fields	: 19.50 ha
Buildings	: 2,592 m^2(in aggregate floor space)
Water system	: Pump station, Form pond

The candidate place for the subcentre is measured as follows.

<u>Land area</u>

Sericulture substation, Forestry Experiment Station	: 0.5 ha
Lalabata Riaja Village	: 18.4 ha
<u>Total</u>	: <u>18.9 ha</u>

<u>Effective area</u>

Mulberry fields	: 17.8 ha
Building lots	: 1.1 ha
<u>Total</u>	: <u>18.9 ha</u>

2-3-1 Engineering for farm development

(a) Scale and layout of farms

The mulberry fields will be locates at a belt-like national land, measuring about 1.0 km east to west and 50 to 200 m south to north, and 120 to 129 m in altitude, available in Lalabata Riaja.

For the purpose of maximizing the area of mulberry fields, the lotting of the land and the construction of a trunk road are arranged as shown in Fig. 2-6.

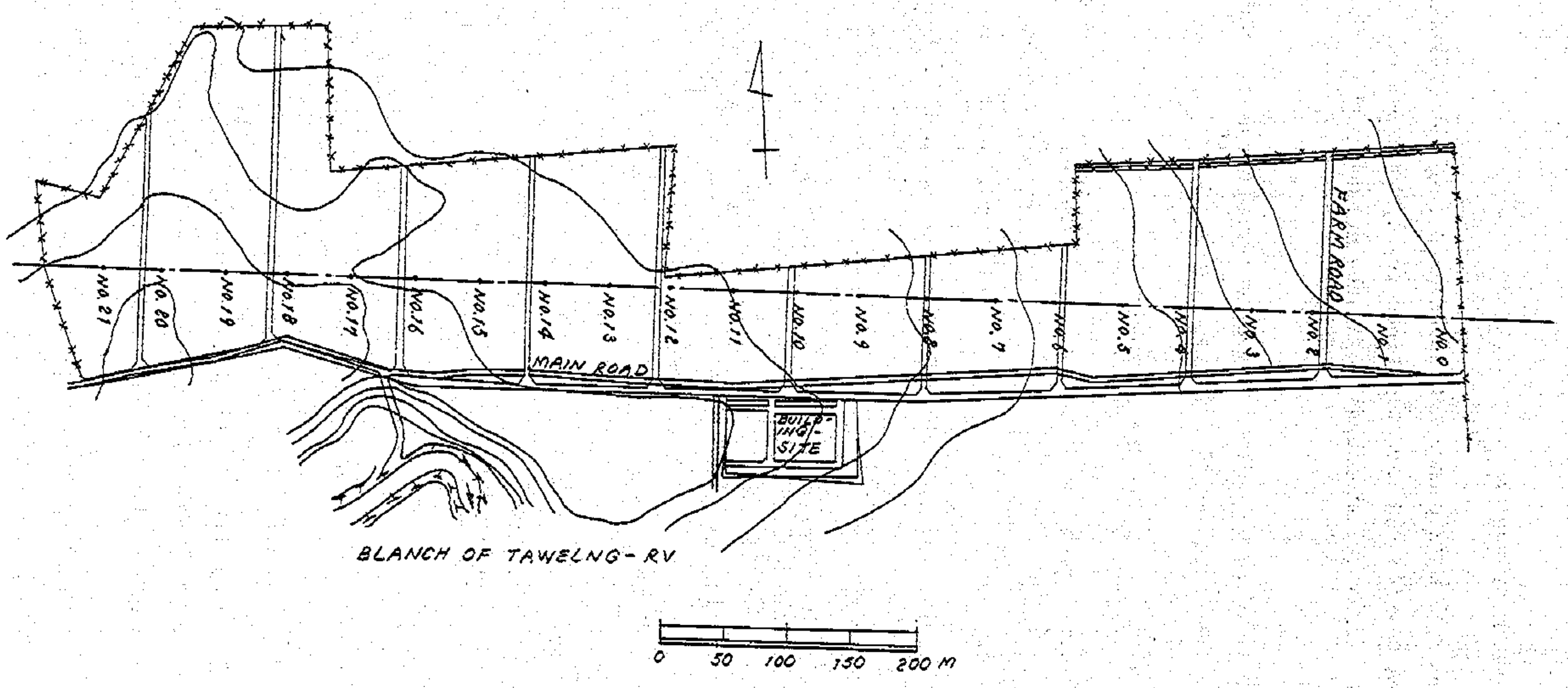


Fig. 2-6 The Map of the New Field (SUB CENTRE)

2-3-2 Size and Layout of Buildings

The buildings shown in the following table will be constructed in the new mulberry field site and Sub-Centre. For the layout of these buildings, see Fig. 2-7 ∿ 2-8.

The buildings to be constructed in Sericulture Subcentre and their size are shown in the following table.

Table 2-6 List of New Construction or Remodelling in Sericulture Subcentre

	Building Name	Description Brief	Total Floor Area	Building Area
	New Mulberry Field			
A	Rearing room, grown silkworm (1)	Single storied brick building w/gable roof	494 m^2	224 m^2
	" (2)	- do -	494	224
	Research room	- do -	110	56
A'	Rearing room, young silkworm	- do -	338	140
	Total		1,436	644
	Sericulture Sub-Station			
B	Rearing room for egg production (1)	Single storied brick	494	224
	" (2)	- do -	494	224
	Research room	- do -	110	56
C	Pebrine inspection room	- do -	180	105
D	Silkworm egg refrigerator	- do - (Prefabricated partitions)	310	286
	Silkworm nursery	Existing building in the Subcentre site to be remodelled	-	-
	Artificial hatchery	- do -	-	-
	Chemicals storage	- do -	-	-
	Storeroom			
	Total		1,588	895

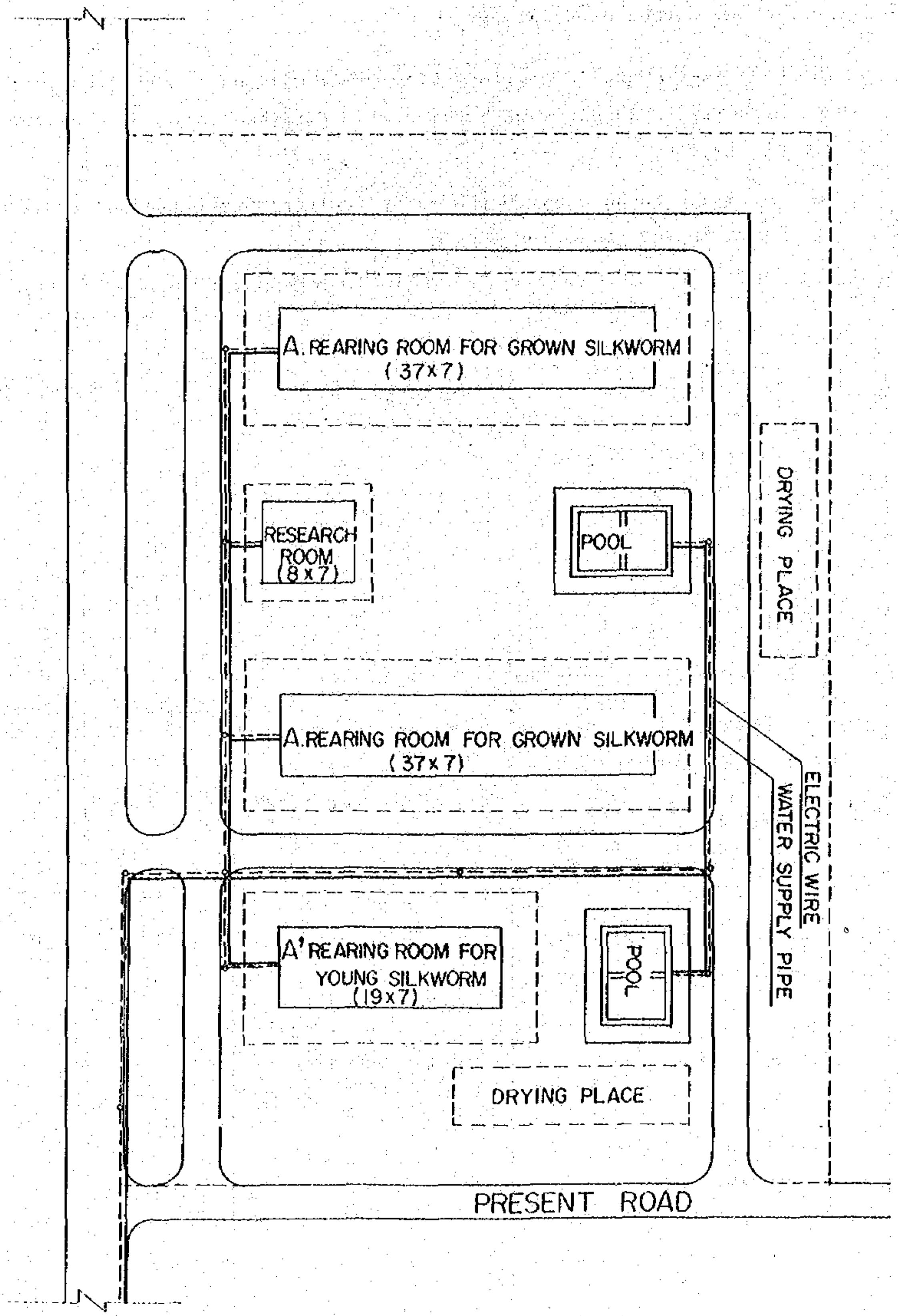


Fig. 2-7 Arrangement Plan for the New Field

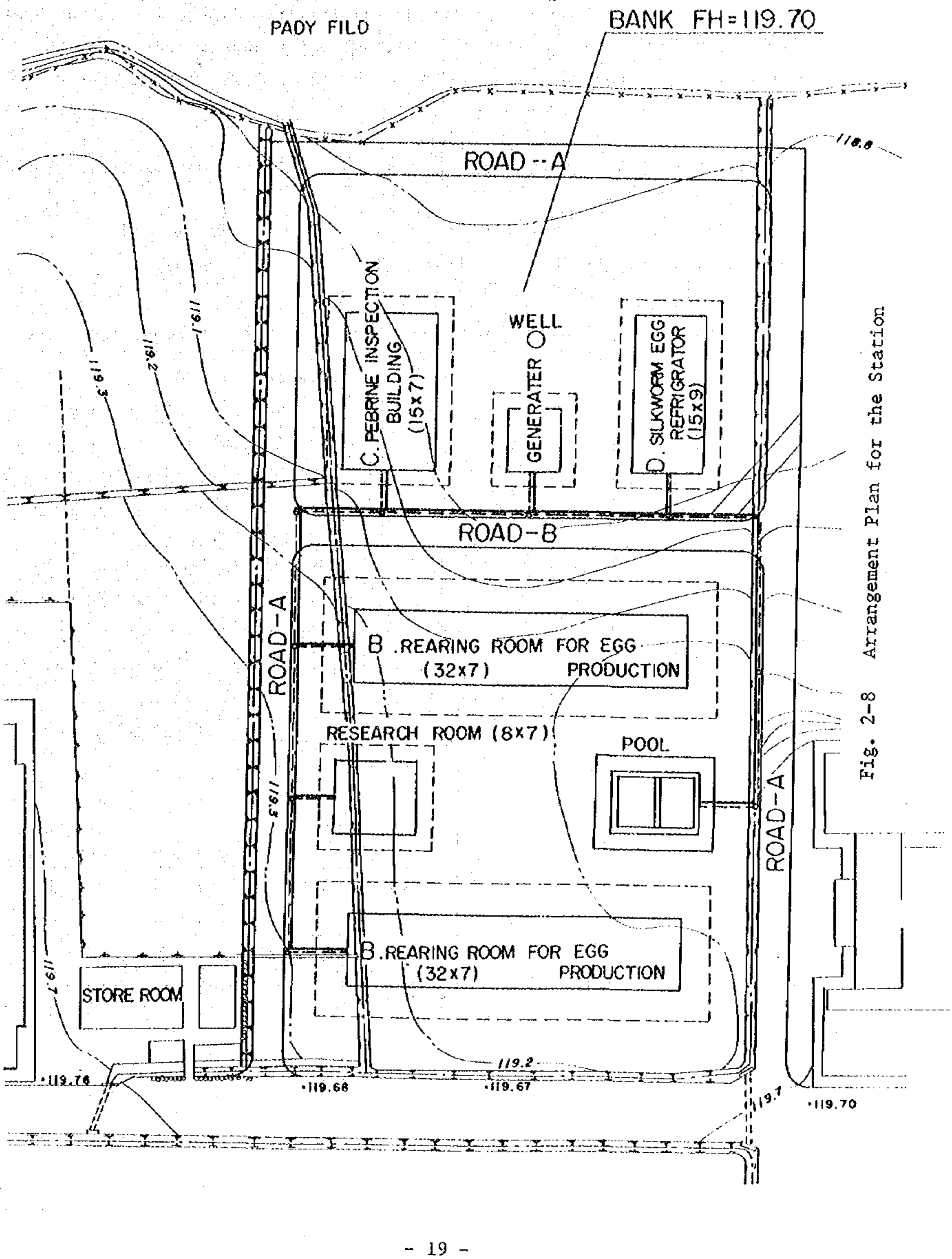


Fig. 2-8 Arrangement Plan for the Station

2-3-3 Design of Irrigation Facilities

In the capacity calculation of irrigation facilities, the irrigation area (mulberry field) was taken at 19.5 ha, the water supply hours from the water source to the farm pond at 24 hours, and the irrigation hours at 16 hours.

The following table shows the quantity and specifications of irrigation facilities.

Table 2-7 List of Irrigation Facilities in the New Field

Name of Facility	Structure/ Equipment	Quantity	Remarks
Intake and conveyance facilities	Intake works	1 set	Structure: Porous pipe, ϕ300
	Pump	2 unit	Diameter : 100 mm Discharge : 1.178 m^3/min Total head: 12 m Power plant: 1p PS diesel engine Type : Single-stage centrifugal pump
	Pump house	33.12 m^2	Structure: RC construction
	Water pipe		Type : Ductile cast iron pipe Diameter : ϕ150 mm
Irrigation Facilities	Farm pond	600 m^3	Structure: RC construction
	Pressure pump	2 units	Diameter : 150 mm Discharge: 1.788 m^3/m Total head: 61m Power plant: 45 kW motor Type : Single-suction single-stage centrifugal pump
	Water supply pipe	1273.0 m	Type : Vinyl chloride pipe Diameter : 150 mm
	Hydrant	22 places	Diameter : ϕ 100
	Sprinkler	2 sets	Type : No.70 (10 units/set)

2-3-4 Rought Cost Estimation and Construction Schedule

a) Construction Cost

Table 2-8 Construction Cost of the New Field and Station

Type of Work/Facility	Main Components	Specification/ Standard	Quantity	Direct Construction Cost
1. Reclamation New Field	Mulberry field	Underdrainage (bamboo)	17.8 ha	RP 14,442,000
	Building site			
	Arterial road	Gravel pavement, B = 5.0 m	1165.0 m	
	Farm road	Gravel pavement, B = 4.0 m		
	Collecting gallery	No timbering	1162.0 m	
	Intra-site road	Gravel pavement, B = 3.0 m	m	
Station	Building site		1.0 ha	1,488,000
	Intra-site road		m	
2. Water source New Field	Intake works	Collecting gallery, ∅600		
		Draft tank, RC	1 place	2,901,000
	Pump house	9.2m x 3.6 m	33.12 m^2	7,242,000
	Pump	∅100 H = 14m 8 PS Single stage centrifugal pump	2 units	2,600,000
3. Water conveyance works New Field		Ductile cast iron pipe	88 m	351,000
4. Irrigation facilities New field	Farm pond	25mx16mx1.8m	720 m^3	13,971,000
	Pressure pump	Single stage centrifugal pump, ∅150	2 units	9,159,000
	Water supply pipe	Vinyl chloride pipe, ∅150	1273.0 m	
	Hydrant	∅100	22 places	
	Sprinkler set	Type No. 70 (10 units/set)	2 sets	

Type of Work/Facility	Main Components	Specification/ Standard	Quantity	Direct Construction Cost
5. Sericultural buildings	STATION NEW-FIELD		895 m^2 644 m^2	80,588,000
6. Appurtenant facilities station	Pump and generator house	5 x 6	30 m^2	9,657,000
	Water supply pump and tank			
	generator			
	For pressure pump	70 KVA	2 units	139,264,000 (NEWFIELD)
	For lighting	10 KVA	1 unit	
	Water supply and drainage facilities		1 set	
	Electric wiring work		1 set	
New-Field	Pump & generator house	10m x 6 m	60 m^2	13,776,000
	Pressure pump		2 units	
	Water supply pump and tank	0.1 m^3 0.75KW	1 unit	
	Radiator	30 KVA	2 units	
	Water supply and drainage facilities		1 set	
	Electric wiring work		1 set	
Total direct construction cost				293,283,000
Overhead cost				57,567,000
Total construction cost				RP 350,850,000

b) Construction Schedule

The construction schedule is shown in Table 2 - 9 .

Table 2-9 Construction Schedule of the Sub Centre

Items	1st Year	2nd Year	3rd Year	Remarks
NEW FIELD				
1 Land Preparation				
Mulberry field	3.5HA ———	6.0HA ———	5.0HA ———	Expected dry season only
Glassland				After the 4th year
Building site		———		Dry season only
2 Pump Station				
Intaice work		L=18M ϕ600 ———		Dry season only
Pump house		1,000M2 ———		Included installation of pumps and pipe laying
3 Buildings		- - - -	- - - -	
SOPPENG SERICULTURAL STATION				
1 Building site preparation		———		Dry season only
2 Buildings		- - - -	- - - - - - - -	

Note The above schedule will be affected with the condition of the road from national road to the new field.

Chapter 3. Field Survey - Approach and Analysis (Centre and Subcentre)

3-1. Water System Survey

3-1-1. Water resources survey

The survey was carried out in search of such resources that are nearest to the beneficiary areas; that can supply ample, quality water throughout the year; and that are easy to convey to the beneficiary areas.

(1) Sericulature centre

According to the report prepared by the project implementation planning team (1975), several springs at the foot of a mountain which were nearest the beneficary were reconnoitered. They all were found depleted and unable to supply water in the dry season.

For this reason, the Berang, flowing about 1.3 km east of the beneficiary areas, was selected as a source, and its potential, quality and intake method were investigated.

(2) Subcentre

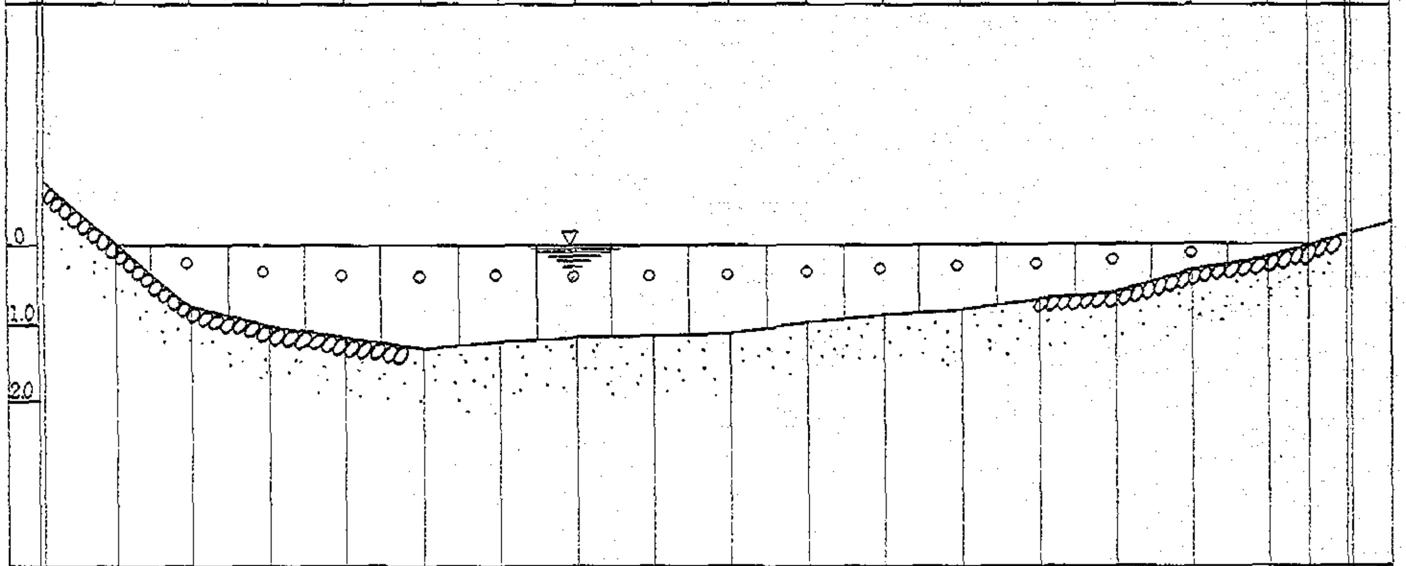
A tributary of the Tawelng is flowing along a proposed mulberry field. It was selected as a source and its potential, quality and intake method were investigated.

3-1-2. Hydrographic survey

At each intake site, the flow velocity by depth was measured across the river by making use of a Price's current meter, and the flow rate was calculated. The results of the computation of flow rate of the Berang at the proposed intake site are as shown in Table 3-1; in the low-water season, the flow rate is as high as 1.891 m^3/sec. or more. The flow rate at the intake site from which water is to be supplied to the Subcentre is as low as about 9 lit./sec. (See Table 3-1). Judging from the observation of

Table 3-1 Water quantities of Belang

DIS.	DEPTH	VELOCITY m/S	AREA m²	Q m³/S
0.0	0	0	—	—
2.0	83	0.038	1.503	0.057
4.0	103	0.049	2.063	0.101
6.0	124	0.056	2.468	0.138
8.0	140	0.055	2.738	0.151
10.0	181	0.063	2.625	0.165
12.0	124	0.077	2.500	0.193
14.0	125	0.093	2.485	0.231
16.0	120	0.095	2.368	0.225
18.0	102	0.103	2.070	0.213
20.0	96	0.081	1.930	0.156
22.0	91	0.081	1.818	0.147
24.0	82	0.070	1.618	0.113
26.0	64	0	—	—
28.0	32	0	—	—
30.0	14	0	—	—
31.0	0	0	—	—
				1.891

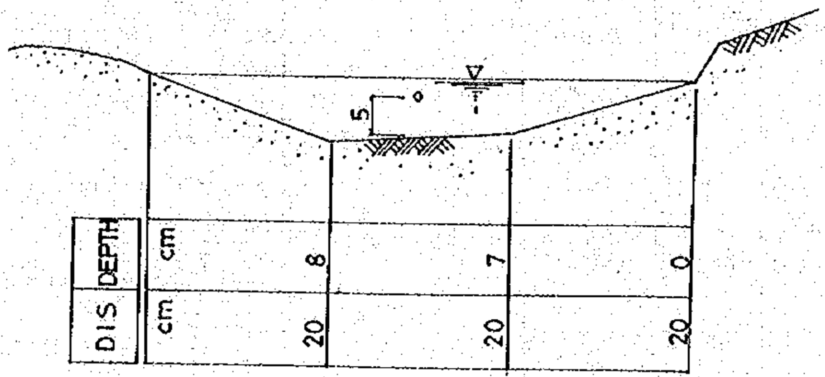


flow rate at the head works site some 1 km downstream of the intake site and the topography shown in Fig. 3-2 , a large underflow is suspected to be.

According to the intake method illustrated under item 5-2-1, 19.5 lit./sec. or more of water necessary for irrigation in the right time will be available.

Fig. 3-1 Hydrographic measurement

Date of measurement: Aug. 21, 1976



The overall width of the waterway is 60 cm, and the velocity at the depth of 5 cm in the center is taken as the mean velocity for computation of discharge.

Area of section, A : 300 cm^2

Velocity, v : 0.291 m/sec. = 29.1 cm/sec.

Flow rate, Q : 300 x 29.1 = 8,730 cm^3/sec.

= 8.73 lit./sec.

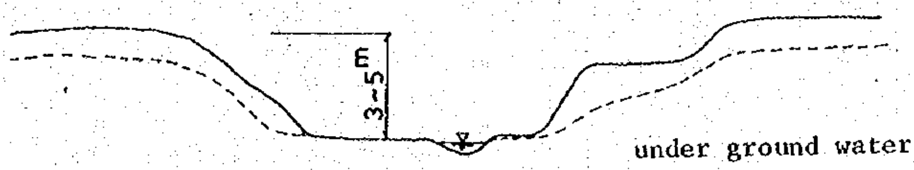


Fig. 3-2 Rough sketch of Cross Section at Intake Site (tributary of the Berang)

3-1-3. Water quality survey

By making use of a AM - 7B type pH meter and a DO - 1B type dissolved oxygen measuring apparatus, pH and COD of water at each intake and of water available in the sub centre were measured.

The results are as shown in Table .

Table 3-2 PH and COD

Place	Sampling Siste	pH	COD (ppm)	Remarks
Sericulture centre (Bili-Bili)	Intake of the Bearing	8.1	0.70	
Subcentre (Soppeng)	Well at filature	7.7	0.70	
	Proposed intake site of the tributary of the Taweing	8.1	0.75	
Ujung Padang	Grand Hotel	7.4	0.50	Tap water

As shown above, pH value of the river water is as high as 8.1. This is because the soil of the catchment area contains much limestone. So long as irrigation is concerned, there is no problem. But, a water prification plant is indispensable for the sericulture, reeling, drinking or other purposes. Also for the refrigerator, demineralizer is required. COD, an index of water pollution, is 0.75 ppm or lower, manifesting that pollution has not been developed yet.

3-2 Soil survey

The soil survey has a great bearing on the reclamation of farms, subsoil improvement, determination of irrigation system and water system planning, fertilizing and eventually on the results of the project.

For this reason, the survey was conducted in a planned way as shown in Table 3 - 3.

Table 3 - 3 Survey subjects

Subjects	Sericulture centre (Bili-Bili)	Subcentre (Soppeng)
Chemical properties:		
pH (kCl)	o	o
Lime requirement	o	o
Phosphate-absorption coefficient	o	o
Physical properties:		
Water retentivity	o	o
Water permeability	o	o
Three phases of soil	o	o

3-2-1. Chemical properties of soil

(1) Sampling

Surface soil and bottom soil were sampled for chemical analysis from three stops each at the proposed mulberry fields of the sericulture centre and subcentre.

(2) Method of analysis

ph (KCl), lime demand and phosphate absorption coefficient which are influential factors in soil improvement were measured by making use of a portable soil tester (Yagi type).

(3) Results of analysis

The results of analysis are shown in Table 3 - 4 .

Table 3-4 PH and PAC

Place	Sampling spot	Layer	pH (KCl)	Phosphate-absorption coefficient
Sericulture center (Bili-Bili)	No.1	I	5.25	1,000∿1,250
		II	4.75	
	No.2	I	5.50	850∿1,250
		II	5.00	
	No.3	I	4.75	850∿1,000
Subcenter (Soppeng)	No.1	I	6.00	700
		II	6.00	850
	No.2	I	5.75	500
		II	6.50	700
	No.3	I	5.75	600
		II	6.00	700

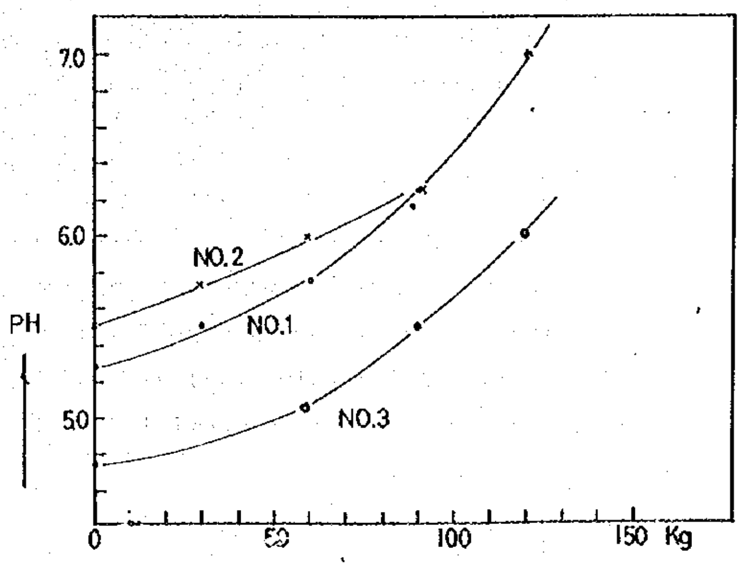


Fig. 3 - 3 Measurement of Lime Requirement
(Sericulture Centre)

3-2-2. Physical characteristics of soil

(1) Survey spot

At the same spots as with the chemical analysis, test holes of 1.0 to 1.5 m deep were dug, and two to three samples were taken from each layer by means of a 100 cc cylinder in a manner not to disturb the stratigraphic profile. The samples were put to the measurement of physical properties.

(2) Survey subjects

The survey covered such subjects that have close relation with the reclamation of mulberry fields, subsoil improvement and irrigation planning, etc., including soil texture, bulk density, porosity, field capacity, first wilting point, available moisture, three phases of soil and water permeability.

(3) Results of survey

The findings are outlined in Table 3 - 5. Of them, those having close relation with subsoil improvement and irrigation planning are put together in (1) through (4) below.

1) Available moisture

The field capacity (FC) meaning the water content in soil emptied of gravity water to the extent of no tangible water movement after being supplied with water to the full, first wilting point (WP) as viewed from cultivation, and the thickness of soil layer (d) have the following relationship.

$$AM = \frac{1}{10}(FC - WP) \cdot d \qquad (mm)$$

Where, AM: available moisture with respect to a soil layer having a thickness of d cm (mm)

FC: field capacity in volumetric percentage (%)

WP: first wilting point in volumetric percentage (%)

d: thickness of soil layer (cm)

FC was taken as water content in volumetric percentage 1 to 2 days after supply of 200 lit. of water per m^2 (water depth, 200 mm), and WP was determined by a regression formula obtained by experiments in the fields covered by the Aichi Irrigation Canal, one of the most famous in Japan.

$$WP = 0.36FC^{1.08}$$

Where, WP: first wilting point (vol.%)

FC: field capacity (vol.%)

As is clear from Table 3-5, the AM values per 10 cm of soil layer thickness were, for the most part, arount 20 mm.

2) Water quantity per irrigation

The water quantity per irrigation is determined chiefly by available moisture, effective root zone, and soil moisture extraction pattern.

Taking layer-wise available moistures as $(AM)_1$, $(AM)_2$, ... $(AM)_n$, effective root zone as d, and the moisture extraction patterns for respective layers as a_1, a_2, ... a_n (in decimal fractions), the water quantity per irrigation (Wd) is given as follows.

1st layer $Wd_1 = (AM)_1 \frac{d}{na_1}$

2nd layer $Wd_2 = (AM)_2 \frac{d}{na_2}$

⋮

n-th layer $Wd_n = (AM)_n \frac{d}{na_n}$

Of these values, the minimum is the upper limit of the water quantity per irrigation, and when the soil moisture in the corresponding layer has attained WP, it is the time to start the irrigation.

On the other hand, the moisture extraction pattern changes with the kind of crop, or more precisely, with the stage of growth and the kind of soil even in regard to the same crop. In fact, it cannot be said decisively. For want of actually measured data, the following extraction pattern which has widely accepted in many countries, including U.S.A., is applied for computation, and the results are given in Table 3-5 .

40% from 1st later, 30% from 2nd layer, 20% from 3rd layer, and 10% from 4th later.

Table 3-5 Physical Characteristics of the Soil

(1) Sericulture center - Mulberry Orchard Planned Site

Location number	Vegetation	Depth	Soil color	Soil texture	True specific gravity	Hypothetical specific gravity	Porosity	Field water content	Initial period wilting point	10cm effective moisture content	Water quantity per 1 irrigation cycle	3 phase division (FC time)			Intake constant		Basic intake rate
												Solid phase	Liquid phase	Gas phase	C	n	
							%	%	%	mm	mm	%	%	%			mm/hr
1	Fallow area	0～5	7.5 R3/3	L	2.65	1.02	61.6	34.0	16.2	17.8	57.8	38.4	34.0	27.6	27	0.62	127.6
		15～20	"	"	"	1.13	57.4	41.6	20.2	21.4		42.6	41.6	15.8			
2	Weed area	0～5	10 R2/3	L	"	0.86	67.8	37.9	18.3	19.6	61.3	32.3	37.9	29.8	66	0.80	1216.0
		20	"	"	"	0.91	65.9	37.8	18.2	19.6		34.1	37.8	28.1			
		40～45	10 R3/4	CL	"	0.96	63.8	35.4	17.0	18.4		36.2	35.4	28.4			
3	Banana orchard	0～5	7.5 R3/2	L	"	1.02	61.6	37.2	17.9	19.3	61.5	38.4	37.2	24.4	11	0.58	37.6
		10～15	"	"	"	1.07	59.5	41.2	20.0	21.2		40.6	41.2	18.2			
		20～25	"	"	"	1.16	56.7	40.1	19.4	20.7		43.4	40.1	16.5			
		30～35	7.5 R3/2	CL	"	1.15	56.8	44.7	21.9	22.8		43.3	44.7	12.0			
		50～55	"	"	"	1.15	56.9	38.3	18.5	19.8		43.2	38.3	18.5			

2, Subcenter Mulberry Orchard Planned Site

Location number	Vegeta-tion	Depth	Soil color	Soil tex-ture	True specific gravity	Hypothe-tical specific gravity	Porosity	Field water content	Initial period wilting point	10cm ef-fective moisture content	Water quantity per 1 irrigation cycle	3 phase division (FC time)			Intake constant		Basic intake rate
												Solid phase	Liquid phase	Gas phase	C	n	
							%	%	%	mm	mm	%	%	%			
1	Corn	0~ 5	7.5 R3/1	C	2.65	1,38	47.8	38.8	18.7	20.1	65,1	52,2	38,8	9.0	10	0.43	9.3
		10~15	"	HC	"	1,34	49.6	46.7	22.9	23.8		50.4	46,7	2.9			
		20	"	"	"	1,37	48.2	43.4	21.1	22.3		51.8	43,4	4,8			
		30	7.5 R2/2	"	"	1,38	48.2	42,3	20,6	21.7		51,9	42,3	5.8			
		40	"	"	"	1,33	50.0	44.7	21.8	22.9		50,0	44,7	5,3			
		55~60	"	"	"	1.31	50.0	46.4	22.7	23.7		50.1	46.4	3,5			
2	Corn (inter-cropping – soy beans)	0~ 5	7.5 R3/1	C	2.65	1.26	52.5	33.6	16.0	17,6	55.4	47,6	33,6	18.8	11	0.44	11.2
		10	"	"	"	1,46	45.0	35.1	16.8	18,3		55.0	35.1	9.9			
		20	"	HC	"	1.48	44,2	39.9	19.3	20.6		55.9	39.9	4.2			
		30	7.5 R4/2	"	"	1.53	42.4	35.8	17.2	18,6		57.6	35,8	6.6			
		40	"	C	"	1,51	43.9	34,4	16.5	17,9		56.1	34.4	9.5			
		50~55	"	CC	"	1,40	47.1	30.0	14.2	15,8		52.9	30.0	17.1			
3	Weed area	0~ 5	7.5 R3/1	C	2,65	1.37	48,4	38,6	18.6	20.0	63,6	51,6	38.6	9.8	20	0.46	24.3
		10	"	HC	"	1.47	44.5	42.3	20.6	21.7		55.5	42.3	2,2			
		20	"	"	"	1.44	45.9	41.1	19.9	21.2		54.2	41.1	4.7			
		30	7.5 R2/2	"	"	1.47	44.4	40.9	19.8	21,1		55,6	40.9	3.5			
		40	"	"	"	1.41	47.1	42,5	20.7	21,8		52.9	42,5	4.6			
		50~55	"	"	"	1.44	45.6	39.8	19.2	20.6		54,4	39.8	5,8			

3) Three phases of soil

The soil is composed of solid phase, liquid phase and vapour phase. The quantitative relationship between these three is very significant for the soil fertility and the living conditions of agroecological system. The most important theme of agrophysics is to find out and formulate the best tri-phase relations. In Europe and the U.S.A., the best conditions are said to have the solid, liquid and vapor phases at a ratio of 50 to 30 to 20 or 50 to 25 to 25.

The research track records in Japan suggest the following norms for soil improvement required for mulberry field construction. (Table 3-6).

Table 3-6 Norms for mulberry field subsoil improvement for efficient use of water

Name	Soil factors
Effective soil layer	50 - 60 cm (mainly in case of non-volcanic soil)
Consistency	20 mm or less
Bulk density	Surface soil, 1.2 - 1.3 (0.7 - 0.8 in case of volcanic soil)
Three-phase distribution	Vapor phase, more than 20%
Porosity	5 - 10% or more, pF 1.5 or more
Water permeability	10^{-2} -10^{-4} cm/sec.
Optimum soil moisture range	pH 1.5 - 3.0 (1.8 - 3.0 in case of volcanic soil)
Available moisture	50 mm or more (pF 1.6 - 3.0)
Factors to be avoided	Spring water level, ground water level (1m or less)

Source: Study on Soil Conditioning for Efficient Use of Water in Orchards - Agriculture, Forestry and Fishery Technology Conference (Nov. 1974).

The survey findings are as shown in Figures 3-4 through 3-6.

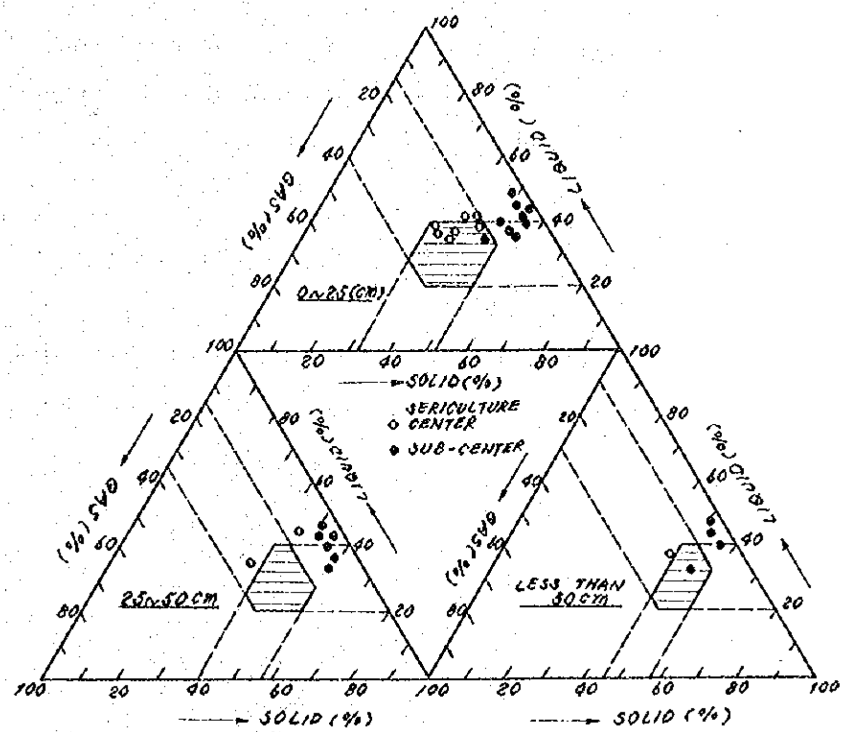
Fig. 3-6 shows the vertical 3-phase distribution of the soil per each survey point.

Fig. 3-4 shows the plotting on an equitriangle chart of the measured 3-phase distribution of the soil by depth.

Based on these findings, following comments can be made:

① 3-phase distribution of the soil at the planned construction site of the mulberry orchard for sericulture center (at Billi-billi) is relatively good, and no special soil improvement work is necessary at the construction period.

② The soil at the sub-center (Larabatariniya Village) has extremely small gas phase ratio (especially at No. 1 and No. 3 points), and is not suited to perrenial crops like mulberry without soil improvement. Therefore, it is necessary to increase the gas phase ratio during the mulberry orchard construction by soil and drainage improvement according to the method shown in 5-1-2.



Lined portions represent the range where the 3 phases of the soil is deemed appropriate.
(The soil conditions are considered to be proper when measurements of 3 phases are within this range.)

Fig. 3-4 3-phase distribution of the soil at the construction site

Fig. 3-5 shows the 3-phase soil distribution of orange orchards classified by high productive and low productive orchards. Soil strata are classified for 0 ∿ 25cm, 25 ∿ 50cm and deeper than 50cm, and the 3-phase distribution of the sample corresponding to each stratum is shown.

For most of the high productive orchards, the ranges of 3 phases of the soil are shown by hexagons on the equi-triangle charts, and the ranges are considered as "proper ranges of 3 phases of the soil".

The ranges are roughly 40 ∿ 50% (solid), 20 ∿ 40% (liquid) and 15 ∿ 37% (gas).
(See soil physical characteristics measurement method - 1975)

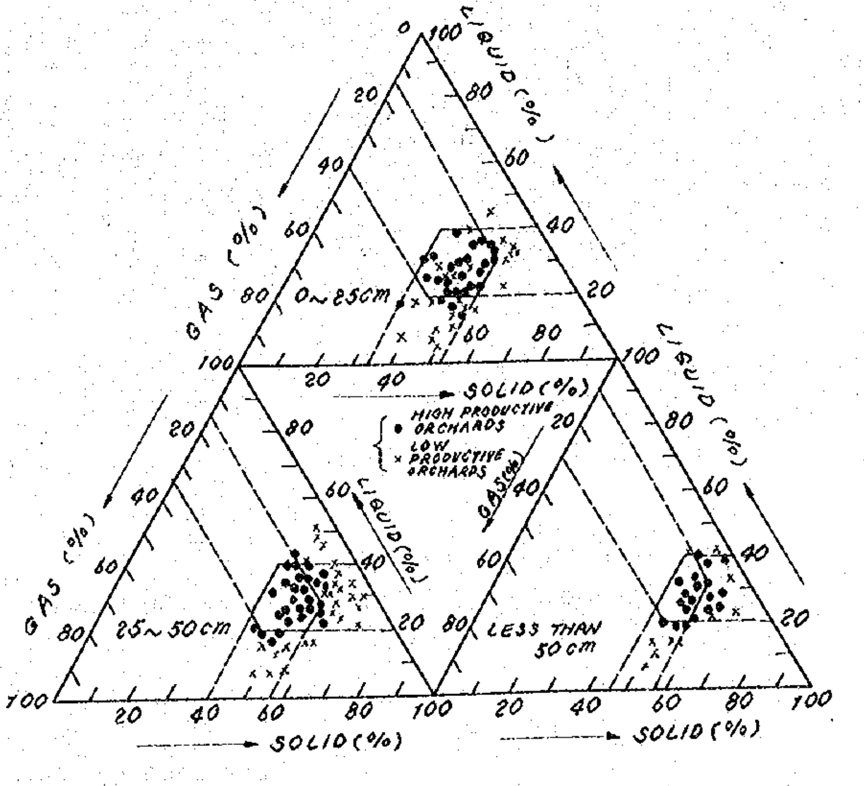
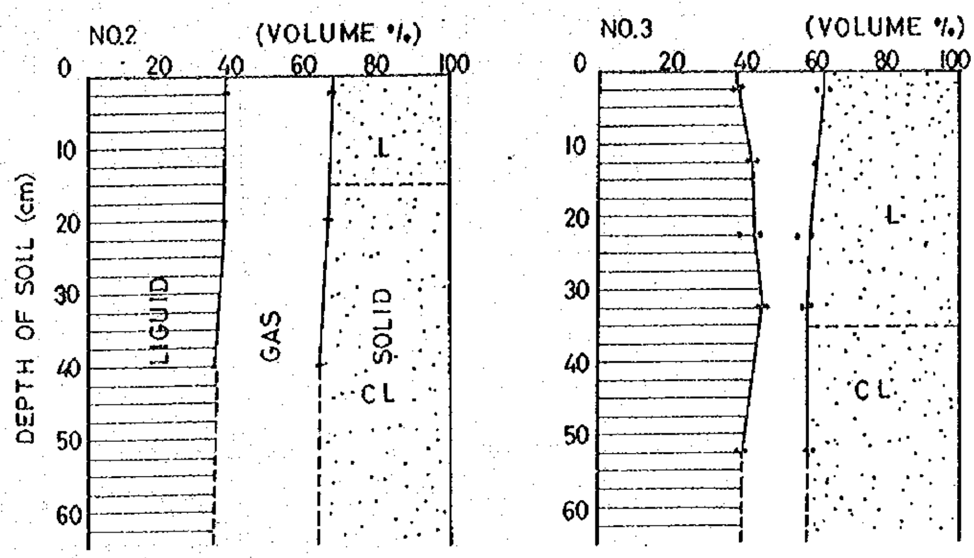


Fig. 3-5 Proper Ranges of 3 phases of the Orchard Soil

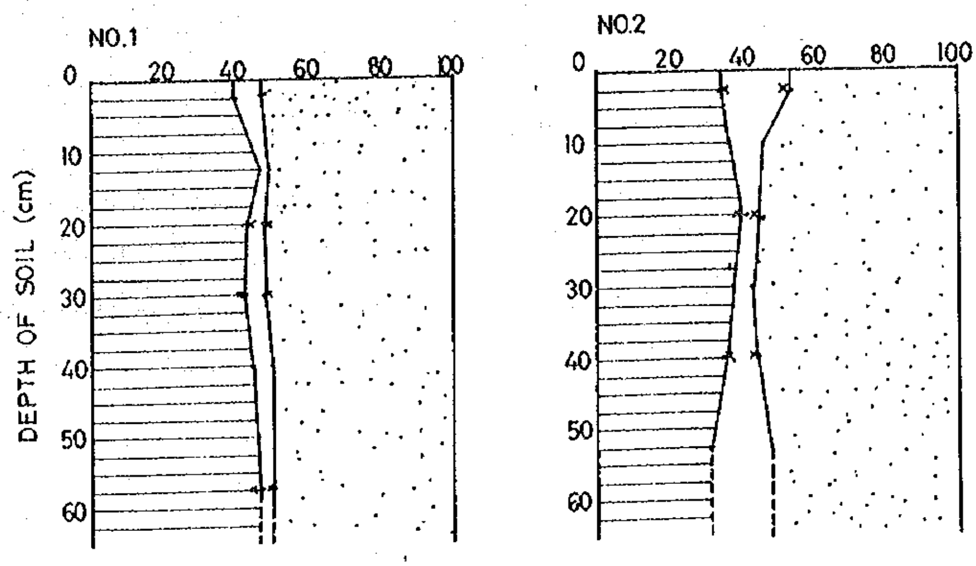
The results of measurement are as shown in Fig.3-4.

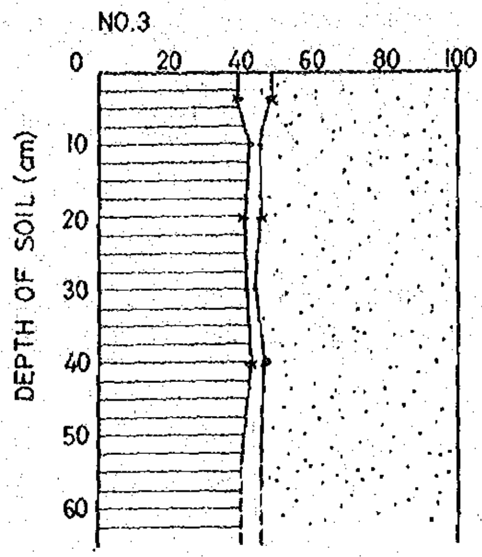
Fig. 3 - 6 Three-phase distribution of soil

(1) Sericulture centre



(2) Subcentre





(4) Intake rate of soil

The intake rate refers to a rate at which the soil absorbs rainwater or irrigation water, and is usually expressed in mm/hr. It serves as one of the most important determinants of irrigation method, irrigation intensity and irrigation period. Namely, it is no exaggeration to say that the intake rate is the basis of the irrigation planning for the present project.

i) Measuring method

The measuring method is usually classified into two in relation to the irrigation method to be applied.

For the projected site, the so-called cylinder method was applied.

Table 3 - 7 Classification of measuring methods by application

Classification of methods		Applied irrigation method
Measuring method	Procedure	
Cylinder method	Measurement of water supply rate with surface water flow checked	Border irrigation, contour ditch irrigation, basin irrigation, spray irrigation
Furrow flushing method	Measurement of the difference between water supply rate in furrow and surface runoff rate	Mainly, furrow irrigation

The preparation of measuring instruments, installation of cylinder, and measuring work were carried out in accordance with the standards established by the Soil Preservation Committee of the Bureau of Reclamation, U.S.A.

ii) Analysis of measured results

Of the measurements obtained as to three cylinders, the medians were taken up to prepare a penetration curve in order to determine the intake constants.

The integrated penetration obtained by the measurement of the cylinder intake rate is given by the following general equation.

$$D = CT^n$$

Where, D: integrated penetration, mm

T: lapse of time of irrigation, min.

C,n: intake constants

However, the integrated penetration varies widely depending on the soil nature, stratographic structure, soil moisture, surface covering, temperature of supply water, turbidity, ground temperature at the time of measurement, and many other factors, and its representative value is hard to come by.

In the projected site, the measurement was conducted by simulating the conditions of the season when the irrigation is required, and the value obtained was taken as the representative value of the spot at which measurement was conducted.

The results of measurement are as shown in Fig.3-5,3-6. Usually, the intake rate goes down with the lapse of time from the start of irrigation, and eventually is settled at a certain fixed value. The intake rate under this final state is called the basic intake rate, and is used as an index showing the water permeability of the soil.

Usually, the basic intake rate is determined as one whose rate of change is 10% of itself.

The time required to attain the basic intake rate is 600 times the exponent (min.) of the following intake rate equation.

$$I = KT^m$$

Where, I: intake rate (mm/hr)
T: lapse of time (min.)
k, m: constants

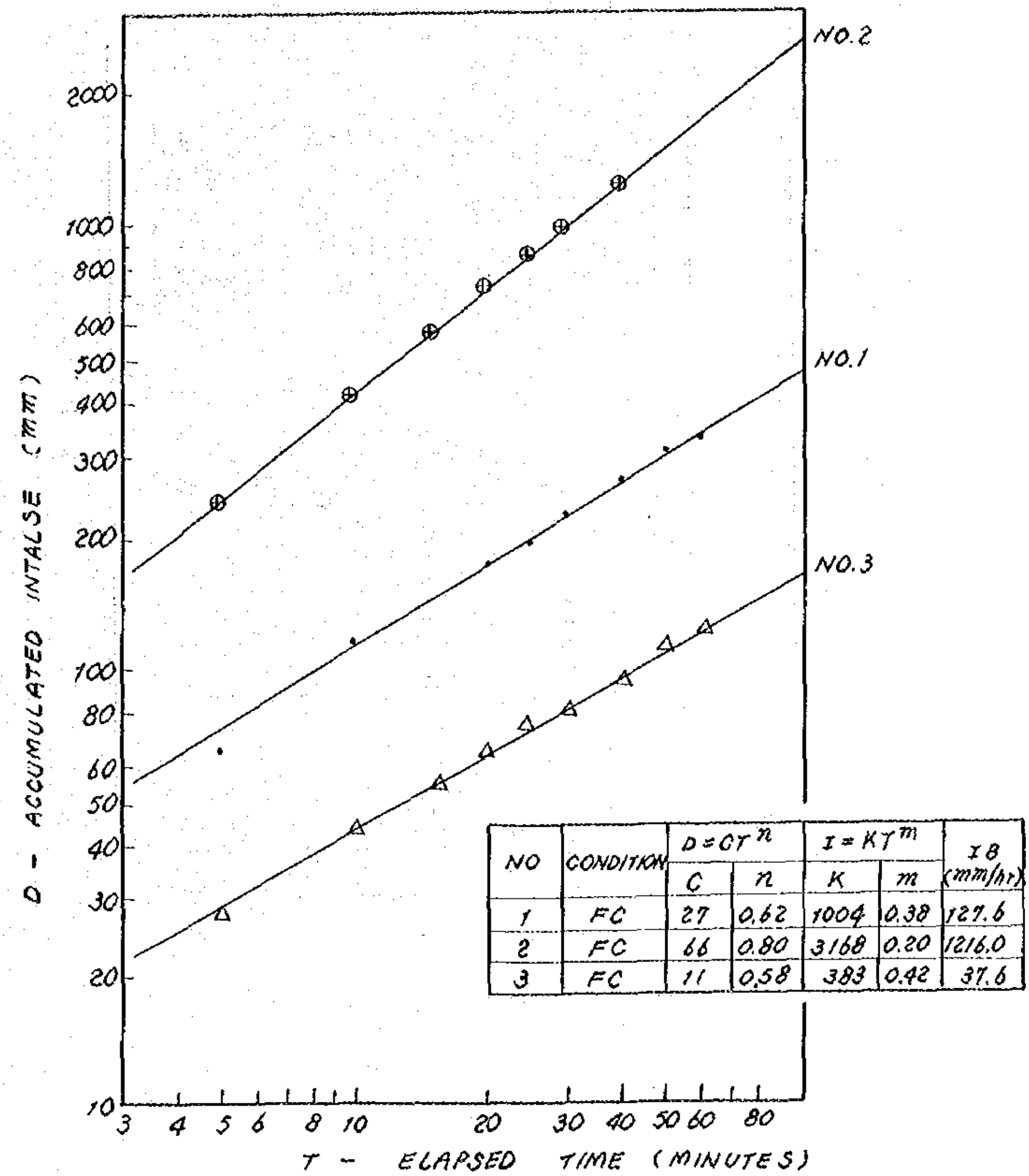
Hence, the basic intake rate is given by the following formula.

$$I_B = K\ (600m)^m \quad (mm/hr)$$

Using $D = CT^n$, I_B can be rewritten as follows.

$$I_B = 60Cn\ \{600(1 - n)\}^{n-1} \quad (mm/hr)$$

The results of calculation are as shown in Table 3 - 5.



NO	CONDITION	$D = CT^n$		$I = KT^m$		IB
		C	n	K	m	(mm/hr)
1	FC	27	0.62	1004	0.38	127.6
2	FC	66	0.80	3168	0.20	1216.0
3	FC	11	0.58	383	0.42	37.6

Fig. 3-7 Cylinder intake curves (Bili-Bili)

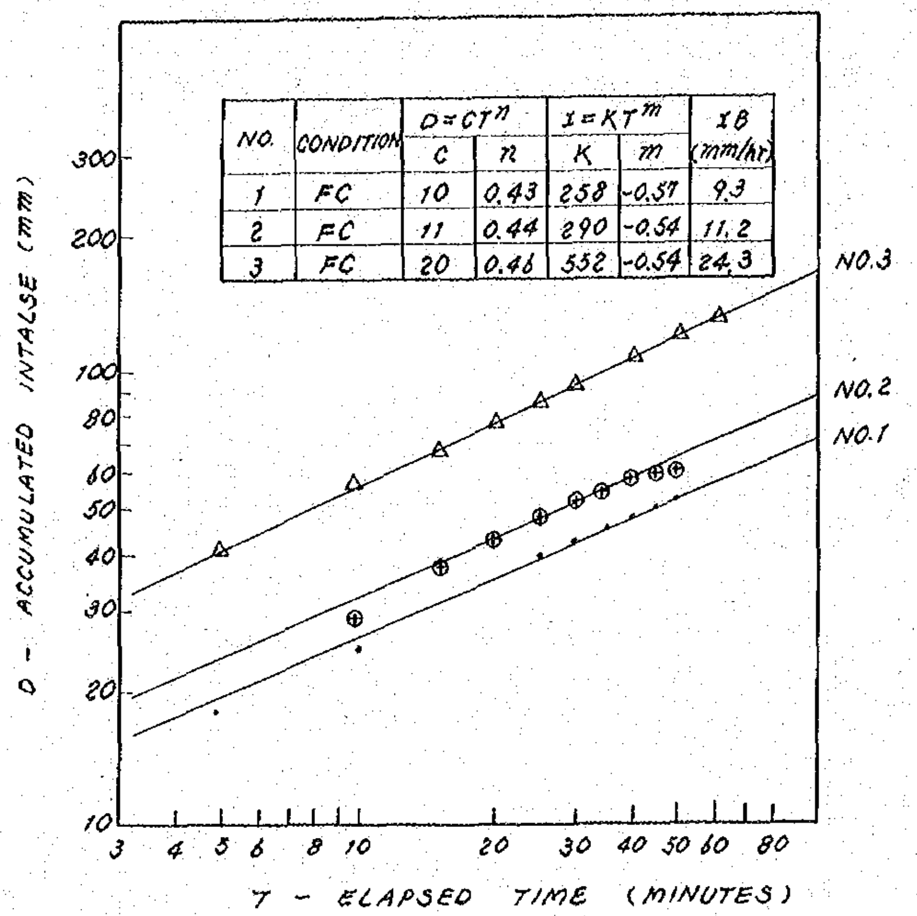


Fig. 3-8 Cylinder intake curves (Soppeng)

3-2-3. Dynamic behaviour of soil moisture

Usually, the water content in the soil is retained by two forces. Part of the water thus retained is directly used for cropping.

One force is the attraction force acting upon water molecules on the surfaces of soil particles. This force acts to form a thin layer in the boundaries between solids and liquids, retaining the water by a strong force. This water is called the hygroscopic moisture (pF 4.5 - 7.0), and is no use for the growing of crops. On the other hand, as the soil moisture gets increased, the other force (inter-molecular force of water) functions to increase the thickness of the aforesaid thin layer. The water in this thickened later is classified into two parts; one is called gravity water which can easily be drained away gravitationally, and the other is capillary water which is hard to drain (water of pF 1.6 or more can be moved gravitationally, while water of pF 1.6 - 2.7 moves on both gravitational force and capillarity pressure).

The modes of moisture are dependent on the soil nature; it is therefore important in irrigation to take clear inventory of the soil nature.

The measurement could not be made for want of time.
It is desired to spot representative measuring stations as early as possible, and to clarify the daily change in soil moisture, seasonal change of moisture consumption, and water consumption ratio by layer, etc. by setting tension meters or other suitable soil moisture measuring instruments at various levels of depth, for the purpose of acquiring basic data on irrigation control.

As is clear from the hydrological and meteorological survey results, the yearly behaviour of soil moisture is inferred to assume the following patterns as the year is divided into the dry season (June to September) and the rainy season (November to March).

I.	All-layer wet type	December to February
II.	Dry surface layer, wet bottom layer type	March to May
III.	All-layer dry type	June to September
IV.	Wet surface layer, dry bottom layer	October to November

3-3. Hydrological and meteorological survey

The climate in Indonesia is tropical as represented by high temperature, much rain and high humidity.

The continental air mass develops east monsoon during the June-September dry season, while the oceanic wet air mass creates west monsoon during the November-March rainy season.

The meteorological data (air temperature, humidity, rainfalls, etc.) in Ujung Pandang and Soppeng are summarized in Table 3-8 ∿ 3-11.

Table 3-8 Temperature, humidity and sunshine time in Ujung Pandang

Item	Year of Observation	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Average temp., °C	1971	25.6	24.2	25.4	26.1	26.0	25.7	-	25.6	26.0	26.1	25.8	-
	1972	24.8	25.4	25.5	26.0	26.2	26.3	25.7	26.2	27.8	27.8	28.0	26.9
Average max. temp., °C	1971	30.1	30.0	29.8	31.1	31.5	30.8	-	31.6	32.1	31.7	30.2	-
	1972	29.1	30.1	30.0	31.8	32.5	33.1	33.2	34.0	34.8	34.3	34.2	32.2
Average min. temp., °C	1971	28.1	21.5	21.8	21.5	21.8	21.1	-	20.4	21.2	21.6	21.8	-
	1972	21.3	21.7	21.7	21.1	20.9	20.2	19.1	19.7	20.5	20.6	22.2	22.7
Average relative humidity, %	1971	86	88	87	79	83	82	-	64	77	82	83	-
	1972	86	84	84	79	77	69	68	64	54	61	68	80
Average sunshine time, %	1971	-	-	-	87	74	-	-	-	65	62	54	-
	1972	30	48	49	77	87	86	92	98	100	99	81	66

Table 3-9 Air temperature

Table	Air temperature
Morning	25 ∿ 26°C
Daytime	29 ∿ 30
Nighttime	28 ∿ 29

Note: Surveyed by Mr. Kiyoshi Aoki, Sept. 1972

Table 3-10 Rainfalls and number of rainy days in W. Soppeng

Year	Monthly total, mm/day						
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
1952	36 (4)	174 (9)	123 (9)	246 (5)	264 (13)	156 (6)	76 (6)
1954	108 (4)	106 (5)	188 (8)	106 (6)	309 (8)	291 (14)	131 (8)
1957	105 (4)	113 (9)	167 (8)	82 (2)	327 (15)	143 (8)	109 (12)
1960	241 (5)	155 (10)	52 (4)	292 (11)	314 (11)	188 (12)	305 (12)
Mean	123 (5)	137 (8)	133 (7)	182 (6)	304 (12)	194 (10)	155 (8)
1972	291	132	64	112	207	9	295
1975	270	279	98	226	339	324	295

Year	Monthly total, mm/day					Yearly total	
	Aug.	Sep.	Oct.	Nov.	Dec.		
1952	60 (4)	74 (3)	123 (5)	73 (5)	221 (11)	1,625	80
1954	111 (6)	63 (4)	115 (8)	119 (9)	305 (12)	1,952	92
1957	60 (4)	0 (0)	41 (2)	81 (11)	210 (9)	1,438	77
1960	88 (10)	54 (4)	31 (1)	149 (11)	68 (9)	1,937	102
Mean	80 (6)	48 (3)	78 (4)	106 (9)	201 (10)	1,741	88
1972	21	0	0	21	205	1,357	
1973	-	236	112	301	103	(2,538)	

Note: According to the survey by Mr. Kiyoshi Aoki and Mr. Den Kuzuma. (The data for the years 1972 and 1973 are according to the statistics by the General Bureau of Forestry.)

Table 3-11 Temperatures and rainfalls in Java and South Sulawesi

Month	Djakarta		Bogor		Ujung Pandang	
	Air temperature	Rainfall	Air temperature	Rainfall	Air temperature	Rainfall
Jan.	25.4°C	270mm	24.1°C	424mm	25.6°C	276mm
Feb.	"	241	24.2	422	25.8	590
Mar.	25.8	175	24.5	387	"	417
Apr.	26.2	131	25.1	403	26.4	153
May	26.4	139	25.2	347	26.2	87
Jun.	26.0	105	25.0	268	25.4	74
Jul.	25.8	72	25.2	243	25.2	36
Aug.	25.9	65	25.3	238	25.6	11
Sep.	26.2	146	"	328	25.4	15
Oct.	26.3	169	24.6	420	26.0	173
Nov.	26.0	183	24.4	408	26.2	182
Dec.	25.7	185	24.8	338	25.4	597

Note: According to the findings by Mr. Kiyoshi Aoki and Mr. Den Kuzuma

Table 3-12 shows the weather conditions at Ujung Pandang arranged from the 1972 RIKA NENRYO (Annual Statistics of Natural Science) for reference purpose.

Table 3-12 Weather Conditions at Ujung Pandang
(1972 Annual Statistics of Natural Science)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average or Total	Period
Average temperature	26.1	26.4	26.4	26.7	27.0	26.1	25.6	25.6	25.9	26.4	26.7	26.1	26.4	1879~1933
Average relative humidity	85	84	84	82	81	79	77	76	75	78	81	85	81	"
Rainfall	686	536	424	150	89	74	36	10	15	43	178	610	2,850	"

Fig. 3-9 shows the shortage of rainfalls calculated based on the rainfalls (Table 3-11) and evapotranspiration (Table 4-2) in Ujung Pandang.

In Indonesia, the difference between the evapotranspiration and rainfalls is taken as the shortage of rainfalls.

If this is viewed from the effective rainfalls (about 50 to 60% of monthly rainfalls, though dependent on rainfall intensity), the shortage is further increased.

Naturally, the irrigation isalmost indispensible to the growing of mulberry and other crops in the projected area.

Table 3-12 shows the meteorological conditions in Ujung Pandang as excerpted from the Science Yearbook (1972 edition) by way of reference.

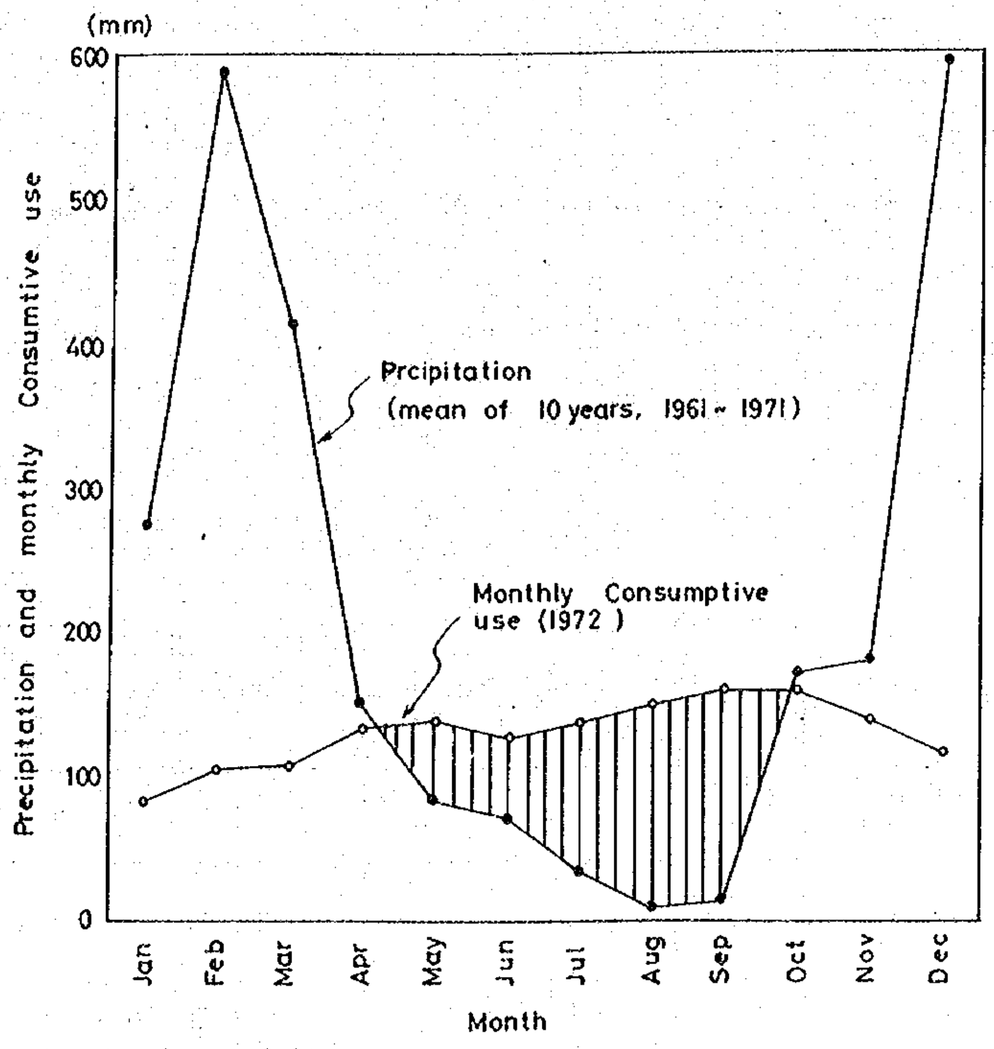


Fig. 3-9 Rainfall shortage in dry season (Ujung Pandang)

3-4 Socio-economic survey

3-4-1. Communities and farming around the proposed site

The communities around the proposed site are each composed of 100 to 200 farmhouses governed by a village headman. Several communities (villages) are governed by a provincial governor. Bili-Bili Village where the sericulture center is to be located is in a rural area forming a debouchure between a plan and the mountains. Paddy rice is the main crop, and dry fields and banana plantations are seen on the moderate slopes of mountains. The subcenter extends over two villages - Donri-Donri Village and Lalabata Riaja; sericulture substation of the Forestry Experiment Station is in Donri-Donri, and mulberry fields stretches between Donri-Donri and Lalabata Riaja. In addition to paddy fields, there are many mulberry fields.

3-4-2. Labour conditions

There are no industrial sites around that attract labour, and both sericulture center and subcenter can take recourse to a considerably large labour potential of farmers.

In an interview survey at Bili-Bili Village, it was found that about 50 labourers would always be ready to bear a hand in shifts. The wages for heavy physical labour currently are RP500 (approx. ¥350) a day. Since the rental charges of heavy machinery are high in Indonesia, it stands to reason that the labour should be employed as much as possible for construction work.

3-4-3. Survey of construction materials, equipment and labour

According to the statistics available from the authorities concerned, the principal construction materials and supplies and labour force are as follows.

Labour cost - 1976 (values parenthesized refer to 1972)

a) Foreman

		RP/day
Equipment repair	:	850
Equipment operation	:	850
Carpentry	:	750 (400)
Masonry	:	750
Others	:	750 (375)

b) Skilled worker

Mechanic	:	600
Operator	:	650 (400)
Carpenter	:	650
Mason	:	650
Barman	:	600 (400)
Others	:	550 (325)

c) Semi-skilled worker

Mechanic	:	500 (300)
Operator	:	550 (400)
Driver	:	550 (350)
Carpenter	:	500 (350)
Mason	:	500 (350)
Barman	:	450 (350)
Others	:	400 (275)

d) Utility hand : 500

(2) Materials and supplies - 1976

a) Stone and aggregate

Crushed stone (for masonry)	:	RP/m^3	2,000 - 3,000 (1,250)
Boulder (for masonry)	:	RP/m^3	2,000 - 3,000 (1,500)
Coarse aggregate (crushed, 5 - 40 mm)	:	RP/m^3	3,000 - 4,000 (1,250)
Fine aggregate (natural sand)	:	RP/m^3	1,500 - 3,500 (1,000)
Crushed stone (for pavement)	:	RP/m^3	3,000 - 3,500

b) Cement

Portland cement (40 kg/bag)	:	RP/bag	2,000 - 2,300

c) Iron and steel

Reinforcement bar	:	RP/kg	400 - 450
Binding wire	:	RP/kg	500 - 550
Wire, 3 - 4 mmø	:	RP/kg	500 - 550
Nail	:	RP/kg	450 - 500

d) Lumber

Lumber, Class 1	:	RP/m^3	40,000 - 45,000
Lumber, Class 2	:	RP/m^3	30,000 - 35,000
Lumber, Class 3	:	RP/m^3	25,000 - 30,000 (14,500)
Log	:	RP/m^3	20,000 - 25,000 (12,000)
Bamboo, 5 m	:	RP/pc.	300

e) Asphalt pavement

Asphalt	:	RP/kg	80 - 100
Heating	:	RP/m^3	900

f)	Brick	:	RP/pc.	8 - 9

g) Oils and greases

Gasoline	:	RP/lit.	57
Diesel oil	:	RP/lit.	28
Engine oil	:	RP/lit.	450
Gear oil	:	RP/lit.	500
Hydraulic oil	:	RP/lit.	500
Brake oil	:	RP/lit.	2,000
Grease	:	RP.kg	670

(3) Cost by type of work

a)	Bushing clearing	:	RP/m^2	200
b)	Top soil removing	:	RP/m^2	544
c)	Excavation, A (ordinary)	:	RP/m^2	755
d)	Excavation, B (gravel & sand)	:	RP/m^3	1,360

e)	Excavation, C (soft rock)	:	RP/m^3	2,030
f)	Banking	:	RP/m^3	1,000
g)	Back filling (for structure)	:	RP/m^3	204
h)	Sodding	:	RP/m^3	132
i)	Road ballsting	:	RP/m^2	810 - 910
j)	Mortar masonry, A (1:4)	:	RP/m^3	15,820 - 16,920
k)	Mortar masonry, B (1:3)	:	RP/m^3	17,820 - 19,120
l)	Concrete work, A (1:2:4)	:	RP/m^3	46,500 - 51,600
m)	Concrete work, B (ferro-concrete)	:	RP/m^3	102,000 - 113,000
n)	Plastering (1:2), t= 50 mm	:	RP/m^2	3,600 - 4,000
o)	Plastering (1:3), t= 30 mm	:	RP/m^2	1,600 - 1,800
p)	Plastering (1:4), t= 30 mm	:	RP/m^2	1,315 - 1,485
q)	Masonry jointing (1:2)	:	RP/m^2	603 - 658

(4) Charges for heavy machinery

a)	Bulldozer rental charge	:	RP/hr.	13,000
b)	Bulldozer freightage	:	RP/unit	150,000

Chapter 4. Final Design of Sericultural Centre

4-1. Field Design (incl. Building Site Design)

4-1-1. Mulberry Field

a) Since four-wheeled riding tractors will be used after reclamation, it is planned that the mulberry fields will have a gradient of less than 14% (≈8°). Reclamation of both Farm No.1 and No.2 will be conducted in natural slope because of their heavy undulation, with the area having a gradient of more than 14% turned into a grassland as illustrated in Fig. 4-1.

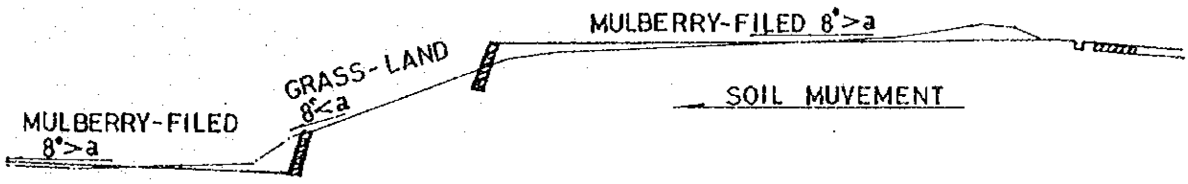


Fig. 4-1

b) Gravels of different sizes are found in the plot of both farms so that the reclamation work will be carried out in parallel with the gravel removing work using bulldozers which will be so operated as will move earth from the upper to the lower part of each farm.

c) Gravels will be removed in time with the deep ploughing to be conducted by bulldozers to a depth of 0.50 m. At this time, gravels in the grassland area will be also removed.

d) In order to secure as large an area as possible for the mulberry fields, stone masonry with filling will be conducted in places where the gradient changes sharply, using gravels in the project area.

e) For the sake of safety, the stone masonry will have a maximum height of 2.0 m, a gradient of 1 : 0.5, and a backing height of 1.0 m. Further, it is planned to avoid mortar caulking of more than 50% to ensure satisfactory drainage of groundwater as illustrated in Fig. 4-2.

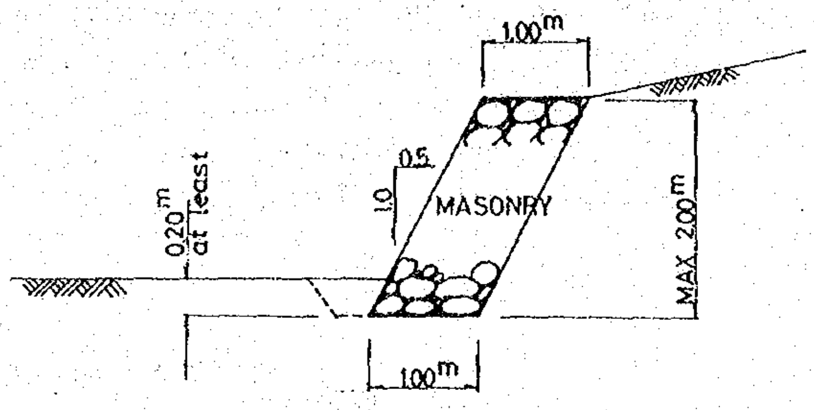


Fig. 4-2

4-1-2 Building Site

a) The building site extends with a mild slope along the existing road and does not call for intensive levelling work. Accordingly, the ground levelling work will be required only to grade off the surface undulation. However, it is planned that the gradient of the whole building area will be reduced to less than 1%.

4-1-3 Road

a) For easy operation and maintenance of the farms which will be operated for experimental purposes, the road area ratio is set at a high value. The roads within the farm area will be serve as butts, and it is planned that the shorter side of each block in the farms will be smaller than 70 m. in length.

b) The maximum gradient of the roads is set at 10%.

c) The roads will have an effective width of 3.0 m and gravel paved. However, the road to be constructed between Field A and the existing road which loads to the microwave station will not be covered with gravels because it is expected to serve as butt for the most part.

d) The thickness of the gravel layer is set at 30 cm.

e) Since there is a height difference of about 1.00 m between the building site and the microwave road site, it is planned to construct a connecting road running through the building site in parallel with the microwave road. The connecting road will be 4.00 m in effective width and protected by random asphalt pavement having a roadbed thickness of 0.25 m and a surface course thickness of 0.05 m.

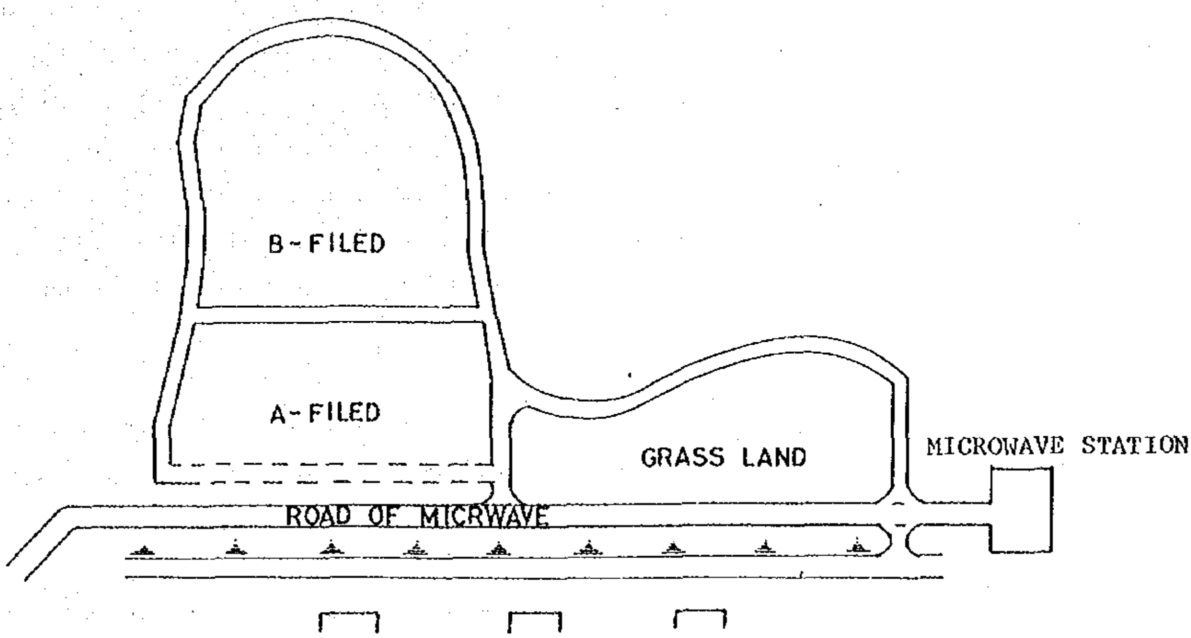


Fig. 4-3 Farm Road Arrangement

f) Curves will be provided only in those sections where the degree of curvature exceeds 30°

4-1-4 Drainage

a) The pronect area is situated near the mountain top an embraces a water shed so that the catchment area is small and the flow rate during rainfall is not very large. Accordingly, it is planned that the side ditches to be provided for surface water drainage will be approximately equivalent in size to those already found along the existing roads. No specific drainage work including underdrainage is required for the farm area because its soil condition is generally favourable except that gravels are found in abundance. Design of drainage structures is therefore intended only to cope with surface water, drinking water and miscellaneous waste water.

b) There are found neither drainage channels nor rivers in the neighbourhood of the project area, so that it is planned that effluent water will be drained on the mild mountain slope. On the side of the building site, however, the slope is steep and the site of Farm No.2 is found downwards. For these reasons and also because of the need for maintaining the limit gradient in the building site, effluent water on this side will be drained down in the direction of the mulberry field and grass-land.

c) A stilling basin will be provided for hillside drainage in order to reduce the flow velocity of drainage and protect the slope from erosion.

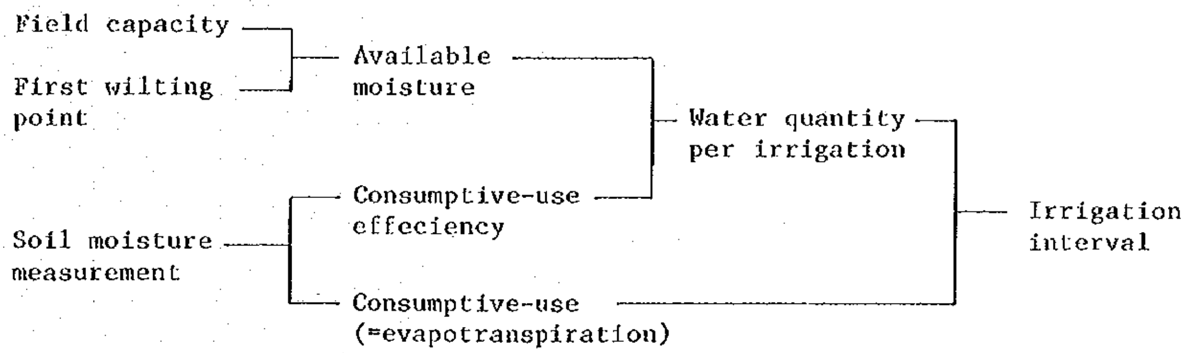
d) As for the drainage of Farm No.2, only the falling water from the mountain side will be led into a drainage canal to be linked to the side ditches along the microwave road, and drainage water from all other directions will be let down the slopes.

e) It is planned that the alignment of the drainage ditch in the site of Farm No.1 will be changed after it is filled up during the reclamation work, and a new concrete pipeline with a diameter of 600 m/m will be installed for connection with the side ditch along a branch agricultural road.

4-1-5 Irrigation

a) Calculation of Irrigation Requirement

The irrigation requirement is calculated in the sequence shown below from the soil moisture and the water consumption of crops in the area under consideration.



b) Evapotranspiration

The evapotranspiration from a crop growing farm varies by the climatic condition, soil type, moisture content, surface covering, kind of crops and growing period of crops, etc. Its value should preferably be obtained directly by the soil moisture measuring method, the lysimeter method or Chamber's method. If this is not applicable it is obtained by a suitable calculation method.

Of a number of measuring methods shown in Table 4-1, Turc's method and Penman's methods are known to produce a relatively correct value. Since the former method is often applied in areas not favoured with an abundant water source, it is employed for measuring of evapotranspiration in the project area.

Table 4-1

Name	Temper-ature	Relative humidity	Sunshine		Wind Velocity
			Duration	Amount	
1. Blaney-Criddle	o		o		o
2. Hargreaves	o	o	o		
3. Lowing-Johnson	o		o		
4. Olivier	o	o		o	
5. Penman	o	o		o	o
6. Thornthwait	o	o	o		
7. Turc	o			o	
8. Evaptranspiration Ratio Method	o	o		o	o

In Turc's method, potential evapotranspiration (Et) is obtained by the following equation.

$$Et = 0.4 \times \frac{T}{T-15} \{Ra\ (0.23 + 0.48\ \frac{n}{N} + 50\} \ \ldots \ (mm/month)$$

where, T : Mean monthly temperature (°C)

Ra : Extra terrestial solar radiation ($Cal/cm^2/day$).

n/N : Sunshine (%).

Results of the calculation are shown in Table 4-2.

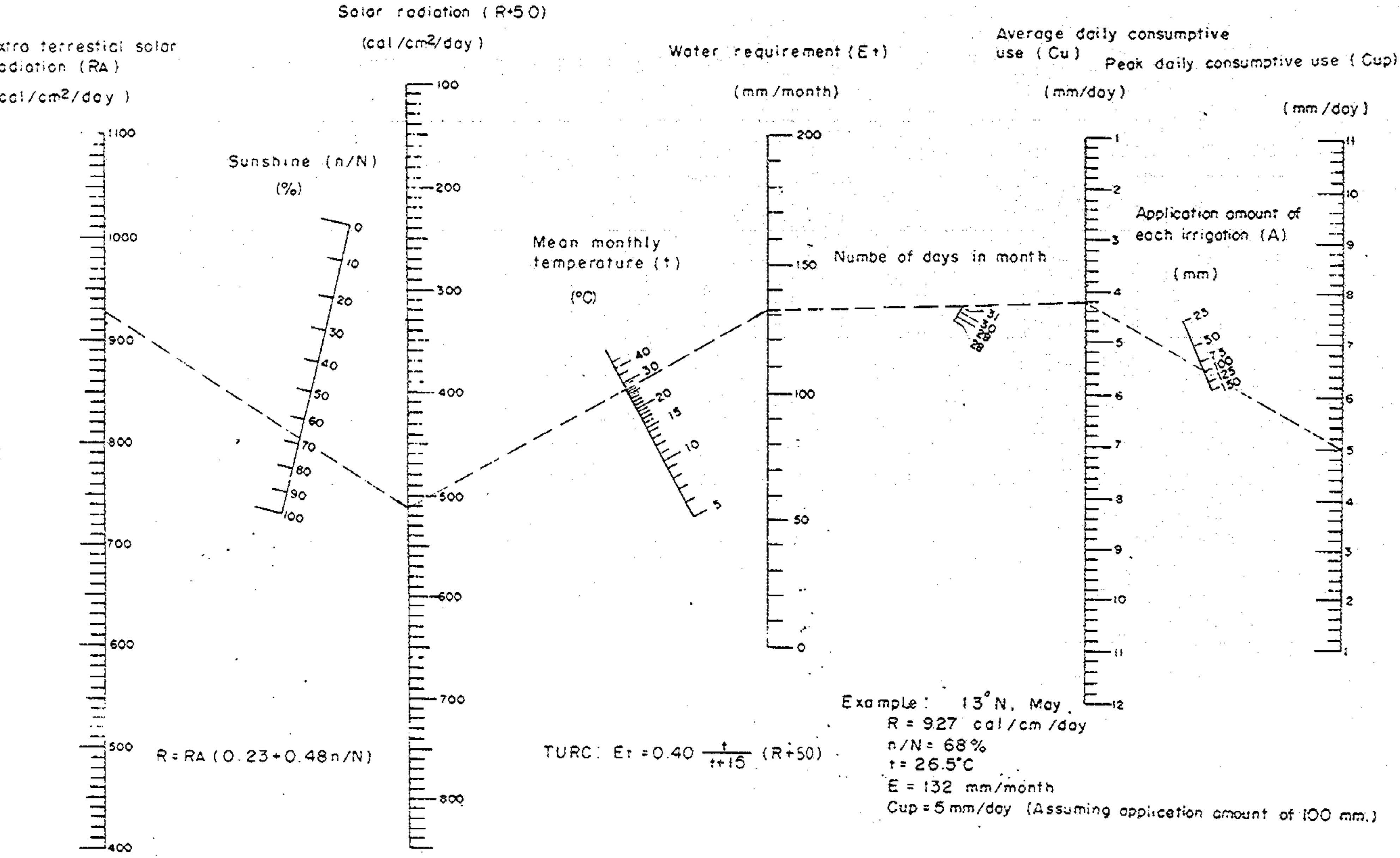


Fig. 4-4 Monograph for estimating water requirement in lower latitudinal regions.

Table 4-2 Calculation of Irrigation Requirement

(Ujung Pandang)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Agt.	Sep.	Oct.	Nov.	Des.
Extra terrestial Solar radiation (RA) ($cal/cm^2/day$)	880	915	930	895	845	815	830	870	910	915	890	870
Sunshine (n/N) (%)	30	48	49	77	87	86	92	98	100	99	81	66
* Solar radiation (R+50) ($cal/cm^2/day$)	330	422	431	532	545	520	560	605	648	640	550	472
Mean monthly temperature (t) (C°)	25.6	25.8	25.8	26.4	26.2	25.4	25.2	25.6	25.4	26.0	26.2	25.4
* Water requirement (Et) (mm/month)	83	106	108	135	139	130	140	152	162	162	140	117
Number of days in month	31	28	31	30	31	30	31	31	30	31	30	31
Average daily consumptive use (Cu) (mm/day)	2.7	3.8	3.5	4.5	4.5	4.3	4.5	4.9	5.4	5.2	4.7	3.8
Application amount of each irrigation (A) (mm)	50	50	50	50	50	50	50	50	50	50	50	50
* Peak daily consumptive use (Cup) (mm/day)	3.8	5.2	4.8	6.2	6.2	6.0	6.2	6.7	7.3	7.1	6.4	5.3
Average monthly consumptive use $(Cu)^1$ (mm/month)	84	106	109	135	140	129	140	152	162	161	141	118
Precipitation (mean of 10 years, 1961 - 1971) (P) (mm)	276	590	417	153	87	74	36	11	15	173	182	597

Note: Asterisked figures were obtained from the nomograph illustrated in Fig. 4-4

c) Irrigation Requirement

If the irrigation efficiency is taken at 75% (0.85 x 0.90 = 0.75) with the effective rainfall assumed to be 60% of monthly rainfall, the irrigation requirement turns out to be as shown in the following Table 4-3 and 4-4.

Table 4-3 Irrigation Requirement

(mm)

	1	2	3	4	5	6	7	8	9	10	11	12	Total
① Effective rainfall	111	141	144	92	52	44	22	7	9	104	109	156	991
② Evapo-trance-piration (net)	83	106	108	135	139	130	140	152	162	162	140	117	1,574
③ Evapo-trance-piration (gross)	111	141	144	180	185	173	187	203	216	216	187	156	2,099
④ Irrigation require-ment	0	0	0	88	133	129	165	196	207	112	78	0	1,108

Note: ① ... 60% of monthly rainfall. If it exceeds ③, ③ is taken as the upper limit. ② is obtained from Table 4-2 .

③ ... ②/0.75;

④ ... ③ - ①

Table 4-4 Water Requirement

(m^3)

	Area (ha)	1	2	3	4	5	6	7	8	9	10
Sericulture centre	8.0	0	0	0	7,040	10,640	10,320	13,200	15,680	16,560	8,960
Sub centre	19.5	0	0	0	17,160	25,935	25,155	32,175	38,220	40,365	21,840

	11	12	Total
Sericulture centre	6,240	0	88,640
Sub centre	15,210	0	216,060

d) Selection of Irrigation Method

While there are a diversity of irrigation methods, selection is generally made according to the following three conditions.

1. Site conditionsincluding the physical conditions of soil, such as water holding capacity of soil, intake rate, etc. and gradient.
2. Managing conditions such as kind of crops and managing scale.
3. Management conditions such as cost of farm reclamation work, cost of irrigation facilities, management cost, etc.

It is often the case that the latter two conditions cannot be determined by technical studies alone because they are influenced by the socio-economic conditions of each locality.

For reference, general classification of irrigation methods is shown below.

- Irrigation Method
  - Spray Irrigation
    - Sprinkler Method
    - Perforated Pipe Method
  - Surface (Flooding) Irrigation
    - Border Method
    - Furrow Method
    - Contour Ditch Method
    - Basin Method
  - Drip Irrigation
  - Sub-irrigation

In some parts of the project area, the soil and topographical conditions make the furrow irrigation preferable over other irrigation methods. However, considering the present technical level of farmers and the expediency for the experts in providing guidance services, it is planned that the spray irrigation will be applied in the whole area.

e) Spray Irrigation

(1) Selection of Sprinkler

There are about 100 different sprinklers available on the market. They differ from each other in shape, nozzle diameter, rotation mechanism, sprinkling pattern, service pressure, delivery rate, spray diameter etc. It is therefore possible to select the one that most suits the planned capacity of irrigation facilities, scale of irrigation farming, kind of soils, topography, and kind of crops.

For irrigation of mulberry fields, it is preferable to use sprinklers like Rainbird No. 70E which can simultaneously cover an extensive area by stationary irrigation from tree tops or high pressure sprinklers like furrow guns which can cover even a larger area by moving irrigation from tree tops. In the sub-centre farm (New Field) where the intake rate is limited, however, application of these large type sprinklers calls for careful previous studies because their high spray intensity is prone to cause soil erosion or decline of irrigation efficiency.

In view of the present soil and topographical conditions in the two farms, it is considered both safe and reasonable to use medium or lower pressure type having a relatively low spray intensity. In the project area, it is planned to increase the soil permeability by soil and soil layer improvement, reduce the gradient to less than 8°, and introduce contour cropping. Accordingly, labour-saving large type sprinklers which involve a low installation cost and permit easy management are selected.

Table 4-5 shows the specifications of the sprinklers reviewed for application in the project area.

Table 4-5 Specifications of Sprinklers

Model	Nozzle Diamenter	Nozzle Pressure (kg/cm^2)	Nozzle Flow Rate (ℓ/min)	Spray Diamenter (m)	Spacing (m)	Spray Area (m^2)	Spray Intensity (mm/hr)	Remarks
Rainbird No. 30B	11/64" x 3/32"	2.46	24.9	27.4	18 x 12	216	6.9	
		2.81	26.6	28.0	18 x 12	216	7.4	
		3.16	28.2	29.0	18 x 12	216	7.8	
		3.62	29.8	29.0	18 x 12	216	8.3	
		3.52	71.2	40.8	24 x 16	384	11.1	
Rainbird No. 70E	1/4" x 11/64"	3.87	74.6	41.5	24 x 16	384	11.7	
		4.22	78.0	42.4	24 x 16	384	12.2	
		4.57	82.1	43.3	24 x 16	384	12.8	
		4.0	308	62	40 x 30	1200	15.4	
NAAN 268	14.5 x 6.0 x 4.0 mm	5.0	350	66	40 x 35	1400	15.0	
		6.0	383	70	40 x 35	1400	16.5	
		7.0	412	72	40 x 35	1400	17.7	
		2.85	273	54	32 x 20	640	25.6	
Rarrow Gun Mod. 50	17 mm	4.28	346	66	40 x 28	1120	18.5	
		5.71	400	74	44 x 28	1232	19.5	
		7.14	446	84	52 x 36	1872	14.3	

Note: $S\ell = 0.6D$, $Sm = 0.4D \sim 0.5D$

(2) Spacing of Sprinklers

Where there is no wind, it is acceptable to set the nozzle spacing at 30 - 50% of the spray diameter and the branch pipe spacing at less than 60% of the spray diameter. When there is wind, however, the spray distribution becomes poor unless the spacing is reduced according to the wind velocity. It is therefore planned that the criteria shown in Table 4-6, will be observed as far as practicable in determining the branch pipe spacing for sprinkling under windy weather.

Table 4-6 Relationship between Wind Velocity and Branch Pipe Spacing

Wind Velocity	Rainbird No. 30B	Rainbird No. 70E	Naan 286	Furrow Gun 50
Less than 2 m/sec	0.6D	0.6D	0.6D	0.55D
2 - 4 m	0.5D	0.5D	0.5D	0.4D
More than 4 m/sec	0.4D	0.4D	0.4D	0.4D

Note: D denotes the spray diameter (m).

Table 4-7. Design Criteria of Sprinkler Irrigation

		Rainbird No.30B	Rainbird No.70E	Furrow Gun Mod.50	NAAN 268
Nozzle Diameter		11"/64×3"/32 7°	1/4"x11/64"	17mm	14.5x6.0x4.0 mm
Service Pressure	kg/cm^2	2.8	3.9	4.3	5.0
Delivery Flow Rate	ℓ/min.	26.6	74.6	345.3	350.0
Branch Pipe Spacing	m	18	24	40	40
Sprinkler Spacing	m	12	16	28	35
Spray Area	m^2	216	384	1120	1400
Spray Intensity	mm/hr	7.4	11.7	18.5	15.0
Irrigation Efficiency	%	85	85	85	85
Gross Water Duty per Sprinkler Operation	mm	60	60	60	60
Time Required for Each Sprinkler Irrigation	hr	8.1	5.2	3.3	4.0
Daily Number of Sprinkler Movements		2	3	5	4
Daily Watering Time	hr	16.2	15.6	16.5	16.0

(3) Terminal Irrigation Capacity

The irrigation plan of the project area is based on the seven day intermittent irrigation of 51 mm (7.3 mm x 7 days), irrigation efficiency of 85%, and daily irrigation time of 16 hours. Accordingly, the terminal irrigation capacity per ha, Q. turns out to be 1.49 ℓ/sec as calculated below.

$$Q = 166.7 \times \frac{1}{16} \times \frac{51}{0.85 \times 7} = 89.3\ \ell/\text{min} = 1.49\ \ell/\text{sec}$$

Assuming that Reinbird No. 70E having a working pressure of 3.9 kg/cm^2 and a delivery flow rate of 74.6 ℓ/min will be used, the irrigable area per sprinkler turns out to be 0.84 ha (=74.6/89.3).

Table 4-8 shows the operational data of different types of sprinklers in Sericulture Centre and Sub-Centre areas.

Table 4-8 The Operational Data of Different Types of Sprinklers

	Sericulture Center (A=8 ha, Q=714ℓ/min, T=16hr)				Sub-Center (A=19.5 ha, Q=1741 ℓ/min, T=16hr)			
	Number of Sprinklers in Simultaneous Operation	Capacity of the left ℓ/min	Daily Net Irrigation Hours hr	Net Number of Days of Irrigation Interval	Number of Sprinklers in Simultaneous Operation	Capacity of the left	Daily Net Irrigation Hours hr	Net Number of Days of Irrigation Interval
Rainbird No. 30B	26 (2)	691.6	16.2	7.0	66 (2)	1755.6	16.2	6.9
Rainbird No. 70E	10 (3)	746.0	15.6	6.9	24 (3)	1790.4	15.6	7.0
Furrow Gun Mod. 50	2 (5)	690.6	16.5	7.0	6 (5)	2071.8	16.5	5.7
NAAN 286	2 (4)	700.0	16.0	7.0	6 (4)	2100.0	16.0	5.7

Note: Figures in parentheses indicate the number of simultaneous sprinkler operations.

f) Pump (Centre)

i. Total head

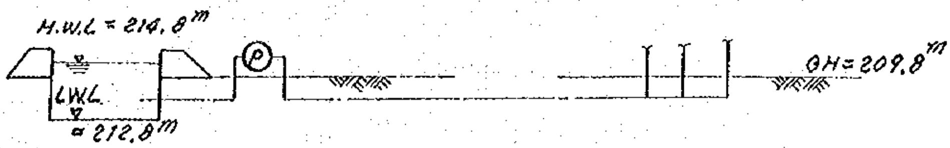


Fig. 4-5

Actual head	H_a = 209.8-212.8 = -3.00m
Capacity	Q = 12.4 ℓ/s = 744 ℓ/min
Type and diameter of pipe	VP ϕ 100 m/m
Required terminal pressure	H_1 = 39.0 m
Pipeline frictional loss	
Branch pipeline	H_{cd1} = 7.15 m
Sprinkler pipeline	H_{cd2} = 6.36 m
Valve and reducer loss (10% of frictional loss)	H_{is} =(7.15+6.36)x0.10=1.35m

Total head (H) :

$$H = H_a + H_1 + H_{cd1} + H_{cd2} + H_{is}$$
$$= -3.00 + 39.0 + 7.15 + 6.36 + 1.35$$
$$= 50.86^m \doteq 51m$$

ii. Shaft power and motor output

$$P = \frac{0.163 \times \gamma \times Q \times H}{\eta_p} \qquad R = \frac{P \times (1 + \alpha)}{\eta_t}$$

$$P = \frac{0.163 \times 1.0 \times 0.744 \times 51}{0.70} = 8.8 \text{ kW}$$

$$R = \frac{8.8 \times (1 + 0.2)}{0.95} = 11.0 \text{ kW}$$

where, P : Shaft power (kW).

R : Prime mover output (kW).

Q : Pump capacity (0.744 m^3/min).

H : TTotal head (51m).

∂ : Bulk density of pumped water (1.0).

μ_p: Pump efficiency (0.70).

μ_t: Transmission efficiency (0.95)

iii. Type of pump

Pump Specifications :

Type	Centrifugal pump
Head	51 m
Capacity	12.4 ℓ/s - 744 ℓ/min.
Suction port diameter	ϕ 80 m/m
Delivery port diameter	ϕ 80 m/m
Motor output	11 kW.

Table 4-9 - Results of Hydraulic Calculation

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD	
Pipe Line No.1	m	m	m	ℓ/s	mm	m/s		m	m	m	
Pump			214.0						262.31	48.31	
Pipe line No.4	10.0		214.0	12.4	100	1.58	22.13	0.22	262.09	48.90	C=150
Pipe line No.3	157.0		213.5	12.4	"	"	"	3.47	258.62	45.12	
Pipe line No.5	33.5		212.0	12.4	"	"	"	0.74	257.88	45.88	
Pipe line No.2	3.8		211.5	12.4	"	"	"	0.08	257.80	46.30	
Hydrant No. 1	23.5		211.8	12.4	"	"	"	0.52	257.28	45.48	
" 2	48.0		211.0	12.4	"	"	"	1.06	256.22	45.22	
" 3	48.0		211.5	12.4	"	"	"	1.06	255.16	43.66	74.6x10÷60
" 4	48.0		210.5	8.7	"	1.11	11.49	0.55	254.61	44.11	74.6x7÷60
								Σ = 7.70			
Pipe line No.2											
Pipeline No.2									257.80	46.30	
Hydrant No.5	123.0		205.0	12.4	100	1.58	22.13	2.72	255.08	50.08	
" 6	52.5		205.0	12.4	"	"	"	1.16	253.92	48.92	74.6x10÷60
" 7	65.5		204.0	8.7	"	1.11	11.49	0.75	253.17	49.17	74.6x7÷60
								Σ = 4.63			
Pipe line No.3											
Pipe line No.3			213.5						258.62	45.12	
Hydrant No.8	78.0		212.5	11.2	100	1.43	18.34	1.43	257.19	44.69	
" 9	84.0		211.3	11.2	100	1.43	18.34	1.54	255.65	44.35	74.6x9÷60
								Σ = 2.97			
Pipe line No.4											
Pipe line No.4			214.0						262.09	48.09	
Hydrant No.10	53.5		213.5	9.9	100	1.26	14.59	0.78	261.31	47.81	74.6x8÷60

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD	
Pipe line No.5	m	m	m	ℓ/s	mm	m/s		m	m	m	
Pipe line No.5			212.0						257.88	45.88	
Hydrant No.11	29.0		211.5	12.4	100	1.58	22.13	0.64	257.24	45.74	
" 12	48.0		213.0	"	"	"	"	1.06	256.18	43.18	
" 13	48.0		213.5	"	"	"	"	1.06	255.12	41.62	
								Σ = 2.76			
Pipe line No.6 (											
Pump			214.0						262.31	48.31	
No.44	42.50		214.13	12.4	100	1.58	22.13	0.94	261.37	47.24	
No.43	26.04		202.29	"	"	"	"	0.58	260.79	58.50	
No.42	28.24		195.56	"	"	"	"	0.62	260.17	64.61	
No.41	25.60		184.04	"	"	"	"	0.57	259.60	75.56	
No.1	22.51		178.08	"	"	"	"	0.50	259.10	81.02	
No.2	19.02		177.52	"	"	"	"	0.42	258.68	81.16	
No.3	27.89		168.88	"	"	"	"	0.62	258.06	89.18	
No.4	19.02		168.74	"	"	"	"	0.42	257.64	88.90	
No.5'	17.02		169.50	"	"	"	"	0.38	257.26	87.76	
Hydrant No.14	42.5		173.50	"	"	"	"	0.94	256.32	82.82	
Pipe line No.7	53.0		173.80	11.2	"	1.43	18.34	1.02	255.30	81.50	
Hydrant No.15	23.0		173.20	11.2	"	"	"	0.42	254.88	81.68	
" 16	53.0		172.0	11.2	"	"	"	0.97	253.91	81.91	74.6x9÷60
" 17	49.0		171.8	8.7	"	1.11	11.49	0.56	253.35	81.55	
" 18	60.5		171.0	8.7	"	"	"	0.70	252.65	81.65	74.6x7÷60
								Σ = 9.66			
Pipe line No.7											
Pipe line No.7			173.80						255.30	81.50	
Hydrant No.19	85.0		165.50	9.9	100	1.26	14.59	1.24	254.06	88.56	
" 20	62.0		160.50	9.9	"	"	"	0.90	253.16	92.66	74.6x8÷60
								Σ = 2.14			

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD	
Pipe line No.3	m	m	m	ℓ/s	mm	m/s		m	m	m	
Pipe line No.3			211.5						255.16	43.66	
A	1.0		211.5	12.4	75	2.81	89.85	0.09	255.07	43.57	74.6x10÷60
B	18.0		211.1	6.2	50	3.16	179.55	3.23	251.84	40.74	74.6x5÷60
C	16.0		210.3	5.0	"	2.55	120.60	1.93	249.91	39.61	74.6x4÷60
D	16.0		209.1	3.7	"	1.88	69.09	1.11	248.80	39.70	74.6x3÷60
E	16.0		208.0	2.5	"	1.27	33.45	0.54	248.26	40.26	74.6x2÷60
F	16.0		206.5	1.2	"	0.61	8.60	0.14	248.12	41.62	74.6x1÷60
								Σ = 7.04"			
A			211.5						255.07	43.57	
G	18.0		211.4	6.2	50	3.16	179.55	3.23	251.84	40.44	
H	16.0		210.5	5.0	"	2.55	120.60	1.93	249.91	39.41	
I	16.0		209.8	3.7	"	1.88	69.09	1.11	248.80	39.00	
J	16.0		208.6	2.5	"	1.27	33.45	0.54	248.26	39.66	
K	16.0		207.1	1.2	"	0.61	8.60	0.14	248.12	41.02	
								Σ = 6.95'			

4-1-6 Appurtenant Structures

a) Collecting Pit

A brick collecting pit will be constructed in places where small drainage canals cross roads in closed conduit or in confluences of such canals.

b) Stilling Basin

Since drainage water in the project area is designed to be drained down the hillside, a stilling basin will be constructed to prevent the slope erosion. The basin will be constructed along the contour line using gravels in the project area and will have a large overflow width so as to obtain a high stilling effect per unit overflow width.

c) Underground Drain Pipe

Since the drainage ditch in the mulberry field area will be filled up during the reclamation work, a new concrete drain pipe with a diameter of 600 mm will be laid beneath the selected branch farm road.

4-2 Water Source Design

4-2-1 Diversion Works

For the purpose of water intake, it is planned to employ the collecting drain method in which a multiporous pipe will be so buried in the river bed that it will be covered with sand and gravels.

a) Collecting Drain

Irrigation requirement :	Irrigation area	- 8.0 ha
	Peak daily consumption	- 7.5 mm/day
	Irrigation efficiency	- 85%

7.3mm/day x 1/0.85 x 8.0 ha x 10 = 687.06 m^3/day

Water requirement for sericultural operation : 30.60 m^3/day

Water requirement for drinking and other purposes	: 19.40 m^3/day
TOTAL	:737.06 m^3/day

737.06/24 = 30.71 m^3/hr

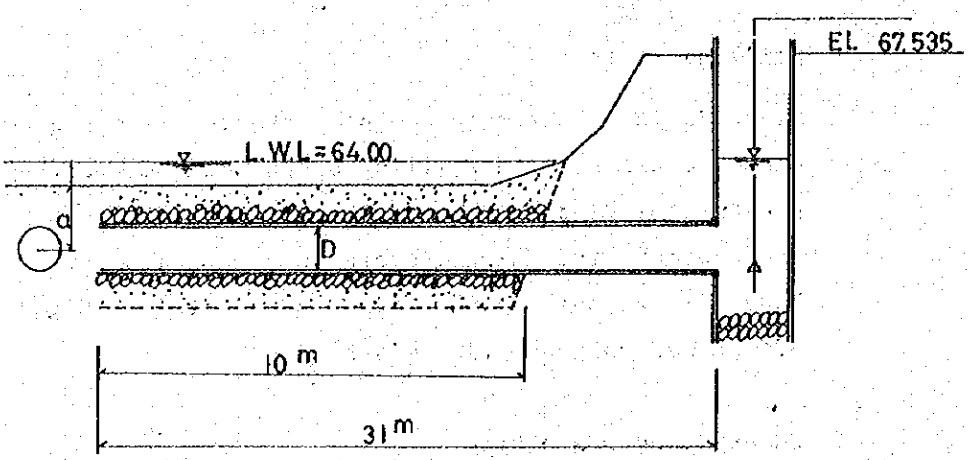


Fig. 4-6

The diameter of the collecting gallery is to be obtained by the following equation.

$$q = \frac{2\ k\pi (H-P/w)}{\ell n \frac{4a}{d}} \qquad \text{(MUSKAT's formula)}$$

where, q : Flow rate per unit length (30.71/10 m = 3.07 m^3/hr/m),

k : Permeability coefficient (10^{-3} = 3.6 m/hr),

H : Depth from the river bed (1.00 m),

P : Water pressure in the pipe (1.60 m),

a : Depth of gallery from river bed (0.60 m),

w : Unit weight of water (1.0)

d : Pipe diameter

$$3.07 = \frac{2\pi \times 3.6 \times 0.6}{\ell n \frac{2.f}{d}} = \frac{13.5648}{\ell n \frac{2.4}{d}}$$

$$\ell n \frac{2.4}{d} = \frac{13.5648}{3.07} = 4.419$$

$$\ell n\ 2.6 - \ell nd = 4.419$$

$$\ell nd = 0.693 - 4.419 = -3.726$$

Taking safety factor at 3.0,

$$\ell nd = -3.726/3 = -1.242$$

$$d = 0.289$$

Hence, a pipe with a diameter of 300 mm will be used.

b) Draft Tank

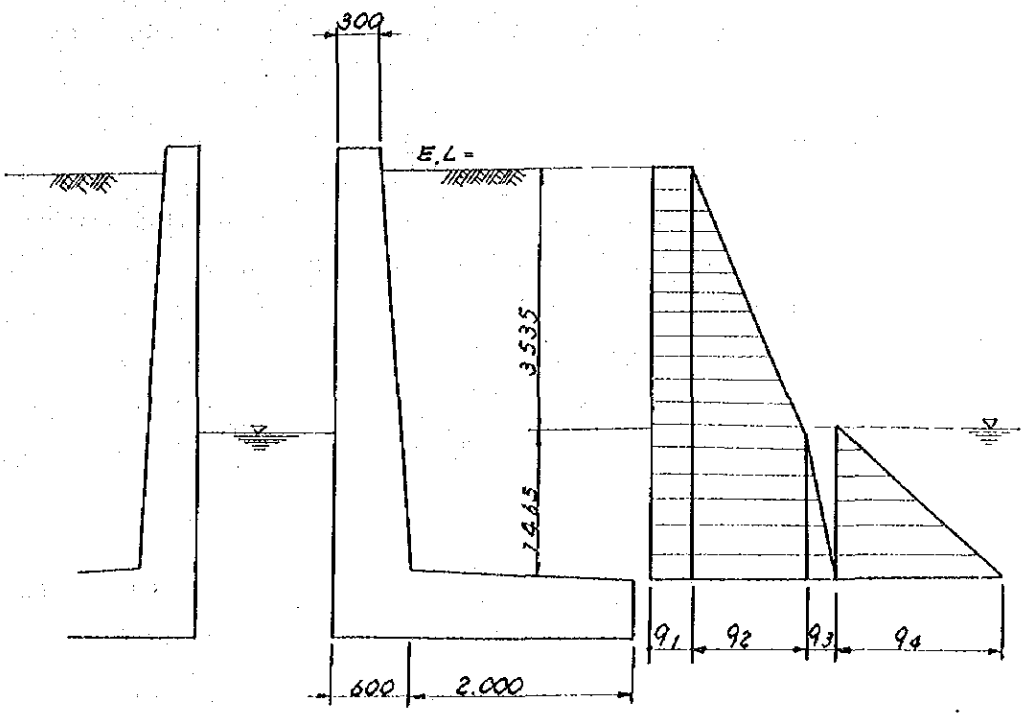


Fig. 4-7

(1) Design Criteria

Unit weight of unsaturated soil	r_c = 1.8t/m^3
Unit weight of saturated soil	r_a = 1.0
Unit weight of water	r_w = 1.0
Coefficient of active earth pressure	KA = 0.3
Allowable tensile stress of reinforcement SD30	sa = 1800 kg/cm^2
Allowable bending stress of concrete	ca = 70
Surface load	q_o = 0.5 t/m^2

(2) Load

q_1 = KA x q_o x 0.3 x 0.5 =0.150 t/m^2

q_2 = KA x r_c x 3.535=0.3 x 1.8 x 3.535= 1.909 t/m^2

q_3 = KA x r_a x 1.465 =0.3 x 1.0 x 1.415= 0.440 t/m^2

q_4 = r_w x 1.465= 1.0 x 1.465 = 1.465 t/m^2

(3) Moment

Point A

M_1 = 1/2 x q_1 x 5.0^2 =1.875 t-m/m

M_2 = 1/2 x q_2 x 3.535 x (1.465+1/3x3.535)=8.919

M_3 = 1/2 x q_2 x 1.465^2 = 2.049

M_4 = 1/6 x q_3 x 1.465^2 = 0.157

M_5 = 1/6 x q_4 x 1.465^2 = 0.524

Total MA =13.524

Point B

M_1 = 1/2 x q_1 x 3.535^2 = 0.937 t.m/m

M_2 = 1/6 x q_2 x 3.535^2 = 3.976

Total MB= 4.913

(4) Amount of Reinforcement

Point A

D19 ctc 15cm Member thickness 60 cm Covering 10 cm

$As = 19.10\ cm^2 \quad j = 0.905 \quad k = 0.287 \quad b = 100cm$

$$Ms = \frac{MA}{As\ .\ j.\ d}$$

$$= \frac{13.52400}{19.10 \times 0.905 \times 50} = 1565\ kg/cm^2 < 1800\ kg/cm^2$$

$$Mc = \frac{2MA}{k.\ j.\ b.\ d^2}$$

$$= \frac{2 \times 1352400}{0.287 \times 0.905 \times 100 \times 50^2} = 42\ kg/cm^2 < 60\ kg/cm^2$$

Point B

D 16 ctc 15cm Member thickness 40 cm Covering 10 cm

$As = 13.24\ cm^2 \quad j = 0.91 \quad k = 0.27 \quad b = 100$

$$Ms = \frac{MB}{As.\ j.\ d}$$

$$= \frac{491300}{13.24 \times 0.91 \times 30} = 1359\ kg/cm^2 < 1800\ kg/cm^2$$

$$MC = \frac{2MB}{k.\ j.\ b.\ d^2}$$

$$= \frac{2 \times 491300}{0.27 \times 0.91 \times 100 \times 30^2} = 44\ kg/cm^2 < 60\ kg/cm^2$$

4-2-2 Pumping Station

a) Determination of Pump Capacity

1) Pumping Capacity

$q = 0.51\ m^3/m = 0.0085\ m^3/sec$

2) Water Level and Actual Head

Maximum design delivery level	214.8 m
Minimum design suction level	64 m
Actual design head	Ha = 150.8 m

3) Head loss

Pipe diameter $D_1 = 0.080$ m

Flow velocity in pipe $V_1 = \frac{q}{A_1} = \frac{q}{\frac{\pi}{4} \times D_1^2} = \frac{0.0085}{0.0050} = 1.70$ m/s

Velocity head $\frac{V_1^2}{2q} = \frac{1.7^2}{2 \times 9.8} = 0.15$ m

Pipe diameter $D_2 = 0.065$ m

Flow velocity in pipe $V_2 = \frac{q}{A_2} = \frac{q}{\frac{\pi}{4} \times D_2^2} = \frac{0.0085}{0.0033} = 2.58$ m/s

Velocity head $\frac{V2^2}{2q} = \frac{2.58^2}{2 \times 9.8} = 0.33$ m

Pipe diameter $D_3 = 0.10$ m

Flow velocity in pipe $V_3 = \frac{q}{A_3} = \frac{q}{\frac{\pi}{4} \times D_3^2} = \frac{0.0085}{0.00785} = 1.08$ m/s

i) Inlet head loss

$h = f \times \frac{V1^2}{2g} = 0.03 \times 0.15 = 0.0045$

ii) Bend head loss

$h = f \times \frac{V1^2}{2g} = 0.146 \times 0.15 = 0.0219$

$$f = \{0.131+1.847(\frac{D}{2R})^{7/2}\}\ (\frac{6}{90})^{1/2}\ \ldots\ldots \text{ Weisbach}$$

$$= \{0.131+1.847\ (\frac{0.08}{2\text{x}0.158})^{7/2}\}\ (\frac{90}{90})^{1/2} = 0.146$$

5 places

5 x h = 0.2415

iii) Check valve head loss

$$h = f \times \frac{V_2^2}{2g} = 1.50 \times 0.33 = 0.495$$

iv) Sluice valve head loss

$$h = f_1 \times \frac{V_2^2}{2g} = 0.14 \times 0.33 = 0.046$$

v) Ductile cast iron pipe will be used with C taken at 130.

$$h = f\ c\ L/D \times \frac{V_3^2}{2g} = 0.024 \times \frac{1368.37}{0.10} \times 0.06 = 19.7 \text{ m}$$

$$f = \frac{134}{C1.35} \times \frac{1}{D\ 1/6 \times V_3 0.15}\ \ldots\ldots \text{ Hagen \& Williams}$$

$$= \frac{134}{130^{1.85}} \times \frac{1}{0.1^{1/6} \times 1.09^{0.15}}$$

$$= 0.0165 \times 1.451 = 0.021$$

Accordingly, the total head, H turns out to be 172 m as calculated below.

$$H = Ha + \Sigma h$$

$$= 150.8 + 0.0045 + 0.2415 + 0.495 + 0.046 + 19.7$$

$$= 171.287\text{m}$$

(4) Output of Prime Mover

i. Pump shaft power

$$L = \frac{Q \times H \times r}{4.5\eta p} = \frac{0.51 \times 172 \times 1.0}{4.5 \times 0.52} = 36.8 \text{ PS}$$

where, Q : Delivery capacity (0.51 m^3/m)

H : Total head (172 m)

r : Bulk density of pumped water (1.0 kg/lit.)

ηp: Pump efficiency (52%)

ii. Required output

$$LW = \frac{L(1 + A)}{\eta G} = \frac{36.8 \times 1.2}{0.95} = 46.4 \text{ PS}$$

where, A : Allowance (20%).

ηG: Reducer efficiency (95%)

Hence, an output of 50 PS planned for the prime mover.

(5) Study of Water Hammer

Table 4-9 ∿ 4-10 show the results of calculation worked out to by the electronic computer to determine the water hammer action.

If there are no flywheels, negative pressure is generated because GD^2 of the pump is extremely small. However, if calculations are worked out with GD^2 taken at about 10 kg.m, no negative pressure develops and the pressure rise can be held near the hydraulic-gradient line.

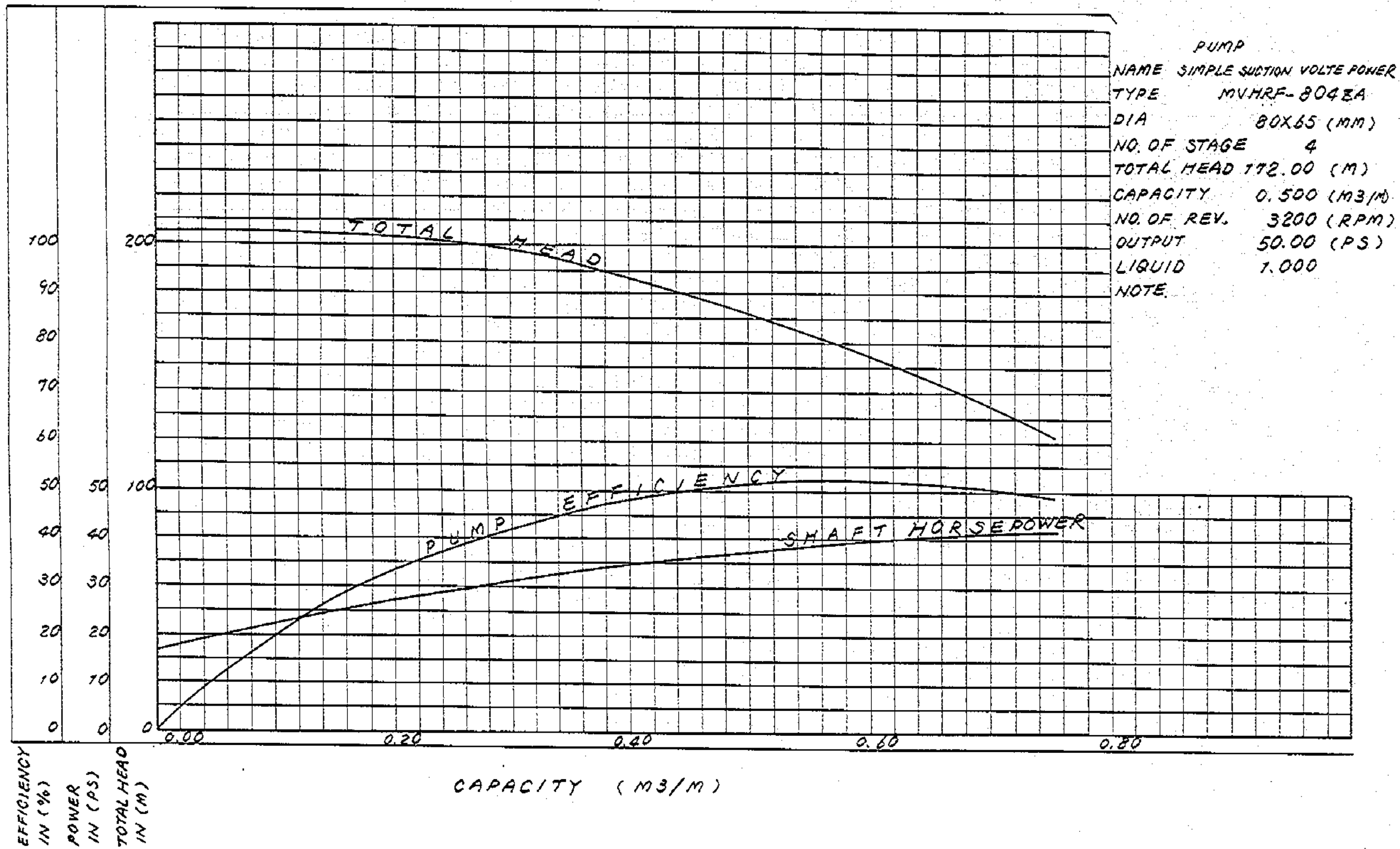


Fig. 4-8 Characteristic curves of the pump (expected)

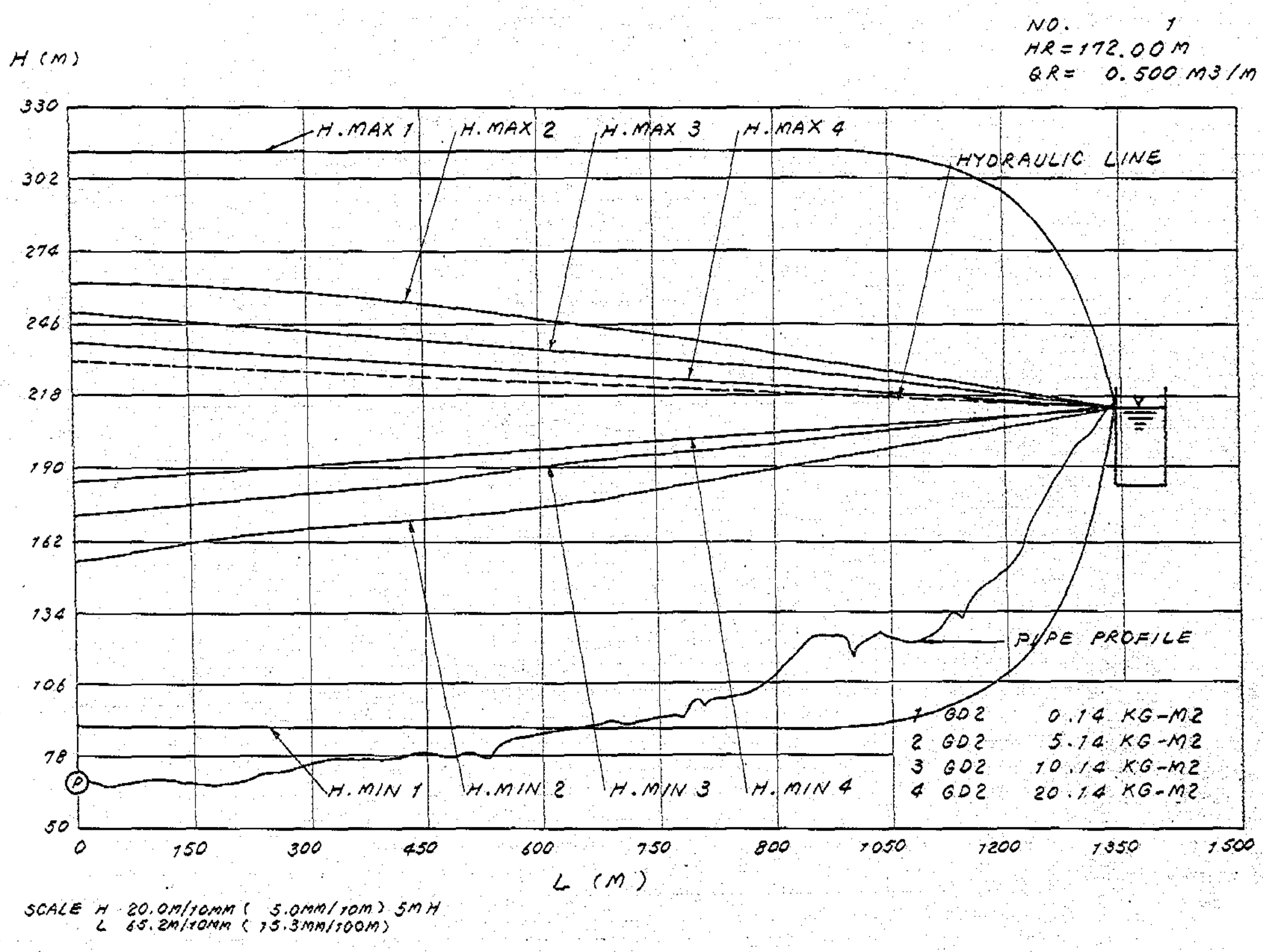


Fig. 4-9 Water hammer pressure curve

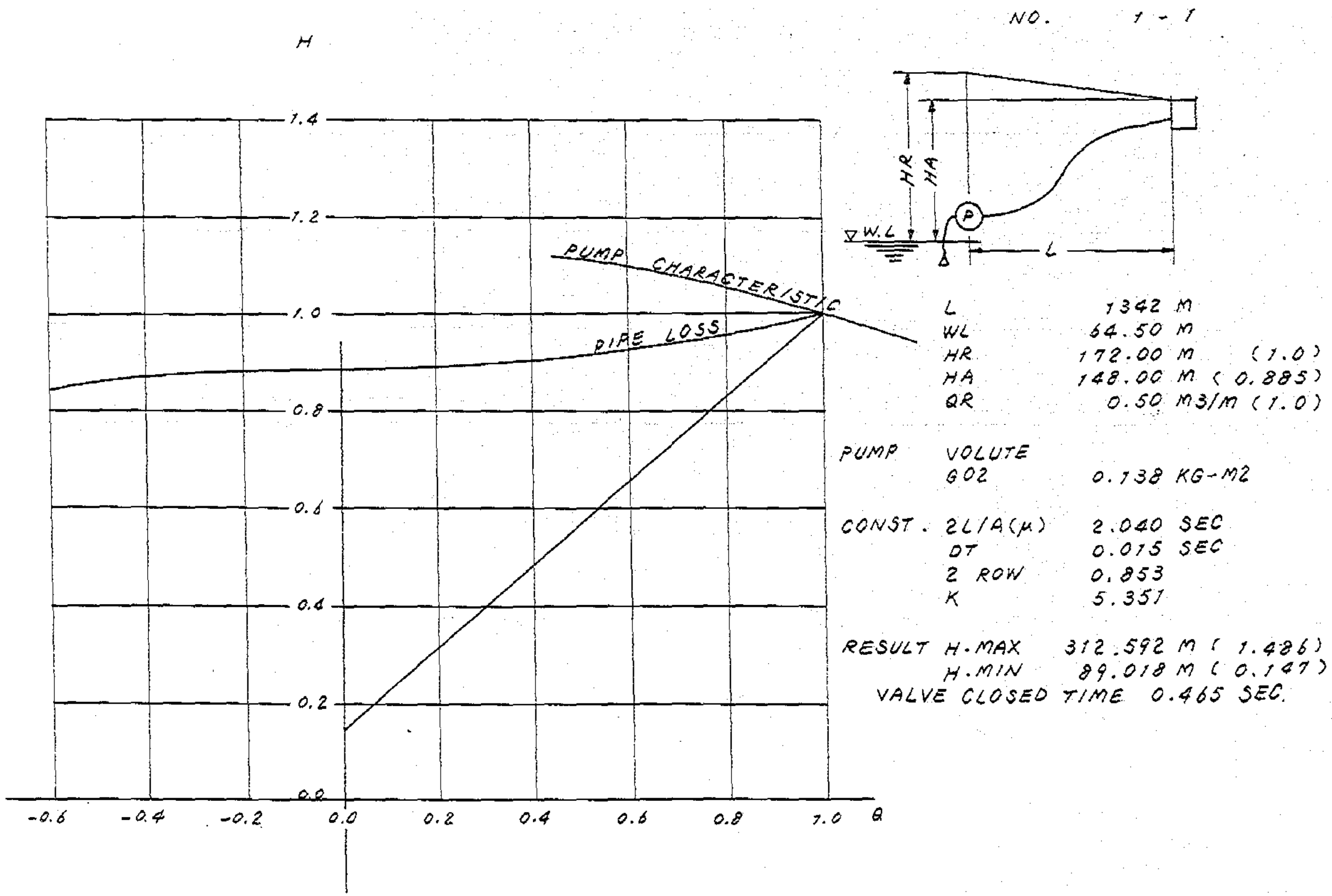


Fig. 4-10 Water hammer analysis

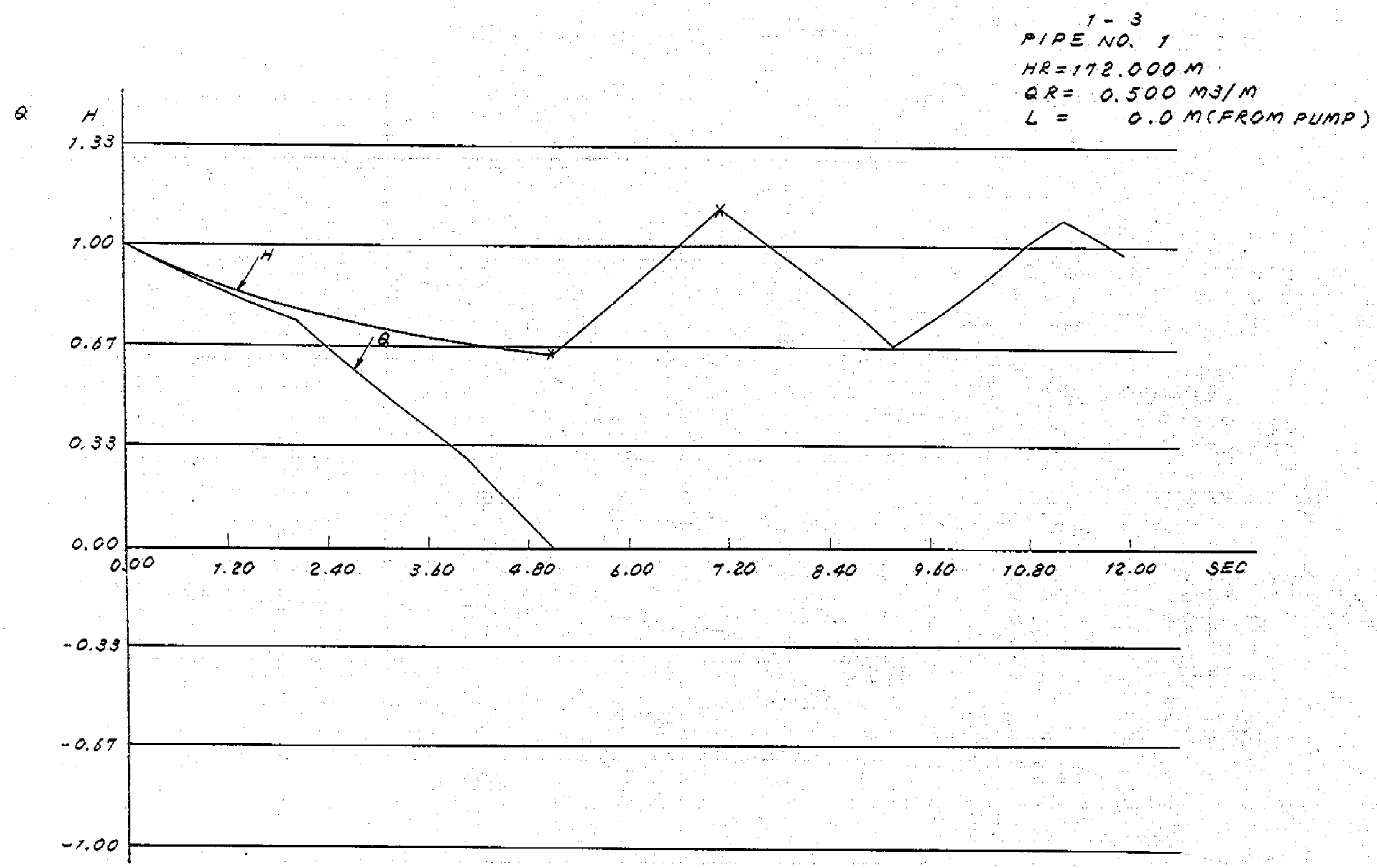
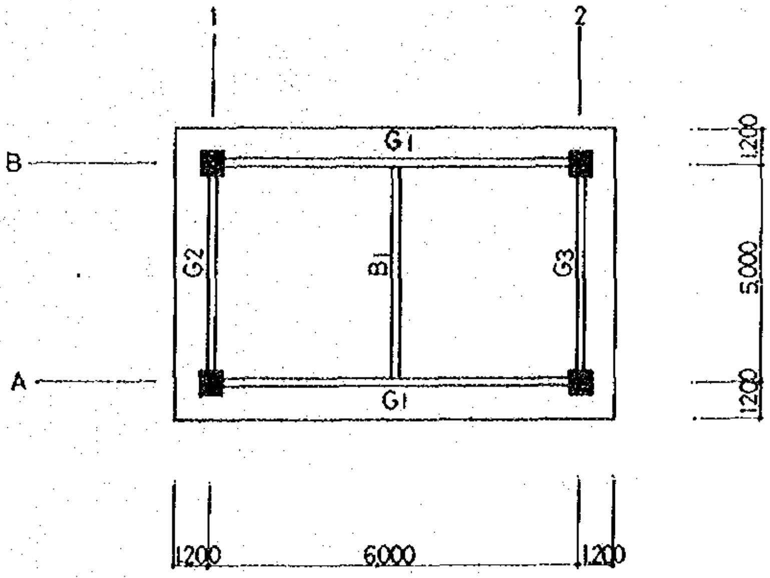
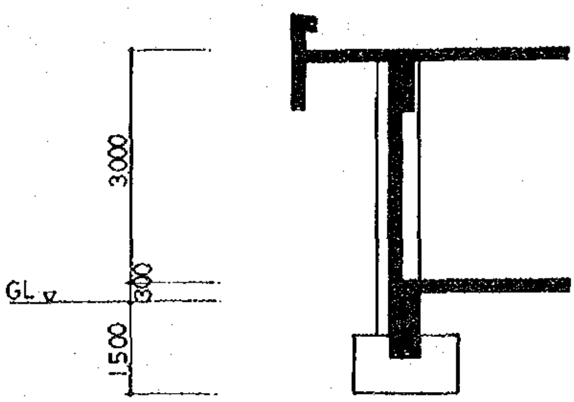


Fig. 4-11 Water hammer H. Q. analysis

(b) Structural Calculations for Pump House



R Stage



Cross-sectional view

1. Preparatory estimates

1-1 Outline of structure:

Definitions	PUMP HOUSE
Location	BILI-BILI
Size	RC structural single-storied building

1-2 Allowable stress etc.:

Allowable stress etc.	Structural references, reinforced concrete structural estimates
Standard references	

1-3 ·

Concrete	fc = 210 kg/m^2
Reinforcing bars	SD 30
Earthquake force	K = 0.2
Pile resistance	Ra =

1-4 Assumed loads:

Roof

Finishing	60	
Cinder	110	
Waterproof layer	20	630
Evening	40	
Slabs (, 50)	360	
Ceiling ( )	40	

	Floor	Beams	Ground
D.L.	630	630	630
L.L.	100	50	0
T.L.	730	680	630

Columns	45 x 45	650 kg/m		
Beams	30 x 60	400 kg/m	25 x 45	250 kg/m
Parapet		850 kg/m		
Walls	W15	450 kg/m^2		

2. Preparatory estimates

2-1 Column axial Force

C_{A1} C_{A2} C_{B1} C_{B2}

Parapet	85 x 7.9	= 6.8
Roof	68 x 3.7 x 4.2	= 10.6
Beams	40 x 5.5	= 2.2
Small beams	25 x 1.25	= 0.4
Walls	45 x 5.5 x 3.0	= 7.5
Columns	65 x 3.3	= 2.2
		29.7

2-2 Calculation of C, Mo, and Q

G_1 $\lambda = 1.67$ $W_1 = 0.68$ $W_2 = 0.85 + 0.82 + 0.40 = 2.07$

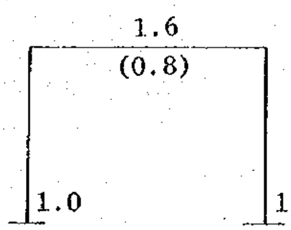
$$C = 6.4 \times 0.68 + 1/12 \times 2.07 \times 6.0^2$$
$$= 4.4 + 6.3 = 10.7$$
$$Mo = 11.3 \times 0.68 + 1/8 \times 2.07 \times 6.0^2$$
$$= 7.7 + 0.4 = 17.1$$
$$Q = 4.98 \times 0.68 + 1/2 \times 2.07 \times 6.0$$
$$= 3.4 + 6.3 = 9.7$$

G_2 $\lambda = 1.67$ $W_1 = 0.68$ $W_2 = 0.85 + 0.82 + 0.40 = 2.07$

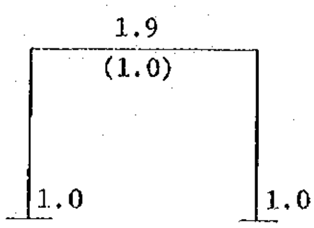
$$C = 2.7 \times 0.68 + 1/12 \times 2.07 \times 5.0^2$$
$$= 1.9 + 4.4 = 6.3$$
$$Mo = 4.5 \times 0.68 + 1/8 \times 2.07 \times 5.0^2$$
$$= 3.1 + 6.5 = 9.6$$
$$Q = 2.6 \times 0.68 + 1/2 \times 2.07 \times 5.0$$
$$= 1.8 + 5.2 = 7.0$$

2-3 Calculation of stiffness ratio

	B	D	L	ϕ	I	O	Q	K
Beams	30	60	55	2.0	110	6.00 5.00	18.4 22.0	1.6 1.9
Columns	45	45	35	1.0	35	3.00	11.7	1.0



AB rigid frame



1.2. rigid frame

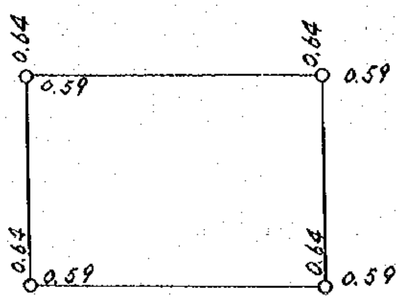
2-4 Calculation of earthquake force

Roof	0.63 x 8.4 x 7.4	= 39.2	
Parapet	0.85 x 31.6	= 26.9	
Beams	0.40 x 22.0	= 8.8	94.95 x 0.2 = 18.99
	0.25 x 5.0	= 1.25	= 19.0t
Walls	0.45 x 22.0 x 3.0 x 1/8	= 14.9	
Columns	0.65 x 4 x 3.0 x 1/2	= 3.9	

2-5 Stress distribution coefficients

k	1.6	k	1.9
a	0.59	a	0.62
D	0.59	D	0.62
y	0.55	y	0.55

AB rigid frame 1.2. rigid frame



Q = 19.0t

ΣDx = 2.36

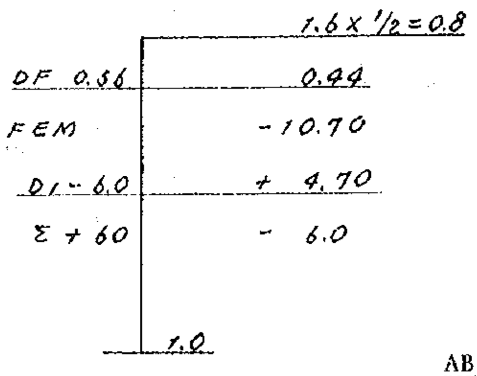
ΣDy = 2.48

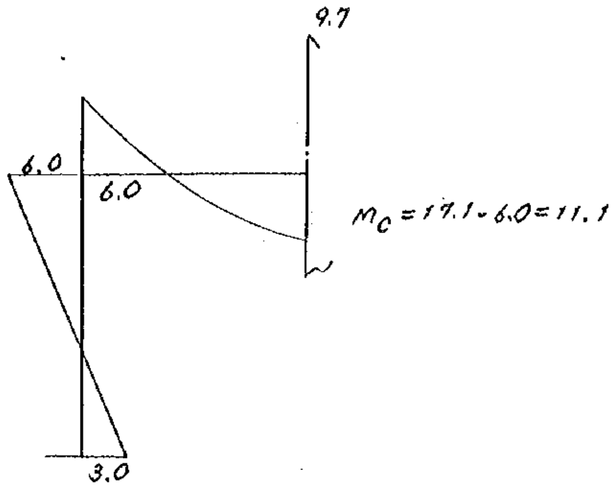
μx = 8.05

μy = 7.70

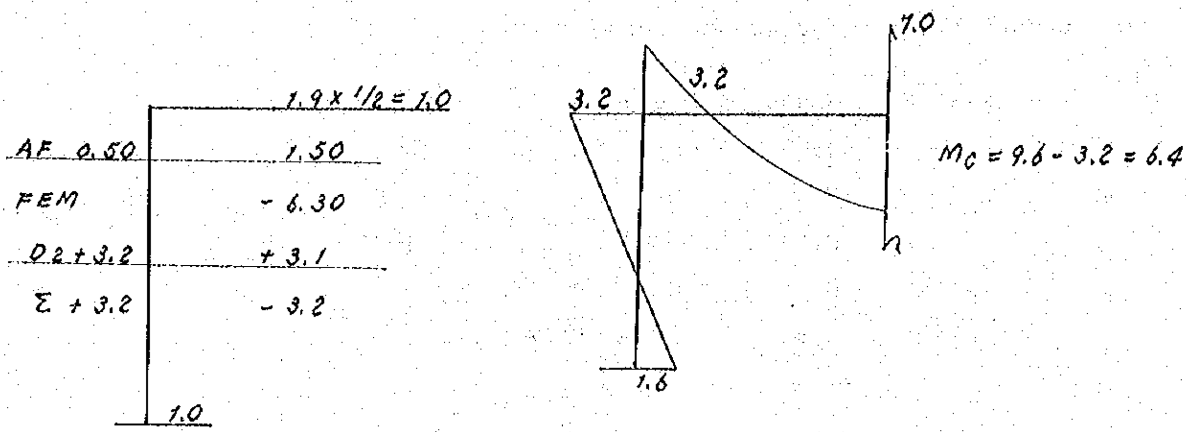
3. Stress estimates

3-1 Stress under vertical load



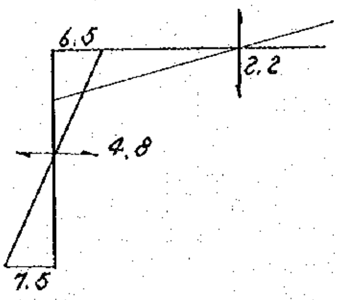


AB rigid frame

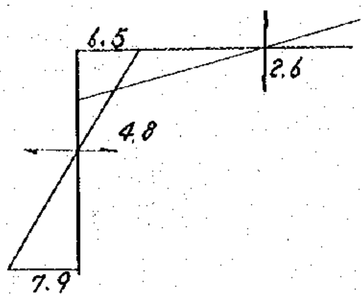


1.2. rigid frame

3-2 Stress under horizontal load



AB rigid frame



1.2. rigid frame

4. Sectional designs

4-1 Floor

S_1 3.00 x 5.00 5 = 15 λ = 1.67 W = 0.73 $W\ell x^2$ = 6.57

Mx_1 = 0.074 x 6.57 = 0.49	at = 49000/1600 x 10.5 = 2.9	
Mx_2 = 0.049 x 6.57 = 0.33	33000/ " = 1.96	9.13ϕ - 200@
My_1 = 0.042 x 6.57 = 0.28	28000/ " = 1.66	
My_2 = 0.028 x 6.57 = 0.25	25000/ " = 1.48	

CS_1 W = 0.73 P = 0.85 t = 15

M = 1/2 x 0.73 x 12^2 + 0.85 x 12
= 0.53 + 102 = 155

at = 155000/1600 x 10.5 = 9.3 13ϕ - 100@

4-2 Small beams

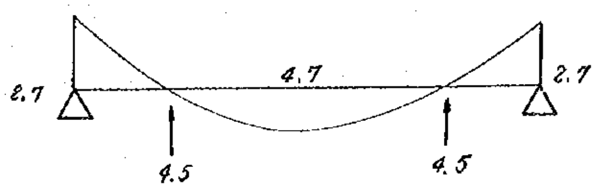
B_1 25 x 45 λ = 1.67 W = 0.73 Beams = 0.25

C = 2 x 2.7 x 0.73 + 1/12 x 0.25 x 5^2
= 3.95 + 0.53 = 4.5

Mo = 2 x 4.5 x 0.73 x 1/8 x 0.25 x 5^2
= 6.57 + 0.79 = 7.4

Q = 2 x 2.6 x 0.73 x 1/2 x 0.25 x 5
= 3.80 + 0.63 = 4.5

0.6C = 0.6 x 4.5 = 2.7
Mo - 0.6C = 7.4 - 2.7 = 4.7



D = 45 α = 40 j = 35

(Outer edge) at = 270000/2000 x 35 = 3.9
ψ = 4500/14 x 35 = 9.2 2 - D19

(Center) at = 470000/2000 x 35 = 6.8 3 - D19

(Stirrup) Q_L = 4.5 < 7 x 25 x 35 = 6.2 pw = 0.2%
2 - 9ϕ X = 2 x 0.64/25 x 0.002 = 25.6 → 9ϕ ∿ 200@

4-3 Main beams

G_1 30 x 60 d = 55 j = 48 bd = 1650 bd^2 = 89000

	Outer edge	Center
	Ms = 12.5	Ms = 11.1
	C = 14.0	C = 12.3
	Pt = 0.53	Pt = 0.69
	at = 8.8	at = 11.3
Upper edge	4 - D19	3 - D19
Lower edge	3 - D19	5 - D19
Stirrup	Q_L = 9.7	Qs = 2.2

afs•b•j (long) 7 x 30 x 48 = 10.1 > 9.7

afs•b•j (short) 10.5 x 30 x 48 = 15.0 > Qo = 9.7 + 2.2 x 1.5
= 13.0

pw = 0.2%

2 - 9ϕ X = 2 x 0.64/30 x 0.02 = 21.2 → 9ϕ ∿ 200@

G_2 30 x 60 d = 55 j = 45 bd = 1650 bd^2 = 8900

Outer edge	Center
Ms = 9.7	ML = 6.4
C = 10.9	C = 7.2
Pt = 0.44	Pt = 0.4
at = 7.2	at = 6.7
Ms = 3.3	
at = 2.3	

Upper edge	4 - D19	3 - D19
Lower edge	3 - D19	4 - D19
Stirrup	QL = 7.0	Qs = 2.6

afs•b•j (long) 7 x 30 x 45 = 10.1 > 7.0

afs•t•j (short) 10.5 x 30 x 45 = 15.0 > QD = 7.0 + 2.6 x 1.5 = 10.9

pw = 0.2%

2 - 9ϕ X = 2 x 0.64/30 x 0.002 = 21.2 → 9ϕ ∿ 200@

4-4 Columns

C_1 45 x 45 BD = 2020 BD^2 = 91000

xMs = 12.5	M/BD^2 = 13.8	Pt = 0.36	
xMs = 31.9	M/BD = 15.8	at = 7.3	4 - D19
27.7	13.8		
yMs = 9.7	M/BD^2 = 10.7	Pt = 0.23	
yMs = 31.9	M/BD = 16.0	at = 4.7	3 - D19
= 27.1	= 13.5		

HOOP 9ϕ - 100@

4-5 Foundation design

Piles	300ϕ RCg
Allowable bearing force	18.0t
Dead weight of foundation	1.5t
Design bearing force	16.5t

F_1 N = 29.7 + 5.0 = 34.7 X = 34.7/16.5 = 2.1 → 3ϕ

Q = 34.7/3 = 11.6

M = 11.6 x 0.5 = 5.8

at = 580000/1600 x 63 = 5.8 5 - 13ϕ

ψ = 11600/105 x 63 = 17.6

t = 11600/80 x 63 = 2.3 < 9.0

FG_1 35 x 100 d = 92 j = 81

M = 10.9

at = 1090000/3000 x 21 = 4.5 3 - D19

Qs = 3.2 (3.2 x 1.5 = 4.8)

afs•b•j = 10.5 x 35 x 81 = 30 > 4.8

Stirrup pw = 0.2%

2 - 9ϕ X = 2 x 0.64/35 x 0.002 = 18.2 → 150@

4-2-3 Farm pond

(a) Capacity estimates

Parameters:

Water supply time	24 hr
Irrigation time	16 hr
Peak daily consumption	7.3mm/day
Irrigation area	8.0 ha
Irrigation efficiency	85%
Quantity of water available for sericulture	$30.6m^3$/day
Quantity of water available for drinking and other purposes	$19.4m^3$/day

Capacity estimates

$$V_1 = 10 \times 8 \times 7.3 \times 1/0.85\ (1 - 16/24)$$
$$= 229.7m^3 = 230m^3$$

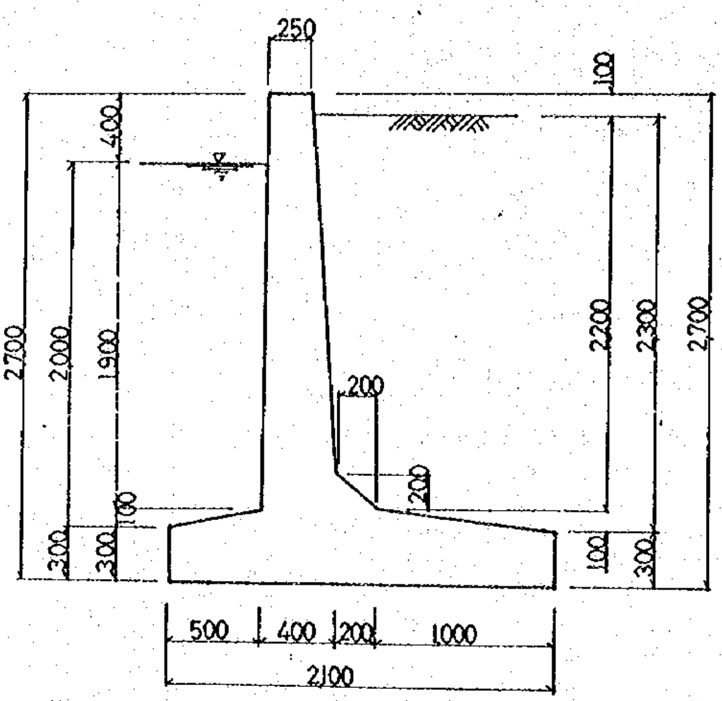
$$V_2 = 30.60$$

$$V_3 = 19.40$$

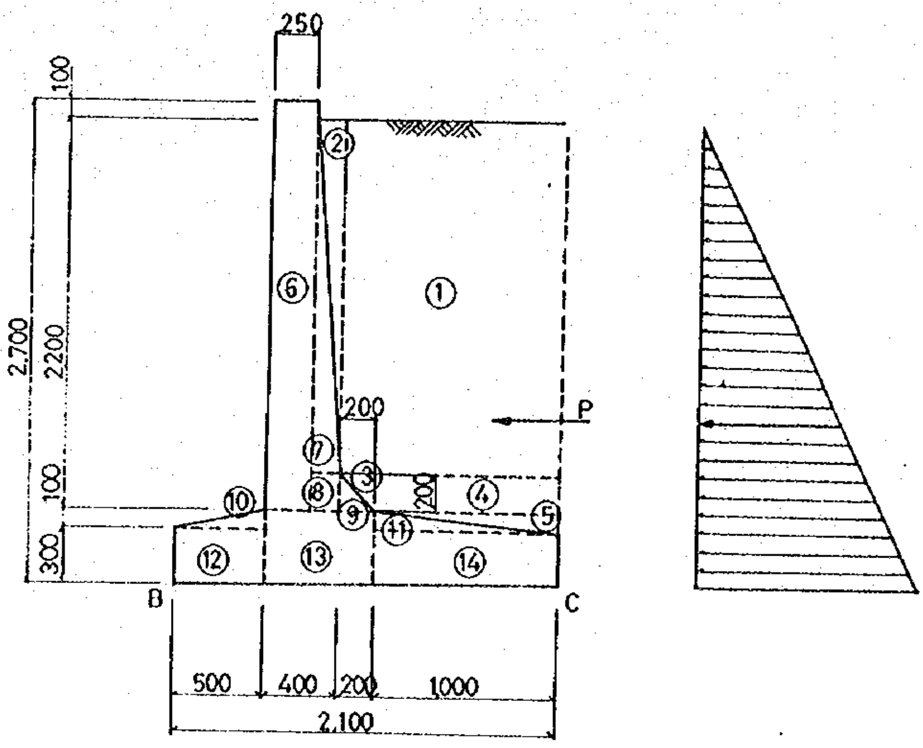
Total $280m^3$

(b) Structural calculations

1. Cross-section - Shape and dimensions



Consideration of earth pressure loads (only) from outer surface



2. Fixed determinants

$W = 1.255 t/m^3$

$\phi = 10°30'00''$

$Ka = 0.69$

$K_E = 0.95$

Pile foundation

3. Stability calculation

Earth pressure

o Under normal circumstances

$$P = \frac{1}{2} \cdot W \cdot K^2 \cdot Ka$$

$$= \frac{1}{2} \cdot 1.255 \cdot 2.6^2 \cdot 0.69$$

$$= 2.93t$$

Height of force application

$$Y = \frac{h}{3}$$

$$= 0.867m$$

o During earthquakes

$$P = \frac{1}{2} \cdot W \cdot K^2 \cdot Ke$$

$$= \frac{1}{2} \cdot 1.255 \cdot 2.6^2 \cdot 0.95$$

$$= 4.03$$

Height of force application

$$Y = \frac{h}{3}$$

$$= 0.867m$$

Total earth pressure

Type		Weight (t)			Moment (t-m)
Soil	1	1.255 x 1.200 x 2.000	3.012	1.500	4.518
"	2	1.255 x 2.000 x 0.143 x 0.5	0.179	0.845	0.151
"	3	1.255 x 0.200 x 0.200 x 0.5	0.025	1.033	0.026
"	4	1.255 x 0.200 x 1.000	0.251	1.600	0.402
"	5	1.255 x 0.100 x 1.000 x 0.5	0.063	1.767	0.111
Vertical wall	6	2.400 x 0.250 x 2.300	1.380	0.625	0.863
"	7	7.400 x 0.150 x 2.300 x 0.5	0.414	0.800	0.331
"	8	2.400 x 0.150 x 0.200	0.072	0.825	0.059
"	9	2.400 x 0.200 x 0.200 x 0.5	0.048	0.967	0.046
Base slab	10	2.400 x 0.100 x 0.500 x 0.5	0.060	0.333	0.020
"	11	2.400 x 0.100 x 1.000 x 0.5	0.120	1.433	0.172
"	12	2.400 x 0.300 x 0.500	0.360	0.250	0.090
"	13	2.400 x 0.400 x 0.400	0.384	0.700	0.269
"	14	2.400 x 0.300 x 1.000	0.720	1.600	1.152
Horizontal component of earth pressure		2.93 x COO5°15'00"	(2.918)	0.867	-2.530
Total			7.088		5.680

Stability calculation

Earth pressure

Check against falling

$$d = \frac{\Sigma M}{\Sigma V} = \frac{5.680}{7.088} = 0.801$$

$$e = \frac{L}{2} - d = \frac{2.1}{2} - 0.801 = 0.249 < \frac{L}{6} = 0.350$$

Safety factor

$$S = \frac{7.088 \times 0.801}{2.918 \times 0.867} = 2.244 > 1.5$$

During earthquakes

Check against falling

$$d = \frac{\Sigma M}{\Sigma V} = \frac{8.210 - 3.784}{7.088} = 0.624$$

$$e = \frac{L}{2} - d = \frac{2.1}{2} - 0.624 = 0.426 < \frac{5\ell}{12} = 0.875$$

4. Stress calculations for protective wall

i) Lateral wall (estimated for earthquakes)

a. Load estimates

$$A = 6 + \sim + 9 = 1.914t$$

Horizontal forces

$$A(h) = A \cdot Kh = 1.914 \times 0.15 = 0.287$$

Height of application of force

$$Y_1 = \frac{h}{2} = \frac{2.3}{2} = 1.15m$$

Earth pressure

$$P = \frac{1}{2} \cdot W \cdot Ke \cdot h^2$$

$$= \frac{1}{2} \times 1.255 \times 0.95 \times 2.3^2$$

$$= 3.154$$

Height of force application

$$Y = \frac{h}{3} = \frac{2.3}{3} = 0.767m$$

b. Bending moment and shear force

$$M = A(h) \cdot Y_1 + P \cdot Y_2$$

$$= 0.287 \times 1.15 + 3.154 \times 0.767$$

$$= 2.749 \text{ t.m}$$

$S = A(t) + P$
$= 0.287 + 3.154$
$= 3.441t$

c. Calculation of cross-sectional force

$M = 2.749t.m = 274.900kg.cm$

$S = 3.441t = 3441kg$

$d = 35cm$

$d' = 5cm$

$b = 100cm$

$As = As' = D13 \text{ cte } 200 = 6.335cm^2$

$$P = \frac{As}{b.d} = \frac{6.335}{100 \times 35} \times 0.0018$$

$$\frac{M}{bd^2} = \frac{274900}{100 \times 35^2} = 2.244kg/cm^2$$

$$\frac{d'}{d} = \frac{5}{40} = 0.125$$

Nomogram estimation

$$\frac{1}{Lc} = 10.4 \qquad \frac{1}{Ls} = 520 \qquad j = 0.932$$

$$\delta s = \frac{M}{b.d^2} \cdot \frac{1}{Lc} = 2.244 \times 10.4 = 23 \text{ kg/cm}^2$$

$$\delta c = \frac{M}{b.d} \cdot \frac{1}{Ls} = 2.244 \times 520 = 1167 \text{ kg/cm}^2$$

$$\tau = \frac{s}{b \cdot j \cdot d} = \frac{3441}{100 \times 0.932 \times 55} = 1.1 \text{ kg/cm}^2$$

ii) At 1 meter below top of wall

a. Load estimates

$A_1 = 0.25 \times 1.00 \times 2.4 = 0.600t$

$A_2 = 0.32 \times 1.00 \times 2.4 \times 0.5 = 0.384t$

$A = A_1 + A_2 = 0.600 + 0.384 = 0.984t$

Horizontal forces

$A(h) = A \cdot K(h) = 0.984 \times 0.15 = 0.148$

Height of force application

$$Y_1 = \frac{h}{2} = \frac{1.0}{2} = 0.5m$$

Earth pressure

$$P = \frac{1}{2} \cdot W \cdot he \cdot h^2$$

$$= \frac{1}{2} \times 1.255 \times 0.95 \times 1^2$$

$$= 0.596$$

Height of force application

$$Y_2 = \frac{h}{3} - \frac{1.0}{3} = 0.333m$$

b. Bending moment

$$M = A(h) \cdot Y_1 + PY_2$$
$$= 0.148 \times 0.5 + 0.596 \times 0.333$$
$$= 0.272tm$$

c. Calculation of cross-sectional force

$M = 0.272$ t.m $= 27200$ kg/cm

$d = 27cm$ $\quad$ $d' = 5cm$

$b = 100cm$

$As = As' = D13\ cte\ 400 = 3.168 cm^2$

$$P = \frac{As}{b.d} = \frac{3.168}{100 \times 27} = 0.012$$

$$\frac{M}{bd^2} = \frac{27200}{100 \times 27^2} = 0.373$$

Nomogram estimation

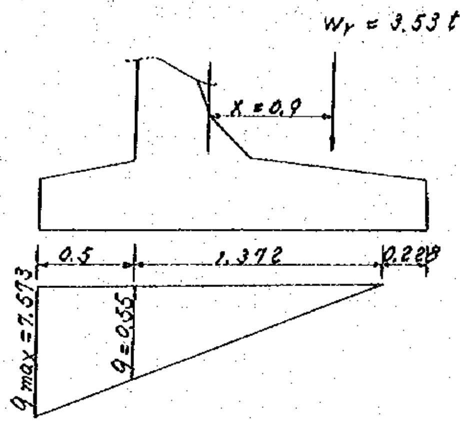
$$\frac{1}{Lc} = 12.4 \qquad \frac{1}{Ls} = 880$$

$$\delta c = \frac{M}{bd^2} \cdot \frac{1}{Lc} = 0.373 \times 12.4 = 4.6 kg/cm^2$$

$$\delta s = \frac{M}{bd^2} \cdot \frac{1}{Ls} = 0.373 \times 380 = 328\ kg/cm^2$$

iii) Base slab

Estimation includes base slab reaction to earthquake load plus weight of soil.



$$X = 3(\frac{B}{2} - e)$$
$$= 3(\frac{2.1}{2} - 0.426)$$
$$= 1.872$$

$$q_{max} = \frac{2.V}{L.x}$$
$$= 7.573$$

a. Bending moment and shear force

$$M = 5.55 \times 0.5^2 \times 1/2 + 2.023 \times 0.5^2 \times 1/3$$
$$= 0.69 + 0.17$$
$$= 0.86 t.m$$

$$S = (7.573 + 5.55) \times 0.5 \times 1/2$$
$$= 3.28 t$$

b. Calculation of cross-sectional force

$M = 0.86t.m = 86000kg.cm$

$S = 3.28t \quad = 3280kg$

$b = 100cm \quad d = 35cm \quad d' = 5cm$

$As = As' = D13 \text{ cte } 200 = 6.335cm^2$

$$P = \frac{As}{b.d} = \frac{6.335}{100 \times 35} = 0.0018$$

$$\frac{M}{b.d^2} = \frac{86000}{100 \times 35^2} = 0.70$$

Nomogram estimation

$$\frac{1}{Lc} = 10.5 \qquad \frac{1}{Ls} = 600 \qquad j = 0.931$$

$$\delta c = \frac{M}{b.d^2} \cdot \frac{1}{Lc} = 0.70 \times 10.5 = 7.35kg/cm^2$$

$$\delta s = \frac{M}{b.d^2} \cdot \frac{1}{Ls} = 0.70 \times 600 = 420\ kg/cm^2$$

$$\tau = \frac{S}{b \cdot j \cdot d} = \frac{3280}{100 \times 0.931 \times 35} = 1.0066$$

a. Bending moment and shear force

$$M = 3.932 \times 0.972^2 \times 1/6 - 3.53 \times 0.6$$

$$= 0.62 - 2.12$$

$$= -1.50 t.m$$

$$S = 1/2 \times 3.932 \times 0.972 - 3.53$$

$$= 1.91 - 3.53$$

$$= 1.62 t$$

b. Calculationof cross-sectional force

$M = 1.50 t.m = 150000 kg.cm$

$S = 1.62 t \quad = 1620 kg$

$b = 100 cm \quad d = 35 cm \quad d' = 5 cm$

$As = As' = D13$ etc $200 = 6.335 cm2$

$$P = \frac{As}{b.d} = \frac{6.335}{100 \times 35} = 0.0018$$

$$\frac{M}{b.d^2} = \frac{150000}{100 \times 35^2} = 1.224$$

Nomogram estimation

$$\frac{1}{Lc} = 10.5 \qquad \frac{1}{Ls} = 600 \qquad j = 0.931$$

$$\delta c = \frac{M}{b.d^2} \cdot \frac{1}{Lc} = 1.224 \times 10.5 = 12.852 kg/cm^2$$

$$\delta s = \frac{M}{b.d^2} \cdot \frac{1}{Ls} = 1.224 \times 600 = 734.4 \ kg/cm^2$$

$$\tau = \frac{D}{b \cdot j \cdot d} = \frac{1620}{100 \times 0.931 \times 35} = 0.497 \ kg/cm^2$$

4-3 Design of Service Pipe Line Route (Incl. Sub-center)

4-3-1 Pipe type selection

Table 4-10

Pipe type	Test water pressure	Max. operating hydrostatic pressure
Asbestos-cement pipe-type 1	2kg/cm^2	9 kg/cm^2
" 2	22 "	6.5 "
" 3	18 "	5 "
" 4	13 "	3 "
Vinyl chloride pipe	-	7.5 "
Ductile cast iron pipe-type 1	60 "	20 " or around
" 2	-	" " "
" 3	50 "	" " "
Reinforced concrete pipe	6 "	-

At the center, the level difference between the headwaters and the field amounts to 150 cm. Accordingly, most parts are applied with over 100 m (10kg/cm^2) water pressure. Especially in the neighborhood of the pump station, over 180 m (18kg/cm^2) inside water pressure is applied when added, with the water hammer pressure.

Therefore, vinyl chloride or asbestos-cement pipe cannot be used because of the lack of strength. In the actual installation design, ductile cast iron pipes are adopted considering the safety and workability.

At the sub-center, vinyl chloride pipes are adopted as the applied water pressure is about 17 m (1.7 kg/cm^2) even when the water hammer is generated.

4-3-2 Hydraulic Calculation

Table 4 - 11 shows the inside water pressure, hydraulic gradient, etc. at each station as disclosed by hydraulic calculation.

The calculation was worked by referring to Hazen-William chart, with the roughness coefficient taken at 130.

HAZEN-WILLIAMS

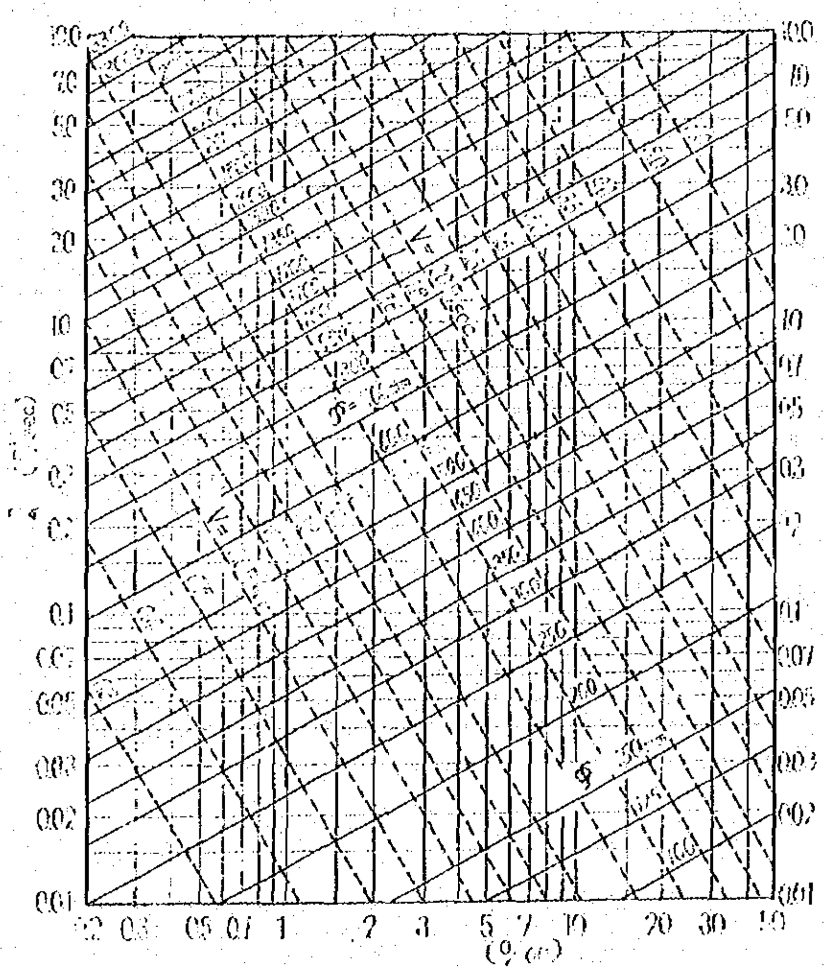


Table 4-11 - Results of Hydraulic Calculation

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRADIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
				ℓ/s				m	m	m
No.0			66.475	8.5	ϕ 100	1.05	13.849		233.424	166.949
No.1	69.800	69,800	66.475	"	"	"	"	0.967	232.457	165.767
No.2	50.670	120.470	67.600	"	"	"	"	0.702	231.755	165.065
+ 37.538	57.590	178.060	65.160	"	"	"	"	0.798	230.957	165.797
No.3	4.244	182.304	65.920	"	"	"	"	0.059	230.898	164.978
+ 10.40	10.570	192.874	64.030	"	"	"	"	0.146	230.752	166.722
+ 20.00	9.600	202.474	64.909	"	"	"	"	0.133	230.619	166.529
No.4	21.382	223.856	67.835	"	"	"	"	0.296	230.323	162.488
No.5	25.760	249.616	71.300	"	"	"	"	0.357	229.966	158.666
No.6	39.920	289.536	72.975	"	"	"	"	0.553	229.413	156.438
No.7	37.120	326.656	75.545	"	"	"	"	0.514	228.899	153.354
No.8	56.070	382.726	77.335	"	"	"	"	0.777	228.122	150.787
+ 58.682	58.724	441.450	79.565	"	"	"	"	0.813	227.309	147.744
No.9	6.933	448.383	78.885	"	"	"	"	0.096	227.213	148.328
+ 40.588	40.620	489.003	77.265	"	"	"	"	0.563	226.650	149.385
No.10	1.414	490.417	76.265	"	"	"	"	0.020	226.630	150.365
No.11	8.798	499.215	76.265	"	"	"	"	0.122	226.508	150.243
No.12	6.385	505.598	79.300	"	"	"	"	0.088	226.420	147.120
+ 21.043	21.079	526.677	78.070	"	"	"	"	0.292	226.128	148.058
+ 22.043	1.000	527.677	78.070	"	"	"	"	0.014	226.144	148.074
+ 23.543	2.121	529.798	79.570	"	"	"	"	0.029	226.085	146.515
+ 32.543	9.000	538.798	79.570	"	"	"	"	0.125	225.960	146.390
No.13+0.4	1.414	540.212	78.570	"	"	"	"	0.020	225.940	197.370
+ 1.40	1.000	541.212	"	"	"	"	"	0.014	225.926	147.356
No.14	16.696	557.908	83.435	"	"	"	"	0.231	225.595	142.160
No.15	77.170	635.078	88.485	"	"	"	"	1.069	224.626	136.141
No.16	47.330	682.408	89.785	"	"	"	"	0.655	223.971	134.186

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRADIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
				ℓ/s				m	m	m
No.17	10.230	692.638	91.470	8.5	ϕ 100	1.05	13.849	0.142	223.829	132.359
No.18	17.580	710.218	89.125	"	"	"	"	0.243	223.586	134.461
No.19	35.700	745.918	91.595	"	"	"	"	0.494	223.092	131.497
No.20	21.650	767.568	92.505	"	"	"	"	0.300	222.792	130.287
+ 12.429	12.432	780.000	92.800	"	"	"	"	0.172	222.620	129.820
+ 13.420	1.000	781.000	92.800	"	"	"	"	0.014	222.606	129.806
No.21 + 0.50	2.121	783.121	94.300	"	"	"	"	0.029	222.577	128.277
+ 8.30	7.931	691.052	95.736	"	"	"	"	0.110	222.467	126.731
+ 9.30	1.120	792.172	96.240	"	"	"	"	0.016	222.451	126.211
+ 14.296	5.585	797.757	98.736	"	"	"	"	0.077	222.374	123.638
+ 18.296	4.272	802.029	100.236	"	"	"	"	0.059	222.315	122.079
No.22	2.062	804.091	100.736	"	"	"	"	0.029	222.286	121.550
+ 5.672	5.682	809.773	100.400	"	"	"	"	0.079	222.207	121.807
+ 19.172	13.500	823.273	"	"	"	"	"	0.187	222.020	121.620
+ 20.172	1.414	824.687	99.400	"	"	"	"	0.020	222.000	122.600
+ 21.172	1.000	825.687	99.400	"	"	"	"	0.014	221.986	122.586
No.23	5.935	831.622	100.046	"	"	"	"	0.082	221.904	121.858
No.24	25.480	857.102	100.201	"	"	"	"	0.353	221.551	121.350
+ 28.248	28.450	885.552	103.631	"	"	"	"	0.394	221.157	117.526
No.25	5.212	890.764	105.101	"	"	"	"	0.072	221.085	115.984
No.26	28.940	919.704	113.264	"	"	"	"	0.401	220.684	107.420
+ 40.746	42.240	961.944	124.400	"	"	"	"	0.585	220.099	95.799
No.27	4.409	966.353	124.311	"	"	"	"	0.061	220.038	95.727
+ 33.212	33.220	999.573	123.600	"	"	"	"	0.460	219.977	96.377
+ 34.212	1.000	1,000.573	123.600	"	"	"	"	0.014	219.517	95.917
+ 35.512	1.830	1,002.411	124.900	"	"	"	"	0.025	219.503	94.603
No.29+1.232	14.081	1,016.492	122.100	"	"	"	"	0.195	219.478	97.378
+ 2.232	1.412	1,017.904	121.100	"	"	"	"	0.020	219.283	98.183
+ 3.232	1.000	1,018.904	"	"	"	"	"	0.014	219.263	98.163

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRADIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
				ℓ/s				m	m	m
No.30	27.827	1,046.731	126.106	8.5	ϕ 100	1.05	13.849	0.385	219.249	93.143
No.31	20.460	1,067.191	121.938	"	"	"	"	0.283	218.864	96.926
No.32	25.450	1,092.641	121.877	"	"	"	"	0.352	218.581	96.704
+ 28.984	29.206	1,121.847	125.473	"	"	"	"	0.404	218.229	92.756
No.33	5.393	1,127.240	127.495	"	"	"	"	0.075	217.825	90.330
+ 16.05	17.318	1,144.558	134.000	"	"	"	"	0.240	217.750	83.750
+ 17.05	1.077	1,145.635	134.400	"	"	"	"	0.015	217.510	83.110
No.35 +1.505	12.603	1,158.238	135.550	"	"	"	"	0.175	217.495	81.945
+ 2.505	1.059	1,159.297	135.900	"	"	"	"	0.015	217.320	81.420
No.36	29.037	1,188.334	145.656	"	"	"	"	0.402	217.305	71.649
No.37	32.350	1,220.684	152.152	"	"	"	"	0.448	216.903	64.751
No.38	12.760	1,233.444	157.583	"	"	"	"	0.177	216.455	58.872
No.39	25.510	1,258.954	172.705	"	"	"	"	0.353	216.278	43.573
No.40	8.100	1,267.054	176.329	"	"	"	"	0.112	215.925	39.596
No.41	19.430	1,286.484	184.038	"	"	"	"	0.269	215.813	31.775
No.42	25.600	1,312.084	195.559	"	"	"	"	0.355	215.544	19.985
No.43	20.240	1,340.324	202.290	"	"	"	"	0.391	215.189	12.899
No.44	26.039	1,366.363	214.130	"	"	"	"	0.361	214.828	0.698
+ 2.00	2.007	1,368.370	214.300	"	"	"	"	0.028	214.8	0.500

(Table 12). Composite angle

Name of pipe line:

Station No.	HP	C	① cos C	A	② cos A	③ sin A	B	④ cos B	⑤ sin B	①②④ =⑥	③⑤=⑦	cos X= ⑥±⑦	X	
No. 2	2	35°38′40″	0.8126	1°01′45″	0.9998	0.0180	2°15′51″	0.9992	0.0395	0.8118	0.0007	0.8111	35°47′47″	⊖
No. 3	3	(−)5°46′45″	0.9949	10°19′01″	0.9838	0.1791	10°18′00″	0.9839	0.1788	0.9630	0.0320	0.9310	21°24′32″	⊖
No. 4	4	38°54′25″	0.7782	10°05′15″	0.9845	0.1752	7°43′49″	0.9909	0.1345	0.7592	0.0236	0.7828	38°28′56″	⊕
No. 5	5	(−)6°02′00″	0.9945	7°43′49″	0.9909	0.1345	2°24′17″	0.9991	0.0420	0.9846	0.0056	0.9902	8°01′41″	⊕
No. 7	7	10°32′55″	0.9831	3°58′12″	0.9976	0.0692	1°49′46″	0.9995	0.0319	0.9803	0.0022	0.9825	10°44′05″	⊕
No. 8	8	17°53′00″	0.9517	1°49′46″	0.9995	0.0319	2°10′35″	0.9993	0.0380	0.9500	0.0012	0.9518	17°51′41″	⊕
No. 9	9	21°11′45″	0.9324	5°37′21″	0.9952	0.0980	2°17′08″	0.9992	0.0399	0.9272	0.0039	0.9311	21°23′35″	⊕
No. 10	10	86°33′52″	0.0599	45°00′00″	0.7071	0.7071	0°	1.0000	0.0000	0.0424	0.0000	0.0424	87°34′11″	⊕
No. 11	11	0°46′40″	0.9999	0	1.0000	1.0000	8°23′31″	0.8797	0.4755	0.8796	0.0000	0.8796	28°24′21″	⊕
No. 12	12	14°02′50″	0.9701	28°23′31″	0.8797	0.4755	2°16′34″	0.9992	0.0397	0.8527	0.0189	0.8338	33°30′32″	⊖
No. 13	13	1°07′15″	0.9998	0	1.0000	1.0000	16°56′26″	0.9566	0.2914	0.9564	0	0.9564	16°58′47″	⊕
No. 14	14	32°35′00″	0.8426	16°56′26″	0.9566	0.2914	3°45′08″	0.9979	0.0654	0.8043	0.0091	0.8234	34°34′40″	⊕
No. 15	15	3°36′00″	0.9980	3°45′08″	0.9979	0.0654	1°34′26″	0.9996	0.0275	0.9955	0.0018	0.9973	4°12′40″	⊕
No. 16	16	24°49′37″	0.9076	1°34′26″	0.9996	0.0275	9°28′51″	0.9863	0.1647	0.8948	0.0045	0.8993	25°56′01″	⊕
No. 17	17	0°23′55″	1.0000	9°28′51″	0.9863	0.1647	7°39′56″	0.9911	0.1334	0.9775	0.0220	0.9555	17°09′25″	⊖

$$\cos X = \cos A \cdot \cos B \cdot \cos C \pm \sin A \cdot \sin B$$

note X : Composite angle
A·B : Vertical angle
C : Horiyontal angle

(Table 12) Composite angle

Name of pipe line:

Station No.	HP	C	① cos C	A	② cos A	③ sin A	B	④ cos B	⑤ sin B	①②④ =⑥	③⑤=⑦	cos X= ⑥±⑦	X	
No. 18	18	25°00′30″	0.9062	7°39′56″	0.9911	0.1334	3°58′03″	0.9976	0.0692	0.8960	0.0092	0.8868	27°31′34″	⊖
No. 19	19	22°26′10″	0.9243	3°58′03″	0.9976	0.0692	2°24′32″	0.9991	0.0420	0.9213	0.0029	0.9242	22°27′07″	⊕
No. 21	21	0°59′00″	0.9833	45°00′00″	0.7071	0.7071	10°25′53″	0.9835	0.1811	0.6838	0.1281	0.8119	35°43′21″	⊕
No. 22	22	65°14′25″	0.4188	14°02′10″	0.9701	0.2425	0	1.0000	0	0.4063	0	0.4063	66°01′39″	⊕
No. 23	23	3°47′30″	0.9978	6°14′55″	0.9941	0.1088	0°20′55″	1.0000	0.0061	0.9919	0.0007	0.9926	6°59′30″	⊕
No. 24	24	37°13′35″	0.7963	0°20′55″	1.0000	0.0061	6°55′29″	0.9927	0.1206	0.7905	0.0007	0.7912	37°42′08″	⊕
No. 25	25	0°56′55″	0.9999	16°23′00″	0.9594	0.2806	16°23′00″	0.9594	0.2806	0.9204	0.0787	0.9991	2°25′52″	+
No. 26	26	2°30′40″	0.9990	16°23′00″	0.9594	0.2806	15°17′09″	0.9646	0.2636	0.9245	0.0740	0.9985	3°08′19″	+
No. 27	27	12°22′55″	0.9767	1°09′32″	0.9998	0.0202	1°09′32″	0.9998	0.0202	0.9763	0.0004	0.9767	12°23′33″	+
No. 28	28	13°59′10″	0.9704	1°13′35″	0.9998	0.0214	0	1.0000	0	0.9702	0	0.9702	14°01′17″	+
No. 30	30	3°27′40″	0.9982	10°21′50″	0.9836	0.1799	11°45′15″	0.9790	0.2037	0.9613	0.0366	0.9979	3°40′24″	+
No. 32	32	16°11′15″	0.9500	0°08′14″	1.0000	0.0024	7°04′21″	0.9924	0.1231	0.9428	0.0003	0.9425	19°31′27″	−
No. 34	34	0°31′22″	1.0000	22°03′45″	0.9268	0.3756	21°48′05″	0.9285	0.3714	0.8605	0.1394	0.9999	0°31′22″	+
No. 36	36	0°05′12″	1.0000	19°37′56″	0.9419	0.3360	11°35′02″	0.9796	0.2008	0.9227	0.0675	0.9902	8°02′27″	+
No. 38	38	1°21′40″	0.9997	25°11′29″	0.9049	0.4256	36°21′17″	0.8054	0.5928	0.7286	0.2523	0.9809	11°12′58″	+

$\cos X = \cos A \cdot \cos B \cdot \cos C \pm \sin A \cdot \sin B$

note X : Composite angle
A·B : Vertical angle
C : Horiyontal angle

(Table 12) Composite angle

Name of pipe line:

Station No.	HP	C	① cos C	A	② cos A	③ sin A	B	④ cos B	⑤ sin B	①②④ =⑥	③⑤=⑦	cos X= ⑥±⑦	X	
No. 40	40	0°49′50″	0.9999	26°34′40″	0.8943	0.4474	23°22′33″	0.9179	0.3968	0.8208	0.1775	0.9983	3°20′29″	+
No. 42	42	0°03′35″	1.0000	26°44′46″	0.8930	0.4500	13°47′21″	0.9712	0.2383	0.8673	0.1072	0.9745	12°58′01″	÷

$\cos X = \cos A \cdot \cos B \cdot \cos C \pm \sin A \cdot \sin B$

note X : Composite angle
A·B : Vertical angle
C : Horiyontal angle

(Table 13) Pipe line

Station No.	EL (m)	Lh=(m)	Lv (m)	tan φ°	φ°	sec φ°	L (m)	d_v	C	X	D (mm)	Q (ℓ/s)
No. 0	66.475											
No. 1	66.690	69.800	0.215	0.0031	0°10′35″	1.0000	69.800	0°10′35″	—	0°10′35″	100	
No. 2	67.600	50.662	0.910	0.0180	1°01′45″	1.0002	50.670	0°51′10″	35°38′40″	35°47′47″		
+57.538	65.160	57.538	−2.440	−0.0424	−2°25′42″	1.0009	57.590	−3°27′27″	—	3°27′27″		
No. 3	65.920	4.175	0.760	0.1820	10°19′01″	1.0164	4.244	12°44′43″	−5°46′45″	21°24′32″		
+10.40	64.030	10.400	−1.890	−0.1817	−10°18′00″	1.0164	10.570	−20°37′01″	—	20°37′01″		
+20.00	64.090	9.600	0.060	0.0063	0°21′29″	1.0000	9.600	10°39′29″	—	10°39′29″		
No. 4	67.385	21.051	3.745	0.1779	10°05′15″	1.0157	21.382	9°43′46″	38°54′25″	38°28′56″		
No. 5	71.300	25.526	3.465	0.1357	7°43′49″	1.0092	25.760	−2°21′26″	(−)6°02′00″	8°01′41″		
No. 6	72.975	39.885	1.675	0.0420	2°24′17″	1.0009	39.920	−5°19′32″	—	5°19′32″		
No. 7	75.545	37.031	2.570	0.0694	3°58′12″	1.0024	37.120	1°33′55″	10°32′55″	10°44′05″		
No. 8	77.335	56.041	1.790	0.0319	1°49′46″	1.0005	56.070	−2°08′26″	17°53′00″	17°51′41″		
+58.682	79.565	58.682	2.230	0.0380	2°10′35″	1.0007	58.724	0°20′49″	—	0°20′49″		
No. 9	78.885	6.900	−0.680	−0.0986	−5°37′21″	1.0048	6.933	−7°47′56″	21°11′45″	21°23′35″		
+40.588	77.265	40.588	−1.620	−0.0399	−2°17′08″	1.0008	40.620	3°20′13″	—	3°20′13″		
		487.879										

note : $dv = \phi_{n+1} - \phi_n$

(Table 13) Pipe line

Station №	EL (m)	Lh= (m)	Lv (m)	ton φ°	φ°	sec φ°	L (m)	d_v	C	X	D (mm)	Q (ℓ/s)
№ 1 0	76.265	1.000	−1.000	−1.000	−45°00′00″	1.4142	1.414	−42°42′52″	(−)86°33′52″	87°34′11″		
№ 1 1	76.265	8.798	0	0	0	1.0000	8.738	45°00′00″	0°46′40″	28°24′21″		
№ 1 2	79.300	5.615	3.035	0.5405	28°23′31″	1.1367	6.383	28°23′31″	14°02′50″	33°30′32″		
+ 2 1.0 4 3	78.070	21.043	−1.230	−0.0585	−3°20′43″	1.0017	21.079	−31°44′14″	—	31°44′14″		
+ 2 2.0 4 3	78.070	1.000	0	0	0	1.0000	1.000	3°20′43″	—	3°20′43″		
+ 2 3.5 4 3	79.570	1.500	1.500	1.0000	45°00′00″	1.4142	2.121	45°00′00″	—	45°00′00″		
+ 3 2.5 4 3	79.570	9.000	0	0	0	1.0000	9.000	−45°00′00″	—	45°00′00″		
№ 13+0.40	78.570	1.000	1.000	1.0000	−45°00′00″	1.4142	1.414	−45°00′00″	—	45°00′00″		
+1.40	〃	1.000	0	0	0	1.0000	1.000	45°00′00″	(−) 1°07′15″	16°58′47″		
№ 1 4	83.435	15.972	4.865	0.3046	16°56′26″	1.0454	16.696	16°56′26″	32°35′00″	34°34′40″		
№ 1 5	88.485	77.005	5.050	0.0656	3°45′08″	1.0021	77.170	13°11′18″	3°36′00″	4°12′40″		
№ 1 6	89.785	47.312	1.300	0.0275	1°34′26″	1.0004	47.330	− 2°10′42″	(−)24°49′37″	25°56′01″		
№ 1 7	91.470	10.090	1.685	0.1670	9°39′51″	1.0138	10.230	7°54′25″	(−) 0°23′55″	17°09′25″		
№ 1 8	89.125	17.423	−2.345	0.1346	−7°58′56″	1.0090	17.580	17°08′47″	(−)25°00′30″	27°31′34″		
№ 1 9	91.595	35.614	2.470	0.0694	3°24′03″	1.0024	35.700	11°37′59″	22°26′10″	22°27′07″		
№ 2 0	92.505	21.631	0.910	0.0421	2°24′32″	1.0009	21.650	1°33′31″	—	1°31′31″		
+ 1 2.4 2 9	92.800	12.429	0.295	0.0237	1°21′35″	1.0003	12.432	− 1°02′57″	—	1°02′57″		
		287.432′					290.997″					

aqueduct $\overline{\Sigma \ell} = 13.50m$

note : $dv = \phi_{n+1} - \phi_n$

(Table 13) Pipe line

Station No.	EL (m)	Lh = (m)	Lv (m)	ton φ°	φ°	sec φ°	L (m)	d_v	C	X	D (mm)	Q (ℓ/s)	
+13.429	92.800	1.000	0	0	0	1.0000	1.000	− 1°21′35″	—	1°21′35″			
No. 21+0.50	94.300	1.500	1.500	1.0000	45°00′00″	1.4142	2.121	45°00′00″	0°59′00″	35°43′21″			aqueduct
+8.30	95.736	7.800	1.436	0.1841	10°25′53″	1.0168	7.931	−34°34′07″	—	34°34′07″			$\bar{\Sigma}\ell = 11.30\,m$
+9.30	96.240	1.000	0.504	0.5040	26°44′53″	1.1198	1.120	16°19′00″	—	16°19′00″			
+14.296	98.736	4.996	2.496	0.4996	26°32′48″	1.1179	5.585	− 0°11′55″	—	0°11′55″			
+18.296	100.236	4.000	1.500	0.3750	20°33′22″	1.0680	4.272	− 5°59′26″	—	5°59′26″			
No. 22	100.736	2.000	0.500	0.2500	14°02′10″	1.0308	2.062	− 6°31′12″	65°14′25″	66°01′39″			
+ 5.672	100.400	5.672	−0.336	−0.0592	− 3°23′25″	1.0018	5.682	−17°25′35″	—	17°25′35″			
+19.172	〃	13.500	0	0	0	1.0000	13.500	3°23′25″	—	3°23′25″			
+20.172	99.400	1.000	−1.000	−1.0000	−45°00′00″	1.4142	1.414	−45°00′00″	—	45°00′00″			aqueduct
+21.172	99.400	1.000	0	0	0	1.0000	1.000	45°00′00″	—	45°00′00″			$\bar{\Sigma}\ell = 15.50\,m$
No. 23	100.046	5.900	0.646	0.1095	6°14′55″	1.0060	5.935	6°14′55″	(−) 3°47′30″	6°59′30″			
No. 24	100.201	25.480	0.155	0.0061	0°20′55″	1.0000	25.480	− 5°54′00″	(−) 37°13′35″	37°42′08″			
+28.248	103.631	28.242	3.430	0.1215	6°55′29″	1.0073	28.450	6°34′34″	—	6°34′34″			
No. 25	105.101	5.000	1.470	0.2940	16°23′00″	1.0423	5.212	9°27′31″	(−) 0°56′55″	2°25′52″			
No. 26	113.264	27.765	8.163	0.2940	16°23′00″	1.0423	28.940	0	(−) 2°30′40″	3°08′19″			
+40.746	124.400	40.746	11.136	0.2733	15°17′09″	1.0367	42.240	− 1°05′51″	—	1°05′51″			
No. 27	124.311	4.400	−0.089	0.0202	− 1°09′32″	1.0002	4.409	−16°26′41″	(−) 12°22′55″	12°23′33″			
		181.001′					186.353″						

note : $dv = \phi_{n+1} - \phi_n$

(Table 13) Pipe line

Station №	EL (m)	Lh= (m)	Lv (m)	ton $\phi°$	$\phi°$	sec $\phi°$	L (m)	dv	C	X	D(mm)	Q(l/s)
№ 27 +33.212	123.600	33.212	−0.711	−0.0214	− 1°13′35″	1.0002	33.220	− 0°04′03″	13°59′10″	14°01′17″		
+34.212	123.600	1.000	0	0	0	1.0000	1.000	1°13′35″	—	1°13′35″		
+35.512	124.900	1.300	1.300	1.0000	45°00′00″	1.4142	1.838	45°00′00″	—	45°00′00″		
№ 29+1.232	122.100	13.800	−2.800	−0.2029	−11°28′10″	1.0204	14.081	−56°28′10″	—	56°28′10″		
+2.232	121.100	1.000	−1.000	−1.0000	−45°00′00″	1.4142	1.412	−33°31′50″	—	33°31′50″		
+3.232	121.100	1.000	0	0	0	1.0000	1.000	45°00′00″	—	45°00′00″		
№ 30	126.106	27.373	5.006	0.1829	10°21′50″	1.0166	27.827	10°21′50″	(−) 3°27′40″	3°40′24″		
№ 31	121.938	20.031	−4.168	−0.2081	−11°45′15″	1.0214	20.460	−22°07′05″	—	22°07′05″		
№ 32	121.877	25.450	−0.061	−0.0024	− 0°08′14″	1.0000	25.450	11°37′01″	(−)16°11′15″	19°31′27″		
+28.984	125.473	28.984	3.596	0.1241	7°04′21″	1.0077	29.206	7°12′35″	—	7°12′35″		
№ 33	127.495	5.000	2.022	0.4044	22°01′06″	1.0787	5.393	14°56′45″	—	14°56′45″		
№ 33+16.05	134.000	16.050	6.505	0.4053	22°03′45″	1.0790	17.318	0°02′39″	(−) 0°31′22″	0°31′22″		
+17.05	134.400	1.000	0.400	0.4000	21°48′05″	1.0770	1.077	− 0°15′40″	—	0°15′40″		
№ 35+1.505	135.550	12.550	1.150	0.0916	5°14′08″	1.0042	12.603	−16°33′57″	—	16°33′57″		
+2.505	135.900	1.000	0.350	0.3500	19°17′24″	1.0595	1.059	14°03′16″	—	14°03′16″		
№ 36	145.656	27.349	9.756	0.3567	19°37′56″	1.0617	29.037	0°20′32″	(−) 0°05′12″	8°02′27″		
№ 37	152.152	31.691	6.496	0.2050	11°35′02″	1.0208	32.350	− 8°02′54″	—	8°02′54″		
№ 38	157.583	11.546	5.431	0.4704	25°11′29″	1.1051	12.760	13°36′27″	(−) 1°21′40″	11°12′58″		
№ 39	172.705	20.545	15.122	0.7360	36°21′17″	1.2417	25.510	11°09′48″	—	11°09′48″		
		279.881					292.601					

aqueduct $\Sigma l = 18.10m$

aqueduct $\Sigma l = 14.55m$

note : $dv = \phi_{n+1} - \phi_n$

(Table 13) Pipe line

Station No.	EL (m)	Lh = (m)	Lv (m)	ton $\phi°$	$\phi°$	sec $\phi°$	L (m)	dv	C	X	D (mm)	Q (l/s)	
No. 4 0	176.329	7.244	3.624	0.5003	26°34′40″	1.1182	8.100	− 9°46′37″	(−)0°49′50″	3°20′29″			
No. 4 1	184.038	17.835	7.709	0.4322	23°22′33″	1.0894	19.430	− 3°12′07″	—	3°12′07″			
No. 4 2	195.559	22.861	11.521	0.5040	26°44′46″	1.1198	25.600	3°22′13″	(−)0°03′35″	12°58′01″			
No. 4 3	202.290	27.426	6.731	0.2454	13°47′21″	1.0297	28.240	−12°57′25″	—	12°57′25″			
No. 4 4	214.130	23.192	11.840	0.5105	27°02′43″	1.1228	26.039	13°15′22″	—	13°15′22″			
+ 2.0 0	214.300	2.000	0.170	0.085	4°51′30″	1.0036	2.007	−22°11′13″	—	22°11′13″			
Total		1336.751					1368.370						1366.243/1336.751 = 1.0221

100.558

note : $dv = \phi_{n+1} - \phi_n$

4-3-3 Safety Facilities

a. Thrust blocks

Thrust blocks are placed along the pipe at bends and coners, and at sluice valves where the action of water pressure may possibly cause dislocations of pipe connections etc.

1. At lateral bends along the pipe

Checking against slippage

$$R_H \geqq SP' = SR_H$$

$$P' = P_H = 2(Pa_c + \frac{aWwV^2}{g}) \sin \frac{\theta}{2}$$

where,

R_H: horizontal resistance = (frictional resistance at block surface) + (passive earth pressure against rear surface of block) (t)

P': displacement force = lateral thrust = P_H (t)

a_c: cross-sectional area of pipe (outer diameter) (m^2)

P : internal pressure = static water pressure + thrust of water flow (t/m^2)

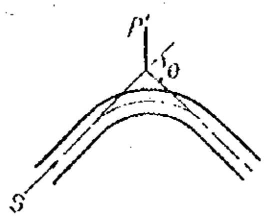
a : corss-sectional area of water flow = 2D /4 (m^2)

D : internal diameter of pipe (m)

Ww: unit weight of water within the pipe 1.0t/m^3

v : average flow rate of water within the pipe (m/s)

π : ratio of circumference to diameter



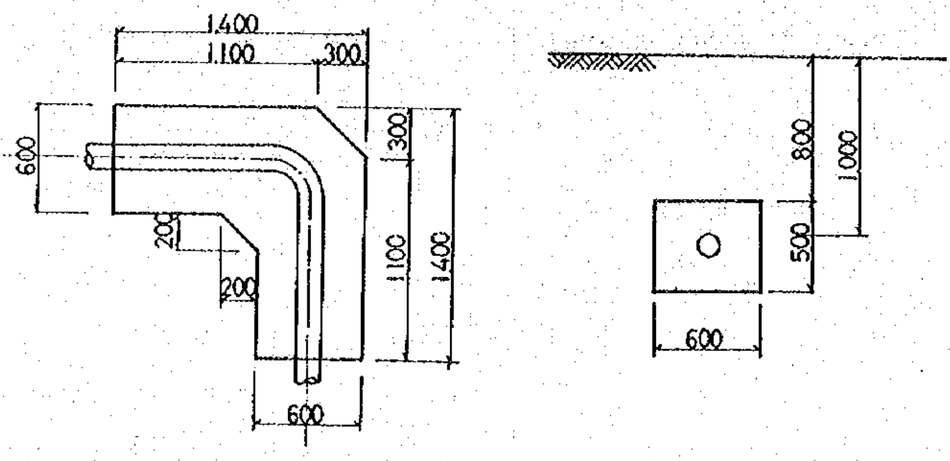


Fig. 4-12 Cross section view of thrust block

Weight of soil above thrust block

$$W_1 = (0.60 \times 1.40 - 1/2 \times 0.30^2 + 0.60 \times 0.80 + 1/2 \times 0.20^2) \times 0.80 \times 1.80$$
$$= 1.865t$$

Dead weight of thrust block

$$W_2 = (0.60 \times 1.40 - 1/2 \times 0.30^2 + 0.60 \times 0.80 + 1/2 \times 0.20^2) \times 0.50 \times 2.30$$
$$- 1/4 \times \pi \times 0.10^2 \times (0.584 + 1.5085) \times 2.30 = 1.451t$$

Dead weight of pipe + weight of water

$$W_3 = (0.018 + 1.5085 \times 0.0186) + 1/4 \times \pi \times 0.10^2 \times (0.584 + 1.5085)$$
$$= 0.062t$$

Frictional resistance at bottom surface of thrust block

$$R_{H_1} = f \cdot W = 0.5 \times \sum_{n=1}^{3} = 0.5 \times 3.378 = 1.689t$$

where f is frictional coefficient = 0.5

Passive earth pressure on rear surface of block

$$Kp = \tan^2(45°+\phi/2) + \frac{2 \cdot C}{\gamma t \cdot Z} \tan(45°+\phi/2)$$

$$= \tan^2(45°+30°/2) + \frac{2 \times 0}{1.8 \times 1.3} \tan(45°+30°/2)$$

$$= 3.00$$

$$P_1 = Kp \cdot \gamma t \cdot H_1 \cdot B = 3.00 \times 1.80 \times 0.80 \times 1.40 = 6.048t$$

$$P_2 = Kp \cdot \gamma t \cdot H \cdot B = 3.00 \times 1.80 \times 1.30 \times 1.40 = 9.828t$$

$$R_{H_2} = 1/2 \times (P_1+P_2) \times H_2 = 1/2 \times (6.048+9.828) \times 0.50 = 3.969$$

$$R_H = R_{H_1} + R_{H_2} = 1.689 + 3.969 = 5.658t$$

$$P' = P_H = 2(p \cdot a_c + \frac{a \cdot Ww \cdot V^2}{g}) \sin \frac{\theta}{2}$$

$$P = 172.16 + 55 = 227.16t/m^2$$

$$a_c = 1/4 \times \pi \times 0.118^2 = 0.01093m^2$$

$$a = 1/4 \times \pi \times 0.100^2 = 0.00785m^2$$

$$Ww = 1.00t/m^2$$

$$V = 0.00853/0.00785 = 1.087m/s$$

$$\theta = 90°$$

$$P' = 2 (227.16 \times 0.01093 + \frac{0.00785 \times 1.00 \times 1.087^2}{9.8}) \sin \frac{90}{2}$$

$$= 2 \times 2.484 \times 0.7071 = 3.513t$$

$$S = R_H/P_H = 5.658/3.513 = 1.61 > 1.5$$

Strength calculations for aqueduct

1. Fixed determinants:

Form	:
Effective span	: ℓ = 12.0m
Pipe diameter	: ϕ100m/m
Pipe thickness	: t = 4.5m/m
Design internal pressure	: 22.7kg/cm^2 (static water pressure 17.2kg/cm^2, thrust of water flow 5.5kg/cm^2)
Steel material	: SS.41
Allowable stress	: tensile stress 1300kg/cm^2 compressive stress 1300kg/cm^2 shear stress 750kg/cm^2
Allowable deflection	: 1/350
Earthquake load	: horizontal seismic coefficient 0.2

2. Loads:

Dead weight of pipe	: 12.8kg/m x 12.0m = 153.6kg
Weight of water	: 1/4 x 3.14 x 0.10^2 x 12.0 x 1.0 = 94.2kg
	Total 247.8kg
Vertical load	: Wv = 247.8/1200 = 0.21kg/cm
Horizontal load	: Wh = 0.21 x 0.20 = 0.04kg/cm

3. Check against stress produced within pipe itself

1) Circumferential stress

Tensile stress due to internal pressure

$$\sigma t = \frac{P \cdot \gamma}{t} = \frac{22.7 \times 5}{0.45} = 252.2\text{kg/cm}^2 < 1300\text{kg/cm}^2$$

where,

P is internal pressure (kg/cm^2)

r is internal radius of pipe (cm)

t is pipe thickness (cm)

2) Bending stress around pipe axis

Bending stress as a beam

$$\sigma_D = \frac{M}{\pi\gamma^2 t} = \frac{0.125\ Wv\ \ell^2}{\pi\gamma^2 t} = \frac{0.125 \times 0.21 \times 1200^2}{3.14 \times 5^2 \times 0.45}$$

$$= 1070.0kg/cm^2 < 1300kg/cm^2$$

3) Shear force perpendicular to pipe axis

$$\tau = \frac{5 \cdot Wv \cdot \ell}{8 \cdot \pi \cdot \gamma \cdot t} = \frac{5 \times 0.21 \times 1200}{8 \times 3.14 \times 5 \times 0.45} = 22.3kg/cm^2$$

4) Check against horizontal loads

a) Ratio of horizontal to vertical loads

$$n = \frac{Wh}{Wv} = \frac{0.04}{0.21} = 0.20$$

b) Bending stress caused by horizontal loads

$$\sigma_R = \sqrt{\sigma_D{}^2 + \sigma_n{}^2} = \sqrt{1070^2 + 214^2} = 1091.2kg/cm^2 < 1300kg/cm^2$$

4. Check against buckling

Critical buckling stress

$$\sigma_K = 0.6E\,\frac{t}{\gamma}$$

$$= 0.6 \times 2.1 \times 10^6\ \frac{0.45}{5}$$

$$= 113.400kg/cm^2$$

E: Young's modulus for the pipe material (kg/cm^2) $= 2.1 \times 10^6$

5. Check against deflections

$$\delta max = \frac{Wv \cdot \ell^4}{185E \cdot I}$$

I = moment of inertia of area

= $340cm^4$

$$= \frac{0.21 \times 1200^4}{185 \times 2.1 \times 10^6 \times 340}$$

$$= 3.3cm$$

$$\frac{3.3}{1200} = \frac{1}{364} < \frac{1}{350}$$

4-4 Basic Design of Buildings

4-4-1 Buildings

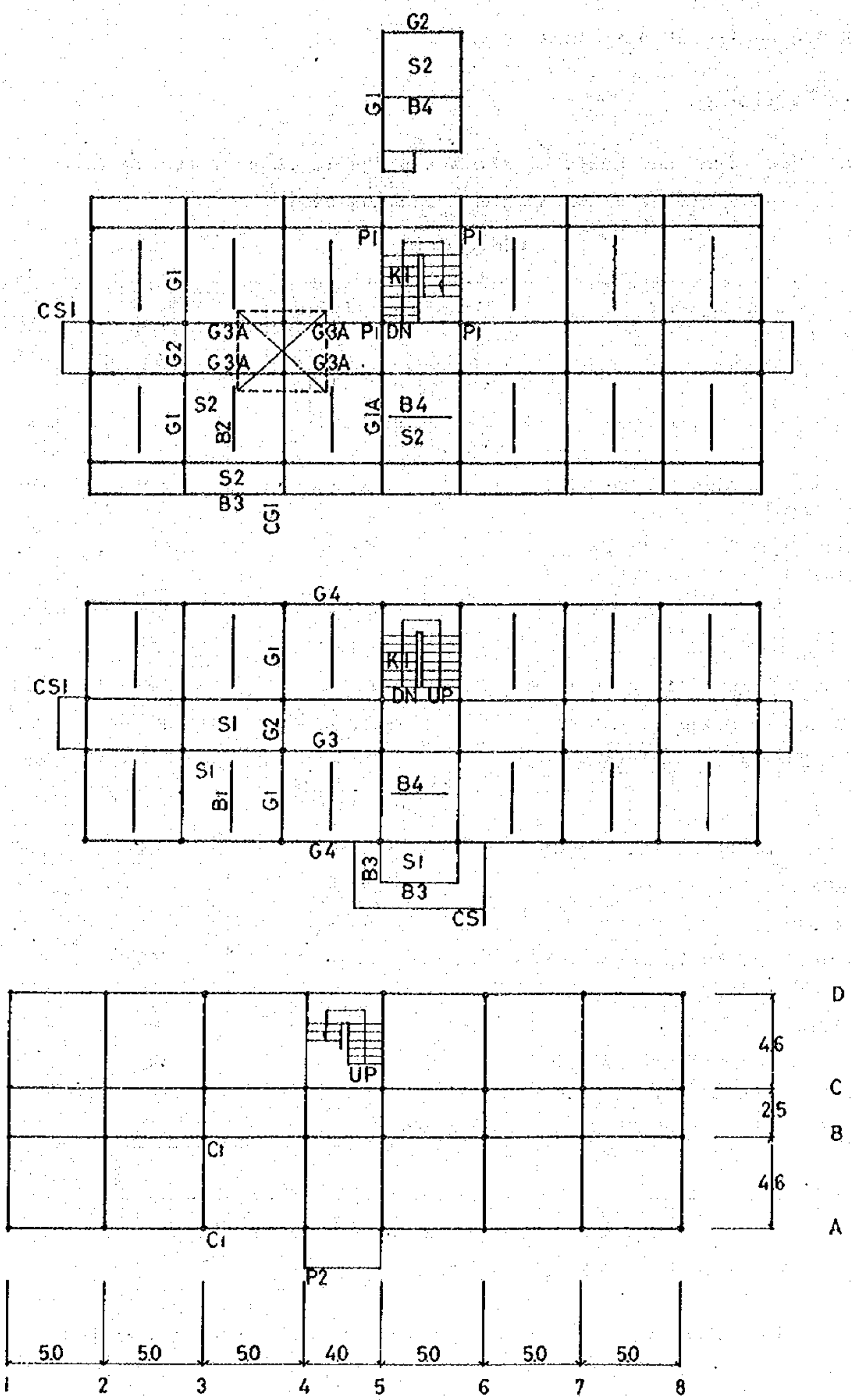
a) The kinds and scale of the buildings to be constructed in Sericulture Centre are as shown in the following table.

Table 4-14

	Building Name	Brief Description	Total Floor Area	Building Area
A	Main building	2-storied reinforced concrete building	848 m²	413
A'	Cocoon testing room	1-storied brick building	242	180
B	Rearing room for rearing method	- do -	456	192
C	Rearing room for egg production (1)	- do -	456	192
	" (2)	- do -	456	192
	Research room	- do -	86	46
D	Pathological rearing room	- do -	264	96
E	Pebrine inspection room	- do -	372	252
F	Silkworm egg refrigerator	- do - (prefabricated partition)	270	180
G	Artificial hatching room	- do -	48	24
H	Chemicals warehouse	- do -	-	4
I	Garage	- do -	-	60
J	Mulberry field maintenance building	- do -	165	117
K	Compost shed	- do -	264	200
L	Agricultural machine and tool warehouse	- do -	187	120
	Sericultural equipment pool	2 places	-	(40 m²)
	Total			2,268

b) Structural Calculation of Main Buildings

The calculation is worked out for the main centre building.


G2
S2
G1
B4
P1
K1
CS1
G3A
DN
G2
G1
S2
B2
G1A
B4
S2
S2
B3
CG1
G4
CS1
S1
G3
UP
B1
S1
G4
B3
CS1
UP
C1
P2
D
C
B
A
4.6
2.5
4.6
5.0
5.0
5.0
4.0
5.0
5.0
5.0
1
2
3
4
5
6
7
8

(1) Preparatory Calculation

i. Design Criteria

a. Basic plan

Rigid frame structure in both X and Y directions.

b. Standard for operation

Standard of Structural Calculation, Japan Architectural Institute.

c. Foundation work

Independent footing considering bearing capacity.

d. Aseismatic design

Rigid drame earthquake proofing.

e. Consideration of rigid zone

Beam ----- column surface, column ---- beam surface.

f. Correction of column base fixed load

Rigidity of footing beam is considered.

g. Increase rate of seismic shearing force
1.5 times.

ii. Assumptions for calculation

a. Material

Reinforcement DS30

Tensile strength	2,000 kg/cm^2 (long time)
Shearing strength	"
	(1.5 times the above value for short time)

Concrete (ordinary concrete), FC = 210

Compressive strength	70 kg/cm^2 (long)	140 kg/cm^2 (short)
Shearing strength	7.0 " (")	10.5 " (")
Adhesive strength	21 " (") (14 upper limit)	1.5 times the long time strength (")

b. Bearing capacity (long time)

50 t/m^2

c. External force

Seismic force	Standard seismic intensity -0.12
Wind Pressure	q = 60 h

d. Load term (kg/m^2)

Water tank (RF) - 50t

Roof:

Finishing mortar	330	60
Covering concrete	60	144
Protective mortar	15	30
Evening mortar		15
	20	40
RC slab	135	324
Ceiling		20
		633
		640

Office room:

Finishing mortar	330	60
RC slab	120	288
Ceiling		20
		368
		370

Toilet:

Finishing mortar	330	60
Covering concrete	60	144
Waterproofing layer		15
Evening mortar	20	40
RC slab	120	282
Ceiling		20
		567
		570

Staircase:

Finishing(average -350)	100
(" -250)	600
Ceiling plaster	50
	750

Landing 370

$\frac{370 + 750}{2} \fallingdotseq 600$

Parapet :

h = 800 0.6t/m

Wall weight:

Interior	t =	100	120	180
RC		240	290	440
Finishing		80	80	80
		320	370	520

Exterior	t =	150	180
RC		360	440
Finishing		100	100
		460	540

Beam weight:

Small $W = 2.4 \times 0.25 \times 0.33 \times 4.6 = 0.92t$

$A = 2.5 \times (4.6-1.25) = 0.4\ m^2$

$W = \frac{920}{8.4} = 109.5 \quad 110\ kg/m^2$

Large (R. 2F) $W = 2.4 \times 0.3 \times 0.48 \times (9.2+10+2.4 \times 0.15 \times 0.48 \times 5.0 \times 2$

$+2.4 \times 0.3 \times 0.33 \times 2.5 + 2.4 \times 0.25 \times 0.33 \times 4.6 \times 2$

$= 6.64 + 1.73 + 0.6 + 0.76 = 9.73t$

$A = 5.0 \times 12 = 60\ m^2$

$W = 162 \quad 170\ kg/m^2$

Column $W = 2.4 \times 0.5 \times 0.5 \times 3.38 \times 2 + 2.4 \times 0.5 \times 0.35 \times 3.38 \times 2$

$= 4.06 + 2.84 = 6.90$

$A = 60\ m^2$

$W = 115 \quad 120\ kg/m^2$

Table 4-14 Floor Load for Building Design (kg/m^2)

Room/Section		Slab	Small beam	Large beam	Column footing	Earthquake	Remarks
Roof	DL	640	750	810	930	930	B 110
	LL	180	160	130	130	60	B+G 170
	TL	820	910	940	1,060	990	C 120
Pent-roof	DL	640	750	810	930	930	
	LL	90	60	60	60	30	"
	TL	730	810	879	990	960	
Office room	DL	370	480	540	660	660	
	LL	400	340	280	280	180	"
	TL	770	820	820	940	840	
Toilet	DL	570	680	740	860	860	
	LL	180	160	130	130	60	"
	TL	850	840	870	990	920	
Staircase	DL	600	710	770	890	890	
	LL	400	340	280	280	180	"
	TL	1,000	1,050	1,050	1,170	1,070	

(2) Design of Slab and Small Beam

Slab:

S1. $\ell_x \times \ell_y = 2.3 \times 4.6$ $\lambda=2.0$

$W = 0.77\ t/m^2$

$D = 12$ $d = 9$ $j = 7.9$

$M_{x1} = \frac{1}{12} \times 0.77 \times 2.3^2 = 0.34$ $at = \frac{34}{2x7.9} = 2.2$ D10-2.24-200@

$M_{x2} = \frac{1}{18} \times 0.77 \times 2.3^2 = 0.23$ "

M_y D10-250@

S2. $\ell_x \times \ell_y = 2.3x4.6$ $\lambda = 2.0$

$W = 0.82$

$D = 13.5$ $d = 10.5$ $j = 9.2$

$M_{x1} = 0.36$ $at = 2.0$ D10 = 200@

M_y D10 = 250@

CS1. $P = 0.46 \times 0.2 - 0.1t$

$W = 0.77\ t/m2$

$M = 0.1x1.5+1/2x0.77x1.5^2=0.15+0.87=1.02\ t.m$

$Q = 0.1+0.77x1.5 = 1.3\ t.$

$D = 15$ $d=12$ $j=10.5$

$at = \frac{102x1.5x}{2 \times 10.5} = 7.3$ D13.174 150@

(Bottom end thickness -180)

Small beam:

B1.
B2. $W = 0.91\ t/m^2$
B4

$C = 2x0.91x1.95 = 3.5$ t.m

$M_2 = 2x0.91x3.0 = 5.5$ t.m

$Q = 2x0.91x2.1 = 3.8$ t

BxD =25x45   d=40   j=35

E,   C

2 19	2
25 x	45
2	3

ST D10-200@

ϕ $at = \frac{550}{2.0x35} = 7.9\ m^2$ 3-D19

$\psi = \frac{3800}{14x35} = 7.8$ 2-D19

$\tau = \frac{3800}{25x35} = 4.3$ 7

B3

2-D19
25 x 40
2-D19
ST D10-250@

Staircase:

K1   W = 1.0

$M_2 = 1/8 \times 1.0 = 4.5^2 = 2.53$

D = 15   d = 12   j = 10.5

at = 12.0   D13 - 100 @

(3) C, M_o and Q under Vertical Load

RG1 (2G1) $W = 0.94\ t/m^2\ (0.82)$

$C = 2 \times 0.94 \times 1.95 = 3.7\ t.m(3.2)$

$M_2 = 2 \times 0.94 \times 3.0 = 5.6\ t.m(4.9)$

$Q = 2 \times 0.94 \times 2.1 = 3.9\ t\ \ (3.4)$

RG2 (2G2) $W = 0.94\ t/m^2\ (0.82)$

$C = 2 \times 0.94 \times 0.4 = 0.8\ (0.7)$

$M_o = 2 \times 0.94 \times 0.65 = 1.2\ (1.1)$

$Q = 2 \times 0.94 \times 0.8 = 1.5\ (1.3)$

RG3 (2B3) $W = 0.94\ (0.82)$

$C = 2 \times 0.94 \times (2.3+4.0) = 11.8\ (10.3)$

$M_o = 2 \times 0.94 \times (3.5 + 7.2) = 20.1\ (17.5)$

$Q = 2 \times 0.94 \times (2.3 + 3.7) = 11.3\ (9.8)$

RCG1 $P = 0.6 \times 5 + 0.94 \times 0.75 \times 5.5 = 3+3.9=6.9t$

$M = 6.9 \times 1.5 = 10.4\ t.m$

B x D = 30 x 60 d = 55 j = 48.1

C = 11.4 Pt = 65

at = 10.7

4-D22

CG1 30 x 60 (45) Extreme end

3 -

ST D10-200@

(4) Axial Force of Column (t)

A-1

W18	0.54 x 4.3 x 4.0	9.2	
	0.6 x 2.5	1.5	
RF	1.06 x 2.5 x (2.5+1.5)	10.6	
OW	0.54 x 4.3 x 3.5	8.1	
	0.46 x 25 x 3.5 x 0.7	2.8	
CB	0.2 x 1.2 x 3.1	0.7	32.9
2F	0.94 x 2.5 x 2.5	5.8	
OW	0.54 x 2.5 x 3.5 x 0.7	3.3	
CB	0.2 x 1.2 x 3.1	0.7	42.7

B-1

W18	0.54 x 3.5 x 4.0	7.5	
RF	1.06 x 3.5 x 2.5	9.2	
	0.6 x 1.5 x 1.2	1.0	
OW	0.54 x 3.5 x 3.5 x 0.7	4.6	
CB	0.2 x 2.2 x 3.1	1.8	24.1

A-2

	0.6 x 5.0	3.0	
RF	1.06 x 5.0 x (2.5 + 1.5)	21.2	
OW	0.46 x 5.0 x 3.5 x 0.7	5.6	
CB	0.2 x 2.5 x 3.1	1.6	31.4
2F	0.94 x 5.0 x 4.0	18.8	
OW	0.46 x 5.0 x 3.5 x 0.7	5.6	
	0.2 x 2.5 x 3.1	1.6	57.4

B-2

RF	1.06 x 5.0 x 3.5	18.6	
	0.2 x 6.5 x 3.1	4.0	22.6

	2F	0.94 x 5.0 x 3.5	16.5	
		0.2 x 6.5 x 3.1	4.0	43.1
B-4				
		0.6 x 2.0	1.2	
		0.46 x 3.0 x 3.25 x 0.8	3.6	4.8
	RF	1.06 x 3.5 x 4.5	16.7	
		0.2 x 4.0 x 3.1	2.5	24.0
	2F	0.94 x 3.5 x 4.5	14.8	
		0.37 x 2.3 x 3.1	2.6	41.4
C-4				
		0.6 x 3.5	2.1	
		0.99 x 3.5 x 2.0	6.9	
	OW	0.46 x 3.5 x 3.25	5.2	14.2
	RF	1.06 x 3.5 x 4.5	4.8	
		0.52 x 2.5 x 3.1	4.0	
		0.2 x 4.0 x 3.1	2.5	25.5
	2F	0.99 x 3.5 x 4.5	15.6	
			6.5	47.6

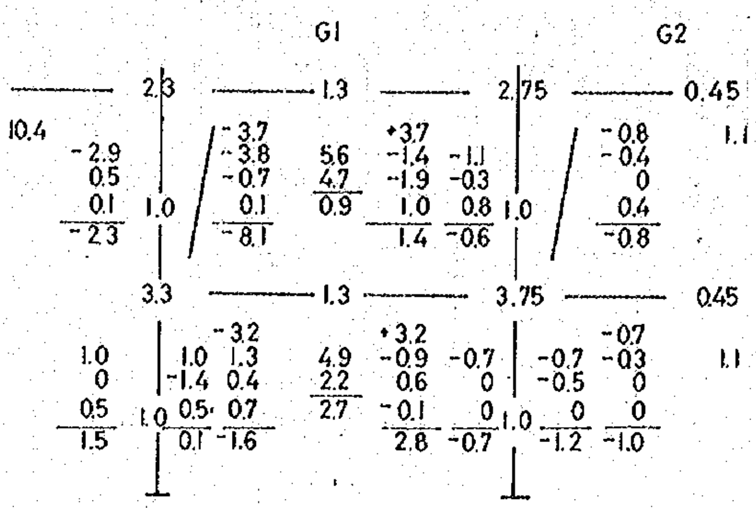
(5) Seismic Force (t)

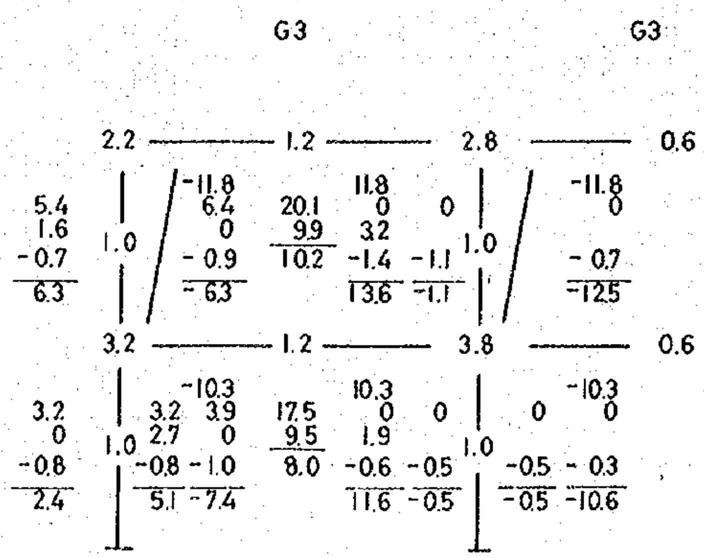
			W		W	k	kW	ΣkW
		0.6 x 20	12.0					
	PRF	0.96 x 4 x 6	23.0					
				66.2	66.2	0.18	11.9	
	OW	0.46 x 22 x 3.25 x 0.95	31.2					
	OW	0.54 x 15.7 x 4.0 x 2	67.8	67.8	67.8	0.18	12.2	
		50t	50.	50.	50	0.18	9.	
		0.6 x 34 x 2	40.8					
	RF	0.99 x 34.0 x 15.0	504.9	547.6				
		0.6 x 1.5 x 3.0	2.7					
2					641.5	0.12	77.0	110.1
	OW	0.54 x 15.7 x 3.5	29.7	93.9				
		0.46 x 34.0 x 2 x 3.5 x 0.7	76.6	187.8				
	iw	0.52 x 5 x 2 x 3.1	16.1	93.9				
		0.2 x (5 x 12 + 3.5x13)x3.1	65.4					
	2F	0.84 x 34 x 12	342.7					
1		(1.07-0.84) x 9 x 5	10.4	376.6	568.5	0.12	68.2	178.3
		0.84 x 1.5 x 3	3.8					
		0.96 x 6.4 x 3.2	19.7					
	OW	0.54 x 12 x 2 x 3.5 x 0.7	31.8					
		0.46 x 34.0 x 2 x 3.5 x 0.7	76.6	98.0				
	iw	0.52 x 5 x 2 x 3.1	16.1	196.0				
		0.37 x 5 x 2 x 3.1 x 0.8	9.2	98.0				
		0.2 x (5x11 + 3.5x13)x3.1	62.3					

(6) Relative Stiffness Ratio

Code	B cm	D cm	$I_D \times 10^4$ cm^4	ϕ	$I \times 10^4$ cm^4	ℓ cm	$K \times 10^3$ cm^3	k
R G1 2	30	55	41.6	2.0	83.2	4.6	18.1	1.3
R G2 2	30	40	16.0	2.0	32	2.5	12.8	0.9
R G3 2 G4	30	55	41.6	2.0	83.2	5.0	16.6	1.2
				1.5	62.4		12.5	0.9
				2.0	83.2	4.0	20.8	1.5
				1.5	62.4		15.6	1.1
2 C1	50	50	52.1			3.5	14.9	1.0
1 C1	50	50	52.1			3.7	14.1	1.0
FG	35	70	100			5.0	20.	1.4
						4.6	21.7	1.5
						4.0	25	1.8
	35	55	48.5			2.5	19.4	1.4

(7) Stress due to Vertical Load



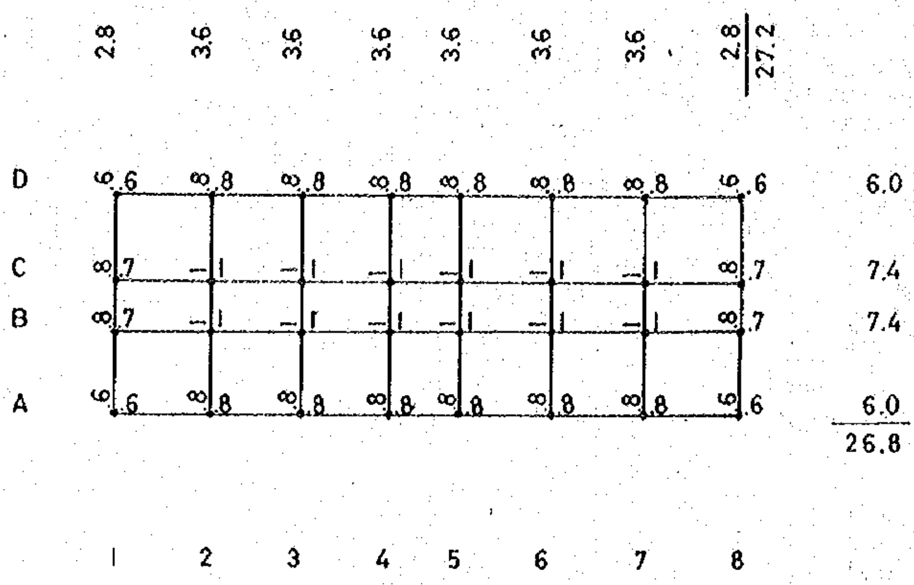


(8) Stress due to Seismic Force

Distribution coefficient and Height Ratio of Inflection Point

			G1				G2
			1.3				0.9
	$\bar{k}$	= 1.3				2.2	
	a	0.4		y = 0.42		0.52	0.45
1.0	D	0.4			1.0	0.52	
	D'	0.8				1.0	
			1.3				0.9
		1.4				2.5	
		0.41		0.57		0.55	0.55
1.0		0.41			1.0	0.55	
		0.8				1.0	
			1.5				1.4

		G3				
		1.2				1.2
	1.2				2.4	
	0.37		0.42		0.54	0.45
1.0	0.37			1.0	0.54	
	0.7				1.0	
		1.2				1.2
	1.3				2.6	
	0.4		0.57		0.56	0.55
1.0				1.0		
	0.4				0.56	
	0.7				1.0	
		1.4				1.4

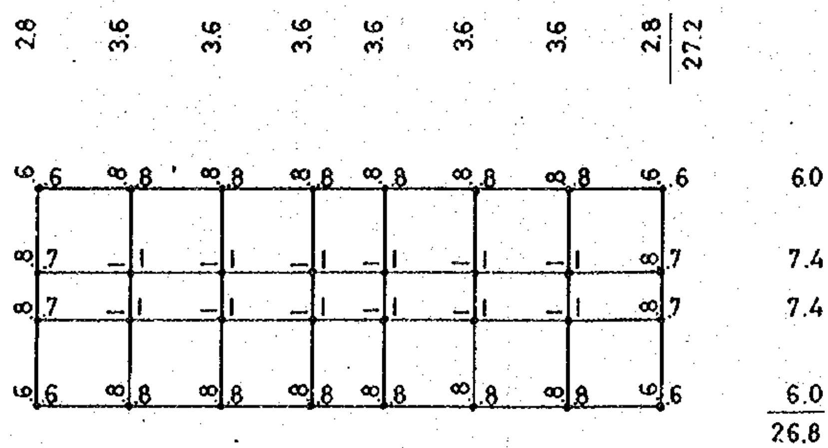


Q = 110.1 t

μQ_x = 4.1

μQ_y = 4.1

2nd flr.



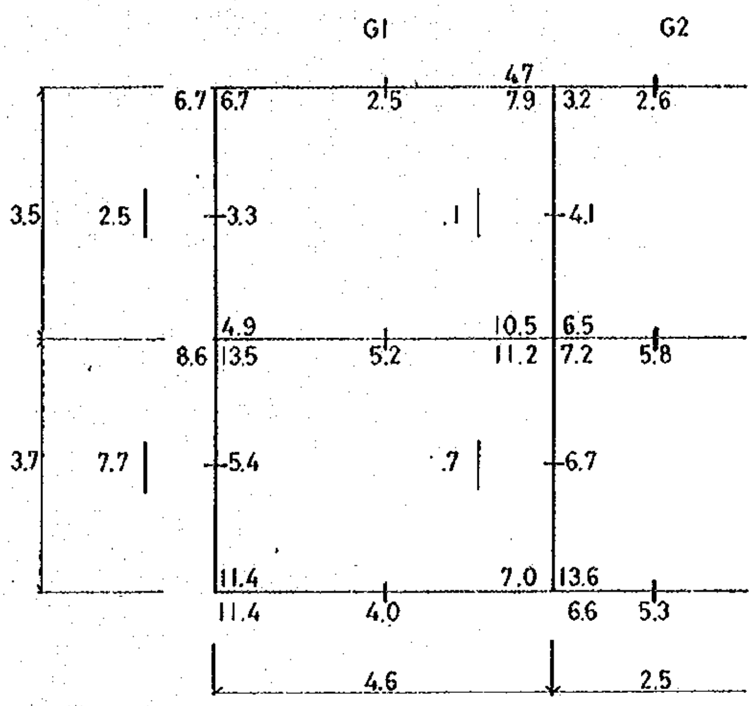
Q = 178.3 t

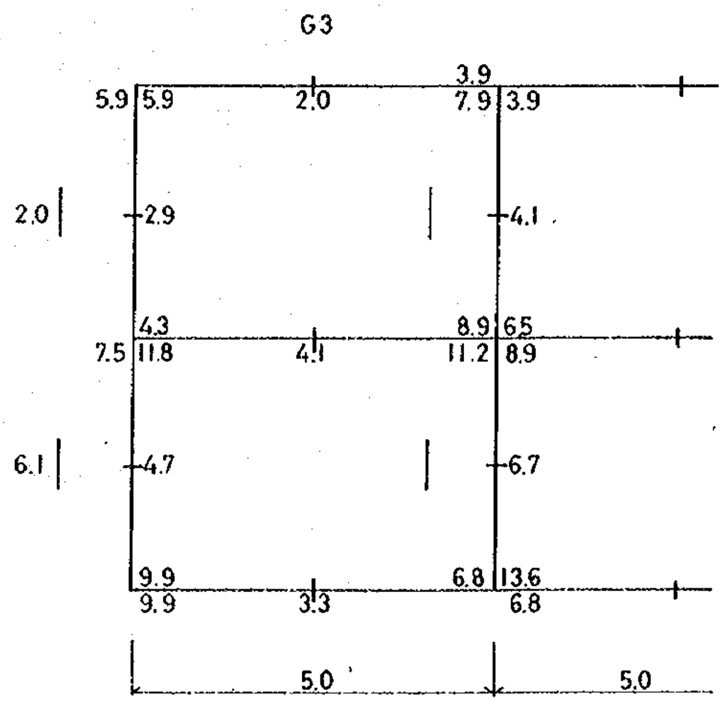
μQ_x = 6.7

μQ_y = 6.7

1st flr.

Stress under Seimic Force





(9) Design of Large Beam

RG1 Face moment considered

DE M_L = 8.1 t.m Q_L = 3.2 t

M_K = 6.7 (6.1) Q_K = 2.5 x 1.5 = 3.8

M_S = 14.2 Q_S = 7.0

B x D = 30 x 55 d = 50 j = 43.7 Bd^2 = 0.75 x 10^5

C = 18.9 γ= 0 Pt = 0.72

at = 10.8 3-D22

ψ = 11.4

τ = 5.3

		DE	C	iE
		3-D22	2	2(3)
(RG1A)	RG1		30 x 55	
	3		2	2
			(3)	
		ST	D10-200@	

C M_L = 0.9

iE M_L = 1.4

M_K = 4.7 (4.1

M_S = 5.5

at = 42 2 - D22

2G1

DE M_L = 1.6 Q_L = 3.4

M_K = 13.5(12.2) Q_K = 5.2 x 1.5 = 7.8

M_S = 13.8 Q_S = 11.2

B x D = 30 x 55

at = 10.5

τ = 8.5 2G1 Same as above

C M = 2.7

iE M_L = 2.8

M_K = 10.5 (9.2)

M_S = 12.0

at = 9.2

RG2

E $M_L = 0.8$ $Q_L = 1.5$

$M_K = 3.2\ (2.6)$ $Q_K = 2.6 \times 1.5 = 3.9$

$M_S = \underline{3.4}$ $Q_S = \underline{3.4}$

B x D = 30 x 40 d = 35 j = 30.6

at = 3.7 2-D22

$\psi = 7.3$

	2 - D22
RG2	30 x 40
	2-

$\tau = 5.9$

2G2 $M_L = 0.7$ $Q_L = 1.3$

$M_K = 7.2\ (5.8)$ $Q_K = 5.8 \times 1.5 \times 8.7$

$M_S = 6.5$ $Q_S = 10.0$

B x D = 30 x 40

at = 7.1

$\psi = 15.5$ 4-D22

	3 - D22
2G2	30 x 40
	3 - D22

$\tau = 10.9$ PW = 0.22 D10=216 200@

Pent house

	3 - D19
RRG1,G2	30 x 50
	3 - D19

ST. D10 - 200@

RG3 RGX_{DE}

M_L = 6.3 Q_L = 11.8

M_K = 5.9 (5.4) Q_K = 2.0 x 1.5 x 3.0

M_S = 11.7 Q_S = 14.8

B x D = 30 x 60 Bd^2 x 0.91

d = 55 j = 48.1

at = 8.9

ψ = 19.2 3-D22

τ_2 = 8.1 PW = .32 D13-264 200

C M = 10.2

	DE	C	i
	4-D22	2	4 (5)
(RG3A)	RG3	30 x 60	
	3	4(5)	4

at = 10.6 4 -D22

iE M_L = 13.6

M_K = 3.9 (3.3) D13-200@

M_S = 16.9

C = 14.9 Pt = 0.84 γ= 0.8

at = 13.8 4-D22

2G3 $2G4_{DE}$

M_L = 7.4 Q_L = 9.8

M_K = 11.8 (10.8) Q_K = 4.1 x 1.5 x 6.2

M_S = 18.2 Q_W = 16.0

B x D = 30 x 60 d = 55 j = 48.1 Bd^2 = 0.91

C = 20.0 Pt = 0.77

	DE	C	i
	4-D22	2	4
2G3	30 x 60		
	4 -	4	4

at = 12.7 4 - D22

ψ = 15.8

τ_S = 11.1 pW = 0.23 D10-207 200@

C M = 8.0

at = 8.3

iE M_L = 11.6

M_K = 8.9 (7.9)

M_S =19.5

C =21.4 pt = 0.82

at = 13.5 4 - D22

(10) Design of Column

2 C1 (B-2)

N_L = 22.6 t M_L = 0

N_K = 0 M_K = 7.9 (6.8) t.m Q_K=4.1x1.5x6.2

N_S = 22.6

B x D = 50 x 50 d = 45 j = 39.4

BD = 2.5 x 10^3 BD^2 = 1.25 x 10^5

$\frac{N}{BD}$ = 9.1

Pt = 0.1

$\frac{M}{BD^2}$ = 5.4

1 C1

N_L = 43.1 M_L = 0

N_K = M_K = 13.6 (11.8) Q_K=6.7x1.5x10.1

N_S = 43.1

B x D = 50 x 50

$\frac{N}{BxD}$ = 17.2

Pt = 0.15 at = 3.8

$\frac{M}{BD^2}$ = 9.4

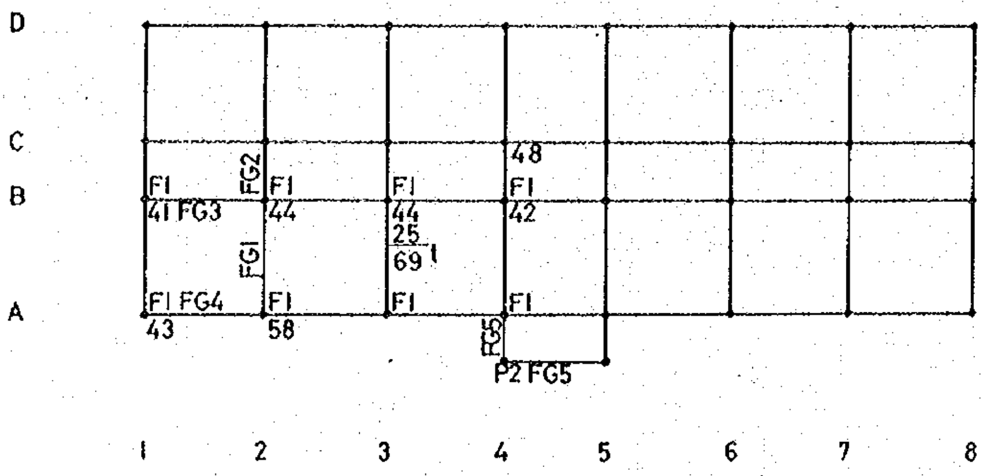
0.8% 20 cm^2

8 - D 22

2.1 C1 τ = 5.1

Pent house P1.

(11) Design of Footing



Axial Force (t)

Bearing capacity(long time) 50 t/m^2 Effective bearing capacity
50-2x1 = 48 t/m^2

F1 N = 69t Required A = 1.44 m^2 1.2 m^2

P = 17.2 t

M = 17.2 x 0.35 x 0.6 = 3.6

D = 60 d = 50 j = 43

at = 4.1 6-D13

ψ = 19

τ = 3.3

F2 D=40

0.6=0.6 3-D13

Design of footing beam, etc.

FG1 $M_L = 1.2$

$M_K = 11.4\ (10.4)$ $Q_K = 4.0x1.5=6.0$

$M_S = \underline{11.6\ t.m}$

B x D = 35 x 70 d = 62 j = 54

	3-D22		
FG1	35x70	at = 7.2	3-D22
FG3 FG4	3-		
	ST D10-200@		

FG2
FG5

3-D22

35x55

3-

ST D10-200@

Floor of 1st floor Concrete floor

120
D10-200@

Wall Outer wall 150 D10-200@

180 D13-200@

"

Inner wall C,B 150 D10-800@

Staircase 180 D13-200@

Outer wall of 2nd floor

Wind pressure P = 1.2x60 10 x 4.0 = 0.9 t/m

At time of earthquake

P = 0.18 x 0.54 x 4.0 = 0.4 t/m

M = 0.9 x 2.0 - 1.8 t.m

D = 18 d - 15 j = 13.1

at = 4.6 D13-276 200@

P2 column of 1st floor 400 x 200

6-D19

4-4-2 Layout of Buildings

Layout of the buildings is shown in Fig. 2-5, Chapter 2.

4-4-3 Design of Appurtenant Facilities

a) Drinking Water Service System and Supply Volume

Drinking water delivered from the water source will be stored in the farm pond and supplied to each building by the automatic operation of the pressure tank type pump after puried in the small clarification device installed immediately in the back of the elevated water tank. The pump will be driven by a motor

(1) Supply Volume

With the number of persons to be served taken at 97 (p.23 and 72 of the previous report) and the daily supply volume at 20 ℓ/person, the total daily supply volume turns out to be 19.4 m^3 as calculated below.

$$V = 0.20 \times 97 = 19.4 \ m^3/day$$

Assuming that the daily average service time is 10 hours and the elevated tank is to be have a capacity for one hour's water supply, the tank capacity turns out to be about 2.0 m^3 as calculated below.

$$v = 19.4/10 = 1.94 \mp 2.0 \ m^3$$

The number of persons to be served is the total of counterparts, full- and part-time staff members and general affairs workers, and excludes temporary labourers.

b) Capacity of Isolated Power Plant

Table 4-15 Capacity Calculation of Isolated Power Plant

Building	Size	Lamp and Heater Load
A Main building		20,000 W
A' Cocoon testing room		1,000
B Rearing room for rearing method	6x32	1,800
C Rearing room for egg production (1)	6x32	1,000
" " " (2)	6x32	1,000
Research room	7x10	2,000
D Pathological rearing room	6x16	2,000
E Pebrin inspection room	9x28	2,600
F Silkworm egg refrigerator		(60,000KVA) 2 units
G Artificial hatching room	4x6	200 W
H Chemicals warehouse	2x2	80
I Garage	6x10	400
J Mulberry field maintenance building	9x13	800
K Compost shed		400
L Agricultural machine and tool warehouse	8x15	800
Total Total excluding cold storages		34,080 W

Water supply pump	750
Irrigation pump	11,000
Total	11,750 W

The lamp and heater load will be as follows.

KVA = 2 kW/0.8 = 34.08 kW/0.8 = 42.6 KVA

For simultaneous power supply to lamps and heaters, the load will be 80% of the above value.

KVA = 42.6 x 0.8 - 34.1 KVA

The pressure pump load calculated with the starting torque load (star-delta connection) taken at 200% and the small water tank load at 600 %

is as given below.

$$KVA = \frac{2 \times 11 + 6 \times 0.75}{0.8} = 33.2 \text{ KVA}$$

Connection of generators for pump operation at 220 V, 60 Hz and lamp illumination at 100 V incures an increase of installation cost. Hence, 1 KVA generator will be installed for lighting and heating and 240 KVA generators will be installed for pump operation as well as to meet emergency or special power demand. As for cold storages, 2 units of 65 KVA generators will be required.

c) Fuel Tank Capacity

The 40 KVA generator consumers 60ℓ of fuel per hour, so that the daily fuel consumption turns out to be as follows.

For irrigation	16 hrs/day x 60 = 0.96 m^3/day
For lighting & heating	10 hrs/day x 60 = 0.60 m^3/day
Total	: 1.56 m^3/day

Assuming that fuel supply is required during the peak 10 days because power supply for irrigation is needed only in the specific period, the total fuel requirement turns out to be as given below.

$1.56 \times 10 = 15.6$ m^3

Hence, 2 fuel tanks each having a capacity of 8 m^3 will be installed.

Chapter 5 Design for the Establishment of Sericulture Sub-centre

5-1 Field desing

5-1-1 Mulberry field design

The field is located in a flat area at 120 to 129 meters above sea level. It is a long narrow field measuring about 1 km long and 50 to 200 meters wide, running slightly towards east-north-east. The soil is a heavy clay type which absorbs water rather poorly.

Therefore, surface undulations have been leveled out, and an underdrainage (covered conduits) system installed.

5-1-2 Soil improvement (ventilation improvement)

Normal conditions in mulberry cultivation require that the vapor phase at a depth of 40 to 50 cm below the surface be at least 18%.

The moisture conditions of the soil at the proposed mulberry field site, however, were very poor indeed. Consequently, subsoil break, deep plowing, and multilayer plowing of the whole field, and adoption of the "filled moat" system (wich involves the digging of "moats" 50 cm deep and 50cm wide) have been considered

- 1 Deep plowing

A subsoil plow is often used when there is a hard layer of soil about 15 to 20 cm below the surface. But a large rotor breater, or a bruck breaker plow may also be used.

The subsoil plow, as shown in Fig. ____, is equipped with two blades. The front blade removes, and inverts the topsoilm while the rear blade breaks up the hard layer underneath. Usually, the front blade plows to a depth of about 15cm, while the rear blade plows a further 15cm, that is, a total of 30cm. A regular tractor of about 40 to 60PS is normally used to pull the plow.

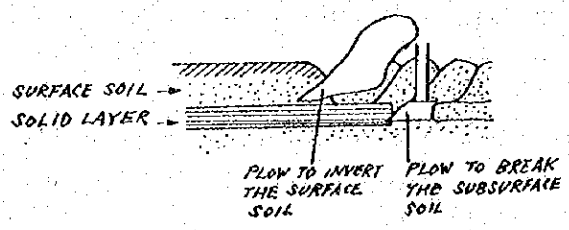


Fig. 5-1 Subsurface Soil Plowing

With the subsoil plow, it is also possible to remove the topsoil rather cleanly, this being of great advantage when the subsoil is rather poor in nutrition.

In order to plow below 30cm, 1 a large sized inversion low, or 2 a bulldozer or raker dozer should be employed.

- 2 Multilayer plowing

In cases where the subsoil is harder than the top soil, but is richer in nutrients, it will have to be broken up, and mixed with the top soil, or the top soil and subsoil simply interchanged. This is the purpose of multilayer plowing.

The job can usually be handled by a large tractor pulling a large plow, but when plowing to depths greater than 80cm, very large plows, and an 18-ton tractor will be required. But since such equipment takes-up 7 to 10 meters across, it is not very practical for narrow or odd shaped fields.

- 3 Subsoil break

The proposed site for the subcenter mulberry field contains large quantities of clay soil below some very hard top layers, resulting in very poor seepage. The ground becomes very boggy after rains, but very hard (like concrete) during dry spells. This makes farming very difficult since labor efficiency and land productivity deteriorate.

In Hokkaido, considerable improvements were made in this kind of clay soil by employing a pan-breaker to break up the subsoil (from around 1965). This pan-breaker is very similar to the mole drain escavator, the projecting section being replaced by a set of chisel-like plows. Normally, 2 or 3 "chisels" are arranged in a row at about 70 to 80cm apart. With a medium or large sized tractor, the subsoil may be broken up to a depth of 40 to 60 cm.

The diagram below (Fig. 5-2) shows one example of how the pan-breaker breaks up the lower hard layers.

Fig. 5-3 shows an example of the hardness distribution of the fracture by the pan-breaker.

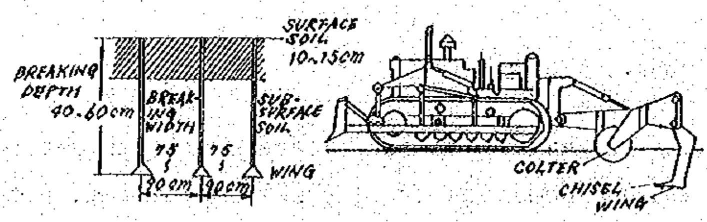


Fig. 5-2 Subsurface Soil Breaking by Pan-Breaker

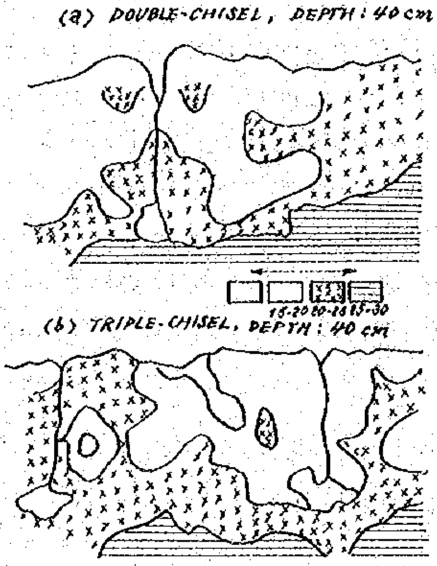


Fig. 5-3 Cross-section of soil broken up by pan-breaker, showing distribution of relative hardness. (Hokkaido Development Bureau)

And Table 5-1 illustrates how well subsoil break has improved the moisture conditions.

Improvement in Vapor Phase due to Subsoil Break (Hokkaido)

Depth(cm) / Area	5∿10	15∿20	25∿30	35∿40	45∿50
Comparative area	3.8	4.3	7.3	2.4	4.1
Subsoil break area	21.0	14.5	18.1	2.2	5.8

Note: Figures are the values measured one month after subsoil breaking.

Although these figures indicate that subsoil break combined with closed conduit drainage, would be the most effective in the vicinity of the subcenter, it was found that a simple covered drain employing bamboo or gravel laid along the bottom of a "filled moat" (50 cem deep, and 50cm wide, dug out by a drench digger) (see Fig.5-4) or a proper closed drain employing a drain hose, was required for efficient drainage of water.

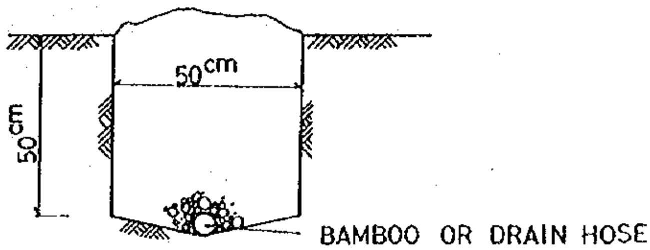
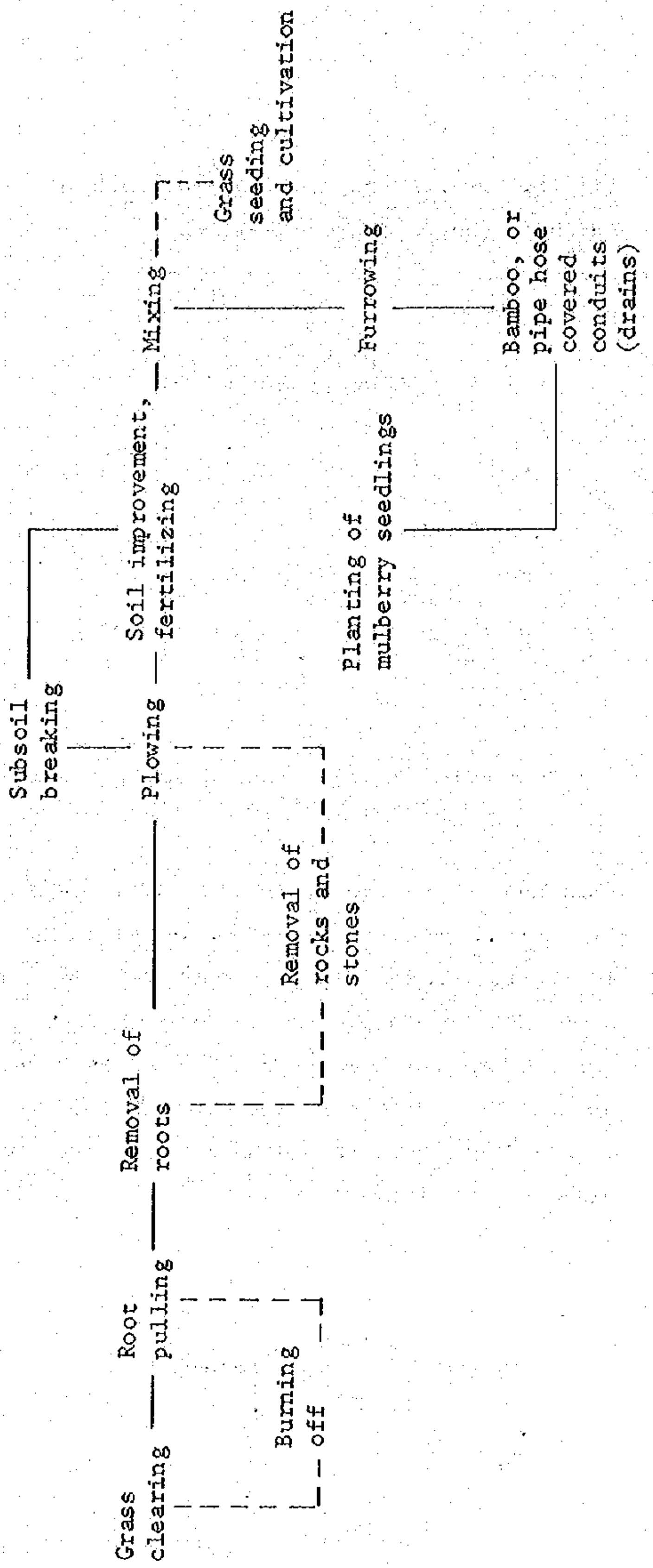


Fig. 5-4 Cross-section of Filled Moat


Grass clearing
Burning off
Root pulling
Removal of roots
Removal of rocks and stones
Plowing
Subsoil breaking
Soil improvement, fertilizing
Mixing
Grass seeding and cultivation
Furrowing
Bamboo, or pipe hose covered conduits (drains)
Planting of mulberry seedlings

5-1-3 Preparation of building site

The building site has a slope of 0.8% in the south-east direction, so it will be made level will the main road.

Drain gutters along roadways within the building site will flow into the drain running along the main road.

5-1-4 Roadway design

a) The present road within the area is an unsealed road running east to west, and 3 to 5 meters in width. But because of its poor condition, it shall be graveled, and used as the main road.

b) As far as has been possible, this road has been made straight between the gate and the building site.

c) The effective width of the road is 4.00 meters, with a strip of 50cm along both sides. The drain along the mulberry field side is just a simple ditch which will not hinder the maneuvering of plowing and tilling equipment etc. The drain on the other side will be laid with stone, forming a proper drain (catch).

d) 30cm of gravel will be laid.

e) Branch roads will connect with the main road at right angles, and at 100 meter intervals. These roads will similarly be graveled with 30cm of gravel, and have an effective width of 3 meters, and 50cm strips along both sides.

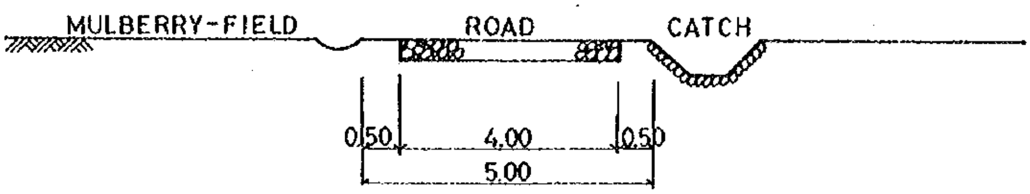


Fig. 5-5

5-1-5 Drainage design

a) The proposed site for the mulberry field slopes gentely towards east-north-east, and is about 50 to 60cm above the neighboring paddy fields. Consequently, drainage from the mulberry field also will serve to supply water for the paddy fields.

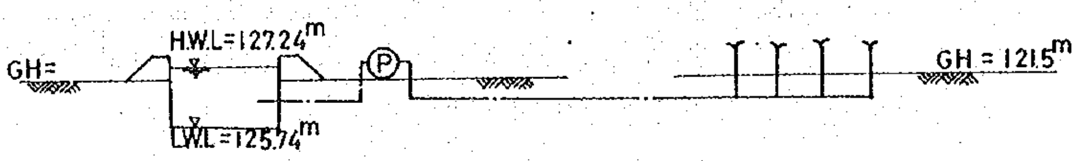
b) Surface water will be drained off between furrows, running into a channel along the north border of the mulberry field. This will then run into the neighboring paddy fields.

A covered conduit drainage system will be employed because of the heavy clay conditions, and the high underground water level.

5-1-6 Design of Irrigation Facilities

a) Pump (Sub-Centre)

(1) Total Head of Pump



Actual head	H_a = 121.5-125.74 = -4.24 m
Capacity	Q = 29.8 ℓ/s = 1.788 m^3/min
Type and diameter of pipe	Vp ϕ 150 m/m
Required terminal pressure	H_1 = 39.0 m
Branch line frictional loss	H_{cd1} = 15.97 m

Sprinkler line frictional loss H_{cd2} = 7.73 m

Valve and reducer loss (10% of frictional loss) H_{is} - (15.97+7.73) x 0.10 = 2.37m

Total head (H):

$$H = H_a + H_1 + H_{cd1} + H_{cd2} + H_{is}$$

$$= -4.24 + 39.0 + 15.97 + 7.73 + 2.37$$

$$= 60.83 \text{ m} = 61\text{m}$$

(2) Shaft Power and Motor Output

$$P = \frac{0.163 \times \gamma \times Q \times H}{\eta_p} = \frac{0.163 \times 1.0 \times 1.788 \times 61}{0.75}$$

$$= 23.70 \text{ kW}$$

$$R = \frac{P \times (1 + \alpha)}{\eta_t} = \frac{23.70 \times (1+0.2)}{0.95} = 29.9 \text{ kW.}$$

(3) Type of Pump

Type	Centrifugal pump
Head	61 m
Capacity	1.788 m^3/min
Suction port diameter	150 mm
Delivery port diameter	150 mm
Motor output	30 kW.

Table 5-2 -- Results of Hydraulic Calculation

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
Pipe line No.1	m	m	m	ℓ/s	mm	m/s		m	m	m
Pump			217.0						184.20	57.20
Pipe line No.2	63.0		127.0	29.8	150	1.69	15.56	0.98	183.22	56.22
Hydrant No.1	39.0		127.3	29.8	150	1.69	15.56	0.61	182.61	55.31
" 2	25.0		127.4	29.8	150	1.69	15.56	0.39	182.22	54.82
" 3	25.0		127.5	29.8	150	1.69	15.56	0.39	181.83	54.33
" 4	54.0		127.6	29.8	150	1.69	15.56	0.84	180.99	53.39
" 5	25.0		127.9	28.6	150	1.62	14.42	0.36	180.63	52.73
" 6	25.0		128.2	28.6	150	1.62	14.42	0.36	180.27	52.08
" 7	54.0		128.0	28.6	150	1.62	14.42	0.78	179.49	51.49
								Σ = 4.71		
Pipe line No.2										
Pipe line No.2			127.0						183.22	56.22
Hydrant No.8,9	55.0		126.5	29.8	150	1.69	15.56	0.86	182.36	55.86
" 10,11	104.0		126.3	"	"	"	"	1.62	180.74	54.44
" 12	194.0		126.5	"	"	"	"	3.02	177.72	51.22
" 13	80.0		125.8	"	"	"	"	1.24	176.48	50.68
" 14	50.0		125.3	"	"	"	"	0.84	174.86	50.36
" 16	50.0		124.0	"	"	"	"	0.78	174.08	50.08
" 17,18	168.0		123.1	"	"	"	"	2.61	171.47	48.37
" 19.20	104.0		121.5	"	"	"	"	1.62	169.85	48.35
" 21.22	104.0		120.3	"	"	"	"	1.62	168.23	47.93
								Σ = 14.99		

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
Pipe line No.21	m	m	m	ℓ/s	mm	m/s		m	m	m
Pipe line No.21			120.3						168.23	47.93
A	1.0		120.3	29.8	100	3.80	112.08	0.11	168.12	47.82
B	12.5		120.5	14.9	100	1.90	31.09	0.39	167.73	47.23
C	30.0		120.6	7.5	75	1.70	35.44	1.06	166.67	46.07
D	15.0		120.7	6.2	50	3.16	179.55	2.69	163.98	43.28
E	15.0		120.8	5.0	"	2.55	120.60	1.81	162.17	41.37
F	15.0		121.0	3.7	"	1.88	69.09	1.04	161.13	40.13
G	15.0		121.3	2.5	"	1.27	33.45	0.50	160.63	39.33
H	15.0		121.5	1.2	"	0.61	8.60	0.13	160.50	39.00
								Σ = 7.73		
B			120.5						167.73	47.23
I	5.0		120.5	7.5	75	1.70	35.44	0.18	167.55	47.05
J	15.0		120.6	6.2	50	3.16	179.55	2.69	164.86	44.26
K	15.0		120.7	5.0	"	2.55	120.60	1.81	163.05	42.35
L	15.0		120.8	3.7	"	1.88	69.09	1.04	162.01	41.21
M	15.0		120.9	2.5	"	1.27	33.45	0.50	161.51	40.61
N	15.0		121.3	1.2	"	0.61	8.60	0.13	161.38	40.08
								Σ = 6.35		
A			120.3						168.12	47.82
O	12.5		120.2	14.9	100	1.90	31.09	0.39	167.73	47.53
P	15.0		120.2	7.5	75	1.70	35.44	0.53	167.20	47.00
Q	15.0		120.3	6.2	50	3.16	179.55	2.69	164.51	44.21
R	15.0		120.4	5.0	"	2.55	120.60	1.81	162.70	42.30
S	15.0		120.5	3.7	"	1.88	69.09	1.04	161.66	41.16
T	15.0		120.6	2.5	"	1.27	33.45	0.50	161.16	40.56
U	15.0		120.8	1.2	50	0.61	8.60	0.13	161.03	40.23
								Σ = 7.09		

STATION	DISTANS	TL	EL	DISCHARGE	DIAMETER	VELOCITY	HYDRAULIC GRANDIENT	HEADLOSS	ELEVATION HEAD	EFFECTIVE HEAD
	m	m	m	ℓ/s	mm	m/s		m	m	m
O			120.2						267.73	47.53
V	30.0		119.8	7.5	75	1.70	35.44	1.06	166.67	46.87
W	15.0		120.0	6.2	50	3.16	179.55	2.69	163.98	43.98
X	15.0		120.0	5.0	"	2.55	120.60	1.81	162.17	42.17
Y	15.0		120.0	3.7	"	1.88	69.09	1.04	161.13	41.13
Z	15.0		120.1	2.5	"	1.27	33.45	0.50	160.63	40.53
I	15.0		120.2	1.2	"	0.61	8.60	0.13	160.50	40.30
								Σ = 7.23		

5-2 Water resources

5-2-1 Water intake work

a) Underground collecting conduits

Quantity of water available for irrigation:-	Irrigation area 19.5 ha
	Peak daily water consumption 7.3 mm/day
	Irrigation efficiency 85%

$$\overset{mm/day}{7.3} \times 1/0.85 \times \overset{ha}{19.5} \times 10 = 1674.71 \ m^3/day$$

Water required for sericulture	11.00 m^3/day
Drinking and other purposes	10.00 m^3/day
Total	1695.71

$$\frac{1695.71}{24} = 70.65 \ m^3/hr$$

The covered conduit drain system has been adopted because of the expected low flow rate within the river, but considerable quantity of subterranean water.
And in order to further make sure of the quantity of water collected, a porous pipe will be connected directly to the well. This is estimated to reach the level of the river bed.

Quantity of water available for irrigation:- Irrigation area 19.5 ha

Peak daily water consumption 7.3 mm/day

Irrigation efficiency 85%

$$\overset{mm/day}{7.3} \times 1/0.85 \times 19.5^{ha} \times 10 = 1674.71 \ m^3/day$$

Water required for sericulture	20.00 m^3/day
Drinking and other purposes	1.00 m^3/day

$$\frac{1695.71}{24} = 70.65 \ m^3/hr$$

The covered conduit drain system has been adopted because of the expected low flow rate within the river, but considerable quantity of subterranean water. And in order to further make sure of the quantity of water collected, a porous pipe will be connected directly to the well. This is estimated to reach the level of the river bed.

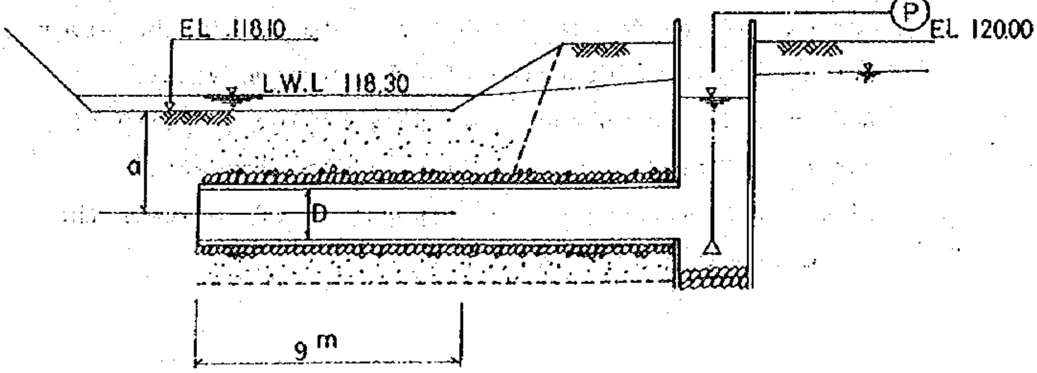


Fig. 5-7 Water Intak System

The required diameter of the water conduit pipes is calculated by the following formula:-

$$-q = \frac{2\pi k(H-P/W)}{\ln\frac{4a}{d}}$$ (Muskat formula)

where q is the flow rate per unit length = 70.65/9-7.8bm^3/hr

k is a permeability coefficient = 183 = 3.6m/hr

H is the water level above the river bed = 0.20m

P is water pressure within the pipe = 1.20m

a is the depth of the covered conduit below the river bed = 1.0m

and d is pipe diameter

$$7.85 \frac{2\pi x\ 3.6x1.0}{\ln\frac{4x1.0}{d}}$$

$$\ln\frac{4}{d} = \frac{22.608}{7.85} = 2.00$$

$$\ln 1.39 - \ln d = 2.88$$

$$\ln d = 1.39 - 2.88 = -1.49$$

Then with a safety factor of 3,

$$\ln d = -149/3 = -0.497$$

$$d \doteq 0.60$$

That is, piping of 600mm diameter will be used.

5-2-2 Pump House

a) Pump Specifications

(1) Design Capacity

Pump capacity

$$q = 1.178\ m^3/m = 0.02\ m^3/sec$$

(2) Water Level and Actual Head

Design maximum delivery side water level	127.54 m
Design minimum suction side water level	118.30 m
Design actual head	$H_a = 9.24$ m

(3) Head Loss

Pipe diameter $D_1 = 0.10$

Velocity in pipeline $V_1 = \frac{q}{A} = \frac{q}{\frac{\pi}{4} \times D_1^2} = 2.55$ m/s

Velocity head $\frac{V_1^2}{2g} = \frac{2.552}{19.6} = 0.33$ m

Pipe diameter $D_2 = 0.08$

Velocity in pipeline $V_2 = \frac{q}{A_2} = \frac{q}{\frac{\pi}{4} \times D_2^2} = 3.98$

Velocity head $\frac{V_2^2}{2g} = \frac{3.98^2}{19.6} = 0.81$

Pipe diameter $D_3 = 0.15$

Velocity in pipeline $\frac{V_3^2}{2g} = \frac{1.11^2}{19.6} = 0.063$

i. Inlet head loss

$$h = f \times \frac{V_1^2}{2g} = 0.03 \times 0.33 = 0.010 \text{ m}$$

ii. Bend head loss

$$h = f \times \frac{V_1^2}{2g} = 0.17 \times 0.33 = 0.056 \text{ m}$$

$$f = \{0.131 + 1.847 \left(\frac{D_1}{2R}\right)^{7/2}\} \left(\frac{D}{90}\right)^{1/2} \quad \text{..... Weisbach}$$

$$= \{0.131 + 1.847 \left(\frac{0.1}{2 \times 0.16}\right)^{7/2}\} \left(\frac{90}{90}\right)^{1/2} = 0.17$$

5 places

5 x h = 0.28m

iii. Check value head loss

$$h = f \times \frac{V_2^2}{2g} = 1.50 \times 0.81 = 1.215 \text{ m}$$

iv. Sluice valve head loss

$$h = f \times \frac{V_2^2}{2g} = 0.14 \times 0.81 = 0.113 \text{ m}$$

v. Water pipe head loss

Ductile cast iron pipe, C = 130.

$$h = f \times L/D \times \frac{V_3^2}{2g} = 0.022 \times \frac{88}{0.15} \times 0.06 = 0.774 \text{ m}$$

$$f = \frac{134}{C^{1.85}} \times \frac{1}{D^{1/6} \times V_3^{0.15}} \quad \text{.......... Hazen \& Williams}$$

$$= \frac{134}{143} \times \frac{1}{0.15^{1/6} \times 1.11^{0.15}}$$

$$= 0.0165 \times \frac{1}{0.73 \times 1.016} = 0.022$$

Hence, the total head, H, turns out to be as caldulated below.

$$H = H_a + \Sigma h$$

$$= 9.24 + 2.458 = 11.728 \doteqdot 12m$$

With an allowance of 20% assumed,

$$H \doteqdot 14\ m$$

(4) Prime Mover Output

i. Pump shaft power

$$L = \frac{Q \times H \times \gamma}{4.5\ \eta_p} = \frac{1.178 \times 14 \times 1}{4.5 \times 0.73} \doteqdot 5.03\ PS$$

where, Q : Delivery capacity (1.178 m^3/mm).

H : Total head (12m).

γ : Bulk density of pumped water (1.0).

η_p: Pump efficiency (73%)

ii. Required output

$$L_W = \frac{L(1+A)}{\eta_G} = \frac{5.03(1 + 0.2)}{100} = 6.04$$

where, A : Allowance (20%).

η_G : Reducer efficiency (100%)

Hence, the required output is set at 8 PS.

5-2-3 Farm pond

a) Quantity calculations

Water supply time	24 hr
Irrigation time	16 hr
Peak daily consumption	7.3mm/day
Irrigation area	19.5 ha
Irrigation efficiency	85%
Water available for sericulture	(V_2) $11m^3$/day
Water available for drinking and other purposes	(V_3) $10m^3$/day

Quantity calculations

$$V = 10 \times 19.5 \times 7.3 \times 1/0.85\ (1 - 16/24)$$

$$= 558.2 \doteqdot 560^{m^3}$$

$$V = 11$$

$$V = 10$$

Total 581^{m^3}

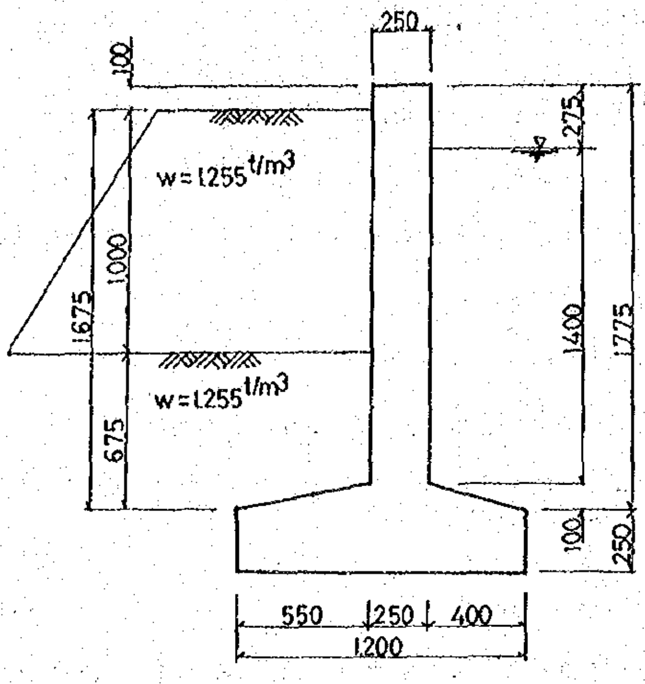
That is, capacity of farm pond should be 600 m .

b) Structural calculations

1. Predetermined conditions

Unit weight of soil	$w = 1255\ t/m^3$
Soil friction angle	$d = 10' - 30'$
Soil coefficient during normal situation	$KA = 0.69$
Soil coefficient during earthquake	$KE = 0.95$

2. General shape and dimensions



3. Stress calculations in vertical wall

Since horizontal forces are greater during earthquakes, only these forces have been considered.

i) Load calculations

Horizontal stress in vertical wall due to horizontal vibration

$P_1 = 240 \times 0.25 \times 1675 \times 0.15 = 2.15^t$

Position of application

$y_1 = hr/2 = \frac{1675}{2} = 0.838$

Water pressure

$P = 1/2 \times w\ hr^2$

$= 0.50 \times 1.00 \times 1.40^2 = 0.98^t$

Position of application

$y = hr/3 = \frac{1.40}{3} = 0.467$

ii) Bending moment and shear stress

$M = P_1 . y_1 + P_2 . y_2$

$= 0.15 \times 0.838 \times 0.98 \times 0.467$

$= 0.584^{t.m}$

$S = P_1 + P_2 = 0.15 + 0.98 = 1.13^t$

iii) Calculation of amount of reinforcing steel required

$M = 0.584^{t.m} = 58,400^{kg/m}$

$S = 1.18^t = 1.130^{kg}$

Thickness of member h = 25cm

Effective thickness d = 20cm

Reinforcing steel covering d' = 5 cm

Amount of steel according to approximate formula $AS = \frac{M}{sa.j.d.} = 1.85^{cm^2}$

Amount of steel (rough estimate)

D10 ctc 300 = 2.378^{cm^2}

$P = \frac{As}{b.d} = \frac{2.378}{100 \times 20} = 0.001189$

$\frac{d'}{d} = \frac{5}{20} = 0.25$

According to nomogram

M-7 $K = 0.18$ M-11 $j = 0.952$

M-17 $[\frac{1}{Lo}] = 119$ $[\frac{1}{Ls}] = 920$

$$\frac{M}{b.d^3} = \frac{58,400}{100 x 20^2} = 1.46 \ kg/cm^2$$

$$Pc = [\frac{M}{b.d^2}] - [\frac{1}{Le}] = 1.46 \times 11.9 = 17.4^{Kg/m^2} 90^{Kg/cm^2}$$

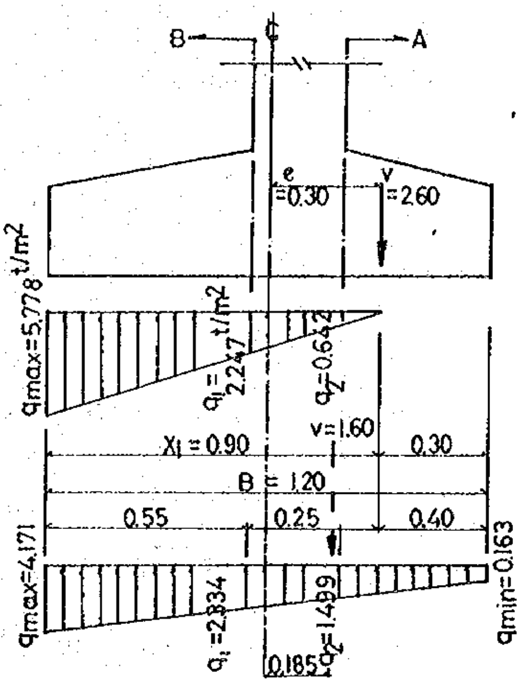
$$s = [\frac{M}{b.d^2}] [\frac{1}{Ls}] = 1.46 \times 920 = 1343^{kg/m^2} < 1,800^{kg/m^2}$$

$$= \frac{S}{b.j.d.} = \frac{1.130}{100x0.952x20} = 0.59^{kg/m^2} < 8^{kg/m^2}$$

Consequently, arrangement of reinforcing bars in the wall will be D10 ctc 300.

4. Stress calculations in

Calculations for normal circumstances, and for earthquakes were compared, and the larger value adopted.



Load diagram

$$q\ max = \frac{2.r}{Lr} = \frac{2\ x\ 2.60}{100\ x\ 0.90} = 5.778\ /m$$

$$x = 3(\frac{B}{2} - e) = 3(\frac{1.20}{2} - 0.30) = 0.90$$

Normal

$$q\ \begin{matrix} max \\ min \end{matrix} = \frac{V}{L.B} \pm \frac{.M}{L.B^2}$$

$$= \frac{2-60}{1.00 \times 1.20} \pm \frac{L \times 260 \times 0.185}{1.00 \times 1.20^2}$$

$$= \begin{cases} 4.171^{t/m} \\ 0.168 \end{cases}$$

Stress calculations in A - A cross-section

1) Bending moment and shear stress

Normal

$M = 0.163 \times 0.40^2 \times 1/2 + 1.336 \times 0.40^2 \times 1/2 \times 1/3$

$- 2.60 \times 0.10$

$= 0.013 + 0.036 - 0.26 = - 0.211$

During earthquakes

$M = 0.642 \times 0.10^2 \times 1/2 \times 1/3 - 2.60 \times 0.10$

$= 0.001 - 0.260 = \underline{- 0.259}^{\ tm}$

Normal

$S = 1/2\ (0.163 + 1.499) \times 0.40 - 2.60$

$= -2.26^t$

During earthquakes

$S = 1/2 \times 0.642 \times 0.10 - 2.60$

$= \underline{- 2.568^t}$

ii) Calculation of amount of reinforcing steel

$M=0.259^{tm} = 25,900^{kg/cm}$

$S = 2.568^{t} = 2.568^{kg}$

Member thickness

Member thickness	h = 35cm
Effective thickness	d = 5cm
Reinforcing steel covering	d'= 5cm

Amount of steel according to approximate formula

$$AS=\frac{M}{\sigma sa.j.d.} = 0.548$$

Amount of steel (rough estimate)

$D10 \text{ ctc } 300 = 2.378^{cm^2}$

$$P = \frac{As}{b.d.} = \frac{2.378}{100 \times 30} = 0.00079$$

$$\frac{d'}{d} = \frac{5}{30} = 0.167$$

According to nomogram

M-8 K = 0.15, M-11 j = 0.952

$$M\text{-}17 \ [\frac{1}{Lc}] = 150 \qquad [\frac{1}{Ls}] = 1,350$$

$$[\frac{M}{b.d^2}] = \frac{25900}{100 \times 30^2} = 0.288 \ kg/cm^2$$

$\sigma_c = 0.288 \times 15.0 = 4.3^{kg/cm^2} < 70^{kg/cm^2}$

$\sigma_s = 0.288 \times 1350 = 389^{kg/cm^2} < 1,800^{kg/cm^2}$

$$\tau = \frac{S}{b.j.d} = \frac{2,568}{100 \times 0.952 \times 30} = 0.9^{Kg/cm^2} < 8^{Kg/cm^2}$$

Consequently, the base slabs will be D10 ctc 300.

Stress calculations in B - B cross-section
(for earthquakes only)

i) Bending moment and shear stress

$M = 2.247 \times 0.55^2 \times 1/2 + 3.531 \times 0.55^2 \times 1/2 \times 2/3$

$= 0.696^{tm}$

$S = 1/2\ (2.247 - 5.778) \times 0.55 = 2.207$

ii) Calculation of amount of reinforcing steel

$M = 0.696^{tm} = 69,600^{kg/cm}$

$S = 2.207^{t} = 2,207^{kg}$

Member thickness	h = 35cm
Effective thickness	d =
Reinforcing steel covering	d'= 5cm

Amount of steel according to approximate formula

$$As \times \frac{M}{\sigma sa.j.\ d} = 1.475^{cm^2}$$

Amount of steel (rough estimate)

D10 ctc 300 = 2,378

$$p = \frac{As}{b.d} = \frac{2,378}{100 \times 30} = 0,00079$$

$$\frac{d'}{d} = \frac{5}{30} = 0.167$$

According to nomogram

M-8 K = 0.15 M-11 j = 0.952

M-19 $[\frac{1}{Le}] = 15.7$ $[\frac{1}{Ls}] = 1,350$

$$\frac{M}{b.d^2} = \frac{69600}{100 \times 30^2} = 0.773 \ kg/cm^2$$

$$\sigma_c = 0.773 \times 15.0 = 11.6 \ kg/cm^2 < \ = 70 \ Kg/cm^2$$

$$\sigma_s = 0.773 \times 1350 = 1,043 \ kg/cm^2 < \ = 1,800 \ Kg/cm^2$$

$$\tau = \frac{S}{b.j.d} = \frac{2,207}{100 \times 0.952 \times 30}$$

$$= 0.8 \ Kg/cm^2 < \tau a = 8 \ Kg/cm^2$$

Consequently, D10 ctc 300 has been adopted.

5-3 Basic Building Design

5-3-1 Building

The type and scale of the building constructed in the sericulture orchard shall conform to 2-3-2.

5-3-2 Layout

For the building layout, see chapter 2, Fig. 2-7 ∿ 8(pages 18 and 19).

5-3-3 Accompanying Facilities Design

(a) Drinking and miscellaneous water supply system

In the mulberry orchard, the drinking and miscellaneous water is pressure-fed to each building from the farm pond using a sole purpose pressure tank. In the sub-center, the water is pumped up from a well. Both pumps are to be motor-driven.

(1) Water supply amount

Sub-center

Number of persons	41
Water supply	When a person consumes 200ℓ per day, $V = 0.20 \times 41 = 8.2m^3/day$

New field

Number of persons	50
Water supply	$V = 0.20 \times 50 = 10.0m^3/day$

(b) Power generation capacity

New field

Table 5-3 Non-utility Generation Capacity

	Description	Existing/New	Size	Load
A	Adult silkworm species, raising room (1)	New	7 x 32	1200W
	" " (2)	"	7 x 32	1200
	Adult silkworm species, inspection room	"	7 x 8	2000
A'	Larva silkworm species, raising room	"	7 x 20	1200
			Total	5600
	Supply water pump	"		750
	Irrigation water pump	"		30000
			Total	30750W

For pump $= \frac{30.75 \times 1.7}{0.8} = 65.34$KVA (Starting torque: 70%)

For illumination $= \frac{5.6}{0.8} = 7$KVA

Accordingly, two 70KVA generators and one 10KVA generator shall be installed taking spare capacity into consideration.

Oil tank capacity is calculated as follows:

Daily consumption 81ℓ/hr x 16 hr/day = 1.3m^3/day (70KVA)

20ℓ/hr x 10 hr/day = 0.2m^3/day (10KVA)

Total 1.5m^3/day

For 10 days supply, 1.5 x 10 = 15m^3

Therefore two 8m^3 tanks shall be installed.