MINISTRY OF PUBLIC WORKS AND WATER RESOURCES
IRRIGATION DEPARTMENT
IRRIGATION IMPROVEMENT SECTOR
ARAB REPUBLIC OF EGYPT

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION AND IMPROVEMENT OF MAZOURA REGULATOR OF BAHR YUSEF CANAL IN THE ARAB REPUBLIC OF EGYPT

SEPTEMBER 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
SANYU CONSULTANTS INC.

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PREFACE

In response to a request from the Government of the Arab Republic of Egypt, the Government of Japan decided to conduct a basic design study on the Project for the Rehabilitation and Improvement of Mazoura Regulator of Bahr Yusef Canal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Egypt a study team from March 22 to April 19, 1998.

The team held discussions with the officials concerned of the Government of Egypt, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to the Egypt in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation extended to the teams.

September, 1998

Kimio Fujita

Kimio Fujita
President
Japan International Cooperation Agency

September, 1998

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Rehabilitation and Improvement of Mazoura Regulator on Bahr Yusef Canal in the Arab Republic of Egypt.

This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period from March 11,1998 to September 24, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Egypt and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

K. Ohtsubo

Kazuo Otubo

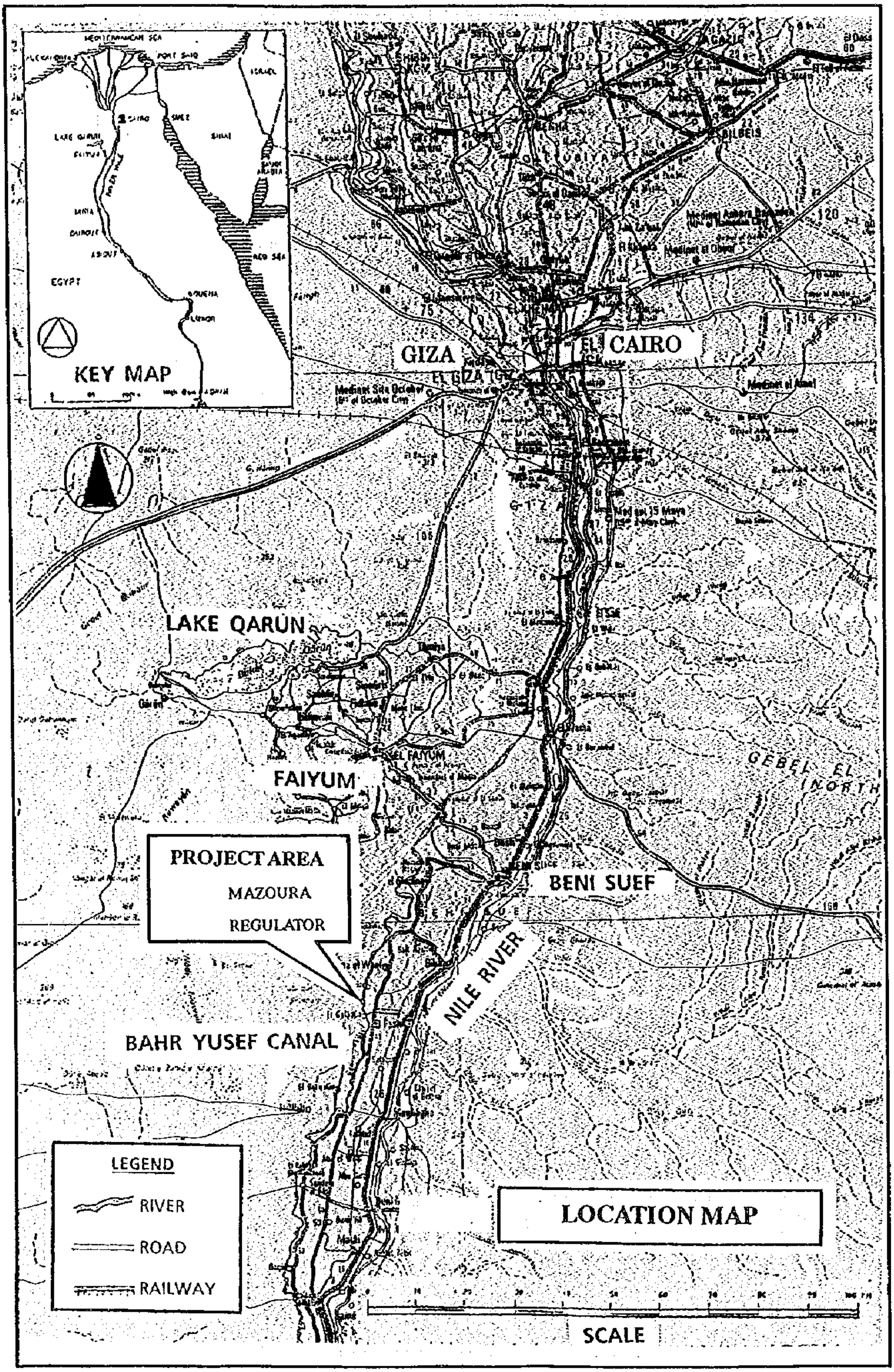
Project manager,

Basic design study team on

The Project for the Rehabilitation and Improvement of

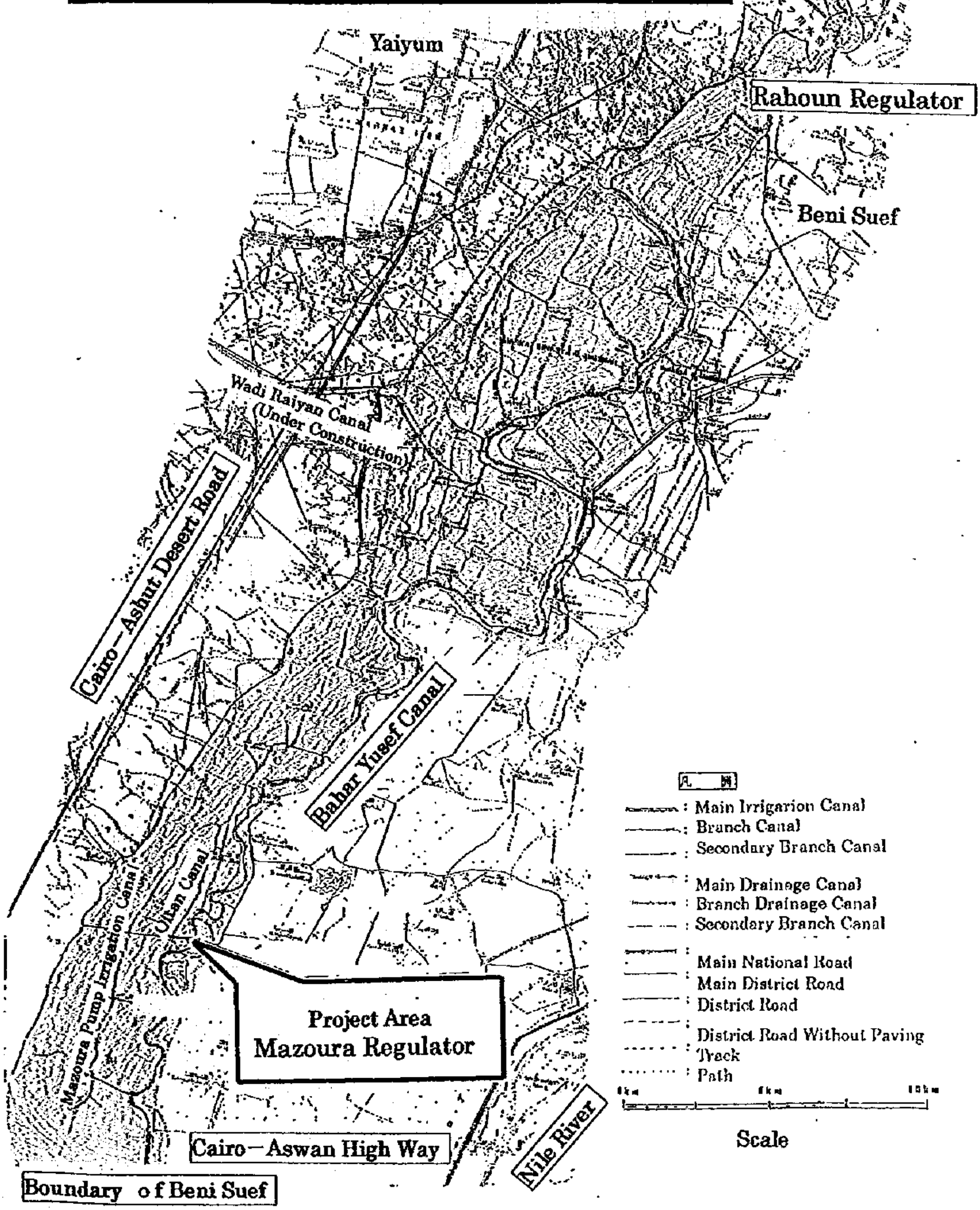
The Mazoura Regulator of the Bahr Yusef Canal

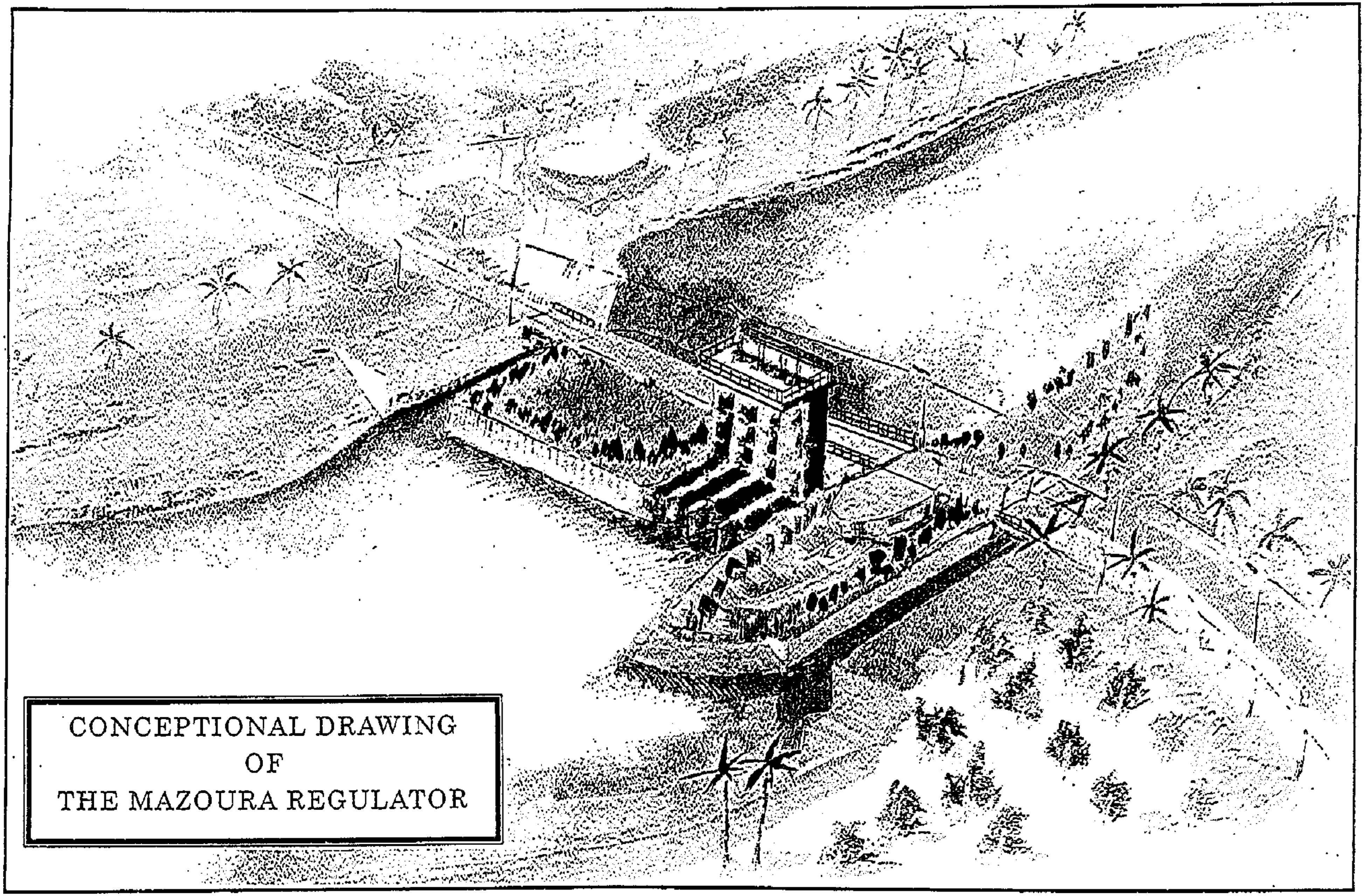
Sanyu Consultants Inc.


KEY MAP
MEDITERRANEAN SEA
PORT SAID
CAIRO
LAKE QARUN
FAIYUM
SUEZ
SINAI
ISRAEL
RED SEA
EGYPT
ASSIUT
LUXOR
GIZA
CAIRO
LAKE QARUN
FAIYUM
PROJECT AREA
MAZOURA
REGULATOR
BENI SUEF
NILE RIVER
BAHR YUSEF CANAL
GEBEL EL
NORTH
LEGEND
RIVER
ROAD
RAILWAY
LOCATION MAP
SCALE

Bahr Yusef Canal

Mzoura Regulator Location Map





CONCEPTIONAL DRAWING
OF
THE MAZOURA REGULATOR

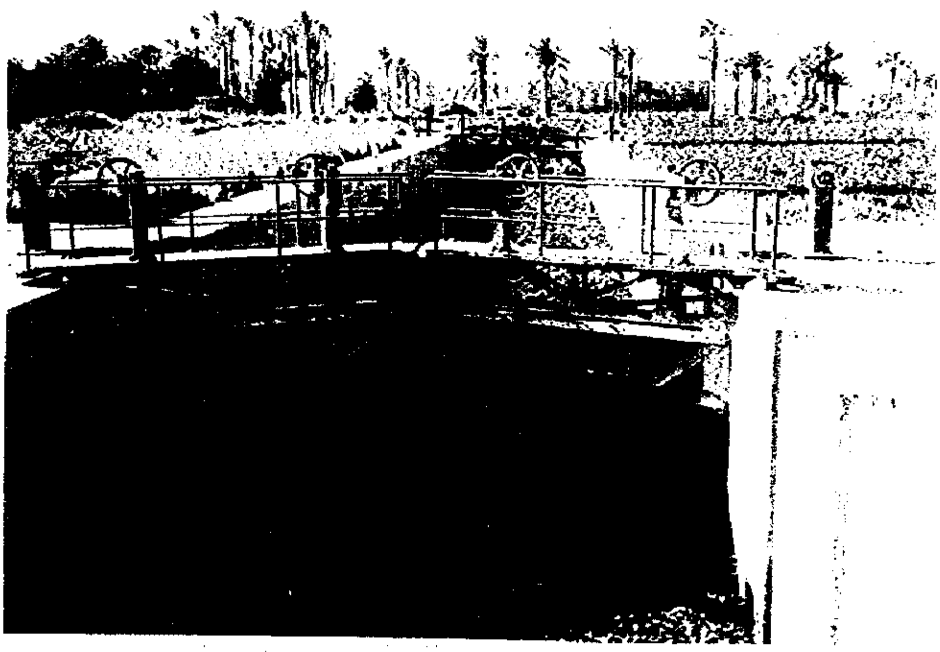
Photograghs on the site survey (1998/3/26)

The Mazoura Regulator

From down stream

Widths of the vents are narrow

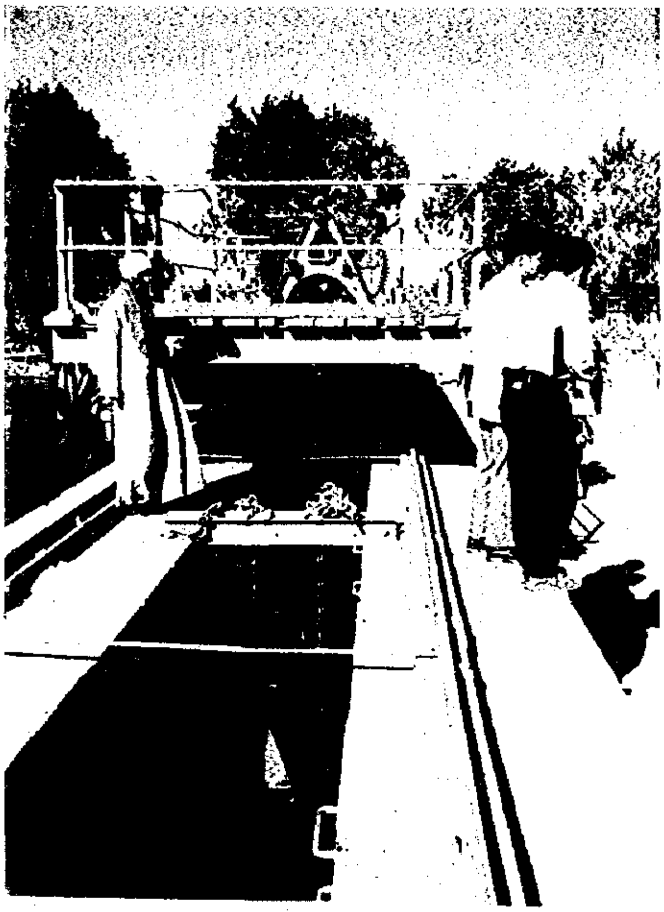
so that the jet flow scours the canal bed.



The Navigation Lock

The Navigation locks on the Bahr Yusef Canal

are not used due to the other developed transportation measures.

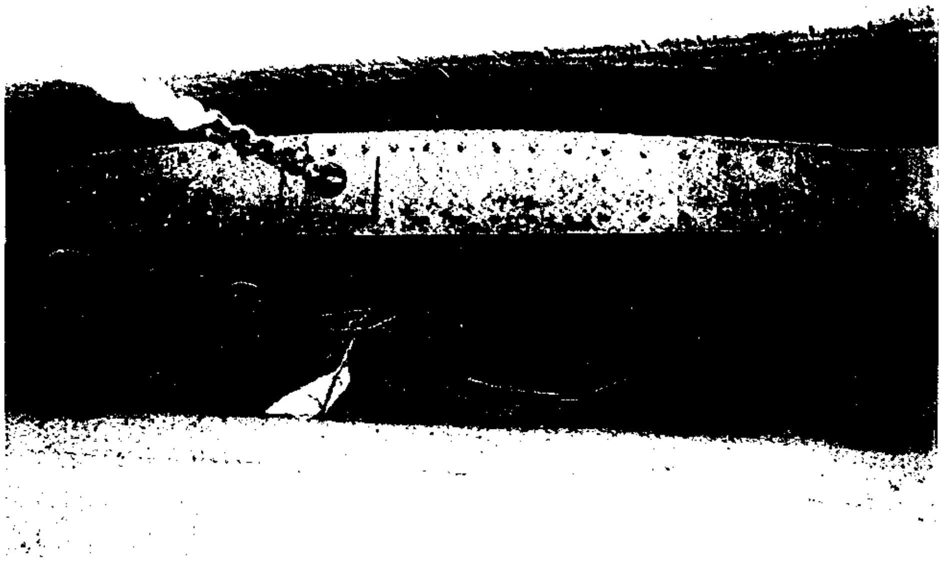


The Lifting Device

It takes 8 persons of men power and one hour to operate a gate.

The Attached Bridge

Some parts of curve have been dropped
and the abuttment of the bridge are destructed
so that passage on the bridge becomes dangerous.



Gate and Chain

The chains and gates got rusty
so that extra labour are required to operate the gates.

Makeshift Repairs at piers of the Gates

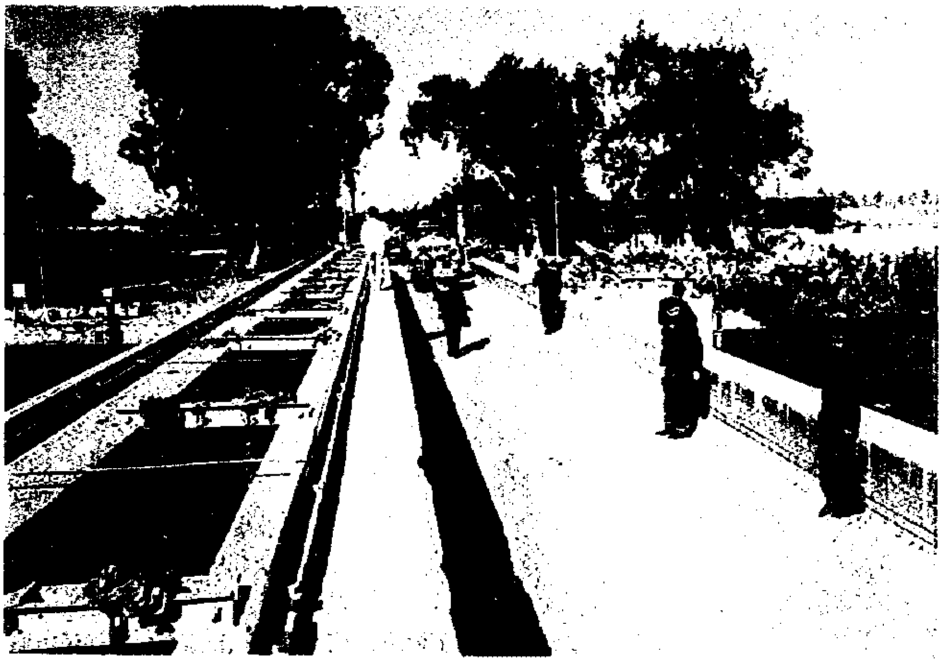
The piers are repaired temporarily near the grouves for gates.

The Farmland on the Project Area

They are cropping onions and wheet in this season.

<u>The Check Point near the Site</u>

The 10 detectors are guarding the regulator permanetly.



<u>The Guarding condition for the Team</u>

The polices stop the trafic during site investigation.

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ABBREVIATION AND GLOSSARY

Abbreviation

ARE	Arab Republic of Egypt
F / S	Feasibility Study
GNP	Gross National Product
GDP	Gross Domestic Products
ID	Irrigation Department
ID	Irrigation Directorate
IDA	International Development Association
IIS	Irrigation Improvement Sector
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
M / P	Master Plan
MFA	Ministry of Foreign Affairs
MOIC	Ministry of International Cooperation
MPWWR	Ministry of Public Works and Water Resources
O / M, O&M	Operation and Maintenance
S / W	Scope of Work
USAID	United States Agency for International Development

Conversion

mm	milimeter
cm	centimeter
m	meter
km	kilometer
t	ton
m^2	square meter
km^2	square kilometer
ha	hectare
fed.	feddan=0.42ha
m^3 (cu.m)	cubic meter
MCM	million cubic meter
m / sec	meter per second
l / sec	liter per second
m^3 / sec	cubic meter per second

cms	cubic meter per second
hr.	hour
℃	centigrade
kg / cm^2	kilometer per square centimeter
t / m^2	ton per square meter
EL	elevation
HWL	high water level
LWL	low water level
CWS	check water surface
WS	water surface
KV	kilo volt
KVA	kilo volt anpere

Currency

LE	Egyptian Pound
Pt	Egyptian Piaster
Yen, ¥	Japanese Yen
US$	US Dollar

Exchange rate (1998)

LE	= 100 Pt
LE	=¥38.93
US$	= ¥137

Summary

Summary

Agriculture in the Arab Republic of Egypt (hereinafter referred to as "Egypt") is one of key industries offering about 30% of the national employment. The arable land in the territory amounts only to 7,800,000 fedans (about 3,280,000 ha) or 3.2%. As for the major food crop supply, 50% of wheat demands is imported. A population growth rate as high as 2.08% (1986-1996) has been marked in current years. From viewpoints of improving self-dependency of food supply and foreign trade balance, Egypt has been trying to increase its agriculture production by two fundamental policies; "the horizontal expansion policy" to increase arable land by exploitation and "the vertical expansion policy" to increase the productivity.

In Egypt, wherein most parts of the territory are desert areas and the available and reliable water source is only the Nile River. Therefore, rehabilitation and improvement of the existing but superannuated irrigation facilities are the most important measures for effective use of the limited water source, and are accordingly expected for urgent implementation. In fact, however, rehabilitation and improvement of deteriorated key facilities are as many as 4,000 in the national total and requires so huge cost that implementation of the works and achievement of improved effective water use have been delayed and difficult.

Bahr Yusef Irrigation Canal runs along left bank of the middle reaches of the Nile River. It is as long as 312.7 km diverted from the Ibrahimia canal at the Dairout Regulator till Qarun saltlake in Faiyum Province serving for about 770,000 fedans (320,000 ha) equivalent to about 13 % of the cultivated land in Egypt as one of the biggest water supply systems supplying irrigation water.

Bahr Yusef Irrigation canal has 5 regulators in need for rehabilitation and improvement. As these regulators had been built about a century ago and badly deteriorated, their functions have come to major causes of difficulties for gate operation, large water losses and resulting uneven water distribution and poor irrigation efficiency.

Improvement of the regulators, as a part of the overall improvement program for irrigation facilities, can promise significant direct benefits and effective use of water resources. On the other hand, Egypt, due to the current tight financial circumstances, is facing

difficulties for independent plan implementation, but needs some financial assistance from Japan, US or European nations.

As is the situation and by request from Egypt, the government of Japan conducted a feasibility study on the improvement of Bahr Yusef Irrigation Canal system in 1991-1992. Based on the study results, the government of Japan implemented a grant aid project for improving the Rahoun Regulator in 1994-1996, which was required for urgent rehabilitation. The government of Egypt subsequently requested rehabilitation of the Mazoura Regulator for urgent rehabilitation next to the Lahoun Regulator.

Responding the request, the government of Japan decided to conduct a survey, and Japan International Cooperation Agency (JICA) implemented a basic design study. JICA dispatched a team for basic design study on the Mazoura Regulator improvement project to the site for 29 days from March 22 to April 19 in 1998. JICA also sent another team for 12 days from August 15 to August 26 in 1998 for explaining the outlines of the basic design, field assessment and coordination with the organizations concerned.

Based on result of the field study, the basic design concepts for this project have been determined as follows.

The regulator shall be located at where has less difficulties and problems in flow conditions, road alignment, compensation for crops, land acquisition, etc. The design water level in the upstream of the regulator shall be HWL=29.70m, and the design discharge shall be Qmax=187.79m^3/sec, as thus programmed in the feasibility study considering the future plan.

A bridge included for construction in the project shall have a total width of 12.80 m (roadway 10.0m , sidewalk 1.0m×2 , curb 0.4m×2) to meet the future plan by Road Department.

By taking account of convenience in operation and maintenance of the regulator by MPWWR and of future systemization of controlling all regulators in the Bahr Yusef Irrigation Canal, the gate type of the Mazoura regulator shall be the same type of the Lahoun regulator.

Gate operation shall be electric-driven, considering the future overall control system planned by MPWWR. And a manual operation system shall also be equipped for occations of electric power failure or and some emergency. The control device shall be provided not only at the gate sides but also in the operation room for remote control so that compatibility with the future telemeter system planned by MPWWR may be secured.

Length of canal bed protection needs to be twice of the regulator width. Some work such as gabion using the natural stones shall be set to dissipate flow energy. As the new regulator is to be reconstructed at the same site of the existing one, a temporary bridge shall be built during construction. The Mazoura Regulator shall be reconstructed within the existing canal land without acquiring any private land, and therefore a cofferdam is temporarily needed during construction.

For construction of the new regulator, it shall be designed not to involve land acquisition. In case an access road has to run partly on some private land, MPWWR will promptly take actions for securing the land for construction work by rent.

Based on the above-mentioned basic design concepts, components of the basic design are decided as follows:

Mazoura Regulator

Gate unit	8.0m span × 4 units
Gate height	5.8 m
Weir length	40.6 m
Weir	Direct foundation, concrete-made, pier height 17.2 m
Attached bridge	Total width 12.8 m (10.0m for roadway, 1.0m×2 for side walks & 0.4m×2 for curbs)
Gate	Double-leaf steel gate by wire rope winch. 8.8m span×2.9m gate height×2 leaves×4 units.
Canal	Direct foundation & concrete-made.
Bed protection	Stone mat (square gabion) 38m×20m
Bank protection	Steel sheep pile protection
Control house	One-floor brick-made 87m^2, with an operation room and a stand-by power generator.

In this construction, the following work flow will be critical: temporary work (installation of double sheet pile cofferdam), earth work, concrete work, mechanical (gates) and electric installation work, temporary work (removing cofferdam), flow switch and closure work on the left bank. Manufacturing, transportation and installation of gates and electric equipment will totally take 21 months, and they will be programmed in a parallel proceeding with the construction work.

The direct and indirect benefits are expected as follows:

(i) Direct effects

① By reconstruction of the Mazoura Regulator electrification of its gate hoists, gate operation will be simplified. This enables prompt and precise water control by minimized ineffective water release to meet the water demands, and allows effective control and distribution of irrigation water to the directly benefited 52,000 fedans (about 22,000 ha) of farmland.

② The present Mazoula Regulator is so superannuated and about to collapse. In case it collapses, it gives not only some direct damages in the downstream reaches of the regulator and but also loss of harvest due to stoppage of irrigation from the upstream. By the reconstruction such direct damages as well as some indirect damages can be prevented.

③ By the project, gate operation will be much simplified and this allows timely and precise water management. This enables supply of irrigation water to a new 12,000 fedans (5,000 ha) of land now under planning.

(ii) Indirect effects

① By the project, operation of the Mazoula Regulator gates in harmony with the operation of the Lahoun Regulator gates in terms of water label and discharge can be achieved. This enables timely control and effective distribution of irrigation water to 550,000 fedans (230,000 ha) of the served area by the Lahoun Regulator.

② By the project, the attached bridge will also be reconstructed to allow traffic of heavey vehicle over 5-ton, which is not at present. And by the wider road width, the district village road will be ranked into a national road connecting Cairo-Asute Desert Road and Cairo-Aswan Highway. The road will function not only as a truck road for agricultural production and marketing but also as a road infrastructure for rural population, and this will contribute to economic and social activities in Benisuef Province.

③ By reconstruction of the Lahoun and Mazoula Regulators, minimum ineffective release from and storage effect in the section between the regulators can be expected

Beneficiaries of the project are;

① 14,000 small sized farm households holding 2 fedans (0.54 ha) or less in the area served by the Mazoura Regulator for the direct benefits,

② 20,000 small sized farm households in the downstream area of Lahoun Regulator for the indirect benefits, and

③ expected immigrant farmers in a 12,000 fedans (5,000 ha) newly reclaimed desert area along the left bank of Bahr Yusef Irrigation canal.

The project aims to contribute to the stable and improved life for farmers who have no way but relying irrigation water on the Nile. And the project plan has been programmed as a part of "Irrigation Improvement Program". The government of Egypt, however due to current financial circumstance, is facing difficulties in implementing the program as required, so that some financial assistance in the implementation from Japan, USA and Europe nations is being sought.

Reconstruction of the Lahoun Regulator, which had the highest priority for reconstruction, was implemented under the Grant Aid project of Japan. However, the Mazoura Regulator, ranked most urgent after the Lahoun Regulator, was also superannuated and about to collapse. Due to its operational difficulties for efficient water delivery, urgent reconstruction of the Mazoura Regulator is also prerequisite. The executing agency, MPWWR, has capable staff for the work but had to wait for financial and some technical assistance from outer sources as having been the case for the Lahoun Regulator. To the project, no assistance from outer sources has been programmed yet. It accordingly seems most appropriate for Egypt to implement the project through technology transfer from and under the Grant Aid program of Japan

After the project construction, ID of MPWWR, which reserves sufficient engineering technology, manpower and budget, will manage the project facilities for O&M.

MPWWR has already experienced a project implementation under the Grant Aid program of Japan for the Lahoun Regulator, and have known the system and proceedings. Accordingly, smooth implementation of the project under the program will reasonably be expected without any particular issues.

As already mentioned the project has been justified since, by its implementation, it can expect not only considerable direct effects but also contribution to life standard of the beneficial farm households. And as for O&M of the project facilities, they will be performed with proper staff, fund and system without any particular issues.

Following to reconstruction of the Lahoun Regulator and the group regulators and at occasion of this project implementation, following aspects are recommended for further improvement of irrigation facilities not only those directly served but also overall Bahr Yusef Canal system and other nation-wide systems.

1) Formulation of effective water use plans and systematic operation and management of irrigation water for efficient uses, and, in cooperation with MPWWR, provision of guidance by ID to the farmers on proper water use.
2) By taking advantage of experience in and following to reconstruction of the Lahoun and Mazoura Regulators, continuous reconstruction of the superannuated existing regulators; the Saquara, El Dahab, Dairout and Ashut regulators in the upper reaches.
3) Assignment of qualified and experienced technical staff in irrigation water management to station at the control houses in the Lahoun and Mazoura Regulators. This shall be the models for other similar cases.
4) By formulation of an overall water management plan for the whole Bahr Yusef Irrigation canal system and by establishment of maintenance and repair program for the facilities, rehabilitation of the irrigation facilities shall be proceeded aiming at effective use of water resources by establishing a complete system for proper water management, maintenance and repair.

For further efficient and proper delivery and use of irrigation water, following aspects may be pointed out for reinforcement.

① Staff training for more water managing specialists
② Preparation of water management manual
③ Reinforcement of water users associations

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Situation for the Request

1-1-1 State Economy

The national development plans of the Egypt were started for development of national industries since the revolution on July 23, 1952. During a period till 1960, a three-year and a five-year development plans had been implemented for improvement of the national revenue, its fair distribution, life standard, employment, minimum wage in line with agrarian reform.

After 1960 by the Republic Decree No.232, the socio-economic plans were divided into three; long-term plans, five-year plans and annual plans. Among them, five-year plans and annual plans are being implemented for improvement of the state production, revenue sources, job creation, promotion of project investment, provisions of cost-benefits assessment, improved individual consumption and living commodities, etc. Two five-year development plans during 1982-1992 had resulted the average increase of GDP by 6.2% and 4%. It had dropped in a short term since then, but marked 4.5% during 1992-1997 and 5.4% during 1995-1996 in the increasing trend.

As for budgetary deficit having been continued over a long period, a budget surplus of 3.1billion LE was marked in 1994-1995. This can contributed to stability of the foreign currency exchange rates, improvement of the savings rate and prevention of inflation (quoted from "State plan, state economy and economic indices" by the Embassy of Egypt in Japan).

The statistics of Egypt in 1997 indicates GDP in 1995/1996 as 153,369 million Egyptian pounds (LE) and the population as 59,272,382 showing per-capita GDP as 2,588LE(762US$).

1-1-2 Current Situations in the Agriculture Sector

The agriculture sector of the Egyptian economy has a 16% share of GDP and provides employment for 31% of the working population (1995/1996). Furthermore, export of agricultural products takes up 12% of the total exports. Especially, export of vegetable are remarkably increasing and becoming one of major foreign currency sources, and playing an important role both in economic terms and in food supply. (quoted from "Statistical Year Book", June 1997)

Most parts of the national territory are desert, and only 3.2% of the land as large as about 780 million fedans (328 million ha) is arable. This is a major constraint for agricultural production in Egypt. The government of Egypt has been trying to increase the agricultural production for better food self-sufficiency to meet the 2.08% population growth rate (1986-1996), and maintaining trade balance through "horizontal expansion policy" which expands arable land by reclamation, and "the vertical expansion policy" which aims to increase harvest by enhancing the productivity of the present areas.

1-1-3 Current Situations in the Irrigation Sector

Due to the desert climate except in the delta area around the Mediterranean Sea coastal region, Egypt can not enjoy sufficient rainfall and therefore has constructed agriculture irrigation systems since the ancient times. Regarding the water resources of the Nile River, the Nile Treaty was concluded in 1959 with Sudan which allocates the annual quantity of water use as 55.5 million m^3 (33.0 million m^3 for irrigation per annum).

From viewpoints of promoting the horizontal and vertical expansion policies and of eradication of the growing unstable supply of irrigation water due to the current desertification, rehabilitation and improvement of the existent irrigation facilities are essential for effective use of the limited water resources and are also expected for the earliest implementation. However the rehabilitation and improvement of some 4,000 deteriorated facilities in total requires a huge sum of investment, and has resulted delay in the implementation. The water is accordingly being managed through the deteriorated facilities, and effective use of water resources may hardly be achieved.

1-1-4 Background of the Request

Bahr Yusef Irrigation Canal runs along the left bank of middle reaches of the Nile River. It is as long as 312.7 km diverted from Ibrahimia canal at Dairout regulator till Qarun saltlake in Faiyum province serving for about 770,000 fedans (320,000 ha) equivalent to about 10 % of the cultivated land in Egypt as one of the biggest water supply systems supplying irrigation water in Egypt.

Bahr Yusef Irrigation canal has 5 regulators in need for rehabilitation and improvement. As these regulators had been built about a century ago and badly deteriorated, they have been found one of major factors not only causing difficulties for gate operation and large water losses but also resulting uneven water distribution and poor irrigation efficiency.

The improvement plan for the regulators, as a part of the overall improvement program for irrigation facilities, can promise a significant direst benefits and effective use of water resources. On the other hand, Egypt, due to the current tight financial circumstances, is facing difficulties for independent plan implementation, but needs some financial assistance from Japan, US or European nations.

As is the situation and by request by Egypt, the Government of Japan conducted a feasibility study on the improvement of Bahr Yusef Irrigation Canal system in 1991-1992. Based on the study results, the government of Japan implemented a Grant Aid project in 1994-1996 for rehabilitation of the Lahoun Regulator, as requested for urgent rehabilitation.

1-1-5 Purpose of the Request

Mazoura regulator is located at 230.3 km along the Bahr Yusef irrigation canal, and is an important structure to irrigate 52,000 fedans (22,000 ha) in the province of Beni Suef, equivalent to about 6.8% of the overall service area of the canal. Result of the study shows that the Mazoura Regulator has the highest priority next to the Lahoun Regulator for urgent project implementation among the 5 regulators. The purpose of this project is therefore rehabilitation of the Mazoura Regulator.

1-2 Major Request Components

Major components of the request are listed as follows:

(1) Improvement of main weir body of the regulator
The Existing superannuated Mazoura Regulator gates are made from the 25 decrepit 2-leaf steel roller gates with 3.0m in width.

(2) Improvement of the attached bridge
The Existing operation bridge (platform) built on the Mazoura Regulator, is 4.0m in width and about 120m in length. The bridge is also used as local communal and main road across the Bahr Yusef irrigation canal.

(3) Improvement of slope protection
The range of the construction shall be the area of construction of the regulator.

(4) Improvement of canal bed protection
In the present bed protection work in the downstream apron of the regulator which may affect to the new regulator, will be reconstructed.

(5) Control house
A control house will be newly built on the upper right bank to accommodate equipment for operation and maintenance of the regulator.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Objectives of the Project

2-1-1 Targets of the Project

The final goal for Irrigation Improvement Project (IIP) is to increase the production through improvement of irrigation systems, and the food self-sufficiency rate of Egypt will also be improved accordingly. Therefore, the final goal of this project is aimed at the improved agricultural production in the command areas of the Bahr Yusef Irrigation Canal in Benisuef Prefecture through the rehabilitated Mazoura Regulator. The improvement of irrigation system down to branch irrigation canals and connected tertiary canals from the Mazoura Regulator can assure the overall goal of the increased harvest. Under the long-term Irrigation development Plan by the Irrigation Department, the improvement project for Bahr Yusef Canal area is programmed for the implementation from 1998/1999 to 2006/ 2007

The project plans urgent improvement of five regulators into the modern ones in the Bahr Yusef Irrigation Canal prior to improvement of the subsequent branch irrigation canals and the on-farm waterways. Improvement of the Mazoura Regulator has been given with the highest priority next to the Lahoun Regulator, which was built through a Grant Aid program of Japan.

2-1-2 Objectives the Project

Objectives of this project are to provide stable irrigation water in effective ways. By reconstructing the Mazoura Regulator into the modern ones, it enables easy but sophisticated precise gate operation so that proper water level can be maintained for the service area near and down from the regulator.

After reconstruction of the Mazoura Regultor, the canal section till the Lahoun Regulator can have some regulating storage function, and with the function, water control in conformity with the water demmads from the command area can be achieved. The present regulating gates are too small as compared with the flow scale, and take a long-time manual operation, and because of this the gates cannot be operated in good combination with that of the rehabilitated Lahoun Regulator.

The present regulator was built in 1902, and has been superannuated and facing danger of collapse. The danger can be prevented by the reconstruction. The present gates are operated by adjusting not the gate opening but number of gates. This causes flow concentration in some particular places in the downstream apron and damages the protection. This problem will also be avoided by the project and stability of canal bed and the regulator body will be assured.

2-1-3 Objects of the Project

Objects of this project is to enable modern water control and management through reconstructing the present but decrepit Mazoura Regulator into the modern one. Objects for the improvement are as follows.

1. Repair the decrepit regulator body.
2. Renewal of the manually-operated gates into the electric-driven steel gates.
3. Construction of an access roads to the regulator and an attached bridge.
4. Construction of a control house to accommodate control equipment to receives water control information from the Lahoun Regulator through telephone circuit and control units for gate operation as instructed from the Benisuef local directorate.

2-2 Basic Concept of the Project

2-2-1 Approach for Improvement

The Mazoura Regulator was constructed in 1902 and has past almost 100 years. The body is brick-made and have badly been superannuated with cracks and facing the sudden collapse. The gates are 2-leaf sluice-type and many in number. Gates are operated by manual labor by use of movable chain-hoists, and this gives a difficulty in smooth and modern water operation. In order to improve functions of the regulator, the body and the gates are to be totally reconstructed accordingly.

2-2-2 Location for Reconstruction

In Egypt, farmlands are so limited and it involves much time and costs in acquiring some land for construction of new structures. A study on four alternatives has been made to examine the costs including land acquisition. Four alternatives of the location, i.e. A. right bank present location, B. upper right bank, C. lower right bank, and D. right bank at the navigation lock, have been compared as shown in Fig. 2.1. It has concluded that the location A is most advantageous both in economy and construction period. In the study, flow conditions, road alignment, compensation for harvest, land acquisition, construction costs, etc. have been examined as shown in Table 2.1.

2-2-3 Width of Regulator

The width of the existing regulator is 110m as shown in the attached data 12. The existing Regulator was constructed 60 years before the construction of the Aswan High Dam. The flow condition of the Bahr Yusef Canal has been changed greatly as that the function of flood regulation for Nile River shall not be considered. Therefore the width of Regulator shall be designed from the maximum design discharge of the Project.

2-2-4 Width of Attached Bridge

Total width of the attached bridge has been decided 12.80m (a roadway width 10.0m, a sidewalk width 1.0m×2, curb 0.4m×2) so as to meet the standard and future road plan of Egypt. The width is wider than a minimum width 10.8m, which is necessary for the installation of the gate, by 2.0m. A difference from that of the Lahoun Regulator is the increased width of the curb to 0.40m from 0.25m.

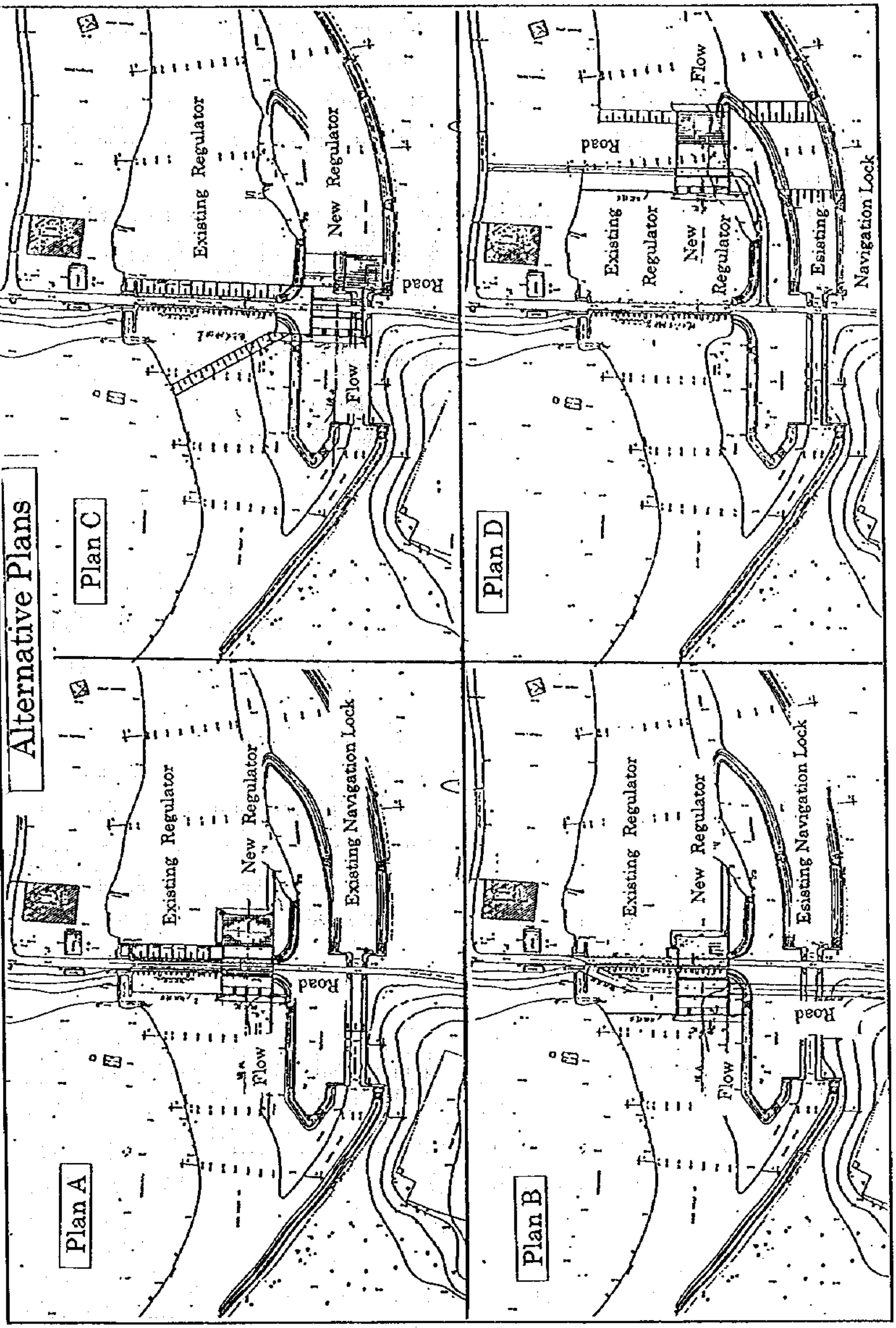
(1) Under the road department plans, the attached bridge is a part of one of four Benisuef local ways (3rd-class national route for 70-T load) which connect a the Asiout-Cairo desert road (the 2nd-class national route) and the Cairo-Aswan agriculture road (the 1st-class national route).

(2) The Irrigation Department (ID) is the sole executing agency for reconstruction of the Mazoura Regulator and is requested by the road department of the State of Benisuef, which is in charge of road O&M, that the total width of the attached bridge to be 12.5m to meet the future plan.

Table 2-1 Comparison of the Location for the Regulator

		Plan A	Plan B	Plan C	Plan D
Location		On the existing regulator at right bank	Upper stream of the existing regulator at right	At the navigation lock on right bank	Lower stream at the right bank
Coffering		Steel sheet pile at upper & lower stream	Steel sheet pile at upper, rip-rap at lower	Steel sheet pile and rip-rap	Steel sheet pile at upper & Lower stream
Attached Bridge		Total 12.8m width & 38m length for public	Total 12.8m width & 38m length for public	Total 12.8m width & 38m length for public	6.8m width & 38m length for the O & M
Land Expropriation		0m²	1200m²	0m²	900m²
Structural Method for Coffering		Double coffeirng sheet pile for 3 directions	Double coffering sheet pile for 3 directions	Double coffering sheet pile for 4 directions	Double coffering sheet pile for 4 directions
Temporary Bridge		Length 65m	50m	100m	120m
Detour		40m	80m	250m	350m
Construction Cost for Civil Wroks (million yen)	Earth Works	89	97	225	102
	Temporary Retaining Wall	216	217	166	266
	Regulator Body	177	177	177	177
	Shore Protection	27	27	29	27
	Appurtenant Works	69	72	69	44
	Total	579	590	666	616
Construction Period (months)	Temporary Works	4	4	6	4
	Regulator Body	10	10	10	10
	Demolish & Coffering	4	4	10	8
	Total	18	18	26	22
Advantage		1.Flow condition is better. 2.Enough water discharge during works 3.No curve for the road 4.No land expropriation 5.Lowest construction cost 6.Few difficulties during works 7.No touch to the navigation lock	1.Flow condition is better 2.Enough water discharge during works 3.Low construction cost 4.Few difficulties during works 5.No touch to the navigation lock	1.No construction works for existing regulator 2.Enough water discharge during works 3.No curve for the road 4.No land expropriation 5.Works on the land	1.No construction works for existing regulator 2.Enough water discharge during works 3.Length of sheet pile is shorter
Defect		1.The demolishing works for existing Regulator 2.Viblation might effect on the existing Regulator	1.The demolishing works for existing Regulator 2.Viblation might effect on the existing Regulator 3.2 curves for the public roads 4.Necessary for land expropriation	1.Long length of a temporary bridge 2.Much earth works volume 3.Borrow area is requires for a work shop 4.Flow condition is not suitable 5.Navigation lock shall be demolished	1.Existing regulator is effected on flow condition 2.Much work volume for embankment 3.Difficult work on fixing works for structure 4.No rehabilitaion on the public bridge 5.Navigation lock shall be demolished 6.Land expropriation is required
Evaluation		1	2	4	3

Fig. 2-1



Alternative Plans
Plan A
Existing Regulator
New Regulator
Existing Navigation Lock
Flow
Road
Plan B
Existing Regulator
New Regulator
Esisting Navigation Lock
Flow
Road
Plan C
Existing Regulator
New Regulator
Flow
Road
Plan D
Existing Regulator
New Regulator
Esisting Navigation Lock
Flow
Road

(3) Width of the attached bridge of the Lahoun Regulator in the local trunk road (national route class) connecting the Fayoum and the Benisuef, is 12.5m (a roadway width 10.0m, sidewalk 1.0m×2, the curb width 0.25m×2).

(4) A bridge in the above Benisuef-Fayoum road is being enlarged for a roadway width 12.0m.

(5) Bridges crossing the waterway controlled by the MPWWR are to be built by the party who initiates the construction, and this requires coordination with the organizations concerned.

The difference in construction costs for the requested bridge with the minimum and necessary widths amounts to 3.0 million yen equivalent to 0.27% of the construction cost or 0.15% of the total cost for the regulator including mechanical costs.

2-2-5 Operation Method and Control House

At the present Mazoura Regulator, gates have been operated three times a day by instructions from the South Sector Inspector of Beni Suef Irrigation Directorate to Somosta Irrigation District. Therefore, it may be said that the gates have been frequently operated.

In Egypt, manual-labor gate operation in irrigation canals is being replaced by electric-driven operation so as to meet the future control system. In line with this, the gates to be renewed will be electric-driven. By operating the gates of the regulator in good combination with those of the Lahoun Regulator, it can expect not only better water management in the service area of the Mazoura Regulator and proper water control to the beneficial area of Fayoum Prefecture but also some indirect benefits in the beneficial area in Fayoum Prefecture.

The gates under the project will, similarly to the Lahoun Regulator, be improved for remote control through a control panel. A control house will be built to accommodate equipment to receive information on water levels, gate openings and discharges in the Lahoun Regulator group through telephone circuit, and those to receive instructions from Benisef local directorate. The above-said control panel will be installed in the control house.

The gate shall be operated in accordance with the up-down stream water surface.

The surcharged water level shall be RWL 30.10m as retention purpose for the gate operation over the high water level HWL 29.70m. The retention water level shall be able to delivery the water with present intake water level (WL30.05).

2-2-6 Construction Methods

The project's regulator shall be constructed at the same location of the existing Regulator by demolishing 50m of the right part of the regulator. The required water shall be discharged through the 13 of remaining existing gates during the construction stage. The discharge capacity of the 5 gates of existing regulator has 150 m^3/sec so that 130 m^3/sec of the existing maximum discharge is able to be regulated through the remaining gates. After construction of the regulator, the 60m of remaining regulator shall be closed by demolishing the upper part of pillar and filling with well compaction lefting the lower part of regulator body in the soil.

2-3 Basic Design

2-3-1 Design Concept

1) Type of Regulator

There are two types of foundation, i.e. fixed type founded on the rock bed and floating type built on the pervious layer. The Mazoura Regulator shall be the floating type because of its geological condition.

2) Body Structure of Regulator

The regulating weir body shall be of a reinforced concrete structure in view of its construction workability and structural durability. The external appearance and colors of the structures shall be those in harmony with the rural scenery.

3) Gate Facility

Gate type shall be chosen taking the structural characteristics into consideration. The comparison of the gate width shall be made on the shell/Girder type with lifting load which will be operated by an electric motor in consideration with the plan of MPWWR. A generator shall be consider for the blackout.

4) Trash Control

Trash control device and screen are not included because the Mazoura Regulator is located in the middle of Bahr Yusef canal and even at present no such device has been installed. In the present operation, a lot of weeds and trash have been trapped at the upper side of gates due to underflow water release, and they have been removed manually. For the new regulator, most of weeds and trash will be flashed out with overflowing water. Large-sized trash like the dead body of animals, which may remain at the gate, shall be removed manually similarly as before.

5) Canal Bed Protection

Protection works for canal bed and embankment are quite necessary since the downstream side of the regulator may be scoured due to velocity change caused by gate operation.

6) Canal Slope Protection

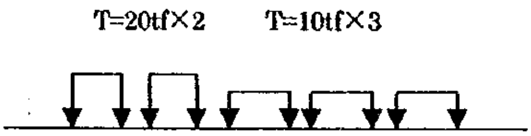
Canal side slopes shall also be protected from scouring. Such side slope protection shall be made with easy maintenance material as stone masonry or gabions or steel sheet piles reused from temporary closing work.

7) Closure Dike

The closure dike shall be constructed for the close of the existing regulator. The closure method shall be decided among the three types; ① Soil dike with rep-rap slope protection, ② Shore protections with sheet steel pile for up stream and rip-rap slope protection for down stream, ③ Shore protection with sheet steel pile on the both side.

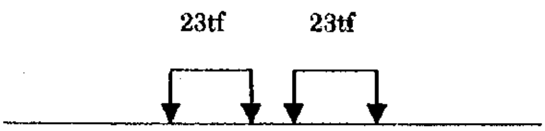
8) Attached Road Bridge

A bridge to be attached to the new Mazoura Regulator will be designed to be a two-lane road with 12.80m of a total width, which is the minimum bridge width under the road standard by the Ministry of Transportation of the government of Egypt. The designed load shall be considered with two parallel T-20 and three T-10 loads as shown below.



Active Load

Japanese Road Bridge Design Standard



2 set of 70 tf Trailer

Egyption Standard

9) In Site Road.

The existing road shall be constructed in side of both navigation locks. The width of road shall be designed in accordance with the plan of the road authority in Benisuef province.

10) Navigation Lock

MPWWR has no intention to use Mazoura navigation lock and there will be no objection to backfill it if so required for construction of the new Mazoura Regulator.

11) Temporary Closing Work

Since the new Mazoura Regulator is to be built inside the existing canal land where no land acquisition from farmers is required, temporary closure work is necessary during the construction period. The temporary closure shall be made by double sheep pile cofferdam because of its narrow work area and deep canal water depth. Stability cofferdam because of its narrow work area and deep canal water depth. Stability analysis and structural calculations for the cofferdam shall be made in accordance with the "Guideline for Design of Double Sheep Pile Cofferdam" (Ministry of Construction of Japan, Nov., 1971). Low-noize vibration method using a high-frequency vibro-pile hammer with water jet, shall be applied for pile driving by taking account of safety of the existing old structure and foundation.

12) Temporary Bridge

A temporary bridge shall be provided during construction as the new regulator is built at the same place of the existing regulator.

13) Land Acquisition

Location of the new Mazoura Regulator requires no acquisition of any private land.

2-3-2 Basic Design

1) Design Criteria

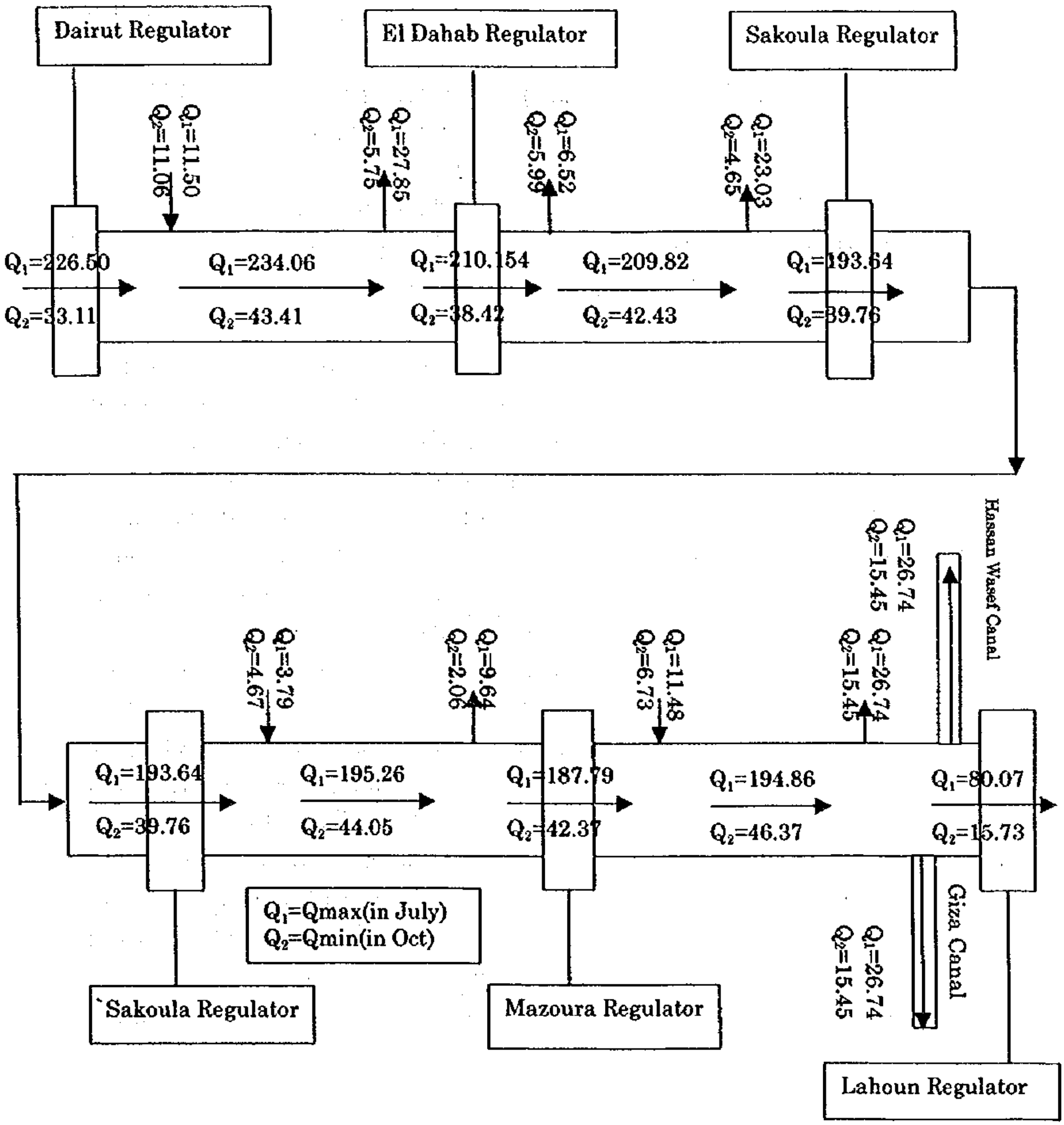
Design criteria for design of the new Mazoura Regulator shall be based on the criteria of "Headwork" for Land Improvement Project Standard of Japan. However, basic conditions such as design loads and hydraulic conditions shall be based on the Egyptian standard/criteria. For the design of steel gates, "Standard for Pipes and Gates" of Japan shall be applied while JIS (Japan Industrial Standard) shall be for machines and materials. For a road bridge and an access road, "Road Standard" of Egypt shall be applied.

2) Design Canal Discharge

The Design Discharge of the Bahr Yusef Canal is shown in Fig 2-2. The Design Discharge shall be described below.

Design Maximum Discharge $Q_{max} = 187.79\ m^3/sec$
Design Minimum Discharge $Q_{min} = 42.37\ m^3/sec$

Fig 2-2 Design Discharge of Bahr Yusef Canal



3) Design Water Level

Design Water Level shall be shown in below.

Disordinary High Water Level (upstream)	HHWL = 30.30 m
Retentional Water Level (upstream)	RWL = 30.10 m
Design High Water Level (upstream)	HWL = 29.70 m
Disordinary High Water Level (downstream)	HHWL= 30.20 m
Design High Water Level (downstream)	HWL = 29.31 m
Design Low Water Level (downstream)	LWL=26.99 m

- Maximum Design Water Level (HWL=29.70m) at upstream is the high water level at the Maximum Design Discharge (Q max=195.26m^3/s) in the Bahr Yusef Canal. It comes to same water level in minimum Design Discharge (Q min=43.41 m^3/s)at which upstream intakes are able to obtain the required discharge.
- Maximum Design Water Level (HWL=29.31m) at downstream is the high water level at the Maximum Design Discharge (Q max=194.86m^3/s) in the Canal. Minimum Design Water Level (LWL=26.99m) is the low water level at the Minimum Design Discharge (Q=46.37m^3/s) in the Canal.
- Extraordinary Water Level (HHWL=30.30m) is the highest water level in the past, at Mazoura Regulator. Water Level shall be allowed to rise up to this water level (HHWL=30.30m) when mis-operation of the Gates might be done. In order to lower the water level to discharge the water urgently, the gate shall be opened completely until the water level at upstream shall be lowered to RWL 30.10m. Hydraulic calculation in Data 8 shows that the discharged volume flows down by maximum 170m^3/s and water level will rise up to HHWL 30.20m. At this maximum discharge, the arable area in the both side of dikes might be inundated by maximum 0.5m, however this case may not effect so much to the arable area because the duration of emergency discharge is estimated as 14 hours.

4) Criteria for Hydraulic Calculation

Mean velocity formula for calculating canal discharge and hydraulic gradient will be by Manning's formula as shown below.

$Q = AV$

Where, Q : Discharge (m^3/s),

A : Flow area (m^2), and
V : Mean velocity (m/s)

$$V = 1/n \quad R^{2/3} \quad I^{1/2}$$

n : Coefficient of roughness
R : Hydraulic radius, and
I : Canal bed slope or hydraulic gradient.

5) Criteria for Structural Calculation

(1) Allowable Strength

Material	Normal Strength (kgf/cm^2)	Seismic Strength (kgf/cm^2)
1) Reinforce Bar in the air	1800	2700
in the water	1600	2700
2) Concrete (compressive bending)	70	105
3) Concrete (shearing)		
Resist by Concrete	3.6	5.4
Resist by Concrete & Stirrups	19.0	24.0
Punching	8.5	12.75
4) Cohesion of Concrete & Steel Bar	15.0	22.50

(2) Unit Weight of Materials

Material	Unit weight (tf/m^3)
1) Reinforced concrete	2.50
2) Plain concrete	2.35
3) Water	1.00
4) Soil (dry)	1.60
5) Soil (wet)	1.80
6) Soil (submerged)	2.00

(3) Seismic Force

Seismic horizontal acceleration for design is taken as $Kh = 0.2$.

(4) Earth Pressure

For earth pressure calculation, Coulomb's Formula is applied to both normal and seismic conditions. By the formula, internal friction angle of soil and wall face friction angle to the soil behind, are as follows (refer to a separate report).

ϕ: Internal friction angle of soil (degree)

Filling material will be good texture of desert soil, so that ϕ=30° is applied to the texture containing mostly sand and gravel and little fine component.

α: Angle of ground slope to horizon

θ: Angle of face behind wall to perpendicular

δ: Wall face friction angle to the soil behind

Purpose	Friction between	Wall Face Friction Angle	
		Normal Case	Seismic Case
Stability Analysis	Soil and Soil	ϕ = 30°	ϕ/2 = 15°
Structural Calculation	Soil and Concrete	ϕ/3 = 10°	0°

(5) Load

Uniform live loads as 0.30 tf/m2 and 1.00 tf/m2 for miscellaneous and vehicles are respectively taken for only normal case.

(6) Concrete Cover

Standard depths of concrete cover for reinforcing bars are taken as 7.5 cm while 10 cm for weir pillars.

(7) Minimum Member Thickness

Minimum thickness of concrete members is taken as 35 cm.

6) Design Criteria for the Gate Facilities

(1) Design Load

Statics Water Load;

P = Woho

Where, P : Statics water pressure (tf/m^2)

Wo : Unit water weight (tf/m^3)

Ho : Different depth between up-downstream (m)

Operation Load; Gate self weight, roller, Friction forth, Pull down forth, Uplift shall be considered.

(2) Allowable Stress

Allowable stress of the steel material for Gate, Guide Frame and embedded material shall be based on the Japanese Technical Standards for Gates and Penstock.

2-3-3 Structural Calculation

1) Regulator Body

(1) Apron Elevation

Apron elevations of sections upstream and downstream of the gates have been designed to meet the design canal bed elevations as EL 23.80 and El 23.40 respectively. The design canal bed elevations are lower than the present ones by 0.70m in accordance with the overall plan of the Bahr Yusef Irrigation Canal.

(2) Still Elevation of the Gate

Sill elevation of gates has been determined EL 24.30 higher than the upstream sill by 0.50 m for preventing sedimentation.

Flow capacity through the gate section is verified with the maximum design discharge (Q=189.79 m^3/s) under a condition that upstream water level as CWS 29.70m, downstream WS29.30 m (backwater level from the Lahoun Regulator). For the verification, Bernoulli's Formula has been applied to non-uniform flow calculation, while two cases of sill elevation at gate section (0.50 m and 0.60 m above design canal bed) have been examined.

Giving the design discharge and gate sill elevation and calculating hydraulic loss heads by inflow, friction, turbulence by pillar and outflow, water surface levels have been worked out from downstream to upstream direction. The calculated water surface level at the upstream end can judge that design discharge can be released in the calculated level is below the upstream design water level and vice versa.

Results of calculations as presented below indicate that gate sill elevation 0.5 m above canal sill can release the discharge while that above 0.6 m can not. (See Table 2-2 ~ Table 2-3)

Table 2-2 Hydraulic Conditions at Maximum Discharge
Mound Up (0.5 m)

	O	①	②	③	④	⑤	⑥	⑦	
Q=	187.79	187.79	187.79	187.79	187.79	187.79	187.79	187.79	
D=	5.910	5.93	5.991	6.04	5.189	5.254	5.891	5.895	
n=	0.03	0.015	0.015	0.015	0.015	0.015	0.015	0.03	
A=	300.021	225.340	191.712	193.280	166.048	168.128	188.512	294.750	
P=	62.585	49.860	79.928	80.320	73.512	74.032	79.128	61.790	
R=	4.794	4.519	2.399	2.406	2.259	2.271	2.382	4.770	
HWL	29.310	29.330	29.391	29.440	29.489	29.554	29.691	29.695	<29.70m
EL	23.400	23.400	23.400	23.400	24.300	24.300	23.800	23.800	
l=	20.000	9.000	13.300	3.600	7.100	5.000	6.000	0.000	
Eng=	29.330	29.391	29.440	29.489	29.554	29.619	29.767	29.716	
hpe=	0.000	0.025	0.000	0.000	0.000	0.000	0.025	0.000	
Vi=	0.626	0.833	0.980	0.972	1.131	1.117	0.996	0.637	
Vi'=	0.599	0.815	1.000	1.002	1.148	1.093	0.995	0.668	
$h_f e$=	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	
h_{dio}=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
i=	0.00004	0.00002	0.00007	0.00007	0.00010	0.00009	0.00007	0.00005	
he=	0.020	0.035	0.049	0.048	0.065	0.064	0.051	0.021	
B=	50.765	38.000	32.000	32.000	32.000	32.000	32.000	50.000	
Eng=	29.330	29.391	29.440	29.489	29.554	29.619	29.695	29.716	

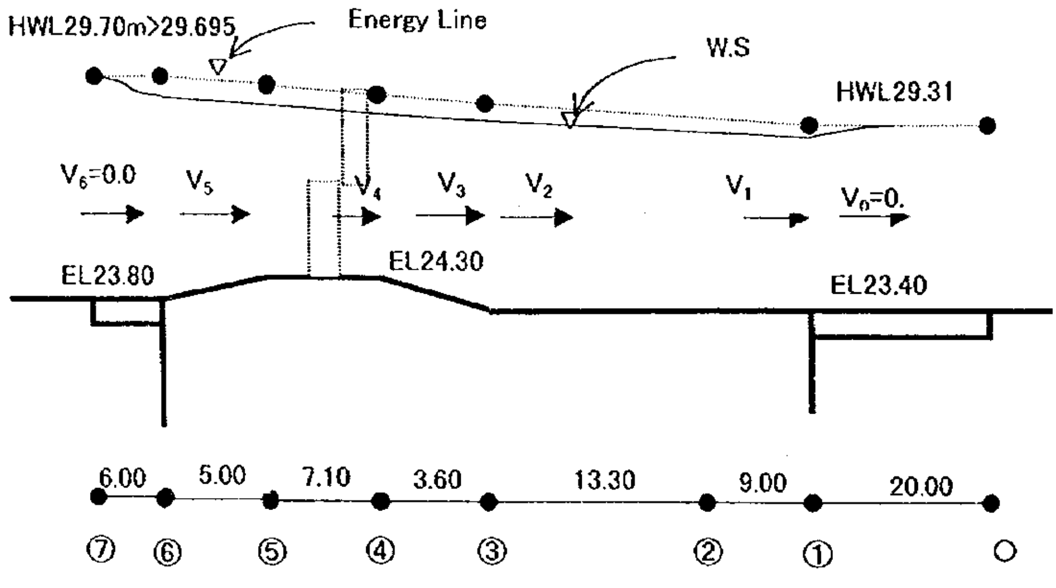


Table 2-3 Hydraulic Conditions at Maximum Discharge
Mound Up (0.6 m)

	O	①	②	③	④	⑤	⑥	⑦	
Q=	187.79	187.79	187.79	187.79	187.79	187.79	187.79	187.79	
D=	5.910	5.93	5.991	5.04	5.11	5.777	5.832	5.908	
n=	0.03	0.015	0.015	0.015	0.015	0.015	0.015	0.03	
A=	300.02	225.34	191.71	161.28	163.52	184.86	186.62	295.40	
P=	62.585	49.860	79.928	72.320	72.880	78.216	78.656	61.816	
R=	4.794	4.519	2.399	2.230	2.244	2.364	2.373	4.779	
HWL	29.310	29.330	29.391	28.440	29.510	29.577	29.632	29.708	>29.70m
EL	23.400	23.400	23.400	23.400	24.400	23.800	23.800	23.800	
l=	20.000	9.000	13.300	3.600	7.100	5.000	6.000	0.000	
Eng=	29.330	29.391	29.440	28.510	29.577	29.631	29.708	29.729	
hpe=	0.000	0.025	0.000	0.000	0.000	0.000	0.025	0.000	
Vi=	0.626	0.833	0.980	1.164	1.148	1.016	1.006	0.636	
Vi'=	0.599	0.815	1.000	1.138	1.143	0.990	0.992	0.669	
$h_f e$=	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	
h_{die}=	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
i=	0.00004	0.00002	0.00007	0.00010	0.00010	0.00007	0.00007	0.00005	
he=	0.020	0.035	0.049	0.069	0.067	0.053	0.052	0.021	
B=	50.765	38.000	32.000	32.000	32.000	32.000	32.000	50.000	
Eng=	29.330	29.391	29.440	29.510	29.577	29.631	29.708	29.729	

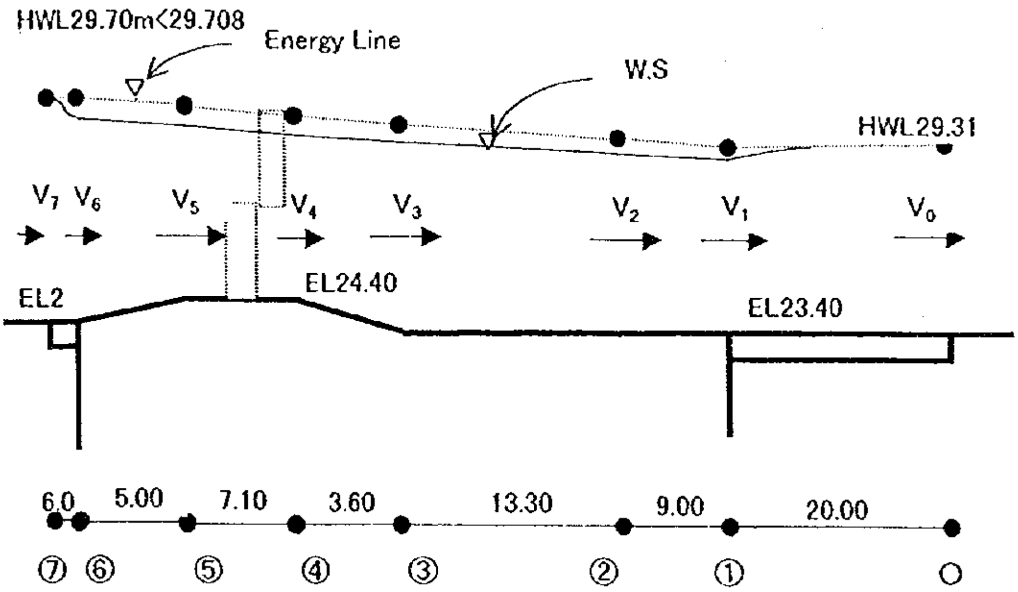
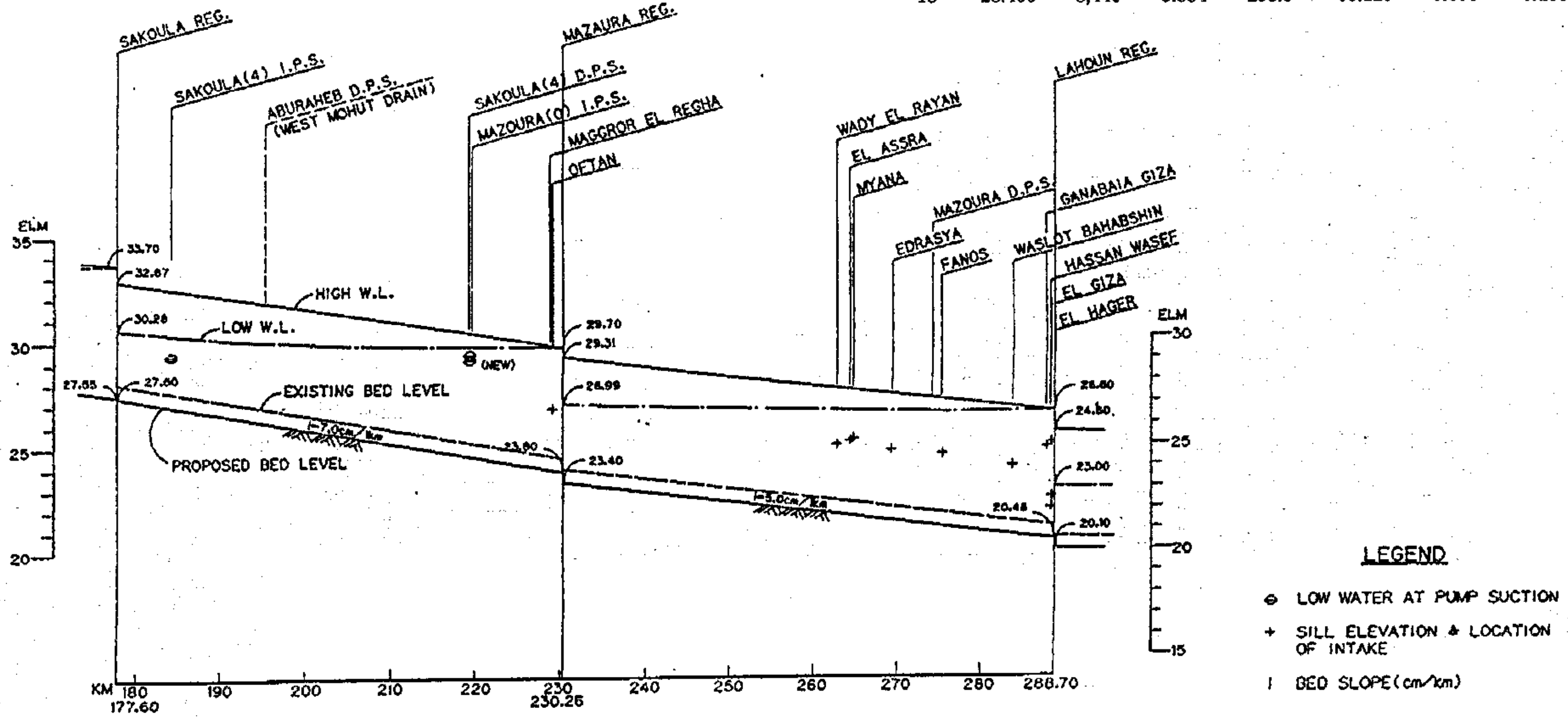


Fig 2-3 Hydraulic Profile of Bahr Yusef Canal

Mazoura to Lahoun (Qmax)
SIDE SLOPE 1 : 1.500
ROGHNESS COEFFICIENT of SIDE SLOPE 0.0300
ROGHNESS COEFFICIENT of CANAL BED 0.0300
Discharge 194.860 (m3/sec)

ST	EL (m)	DIS (m)	H (m)	A (m²)	P	V (m/sec)	HF (m)	WL (m)
1	20.480	0	6.120	312.6	63.966	0.623	0.0000	26.600
2	20.730	5,000	6.083	310.4	63.832	0.628	0.2131	26.833
3	20.980	5,000	6.050	308.4	63.713	0.632	0.2174	27.050
4	21.230	5,000	6.021	306.7	63.609	0.635	0.2213	27.272
5	21.480	5,000	5.995	305.1	63.517	0.639	0.2248	27.496
6	21.730	5,000	5.973	303.8	63.437	0.641	0.2279	27.724
7	22.980	5,000	5.954	302.6	63.366	0.644	0.2307	27.955
8	22.230	5,000	5.937	301.6	63.305	0.646	0.2331	28.188
9	22.480	5,000	5.922	300.7	63.252	0.648	0.2353	28.423
10	22.730	5,000	5.909	300.0	63.205	0.650	0.2372	28.661
11	21.980	5,000	5.898	299.3	63.165	0.651	0.2389	28.899
12	23.230	5,000	5.888	298.7	63.130	0.652	0.2404	29.140
13	23.400	3,440	5.884	298.5	63.115	0.653	0.1660	29.306



Item	Gate Sill EL 24.30(Sill 0.5m above canal bed)	Gate Sill EL 24.40 (Sill 0.6m above canal bed)
Discharge (m^3/s)	189.79	189.79
Design D/S WL (m)	WS 29.31	WS 29.31
Design U/S WL (m)	WS 29.70	WS 29.70
Calculated U/S WL (m)	WS 29.67	WS 29.72
Judgement	Releasable	Not releasable

Therefore the Sill elevation of gates shall be EL24.30 m as shown in Fig 2-3 conforming with the un-uniformed flow condition in the FS report.

(3) Width of Regulator

Gate section required for the new regulator shall be determined not exceeding 1.5-2.0 times of the present flow velocity which is around 0.6m/sec in both up- and downstream areas of the Mazoura Regulator.

Total span length required for the new Mazoura Regulator shall be determined based on the design velocity around 1.0 – 1.2 m/sec.

— Total span length = (Design discharge) ÷ (Design velocity) ÷ (Water depth)

= 187.79 m^3/sec÷1.1 m/sec÷5.4 m

= 31.6 m

≒ 32.0 m

Therefore, the total span length shall be 32.0m.

(4) Number of Regulator Spans

Total length of the regulator has been decided 32m judging from the above design values and water depth. The sizes of the gates were studied except one gate on the alternatives; i.e. ① 16m width×2 units, ② 10.7m ×3 units, ③ 8.0m×4 units, ④ 5.4m×6 units, and ⑤ 4.0m ×8 units from economical viewpoint. The plan, ③ 8.0m×4 units was found most economical, as shown in the Table 2-4.

Table 2-4 Comparison of Alternatives on No. of Gate Span & Length by Major Costs

(Unit:Yen)

Item		Unit	Unit Cost	Case No.1		Case No.2		Case No.3		Case No.4		Case No.5	
				2-span	16m/span	3-span	10.7m/span	4-span	8m/span	6-span	5.4m/span	8-span	4m/span
				Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
Work	Contents			541,541,710		560,621,682		558,940,140		614,691,680		639,320,724	
Earth Work													
	Exavation	m^3	185	24,000	4,440,000	25,500	4,717,500	26,000	4,810,000	28,000	5,180,000	29,000	5,365,000
	Hanling	m^3	219	56,000	12,264,000	56,000	12,264,000	56,000	12,264,000	57,000	12,483,000	58,000	12,702,000
	Fill	m^3	246	32,000	7,872,000	30,500	7,503,000	30,000	7,380,000	28,000	6,888,000	26,000	6,396,000
	Surplus soil	m^3	133	24,000	3,192,000	25,500	3,391,500	26,000	3,458,000	28,000	3,724,000	30,000	3,990,000
Demolition													
	Demolotion	m^3	8,779	7,600	66,720,400	8,250	72,426,750	8,500	74,621,500	9,400	82,522,600	10,000	87,790,000
Bank protection													
	Steel sheet pile	pcs	117,458	730	85,744,340	690	81,046,020	670	78,696,860	630	73,998,540	610	71,649,380
Bank slope protection													
	Grouted riprap	m^2	7,177	1,000	7,177,000	930	6,674,610	900	6,459,300	810	5,813,370	760	5,454,520
Bed protection													
	Sheet gabion	m	6,281	850	5,338,850	940	5,904,140	1,000	6,281,000	1,170	7,348,770	1,180	7,411,580
	Riprap	m^2	1,482	1,900	2,815,800	1,900	2,815,800	1,900	2,815,800	2,200	3,260,400	2,242	3,322,644
	Sheet pile	pcs	64,075	170	10,892,750	190	12,174,250	200	12,815,000	240	15,378,000	260	16,659,500
Weir body (Concrete)													
	Base	m^3	26,610	2,400	63,864,000	2,600	69,186,000	2,700	71,847,000	3,160	84,087,600	3,200	85,152,000
	Pillar	m^3	26,610	1,300	34,593,000	1,800	47,898,000	2,200	58,542,000	3,100	82,491,000	3,960	105,375,600
	Slab	m^3	26,610	420	11,176,200	385	10,244,850	350	9,313,500	310	8,249,100	280	7,450,800
	Bridge	m^3	26,610	372	9,898,920	341	9,074,010	310	8,249,100	280	7,450,800	250	6,652,500
Others													
	Pavement	m^2	4,639	2,200	10,205,800	2,200	10,205,800	2,200	10,205,800	2,200	10,205,800	2,200	10,205,800
Building													
	Control house	m^2	190,055	200	38,011,000	180	34,209,900	88	16,724,840	120	22,806,600	88	16,724,840
Temporary work													
	Pier	m^2	27,991	410	11,476,310	372	10,412,652	360	10,076,760	300	8,397,300	200	5,598,200
	Cofferdam	pcs	75,339	1,060	79,859,340	1,100	82,872,900	1,120	84,379,680	1,200	90,406,800	1,240	93,420,360
Freight & transportation													
	Sheet pile & others	F/T	40,000	1,900	76,000,000	1,940	77,600,000	2,000	80,000,000	2,100	84,000,000	2,200	88,000,000
				1,260,000,000		1,000,000,000		895,000,000		1,016,000,000		953,000,000	
Machinery													
	Gate and hoist	L.S.	—	402 ton	1,055,000,000	356 ton	795,000,000	348 ton	777,000,000	362 ton	810,000,000	364 ton	818,000,000
	(40 & 60% for gate & hoist resp.)												
	Electrics	L.S.	—		70,000,000		70,000,000		57,000,000		67,000,000		67,000,000
	Stop log	L.S.	—	84 ton	130,000,000	80 ton	130,000,000	18 ton	45,000,000	80 ton	134,000,000	24 ton	62,000,000
	Spare parts & others	L.S.	—		5,000,000		5,000,000		5,000,000		5,000,000		6,000,000
Total				1,801,541,710		1,560,621,682		1,453,940,140		1,630,691,680		1,592,320,724	

MEMO
1. Unit costs from attached tables.
2. Stoplogs for cases of 4 and 8 spans are those of present use.

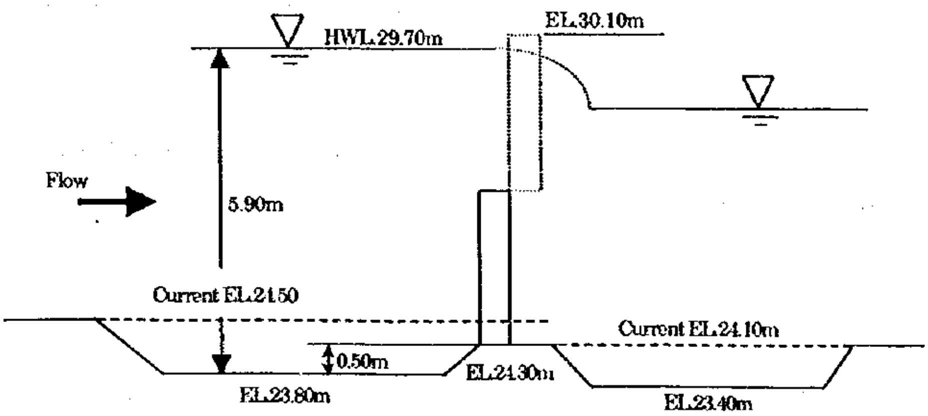
(5) Gate Top Elevation and Gate Height

Gate top elevation shall assure the existing gate top elevation (EL30.05) to be EL30.10m as the retention water level with retention capacity of $10^6 m^3$.

— Gate top elevation = (Gate sill elevation) + (Gate height)
= El 24.30 + 5.80
= El 30.10 m

— Gate height = (Design water level) - (Gate sill elevation) + (Freeboard)
= HWL 29.70 – El 24.30 + 0.40
= 5.80 m

(Water level and sill elevation)



(6) Crest Elevation of Top Slab on Weir Pillar

As HWL of upstream is 29.70, crest elevation of the side wall is determined EL 31.00 considering 1.30 m as freeboard. Height of weir pillar above crest of side wall is taken 10.0 m taking account of 1.07m for top slab thickness and height of mono-rail, 1.045 m for height of mono-rail, 1.335 m of allowance for installation/removal and 6.55 m for height of stop-log pillar. The elevation is accordingly EL 41.00.

Height of side wall = HWL + Freeboard
= HWL 29.70 + 1.30

= 31.00 m

Height of top slab = Height of side wall + Height of stop-log pillar + Allowance for installation/removal +Height of chain block + Height of rail + Top slab thickness

= EL 31.00 + 6.55 + 1.335 + 1.045 + 0.37 + 0.70

= EL 41.00 m

2) Upstream Apron Length

Upstream apron before the weir pillars will be extended to a triple-length of the pillar span (2.0 m x 3 = 6.0 m) as specified in the design criteria on "Headwork". A 0.80 m of the apron thickness will be employed considering 1/2 to 2/3 of the downstream apron thickness (1.50 m).

At the upstream end, placing of the apron slab into canal bed with reverse slope of 1:3 in 1.50 m-length is popularly practiced. However, considering economy for temporary work and the workability, a cut-off wall of 1.20 m in length will be applied instead at the place. In addition, riprap for canal bed protection against scouring will also be applied before the apron in a length equivalent to the gate span (10.0 m).

3) Downstream Apron Length

Length of the downstream apron to prevent piping or scouring shall be calculated from Bligh's Formula.

— Bligh's Formula

$L = 0.9C\sqrt{(H)}$

where,

L : Downstream apron length (m)

C : Bligh's coefficient, (C=15 for fine sand; from soil mechanical test)

H : Water head (m)

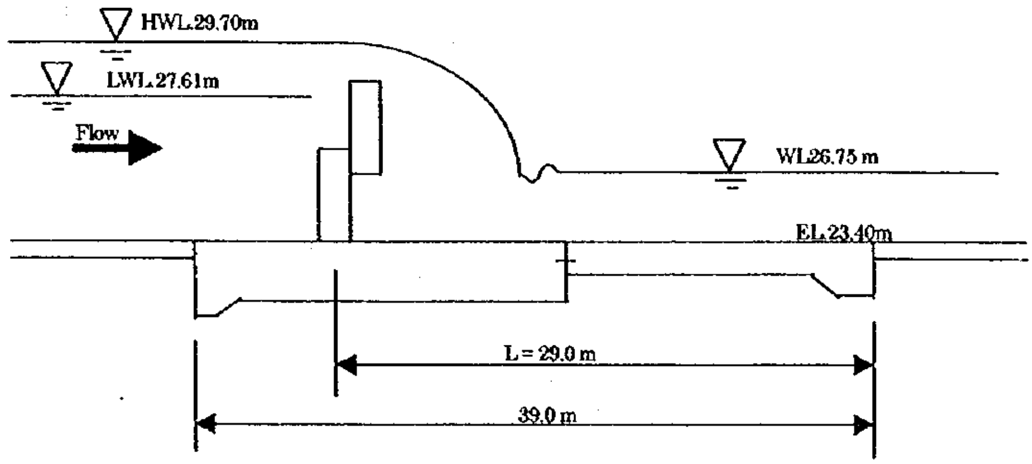
The water head shall be the water level differences between up- and downstream of the regulator. Larger water head, i.e. more critical condition, between "upstream HWL – downstream LWL" and "upstream LWL – downstream dry" shall be applied according to the design criteria of MPWWR.

- Upstream HWL (29.70m) – Downstream LWL (26.75m) = 2.95 m
- Upstream LWL (27.61m) – Downstream Apron (EL 23.40m) = 4.21 m

Therefore, the design water head is H=4.21m. Then,

$L = 0.9 \times 15 \times \sqrt{(4.2)} = 27.7\ m \fallingdotseq 29\ m$

Therefore, the downstream apron length shall be 29m.



4) Sheet Steel Pile Length for Water Stop

According to the result of boring and soil tests, the foundation layer is medium to fine sand with the coefficient of permeability (K) of 8.5 to 1.5×10^{-2} which is judged not impermeable (below 10^{-6}) but permeable. When a weir body is built on a permeable layer, sufficient creep length must be secured to control percolation water velocity and to prevent destruction of the foundation by piping. Therefore, necessary creep length against piping is examined below.

(1) Design Creep Length

- Vertical creep length Lv = (front apron thickness) + (upstream sheet pile)
  = 2.9m + (2×11.5m) = 25.9 m
- Horizontal creep length Lh = (apron length) + (gate upstream length)
  = 29m + 10m = 39.0 m

・Design creep length Lp = Lv+Lh = 25.9+31.0 = 64.9 m

(2) Examination on piping

— By Bligh's Formula

$Lp \geqq C \cdot H$

where, Lp : Design creep length (=64.9 m)

C : Bligh's coefficient, C=15 for fine sand

H : Maximum water head (H = 4.21 m)

Lp = 64.9 m > 15×4.21 = 63.2 m

Therefore, the structure is safe with the designed creep length.

— By Lane's Formula

$Lp' \geqq C' \cdot H$

Lp' : Weighted design creep length (m),

Lp' = Lv+1/3×Lh = 25.9+1/3×39.0

= 38.9 m

Lv : Vertical creep length (Lv = 25.9 m)

Lh : Horizontal creep length (Lh = 39.0 m)

C' : Weighted creep ratio (C' = 7.0)

H : Maximum water head (H = 4.21 m)

Lp' = 38.9 m > 7.0×4.21 = 29.5 m

Therefore, the structure is safe with the designed creep length.

Table 2-5 Bligh's Coefficient and Weighted Creep Ratio

Foundation	Bligh's C	Lane's Weighted Creep Ratio C'
Silt or Clay	18	8.5
Fine Sand	15	7.0
Medium Sand	-	6.0
Coarse Sand	12	5.0
Gravel/Sand Mix	9	-
Stone or Gravel	4~6	-

Source: "Headwork" for Land Improvement Project Standard, MAFF, Japan

As shown above, use of 12-m long water-tight sheet pile can secure safe creep length by both Bligh's and Lane's Formulae and therefore employed. Traverse directional creep length is equivalent to vertical one at the maximum section and becomes zero at water face. For safety, accordingly, sheet pile wall shall be extended in the traverse direction to the same length of longitudinal sheet pile.

5) Thickness of Apron

Thickness of the apron is to be the necessary thickness against uplift pressure.

— Applied formula

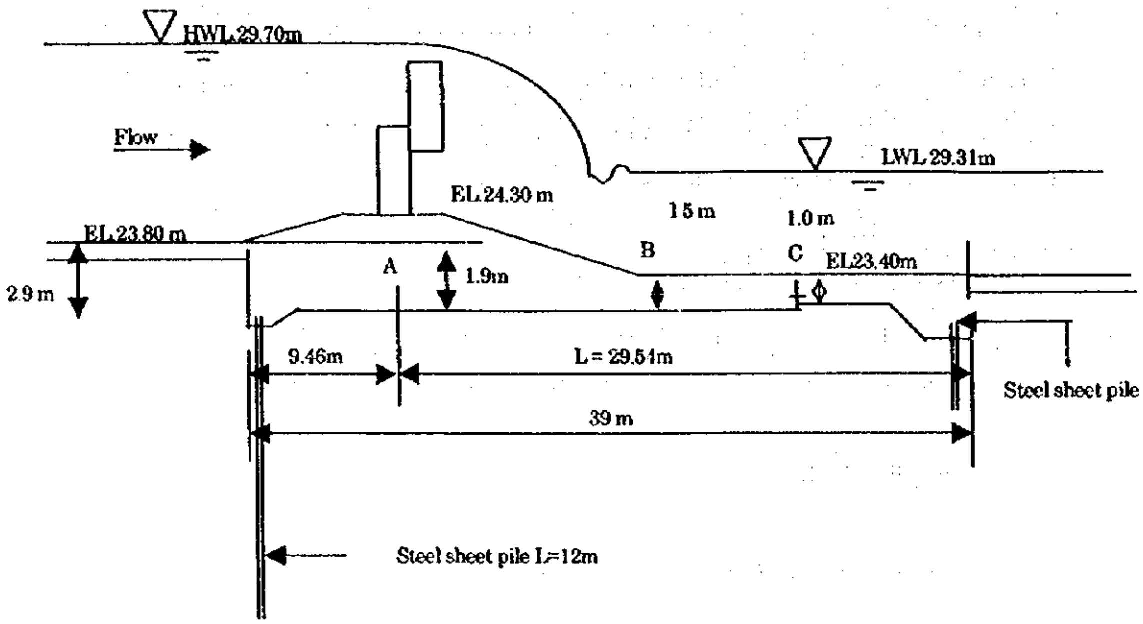
$$Ti \geqq 4/3 \cdot (H - Hf)/(\gamma - 1) \qquad Hf = H \cdot Li/L$$

where	Ti	: Apron thickness at certain point (m)
	H	: Maximum water head (H = 4.21m)
	Hf	: Head loss of percolated flow at certain point (m)
	γ	: Unit weight of reinforced concrete (2.35 tf/m^3)
	4/3	: Safety factor
	L	: Design creep length (L = 64.9m)
	Li	: Creep length at certain point (m)

If calculated at point A of the figure below:

$$Hf = 4.21 \times (2.9 + 2 \times 11.5 + 9)/64.9 = 2.29 \text{ m}$$
$$Ti = 4/3 \times (4.21 - 2.29)/(2.40 - 1) = 1.89 \text{ m} \fallingdotseq 1.90\text{m}$$

Therefore, the maximum apron thickness shall be 1.90m.



Calculated at B point by 5.7m downstream from beginning point, thickness becomes Ti = 1.49m. Calculated at C point by 29.0m downstream from beginning point, thickness comes to Ti = 0.64m, but from the structural calculation, thickness shall be 1.0m.

6) Bed Protection Length

For prevention of canal bed from scouring, the bed protection shall be provided. The length of the bed protection is determined from the following formula.

— Applied formula

$$L = L_B \cdot La$$
$$L_B = 0.67 \cdot C \cdot \sqrt{(H \cdot q)} \cdot f$$

where,

L	:	Length of bed protection work (m)
L_B	:	Length of total bed protection (m)
La	:	Downstream apron length (La = 29.0 m)
H	:	Water head (H = 2.95 m)
		HWL 29.7 m at upstream
		LWL 26.75 m at downstream

q	: Unit discharge per meter at design discharge ($q = 5.87\ m^3/sec/m$)
f	: Safety factor (1.5)
C	: Bligh's coefficient ($C = 15$)

q = $187.79\ m^3/sec / 32\ m = 5.87\ m^3/sec/m$

LB = $0.67 \times 15 \times \sqrt{(2.95 \times 5.87)} \times 1.5 = 62.7$ m

L = $62.7 - 29.0 = 17.7 \fallingdotseq 33.7$ m

Therefore, the length of bed protection work shall be 35 m.

The canal bed protection shall be designed to be not only stable against canal flow but also flexible against canal bed scouring. For stability against flow velocity, protection structure shall have enough weight. In general natural stones or concrete blocks or gabions are used depending on availability of the materials. In this project, gabions are employed considering the unavailability of large size stones and easiness in fabricating gabions for 15.0 m in length and riprap for 20.0 min length.

(1) Gabion

The weight of gabion per unit shall satisfy the weight calculated by the following formula;

— Applied formula

$$W > 3.75 \cdot A \cdot V^2/2g$$

where,

W	: Weight of gabion (tf)
A	: Area to reigist flow (m^2)
V	: Flow velocity on gabion (m/sec)
g	: Acceleration by gravity (9.8 m/sec^2)

Assuming the gabion size to be 0.5m×1.2m×2.0m and unit weight of stone for gabion to be $1.8t/m^3$,

W = $0.5 \times 1.2 \times 2.0 \times 1.8 = 2.16$ t

A = $0.5 \times 1.2 = 0.6\ m^2$

V = 4.0 m/sec (assumed maximum velocity on gabion)

$W = 2.16 > 3.75 \times 0.6 \times 4.0^2/2/9.8 = 1.84$ t

Therefore, safety of the designed gabion is secured against high velocity up to 4.0m/sec.

(2) Rip Rap (Bed protection)

Riprap shall be placed at the end of gabion in order to make smooth in flow. The average velocity will be reduce to 0.70 m/s at the end of gabion so that the average diameter of riprap shall be calculated form a following formula by using extra coefficient of velocity as $\alpha = 1.1$.

$$D = 1 / \{(E_1^2 \cdot 2g(\rho s/\rho - 1)\} \cdot Vo^2 \text{ (m)}$$

Where,
- D : Average diameter ρ riprap (m)
- Vo : Velocity (0.8m/sec)
- E_1 : 1.2(experimental coefficient)
- g : Acceleration by gravity (9.8m/sec²)
- ρs : Density of stone (2.65 tf/m³)
- ρ : Density of water (1.0 tf/ m³)

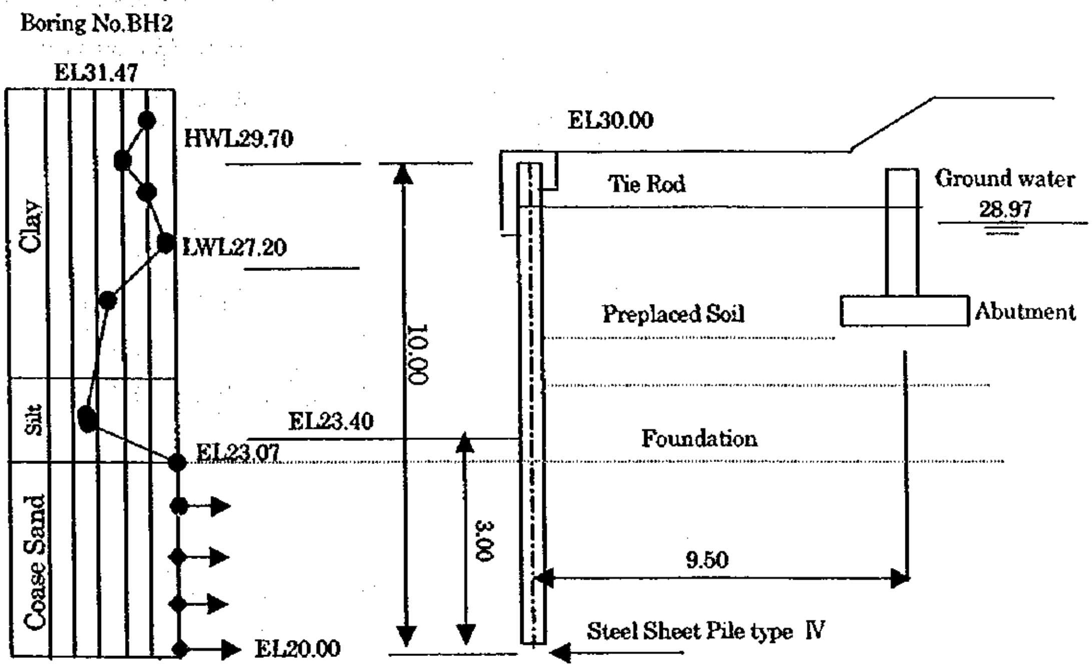
$$D > 1 / \{(1.2^2 \times 2 \times 9.8(2.65 - 1)\} \times 0.8^2 = 0.018$$

The average size of riprap shall be 50 cm because unit price for 50 cm of diameter of stone is cheaper than 2 cm of diameter of stone and will be more stable even though the calculation indicates 2 cm size of stone.

7) Miscellaneous Works

(1) Shore Protection

(a) Steel Sheet Pile



(b) Rip Rap (slope protection)

Required minimum weight of riprap piece for surface protection depends on wave height, wave cycle, water depth, slope gradient, method of placing, etc. The weight can be determined by Hadson's Formula as follows.

$$W = (\gamma r H3) / Kd ((\gamma r / w) - 1)3 \quad \cot \alpha)$$

Where, W : Weight of riprap on slope (ton)

γr : Unit weight of riprap (= 1.8 tf/m^3)

w : Unit weight of water (= 1.0 tf/m^3)

α : Slope gradient in degree(= 27 for 1:2)

H : Wave height before slope (= 0.5 m)

Kd : A constant dependent on material (= 4.0 for angular)

$$W = (1.8 \times 0.53) / (4.0 ((1.8 / 1.0) - 1) 3 \cot 27$$
$$= 0.225 / 4.019$$
$$= 0.056 \text{ (ton)}$$

Calibrating the weight into size of round boulder, the volume becomes 21,500 cm^3 by applying a unit weight of 2.6 and the diameter becomes 17.25 cm by assuming sphere-shape. Consequently stone larger than 18 cm in diameter will be used for the protection. Stone with 50 cm in diameter is recommended as the unit price of big size stone is cheaper.

(2) Closure Dike

During construction stage the required water shall be discharged through the left side remained gates of the existing regulator, and this part of the regulator shall be closed with the dike. The shore protection for the closure dike shall be examined with three types of works.

(a) Rip Rap on Both Side of Dike;

The both slopes of the dike are covered with rip-rap. The construction area for the dike shall be closed with double sheet pile coffering. The whole existing regulator shall be demolished before backfilling commenced in order to reduce sepage alonging with the structure if the existing structure will not be demolished.

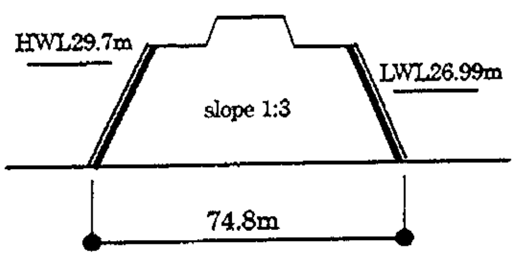
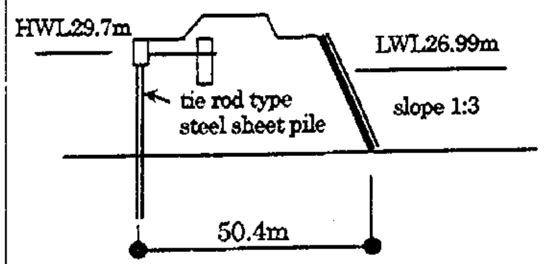
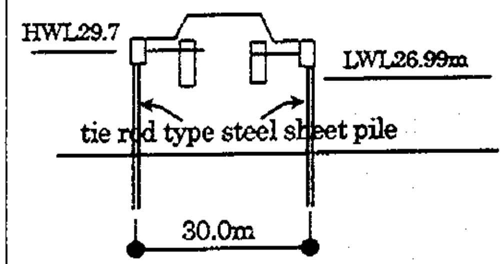
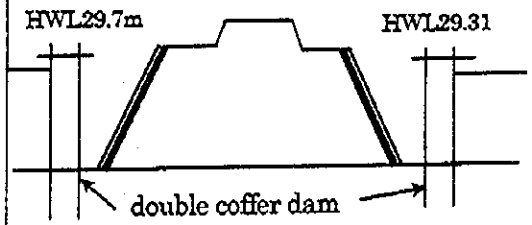
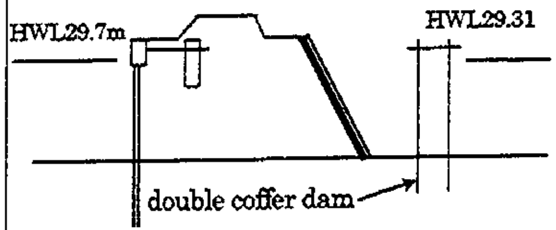
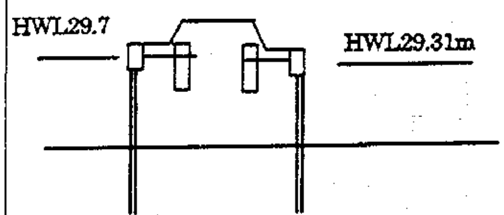
(b) Steel Sheet Pile and Riprap;

Upstream shore of the dike shall be protected by the steel sheet piles which are used on the temporary closure. Downstream shore of the dike shall be protected by riprap. During the construction of downstream dike the double coffer dam shall be constructed by steel sheet pile as temporary closure. The existing regulator shall be demolished due to the reason mentioned above.

(c) Steel Sheet Piles on Both Side of Dike;

The both side of dike shall be protected by the steel sheet piles which are used on the temporary closure. Temporary closure is not necessary during construction of the dike because the sheet pile works as closure. The existing regulator shall be demolished only at some part which may effect on the construction for the road embankment. All sections for alternative plan are safe for the piping and stability as the results of examination. The steel sheet pile on both side of dike are selected taking economic, construction period, workability and environmental favorability as shown in table 2-6.

Table 2-6 Alternative plan for the closure dike protection

	Riprap on both sides of dike plan 1	Steel sheet pile on upstream of dike, Riprap on downstream of dike plan 2	Steel sheet piles on both sides of dike plan 3
Structural figure			
Temporary closure work			
Direct Construction Cost	220million yen	200 million yen	150 million yen
Work Period	9 months	7.5 months	6 months
Workability	Double coffer dams are required for the construction on both sides. Detour period of the existing road is longer than others and shape of alignment of temporary road is worse. The order of construction is complicated.	Double coffer dam is required on downstream. The workability is easier than the plan.	The existing road able to be used up to completion of the installation of the steel sheet piles.

2-3-4 Gate Section

1) Gate Type

The following gate types may be taken into consideration for the Mazoura Regulator, as the major purpose is to regulate discharge and water level of the Bahr Yusef Canal.

(a) Single leaf roller gate

(b) Radial gate

(c) Double leaf roller gate (slide-type)

(d) Roller gate with flap

In Egypt, double leaf sluice gates have been used for a very long time. The gates of this type control water level by operating the lower leaf to release underflow water. The gates are small in size and operated by movable chain-block-type winches. Many of gates of this type, however, have been superannuated and can not be operated smoothly and efficiently due to mechanical deterioration and deformation of gate body.

Single leaf roller gates are the underflow water release type by which water level adjustment is difficult in the small opening condition. If gates are continuously operated within the domain of wave motion, which arises from the relation between up- and downstream water levels and the degree of gate opening, the gate body might cause vibration and endanger the structure. High flow velocity due to underflow water may damage canal beds, and the height of pier becomes higher as the water depth becomes deep. Moreover, frequent gate operation will induce fatigue of wire ropes and haunting of the motor due to heavy winding load by deep water pressure. Therefore, single leaf roller gates are not recommendable for the Mazoura Regulator.

Recently in Egypt, radial gates have been used for small size regulators. Radial gates can be employed for small sized shallow canals, however they are not well suited to large scale deep water canals like the Bahr Yusef Canal. The reason is the high manufacturing and installation costs of large radial gates. Large gates require large structures with long arms and hinges above water. Furthermore, similarly to single leaf roller gates, the water level control capacity of radial gates in small opening is limited due to the underflow water and high discharge velocity, and this may damage the canal beds.

Roller gates with flap are one of the most popular types of gates used for both discharge and water level control in Japan because of its simple water-tight structure and easy gate operation. In Egypt, however, there is no experience of this type in the past due to unstable power supply and complex gate body structure.

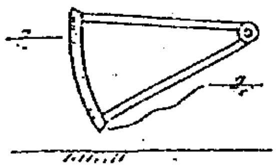
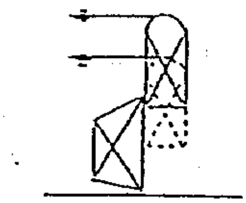
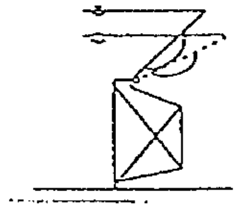
Double-leaf roller gates are widely used in rivers and canals because of its simple gate structure and reliable water-tightness. Advantages of this type of gates are to enable effective water level control by operating the upper leaf and maintaining the lower leaf closed, and in case of having large differences in the water levels between up- and downstream, overflow from the upper leaf will bring a dissipation effect.

From such points of view, double-leaf roller gates shall be employed for the Mazoura Regulator. Double-leaf roller gates are the same gate type used for the Lahoun Regulator in 1997, and therefore the same gate type is to be employed considering the operation and maintenance convenience by MPWWR and the future plan for the integrated water supply control system of the Bahr Yusef Canal. Merits and demerits of these types of gates are shown in Table 2-7.

2) Lifting Device of the Gates

The slowdown ration of gear becomes approximately 1/2000 in case of drum pinion gear. The drum shaft direct connection type lifting device shall be selected from the view point of the maintenance and installation space. Even if the drum-pinion gear was adopted the operation time to open will be 24 hours. Therefore the power source shall be public electric power and diesel generator shall be provided as share power source.

Table 2-7 Comparative Table for Gate Selection

Description	Radial Gate	Double Leaf Roller Gate (Slide Type)	Roller Gate with Flap
Plan			
Operation System	Gate is operated rotationally with underflow water release system.	Gates are operated up and downward with overflow water release system.	Flap gate is operated falling backward and raising up with overflow water release system. Roller gate is operated up and downward.
Control Capacity	Downstream water level control capacity under small opening is limited due to underflow water.	Downstream water level control under small opening is easy due to overflow water.	Downstream water level control under small opening is fair due to overflow water.
Merit	• Pier structure is not necessary. • Large water can be discharged at small opening due to underflow water release. • Gate operation load is small because of its rotational winding.	• Easy water level control due to overflow water. • Normal water is released with upper gate only, thus operation cost is low. • Gate body maintenance is easy.	• Water level control is easier than radial gate. • Flap gate operation is free from sediment. • Pier structure becomes smaller than double leaf roller gate. • Flap gate can be operated at small winding load, thus operation cost becomes low.
Demerit	• Energy dissipater for released water is necessary. • Delicate water level control is difficult. • Gate body is complex and heavy, about 1.5 times of roller gate. • Replacement of hinge is quite difficult.	• Gate mechanical system is rather complex. • Watertight efficiency may be lowered if flowing objectives are caught at gate guides.	• Gate body structure is complex. • Water control capacity at small water flow is inferior to double leaf roller gate. • Gate body maintenance is inconvenient because flap and roller gates are one structure.
Consider-ation	• Not recommendable mainly due to high manufacturing cost, poor water level control capacity and inconvenient gate maintenance. • This gate is normally used for dam wasteway as large water can be released under small opening.	• Recommendable due to easy gate operation with separated gate leaves, easy water level adjustment with overflow water release and easy gate maintenance.	• Less recommendable due to less water level control capacity and non-experience of this type of gate in Egypt.
Judgement	×	○	△

3) Design specification of the Gate

The Design specification shall be shown in the table 2-8 as the result.

Table 2-8 Design Specification of the Gate

Type		Steel Double Leaf Rotter Gate
Number of Gate		4 Gates
Clear Span		8.00 m
Total Gate Height		5.60 m
Design Water Level	Front	RWL 30.10 m
	Rear	EL 24.30 m
Operation Water Level	Front	HHWL 30.10 m
	Rear	EL 24.30 m
Control Water Level		HWL 29.70 m
Gate Sill		EL 24.30 m
Water Seal Method		Three Way, Rubber Seal
Hoisting Type		Electric Powered Wire Rope Winding Type
Operation Speed		0.3m/min
Lifting Height		Upper Leaf 9.85 m
Control Type		Local and Remote Control

2-3-5 Structural Calculation

1) Foundation

Elevation of the apron sill is EL. 21.90m, around 10m deep from the ground surface. According to the Feasibility Study Report, foundation layer is medium to fine sand containing some silt with N-value of 20, then a hard layer with more than 50 in N-value continues below 13m from the ground surface.

According to the result of boring survey conducted during the field survey, the foundation layer is very hard medium to fine sand with 0.93 of relative density and more than 50 of N-values.

Terzagi's Formula is applied for calculating the allowable bearing capacity of the foundation layer.

— Terzagi's Formula

$$qa = 1/3 \times qu$$
$$qu = \alpha \cdot c \cdot Nc + \beta \cdot \gamma 1 \cdot B \cdot Nr + \gamma 2 \cdot Df \cdot Nq$$

where,

qa	:	Allowable bearing capacity (tf/m^2)
qu	:	Ultimate bearing capacity (tf/m^2)
c	:	Cohesion of foundation layer (tf/m^2)
$\gamma 1$	:	Unit soil weight under foundation (tf/m^3) (Submerged unit weight is adopted for soils below water table)
$\gamma 2$	:	Unit soil weight above foundation (tf/m^3) (Submerged unit weight is adopted for soils below water table)
α, β	:	Form factor
Nc,Nr,Nq	:	Bearing capacity factor (Function of internal friction ϕ)
Df	:	Depth of foundation from the lowest ground level near the foundation (m)
B	:	Smallest width of foundation (m)

The result of examination is presented in Table 2-9. As shown in the Table, the allowable bearing capacity of foundation layer is more than the design load, therefore the direct foundation is applied to the new Mazoura Regulator.

Table 2-9 Calculation of Allowable Bearing Capacity

Item	Number of Bore-hole	
	B-1,B-2	B-7 at F/S
Average N-value	50	20
Internal Friction ϕ	42	35
Form Factor α	1.3	1.3
Cohesion C (tf/m^2)	0.0	0.0
Bearing Capacity Factor Nc	95.7	36.0
Form Factor β	0.4	0.4
Unit Weight γ1 (tf/m^3)	0.9	0.8
Smallest Width of Foundation B (m)	36.0	36.0
Bearing Capacity Factor Nr	114.0	25.0
Unit Weight γ2 (tf/m^3)	0.9	0.8
Penetration Depth Df (m)	0.0	0.0
Bearing Capacity Factor Nq	83.2	29.0
Ultimate Bearing Capacity qu (tf/m^2)	1,477.4	288.0
Allowable Bearing Capacity qa (tf/m^2)	492.5	96.0
Width of Structure (m)	41.0	41.0
Weight of Concrete Structure (tf)	552.0	552.0
Weight of Water (tf)	189.0	189.0
Weight of Gate and Equipment (tf)	176.0	176.0
Total Weight (tf)	917.0	917.0
Total Load (tf/m^2)	22.4	22.4
Judgement	Safe	Safe

2) Stability of Weir Pillar

(1) Study Conditions

(a) Examination Case

Following 7 cases will be examined on stability of pillars.

Case 1 ; Stability on flood time, gate-open & normal loads in flow direction

Case 2 ; Stability on low water, gate-closed, normal loads, 0.30 m-overtopping flow above gate & 0.70 m-sediment before gate in flow direction

Case 3 ; Stability on low water, gate-close, seismic loads(downstream direction), 0.30 m-overtopping flow above gate & 0.70 m-sediment before gate in flow direction

Case 4 ; Stability on low water, gate-close, seismic loads(downstream direction), 0.30 m-overtopping flow above gate & 0.70 m-sediment before gate in traverse direction

Case 5 ; Stability on no flow, gate-opened, normal loads in flow direction

Case 6 ; Stability on no flow, gate opened & seismic loads (downstream direction) in flow direction

Case 7 ; Stability on no flow, gate-opened & seismic loads in traverse direction

(b) Load

Combination of loads by cases is as shown in Table 2-10, and simultaneous combinations of flood & seismic loads, wind load & seismic load and live loads and seismic loads, are not assumed.

(c) Safety Condition

Required safety conditions against failure are applied as follows.

Stability Against	Safety Condition	
	Normal Time	Quake Time
Overturn	$e \leq B/6$	$e \leq B/6$
Sliding	$Fa \geq 1.5$	$Fa \geq 1.2$
Base Load	$Q \leq Qa$	$Q' \leq Qa'$

N.B. Weir pillars are quite important structure that the resultant force shall be within middle-third if the base in both normal and quake times.

(d) Results of Stability Examination

The results of stability for the Regulator are safe as shown in the table 2-11.

Table 2-10 Combination of Loads by Examination Case

	Condition & Load Case	1	2	3	4	5	6	7
Condition	Water Flow	Flood	Low Water	Low Water	Low Water	No Water	No Water	No Water
	Gate	Open	Close	Close	Close	Open	Open	Open
	Normal/Quake	Normal	Normal	Quake	Quake	Normal	Quake	Quake
	Direction	Flow	Flow	Flow	Traverse at Right & Left Ends	Flow	Flow	Traverse at Right & Left Ends
Vertical Load	Wo :Pillar Weight	○	○	○	○	○	○	○
	W1 :Machine Room	○	○	○	○	○	○	○
	W2 :Gate	○	○	○	○	○	○	○
	W3 :Hoist	○	○	○	○	○	○	○
	W4 :Ope. Platform	○	○	○	○	○	○	○
	Ww :Water	○	○	○	○			
	U :Uplift	○	○	○	○			
	W5 :Snow Load		○					
	W6 :Earth				○		○	○
	KhWo : Pillar			○	○		○	○
	KhW1 :Machine Room			○	○		○	○
	KhW2 : Gate			○	○		○	○
	KhW3 : Hoist			○	○		○	○
	KhW4 :Ope. Platform			○	○		○	○
	KhW5 :Snow							
Horizontal Load	Pw1 :Wind to Gate	○				○		
	Pw2 :Wind to Pillar	○	○			○		
	Pw3 :Wind to Machine Room	○	○			○		
	Pg :Static water Pressure to Gate		○	○				
	Pp :Static water Pressure to Pillar	○	○	○				
	Pδ1 :Dynamic W. Pressure to Gate			○				
	Pδ2 :Dynamic W. Pressure to Pillar			○				
	Pe1 :Sediment Pressure		○	○				
	Pi :Ice Pressure		○					
	Pe2 :Earth Pressure				○			○
	KhPe2 :Seismic Earth Pressure						○	○

Table 2-11 Results for Stability

Pier \ Item	case	N or E	Direction	Vertical Load ΣV (tf)	Resistant Moment ΣV・x (tf・m)	Horizontal Moment ΣH (tf)	Tilting Moment ΣH・y (tf・m)	Examination for Sliding: Shearing τ (kgf/cm²)	Examination for Sliding: Sliding F	Examination for Tilting Moment: Eccentricity of Base reaction e (m)	Examination for Tilting Moment: B/6 (m)	Examination for Bearing Capacity of the Soil: Reaction Forth Q1 (tf/m²)	Examination for Bearing Capacity of the Soil: Reaction Forth Q2 (tf/m²)	Bearing Capacity (tf/m²)
Middle Pier	①	N	F	3466.50	51802.65	27.63	343.63	0.01≦3.6	87.20≧1.5	-0.10	≦ 4.92	11.53	11.98	—
	②	N	F	2026.67	29162.61	236.62	1089.65	0.12≦3.6	6.00≧1.5	-0.90	≦ 4.92	5.62	8.13	—
	③	E	F	1836.67	27585.61	822.42	3556.77	0.42≦5.4	1.56≧1.2	-1.67	≦ 4.92	4.12	8.34	—
	④	E	A	1836.67	9183.31	574.57	2558.52	0.29≦5.4	2.24≧1.2	1.39	≦ 1.67	11.43	1.02	—
	⑤	N	F	2981.48	43340.28	31.52	363.47	0.02≦3.6	66.21≧1.5	0.34	≦ 4.92	10.80	9.42	—
	⑥	E	F	2791.48	39312.28	554.30	2457.16	0.28≦5.4	3.53≧1.2	1.55	≦ 4.92	12.44	6.49	—
	⑦	E	A	2791.48	13957.38	554.30	2457.16	0.28≦5.4	3.53≧1.2	0.88	≦ 1.67	14.46	4.47	—
Side Pier	①	N	F	4286.49	63099.96	27.63	343.64	0.01≦3.6	93.08≧1.5	0.11	≦ 4.92	14.85	14.21	—
	②	N	F	3543.93	50636.34	146.84	700.60	0.08≦3.6	14.48≧1.5	-0.66	≦ 4.92	10.40	13.63	—
	③	E	F	3423.93	49640.34	1068.36	9644.72	0.54≦5.4	1.92≧1.2	-3.07	≦ 4.92	4.36	18.85	—
	④	E	A	3423.94	10777.55	0.00	620.86	0.00≦5.4	∞ ≧1.2	-2.03	≦ 1.67	-2.56	25.77	—
	⑤	N	F	4585.11	66931.38	31.52	363.47	0.02≦3.6	87.28≧1.5	0.23	≦ 4.92	16.28	14.81	—
	⑥	E	F	4465.11	64387.39	552.25	2091.13	0.28≦5.4	4.85≧1.2	0.80	≦ 4.92	17.59	12.68	—
	⑦	E	A	4465.11	27516.29	0.00	627.95	0.00≦5.4	∞ ≧1.2	1.02	≦ 1.67	24.42	5.86	—

3) Structural Design of Side Wall

Structural calculation of a side wall is carried out considering quake forth as the maximum load condition at cross sectional direction. For the flow direction, it is enough to give the same amount of reinforcing bars with the calculation result of cross sectional direction because the side wall has enough length in flow direction.

(1) Loads

Such loads on side wall are considered as a side wall weight, gate weight, lifting device, reaction forth of attached bridge, seismic forth, hydrostatic pressure, dynamic water pressure and earth pressure. The gate locations are opened and lifted considering such location as maximum load.

(2) Stress Calculation

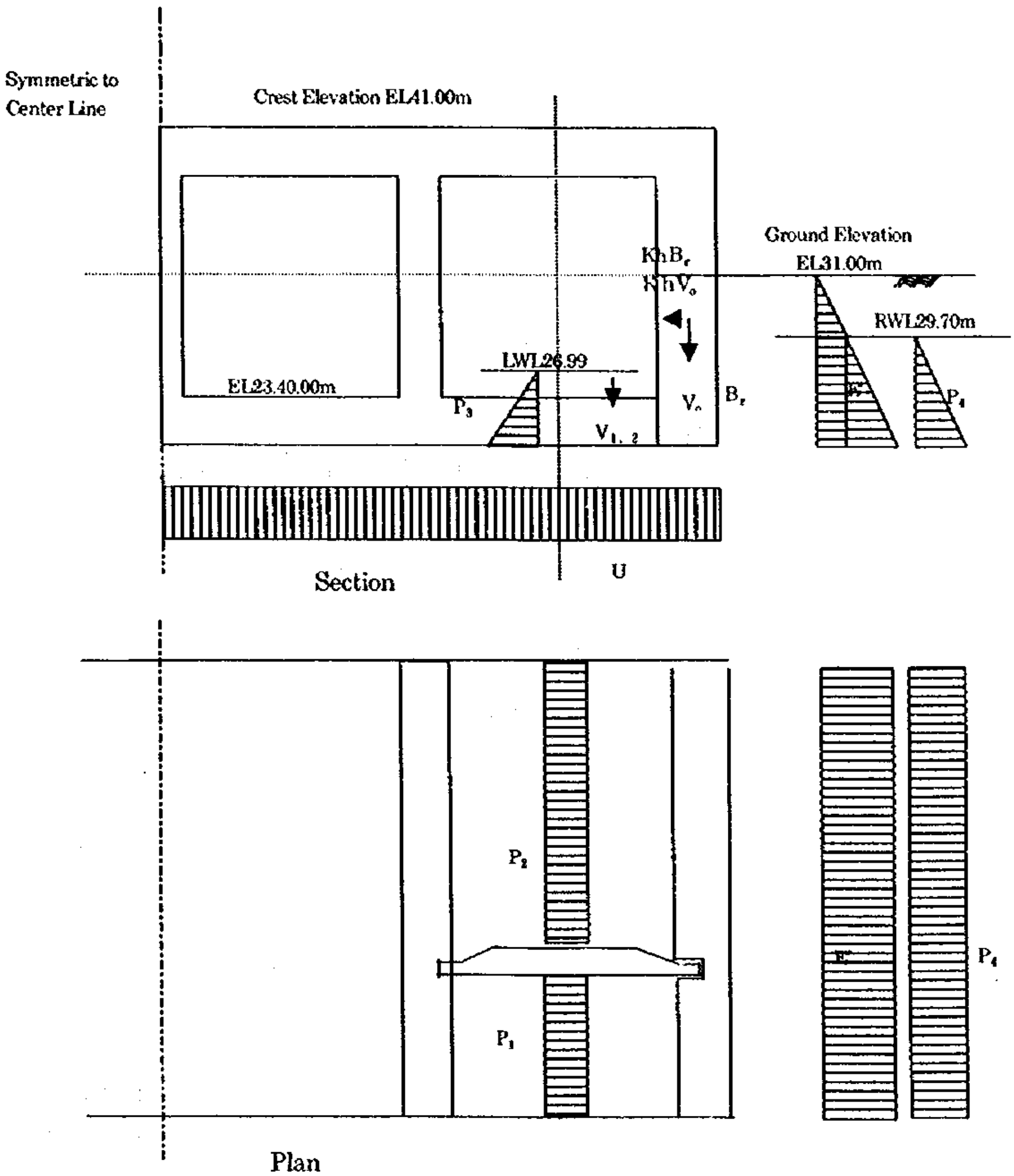
Stress calculation is examined considering a side wall as a cantilever beam at a side wall with a pier 5 which is effected by earth pressure. Calculation results are summarized as below.

Sectional Dimension	b=	100.0cm	Reinforcing Bars		
	h=	130.0cm	Diameter	D29cm	
	d=	120.0cm	Pitch	@200mm	
Bending Moment	M=	196.01tf・m	Amount	As=32.12cm²	
				As=32.12cm²	
			Stress	σc=68kgf/cm²	< 105
Shearing Forth	S=	58.95tf		σs=2574kgf/cm²	< 2700
				$\sigma s'$=939kgf/cm²	< 9
				τm=5.5kgf/cm²	

(3) Load Conditions

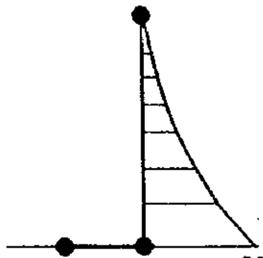
The load conditions are shown in Fig 2-4.

Fig 2-4 Loads Diagram at Seismic Condition for Right Side (Side Wall)



E'	; Seismic Earth Pressure	987.1 tf
V_o	; Vertical Load	996.6 tf
$V_{1,2}$	; Internal Water Weight	3.6 tf
KhVo	; Seismic Inertia force	199.3 tf
$P_{1,2,3}$	; Internal Water Pressure	-467.3 tf
P_4	; Ground Water Pressure	776.6 tf
U	; Uplift Reactive Force	-38.4 tf/m^2
M	; Moment	209.8 tf·m

(4) Maximum Bending Moment



Moment M=209.79tf

4) Structural Design of Floor Slab

(1) Loads

Slab weight, water weight, uplift, reaction forth from ground, sedimentation weight are considered for structural design.

(2) Stress Calculation

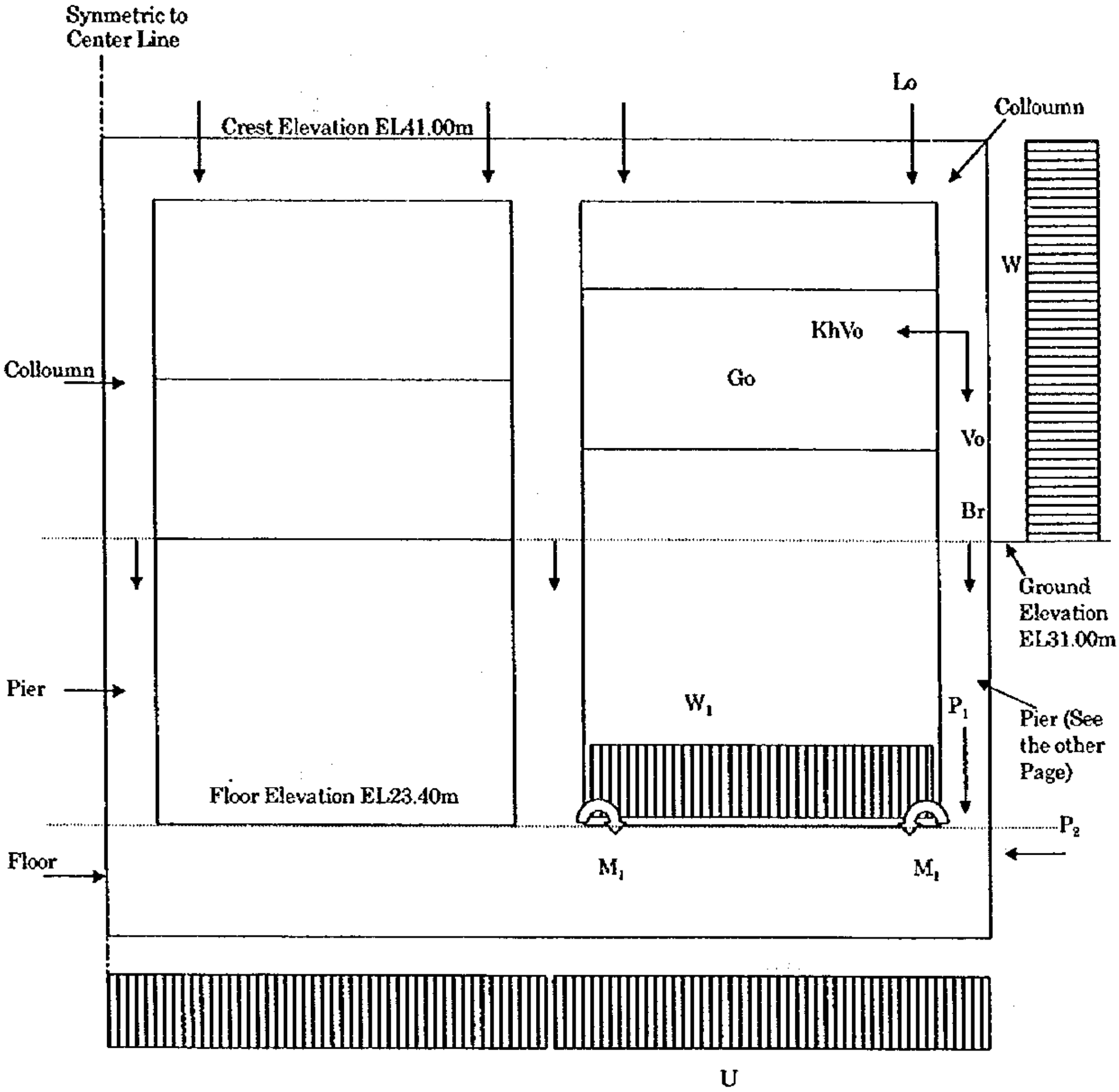
Stress is calculated regarding floor slab as single beam with both side fixed condition. The calculating point is 13.3m from the end of the lower reaches, where the load condition is the severest.

Sectional Dimension	b=	100.0cm	Reinforcing Bars(side part)			
	h=	150.0cm	Diameter	As D25mm		
				As' D19mm		
	d=	140.0cm	Pitch	@200mm		
Bending Moment			Amount	2.12cm²		
center part	M=	141.94tf・m	Stress	σc=56.1kg/cm²	<105	
side part	M=	198.7tf・m		σs=2426kg/cm²	<2700	
				σs=624kg/cm²		

(3) Load Conditions

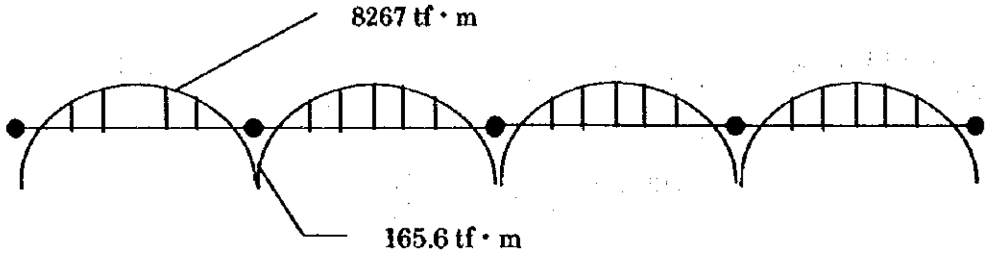
The load conditions are shown in Fig 2-5.

Fig 2-5 Loads Diagram for Floor and Colloumn



W_2	; Wind Load	0.3 tf/m²
V_o	; Vertical Load	996.6 tf/m²
$V_{1,2}$	; Internal Water Weight	3.6 tf/m²
KhVo	; Seismic Inertia Force	199.3 tf/m
$P_{1,2,3}$	; Internal Water Pressure	-467.3 tf
P_4	; Ground Water Pressure	776.6 tf
U	; Uplift and Reaction Force	-38.4 tf/m²
L_o	; Weight of Lifting Devices	41/2 tf
G_o	; Weight of Gates	30/2 tf
B_r	; Reaction Force from Bridge	54×4 tf

(4) Maximum Bending Moment



5) Structural Design of Pillar

(1) Basic Load

Load 1 : Dead loads including machinery

Load 2 : Wind loads

Load 3 : Live loads (100% for 4 middle gates)

Load 4 : Inertia loads (quake time)

Load 5 : Mono-rail load (live load)

Load 6 : Live loads (300% for 1 of 4 gates

Load 7 : Live loads (100% for 3 gates and 300% for 1 gate)

Load 8 : Live loads (100% for 3 gates and 300% for 1 gate)

Load 9 : Live loads (inertia force of gate)

(2) Load Combination

Load case 1 : Loads 1+3+5

Load case 2 : Loads 1+2+6

Load case 3 : Loads 1+7

Load case 4 : Loads 1+8

Load case 5 : Loads 1+4

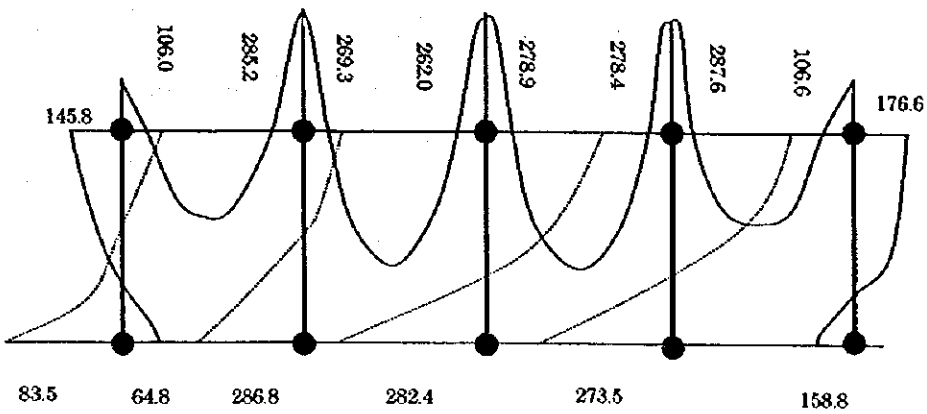
Load case 6 : Loads 1+4+9

(3) Structural Calculation and Reinforcement Content

By applying the above combinations of loads, stresses of members at required positions of the assumed dimensions of structure have been worked out, and the required reinforcement content has also been calculated therefrom.

Maximum Bending Moment

(Unit : tf・m)



2-3-6 Scale of Regulator

The scale of the regulator shall be shown in the table below as the result of structural calculation. The design drawings for rehabilitation and improve of the Mazoura regulator are attached in Appendix as Basic Design Drawings.

Regulator	: 8.0 m × 4 gates
Gate Height	: 5.8 m
Total Width of Regulator	: 40.6 m
Regulator Body	: Direct foundation, Reinforced concrete Pier height 17.20 m
Attached Bridge	: Total width 12.8 m (Drive way 10.0m, Pedestrian way 1.0m×2, Curve 0.40m×2)
Gate	: Steel two leaf roller gates wire rope winch type
Bed Protection	: Gabion W38.0 m × L20.0 m
Shore Protection	: Steel sheet pile protection
Control House	: Concrete block, 1 story house with a operation room and a generator room. Total area is 87 m^2.

2-4 Project Implementation and Operation

2-4-1 The Executing Agency

An executing Agency shall be Irrigation Department (ID) of MPWWR and Irrigation Improvement Sector (IIS) shall carry out the substantial project services. The IIS in Benisuef Province shall take charge of the work in the Project site under administration of ID in the Benisuef Government. The Asian and Japan Section of MOIC shall be in charge of such foreign cooperative services as the International cooperation and Grant did.

1) Ministry of Public Works and Water Resources (MPWWR)

MPWWR is composed of ten (10) departments such as Irrigation Department, Planning sector, Egyptian Public Authority for Drainage Projects, General Authority for Survey, General Authority for the High Dam and Aswan Reservoir, General Authority for Coast Protection, North Sainai Development Organization, Mechanical and Electrical Department, Financial Affairs and Administrative Development Department, and Water Research Center. MPWWR is in charge of services for water and administrates in planning and management concerning with water resources, irrigation and drainage canal and related facilities as well as construction, rehabilitation and Improvement. Organization of MPWWR is shown in Fig. 2-6.

2) Irrigation Department (ID)

Irrigation Department (ID) of MPWWR is composed of four sectors such as Irrigation Sector (IS), Horizontal Expansion and Project Sector (HEPS), Reserver and Great Barrages Sector (RGBS), and Irrigation Improvement Sector (IIS). IS is composed of 21 directorates including Benisuef Directorates which will be in charge of managing water control for post Construction of Mazoura Regulator. HEPS will arrange water to new reclamation area. RGBS will take the maintenance rehabilitation and improvement services to the facilities in the main Canal system such as Mazoura Regulator. The construction works will be taken by the IIS. Organization of ID is shown in Fig. 2-6.

3) Irrigation Improvement Sector (IIS)

IIS, which is the executing agency of the project up to construction works, is in charge of projects for improvement and rehabilitation of superannuated facilities including private small canals such as Mesca · Marwa and projects for improvement of agricultural rural infrastructures to increase productions by improve irrigation methods. IIS has five directorates in Esna, Minia, Zagagig, Tanta and Damanhour province as well as subordinate in each province. IIS in Benisuef province is a subordinate of Minia directorate of IIS. Fig 2-6 and Fig 2-7 show the organization chart of IIS and Benisuef directorate respectively. Fig 2-8 shows the organization of Somosta district office to carry out irrigation services.

2-4-2 Personnel and Engineering Level

IIS takes services related this Project for plan, survey, detailed design tender, construction supervision, securing budget, conducting necessary procedures, negotiation with other Ministry, and so forth. After construction, Benisuef Irrigation Directorate will manage Operation and maintenance works of the Regulator.

IIS has implemented many international cooperation projects with USAID, World Bank, the Netherlands as well as Japan. Benisuef Directorate has electric engineers as well as civil and irrigation engineers and has carried out maintenance work for many mordern facilities. Therefore their engineering level is high.

However the construction of the electric powered gate at Lahoun Regulator was first experience for the Benisuef directorate even though modern electric powered pumps has been constructed at many places. Therefore the On the job Training (OJT), concerning operation, check, maintenance for the facilities, shall be conducted to the electric engineers by the contractor. Moreover, the operators shall be trained for daily check, clean, simple maintenance ways on OJT.

Figure 2-6 Organization Chart of MPWWR

(as of March 1998)

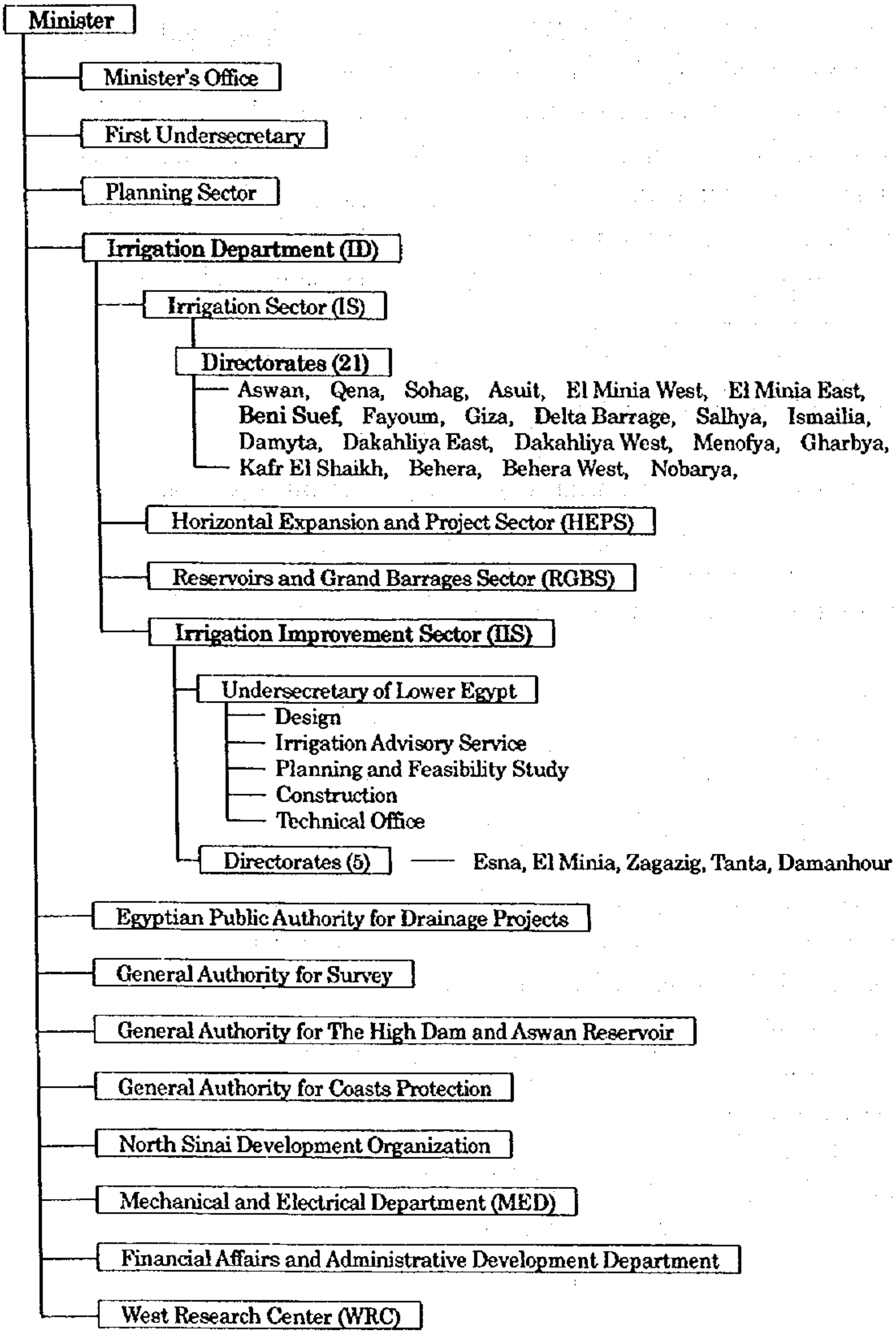


Figure 2-7 Organization Chart of Beni Suef Irrigation Directorate

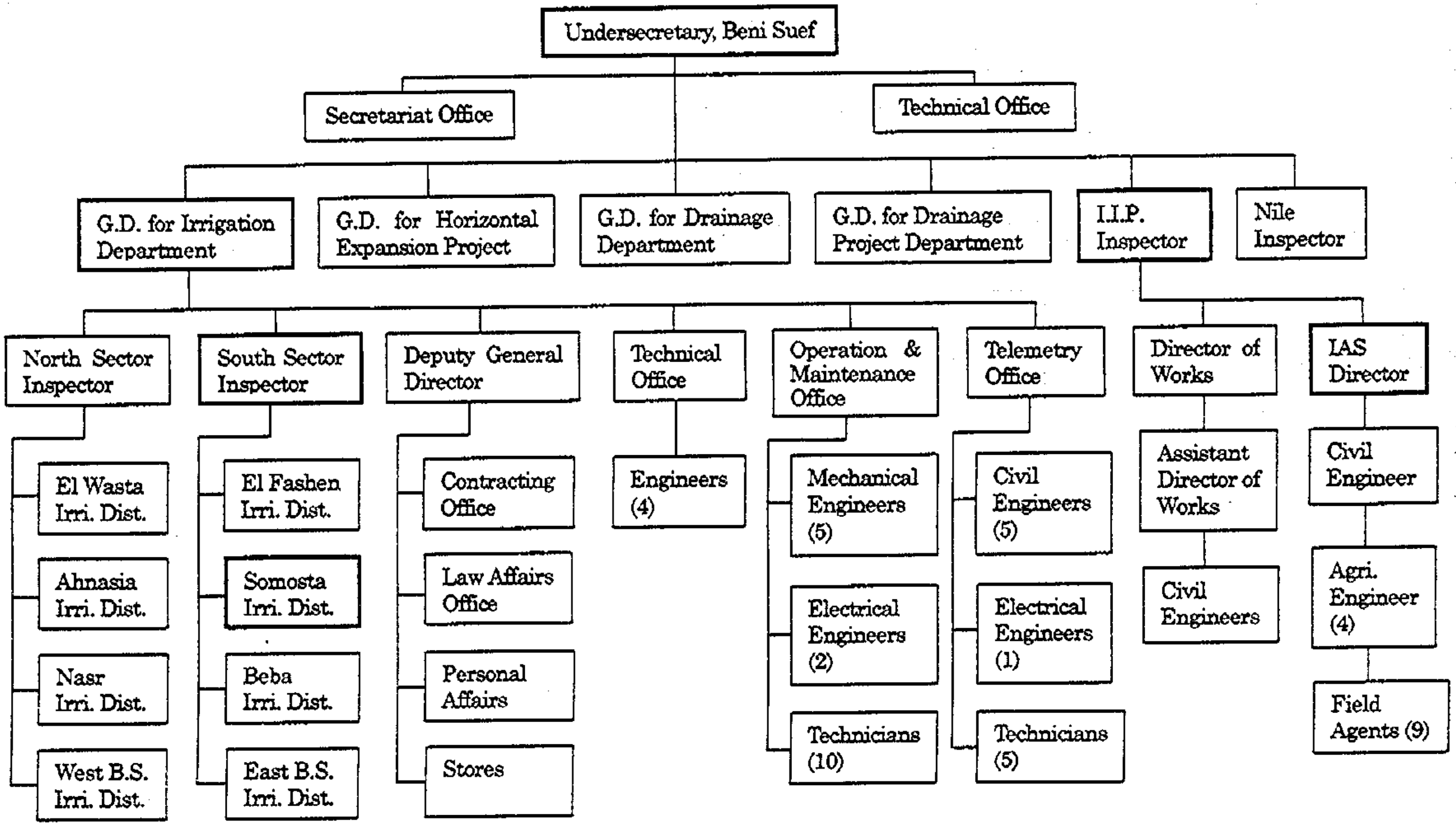
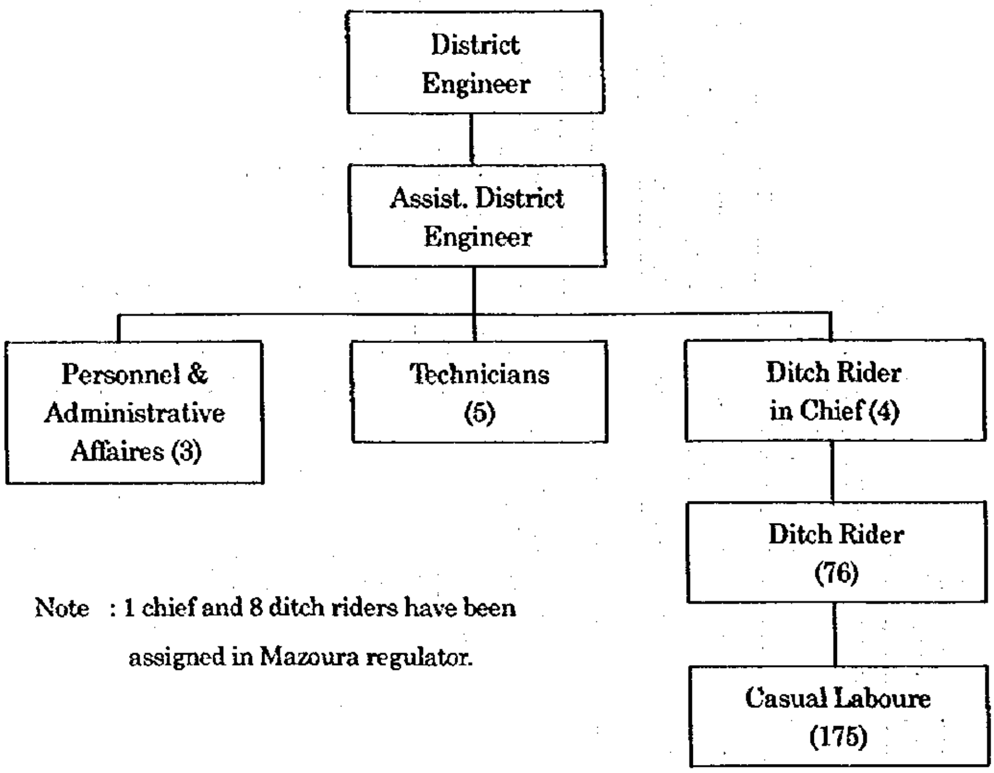


Figure 2-8 Organization Chart of Somosta Irrigation District Office of Beni Suef Irrigation Directorate



Note : 1 chief and 8 ditch riders have been assigned in Mazoura regulator.