

**HIS MAJESTY'S GOVERNMENT OF NEPAL
KANKAI DEVELOPMENT BOARD**

**KANKAI IRRIGATION PROJECT
COMPLETION REPORT**

OCTOBER 1979

**NIPPON KOEI CO., LTD.
TOKYO JAPAN**

FRONTISPIECE



Diversion Weir



Main Irrigation Canal



MIC, No. 2 Bifurcation Structure

SUMMARY OF THE PROJECT

1. Purpose

To irrigate about 5,000 ha which will be extended for about 10,000 ha in the near future, of the existing paddy land with the aim to expand agricultural potential providing with year round irrigation by constructing the irrigation and drainage systems as well as road system, as the initial stage of agricultural development in the Kankai river basin.

2. Location

Far eastern Terai plain along the right bank of the Kankai River, Jhapa District, Mechi Zone

3. Water Resource

Kankai River, Tributary of Ganges River

4. Construction Period

Main Civil Works October 1973 to June 1980

Agricultural Sub-Station October 1973 to January 1976

5. Administrator

Kankai Development Board, HMGN

6. Contractor

Korea Development Corporation, Seoul, Republic of Korea

7. Engineering Consultant

Nippon Koei Co., Ltd., Tokyo, Japan

8. Construction Cost

Foreign Currency	US\$3,786,959
	¥192,982,000
Local Currency	NR.45,324,000

9. Financial Sources

Loan from Asian Development Bank and National Budget of HMGN

10. Principal Features

a) Cropping Pattern

5,000 ha of paddy in wet season
1,750 ha of paddy in dry season
1,500 ha of wheat in dry season
750 ha of jute in dry season
500 ha of maize in dry season
500 ha of miscellaneous in dry season

b) Main Civil Works

i) Headworks

Concrete weir	Crest Length: 126.0 m
	Weir Height : 1.85 m
Scouring sluice	Sluice Gate : 3.50m x 1.85m x 3 Nos.

ii) Head Reach

Type	Trapezoidal concrete lined
Length	1,426 m
Design capacity	10.15 m ³ /sec

iii) Settling Basin

Width	Base: 6.3 m	Top: 12.8 m
Length	144 m including inlet & outlet transitions	
Outlet channel	Trapezoidal concrete lined: 367 m	

iv) Irrigation Canal

	<u>Type</u>	<u>Discharge</u> (m ³ /sec)	<u>Length</u> (m)
Main canal	Trap. conc.	10.15	11,500
	Trap. unlined		10,884
Secondary canals	"		56,900
Tertiary canals	"		71,500

v) Drainage Canals

Type Trapezoidal unlined
 Length 30,000 m

vi) Road

	<u>Width</u> (m)	<u>Metaling</u> (m)	<u>Length</u> (m)
Trunk road	6.5	Gravel 3.5 x 0.2	20,364
Main roads	4.0		70,694
Secondary roads	3.5		71,500

vii) Related Structures

	<u>Main Canal</u> (Nos.)	<u>Secondary Canal</u> (Nos.)	<u>Tertiary Canal</u> (Nos.)
<u>Irrigation System</u>			
Siphon	5	-	-
Culvert	13	65	-
Turnout	41	128	-
Check	10	29	-
Spillway	5	12	-
Drop	22	67	-
Cross drain	-	16	1
Bridge (concrete)	7	1	-
<u>Drainage System</u>			
Box culvert	1	-	-
Pipe culvert	-	-	-
Drop	4	1	1
<u>Road System</u>			
	<u>Trunk Road</u> (Nos.)	<u>Main Road</u> (Nos.)	<u>Secondary Road</u> (Nos.)
Bridge	3	7	1
Causeway	1	12	-
Cross drain	7	1	1
Cross culvert	3	-	-
<u>Flood Protection</u>			
Gabion	14,000 m ³		

viii) Engineer's Office & Quarters

Office	1 No.	292.5 m ²
Quarters	12 Nos.	1,702.4 m ²
Store house	1	300.0 m ²
Garage & others	6	507.5 m ²

c) Agricultural Sub-Station

i) Buildings

	<u>Nos.</u>	<u>Area</u> (m ²)
ASS office	1	260
Co-op. office	1	497
Staff quarter	2	285
Trainee hostel	3	613
Engineer's residence	1	268
Store house	4	800
Work shop	2	250
Garage & others	3	155

ii) Farm

Experimental farm	5 ha
Seed multiplication farm	35 ha

iii) Irrigation & Drainage System

Irrigation canal	3,000 m
Drainage canal	1,300 m
Related structures	31 Nos.
Farm road	3,000 m

CONTRACT ADMINISTRATION

A. ASIAN DEVELOPMENT BANK

A-1 Technical Assistance Agreement

Purpose : Technical assistance for feasibility study and preparation of tender drawings and tender documents for civil engineering works for the Kankai Irrigation Project.

Agreement : Agreement was signed on between the Asian Development Bank and His Majesty's Government of Nepal.

Amount : US\$190,000

Period : January, 1971 - January, 1972

A-2 Loan Agreement

Purpose : To develop about 5,000 ha of the existing farm land for year-round irrigation farming by means of constructing irrigation, drainage and road facilities in the project area.

Agreement : Agreement was signed on between the Asian Development Bank and His Majesty's Government of Nepal, Loan No. 85 NEF (SF).

Amount : US\$4,500,000 (Original)
US\$6,100,000 (Amended)

A-3 Contract for Consulting Services

Purpose : To provide for an overall study of the Kankai Multipurpose Project and a feasibility study of the Kankai Irrigation Project as well as preparation of tender designs and specifications for the major civil works.

Contract Date : Contract was made on January 15, 1971
between the Asian Development Bank and
Nippon Koei Co., Ltd.

Contract Amount : US\$190,000

Period : January 15, 1971 - January 15, 1972

B. HIS MAJESTY'S GOVERNMENT

B-1 Contract for Main Civil Works

Purpose : To construct major project facilities such
as headworks, main and secondary irrigation
canals, drainage canals, farm roads and
various related structures.

Contract Date : Contract was signed on September 13, 1973
between the Kankai Development Board and
Korea Development Corporation.

Amount : NR 45,055,525 of which 63 % is to be paid
by US dollars. (Revised amount NR.49,805,283)

Period : September 21, 1973 to May 31, 1980 including
maintenance period of 365 days.

B-2 Contract for Construction of the Agricultural Sub-Station

Purpose : To establish an agricultural sub-station
which has an experimental and demonstration
farm of about 40 ha.

Contract Date : Contract was signed on September 13, 1973
between the Kankai Development Board and
Korea Development Corporation.

Amount : NR 3,600,000 (Revised amount NR 2,868,647)

Period : September 21, 1973 to February 5, 1977
including 365 days of maintenance period.

B-3 Contract for Supply of Laboratory and ASS Equipment

Purpose : To supply and deliver laboratory and ASS equipments at site.

Contract : Contracts were made between KDB and the following suppliers.

(1) Supply of Micro Bus

Contract Date : January 27, 1975
Supplier : Nepal Impex Ltd. (Nepal)
Contract Amount : ¥1,431,901 (CIF Calcutta)

(2) Supply of Motor Cycle

Contract Date : April 23, 1975
Supplier : Bhajuratna Agency Ltd. (Nepal)
Contract Amount : ¥439,500

(3) Supply of Tractor and Agri. Tools

Contract Date : February, 1974
Supplier : Clarke Gravely Corp. (USA)
Contract Amount : US\$2,800

(4) Supply of Laboratory Equipment

Contract Date : January, 1975
Supplier : Saco International (Nepal)
Contract Amount : DM 28,161
NR 5,328

(5) Supply of Laboratory Equipment

Contract Date : November, 1974
Supplier : Trump Adler Facture (UK)
Contract Amount : £2,808

(6) Supply of Photocopy Machine

Contract Date : January, 1974
Supplier : Rex Rotary Inc. (Denmark)
Contract Amount : D.Kr 9,782

(7) Supply of Typewriter

Contract Date : January, 1974
Supplier : Trump Adler Factory (West Germany)
Contract Amount : DM 1,696.9

(8) Supply of Hand Duster, Sprayer and Etc.

Contract Date : June, 1975
Supplier : Chiyoda Trading Co., Ltd.
Contract Amount : US\$352.80

(9) Supply of Projector and Screen

Contract Date : June, 1975
Supplier : Sumitomo Shoji Corp., Ltd.
Contract Amount : ¥412,530

(10) Supply of Elmo Screen

Contract Date : July, 1975
Supplier : Osaka Foreign Trade, Ltd.
Contract Amount : ¥58,645

(11) Supply of Meteorological Equipments

Contract Date : June, 1975
Supplier : Sumitomo Shoji Corp., Ltd.
Contract Amount : ¥2,080,720

B-4 Contract for Construction Equipments for Minor Works

Purpose : To supply and deliver the following construction equipments and spare parts at the site.

Contract : Contracts were made between KDB and the following suppliers.

(1) Supply of Concrete Mixer and Concrete Vibrator

Contract Date : June 13, 1975
Supplier : Dejong Viamen (Netherland)
Contract Amount : D.G1 36,623.41

(2) Supply of Road Roller

Contract Date : May 10, 1975
Supplier : Tractor India Ltd. (India)
Contract Amount : ¥6,042,292

(3) Supply of Bulldozer (3)

Contract Date : June, 1975
Supplier : Bharat Earth Mover Ltd. (India)
Contract Amount : ¥36,241,920
IR 195,000

(4) Supply of Grader, Truck Crane, Trucks and Etc.

Contract Date : April, 1975
Supplier : Toyota Tsusho (Japan)
Contract Amount : ¥60,922,300

B-5 Contract for Engineering Services

Purpose : To supervise the construction of facilities of the Major Civil Works for about 5,000 ha of farm land and the Agricultural Sub-Station, and assist the Government in procurement of equipment and materials required for the project.

Contract Date : Contract was signed on November 10, 1972
between the Department of Irrigation,
Hydrology and Meteorology and Nippon Koei
Co., Ltd.
Amount : ¥447,268,000 (Amended to ¥192,982,600)

B-6 Contract for Minor Civil Works

Purpose : To construct and complete minor civil works.
Contract Date : 1977 - 1979
Amount : NR 1,658,000
Period : 1977 - 1979

B-7 Force Account Works for Minor Civil Works

Purpose : To construct minor irrigation facilities on
Tertiary Irrigation Canals.
Estimated Amount : NR 2,447,000
Period : January 1977 - June 1980

ABBREVIATION

HMGN	: His Majesties Government of Nepal		
ADB	: Asian Development Bank		
MCW	: Main Civil Works		
ASS	: Agricultural Sub-Station		
KDB	: Kankai Development Board		
KIP	: Kankai Irrigation Project		
EOQ	: Engineer's Office and Quarter		
NR	: Nepalese Rupee	US\$: United State Dollar
IR	: Indian Rupee	¥	: Japanese Yen
D.Kr	: Denmark Krone	DM	: Germany Mark
D.G1	: Netherlands Guilder	£	: United Kingdom Pound
cm	: Centimeter	m	: Meter
km	: Kilometer	m ³	: Cubic meter
m ³ /sec	: Cubic meter per second	m ³ /min	: Cubic meter per minute
m ³ /ha	: Cubic meter per hectare	ha	: Hectare
kg	: Kilogram	ℓ	: Liter
t/ha	: Ton per hectare	t	: Ton
cm/sec	: Centimeter per second	t/m ²	: Ton per square meter
kW	: Kilowatt	kVA	: Kilovolt ampere
HP	: Horse power	cft	: Cubic feet
cu.m	: Cubic meter	cc	: Cubic centimeter
El	: Elevation	%	: Percentage
Fig.	: Figure	DRW	: Drawing
Q'ty	: Quantity	MIC	: Main Irrigation Canal
HR	: Head Reach	SIC	: Secondary Irrigation Canal
TR	: Trunk Road	TIC	: Tertiary Irrigation Canal
MR	: Main Road	SR	: Secondary Road
R-I	: Reach I		

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I. INTRODUCTION

1.1 General

The water resources development of the Kankai river had long been drawing attention of HMGN. In 1970, HMGN prepared a nation wide master plan for the irrigation development in which the Kankai Irrigation Project was accorded with the top priority.

HMGN formally requested technical assistance in carrying out a feasibility study of the Project to the Asian Development Bank (ADB) in October 1970. In response, ADB despatched a Technical Assistance Team consisting of members of Nippon Koei Co., Ltd. in January 1971. The term of reference of above T/A team covered on overall study of the Kankai Multi-purpose project and a feasibility study of the Kankai Irrigation Project as well as preparation of the subsequent tender designs and specifications together with the detailed design of the Agricultural Sub-Station to be established within the Project area. The feasibility report as well as tender documents were prepared in February 1972.

The construction of the project was divided into two contracts namely, Main Civil Works (MCW) and Agricultural Sub-Station (ASS). Invitation for prequalification of tenders for the contract for MCW was advertised in March 1972, while invitation to tenders for contract for ASS was made in August 1972. The both contracts for MCW and ASS were signed between the Kankai Development Board (KDB) and the Contractor in September 1973.

The construction of the both MCW and ASS was commenced in October 1973 and successfully completed in May 1979 for MCW and February 1976 for ASS respectively. Since the beginning, the construction works had been often suspended and interrupted due to shortage of construction materials imported as well as delay in delivery of the materials and equipment mainly because of port and inland transportation congestions in India. Accordingly, the completion time of MCW and ASS was extended for three (3) years for MCW and 22 months for ASS respectively from those times contracted originally.

Since July 1977 about 700 ha located upper part of the irrigation area has been irrigated after the upper reach of the irrigation system was constructed. On the other hand, ASS has been partially put into operation from February 1975 and been in full operation since the beginning of 1976. Approximately 2,000 ha have been irrigated from July 1978 and 5,000 ha in total from July 1979.

Acknowledgement is sincerely expressed to all those who participated in the construction of the project since the beginning.

1.2 The Project

1.2.1 Purpose

The project envisages to achieve an agricultural development through introduction of the intensified year round irrigation farming into about 5,000 ha of the existing farm land, utilizing the natural flow of the Kankai river. For this purpose, the following major project works are to be carried out.

- i) Construction of headworks in the Kankai river,
- ii) Construction of irrigation and drainage facilities up to 40 ha of service units,
- iii) Construction of trunk road, main roads and farm roads, and
- iv) Establishment of Agricultural Sub-Station and construction of irrigation, drainage and road facilities for about 40 ha of demonstration farm.

The project includes not only provision of above physical facilities, but also introduction of modern improved irrigation farming for which special efforts of coordination are required on the following various activities;

- i) Operation and maintenance of project facilities,
- ii) Setting up of water users' organization,
- iii) Adequate supply of agricultural inputs and credit,
- iv) Provision of agricultural extension services and
- v) Provision of processing and marketing facilities.

1.2.2 Cropping Pattern and Irrigation Requirement

The cropping pattern proposed in the original feasibility report consisted mainly of jute from March to July and paddy from August through December. However, from the viewpoints of available farm labor and stable farm income, the following cropping pattern is to be proposed to be introduced in the project area.

<u>Crop</u>	<u>Area</u> (ha)	<u>Cropping Season</u>
1st paddy	1,750	Mar. 20 - Aug. 10
Wheat	1,500	Nov. 10 - Apr. 10
Jute	750	Mar. 10 - Aug. 10
Maize	500	Feb. 1 - Jun. 20
2nd paddy	5,000	Jul. 1 - Dec. 10

Based on the above cropping pattern, irrigation water requirement was estimated at full development. Diversion requirement for 5,000 ha was accordingly estimated for each month as follows:

	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>Jun.</u>	<u>Jul.</u>	<u>Aug.</u>	<u>Sep.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>
D/R	1.2	1.3	1.8	3.2	3.0	1.7	2.3	2.4	3.2	4.5	1.7	0.9
R/F	13.0	10.0	8.2	7.5	11.7	27.5	153	158	124	40	27.6	17.1

Unit: m³/sec

Note: D/R Monthly diversion requirement
R/F Monthly average river flow of the Kankai river

From the available run-off of the Kankai river, another 5,000 ha of farm land could be irrigated so that the upper reach of the main canal was constructed so as to have a maximum ten-day design discharge capacity of 10.6 m³/sec to cover 10,000 ha of farm land.

1.2.3 Anticipated Yield and Production Value

Since 1976, test farming of the proposed crops has been conducted at ASS. Though the results of test are rather short, the anticipated yield at full development in the project area is estimated at 3.5 ton/ha of 1st paddy, 3.5 ton/ha of 2nd paddy, 2.0 ton/ha of wheat, 2.0 ton/ha of maize and 1.9 ton/ha of jute based on the above results. The total production of crops a year in the project area of 5,000 ha is thus estimated as follows:

<u>Crops</u>	<u>Area</u> (ha)	<u>Yield</u> (T/ha)	<u>Production</u> (10 ³ T)	<u>Unit Price</u> (NR)	<u>Gross Value</u> (NR 10 ³)
1st paddy	1,750	3.5	6,125	1,300	7,962
2nd paddy	5,000	3.5	17,500	1,300	22,750
Wheat	1,500	2.0	3,000	1,500	4,500
Maize	500	2.0	1,000	750	750
Jute	750	1.9	1,425	2,500	3,563
Miscellaneous	500	1.0	500	500	250
<u>Total</u>	<u>10,000</u>				<u>39,775</u>

Meanwhile, the present production of crops in the project area and those gross value are estimated as follows:

<u>Crops</u>	<u>Area</u> (ha)	<u>Yield</u> (T/ha)	<u>Production</u> (10 ³ T)	<u>Unit Price</u> (NR)	<u>Gross Value</u> (NR 10 ³)
Paddy	5,000	1.2	6,000	1,300	7,800
Jute	650	0.9	585	2,500	1,462
Wheat	200	0.6	120	1,500	180
Maize	100	1.0	100	750	75
Miscellaneous	100			500	50
<u>Total</u>	<u>6,050</u>				<u>9,567</u>

Incremental production value of the project is thus estimated at about NR 30,000,000.

II. DESIGN OF THE WORKS

2.1 General

KDB is responsible for the design and implementation of the project, under which the Project Office have been set up at the site. The Project Office have been carrying out investigation, canal alignment survey, detailed design, construction supervision and operation and maintenance of irrigation system.

Immediately after the Contract for MCW was signed between KDB and the Contractor, the layout of irrigation canals, subsequent road layout and the design discharge of canals were substantially revised from those shown in the tender design drawings. The major reasons and circumstances are as follows:

- i) River banks of the Kankai and its tributaries running through the project area have been considerably eroded so that the some of canal routes aligned previously were needed to be replaced.
- ii) After revising the cropping pattern, about 10,000 ha of the farm land in total were found to be irrigated by the natural flow of the Kankai. Accordingly the upper reaches of the main irrigation canal were required to be enlarged so as to enable to have sufficient design capacity.

The foundation investigation for facilities, and canal re-alignment survey were carried out parallelly from the beginning of 1973 and completed May 1976. Subsequently, those detailed design works were carried out from the upper reach of the canal through the lower end, and completed approximately two years in advance of the completion of the construction work.

2.2 Headwork

The diversion weir site was selected at the debouching point of the Kankai river from the hills to the Terai plain, about 3 km north of the East-West Highway bridge. The river bed of the site is covered by a rich

layer of sand and gravel with rather hard stratification of non-cohesive. The permeability coefficient is in an order of 10^{-3} cm/sec in the sand and gravel layer and 10^{-4} cm/sec in the bare rock respectively. The thickness of sand and gravel layer is about 12 m in the center and becomes gradually thinner towards both banks. The base rock consists mainly of shale and partly of sand stone, silt stone, mud stone and sandy shale. The results of field penetration test show that allowable bearing capacity of foundation ranges from 4.7 t/m² to 7.0 t/m² which is less than load of weir body designed.

Concrete diversion weir with a length of 126 m and 1.85 m height was adopted. 28 m long of rear apron with 1 m thick was provided. In the right most portion of the weir a scouring sluice of 16.5 m wide with 3 sets of gate was provided. Each gate 3.5 m wide and 1.85 m high, is to be operated by man power. Crest elevation of the weir and rear apron was determined at El. 121.35 and El. 119.20 respectively taking the current river bed and quantity of canal excavation of head reach into account. For the downstream protection against scouring, matters of articulated concrete blocks were designed to be provided for 10 m long. Because of rather high permeability of the foundation, steel sheet pile with about 10 m depth at the deepest portion was designed to be driven at the cutoff wall. The weir body was designed to be supported by concrete bearing pile, 350cm x 350cm, with 2.5 m interval.

Implementation of the diversion weir and scouring sluice resulted in the following two unforeseen phenomena.

- i) The front of scouring sluice gate was heaped with tremendous drift woods and objectionables and subsequently clogged up with sediment materials by the flood flow of the Kankai.
- ii) The certain reaches of downstream river bed of the Kankai have been eroded for 1.0 m to 1.5 m depth by the flood flow because the annual river bed loads and sediment loads transported from the upstream have been mostly accumulated at the upstream portion of the diversion weir without being transported to the downstream. Accordingly, the most of articulated concrete block matters have sunk about 1.2 to 1.5 m.

In order to cope with above problems the following countermeasures were taken:

- i) Log protection structure with nine (9) piers at 2.3 m intervals were designed to be provided at about 30 m upstream of the scouring sluice;
- ii) Launching apron with concrete block with 20 to 30 m long were designed to be placed from the end sill of concrete apron. Then, 6 m long of riprap with wire crate were further provided at the most downstream portion.

The intake structure was designed to be constructed at immediately upstream of the scouring sluice on the right bank of the river. The intake bed elevation is to be El. 120.20 m which is 0.70 m higher than that of the scouring sluice. The front width of intake is 15 m. The capacity of structure is taken at $10.15 \text{ m}^3/\text{sec}$ ^{/1} at maximum. Discharge is controlled by a sluice gate with 1.5m width x 1.80m height to be installed at the inlet of intake culvert.

Remarks: /1 The actual discharge is about $10.6 \text{ m}^3/\text{sec}$ because the actual roughness coefficient is smaller than the designed.

2.3 Headreach and Settling Design

Because of the topographic reason, the settling basin was designed to be constructed at about 1.3 km downstream from the intake structure. Headreach was planned to have a discharge capacity of $10.15 \text{ m}^3/\text{sec}$. The canal runs southwestward with trapezoidal concrete lined canal. The deposit materials of settling basin were designed to be scoured to the Kankai river through 367 m long of trapezoidal outlet channel lined with concrete. Three concrete box culverts were designed to be constructed at the points where the headreach crosses with natural drains. Design features of headreach and settling basin are as follows. The general plan and sections of settling basin is shown in DRW No. 4 attached.

i) Headreach

	<u>Open Channel</u>	<u>Culvert</u>
Type	Trapezoidal cross section of 1:1.25 lined with concrete	Concrete box culvert with two barrels
Length	1,426 m	246 m in total
Design Capacity	10.15 m ³ /sec	10.15 m ³ /sec
Slope	1/2,000	1/950
Thickness of Lining	15 cm	25 cm

ii) Settling Basin

Type	Bottom width is 6 m and deepened gradually towards downstream. Depth is 2.6 m at upper end and 3.6 m at lower end
Length	144 m

iii) Outlet Channel

Type	Trapezoidal cross section lined with concrete
Length	367 m
Slope	1/700
Thickness of Lining	15 cm

2.4 Main Irrigation Canal (MIC)

2.4.1 Canal

MIC starts from the settling basin and runs southeastward. After crossing the Jhilijhili river, at about 10 km from the beginning point, MIC changes its direction to south and then bifurcates at about 14 km point. About 11.5 km long of the upper reach was designed to be lined with concrete of which 3.3 km long was to be placed with concrete block where ground watertable is relatively high. MIC is classified into four (4) reaches according to the discharge capacity. Each reach is designed

to have a trapezoidal cross section with 1:1.25 in concrete lined section and 1:1.5 in unlined section respectively as shown in DRW No. 5 attached. The design features are shown below.

Table 2.1 Canal Type and Capacity of MIC

<u>Name</u>	<u>Type</u>	<u>Length</u> (m)	<u>Slope</u>	<u>Discharge</u> (m ³ /sec)
Reach I	Concrete Lining (partly block lining)	11,500	1:1000	10.15
Reach II	Unlined	2,600	1:1850	4.55
Reach III	Unlined	2,767	1:1540	1.95
Reach IV	Unlined	5,533	1:1540	1.95

2.4.2 Related Structures

Major structures related to MIC are siphons, culverts, turnouts, spillways, checks, bridges and bifurcation structure. Siphon and culvert were planned to be provided at the place where MIC runs across the river and drain. Major features of those structures are shown below.

- i) Five (5) siphons are planned to be constructed with concrete box culvert and a trash rack is provided at the head of each siphon.

Table 2.2 Design Feature of Siphon

<u>Name</u>	<u>Location at B.P.</u>	<u>Length</u> (m)	<u>Width</u> (m)	<u>Height</u> (m)	<u>Discharge</u> (m ³ /sec)
No. 1 Siphon	0+15.65 Reach I	194.50	1.90	1.90	10.15
No. 2 "	12+39 Reach I	52.0	1.90	1.90	10.15
No. 3 "	70+55.3 Reach I	183.0	1.90	1.80	9.11
No. 4 "	96+37 Reach I	85.0	1.90	1.80	8.67
No. 5 "	27+36.5 Reach IV	108.5	1.10	1.10	1.95

ii) Culverts

Concrete box culverts with two barrels are provided at the places where MIC cross the East-West Highway. Trunk road and the natural drains which run through the topography of comparatively higher elevation. Eight (8) culverts are planned to be provided. The major feature is shown in the following table.

Table 2.3 Design Feature of Culverts

<u>Name</u>	<u>Location at B.P.</u>		<u>Length</u> (m)	<u>Width</u> (m)	<u>Height</u> (m)	<u>Discharge</u> (m ³ /sec)
No. 6 Culvert	15+29	Reach I	37	1.65x2	1.90	10.15
No. 7 "	16+52	Reach I	45	1.65x2	1.90	10.15
No. 8 "	21+11	Reach I	45	1.65x2	1.90	10.15
No. 9 "	31+2	Reach I	53	1.65x2	1.90	10.15
No.10 "	45+83	Reach I	48	1.65x2	1.90	10.15
No.11 "	48+60	Reach I	48	1.65x2	1.90	10.15
No.12 "	62+2	Reach I	21	1.65x2	1.80	9.20
No.13 "	125+91.5	Reach II	16.50	1.65x2	1.60	4.55

iii) Turnouts

10 secondary and 31 tertiary turnouts were designed to be provided on MIC. In order to distribute irrigation water properly, each secondary turnout is provided with a Parshall flume at its immediately downstream. Design feature of those turnouts is tabulated in the following Table 2.4.

Table 2.4 Design Feature of Turnouts

<u>Name</u>	<u>Location</u>	<u>Size of Gate</u> (W(m) x H(m))	<u>Discharge</u> (m ³ /sec)	<u>Command Area</u> (ha)
S-1 Turnout	56+50 (R-I)	1.2 x 1.1	0.851	736.1
S-2 "	75+90 (")	0.7 x 0.9	0.259	226.6
S-3 "	107+82 (")	1.0 x 0.8	0.425	372.0
S-4 "	115+00 (")	1.0 x 0.8	0.477	417.5
S-5 "	136+00 (R-II)	1.0 x 1.1	0.910	798.0
S-6 "	14+00 (R-III)	0.4 x 0.9	0.154	136.1
S-7 "	27+64 (")	0.7 x 0.9	0.262	230.2
S-9 "	25+23 (R-IV)	0.6 x 0.7	0.144	126.5
S-10 "	40+00 (")	0.7 x 0.9	0.295	259.3
S-11 "	55+30 (")	0.7 x 0.9	0.165	144.4
TO-1 "	66+19 (R-I)	0.4 x 0.6	0.083	72.7
TO-2 "	83+97 (")	0.4 x 0.6	0.019	16.6
TO-3 "	83+97 (")	0.4 x 0.6	0.028	24.8
TO-4 "	95+35 (")	0.4 x 0.6	0.032	27.8
TO-5 "	98+97 (")	0.4 x 0.6	0.012	10.1
TO-6 "	98+97 (")	0.4 x 0.6	0.045	37.2
TO-7 "	115+00 (")	0.4 x 0.6	0.019	16.6
TO-8 "	121+48.8 (R-II)	0.4 x 0.6	0.020	17.7
TO-9 "	126+10 (")	0.4 x 0.6	0.052	45.5
TO-10 "	126+10 (")	0.4 x 0.6	0.026	22.4
TO-11 "	131+00 (")	0.4 x 0.7	0.039	33.8
TO-12 "	131+00 (")	0.4 x 0.6	0.031	27.6
TA-1 "	0+50 (R-III)	0.4 x 0.6	-	-
TA-3 "	7+00 (")	0.4 x 0.6	0.029	25.8
TA-4 "	7+00 (")	0.4 x 0.6	0.024	21.7
TA-5 "	14+00 (")	0.4 x 0.6	0.022	19.0
TA-6 "	27+164 (")	0.4 x 0.6	0.025	22.1

<u>Name</u>	<u>Location</u>	<u>Size of Gate</u> (W(m) x H(m))	<u>Discharge</u> (m ³ /sec)	<u>Command Area</u> (ha)	
TB-0	Turnout	1+50 (R-IV)	0.4 x 0.6	0.023	20.3
TB-1	"	4+90 (")	0.4 x 0.6	0.033	29.3
TB-2	"	4+90 (")	0.4 x 0.6	0.026	23.0
TB-3	"	12+50 (")	0.4 x 0.6	0.038	32.9
TB-4	"	12+50 (")	0.4 x 0.6	0.032	28.4
TB-5	"	18+50 (")	0.4 x 0.6	0.038	33.5
TB-6	"	18+50 (")	0.4 x 0.6	0.022	19.2
TB-7	"	29+00 (")	0.4 x 0.6	0.028	24.3
TB-8	"	29+00 (")	0.4 x 0.6	0.025	21.9
TB-9	"	40+00 (")	0.4 x 0.6	0.022	19.6
TB-10	"	48+50 (")	0.4 x 0.6	0.074	67.1
TB-11	"	48+50 (")	0.4 x 0.6	0.017	14.8
TB-12	"	55+30 (")	0.4 x 0.7	0.052	45.8

iv) Checks

Check structures were designed to be provided for maintaining water level of MIC mainly at immediately downstream of secondary turnouts. Some of the check are provided with a drop where required from the hydraulic viewpoint. 10 checks of altogether are provided on MIC as shown in the following Table 2.5.

Table 2.5 Design Feature of Checks

<u>Name</u>	<u>Location</u>	<u>W(m) x H(m) x Nos.</u>	<u>Discharge</u> (m ³ /sec)	<u>Remarks</u>	
S-1	Check	56+53 (R-I)	1.65 x 1.8 x 2	9.20	
S-2	"	75+93 (")	1.65 x 1.8 x 2	8.77	
S-3	"	107+85 (")	1.65 x 1.5 x 2	5.70	W/Drop
S-4	"	115+3 (")	1.65 x 1.5 x 2	4.55	"
S-5	"	135+3 (R-II)	1.65 x 1.4 x 2	3.62	
S-6	"	14+3 (R-III)	1.5 x 1.1 x 1	1.34	W/Drop
S-7	"	27+67 (")	1.2 x 1.1 x 1	0.704	"
S-9	"	25+26 (R-IV)	1.5 x 1.1 x 1	1.69	"
S-10	"	40+3 (")	1.2 x 1.15 x 1	1.51	"
S-11	"	55+33 (")	1.2 x 1.1 x 1	0.44	

v) Drops

The following drops are provided at the places where required from the hydraulic and economical viewpoints. Such drop is equipped with stop log to maintain the water level of MIC as required.

Table 2.6 Design Feature of Drops

<u>Name</u>	<u>Location</u>	<u>Height</u> (m)	<u>Discharge</u> (m ³ /sec)	<u>Remarks</u>
No. 1	84+00 (R-I)	1.40	10.0	
No. 2	89+00 (")	1.40	10.0	
No. 3	92+00 (")	0.70	10.0	
No. 4	99+00 (")	0.70	5.1	
No. 5	104+00 (")	1.06	5.1	
No. 6	107+85 (")	1.70	5.1	
No. 7	115+03 (")	1.75	4.55	
No. 8	115+50 (R-II)	1.40	4.55	
No. 9	121+51.8 (")	0.55	4.43	
No. 10	126+13 (")	1.40	4.29	
No. 11	131+03 (")	1.00	4.29	
No. A-1	0+53 (R-III)	1.10	1.67	
No. A-2	7+03 (")	1.10	1.67	
No. A-3	9+00 (")	1.10	1.67	
No. A-4	14+13.4 (")	1.15	1.34	
No. A-5	21+03 (")	1.15	0.94	
No. A-6	27+77.4 (")	1.10	0.704	
No. B-1	4+93 (R-IV)	1.40	1.88	
No. B-2	8+50 (")	1.40	1.88	
No. B-3	12+53 (")	1.40	1.80	
No. B-4	18+03 (")	1.10	1.80	
No. B-5	25+37 (")	1.10	1.69	
No. B-6	40+08 (")	1.10	0.585	
No. B-7	41+00 (")	1.10	0.585	
No. B-8	48+53 (")	1.10	0.585	
No. B-9	53+00 (")	1.10	0.585	

vi) Spillways

Three (3) side spillways with outlet structure were designed to be constructed at the crossing points with Balwa river, Jhilihili river and Baniyani river and two (2) overflow type side spillway without outlet structure are provided one at the crossing natural drains and the other at No. 2 bifurcation structure. Design feature of the spillways are shown in the following Table 2.7.

Table 2.7 Design Feature of Side Spillway

	<u>Location</u>	<u>Discharge</u> (m ³ /sec)	<u>Width</u> (m)	<u>Overflow</u> (m)	<u>Remarks</u>
Overflow spillway No. 1	52+39.8 (R-I)	2.5	5.50	0.40	Overflow inlet and outlet with gate
No. 1 spillway	70+38.75 (R-I)	2.5(10.15) $\frac{1}{1}$	7.5	0.31	
No. 1 bifurcation spillway	97+22 (R-I)	3.5(5.4) $\frac{1}{1}$	8.2	0.36	With gate
Overflow spillway No. 2	140+60 (R-II)	3.2	8.0	0.38	Overflow outlet
No. 2 spillway	27+20 (R-IV)	1.6(2.5) $\frac{1}{1}$	4.0	0.35	With gate

Remarks: $\frac{1}{1}$ Discharge from outlet structure with gate

vii) Bridges

Those places where lined MIC (Reach I) crosses the secondary roads were designed to be provided with a precasted concrete bridge. The location and dimension are shown in the following Table 2.8.

Table 2.8 Design Feature of Bridges

<u>Name</u>	<u>Location</u>	<u>Type</u>	<u>Length (m)</u>
1	St. 9+33	Precast 0.3 x 0.3 x 9 Nos.	7.45
2	" 38+68.5	" "	7.45
3	" 66+15	" 0.4 x 0.3 x 13 Nos.	7.20
4	" 83+92	" "	7.20
5	" 95+40	" "	7.20
6	" 98+93	" "	6.45
7	" 115+00	" 0.3 x 0.3 x 8 Nos.	6.20

viii) Bifurcation Structures

Two bifurcation structures were designed to be constructed, one for diverting water to the extension project area and the other for diverting the irrigation water to Reach II and Reach IV. The design features are shown in the following Table 2.9.

Table 2.9 Design Feature of Bifurcation

<u>Name</u>	<u>Location</u>	<u>Discharge</u> (m ³ /sec)	<u>Length</u> (m)	<u>Barrel</u>		
				W(m)	x H(m)	x Nos.
1	St. 98+2.2	10.0	10.0	1.65	x 1.8	x 2
2	" 140+83	3.62	-	1.028	x 1.15	x 2

2.5 Secondary Irrigation Canals (SIC)

2.5.1 Unlined Canals

Twelve (12) secondary canals branch off from the MIC and were designed to be of trapezoidal unlined type. Slope of the canals were designed to range from 0.00095 to 0.00075. The cross section is 1:1.5 as shown in DRW No. 5. Design features of SIC are shown in the following Table 2.10.

Table 2.10 Design Feature of SIC

<u>Name</u>	<u>Length</u> (m)	<u>Area (net)</u> (ha)	<u>Discharge</u> (m ³ /sec)	<u>Slope</u>
S-1	5,800	746.1	0.851	1:1330
S-2	3,900	226.6	0.259	1:1180
S-3	3,400	372.0	0.425	1:1180
S-4	4,650	417.5	0.477	1:1200
S-5	6,600	798.0	0.910	1:1250
S-6	2,150	136.1	0.154	1:1160
S-8	8,700	676.1	0.704	1:1300
S-9	1,200	126.5	0.144	1:1065
S-10	3,230	259.3	0.295	1:1180
S-11	3,200	144.4	0.165	1:1120
S-12	11,100	385.0	0.441	1:1225

2.5.2 Related Structures

The following structures related to SIC were designed to be constructed.

Table 2.11 Related Structures to SIC

<u>Name</u>	<u>T0</u>	<u>CK</u>	<u>DP</u>	<u>PC</u>	<u>CD</u>	<u>BD</u>	<u>TS</u>
S-1	12	5	10	9	1	1	1
S-2	11	x	15	6	1	x	1
S-3	13	x	10	7	x	x	1
S-4	11	2	5	6	2	x	1
S-5	13	3	10	8	2	x	2
S-6	3	1	2	2	1	x	1
S-7	5	1	5	2	1	x	1
S-8	13	6	3	8	3	x	1
S-9	4	1	2	2	x	x	1
S-10	9	4	1	4	1	x	1
S-11	5	3	1	4	2	x	1
S-12	13	3	3	7	1	x	1
<u>Total</u>	<u>112</u>	<u>29</u>	<u>67</u>	<u>65</u>	<u>15</u>	<u>1</u>	<u>13</u>

Note: T0 - Turnout
 DP - Drop
 CD - Cross Drain
 TS - Terminal Structure
 CK - Check
 PC - Pipe Culvert
 BD - Bridge

2.6 Tertiary Irrigation Canals (TIC)

TIC were basically designed to branch off from SIC at approximately 600 m interval. Along the MIC 30 TIC branch off directly from MIC from the topographic reasons. From TIC several supply ditches commanding about 10 ha each branch off through division box to be provided at approximately 100 m intervals. The schematic layout of irrigation system is shown in Fig. 2.1. The division box was designed to be installed by a precasted concrete. Three types of canal section with 1:1.5 of cross section are applied for the supply ditches according to the design discharge, namely, Type A with range of discharge from 216 l/sec and Type C with 124 l/sec or less as shown in DRW No. 6. Slope of TIC was designed to be of approximately 1 to 1,000 numbers of TIC and those division box provided and total length are shown in the following table.

Fig. 2-1 SCHEMATIC LAYOUT OF TIC

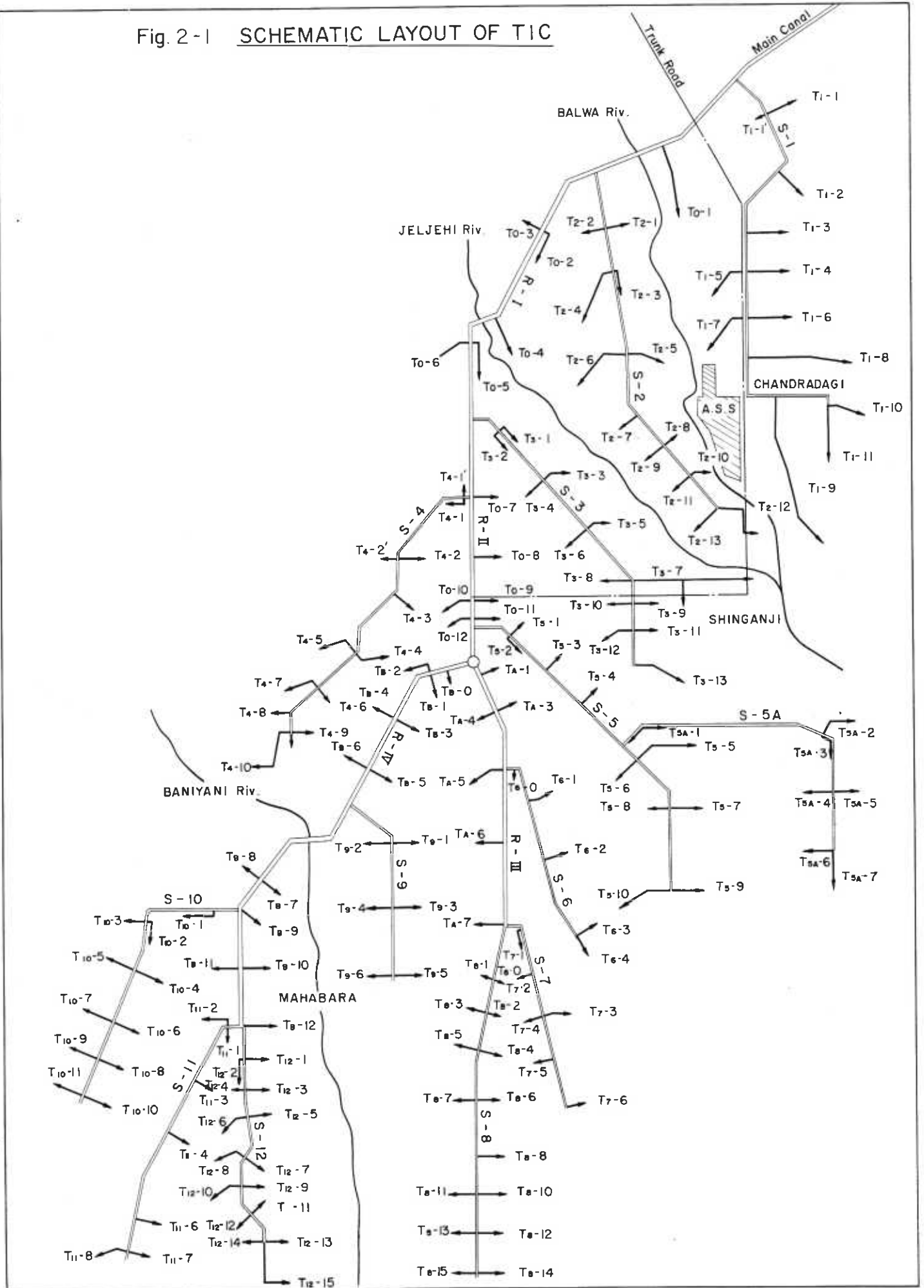


Table 2.12 Numbers of TIC and Division Box and Length

	<u>Number of TIC</u>			<u>Total</u>	<u>Length</u> (m)	<u>Division Box</u> (Nos.)
	<u>Type A</u>	<u>Type B</u>	<u>Type C</u>			
S-1	8	1	3	12	8,850.0	81
S-2	13			13	4,525.0	41
S-3	13		1	14	7,600.0	62
S-4	13			13	5,775.0	52
S-5	10			10	4,300.0	55
S-5A	7			7	2,700.0	36
S-6	5			5	1,868.0	20
S-7	6			6	3,068.5	37
S-8	14		1	15	8,798.0	113
S-9	6			6	1,766.0	24
S-10	11			11	3,327.0	57
S-11	7			7	1,546.0	32
S-12	15			15	6,798.2	89
MIC R-I	7			7	3,000.0	35
MIC R-II	5			5	2,900.0	14
MIC R-III	6			6	1,875.0	19
MIC R-IV	12	1		13	2,657.5	64
Total	<u>158</u>	<u>2</u>	<u>5</u>	<u>165</u>	<u>71,353.5</u> say 71,500.00	<u>831</u>

2.7 Road System

2.7.1 Roads

The road system was designed to be provided with three classes of road, namely, trunk road (TR), main roads (MR) and secondary roads (SR), TR is 20 cm gravel-metaled with 3.5 m of width and of 6.5 m in total width. MR and SR are non-metaled. Total width of MR along MIC and S-8 and S-12 of SIC is 5 m and that of the remaining SIC is 4 m respectively. Total width of SR is of 3.5 m. The typical section of roads are shown in DRW No. 6.

TR starts from the East-West Highway at Dudhe and runs almost south ward along the existing village road between Dudhe and Shivganj. Then,

TR turns to west direction toward the MIC and is to be constructed along MIC and SIC, S-12 up to No. 1 culvert on S-12. Total length of TR is 20.4 km long.

MR were designed to be provided along the remaining MIC and SIC and SR along the TIC respectively total length of MR and SR are 71 km and 72 km respectively.

2.7.2 Road Structures

Three (3) concrete bridges were designed to be constructed at the places across the three rivers, Balwa, Jhilijhili and Baniyani rivers. At the places crossing the small river and depression, causeway or cross drain are provided. The following Table 2.13 shows number of structures related to the road system. (Typical drawing of bridges is shown in DRW No. 7 attached.)

Table 2.13 Road Structures

<u>Road</u>	<u>Bridge</u>	Unit: Nos.		
		<u>CW</u>	<u>CD</u>	<u>CC</u>
Trunk Road	3	1	7	3
Main Road	7	12	1	-
Secondary Road	1	-	1	-

Note: CW - Causeway CD - Cross drain
 CC - Cross culvert

2.8 Drainage Canals

Collector drains along TIC are planned to be constructed. It was judged after the detailed field investigations that the most of natural drains are capable of coping with draining the flood within the drainage basin, because MIC to be constructed reduces the flood from the upstream of those drains by means of cutting. In this connection, the drainage ditches with some structures were designed to be constructed along the right side of MIC. Accordingly, collector drains inside the project area designed originally were deleted. Total length of drainage ditches are about 30,000 m and those related structures are tabulated in the following Table 2.14.

Table 2.14 Related Structure to Drainage System

<u>Location</u>	<u>Height</u> (m)	<u>Width</u> (m)	<u>Length</u> (m)	<u>Discharge</u> (m ³ /sec)	<u>Remarks</u>
Drops 27+47 (R-IV)	2.0	0.50	7.0	0.05	
Drops 27+71 (") (Term. Stru.)	2.0	0.50	7.0	0.05	No. 5 siphon
BC near No. 12 culvert	1.3	2.00	5.6	-	
TS No. 3 siphon	4.0	2.00	13.0	-	
TS No. 4 siphon	2.0	0.50	8.0	-	
TS SIC, S-11	2.0	2.50	7.0	-	

Note: BC - Box culvert TS - Terminal structure

2.9 Engineer's Office and Quarters (EOQ)

EOQ during the construction period of the project as well as the operation and maintenance period of the project were designed to be constructed at the corner of East-West Highway and MIC. The following Table 2.15 shows number of buildings required and area in each kind of building.

Table 2.15 Engineering Office and Quarters

	<u>Number</u>	<u>Unit Area</u> (m ²)	<u>Total Area</u> (m ²)	<u>Remarks</u>
Office	1	292.50	292.50	8 rooms
FEBQ	1	278.00	278.00	6 bedrooms & 1 living room
FEFQ	2	98.45	196.90	
POQ	1	141.90	141.90	PMQ
HMG FQ-A	3	112.00	336.00	
HMG FQ-B	4	86.00	344.00	
HMG BQ	1	405.60	405.60	
Guest House	1	245.00	245.00	
Storage	1	300.00	300.00	
Generator House	1	50.00	50.00	
Pump House	1	25.00	25.00	
Guard House	1	7.50	7.50	
Garage	2	90.00	180.00	

Note: FEBQ - Foreign engineer's bachelor quarter
 FEFQ - Foreign engineer's family quarter
 POQ - Project officer's quarter
 HMG FQ - HMG family quarter
 HMG BQ - HMG bachelor quarter
 PMQ - Project manager's quarter

2.10 Agricultural Sub-Station (ASS)

ASS is established at about 7 km south from Dudhe along the trunk road proposed. The works included for the construction of ASS are:

- i) irrigation and drainage facilities for the experimental and demonstration farm of 40 ha;
- ii) farm roads of about 3 km and farm land preparation of about 18 ha; and
- iii) buildings such as an office, work shop, storage, residence and tenement houses, etc., with necessary electrification, water supply and sewerage facilities.

Immediately after the Contract for construction of ASS was signed between KDB and the Contractor, the plan of irrigation water supply from the Balwa river including to storage ponds and a pumping system which was originally contemplated was substantially revised from the following reasons and circumstances.

- i) The Balwa river is not perennial and the sediment loads from the upstream is considerably large amount, which would result in sand deposition of ponds designed to be constructed originally within few years.
- ii) It was found out that the permeability in the subsurface of the earth dam sites is rather high which would bring about certain additional costs for its treatment.
- iii) After implementation of the upper portion of irrigation system of the Main Civil Works, the irrigation water will be made available from the Kankai river within a year after the implementation of ASS. Consequently, a temporary pond is planned to be constructed for the first dry season farming in ASS.

For the above reasons, the plan of construction of two dams and one pump station was deleted, but the irrigation canal for ASS was designed so as to be connected with S-1 secondary canal in MCW. Irrigation network in ASS was so planned to enable the each plot to supply water one by one.

Type of canals is trapezoidal unlined with 1:1.5 cross section. The length of irrigation and drainage canals totals about 3 km and 3 km respectively. The related structures to irrigation and drainage systems are as follows:

Table 2.16 Structures for Irrigation and Drainage System for ASS

<u>Siphon</u>	<u>Drainage Culvert</u>	<u>Road Culvert</u>	<u>Brick Sewer</u>
19 Nos.	10 Nos.	2 Nos.	1,876 m

The farm roads within ASS were designed to be gravel metaled with 3.5 m width. Total length of roads is about 10 km of which 5 km is to be paved by gravel. 40 ha of the existing paddy land are to be readjusted to have a plot with rectangular shape of 100m x 30m. The following table shows the number of house and area required for ASS.

Table 2.17 Buildings for ASS

	<u>Number</u>	<u>Unit Area</u> (m ²)	<u>Total Area</u> (m ²)	<u>Remarks</u>
Office	1	260	260	
HMG Manager Residence	1	65	65	
HMG Family Residence	5	44	220	
HMG Staff Tenements	2	148	296	
Trainee Hostel	1	167	167	
Mess & Meeting House	1	150	150	
Foreign Engineer's Residence	1	268	268	
KPO Work Shop	1	100	100	
ASS Work Shop	1	150	150	
ASS Storage	1	50	50	
CO-OP. Office	1	497	497	
CO-OP. Warehouse	1	500	500	
Tocl Shed	1	100	100	
Seed Store	1	150	150	
Generator House	1	50	50	
Pump House	1	25	25	
Cattle Shed	1	80	80	
<u>Total</u>			<u>3,128</u>	

III. CONSTRUCTION TIME SCHEDULE AND PROGRESS

3.1 Main Civil Works

3.1.1 General

The project was originally scheduled to be completed within 12 months after signing of the contract between HMG and the Contractor, which include the mobilization of the Contractor as well as the procurement of construction materials and equipment to be made by the Contractor. The Contractor commenced the works in the middle of September 1973. However, the Contractor had encountered with a difficulty on procurement of the construction equipments and materials since the beginning mainly due to the worldwide oil crisis occurred in the late 1973 and the port congestion at Calcutta. The construction works were often interrupted due to the shortage of mainly cement, steel sheet piles, fuel, etc. Then, the Contractor claimed the Engineer to extend the time of completion of the works for 37 months in total in three times. The Engineers finally granted the extension until May 31, 1979 after the careful investigations. The details are shown in Fig. 3.1.

In the first two dry seasons, the progress of the works was very little, only about 15 % of the total works, which was about one fourth of the original schedule. The construction works were rather progressed in the third and fourth dry seasons and about 60 % of the works had been finished by the end of June 1977. Namely, all the facilities from the diversion weir through S-1 secondary irrigation canal were successfully implemented so that the irrigation water had been diverted to about 700 ha of paddy land commanded by the said secondary canal. The works in the last two dry seasons, 1977/78 and 78/79, were smoothly progressed and all the construction works have been completed by the end of May 1979, notwithstanding the supply of construction materials interrupted the works considerably.

3.1.2 Headworks

Construction of the diversion weir including scouring sluice, and intake structure was scheduled to be carried out in two dry seasons,

1974/75 and 75/76, but extended to another one dry season, 1976/77, due to delay of delivery of steel sheet piles to be driven under the weir body.

It was planned to construct the head reach of about 1.4 km long and a settling basin in the dry season of 1974/75. Because of revisions of canal alignment and design discharge from the original, earth excavation of the canal as well as it's quantities of related structures increased substantially, which resulted in the need of three dry seasons construction. Gates for scouring sluice, intake and settling basin were installed in 1978.

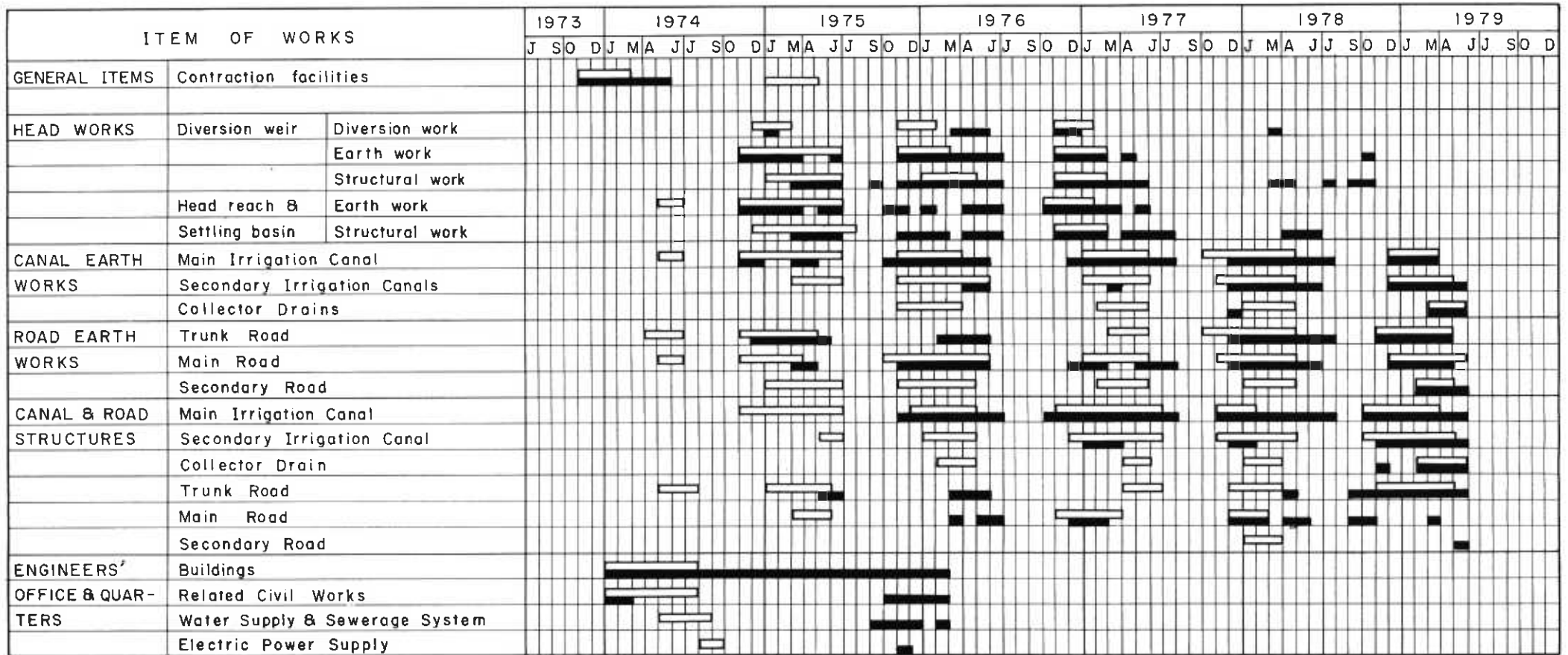
3.1.3 Main and Secondary Irrigation Canals

Earthworks for the Main Irrigation Canal was scheduled to be commenced within the first dry season as soon as the construction equipment have been delivered, and by the end of April 1976 all the main and secondary systems were planned to be completed. However, the construction works were extended to the end of May 1979 mainly due to the following reasons and circumstances.

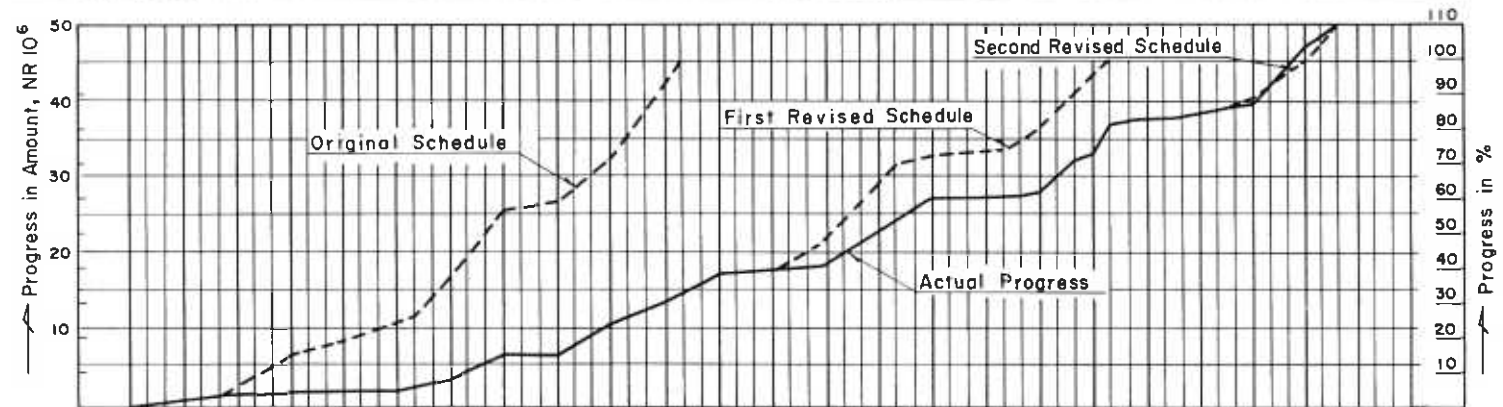
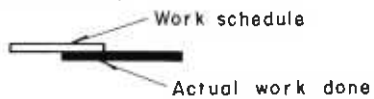
- i) Canal alignment have been changed substantially according to the actual topography of the project area.
- ii) Canal design capacity and slope of the upper main canal were revised from the original one resulting in certain modifications of the canal structure design.
- iii) Delivery of the earth moving equipment at the site were delayed due to the port congestion.
- iv) Cement for concrete lining of the upper reach of main canal were crucially short throughout the construction period.

After the delivery of the construction materials the Contractor carried out the works adopting the 2 shift system to expedite the construction work. Notwithstanding the earthworks increased in quantity at about 170 % of the original, the construction work has been successfully completed by the end of April 1979.

Fig. 3.1 CONSTRUCTION TIME SCHEDULE AND PROGRESS
MAIN CIVIL WORKS



Legend :



3.1.4 Roads

The construction of farm roads was scheduled to be carried out in two dry seasons of 1974/75 and 75/76 concurrently with the canal earthworks. As the construction of canal earthworks was extended to April 1979 because of the reasons described in the preceding section, the road earthworks were accordingly extended to May 1979. Construction of the trunk road was suspended in one dry season of 1976/77 mainly due to the concentration of heavy equipments into the headwork construction.

3.1.5 Engineer's Office and Quarters

Since the beginning the Engineer had requested strongly the Contractor to expedite the completion of Engineer's Office and Quarters. Because of short coming of cement and asbestos sheet as well as hardware which are mostly locally available, the construction work were largely delayed. Though an office and some quarters has been taken over by the project by May 1975, it has taken for 26 months for the completion as compared with the original schedule of 7 months.

3.2 Agricultural Sub-Station (ASS)

3.2.1 General

The time required for the construction work of the ASS was estimated to be 6 months from October 1973 through March 1974 in the contract. However, the works were severely affected by the crucial shortage of construction materials, particularly, cement and asbestos sheets and delay of delivery of construction equipment at the site. Then the Contractor claimed to extend the time of completion in three times accompanied with the detailed particulars. After careful examination of above particulars the Engineer granted about 22 months of extension of completion time to the Contractor.

Meanwhile, the Engineer deleted the construction of two irrigation storage ponds and a irrigation pump station on the Balwa river after careful studies made in view of availability of irrigation water in the said river. The contract amount of the said works corresponded to about 15 % of the total amount. Except for installation of overhead tank for raw water supply system the construction of both civil work and building

works have been completed in the beginning of February 1976. The details are shown in Fig. 3.2.

3.2.2 Civil Works

Due to delay of delivery of construction equipment at the site, the civil works for construction of irrigation and drainage system as well as land readjustment of 40 ha of demonstration farm were suspended in the dry season of 1973/74.

Earthworks for irrigation and drainage canals and roads as well as land readjustment have been completed by the end of dry season of 1974/75, but those structural works were suspended to the dry season of 1975/76 due to shortage of cement. All the civil works have been completed by the beginning of February 1976.

3.2.3 Building Works

The construction of office and quarters was taken for 24 months except for installation of overhead tank for raw water supply system, comparing with the original schedule of 6 months. The Contractor was compelled to be interrupted often due to shortages of cement, asbestos sheet and hardware, transportation difficulty of the materials from the East-West Highway to the site, etc. From the middle of September 1975 through the end of November 1975 all the buildings were completed and handed over to the Employer.

3.3 Minor Works

They are desirable to carry out the construction of the minor works in parallel with the major works and to complete it at the same time when the major works will be completed. However, the construction of the minor works is not practical unless the construction of Diversion Weir and Main and Secondary Canals is to be completed because the traditional irrigation system is to be blocked due to the construction of the minor works and no irrigation may be available for a few years. Accordingly, the construction of the minor works under force account basis was originally scheduled to be completed within three dry seasons, 1974/75, 75/76 and 76/77 which is

Fig.3.2 CONSTRUCTION TIME SCHEDULE AND PROGRESS
AGRICULTURAL SUB-STATION

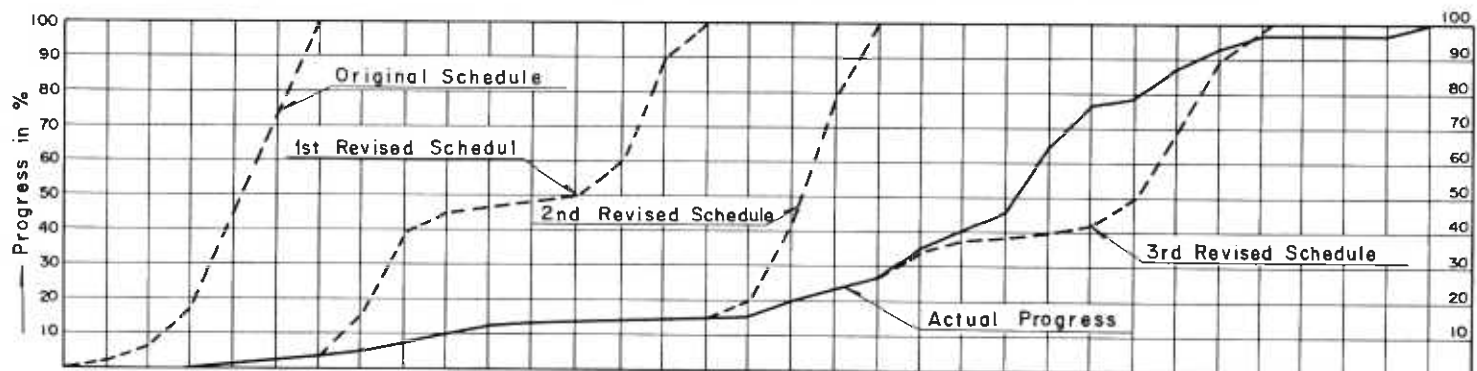
ITEM OF WORKS	%	1973			1974												1975												1976								
		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J			
MOBILIZATION		█																																			
GENERAL ITEMS																																					
	Assistance to Engr.	█																																			
	Contingency	█																																			
IRRIGATION	Upper Pond Earthworks	█																																			
STORAGE PONDS	Structures	█																																			
	Lower Pond Earthworks	█																																			
	Structures	█																																			
IRRIGATION PUMP	Structure	█																																			
STATION	Pump	█																																			
CANAL EARTHWORKS		█																																			
ROAD EARTHWORKS		█																																			
CANAL AND	Str. on Irrigation Canals	█																																			
ROAD STRUCTURE	Str. on Drainage Canals	█																																			
	Brick Sewer	█																																			
LAND READJUSTMENT		█																																			
OFFICE AND	Site Clearing	█																																			
RESIDENCE	Building Work	█																																			
QUARTERS	Electrical Work	█																																			
	Plumbing	█																																			
	Facilities	█																																			

Note :

- 1) The works for irrigation storage ponds and pump station which corresponds to about 20% of the contract amount were deleted after the commencement of the construction works.
- 2) Because of the Contractors request raw water supply system was revised from pneumatic tank system to overhead tank system.

Legend :

- ▬ Work schedule
- █ Actual work done



one year delay with the construction schedule of the major works. On the other hand, because of the delay in delivery of construction equipment at the site which were delivered during a period from November 1975 to July 1976, the commencement of the works was considerably delayed. Particularly, due to delay in delivery of bulldozers arrived in July 1976, the actual construction work was started from January 1977 after harvesting of paddy crop at the site. The progress of the works was also severely affected by the shortage of cement in 1977. Only few division boxes for TIC were installed by the end of dry season in 1977.

The progress of earthworks in the first year of 1977 was very slow partly because heavy equipment operators were not so skilled and partly because of shortage of fuel. It was only 10 % of progress in 1977 and about 20 % in 1978 respectively, but repaidly progressed in 1979 and completed by the end of May 1979. Out of total quantity of earthfilling, about one third was carried out by the Contractor of MCW. Excavation of TIC was carried out mainly by the local contractor.

Precast concrete cutoff walls were produced at ASS from July 1977 and the installation of division boxes was resumed from December 1977. Because of delay in delivery of precast concrete pipes, the progress of structure works in the minor works were considerably slow, up to date only about 30 % of progress. Unless particular emphasis is placed upon expediting prefabrication of concrete cutoff walls, it will take approximately further two years for the completion of the Minor Works. Fig. 3.3 shows the details of construction time schedule and progress.

3.4 Protection Works

As the river of the project area are not trained, some of the project facilities are to be endangered due to the river bank erosion. Therefore, the river bank protections by the gabions were ordered to the local contractors as well as the Contractor of MCW from 1975 to 1979.

IV. CONSTRUCTION

4.1 Main Civil Works (MCW)

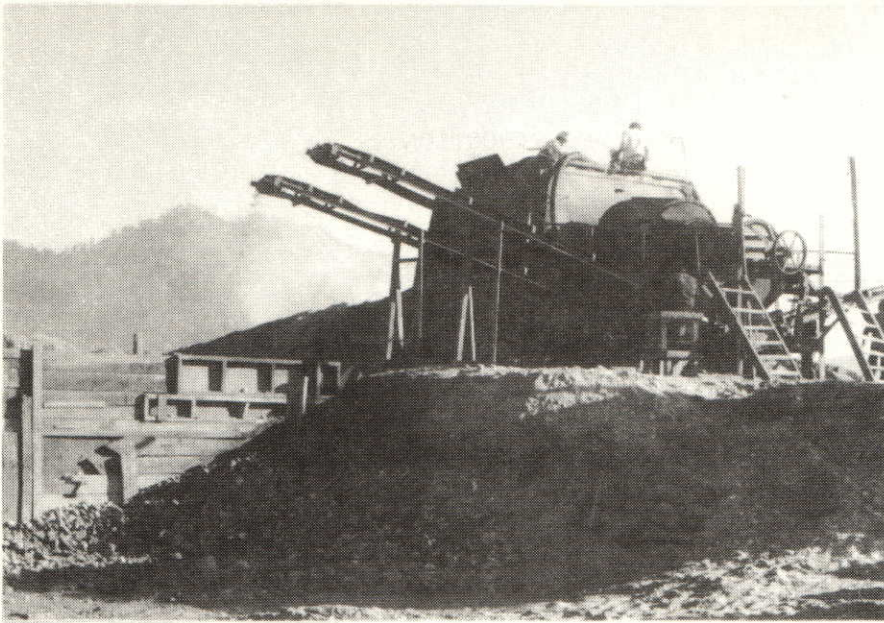
4.1.1 General

MCW include the following works;

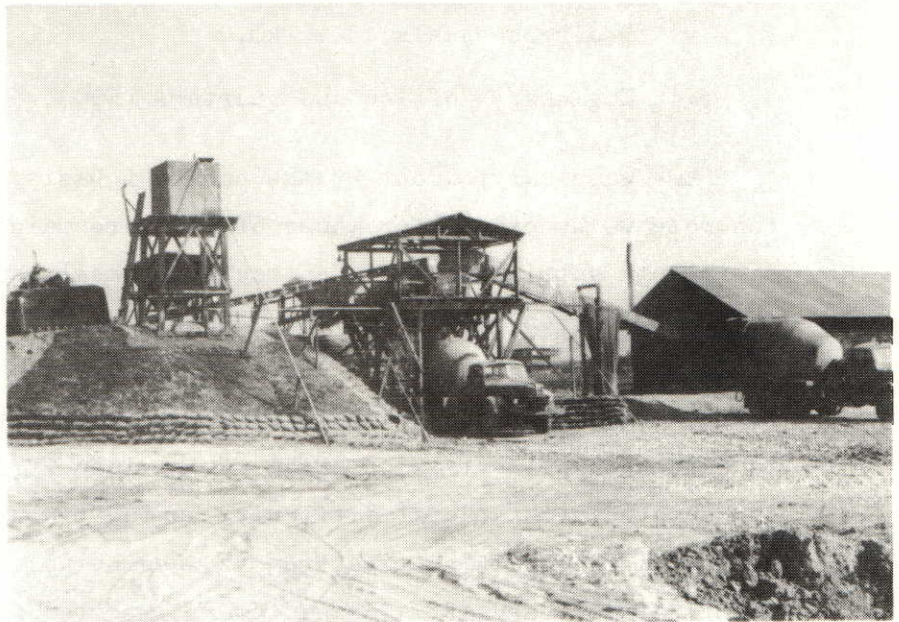
- i) Headworks including head reach and settling basin,
- ii) Main irrigation canals (MIC), about 22.4 km,
- iii) Secondary irrigation canal (SIC), about 53.9 km,
- iv) Road system, 140.0 km,
- v) Drainage canals, 30.0 km,
- vi) Engineer's office and quarters (EOQ).

MCW were carried out by the contract basis. The earthworks and concrete works except for these of EOQ were mainly carried out by heavy equipment, supplied by the Contractor themselves. For procurement of the construction equipments and materials, the Contractor had received as advance payment of about US\$0.9 million and about 0.3 million equivalent, respectively, which correspond to about 26 % of the contract amount. Due to unforeseen oil crisis occurred in the late 1973, the Contractor had encountered with crucial difficulty on the procurement of imported equipments and materials on time from the beginning of the construction works. The first delivery of major equipment imported at the site was made in April 1974 resulted almost in a loss of one dry season for the works. The procurement of cement was very crucial. By the end of March 1974, six (6) months after the commencement of the works, by the Contractor total cement delivered at the site was about 150 t which was negligible small amount of quantity to the works to be done during the said period. Consequently the Contractor had been compelled to often interrupt the works. The shortage of cement had largely affected the progress of the works throughout the construction period.

Concrete aggregates were obtained from the Kankai river at around 1 km downstream from the diversion weir site where a screen plant was installed. The Contractor provided two unit of concrete batcher plant,



Screen Plant
at Kankai River



Batching Plant
at ASS



Crushing Plant
at Dudhe

one installed at the weir site and the other at the Balwa river side near ASS. The former plant was operated during a period from March 1975 to July 1978 for the concrete works of the headworks and the upper reach of MIC and then removed to the Baniyani river side near the No. 5 siphon site of MIC and operated during the 1978/79 dry season. The latter was operated during a period from December 1977 to May 1979. Boulder used for rubble masonry as well as for broken stone for road pavement were mainly obtained from three rivers, Ratuwa river and Dhans river, about 20 km and 25 km west of EOQ site respectively and Timai river approximately 30 km east of EOQ. Two stock piles of crushed stones for road pavement were established, one at Dudhe along the trunk road and the other at the vicinity of ASS, where the materials were crushed by the crushing plant.

The earthworks were mainly carried out during the dry season from November to May in which earth embankment for both canals and roads were made from the late December taking the soil moisture contents into account. The embankment materials were placed in layers not exceeding 20 cm compacted thickness and the compaction was carried out by mainly pneumatic tire roller at an optimum moisture content. The compaction test was made in every 200 m interval of embankment for canals and roads. The following Table 4.1 shows a part of the compaction test results.

Table 4.1 Compaction Test Results of Embankment

<u>Date</u>	<u>Canal/Road</u>	<u>Location</u>	<u>Proctor Value</u> (gr/cm ³)	<u>Relative Value</u> (%)
Jan. 9, '76	Main Road (R-I)	14+00	1.87	98.5
Jan. 12, '76	Road	EOQ	1.87	99.4
Feb. 11, '76	MR (R-I)	19+10	1.87	100.6
Feb. 14, '76	Trunk road	39+00	1.69	96.0
Feb. 22, '76	Trunk road	28+00	1.69	99.0
Feb. 24, '76	MIC R-I	10+59	1.87	98.1
May 11, '76	MIC R-I	No. 1 Siphon ^{/1}	1.87	98.8

Remarks: /1 Backfilling

<u>Date</u>	<u>Canal/Road</u>	<u>Location</u>	<u>Proctor Value</u> (gr/cm ³)	<u>Relative Value</u> (%)
May 16, '76	MIC R-I	No. 7 Box Culvert	1.87	99.2
Nov. 26, '76	Headwork	River bank	1.95	98.4
Dec. 1, '76	Headreach	4+15	1.94	98.5
Dec. 3, '76	Headworks	River bank	1.95	96.5
Dec. 31, '76	Headreach	Outlet channel	1.93	97.0
Mar. 11, '77	MIC R-I (Road)	27+83	1.93	97.9
Apr. 20, '77	SIC S-1	21+45	1.92	96.4
Jan. 24, '78	MIC R-I	95+60	1.72	99.4
Feb. 2, '78	MIC R-I	87+50	1.72	106.4
Mar. 5, '78	MIC R-I	109+50	1.68	95.0
Mar. 8, '78	SIC S-2	7+50	1.66	103.0
Feb. 16, '79	SIC S-8	51+80	1.66	97.0
Mar. 7, '79	SIC S-12	73+15	1.62	103.0
Mar. 12, '79	SIC S-11	8+40	1.62	98.0
Mar. 16, '79	SIC S-10	15+50	1.57	95.4
Mar. 3, '79	Trunk road	11+50	1.70	96.8

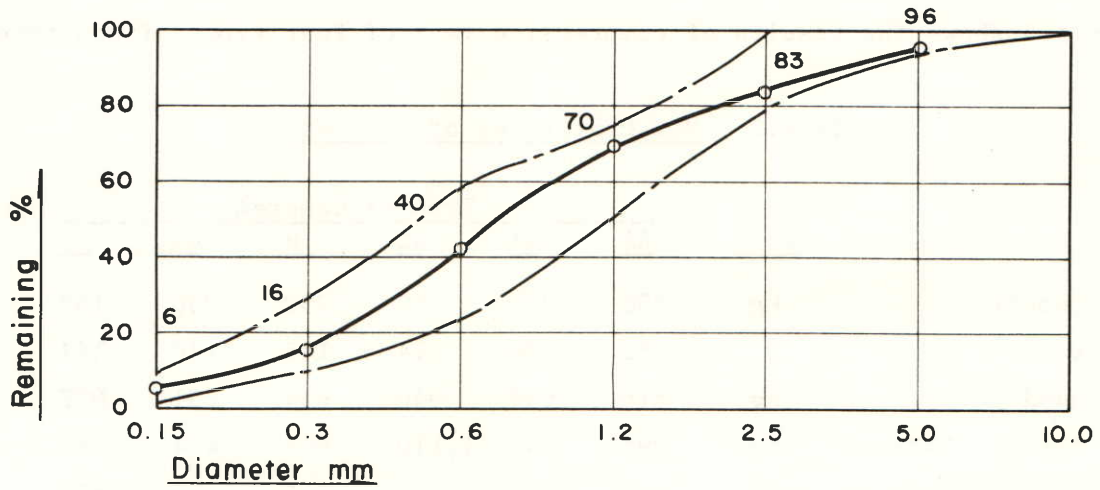
Sod facing were performed on the slope of embankment or excavation for the canals and roads construction. It is worthy of special mention that the sod facing for the slope protection was quite effective against such non-cohesive soils under the intensive rainfall in the project area.

The sieve analysis test carried out on gravel and sand showed that the both were so well graded as to satisfy the requirements in the specifications. Fig. 4.1 shows the typical results of sieve analysis test carried out by the Contractor and the Project.

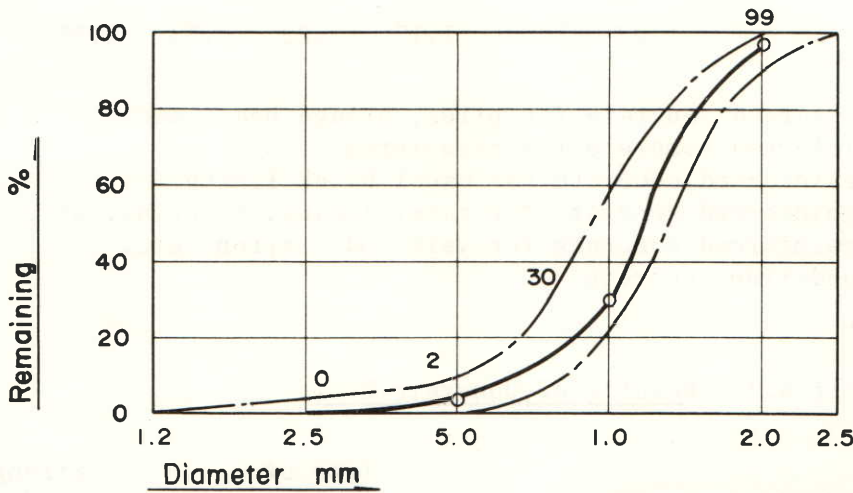
The concrete test was also carried out to determine the most proper concrete mixing proportions for various type of concrete. The following Table 4.2 shows the specified mix proportions recommended to the Contractor. It was controlled and checked by the Engineer from time to time in order to produce high quality of concrete, but such proportions particularly water cement ratio was varied to some extent due to the water content of the aggregates used. The slump test was conducted for approximately

Fig.4 - 1 TYPICAL RESULT OF SIEVE TESTS
FOR
CONCRETE AGGREGATE

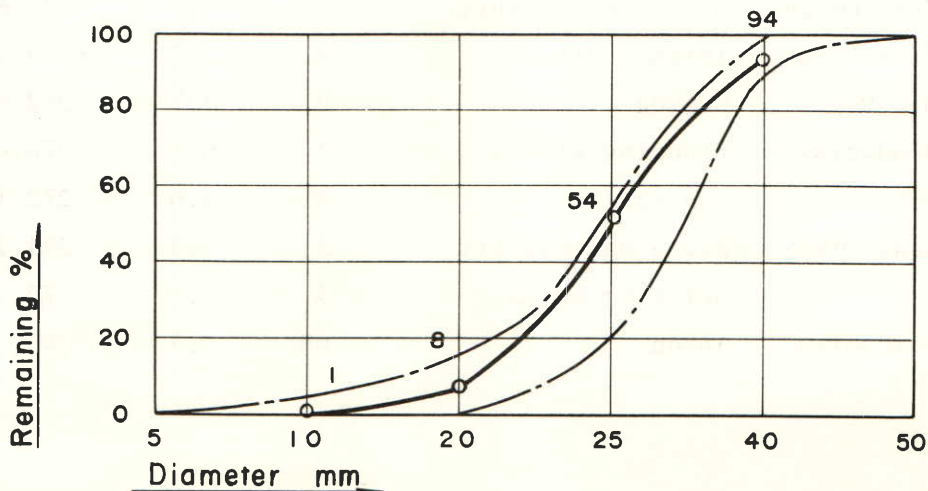
1. SAND 25 DEC. 1976



2. 5 ~ 20 mm GRAVEL 23 JAN. 1977



3. 20 ~ 40 mm GRAVEL 17 JUL. 1977



every 100 m³ of concrete casted. Concrete test pieces for compression tests were sampled and tested for every 200 m³ of concrete produced. Table 4.3 shows the results of compression test of four types of concrete.

Table 4.2 Mix Proportion of Concrete

	<u>Unit</u>	<u>Type of Concrete</u>					
		<u>AA</u>	<u>A1</u>	<u>A2</u>	<u>B</u>	<u>BB</u>	<u>C</u>
Cement	kg	350	300	300	250	250	180
Water	ℓ	182	150	114	145	140	144
Sand	kg	816	695	946	634	621	627
Gravel 5-20 mm	kg	994	646	1,110	695	414	585
Gravel 20-40 mm	kg	-	646	-	715	414	877
Gravel 40-80 mm	kg	-	-	-	-	621	-
W/C ratio	%	52	50	38	58	56	80
G/S		1.22	1.86	1.17	2.22	2.33	2.33

Note: AA - Reinforced concrete for piles, bridge beam, etc.
 A1 - Reinforced concrete for structures
 A2 - Unreinforced concrete for canal block lining
 B - Unreinforced concrete for canal lining, flooring, etc.
 BB - Unreinforced concrete for weir body, apron, etc.
 C - Foundation concrete

Table 4.3 Results of Concrete Test

<u>Date</u>	<u>Canal/Road</u>	<u>Structure</u>	<u>Type of Concrete</u>	<u>Slump</u>	<u>Strength kg/cm²</u>
Nov. 19, '75	MIC R-I	Lining	B	3.0	262.7
Nov. 21, '75	Head reach	No. 2 box culvert	A	4.5	255.6
Dec. 6, '75	Headworks	Intake culvert	A	5.5	259.0
Dec. 9, '75	MIC R-I	Lining	B	3.5	262.6
Dec. 18, '75	Headworks	Scouring sluice	A	6.0	270.0
Dec. 24, '75	MIC R-I	Lining	B	3.0	272.1
Dec. 24, '75	Head reach	No. 3 box culvert	A	5.5	294.7
Jan. 29, '76	"	Settling basin	A	5.5	272.8
Jan. 22, '76	Headworks	Apron	BB	5.5	205.7

<u>Date</u>	<u>Canal/Road</u>	<u>Structure</u>	<u>Type of Concrete</u>	<u>Slump</u>	<u>Strength kg/cm²</u>
Jan. 16, '76	MIC	Lining	B	3.0	230.8
Feb. 16, '76	Headworks	Apron	BB	5.0	242.7
Feb. 17, '76	"	Art. concrete block	B	2.5	273.2
Mar. 23, '76	MIC R-I	Lining	B	4.0	246.4
Mar. 25, '76	MIC R-I	No. 2 siphon	A	5.0	241.2
Apr. 8, '76	MIC R-I	No. 7 culvert	A	5.0	243.6
May 4, '76	Headworks	Apron	BB	4.5	214.3
May 4, '76	MIC R-I	No. 8 culvert	A	4.0	234.5
Apr. 25, '76	Head reach	Lining	B	4.0	199.8
Nov. 12, '76	"	Settling basin	B	3.5	241.1
Dec. 29, '76	MIC R-I	Lining blocks	A	0	228.4
Dec. 5, '76	Headworks	Pile	AA	3.0	260.6
Dec. 6, '76	"	Apron	BB	3.5	202.8
Dec. 2, '76	Head reach	Lining	B	3.0	200.5
Dec. 4, '76	MIC R-I	Intake	A	4.0	241.2
Jan. 29, '77	MIC R-I	Lining	B	3.0	203.6
Jan. 31, '77	MIC R-I	No. 9 box culvert	A	3.5	258.9
Feb. 5, '77	Headworks	Weir body	BB	4.0	219.7
Apr. 9, '77	MIC R-I	No. 11 box culvert	A	4.5	268.0
Apr. 12, '77	MIC R-I	No. 3 siphon	A	5.0	222.5
Apr. 16, '77	Headworks	Apron	BB	5.0	219.7
Apr. 14, '77	Headworks	Art. conc. blocks	B	4.0	218.3
Jul. 4, '77	MIC R-I	Lining	B	3.0	230.8
Dec. 20, '77	MIC R-I	No. 12 box culvert	A	3.0	224.8
Dec. 22, '77	MIC R-I	Lining	B	4.0	206.5
Jan. 21, '78	MIC R-I	S-2 check	A	4.0	243.3
Jan. 26, '78	MIC R-I	Lining	B	4.0	240.5
Dec. 14, '78	Trunk road	No. 2 bridge	A	<u>/1</u>	181.4
Dec. 31, '78	"	No. 3 bridge	AA	8.0	234.0
Feb. 7, '79	Headworks	Launching apron	B	<u>/1</u>	187.7

Remarks: /1 Not checked

The construction works were carried out from the upper reach of the works in view of the stage wise irrigation water supply to the project area. Then, about 750 ha of paddy land, 15 % of the project area has been irrigated since July 1977 and about 2,000 ha, 40 %, from July 1978. The major works done by the Contractor summarized in Table 4.4. The number of workers employed by the Contractor is listed in the Table 4.5.

Table 4.4 Major Works Done for MCW

<u>Work Item</u>	<u>Earthworks</u>		<u>Concrete</u>			<u>Metal</u>
	<u>Exca.</u> (10 ³ m ³)	<u>Filling</u> (10 ³ m ³)	<u>PCL</u> (10 ³ m ³)	<u>BL</u> (10 ³ m ²)	<u>Struc.</u> (10 ³ m ³)	(Ton)
Diversion Weir	24.5	23.5	-	-	12.68	195.45
HR & SB	99.9	12.2	2.18	-	1.71	8.82
MIC	265.3	74.8	9.56	19.73	4.86	64.18
SIC	30.5	208.3	0.17	-	1.62	50.35
Collector Drain	12.6	-	-	-	0.04	-
Road	7.8	382.1	-	-	2.00	1.25
<u>Total</u>	<u>440.4</u>	<u>700.9</u>	<u>11.91</u>	<u>19.73</u>	<u>22.91</u>	<u>320.05</u>

Note: HR & SB - Head reach and settling basin
PCL - Plain concrete lining
BL - Block lining

Table 4.5 Number of Contractor's Employee for MCW

	Unit: M/M			
	<u>Engineer</u> <u>& Officer</u>	<u>Technic.</u> <u>& Operator</u>	<u>Common</u> <u>Labor</u>	<u>Total</u>
Foreign Staff	581	800	-	1,381
Local Personnel	394	8,914	12,398	21,706

Note: Above figures not include the number employed during a period of the initial stage from October 1973 to April 1974 because of no data available in those period.

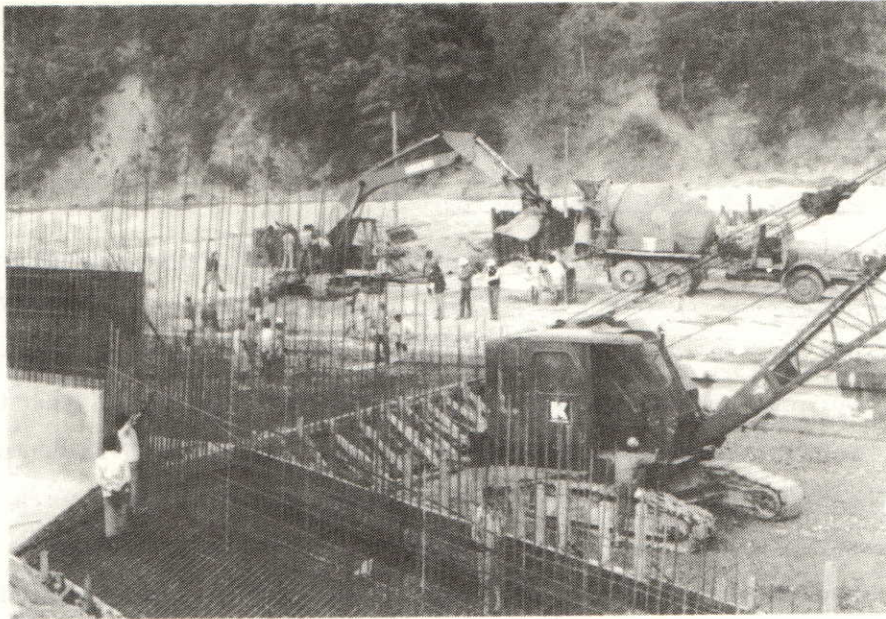
4.1.2 Headworks

i) Diversion Weir and Intake

The construction of diversion weir and intake structure were scheduled to be carried out in two dry seasons, 1974/75 and 75/76. Namely, the right half portion including intake structure was to be constructed in 1974/75 dry season and the remaining half in the 1975/76 dry season, for which multiple stage diversion method was applied for diversion work. However, three dry seasons were required to complete the headworks mainly because of delay in delivery of equipment and materials as explained below.

In the beginning of January 1975, the coffer dam surrounding the right half working area was constructed on the Kankai river by using mainly bulldozer. The coffer materials used were mainly of the river bed gravel and sand surrounding the dike. Some fine soil materials were also used for the dike embankment where needed.

As soon as the site was dewatered, the excavation work for intake was carried out. Subsequently the foundation concrete works were proceeded. The concrete piles for weir foundation were precasted in keeping pace with installation of batching plant as well as construction of the river bank protection. Because of delay in delivery of steel sheet piles which were delivered at the site in the last decade of March 1975, the driving of both steel sheet piles and concrete foundation piles was made in April 1975 which was 3 months behind the schedule. The concrete placing for weir body and apron was commenced in April 1975 which was also 3 months behind the schedule due to delay in delivery of the concrete truck mixers. Total quantity of concrete cast for weir and apron by the end of June 1975 was only about 850 m³ corresponding to about 7 % of the total quantities of concrete for the weir. The construction of weir and intake were suspended when the coffer dam was evertopped and destroyed by the flood in the middle of June 1975.



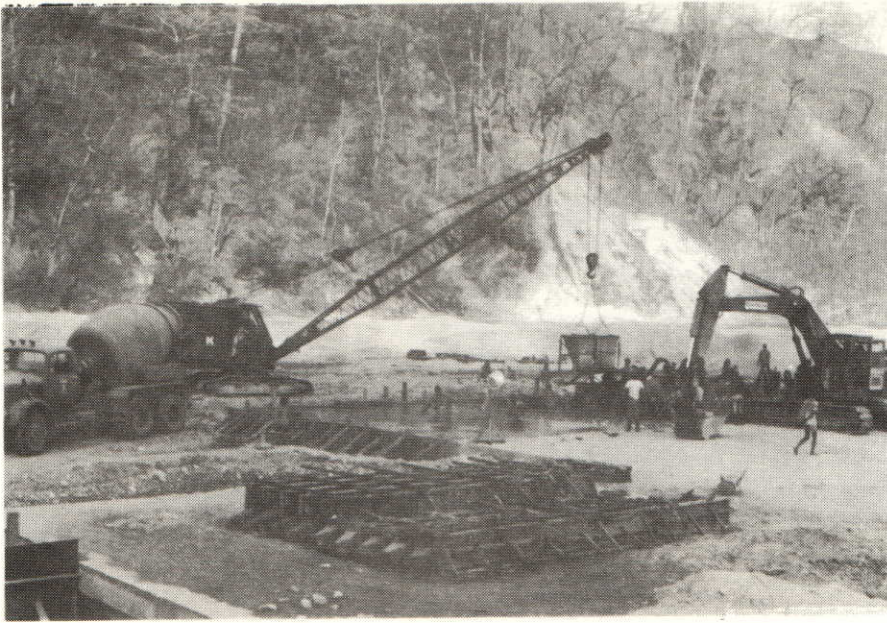
Scouring Sluice Dec. '75



Weir Body Piling
Apr. '75

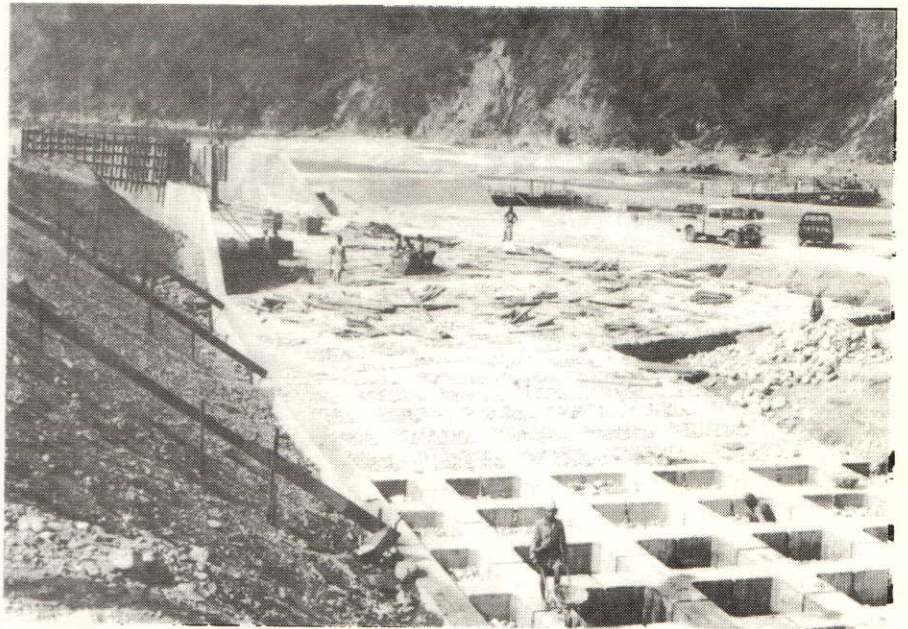


Weir Body Cutoff
Mar. '76



Diversion Weir
Apron Concreting

Feb. '76



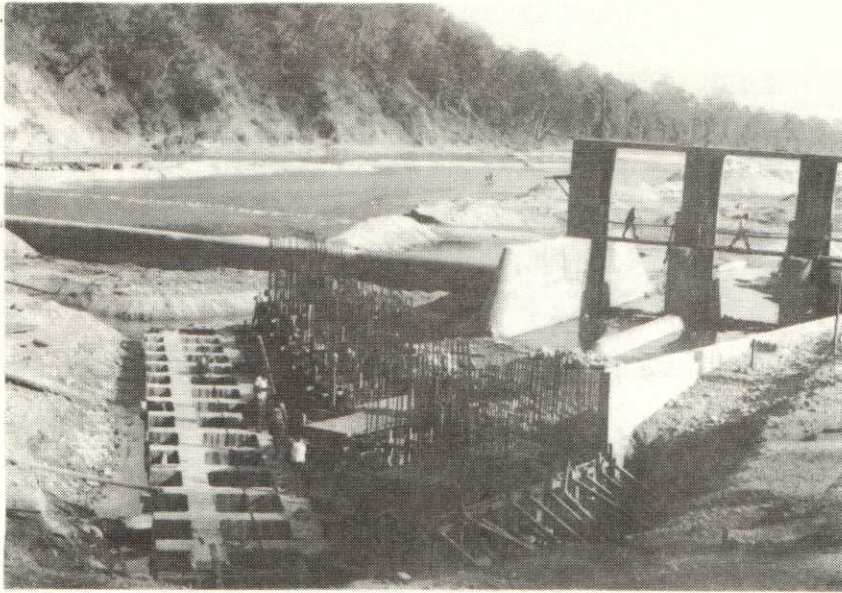
Diversion Weir
Scouring Sluice
Downstream

Mar. '76



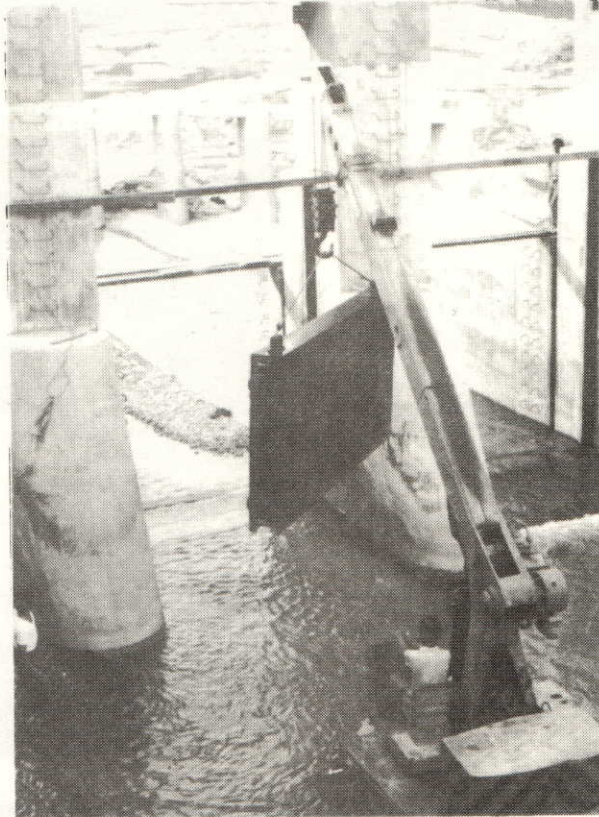
Diversion Weir
Intake

Mar. '76



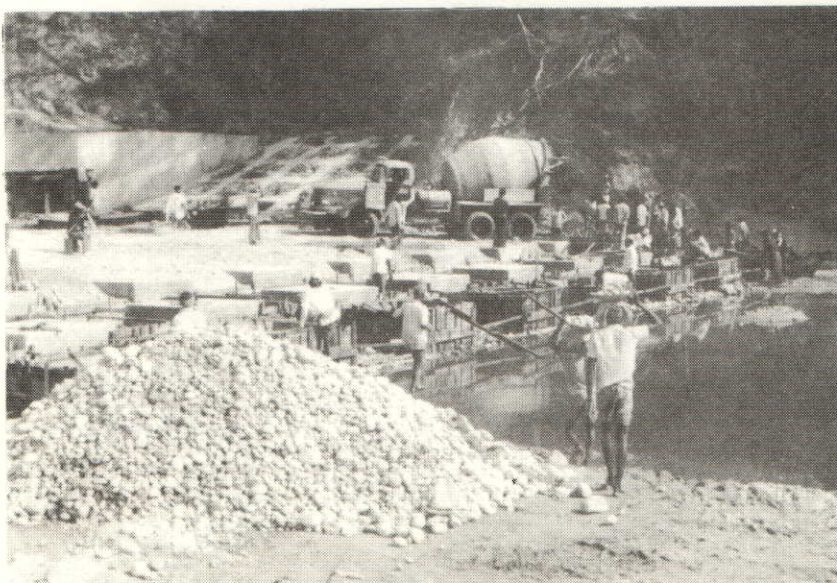
Diversion Weir
Log Protection

Jun. '77



Diversion Weir
Scouring Sluice
Gate Installation

Mar. '78



Diversion Weir
Launching Apron

Feb. '79

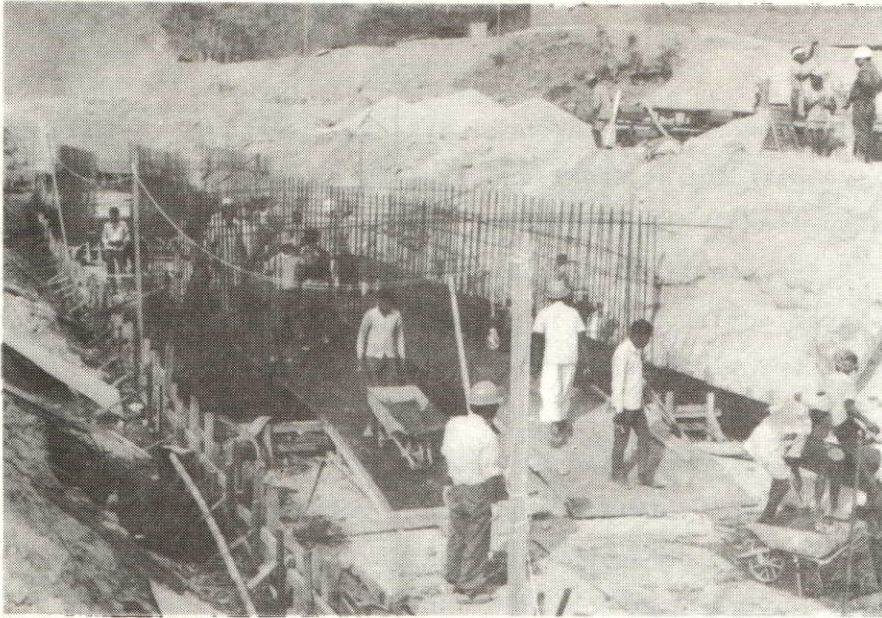
The concrete works for the headworks were resumed in the beginning November 1975. Steel sheet piles for cutoff portion were driven by diesel pile hammer to the base rock. Though the special care was taken to ensure that the piles are properly interlocked during the whole extent of driving, the joint was put out at two places where hard stone exists underneath. Repiling was made carefully at above places. Dewatering by pump for concrete placing at deep cutoff portion was most hard particularly at the both front and near cutoff walls. The headworks construction in the second dry season was fairly progressed at about 78 % of the works by the June 1976.

In June 1976 the front of scouring sluice was completely clogged by tremendous drift wood and objectionables carried away by the flood from the upstream. In order to protect such clogging, the log protection piers were constructed in front of the scouring sluice in January 1977. The articulated concrete mattress with cross-shaped concrete blocks were constructed at the site. Except for the installation of gates and trash racks at the scouring sluice and intake and the river bank protection works, all the headwork construction was smoothly finished by the end of April 1977.

ii) Headreach and Settling Basin

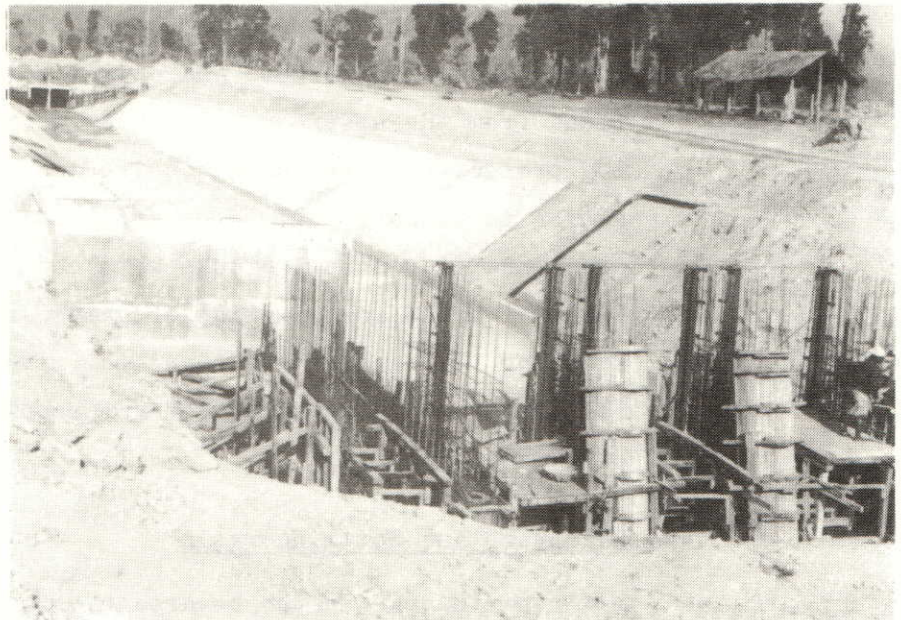
Major earthworks in the headreach were excavation which totalled about 100,000 m³. The excavation was mainly made by means of equipment, such as bulldozer and backhoe. Since the canal base is relatively low, the superpassage structure was provided at the points where the canal crosses the natural drains.

The concrete for canal lining was placed in alternate bays with a slope form with 4 m long panel which was prefabricated with steel plate at the site. The concrete was transported from the batcher plant by truck mixer and the cast by using either backhoe or crawler crane. The slope form was travelled by a



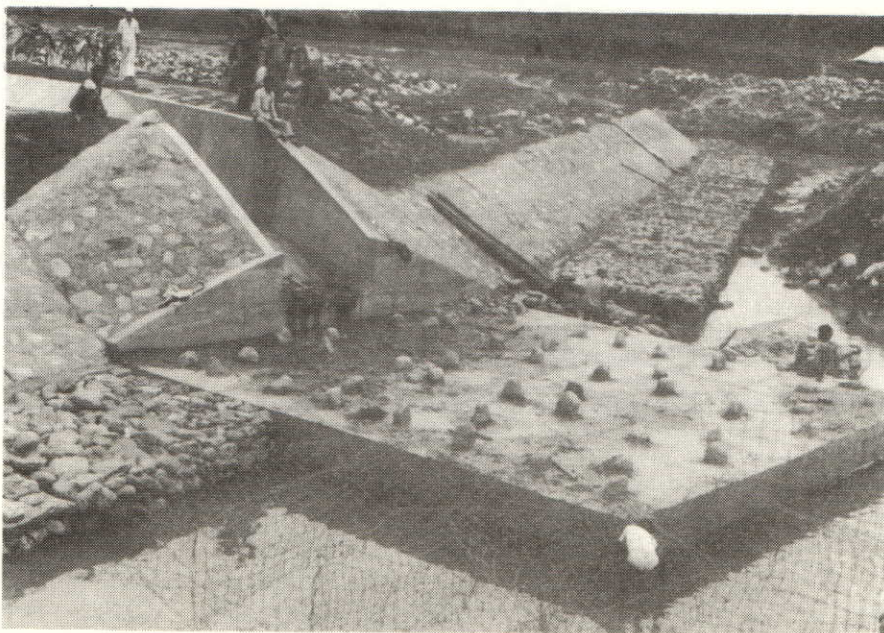
Head Reach
No. 1 Culvert

Feb. '75



Head Reach
Settling Basin

Dec. '76



Head Reach
Outlet Channel
Terminal Structure

Jun. '78

D-6 bulldozer with side boom. The progress of concrete lining ranged from 20 to 30 panels per day according to its site conditions. It is worthy of special mention that the concrete loss in lining amounted more or less 20 % of the quantity designed in case of 15 cm thickness. Under drain was provided for all portions of the head reach and settling basin. Flap valves with a diameter of 100 mm were provided at an interval of 40 mm. Weep holes with flap valve of 50 mm diameter were provided at 4 m interval (one hole per panel) for both slope of the canal.

The canal earthworks were commenced in December 1974 and completed by the end of February 1977. The concrete works started in March 1975 and were finished in May 1977.

4.1.3 Main Irrigation Canals (MIC)

i) General

The utmost essential works of MIC are the earthworks and canal concrete lining. After the final alignment of MIC, auger test pitting along the MIC route with about 200 m intervals was carried out so as to confirm the ground water table as well as the soil conditions. Based on the above tests and the laboratory tests on the soil mechanics such as soil texture, density, permeability, water content, etc., the canal type was classified into three types, unlined, plain concrete lining and concrete block lining. These typical sections are shown in DRW No. 5. For the purpose of construction administration, MIC was divided into the following four reaches.

Table 4.6 General Feature of MIC

<u>Reach</u>	<u>Length</u> (m)	<u>Location</u>	<u>Remarks</u>
Reach I	11,500	BP - No. 115	Concrete lining
Reach II	2,600	No. 115 - No. 141	Unlined
Reach III	2,788	No. 141 - No. 27+88 (No. 0)	Unlined
Reach IV	5,544	No. 141 - No. 55+44 (No. 0)	Unlined
<u>Total</u>	<u>22,434</u>		

ii) Earthworks

Subsequent to the land clearing including the cutting down and uprooting of trees, using bulldozers and backhoes, excavation works were performed. Equipment used for excavation are mainly bulldozers, backhoes and dump trucks. The following table shows summary of canal earthworks excluding earthworks for the structures in each reach.

Table 4.7 Quantities of Earthworks in MIC

<u>Reach</u>	<u>Excavation</u> (10 ³ m ³)	<u>Earthfill</u> (<u>Excavated</u>) (10 ³ m ³)	<u>Earthfill</u> (<u>Borrowed</u>) (10 ³ m ³)	<u>Sod Facing</u> (10 ³ m ³)
Reach I	196.7	13.4	11.0	51.6
Reach II	13.6	5.3	2.2	4.4
Reach III	11.7	2.3	1.8	4.5
Reach IV	8.8	3.1	11.8	8.2
<u>Total</u>	<u>230.8</u>	<u>24.0</u>	<u>26.8</u>	<u>68.7</u>
B/Q	185.0	31.0	10.1	46.0
%	125	77	265.5	149

As seen in the above table, the total quantities of excavation was amounted to about 231 thousand m³ which was as much as about 125 % of the Bill of Quantities in the Contract, particularly, those quantities in Reach I was considerably much as compared with others. In the deep excavation portion in Reach I from St. No. 13 through No. 52, six (6) super passages structures were provided for the natural drains, resulting in relatively large quantity of structural works. In about 3.3 km long between St. No. 40 and St. No. 85 the ground water-table were higher than the canal base designed, where the side slope collapsed considerably, resulting in certain extent of replacement of materials with gravels and sands.

Total earthfill works amounted about 55,000 m³ of which about 50 % of embankment materials were borrowed from the surroundings



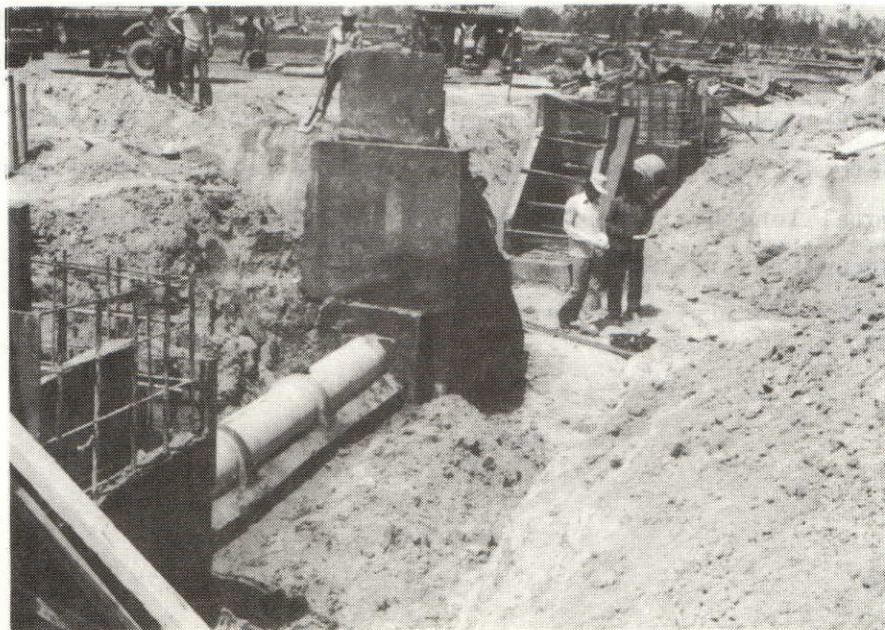
MIC
General Earthworks

Dec. '76



MIC
Excavation

Mar. '79



MIC
Turnout Construction

Apr. '78

of canals. All the earthworks were carried out under the strict control of soil moisture content, compaction of canal embankment was carefully made by using mainly tire-roller to obtain at least 92 % of maximum dry density.

iii) Related Structures

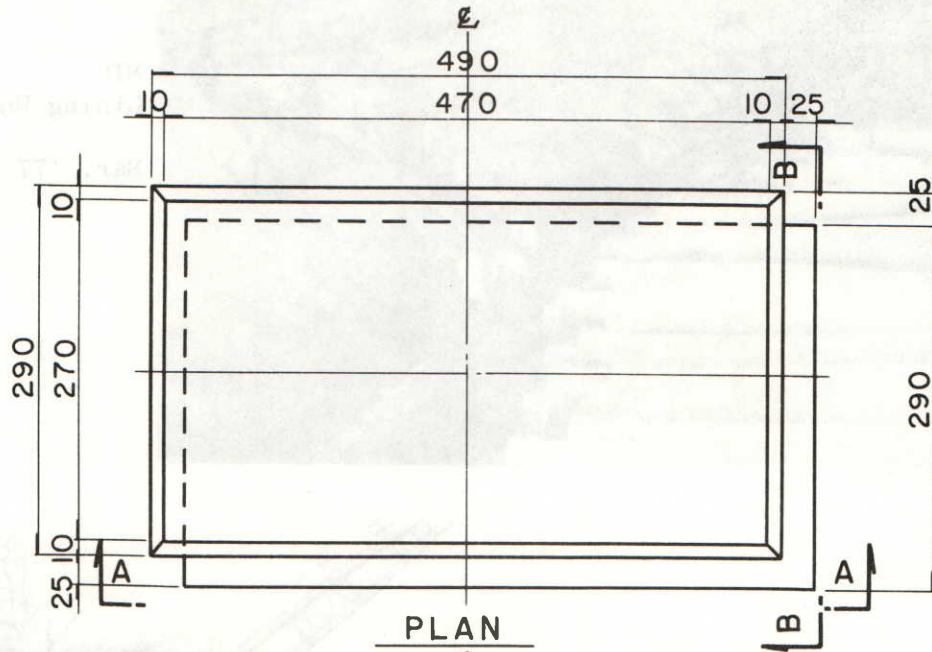
a) Canal Lining

The concrete placing was carried out as same manner as that in the head reach. In the lower reach of the lining portion where canal earthworks are almost balanced between the excavation and embankment, the progress of concrete lining was as smooth as ranging from 40 to 50 panels per day.

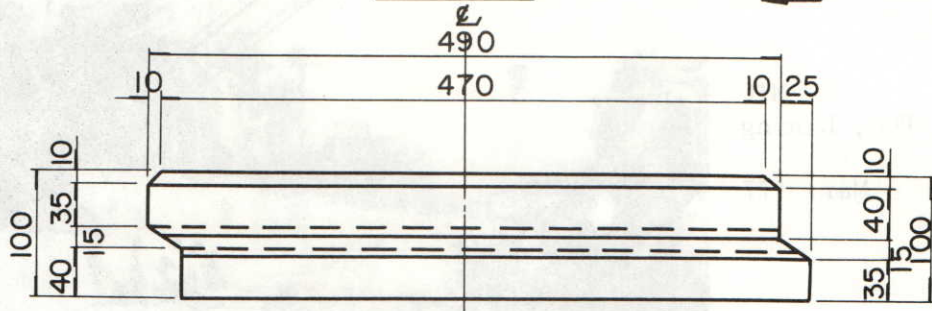
About 3.3 km long in the upper reach of MIC between St. No. 40 to St. No. 85 were relatively high ground water table where the block concrete lining is introduced. After dewatering the site, the soils of side slope were replaced with gravel and sand and then precasted concrete blocks were placed by mainly man powered. The each block was jointed with 1:3 cement mortar. Fig. 4.2 shows the dimensions of three typical concrete blocks which were precasted by the concrete block machine loaned from the Employer to the Contractor and established at the block making yard near EOQ. The progress of block lining was rather slow ranging from 15 to 20 m per day for both side slope. Under drain with 100 mm flap valve was provided for all lined portions at 40 m interval and side drain with 50 mm weep hole with valve was provided at 4 m interval for about 5,260 m in both deep excavated and high ground water table portions. Total length of the lined canal including the related structures is 11.5 km. Total quantities of the major works are listed below.

Fig. 4-2 TYPICAL SHAPE OF CONCRETE BLOCK

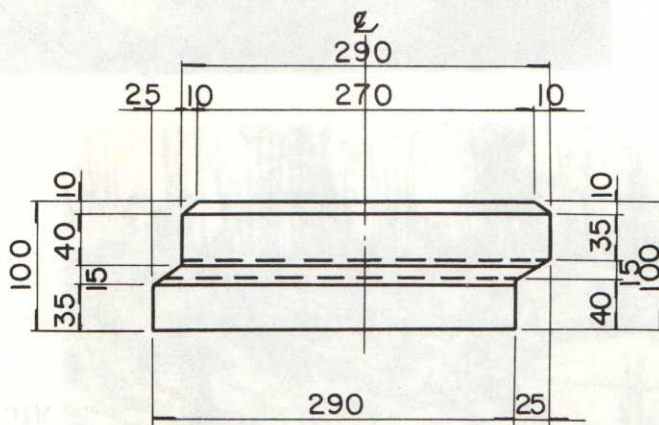
A - Type



PLAN



SECTION A-A



SECTION B-B

Remarks : B-Type and C-Type are a right half and a left half of A-Type Block.



A - Type

MIC
Lining Underdrain
Mar. '77



MIC
PCC, Lining
Mar. '77



MIC
Block Lining
Mar. '77

Table 4.8 Major Work Quantities of Concrete Lining

Work Item	Unit	Quantity
Concrete Lining	m ³	8,643
Concrete Block Lining	m ²	19,730
Gravel Filter for Foundation	m ³	2,986
Flap Valve, 100 mm	Nos.	252
Flap Valve, 50 mm	Nos.	2,626
Asbestos Pipe	m	4,665
Replacement Soil	m ³	4,564
Steel Bar for Step	kg	1,762

During the excavation of canals in Reach II & Reach IV, it was found out that the downstream portion of No. 2 Bifurcation structure was mostly covered with very sandy soils which might result in sliding of the side slope when the irrigation water was diverted. Accordingly, about 265 m long of canal portion curving in Reach IV was lined with concrete. Slope of the canal section was 1:1.5 and the thickness was 7.5 cm.

b) Siphons

Five siphon structures in MIC were constructed at the site where MIC runs across the deep natural drains and streams. The construction works were encountered with a difficulty in the foundation preparation of siphon barrels where loose maddy materials were replaced with gravel and sand of which the quantity totalled 460 m³. After the coffering works were done, the dewatering was carried out by pumps. Construction joint was provided in every 10 m jointed with rubber water stop. The major work quantities of siphon structures are shown in the following Table 4.9.

Table 4.9 Quantities of Major Works of Siphon

<u>Description</u>	<u>Unit</u>	<u>No. 1</u>	<u>No. 2</u>	<u>No. 3</u>	<u>No. 4</u>	<u>No. 5</u>	<u>Total</u>
Length	m	179	36	184	85	109	593
Excavation	m ³	10,060	1,460	8,400	5,210	3,530	28,660
Backfill	m ³	8,320	1,150	7,000	4,660	3,280	24,410
Concrete, Type A	m ³	361	101	399	198	110	1,169
Concrete Form	m ²	2,041	608	1,912	1,144	728	6,433
Steel Bar	t	48.2	13	51.6	27.6	14.3	154.7
Water Stop	m	176	58	175	91	60	560
Steel Gate	kg	3,471	-	3,743	-	1,756	8,970
Trash Racks	kg	340	349	584	332	248	1,853
Replace Material	m ³	157	33	159	46	65	460
Wet Masonry	m ²	67	64	91	56	87	365
Boulder Crate	m ³	-	-	149	182	-	331

c) Spillways

The following three different types of spillways were constructed in MIC.

- i) Gate spillway with side overflow spillway,
- ii) Both side overflow spillway, and
- iii) One-side overflow spillway.

Three gate spillways were respectively provided at the front of No. 3 siphon, No. 5 siphon and at the end of No. 4 siphon, which aimed to draw off the canal water to the adjacent river by the control of gates when and as required. One both side spillway was mainly provided for two purposes, one is almost to collect drain water from the one side and spill out to another, and the other in the spill out the excess water of canal. Two one side spillways were constructed, one (R-I side) at about 100 m downstream from the crossing point with trunk road and the other (No. 2 BC) at the front of No. 2 bifurcation. The former is aimed to collect the excess drain water into MIC and the later to spill out the excess water of MIC to the outlet channel from No. 1 spillway.



MIC
No. 2 Bifurcation

Jun. '78

MIC
Turnout for
Tertiary Canal

Jun. '79



MIC
S-3 Check &
Turnout

Jun. '79

Table 4.10 Quantities of Major Works of Spillway

<u>Description</u>	<u>Unit</u>	<u>Both Side</u>	<u>R-I Side</u>	<u>No.1</u>	<u>No.1 BC</u>	<u>No.2 BC</u>	<u>No.2</u>	<u>Total</u>
Excavation	m ³	-	350	2,985	470	344	480	4,629
Concrete, Type A	m ³	35	22	181	80	6	76	400
Concrete, Type B	m ³	-	54	26	-	78	-	158
Form	m ²	102	90	921	330	230	480	2,053
Re-bar	kg	556	816	18,756	4,373	320	6,165	30,986
Water Stop	m	40	-	83	18	-	58	179
Gate	kg	-	-	1,865	594	-	983	3,442
Backfill	m ³	-	90	652	130	85	153	1,110
Masonry	m ²	-	-	207	-	-	-	207
Replacement	m ³	-	-	68	-	-	-	68

d) Turnouts

10 turnouts for secondary canals and 31 turnouts for tertiary canals were respectively constructed on MIC. All turnouts were equipped with steel gate and Parshall flume for the distribution control of water. The following Table 4.11 shows the quantities of major works for turnouts in MIC.

Table 4.11 Quantities of Major Works of Turnouts

<u>Description</u>	<u>Unit</u>	<u>Second. TO</u>	<u>Tertiary TO</u>	<u>Parshall Flume</u>	<u>Total</u>
Number of TO	Nos.	10	31	-	43
Excavation	m ³	752	743	-	1,495
Backfill	m ³	519	484	-	1,003
Concrete, Type A	m ³	65	139	103	307
Concrete, Type C	m ³	42	59	66	167
PC Pipe ϕ 300	m	-	149	72	221
PC Pipe ϕ 400	m	-	43	-	43
PC Pipe ϕ 500	m	14	-	-	14
PC Pipe ϕ 800	m	41	-	-	41
PC Pipe ϕ 1,000	m	9	-	-	9
Form for Concrete	m ²	600	1,354	1,240	3,194
Re-bar	kg	4,563	8,454	4,021	17,038
Slide Gate	kg	6,154	11,576	-	17,730

c) Check Structures

12 check structures were provided in MIC in order to control the water level for distributing water to the respective turnouts. In the most cases the check structure was constructed at an immediately downstream of the turnout and equipped with stop logs and gates. Except S-4 and TB-7 checks, each check was furnished with a slab on its top to provide a passage to go across the canal. The quantities of major works are tabulated below.

Table 4.12 Quantities of Major Works of Checks

<u>Name</u>	<u>Conc. A</u> (m ³)	<u>Conc. C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Water Stop</u> (m)	<u>Stop Log</u> (m)	<u>Gates & Screen</u> (kg)
S-1	61	5	250	5,845	33	1.0	2,802
S-2	73	6	284	7,241	33	1.0	2,802
S-3 ^{/1}	58	5	281	5,836	40	0.7	3,252
S-4 ^{/1}	44	7	261	4,171	26	0.7	2,511
S-5	42	4	314	4,772	28	0.7	3,073
S-6 ^{/1}	26	4	167	2,265	18	0.2	1,156
S-7 ^{/1}	24	3	159	2,075	17	0.2	908
S-9 ^{/1}	27	4	164	1,907	18	0.2	1,118
S-10 ^{/1}	19	3	141	1,724	18	0.2	892
S-11	12	2	82	736	8	0.2	889
TB-7	8	4	53	469	9	0.2	150
<u>Total</u>	<u>394</u>	<u>47</u>	<u>2,056</u>	<u>37,041</u>	<u>248</u>	<u>5.3</u>	<u>19,553</u>

Note: ^{/1} equipped with drop structure

f) Box Culverts

8 box culverts were constructed in MIC, of which 3 culverts were provided for road crossing and the remaining for running across the natural drains for which super passages were provided on the culverts. Because of rather high velocity of the canal flow, trash racks were provided for those culverts in the concrete lined canal for safety. The following Table 4.13 shows the quantities of major works of box culverts constructed.

Table 4.13 Quantities of Major Works of Culverts

<u>Item</u>	<u>Unit</u>	<u>No.6</u>	<u>No. 7</u>	<u>No. 8</u>	<u>No. 9</u>	<u>No.10</u>	<u>No.11</u>	<u>No.12</u>	<u>No.13</u>	<u>Total</u>
Concrete, Type A	m ³	156	181	173	193	184	186	65	44	1,181
Concrete, Type B	m ³	-	59	41	34	82	41	-	-	257
Concrete, Type C	m ³	9	15	15	13	13	13	5	5	87
Form	m ²	548	907	886	1,041	936	811	290	198	5,618
Re-bar	t	16.4	12.6	12.9	16.1	13.1	13.7	5.3	5.2	95.6
Water Stop	m	61	71	71	71	71	71	36	17	471
Excavation	m ³	631	792	1,083	3,940	1,475	1,336	-	-	9,256
Backfill	m ³	331	240	352	2,623	647	667	-	-	4,860
Embankment	m ³	164	1,059	811	369	835	442	-	-	3,680
Replacement	m ³	-	-	-	9	62	64	-	-	195
Masonry	m ²	-	191	184	233	223	150	-	-	981
Trash Rack	kg	615	615	615	615	615	615	-	-	3,689

g) Drops

The following numbers of drop structures were provided in MIC, some of which were equipped with a concrete slab constructed on its stilling basis to go across the canal to connect with secondary read.

Table 4.14 Number of Drops

	<u>With Slab</u>	<u>W/O Slab</u>	<u>Total</u>	<u>Remarks</u>
Reach I	-	8	8	2 drops were provided as a part of check structure.
Reach II	2	1	3	
Reach III	3	3	6	2 drops were provided as a part of check structure.
Reach IV	4	5	19	2 drops were provided as a part of check structure.
<u>Total</u>	<u>9</u>	<u>17</u>	<u>26</u>	

Table 4.15 shows the quantities of major works made in the drop structures excluding 6 drops for which those quantities were included into these of check structures.

Table 4.15 Quantities of Major Works of Drops

	<u>Unit</u>	<u>Reach I</u>	<u>Reach II</u>	<u>Reach III</u>	<u>Reach IV</u>	<u>Total</u>
No Drops	Nos.	6	3	4	7	20
Concrete, Type A	m ³	203	109	66	113	491
Concrete, Type C	m ³	28	18	12	21	79
Form	m ²	859	531	429	732	2,552
Re-bar	t	21.71	11.03	5.09	8.95	46.78
Water Stop	m	153	39	40	67	299
Stop Log Guide	kg	1,910	590	588	550	3,639
Stop Log	m ³	0.6	1.2	0.5	0.6	2.9

4.1.4 Secondary Irrigation Canals (SIC)

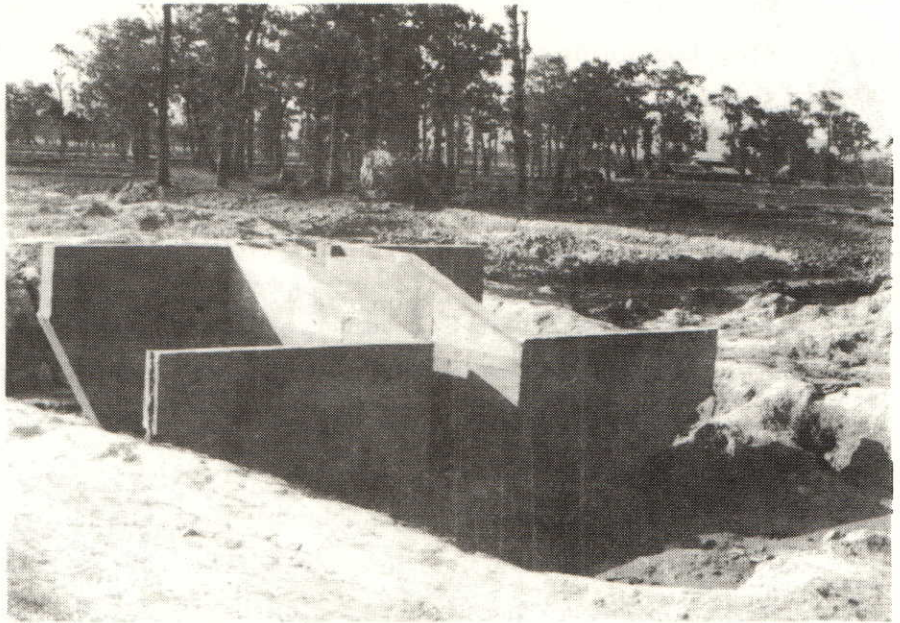
i) Earthworks

Except for S-1 canals, SIC run parallelly with the main roads. Because of rather small cross section of canals, the earth-filling was carried out up to the formation level of the dike for both canal and road by using mainly bulldozer and tire roller in the embankment portions. The most of the earthfill materials were employed from the surroundings of the canals. Ther, the canal section was excavated mainly by man power.

After the excavation of the canals of SIC, it was found out that two portions in the upper part of SIC, namely about 150 m long of S-1 canal at an approximately 1.7 km downstream from its intake and about 390 m long of S-2 canal at its head portion were mostly composed of very sandy soils resulted in various land sliding of those side slopes after diverting irrigation water. Then those portions were lined with concrete as an additional work. The canal section lined was 1:1.5 inside slope and 7.5 cm in thickness, and the under drain with 50 mm diameter flap valve was provided on SIC, S-2. The following Table 4.16 shows the total quantities of earthworks made in each SIC.



SIC
Earth Filling
Mar. '79



SIC
Drop Structure
Apr. '78



SIC
Excavation
Feb. '78

Table 4.16 Quantities of Earthworks in SIC

	<u>Length</u> (m)	<u>Excavation</u> (m ³)	<u>Earthfill</u> <u>(Excavated)</u> (m ³)	<u>Earthfill</u> <u>(Borrowed)</u> (m ³)	<u>Sod-facing</u> (m ²)
S-1	4,800	9,839	4,602	7,424	4,263
S-2	3,891	9,445	957	9,180	7,720
S-3	3,190	816	502	13,678	4,967
S-4	4,100	528	420	23,260	7,256
S-5	3,219	1,568	602	13,664	5,698
S-5A	2,540	636	243	11,894	4,247
S-6	1,571	253	169	6,941	2,443
S-7	1,700	871	533	4,382	1,938
S-8	5,197	2,406	1,243	46,533	11,646
S-9	1,200	428	212	2,552	1,407
S-10	2,739	396	318	16,330	4,919
S-11	2,660	646	491	8,874	3,458
S-12	5,260	3,625	1,621	31,097	9,520
<u>Total</u>	<u>42,067</u>	<u>31,457</u>	<u>11,913</u>	<u>195,811</u>	<u>69,482</u>
B/Q		64,000	31,000	11,000	23,000
%		49	38	1,780	302

As seen in above table, the quantities of earthfill worked out actually were as much as about 5 times of those estimated in the Bill of Quantities. This is mainly attributable to that there exist certain micro-reliefs in the irrigable area so that the canals were constructed to be rather elevated so as to maximize the irrigable area. Average quantities of earthworks per canal length and the command area are about 5.7 m³/m and about 48 m³/ha respectively.

ii) Related Structures

a) Canal Lining

As described in the preceding section, 150 m long in S-1 and 390 m in S-2 canals were lined with concrete. Total quantities of concrete used were 56 m³ in S-1 and 110 m³ in S-2 respectively.

b) Turnouts

The following Table 4.17 shows the quantities of major works for SIC turnouts. All concrete were casted at site by using truck mixer.

Table 4.17 Quantities of Major Works for SIC Turnouts

	<u>TO</u> (Nos.)	<u>Exc.</u> (m ³)	<u>Fill</u> (m ³)	<u>Con.A</u> (m ³)	<u>Con.B</u> (m ³)	<u>Con.C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Gate</u> (kg)	<u>Pipe</u> <u>ø300</u> (m)	<u>Pipe</u> <u>ø400</u> (m)	<u>Pipe</u> <u>ø500</u> (m)
S-1	12	129	74	62	4	29	685	2,274		53	16	-
S-2	13			33	1	20	355	1,285		54	4	-
S-3	14			39	1	21	406	1,452		54	8	-
S-4	13			36	2	19	378	1,366		42	4	4
S-5	10			39	1	17	374	1,837		28	6	-
S-5A	7			19	1	14	204	745		9	19	4
S-6	5			13	1	7	128	451		9	5	-
S-7	6			20	1	10	186	649		12	13	-
S-8	15			47	2	28	485	1,779		29	24	7
S-9	6			15	-	11	153	541		16	5	-
S-10	11			30	1	17	309	1,060		26	8	5
S-11	7			18	1	11	188	641		18	5	-
S-12	15			45	2	28	485	1,749		47	14	-
<u>Total</u>	<u>134</u>	<u>874</u>	<u>496</u>	<u>417</u>	<u>18</u>	<u>232</u>	<u>4,337</u>	<u>15,821</u>	<u>50,351</u>	<u>397</u>	<u>131</u>	<u>20</u>
Ave.		6.5	3.7	3.1	0.1	1.7	32	118	376			

c) Check Structures

20 check structures on total were constructed in SIC. Concrete for structures were also placed by using truck mixer. Out of 29 structures, 13 checks were equipped with steel slide gate and the remaining were only equipped with stop logs. Since all the drop structures in SIC were provided with stop logs at its head to function as a check, certain checks were eliminated. Table 4.18 shows the summary of work quantities of check structures in SIC.

Table 4.18 Quantities of Major Works of Check in SIC

	<u>Number</u>	<u>Con. A</u> (m ³)	<u>Con. C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Stop Log</u> (m ³)
S-1	5	14.3	5.9	116.0	4,863	0.32
S-4	2	4.3	3.2	53.1	185	0.03
S-5	3	14.7	6.6	128.5	379	0.09
S-6	1	1.6	1.3	19.2	46	0.01
S-7	1	1.9	1.7	25.9	73	0.02
S-8	6	30.0	16.6	298.6	1,274	0.22
S-9	1	1.7	1.3	19.2	47	0.01
S-10	4	8.7	6.8	103.5	293	0.08
S-11	3	4.7	4.5	64.2	189	0.05
S-12	3	8.1	5.7	108.3	417	0.06
<u>Total</u>	<u>29</u>	<u>89.0</u>	<u>53.6</u>	<u>936.6</u>	<u>7,766</u>	<u>0.88</u>
Average		3.1	1.8	32.3	268	0.03

d) Culverts

Concrete pipe culverts were provided in SIC to be aimed to mainly connect the secondary reads with either the trunk road or the main roads. 65 culverts in total were constructed. Except S-1 canal, cut-off walls of culvert under the diameter of 800 mm were prefabricated at the batcher plant site and then established at the site. Table 4.19 shows the work quantities of culverts in each SIC and those average ones.

Table 4.19 Quantities of Major Works of Culverts in SIC

	<u>Number</u> (Nos.)	<u>Con.A</u> (m ³)	<u>Con.C</u> (m ³)	<u>Pipe</u> <u>∅500</u> (m)	<u>Pipe</u> <u>∅600</u> (m)	<u>Pipe</u> <u>∅800</u> (m)	<u>Pipe</u> <u>∅1,000</u> (m)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)
S-1	9	24.0	38.1	-	-	53	4	402	1,133
S-2	6	11.8	18.7	4	4	17	-	201	764
S-3	7	14.6	26.2	12	12	4	12	257	902
S-4	6	12.6	19.3	-	-	12	8	208	823
S-5	6	14.0	25.8	4	4	-	20	240	905
S-5A	2	3.7	5.8	-	4	4	-	63	230
S-6	2	2.8	5.0	-	8	-	-	50	158
S-7	2	4.6	6.9	-	-	8	-	77	301
S-8	8	23.2	44.7	-	-	40	12	381	1,548
S-9	2	2.8	5.0	-	8	-	-	50	158
S-10	4	9.3	13.8	-	-	16	-	153	602
S-11	4	9.3	13.4	-	-	16	-	153	602
S-12	7	19.9	35.9	-	-	-	32	334	1,300
<u>Total</u>	<u>65</u>	<u>152.6</u>	<u>258.4</u>	<u>20</u>	<u>40</u>	<u>170</u>	<u>88</u>	<u>2,568</u>	<u>9,426</u>
Ave.		2.3	4.0					40	145

e) Drops

Drops structures were provided for the places where the canal base has to be lowered from the topographic conditions. 69 drops were constructed on SIC of which two (2) drops in S-8 were provided as a part of the check structures. All drops were equipped with stop logs at their head to function as a check to control water level. The quantities of major works of the drops in each SIC are shown in the following Table 4.20.

Table 4.20 Quantities of Major Works of Drops in SIC

	<u>Number</u> (Nos.)	<u>Con.A</u> (m ³)	<u>Con.C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Drain</u> (m)	<u>Stop Log</u> (m ³)
S-1	10	68.5	33.5	598	1,820	5.0	0.09
S-2	15	44.2	27.0	491	3,461	9.5	0.05
S-3	10	34.2	21.1	364	2,898	6.8	0.08
S-4	5	24.7	12.9	241	2,110	3.6	0.06
S-5	5	12.3	7.7	145	959	2.4	0.01
S-5A	5	13.9	9.4	163	1,216	2.6	0.04
S-6	2	4.6	3.3	57	372	1.2	0.01
S-7	5	21.9	14.2	236	2,073	3.8	0.04
S-8	5	21.6	13.7	222	2,019	2.8	0.02
S-9	2	5.4	3.7	67	423	1.2	0.01
S-10	1	5.7	2.9	61	517	0.8	0.02
S-11	1	4.3	2.2	47	388	0.8	0.01
S-12	3	17.0	10.6	179	1,579	2.2	0.01
<u>Total</u>	<u>69</u>	<u>278.4</u>	<u>162.1</u>	<u>2,870</u>	<u>19,833</u>	<u>42.5</u>	<u>0.45</u>
Ave.		4.0	2.3	41.6	287	0.6	0.007

f) Cross Drains

16 cross drains were constructed under the SIC at the places where SIC run across the natural drains. Out of the total, 15 cross drains were provided with precast concrete pipe and the remaining one in S-12 canal was constructed with concrete box culvert. The quantities of the works are tabulated below.

Table 4.21 Quantities of Major Works of Cross Drains in SIC

	<u>Number</u> (Nos.)	<u>Exc.</u> (m ³)	<u>B.Fill</u> (m ³)	<u>Con.A</u> (m ³)	<u>Con.B</u> (m ³)	<u>Con.C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Pipe</u> <u>over 800</u> (m)	<u>Pipe</u> <u>under 600</u> (m)
S-1	1			15.5	1.7	6.7	81.6	1,374	12	-
S-2	1			3.4	-	2.6	36.2	200	-	8
S-3	1			23.0	1.7	12.9	93.4	711	8	-
S-4	2			7.0	4.5	4.2	68.3	329	-	20

<u>Number</u> (Nos.)	<u>Exc.</u> (m ³)	<u>B.Fill</u> (m ³)	<u>Con.A</u> (m ³)	<u>Con.B</u> (m ³)	<u>Con.C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Pipe</u> <u>over 800</u> (m)	<u>Pipe</u> <u>under 600</u> (m)	
S-5	2		7.7	4.6	4.2	72.0	371	-	17	
S-6	1		3.4	1.0	2.5	37.6	235	-	9	
S-7	1		3.8	2.6	4.7	36.3	186	-	10	
S-8	3		51.0	2.8	46.7	248.0	1,646	8	12	
S-10	1		6.1	2.6	6.4	49.0	287	-	20	
S-11	2		45.9	4.6	37.0	196.5	1,421	7	-	
S-12	1		18.6	1.9	1.9	152.7	2,390	-	-	
<u>Total</u>	<u>16</u>	<u>1,507.0</u>	<u>850.0</u>	<u>185.3</u>	<u>34.9</u>	<u>129.7</u>	<u>1,071.6</u>	<u>9,149</u>	<u>35</u>	<u>96</u>
Ave.		94.2	53.1	11.6	2.2	8.1	67.0	572		

4.1.5 Drainage Canals

i) Earthworks

Along the right side of R-I of MIC, the drainage ditches were excavated, which were connected with the Balwa and Jhiljhile rivers. Right side of R-II and R-IV were excavated to drain out the excess water of MIC as well as the natural drainage water through TIC side ditches. In case of R-III, the drain ditches was excavated on the left side and then led to the natural drain through the left side drain ditches of S-6 and S-7 canals. Along the right side of S-11 canal a drainage ditch was provided to lead the drain water of the area sandwiched by R-IV and S-10 canals. Collector drains along the northern side (elevated side) of all TIC were constructed. The following table shows the excavated volume of the drainage works.

Table 4.22 Quantities of Earthworks of Collector Drain

	<u>R-I</u>	<u>R-II</u>	<u>R-III</u>	<u>R-IV</u>	<u>SIC</u>	<u>TIC</u>	<u>Total</u>
Excavation	9,200	568	3,758	3,531	3,592	15,859	36,508

Unit: m³

ii) Related Structures

Two (2) drainage culverts were constructed, one near ASS and the other at about 200 m downstream from the crossing point of R-I canal and trunk road. In addition to above, two (2) drops and four (4) terminal drainage structures were provided. The following Table 4.23 shows the quantities of major works done in respective structure.

Table 4.23 Quantities of Major Works of Drainage Structures

	<u>Con.A</u> (m ³)	<u>Con.C</u> (m ³)	<u>Form</u> (m ²)	<u>Re-bar</u> (kg)	<u>Pipe</u> (ϕ 1,000) (m)	<u>Boulder</u> <u>Gravel</u> (m ³)	<u>Masonry</u> (m ²)
ASS Culvert	6.6	6.3	86.9	311	10	14	24
R-I Culvert	20.2	5.0	160.6	1,834	-	-	-
TR Drop	11.3	5.6	101.5	930	-	-	-
R-IV Drop	4.9	1.3	48.6	467	-	-	-
Balwa Ter.	18.6	1.7	129.8	741	-	27	20
Jhiljhile Ter.	7.8	1.2	78.4	675	-	1	-
R-IV Ter.	5.6	0.7	56.0	519	-	-	-
S-11 Ter.	10.3	3.7	100.6	897	-	-	-
<u>Total</u>	<u>85.3</u>	<u>25.5</u>	<u>762.4</u>	<u>6,374</u>	<u>10</u>	<u>42</u>	<u>45</u>
Ave.	10.7	3.2	95.3	797			

4.1.6 Road System

i) Earthworks

All the earthworks were carried out by the equipment. Because of delay in delivery of the earth moving equipment which were delivered at the site in the end of April 1974, actual construction of roads was commenced from the beginning of December 1974. Since the proposed trunk road are mostly the improvement of the existing village road, the construction was carried out so as not to disturb the normal village traffic activities for which temporary by-pass roads were provided.

Gravel pavement was originally designed to have minimum thickness of 15 cm and to be made in all trunk roads and main roads. Due to the soil property of road bed and the limited fund for gravel pavement, however, the thickness of pavement was revised to have 20 cm and the pavement was made on the trunk road of about 18.1 km long. The broken stone for pavement was produced by using a crushing plant established at near Dudhe along the trunk road during a period from 1974 to 1976 and removed at near ASS during period from 1978 to 1979.

Earthfill materials were mostly borrowed from the both sides of the reads or obtained from the excavated materials in adjacent canals. The compaction was carried out by read roller, pneumatic tire roller as well as bulldozer and to obtain at least 95 % of the maximum dry density. For this purpose, the compaction test was carried out for approximately 200 m interval.

As to the secondary roads, the construction in the upper half portion of the project area was carried out by HMG as a force account basis. Accordingly, the Contractor carried out the construction of secondary roads in the lower half of the project area, namely about 350 km long by the Contractor while 36.5 km by HMG. The following Table 4.24 shows the quantities of earthworks carried out by the Contractor.

Table 4.24 Quantities of Earthworks for Roads

	<u>Length</u> (km)	<u>Earthfill</u> <u>(Excavated)</u> (m ³)	<u>Earthfill</u> <u>(Borrowed)</u> (m ³)	<u>Gravel</u> <u>Pavement</u> (m ³)	<u>Sod-facing</u> (m ²)
Trunk Road	20,364	6,793	81,174	12,995	35,356
Main Road	70,694	61,442	144,647	-	80,130
Secondary Road	71,500	9,836	101,525	-	56,165



Trunk Road
Compaction Test

Mar. '79



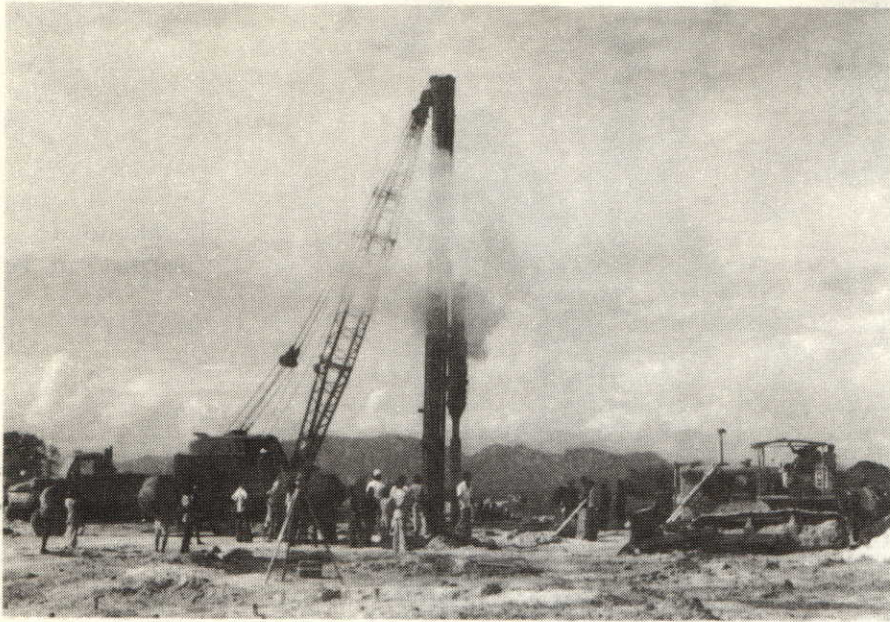
Trunk Road
Gravel Pavement

Dec. '78



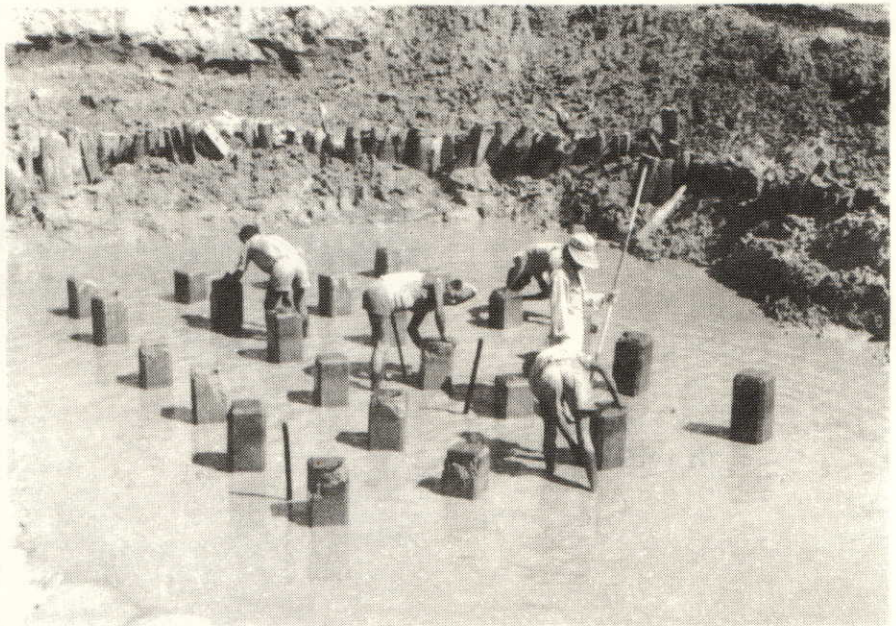
Trunk Road
No. 2 Bridge Completed

Apr. '79



Trunk Road
No. 1 Bridge Piling

Sep. '78



Trunk Road
No. 1 Bridge
Abutment

Sep. '78



Trunk Road
No. 3 Bridge
Concrete Placing

Jan. '79

ii) Road Structures

a) Trunk Roads

Three (3) concrete bridges on the Balwa, Jhilijhili and Baniyani rivers, one causeway, seven (7) cross drain and three (3) culverts were constructed for the trunk road. As the results of penetration tests at the three bridge sites, it was found out that the bearing pile is required to support the load of bridge designed. Accordingly, concrete piles with 5 m long were driven for each abutment and pier foundation in the density of one per 1.3 m² and 1.7 m² respectively. The piles were driven by a diesel pile hammer. Causeway and cross drains were provided at the places where the road runs across the natural small streams and drains. The cross drains were equipped with concrete pipe. The culverts with concrete pipe were provided for crossing the tertiary irrigation canals. The following Table 4.25 shows the quantities of major works employed into the trunk road structures.

Table 4.25 Quantities of Major Works for Trunk Road Structures

	<u>Unit</u>	<u>No. 1 Bridge</u>	<u>No. 2 Bridge</u>	<u>No. 3 Bridge</u>	<u>Road Structure</u>	<u>Total</u>
Excavation	m ³	3,929	2,325	3,991	259	10,505
Backfill	m ³	2,632	1,635	2,983	116	7,367
Concrete, Type A	m ³	330	131	263	69	793
Concrete, Type B	m ³	122	71	88	54	336
Concrete, Type C	m ³	14	6	11	52	83
Concrete, Type AA	m ³	31	8	23	-	62
Form	m ²	1,531	768	1,194	612	4,105
Re-bar	kg	27,999	10,113	20,037	3,116	63,265
Steel Plates	kg	627	157	470	-	1,255
Gravel	m ³	41	19	34	47	140
Concrete Pile	m	465	240	390	-	1,095
Wet Masonry	m ³	500	312	430	-	1,241
Boulder	m ³	243	158	142	-	543

	<u>Unit</u>	<u>No. 1 Bridge</u>	<u>No. 2 Bridge</u>	<u>No. 3 Bridge</u>	<u>Road Structure</u>	<u>Total</u>
Handrail	kg	1,274	319	956	-	2,548
Embankment	m ³	1,869	996	676	-	3,542
Sod Facing	m ²	1,199	529	579	-	2,308
Con. Pipe ø1,000	m	-	-	-	78	78
Con. Pipe ø800	m	-	-	-	22	22
Con. Pipe ø600	m	-	-	-	23	23
Con. Pipe ø400	m	-	-	-	22	22

b) Main and Secondary Road Structure

Seven (7) precast concrete bridges crossing the lined canal, twelve (12) causeway for MIC siphons and culverts and one (1) cross drain were constructed as main road structures and one (1) bridge across SIC, S-1 was constructed as a secondary road structure.

The following Table 4.26 shows the quantities of major works employed into main and secondary road works.

Table 4.26 Quantity of Major Works for
Main and Secondary Road Structure

<u>Work Item</u>	<u>Unit</u>	<u>Main Road Structure</u>	<u>Secd. Road Structure</u>	<u>Total</u>
Excavation	m ³	1,443	-	1,443
Backfill	m ³	429	-	429
Concrete, Type AA	m ³	61	-	61
Concrete, Type A	m ³	35	1	36
Concrete, Type B	m ³	957	-	957
Concrete, Type C	m ³	4	1	5
Form	m ²	2,088	19	2,107
Re-bar	kg	20,316	149	20,465
Gravel	m ³	300	-	300
Con. Pipe ø800	m	9	-	9
Handrail	kg	1,135	-	1,135

4.1.7 Engineer's Office and Quarters (EOQ)

Immediately after commencement of the project works, the Contractor initiated to construct their own office and quarters. According to the original construction time schedule, EOQ ought to have been constructed within 7 months after the commencement. However, the Contractor had encountered with crucial shortage of cement and hardware as well as asbestos sheet and seasoned wood materials which are locally made available. Moreover, concrete batching was compelled to be made almost by man power due to delay in delivery of batcher plant and truck mixer at the site.

For the above reasons and circumstances, the construction works were largely delayed. Since location of EOQ site was slightly revised from the original design to far place from the Kankai river bank where an intake well for water supply system was constructed, the electric power supply system for driving an intake pump designed originally was changed into the direct driving system by diesel engine. Furthermore, the pneumatic tank for distributing water was changed an overhead tank in view of the maintenance in future.

In May 1975, the following houses including water supply system, power supply system as well as sewerage system were completed and handed over to the Employer.

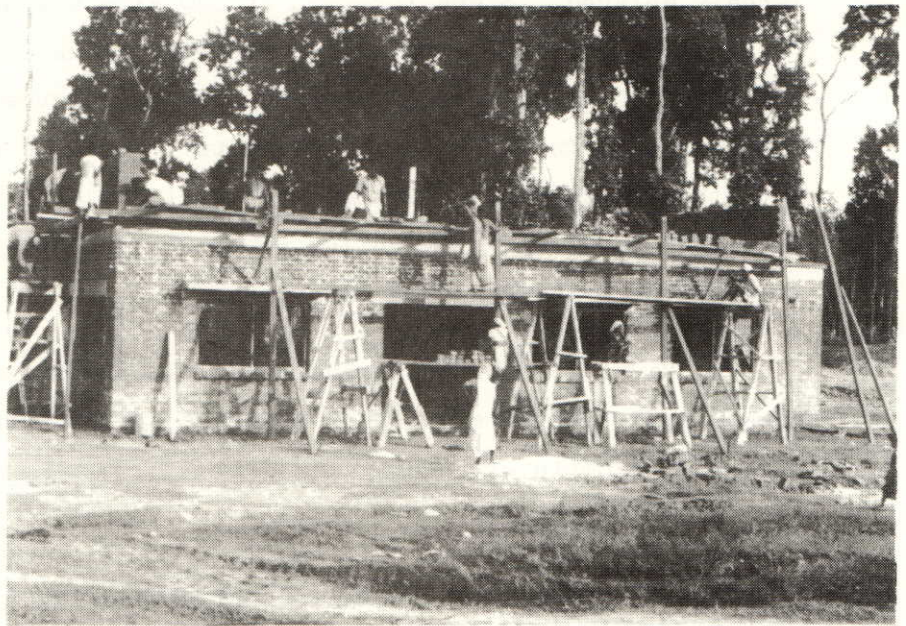
1 - Office	292.5 m ²
1 - Foreign engineer's bachelor quarter	278.0 m ²
2 - Foreign engineer's family quarters	196.9 m ²
1 - HMG staff bachelor quarter	405.6 m ²
2 - HMG staff family quarters	224.0 m ²
1 - Pump house	25.0 m ²
1 - Generator house	50.0 m ²

Then, the remaining houses and other related works were handed over to the Employer as shown below.

1 - Officer's quarter	141.9 m ²
5 - HMG family quarters	456.0 m ²
1 - Warehouse	300.0 m ²



EOQ
Building Construction
Apr. '75



EOQ
Building
Construction
Sep. '75



EOQ
Building Completed
Jan. '76

1 - Guest house	276.2 m ²
2 - Garages	180.0 m ²
1 - Guard house	7.5 m ²
Reads with 5 m width	970.0 m
Land clearing and levelling	25.4 ha

4.2 Agricultural Sub-Station (ASS)

4.2.1 Canal and Road Earthworks (CRE)

Earthworks were actually commenced from November 1974. The canal embankment was made by using bulldozer from the surroundings. Because of the very small irrigation canal section to be excavated the embankment was carried out upto the canal top level and compacted carefully so as to obtain sufficient dry density, and then the excavation of canal section was carried out by man power.

Gravel metaling for the reads was carried out in the same way as that for the trunk road. The following Table 4.27 shows the quantities of the works involved in CRE.

Table 4.27 Quantities of Works for CRE

	<u>Land Clearing</u> (m ²)	<u>Excavation</u> (m ³)	<u>Earthfill</u> (m ³)	<u>Side Gutter</u> (m ³)	<u>Gravel Metaling</u> (m)
ID Canals	16,860	3,658	8,446	-	-
Reads	3,098	-	-	802	2,404



ASS
Canal Excavation

Feb. '75



ASS
Canal Earthworks
&
Land Readjustment

Feb. '75



ASS
Trial Cultivation
Jute Crop

July '75

4.2.2 Canal and Road Structures (CRS)

19 irrigation canal siphons, 10 drainage pipe culverts, 2 road pipe culverts and 1,876 m long of brick sewer were provided for the structural works. These construction were mostly carried out by man power. The following Table 4.28 shows the quantities of the works thrown in the canal and road structures.

Table 4.28 Quantities of Works for CRS

	<u>Unit</u>	<u>Siphon</u>	<u>Drainage Culvert</u>	<u>Road Culvert</u>	<u>Brick Sewer</u>	<u>Other</u>
Number		19 Nos.	10 Nos.	2 Nos.	1,876 m	-
Excavation	m ³	920	186	281	1,245	65
Backfill	m ³	836	109	249	823	15
Embankment	m ³	-	136	82	-	-
Concrete, Type C	m ³	20.9	14.4	3.9	119.8	5.5
Brick Work	m ³	83.1	21.1	15.0	127.5	3.8
P.C. Pipe	m	144	58	50	-	-
Concrete, Type B	m ³	-	-	-	7.2	-
Form	m ²	-	-	-	5.3	-
Re-bar	kg	-	-	-	748.0	-

4.2.3 Land Readjustment

Land readjustment works were carried out by using bulldozer. Since the lands are to be used for mainly paddy cultivation, the particular emphasis was placed on grading of the farm plot. Total area of land readjustment was 18 ha. The grading quantities of earth were 4,589 m³ and the quantities of embankment of border were 1,232 m³ respectively.

4.2.4 Office and Residence Quarters (ORQ)

Land clearing and levelling were carried out for about 2.7 ha as compared with the original plan of 0.4 ha. Because of crucial shortage of cement, asbestos sheet and hardware, the building construction works were substantially affected and the progress was delayed largely. The works were actually progressed from the beginning of 1975. In August

and September 1975, the following buildings were completed and subsequently handed over to the Employer.

1) August 1975

1 - ASS Office	260 m ²
1 - Foreign experties residence	268 m ²
1 - Manager residence	65 m ²
3 - General staff residences	132 m ²
1 - Storage	50 m ²

2) September 1975

2 - General staff residences	88 m ²
2 - General staff tenements	296 m ²
1 - Hostel for trainee	167 m ²
1 - Generator house	50 m ²
1 - Pump house	25 m ²
1 - Cattle shed	80 m ²

Subsequently, the remaining buildings were completed by the end of November and handed over to the Employer as follows:

1 - Mess and meeting house	150 m ²
1 - CO-OP. office	497 m ²
1 - Work shop and fertilizer storage	150 m ²
1 - Tool shed	100 m ²
1 - Seed store	150 m ²
1 - Work shop for KPO	100 m ²
1 - CO-OP. warehouse	500 m ²

4.3 Minor Works

The Minor Works include the construction of tertiary irrigation canals and those related structures. The construction of the works were carried out by the force account basis using construction equipments for which the Government procured and those equipments which would be used as maintenance equipment after the completion of the works.

The construction work for TIC was started in the beginning of 1977 from S-1 canal for supplying urgently water to it. Earthfilling for both tertiary irrigation canals and secondary farm roads which run along the TIC, was carried out to the formation level and then excavated the canal section up to the bottom level. The concrete of division box were casted at site in the first time but it was changed into precast system after constructing 4 division boxes from the following viewpoints.

- i) The construction of such small structure requires rather long time in terms of work quantities as compared with other concrete works, resulting in rather expensive.
- ii) Total division boxes to be equipped are approximately 830 numbers.
- iii) In case some parts of the structures are precasted at the appropriate place and then installed at the site, the construction works are more easily made resulting in time saving and economical.

Out of the one unit of division box, three walls, namely, upstream cutoff, downstream cutoff and turnout wall, were precasted at ASS. Precast concrete pipes for culvert and turnout were purchased from the local suppliers.

The earthfilling of TIC and secondary roads for the upper portion of the project area, namely, TIC branching off from S-1, S-2, S-3, S-4, S-5, S-6 and R-I and R-II of MIC, were carried out by the force account as one of the minor works. The remaining earthfill, the downstream portion of the project area, was carried out by the Contractor of MCW. The earthfilling works by both the force account of HMC and the Contractor were completed by the end of May 1979.

After the earthfilling was properly compacted excavation of canal was carried out by the local contractors and completed by July 1979.

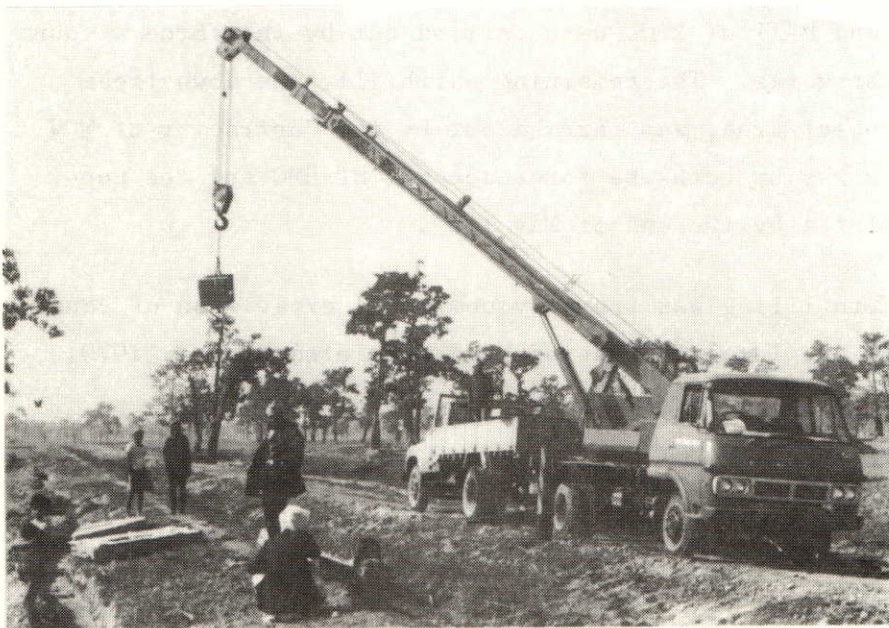


Minor Works
Precasting Works

Jan. '78

Minor Works
Precasting Works

Jan. '78



Minor Works
Installation of
Prefabricated Division
Box

Jan. '78

The construction of division boxes as well as precasting concrete walls were rather less progress. By the end of June 1979, about 30 % of total division boxes required has been constructed. The following Table 4.29 shows the total quantities required for the Minor Works.

Table 4.29 Quantities of Works for Minor Works

<u>Item</u>	<u>Unit</u>	<u>Quantities</u>
Earthfilling	m ³	307,939 ^{/1}
Excavation of TIC	m ³	33,536
Division Box	Nos.	831
Concrete for Box	m ³	1,400

Note: ^{/1} Out of above quantity, 113,821 m³ of earthfilling was carried out by the MCW Contractor.

4.4 Protection Works

The various protection works for bank of Kankai, Sardare and Balwa rivers and others were ordered to local contractors from time to time since 1975. The following table shows the total work quantity of protection works measured based on the boulders quantity.

Table 4.30 Quantities of Works for Protection Works

<u>No.</u>	<u>Description</u>	<u>Year</u>	<u>Q'ty of Boulders (m³)</u>
1	Kankai No. 2 Spur	1975/76	860
2	Balwa River	1975/76	740
3	Trunk Road	1975/76	415
4	Kankai Lower Reach	1976/77	3,516
5	Kankai Upper Reach & Sardere River	1976/77	4,050
6	Headworks & No. 1 Culvert	1977/79	2,838
	<u>Total</u>		<u>12,419</u>

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V. CONSTRUCTION COST

5.1 Summary of Project Cost

The project cost of the Kankai Irrigation Project is summarized as follows and the details are described in the following sections.

Table 5.1 Summary of Project Cost

<u>Description</u>	<u>Domestic</u>	<u>U. S.</u>	<u>Yen</u>	<u>Total (10³)</u>	
	<u>Currency</u> (10 ³ NR)	<u>(US\$)</u>	<u>Currency</u> (10 ³ ¥)	<u>US\$</u>	<u>(NR)</u>
1. MCW Contract ^{/1}	18,510	3,162,471		4,991	(50,529)
2. Price Variation ^{/1} for MCW	4,224	555,688		973	(9,850)
3. ASS Contract ^{/1}	2,869			283	(2,869)
4. Price Variation ^{/1} for ASS	152			15	(152)
5. Depreciation of Equip. for Minor Works	2,953			292	(2,953)
6. Protection Works	2,082			206	(2,082)
7. Minor Works Cost	4,105			405	(4,105)
8. Depreciation of Concrete Block Machine		(49,680) ^{/2}			
9. Laboratory and ASS Equipment		36,024		36	(365)
10. Consulting Services	77	32,776	192,982 ^{/3}	667	(6,753)
11. HMG Expenditure	10,352			1,022	(10,352)
<u>Total</u>	<u>45,324</u>	<u>3,786,959</u>	<u>192,982</u>	<u>8,890</u>	<u>(90,010)</u>

Note: ^{/1} Conversion rate: NR 10.125/US\$

^{/2} Cost of block machine is included in MCW contract

^{/3} Conversion rate: ¥308/US\$

5.2 MCW Contract

MCW contract amount covers all direct construction costs paid to the Contractor including materials costs, wages, operation and maintenance costs of equipment and those depreciation costs except for price escalation costs for the imported materials. The contract amount for MCW was expressed in Nepalese currency of which 63 % were paid to the Contractor in U.S. currency with a conversion rate of NR 10.125/US\$. Since the contract was made in the unit price contract basis, the contract amount paid finally was considerably differed from the original contract amount. The following Table 5.2 shows the summary of contract amount actually paid (see details in ANNEX 1).

Table 5.2 MCW Contract Amount Paid Actually

		Unit: 10 ³ NR (%)	
<u>Section</u>	<u>Contract Amount</u>	<u>Actually Paid</u>	
2. General Items	<u>5,320</u>	<u>4,950 (93.0)</u>	
Contractor's Buildings	1,223	1,223 (100.0)	
Water Supply System	128	128 (100.0)	
Power Supply System	933	933 (100.0)	
Other Works	536	204 (38.1)	
Contingency	2,500	2,462 (98.5) ^{/1}	
3B Headworks	<u>10,638</u>	<u>12,391 (116.5)</u>	
Diversion Weir & Intake	7,428	8,200 (110.4)	
Head Reach & Settling Basin	3,210	4,191 (130.6)	
3C Canal Earthworks	<u>4,257</u>	<u>6,169 (144.1)</u>	
MIC	2,411	3,058 (126.8)	
SIC	940	2,821 (300.0)	
Collector Drains	906	290 (32.0)	
3D Road Earthworks	<u>5,761</u>	<u>6,230 (108.1)</u>	
Trunk Road	2,598	2,287 (88.0)	
Main Road	1,297	2,518 (194.1)	
Secondary Road	1,866	1,425 (76.4)	

Remarks: ^{/1} The cost of Block Making Machines and Yard are included.

<u>Section</u>	<u>Contract Amount</u>	<u>Actually Paid</u>
3E Canal and Road Structures	<u>14,304</u>	<u>16,475</u> (115.2)
MIC	10,793	12,110 (112.2)
SIC	1,471	1,984 (134.9)
Drainage Canal	578	104 (18.0)
Trunk Road	622	1,692 (272.0)
Main Road	530	583 (110.0)
Secondary Road	310	2 (0.6)
3F EOQ	<u>4,775</u>	<u>4,315</u> (90.4)
<u>Total</u>	<u>45,056</u>	<u>50,530</u> (112.1)

In accordance with Clause 1.70 of the General Conditions of the Contract, the increases in the prices of imported materials delivered to the site of the works were added to the contract amount as shown in the following Table 5.3.

Table 5.3 Additional Payment by Price Escalation

	<u>Unit</u>	<u>Quantity</u>	<u>Additional Payment</u>	
			(US\$)	(NR)
Cement	ton	12,226	158,007	3,407,798
Re-bar	ton	908	111,088	108,629
Petrol	kℓ	211	51,660	181,519
Diesel Oil	kℓ	2,689	198,128	186,462
Lubricant	kℓ	86	34,340	314,668
Grease	kg	6,625	2,444	24,513
<u>Total</u>			<u>555,667</u>	<u>4,223,589</u>

5.3 ASS Contract

ASS construction contract amount includes all civil engineering works for constructions of buildings and irrigation and drainage system. The contract was proceeded under the local contract so that all payments due to the Contractor were made in the Nepalese currency. Since the contract was made in the unit price contract basis and the project feature was substantially revised from the original design, the contract amount paid finally was considerably differed from the original contract amount. The following Table 5.4 shows the summary of contract amount paid to the Contractor (see details in ANNEX-2).

Table 5.4 ASS Contract Amount Paid

<u>Section</u>	<u>Contract Amount</u>	Unit: NR
		<u>Paid Amount</u>
2. General Items	228,000	101,887
3B Irrigation Storage Pond	476,700	-
3C Irrigation Pump Station	64,895	-
3D IDC Earthworks	57,672	142,633
3E Road Earthworks	375,894	240,672
3F Canal and Road Structures	104,988	150,948
3G Land Readjustment	25,329	35,928
3H Office & Residences	2,266,522	2,196,578
<u>Total</u>	<u>3,600,000</u>	<u>2,868,646</u>

Based on the Contractor's claim in accordance with Clause 1.51 of the General Conditions, the increases in the prices of imported materials delivered to the site of the works were added to the contract price. The Contractor however claimed only for increase in NR 151,659 of cement prices.

5.4 Depreciation of Construction Equipment for Minor Works

In order to construct the minor works including tertiary irrigation canals and those related structures as well as the operation and maintenance of the project, HMG procured the construction and maintenance

equipment. The construction period of the minor works will last about five years. In the normal practices in the developing countries the useful lives of construction equipment are considered to be 7 years on an average and about 50 % of equipment cost are to be needed for the spare parts. It is estimated that it would take about 5 years for the completion of the minor works. So, the depreciation costs for construction of the minor works is roughly calculated as follows.

Table 5.5 Depreciation Cost of Minor Work Equipment

<u>Depreciation</u>	<u>1.5 Times of Purchase Cost</u> (10 ³ NR)	<u>Useful Life</u> (Year)	<u>Operated Years</u> (Year)	<u>Depreciation Cost</u> (10 ³ NR)
3 Angle Dozer D.50A	2,352	7	7	1,680
1 Motor Grader (3 m)	753	7	5	538
1 Macadam Roller (8 t)	296	7	5	211
1 Truck Crane (6 t)	244	7	5	174
1 Ordinary Truck (6 t)	183	6	5	152
1 Ordinary Truck (3 t)	101	6	5	84
5 Concrete Mixer	114	5	5	114
(6 Concrete Vibrator)				
<u>Total</u>	<u>4,043</u>			<u>2,953</u> ^{/1}

Remarks: ^{/1} As other equipments such as a fuel tanker, a water tanker, tamping hammer and compactor have not been used for works no depreciation cost for those equipment was considered.

5.5 Minor Works Cost

In order to expedite the progress of the minor works, the excavation of TIC were carried out by the contract basis employing local contractor. The earthfilling works for TIC and secondary roads in the upper portions of the project area, about 60 % of the area, were performed by the force account basis and the remainings by the Contractor of MCW. The construction of division boxes as well as producing concrete cutoff wall were carried out by the force account basis.

The minor work costs cover all direct costs paid for the force account works including materials costs, fuel charges and labor wages, and the costs of canal excavation carried out by the local contractors. The total construction cost was estimated proportionally based on the actual costs paid for the concrete works during the period for 1977 to 1979 which is about 30 % of total concrete works. The following Table 5.6 shows the estimated construction costs for the Minor Works.

Table 5.6 Estimated Construction Costs for Minor Works

<u>Description</u>	<u>Cost Paid So Far (10³ NR)</u>	<u>Progress (%)</u>	<u>Construction Cost (10³ NR)</u>
Materials Cost	366.5	28.4	1,290
Fuel Cost	201.4	50.0	403
Wages	214.2	28.4	754
Contracted Amount	1,658.2	100.0	1,658
<u>Total</u>	<u>2,440.3</u>		<u>4,105</u>

5.6 Protection Works Cost

The total cost required for the river bank protection works ordered to the local constructors are shown in the following table.

Table 5.7 Contract Amount Paid for Protection Works

<u>No.</u>	<u>Description</u>	<u>Q'ty of Boulders (m³)</u>	<u>Amount (NR)</u>
1	Kankai No. 2 Spur	860	185
2	Balwa River	740	118
3	Trunk Road	415	70
4	Kankai Lower Reach	3,516	557
5	Kankai Upper Reach and Sandare River	4,050	675
6	Headworks and No. 1 Culvert	2,838	477
	<u>Total</u>	<u>12,419</u>	<u>2,082</u>

5.7 Concrete Block Machine Cost

Two units of block making machine was procured at the cost of US\$49,680 by the Contractor as a loaned equipment by the Employer in the beginning of 1976 and the Employer reimbursed the procurement cost of the above after the delivery at the site.

In estimating the construction cost of concrete block lining, it was calculated that the machine was to be fully depreciated at the production of concrete block of 122,000 Nos. which corresponds to 3 km long of the block lining. The production of concrete block made actually was about 131,000 blocks in total for MCW. Accordingly, the cost of US\$49,680 was fully counted up to the depreciation cost even though certain salvage value of the machine is still remained.

5.8 Laboratory and ASS Equipment

Equipment purchased for ASS and their cost are as follows:

Table 5.8 Cost of Equipments for ASS

<u>Item</u>	<u>Quantity</u>	<u>U.S.\$</u>	<u>NR</u>
Mini-bus	1	4,649	47,071
Motor Cycle	3	1,427	14,448
Tractor	2	2,800	28,350
Laboratory Apparatus	L.S.	16,582	167,893
Meteorological Equip.	L.S.	6,756	68,405
Projector and Screen	1	1,529	15,481
Office Equipment	L.S.	1,928	19,521
Sprayor, Etc.	L.S.	353	3,574
<u>Total</u>		<u>36,024</u>	<u>364,743</u>

5.9 Consulting Services

5.9.1 Supervision of Construction Works

The construction period of MCW was extended by three years. Accordingly, the consulting services period as well as the service fees were revised. Moreover, the conversion rate between Yen and U.S. Dollar was considerably fluctuated during the period of 7 years of the consulting services. The following Table 5.7 shows the total amount of fees for the consulting services in both Japanese Yen and Nepalese Rupees.

Table 5.9 Fee for Consulting Services

<u>Item</u>	<u>Yen Currency</u> (10 ³ Yen)	<u>Local Currency</u> (NR)
Remuneration	163,980	
Out of Pocket Expenses		
Per-Diem	13,920	
Travel costs	9,645	68,946
Communication Charges	2,957	8,400
Other Expenses	2,480	
<u>Total</u>	<u>192,982</u>	<u>77,346</u>

5.9.2 ASS Consulting Services

In order to assist in establishing the Agricultural Sub-Station and all its activities including operation of its irrigation system, water management, agronomic experiments and the design of cropping pattern, the HMG engaged an agronomist for two years from February 1975 to January 1977. The total fees paid to the consultant amounted to US\$32,776.

5.9.3 Government Expenditure for the Project

The government expenditure for the execution of the project including construction supervision of MCW and ASS and ASS operation were allocated from the national budget. The total expenditure amounted until the completion of the project is approximately NRs 10,352,000.

VI. PERFORMANCE OF EQUIPMENT

6.1 Contractors Equipment for MCW and ASS

6.1.1 Construction Plans Used

The following equipment and plants were delivered by the Contractor.

Table 6.1 Plants Procured by Advance Payment

<u>Plants</u>	<u>Model</u>	<u>Capacity</u>	<u>Numbers</u>	<u>Delivery Date</u>
Bulldozer	D4D	7 t	2	Apr. 26, 1974
"	D7F	17 t	3	May 5, 1974
Motor Grader	LG3H7	3.7 m	2	May 5, 1974
Back Hoe	UN06D	0.7 cu.m	2	Apr. 24, 1974
			1	May 2, 1974
Wheel Loader	950	2.3 cu.m	2	Apr. 27, 1974
			1	May 8, 1975
Tractor Loader	955L	1.5 cu.m	1	Apr. 22, 1974
Tyre Roller	WP902	9.2 t	2	May 3, 1974
Soil Compactor	NVE-110	110 kg	6	Apr. 26, 1974
Dump Truck	TC818D	7 t	6	Apr. 28, 1974
"	TF200DN	7 t	9	Mar. 9, 1975
Cargo Truck	TK20LRN	8 t	3	Aug. 18, 1974
Pick-up Truck	RK101-J	1.5 t	3	Apr. 29, 1974
			2	May 1, 1974
Concrete Mixer	KDP-12U	12 cft	3	Jan. 26, 1974
Gasoline Engine	EYB-2ACB	15 HP	3	Apr. 26, 1974
Concrete Vibrator	MVI-CE-45/69		10	"
Pump W/Engine	150 mm	13 HP	2	Jan. 25, 1974
"	YKS4D	7 HP	2	"
"	YKS3D	5 HP	4	"
"	YKS3D	4 HP	2	"
Diesel Generator	DC-73	58.4 kW	3	Apr. 29, 1974
"	DC-45	36 kW	2	Apr. 30, 1974
"	DC-30	24 kW	2	"
Rock Crusher	RJ-J	50 HP	1	Jul. 8, 1974

Table 6.2 Contractor's Own Plants Delivered

<u>Plants</u>	<u>Proposed Numbers</u>	<u>Delivered Numbers</u>	<u>Condition</u>	<u>Usable Numbers</u>
Bulldozer, 12 t D6	1	1	Used	-
" 7 t D4	-	1	"	1
Side Boom D6	-	1	"	1
Motor Grader, 12 ft.	1	1	"	-
Crawler Crane, 20 t	2	1	"	1
Tamping Roller, 1.5 ft.	-	2	"	-
Wheel Tractor, 50 HP	1	4	"	2
Macadam Roller, 10 t	1	1	"	1
Tank Lorry, 5,000 l	3	3	"	1
Land Rover	2	3	"	2
Pick-up Truck	-	2	"	2
Concrete Mixer (W/O Engine)	3	3	"	-
Ambulance	1	1	"	-
Concrete Mixer (Bromax 7 ft.)	2	2	"	-
Concrete Vibrator	-	2	"	1
Truck Mixer, 3 cu.m	3	6	"	4
Screen Plant	1	1	"	1
Water Pump, 4" W/10 HP Engine	-	5	New	5
" 4" W/10 HP Engine	-	3	"	3
" 6" W/14 HP Engine	-	6	"	5
" 3" 7 HP Diesel Engine	-	1	Used	-
" 2" 3 HP Gas. Engine	-	1	"	-
" 2" 6.5 HP Diesel Engine	-	1	"	-
" 2" 3.5 kW Motor	-	1	"	1
Generator Electric kVA/5000	-	1	"	1
Air Compressor	-	2	"	2
DC Welder, 300 amps	1	2	"	2
Diesel Pile, Hammer 3 t	1	1	"	1
Motorcycle	-	2	"	2
Electric Concrete Vibrator	-	2	New	2
Concrete Breaker	-	1	Used	1

<u>Plants</u>	<u>Proposed Numbers</u>	<u>Delivered Numbers</u>	<u>Condition</u>	<u>Usable Numbers</u>
Conveyor Belt	-	1	Used	1
Soil Compactor, 6.5 HP	-	2	"	2
Truck Crane	-	2	"	2
Sand Pump, 3"	-	1	New	1
Transformer	-	1	Used	1
Portable Generator	-	7	New	7
Block Making Machine ^{/1}	-	2	"	2

Note: /1 The cost of the Block Making Machine has been reimbursed by the Employer and after completion of the production for MCW the machine was handed over to the Employer in good working condition.

6.1.2 Operation Hours of Plants and Equipment

The operation hours and fuel consumption of the major construction equipment during the construction period from October 1973 to May 1979 are summarized in Table 6.3 and the details are shown in ANNEX 3.

Table 6.3 Summary of Running Hours and Fuel Consumption of Equipment

<u>Equipment</u>	<u>Number (Unit)</u>	<u>Running Hours</u>	<u>Fuel Consumed (ℓ)</u>	<u>Ave. Consumption</u>	<u>Probable Max. Consump.</u>
Land Rover	3	97,596 M	37,272	0.38 ℓ/M	-
Pick-up Truck, 1.5 t	8	382,601 M	118,477	0.31 ℓ/M	-
Dump Truck, 7 t	15	1,167,548 km	623,247	0.53 ℓ/km ^{/1}	1.82 ℓ/km
Cargo Truck, 8 t	3	214,822 km	68,489	0.32 ℓ/km ^{/2}	1.22 ℓ/km
Mixer Truck, 3 m ³	5	20,347 hr	140,702	6.92 ℓ/hr	36.5 ℓ/hr
Crane Truck, 5 t	2	4,390 hr	29,168	6.64 ℓ/hr	-
Bulldozer, D7F	3	14,300 hr	397,375	27.8 ℓ/hr	34.6 ℓ/hr
" D4	2	8,590 hr	112,589	13.1 ℓ/hr	14.4 ℓ/hr
Motor Grader, 3.7 m	3	5,879 hr	54,134	9.21 ℓ/hr	22.1 ℓ/hr
Crawler Crane, 20 t	1	2,699 hr	11,007	4.08 ℓ/hr	-
Back Hoe, 0.6 m ³	3	18,513 hr	231,687	12.5 ℓ/hr	16.3 ℓ/hr
Wheel Loader, 2.3 m ³	3	10,684 hr	149,065	13.9 ℓ/hr	24.9 ℓ/hr
Tractor Loader, 1.5 m ³	1	3,204 hr	55,328	17.3 ℓ/hr	-
Tractor, 50 HP	4	9,915 hr	26,750	2.7 ℓ/hr	-
Tyre Roller, 9.2 t	2	4,606 hr	16,137	3.5 ℓ/hr	20.2 ℓ/hr
Mac. Roller, 10 t	1	1,578 hr	6,829	4.33 ℓ/hr	-
Generator, 73 kVA	3	36,924 hr	354,653	9.6 ℓ/hr	17.3 ℓ/hr
" 45 kVA	2	15,869 hr	102,531	6.46 ℓ/hr	10.8 ℓ/hr
" 30 kVA	2	22,432 hr	117,696	5.25 ℓ/hr	8.26 ℓ/hr
Water Pump	29	61,016 hr	91,928	1.50 ℓ/hr	-
Crusher, 50 m ³ /hr	1	846 hr	9,020	10.66 ℓ/hr	-
Screen Plant	1	6,367 hr	55,574	8.73 ℓ/hr	-
Con. Vibrator	17	11,486 hr	8,171	0.71 ℓ/hr	-

Remarks: /1 Average operation speed is assumed as 20 km/hr
/2 Average operation speed is assumed as 30 km/hr

As seen in the above table, back hoes, bulldozers and dump trucks were quite contributed for the earthworks and screen plant and truck mixers for the concrete works. It is worthy of special mention that the back hoe was not only useful for earthworks but for various purposes such as concrete placing, wooden piling etc.

As the consumption of fuel of diesel engine is to be 0.24 ℓ/hr - horse power at full load and full operation, the probable maximum consumptions of fuel of the important equipments are calculated based on the capacity of each equipment at 80 % of the operation factor as shown in the above table. The fuel consumptions of those equipments are considered reasonable because the average consumptions of fuel are not more than 90 % of the probable maximum consumption.

Though it is rather difficult to estimate an average performance of the major equipment since the most of heavy equipment were used for various purposes, the earthworks performance at both the head reach and SIC were examined from the Contractor's daily report. The following Table 6.4 shows average performance of earthwork and consumption of fuel.

Table 6.4 Performance of Heavy Equipment

Equipment Used	Unit	Head Reach		SIC ^{/1}
		D7	W/Back Hoe	D7
Running Hours	hr		2,586	1,704
Quantity of Works	m ³		118,016	151,414
Fuel Consumption	ℓ		-	45,436
Earthwork/hr	m ³		45.6	88.9
Fuel Consumption/hr	ℓ		-	26.7

Remarks: ^{/1} Total filling works for SIC, S-3, S-4, S-5, S-5A, S-6 and S-7.

6.2 Minor Works

The following constructional plants were procured and used for the construction of the minor works and the future operation and maintenance.

Table 6.5 Constructional Plants for Minor Works

<u>Name of Plant</u>	<u>Model</u>	<u>Capacity</u>	<u>Number</u>	<u>Delivery Date</u>
Macadam Roller	MM82	67 HP	1	Nov. '75
Angle Dozer W/Back Hoe	D50A	90 HP	3	Jul. '76
Motor Grader	N525S	7,982 cc	1	Apr. '76
Truck Crane	T652	6 t/122 HP	1	Mar. '76
Concrete Mixer	C 150	150 cc/2.5 HP	3	May '76
Concrete Mixer	C 200	200 cc/2.5 HP	2	May '76
Concrete Vibrator		2 HP	6	May '76
Tamping Hammer	MTE70H		8	Mar. '76
Compactor	MVE70		8	Mar. '76
Cargo Truck	BU-15	2977 cc/3 t	4	Mar. '76
Pick-up Truck	FJ-45	130 HP	2	Mar. '76
Cargo Truck	DA-115	6 t	2	Mar. '76
Fuel Tanker	DA-11-3	6.5 m ³	1	Mar. '76
Water Tanker	DA-110-3	5.0 m ³	1	Mar. '76

Earthfilling in the minor works was exclusively carried out by bulldozer, D50A. The following Table 6.6 shows the performance of equipment operated under the force account basis for the minor works.

Table 6.6 Performance of Equipment in Minor Works

<u>Equipment</u>	<u>Running</u>	<u>Earthworks</u>	<u>Fuel</u>	<u>Performance</u>	<u>Fuel</u>
		<u>(m³)</u>	<u>Consump.</u>	<u>per Hour</u>	<u>Consump.</u>
			<u>(ℓ)</u>	<u>(m³/hr)</u>	
Bulldozer, D50A	3,653 hr	194,118	42,306	53.1	11.6 ℓ/hr
Road Roller, 8 t	158 hr	-	980	-	6.2 ℓ/hr
Motor Grader (3 m)	282 km	-	1,814	-	6.4 ℓ/km
Truck Crane, 6 t	4,940 km	-	2,851	-	0.6 ℓ/km
Cargo Truck, 6 t	5,291 km	-	2,555	-	0.5 ℓ/km
Cargo Truck	20,954 km	-	3,274	-	0.2 ℓ/km

VII. CONSTRUCTION MATERIALS AND LABOR EMPLOYED

7.1 Main Civil Works (MCW) and ASS

The following major construction materials were used for MCW and ASS.

Table 7.1 Construction Materials used for MCW and ASS

<u>Materials</u>	<u>Unit</u>	<u>MCW</u>	<u>ASS</u>	<u>Total</u>
Portland Cement	ton	13,223.28	843.52	14,066.80
Steel Bar (S)	ton	375.65	34.65	410.30
Steel Bar (L)	ton	553.91	12.57	566.22
Petrol	kℓ	212.90	5.13	218.03
Diesel Oil	kℓ	2,688.94	88.96	2,777.9
Lubricant	kℓ	103.60	2.50	106.1
Grease	kg	7,140.04	231.96	7,372.0
Steel Sheet Pile	ton	169.93	-	169.93
Gate	ton	144.59	-	144.59
Trash Racks	ton	17.78	-	17.78
Water Stop	m	162.89	-	162.89
"	m	2,783.53	-	2,783.53
Flap Valve, 100 mm	Nos.	322	-	322
" 50 mm	Nos.	3,501	-	3,501
Stop Log	m ³	19.79	-	19.79

The following numbers of workers employed by the Contractor were engaged in the construction of MCW and ASS respectively. The details are shown in ANNEX-4.

Table 7.2 Contractor's Employee Engaged in MCW

<u>Foreign Personnel</u>	Unit: M/M						<u>Total</u>
	<u>'74</u>	<u>'75</u>	<u>'76</u>	<u>'77</u>	<u>'78</u>	<u>'79</u>	
Project Engineer	50	12	10.7	12	10.6	5	35.3
Asst. P/Engineer			4.6			2.2	6.8
Civil Engineer	29.3	88.2	84.0	48.2	53.5	29.0	332.2
Arc. Engineer	17.8	28.6	12.2	-	-	-	58.6

Unit: M/M

	<u>'74</u>	<u>'75</u>	<u>'76</u>	<u>'77</u>	<u>'78</u>	<u>'79</u>	<u>Total</u>
<u>Foreign Personnel</u>							
Admin. Officer	8	8.4	9.6	8.5	10.3	5	49.8
Procurement Officer	8	12	1.1	2.0	-	-	23.1
Accountant	8	12	9.0	10.3	10.5	5	54.8
Equipment Operator	28.7	73.0	51.2	35.0	35.7	15	238.6
Carpenter	2.3	35.0	49.1	64.8	71.8	61.8	284.8
Electrician	-	3.0	2.3	-	-	-	5.3
Plumber	-	4.4	3.0	-	-	-	7.4
Pileman	-	11.4	13.4	6.4	2.2	-	33.3
Mechanic	-	18.7	36.7	42.7	40.5	34.2	172.8
Mechanic for Gate	-	-	-	-	8.8	14.9	23.7
Cook	6.4	7.0	2.8	1.2	12.0	5.0	34.4
<u>Sub-total</u>	<u>113.5</u>	<u>313.7</u>	<u>289.7</u>	<u>231.1</u>	<u>255.9</u>	<u>177.1</u>	<u>1,381.0</u>
<u>Local Personnel</u>							
Staff Personnel	135	479	515	454	596	275	2,453
Civil Engineer	-	5	7	221	24	10	68
Electrical Engineer	-	9	12	12	12	5	50
Plumbing Engineer	-	9	-	-	-	-	9
Building Super.	-	5	-	-	-	-	5
Overseer	-	35	30	47	36	10	158
Medical Officer	-	9	10	3	-	-	22
Medical Assistant	-	6	12	12	12	4	46
Foreman	32	199	180	192	227	100	930
Labor, Common	334	1,750	1,824	2,254	2,111	1,851	10,125
Labor, Heavy	-	35	30	-	-	-	65
Equipment Operator	50	351	321	577	497	240	2,236
Vehicle Driver	53	212	203	247	208	123	1,046
Carpenter	128	542	540	348	534	272	2,364
Bar Worker	13	60	47	98	155	59	432
Mason	74	200	137	190	237	87	925
Plumber	8	50	21	5	-	2	86
Electrician	8	78	40	23	14	23	186

Unit: M/M

	<u>'74</u>	<u>'75</u>	<u>'76</u>	<u>'77</u>	<u>'78</u>	<u>'79</u>	<u>Total</u>
<u>Local Personnel</u>							
Bar Bender	-	66	54	-	-	-	120
Painter	-	68	20	-	-	-	88
Survey Helper	11	20	33	37	51	29	181
Tin Smith	18	27	30	15	17	4	111
<u>Sub-total</u>	<u>864</u>	<u>4,215</u>	<u>4,266</u>	<u>4,536</u>	<u>4,731</u>	<u>3,094</u>	<u>21,706</u>
<u>Total</u>	<u>978</u>	<u>4,529</u>	<u>4,556</u>	<u>4,767</u>	<u>4,987</u>	<u>3,271</u>	<u>23,087</u>

Note: i) No data on the figure during a period from Oct. '73 to Apr. '74 was made available, so not counted in those period.

ii) From the dry season of '76/'77 to '79, the bar bending was carried out by piece work basis. So, nothing was counted in those period

Table 7.3 Contractor's Employee Engaged in ASS

Unit: M/M

	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>Total</u>
<u>Foreign Personnel</u>				
Civil Engineer	0.7	8.9	1.2	10.8
Architect Engineer	8.0	11.1	-	19.1
Equipment Operator	12.0	11.1	1.2	24.3
Carpenter	1.3	13.2	2.4	16.9
Electrician	-	5.5	-	5.5
Plumber	-	5.6	-	5.6
Rigger	1.3	1.1	-	2.4
<u>Sub-total</u>	<u>23.3</u>	<u>56.5</u>	<u>4.8</u>	<u>84.6</u>
<u>Local Personnel</u>				
Staff Personnel	75.1	132.3	11.0	218.4
Foreman	24.8	60.8	4.1	89.7

Unit: M/M

	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>Total</u>
<u>Local Personnel</u>				
Labor, Common	338.3	1,447.9	50.9	1,837.1
Labor, Heavy	0.3	17.5	1.0	18.8
Equipment Operator	30.6	59.7	10.1	100.4
Vehicle Driver	7.9	9.5	3.2	20.6
Carpenter	120.8	249.1	6.2	3,761.1
Steel Bar Worker	12.3	18.6	0.3	31.2
Mason	90.1	161.0	3.6	254.7
Plumber	-	22.8	-	22.8
Electrician	-	44.7	-	44.7
Painter	-	73.6	0.8	74.4
Survey Helper	-	9.3	2.9	12.2
Tin Smith	-	7.9	3.8	11.7
Welder	-	0.9	-	0.9
Surveyor	-	5.3	-	5.3
<u>Sub-total</u>	<u>700.2</u>	<u>2,320.9</u>	<u>97.9</u>	<u>3,119.0</u>
<u>Total</u>	<u>723.5</u>	<u>2,377.4</u>	<u>102.7</u>	<u>3,203.6</u>

Note: As no data on the figure during a period from Oct. '73 to Apr. '74 was available, those data were not counted.

7.2 Minor Works

The following materials were used for the construction of the Minor Works up to the end of May 1979.

Table 7.4 Construction Materials used for Minor Works

<u>Description</u>	<u>Unit</u>	<u>Quantity</u>
Cement	Bag	2,392
Steel Bar	kg	17,302
Sand	m ³	211

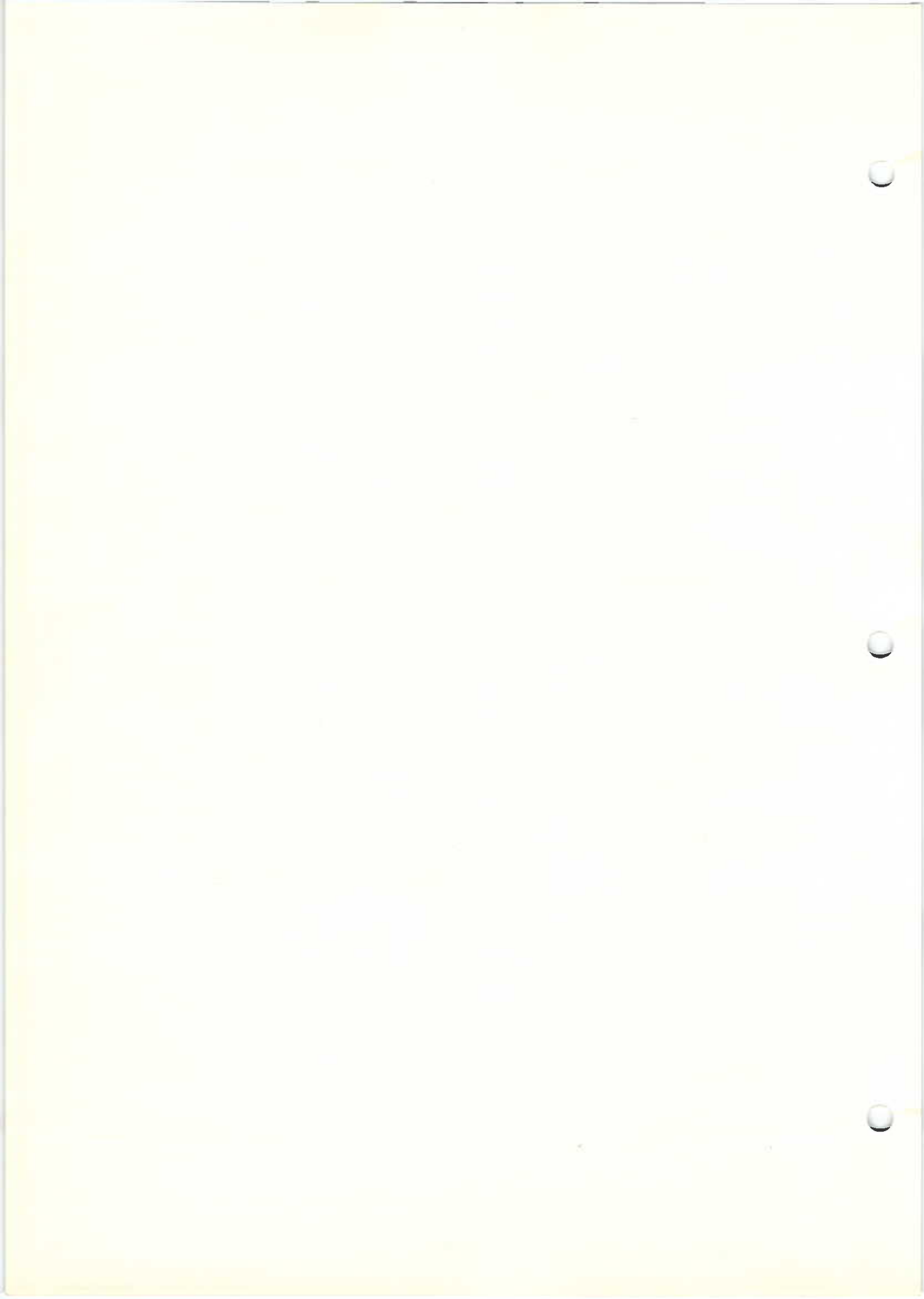
<u>Description</u>	<u>Unit</u>	<u>Quantity</u>
Gravel (20 mm)	m ³	180
Gravel (40 mm)	m ³	179
Concrete Pipe ϕ 300 mm	Nos.	256
" ϕ 460 mm	"	149
" ϕ 530 mm	"	34
" ϕ 610 mm	"	16

Table 7.5 shows the number of workers excluding engineer and overseers for construction of the minor works from 1977 to the end of May 1979, under the force account basis.

Table 7.5 Number of Workers for Minor Works

<u>Description</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>Total</u>
Supervisor	17.0	17.0	5.7	39.7
Dozer Operator	31.8	31.8	10.6	74.2
Vehicle Driver	22.1	22.1	7.3	51.5
Carpenter	12.7	12.7	4.2	29.6
Mason	8.8	8.8	2.9	20.5
Bar Bender	7.5	7.5	2.5	17.5
Helper	53.6	52.6	17.5	122.7
Labor, Common	193.6	193.6	64.5	451.7
Watchman	37.7	37.7	13.6	98.0
<u>Total</u>	<u>383.8</u>	<u>383.8</u>	<u>127.8</u>	<u>895.4</u>

Unit: M/M



VIII. SUPERVISION OF CONSTRUCTION WORKS

8.1 Engineering Services of Consultant

The engineering services to be rendered by the consultant for both MCW and ASS are briefly described as follows:

- i) Engineering supervision for the construction of various facilities for the agricultural development of approximately 5,000 ha of farm land (MCW).
- ii) Engineering supervision for the construction of facilities of the ASS.
- iii) Advisory services in setting up of the ASS.
- iv) Advisory services for the accounting system of the project.
- v) Assistance in procurement by the HMG of equipment and materials required for the project.

Out of above five items, the item iv) has been deleted after the contract was signed. As mentioned previously the construction period was substantially extended from three dry seasons to six dry seasons. Subsequently, the engineering services were extended. The consultant assignment and the total man-months provided during the service period are shown in the following Table 8.1.

Table 8.1 Engineering Services for MCW and ASS

Unit: M/M

<u>Assignment</u>	<u>'72</u>	<u>'73</u>	<u>'74</u>	<u>'75</u>	<u>'76</u>	<u>'77</u>	<u>'78</u>	<u>'79</u>	<u>Total</u>
Resident Engr.	0.9	0.2	3.2	6.3	5.7	1.5	1.4	11.5	20.7
Acting Resident Engr.	0.9	4.7	12.0	9.1	8.6	8.7	5.6	-	48.6
Irri. Civil Engr.	-	-	6.2	12.0	12.0	12.0	12.0	6.7	60.9
Civil Const. Engr.	-	1.5	10.6	6.1	-	-	-	-	18.2
Irri. Civil Engr.	-	-	-	-	-	3.2	-	-	3.2
Mechanical Engr.	-	-	-	-	-	0.7	1.7	0.5	2.9
Architect	0.6	1.7	1.2	-	-	-	-	-	3.5
Office Manager	0.5	4.0	3.8	2.8	1.2	1.2	1.0	0.4	14.9
Project Engr.	-	-	-	-	-	1.7	-	-	1.7
<u>Total</u>	<u>2.9</u>	<u>12.1</u>	<u>37.3</u>	<u>35.3</u>	<u>29.2</u>	<u>27.3</u>	<u>21.7</u>	<u>9.1</u>	<u>174.6</u>

8.2 HMG Staff for the Construction Works

Since the commencement of the construction of MCW and ASS, the Government provided the following staff including the counterpart personnel for the successful and timely completion of the project. In the first three years the most of staff were engaged in mainly the detail design and construction supervision of MCW and ASS and in the latter three years in the minor work construction carried out by the force account basis in addition to the said MCW supervision.

Table 8.2 HMG Staff Engaged in MCW and ASS

Unit: M/M

<u>Assignment</u>	<u>'73</u>	<u>'74</u>	<u>'75</u>	<u>'76</u>	<u>'77</u>	<u>'78</u>	<u>'79</u>	<u>Total</u>
Project Manager	12	12	12	12	12	12	6	78
Divisional Engineer	-	12	12	11	12	12	6	65
Civil Engineer	5	37	37	64	40	20	18	221
Mechanical Engineer	-	12	4	12	1	-	-	29
Overseer	28	45	45	126	144	106	48	542
Supervisor	-	108	108	108	108	113	60	605
Mechanics & Electrician	-	12	12	36	54	48	24	186
Driver & Operator	-	12	17	53	108	144	110	444
Administer Officer	-	12	4	14	16	9	-	55
Adminster Assistant	-	16	16	88	116	120	60	416
Accounting Officer	-	12	4	12	22	12	6	68
Accounting Assistant	12	8	8	36	36	45	10	155
<u>Total</u>	<u>57</u>	<u>298</u>	<u>279</u>	<u>572</u>	<u>669</u>	<u>641</u>	<u>348</u>	<u>2,864</u>

IX. RECOMMENDATION

The major works of the project, irrigation development of about 5,000 ha, were successfully completed in May 1979 with the great efforts and cooperation among those who participated in the project implementation. The operation and maintenance of irrigation, drainage and roads facilities, however, have just started and the water management and agricultural extension services play an important role of the full development the project from now on. Furthermore the project is the first fully integrated substantial project which will be extended to the multipurpose development in Kankai river. For the successful implementation of the project it is desired to take the following points into consideration.

- i) Up to date, progress of installation of division boxes in TIC are only about 30 % of total numbers required. For the proper water management of the canal the division box is quite essential. It is desired to expedite the completion of the remaining works with the best efforts.
- ii) Although the operators and mechanics employed by KDB are generally skillful for the operation, dismantling and assembling of the equipment, it is considered that they are not so acquainted to do them properly. This is mainly due to a lack of the basic knowledge of mechanical and electrical engineerings and less experiences in the practical operation. Therefore, it is recommended to train efficiently them at the appropriate places.
- iii) Systematic operation and maintenance of irrigation system are very essential. Without proper water management, no optimum distribution of irrigation water is expected. In this connection, it is proposed to establish the most efficient organization of O&M system for which the draft O&M manual was submitted by the Consultant.

Furthermore, in order to ensure the successful water management practices, it is recommended to train thoroughly the project water management staff through either overseas training in the

similar type of project or engaging the well experienced foreign expert on water management.

- iv) Though spare parts of heavy equipment required for about 2,000 ha operation were purchased for the minor work construction, certain parts were used during the past three years operation. Some of equipment have not been in use due to shortage of spare parts. For the efficient use of the equipment, it is strongly recommended that timely and sufficient supply of spare parts are to be made for which usual checking and list up of spare parts required are essential.
- v) The present activity of ASS is quite satisfactory on the selection of most suitable variety of crops proposed, multiplication of recommendable seeds of crop and those distribution to the surrounding farmers as well as extension services for proper improved irrigation farming to the surroundings of ASS. The present staff provided for ASS is, however, considered to be acute short for ensuring the function of ASS.

It is therefore recommended to strengthen such technical staff as agronomist, extensionist, J.T. and J.T.A. as proposed in the Draft Operation and Maintenance Manual.

- vi) Rainfall distribution pattern in the project area is considerably differed from the north to the south. For the efficient and proper O&M of the irrigation system, four meteorological observations at EOQ and O&M section offices are proposed to be established in addition to the present station located at ASS.
- vii) It has taken about six (6) years for the implementation of the project and the operation of irrigation facilities are being carried out by KIP. However some of the plants and equipment which is under operation by the Contractor and will be handed over to KIP in the near future, have been long used and some of the equipment had been deleted from the procurement list of BOQ in the contract for MCW. Most of the above equipment and plants

are very essential for proper operation and maintenance of the project. It is strongly recommended to procure the following equipment and goods as soon as possible.

1. Radio telephone set	1
2. Submergible sand pump (ϕ 80 mm)	3
3. Generator for sand pump (30 kVA)	1
4. Motorcycle (90 cc)	4
5. Meteorological equipment	4
6. Generator for EOQ (60 kVA)	1
7. Generator for ASS (45 kVA)	1
8. Pump with engine for EOQ water supply (6.5 HP)	1

