Operation and Maintenance Manual for Anayirankal Dam State of Kerala

Doc. No. DSO_O&M_ANAYIRANKAL_DAM
KSEBL_18_v1.0

DRIP
Rehabilitation & Improvement Project

KSEB

Chief Engineer
(Civil- DRIP & Dam Safety)
Kerala State Electricity Board

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Government of Kerala

Operation and Maintenance Manual

Anayirankal Dam

KSEB
കേരളത്തിന്റെ ഊർജ്ജം

Prepared

Sd/-

Deputy Chief Engineer (Civil)
Dam Safety & DRIP

Approved

Sd/-

Chief Engineer (Civil)
Dam Safety & DRIP

Kerala State Electricity Board Ltd
Pallom, Kottayam.

January 2020

Government of Kerala
Kerala State Electricity Board Ltd
Dam Safety Organisation

Disclaimer

This *Operation and Maintenance Manual for Anayirankal Dam* in no way restricts the dam operators in digressing from her/his responsibilities. The Dam Operators must exercise appropriate discretion and good judgement based on actual site condition when implementing and using the operation and maintenance manual for managing the workings of the dam and appurtenant structures.

The manual is developed for the purposes of organizing and managing the operation, inspection and maintenance of the dam for reducing risk and optimizing performance of the dam as a general guide.

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Message

India has more than 5200 large dams. The health and safety of these valuable assets is of are of paramount importance in order to derive benefits from them continuously on a sustainable basis, besides providing protection to the people and property in the downstream areas. The Ministry of Water Resources, River Development & Ganga Rejuvenation through the Central Water Commission (CWC), with financial assistance from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to rehabilitate 198 large dam projects in seven states. Kerala State Electricity Board Ltd, through Government of Kerala participated in DRIP to rehabilitate 37 dams under 12 Hydro Electric Projects in the state.

For managing a dam in a sustainable and scientific manner, it is very crucial for each dam owner to have dam specific Operation and Maintenance Manual that lays down procedures for the daily upkeep of the dam. An Operation and Maintenance Manual for a dam is essential for ensuring its safe functioning and for deriving continued benefits. This Operation and Maintenance Manual for Dam has been prepared following the Guidelines for Preparation, Operation and Maintenance Manuals published by CWC in January 2018 under DRIP and covers requirements for project Operation, Inspection, Maintenance, Instrumentation and Monitoring the health of Dam both during monsoon and non-monsoon periods.

I recommend the dam officials to use this manual for the efficient and safe Operation and Maintenance of the Dams on regular basis.

I compliment all the experts who have contributed to the development of this manual and congratulate the Dam Safety Organisation, KSEB Ltd, Pallom and CWC for the initiation of such important policy protocol to address dam safety management in Kerala.

Bibin Joseph,
Director Generation (Civil),
KSEB Ltd,
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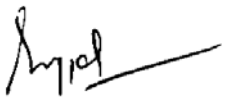
Foreword

Globally, the Operation and Maintenance (O&M) Manual of a dam is one of the most important documents which is supposed to be put in practice right from the initial filling of reservoirs. In order to address the operation and maintenance aspects, ongoing Dam Rehabilitation and Improvement Project (DRIP) has requisite scope to prepare new or update existing O&M manuals for all DRIP dams, which will become very helpful to Dam Owners in addressing the dam specific issues comprehensively in future.

This Operation and Maintenance (O & M) Manual developed contains detailed procedures for ensuring that the dam is safely operated, frequently inspected and properly maintained. In this era of shrinking budgets, timely inspection and preventative maintenance is necessary for the safe functioning of the dam and continued productive use of the dam and reservoir.

The format of this manual is prepared following the principles published in 2018 CWC Guidelines for Operation and Maintenance of dams for the use by all Dam Owners in developing their own site-specific manuals. Each section of the document provides the necessary instructions to operate inspect and maintain their dams.

It is recommended that all dam officials in charge to use this manual for ensuring that the dam is operated and maintained in a sustainable manner and will continue to derive benefits.



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Field Officers associated in giving Data

Executive Engineer, Assistant Executive Engineers, Assistant Engineers and Sub Engineers of Dam Safety Division, KSEB Ltd, Pambla.

PREFACE

Operation and Maintenance (O&M) Manual contains detailed procedures and protocols for ensuring that a dam is operated and maintained properly and timely to avoid further health deterioration and extend service life of these assets. An Operation and Maintenance Manual is essential for a dam for ensuring its safe functioning and for deriving desired benefits from it by describing all the elements systematically for its operation, inspection, maintenance, instrumentation and monitoring of the health.

Central Water Commission has published the Guidelines for the development of New Manual and Updating of Existing Manual vide CDSO_GUD_DS_03_v1.0 Page xii January 2018. Accordingly KSEB Ltd is developing and updating the Operation and Maintenance Manual of Dams under their ownership for a healthy dam safety management system. **Anayirankal** dam under KSEB Ltd do not have a comprehensive Operation and Maintenance Manual. Hence an attempt is made here to prepare the manual as per the new guidelines by CWC.

Panniar Hydro Electric Project 30 MW (PHEP) is in Mudirappuzha basin, a sub basin of Periyar River basin. The project consists of two dams, Ponmudi and Anayirankal. Anayirankal reservoir has been created by constructing an earth and rock fill dam at Anayirankal with an ungated spill way across Panniar River. The water stored in the reservoir is released to the river downstream through an outlet arrangement. The controlled release from the reservoir leads to Ponmudi reservoir which is created in the river downstream. The water from the Ponmudi reservoir is diverted to Panniar Power station (30 MW) located on the left bank of Mudirappuzha. The project was commissioned in 1965. A flow chart of **Panniar** HEP is given in the next page for reference.

This Operation and Maintenance Manual is prepared for the Anayirankal dam of Panniar HEP.

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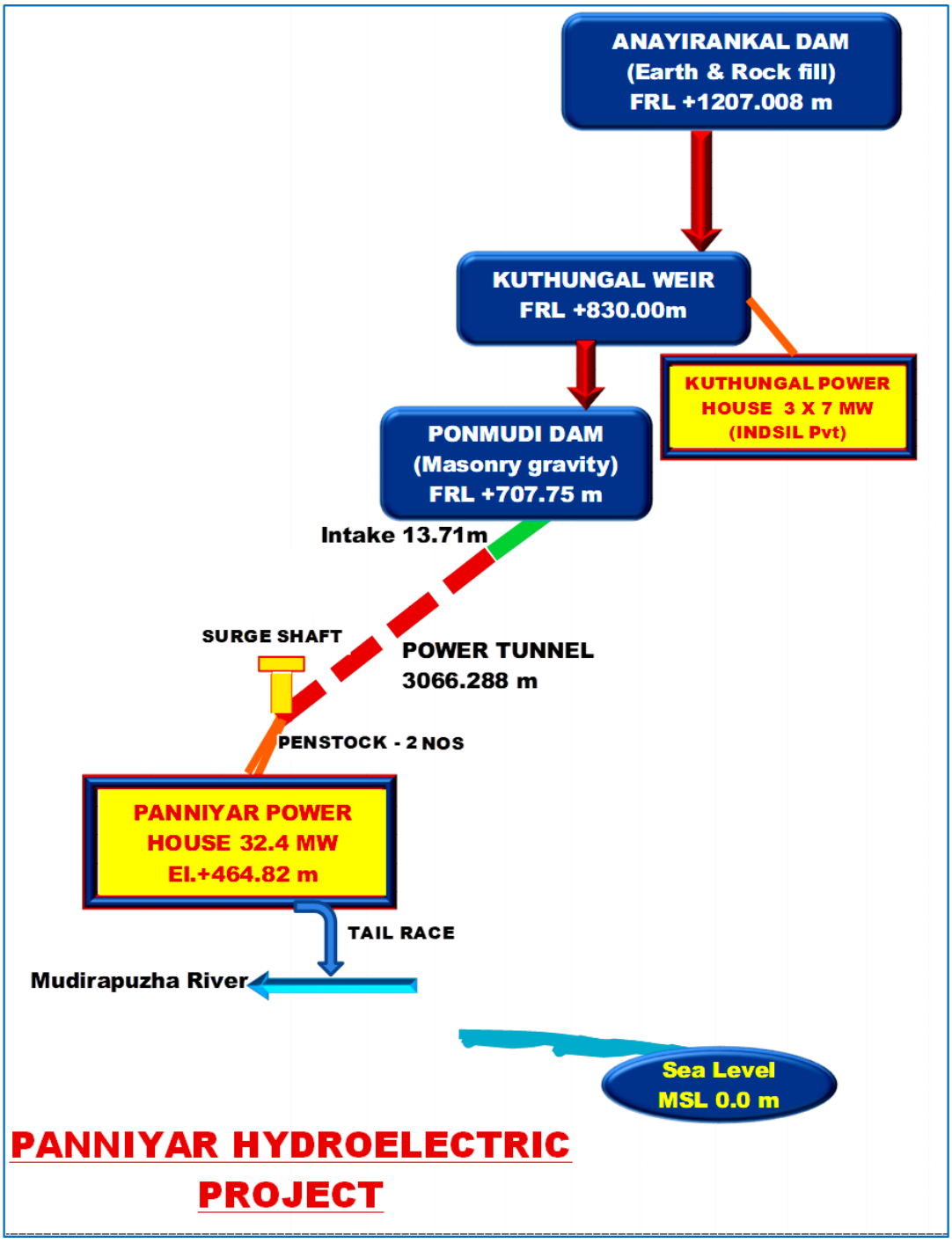
ANAYIRANKAL DAM
(Earth & Rock fill)
FRL +1207.008 m
KUTHUNGAL WEIR
FRL +830.00m
KUTHUNGAL POWER
HOUSE 3 X 7 MW
(INDSIL Pvt)
PONMUDI DAM
(Masonry gravity)
FRL +707.75 m
Intake 13.71m
SURGE SHAFT
POWER TUNNEL
3066.288 m
PENSTOCK - 2 NOS
PANNIYAR POWER
HOUSE 32.4 MW
El.+464.82 m
TAIL RACE
Mudirapuzha River
Sea Level
MSL 0.0 m
PANNIYAR HYDROELECTRIC
PROJECT

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LIST OF ACRONYMS

The following acronyms are used in this publication:

AAR	**Alkali-Aggregate Reaction**
ACI	**American Concrete Institute**
ASTM	**American Society for Testing Materials**
CDSO	**Central Dam Safety Organization**
CWC	**Central Water Commission**
CWPRS	**Central Water and Power Research Station**
DDMA	**District Disaster Management Authority**
DHARMA	**Dam Health and Rehabilitation Monitoring Application**
DRIP	**Dam Rehabilitation and Improvement Project**
EAP	**Emergency Action Plan**
FSCT	**Federation of Societies for Coatings Technology**
HCC	**Hindustan Construction Corporation Ltd**
IS	**Indian Standard**
KERI	**Kerala Engineering Research Institute**
KDSA	**Kerala Dam Safety Authority**
KSEB Ltd	**Kerala State Electricity Board Ltd**
KWA	**Kerala Water Authority**
NCDS	**National Committee on Dam Safety**
NCSDP	**National Committee on Seismic Design Parameters**
PMF	**Probable Maximum Flood**
PMP	**Probable Maximum Precipitation**
RCC	**Reinforced Cement Concrete**
ROUV	**Remotely Operated Underwater Vehicle**
ROV	**Remotely Operated Vehicle**
SDSO	**State Dam Safety Organization**
SISF	**State Industrial Security Force**
UAV	**Unmanned Aerial Vehicle**
USBR	**United States Bureau of Reclamation**
USACE	**United States Army Corps of Engineers**

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LIST OF ANNEXURES

REFERENCES

Central Water Commission (2018): Guidelines for Preparing Operation and Maintenance Manual for Dams, Doc. No. CDSO_GUD_DS_03_v1.0 published under DRIP

Central Water Commission (1987): Guidelines for Safety Inspection of Dams, Doc. No. CDSO_GUD_DS_07_v1.0 published under DRIP

Central Water Commission (2016): Guidelines for Developing Emergency Action Plan (EAP) for Dams, Doc. No. CDSO_GUD_DS_01_v1.0 7.

Project Screening Template of Panniar HEP under DRIP I

Dam Safety Review Panel Report of Panniar HEP under DRIP I

Hydrology Review Report of Panniar HEP under DRIP I

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Chapter 1

General Information

1.1 Introduction

Panniar Hydro Electric Project is the first project on Panniar River of Mudirappuzha basin. Project consists of two dams, Ponmudi and Anayirankal and a Power house located almost opposite to Sengulam Power Station, but a few metres downstream of it. This project utilises the yield from 221.75 sq km of free catchment area above Ponmudi dam along with the yield from 64.92 sq km of free catchment area above Anayirankal dam. The water conductor system was designed for an installed capacity of 30 MW. Two machines of 15 MW each are installed in the Power station.

Anayirankal dam is the uppermost dam on Panniar River. The regulated discharge from this dam is used for power generation at Kuthungal powerhouse (21 MW), a private sector captive power plant (CPP) constructed by INDSIL Company, Coimbatore. The tail water from this power station along with Kuthungal weir overflow joins Panniar River and reaches Ponmudi reservoir. This stored water is utilized for power generation at Panniar power house of KSEB Ltd with an installed capacity of 30 MW. The tail water of Panniar power house reaches Kallarkutty reservoir. The Panniar and Mudirapuzha Rivers constitutes the Mudirapuzha basin.

1.2 Purpose, Location, Description of the Project

Panniar Hydro Electric Project

Anayirankal reservoir is created for the purpose of power generation. The project is in Mudirappuzha basin, a sub basin of Periyar River basin. The reservoir has been created by constructing a dam at Anayirankal. The dam is provided with an ungated spill way. The water stored in the reservoir is released to the river downstream through an outlet arrangement. The controlled release from this reservoir is lead to the downstream Ponmudi reservoir. The water from Ponmudi reservoir is diverted to Panniar Power station (30 MW) located on the left bank of Mudirappuzha.

The project is located in Idukki District of Kerala State. Anayirankal dam is constructed across Panniar River in Mudirappuzha river sub basin of Periyar basin. The location of dam is at latitude 10^0 00' 35" N and longitude 77^0 12' 26" E. The nearest airport is CIAL, Nedumbasserry. The distance from airport to Anayirankal dam is 125 km. The nearest rail head is Aluva. It is about 127 km from dam site. The nearest city is Kochi.

The Panniar river is one of the important tributaries of Mudirapuzha and joins it about 2 miles (3.22 km) upstream of the present Sengulam Power Station and 4 miles (6.44 km) downstream to Pallivasal Power Station. It starts at about El. 7000 ft (2134.15 m) and joins the Mudirapuzha at about El. 1832 ft (558.54 m). Two reservoirs, an upper reservoir at Anayirankal and a lower reservoir at Ponmudi are formed for impounding and controlling the waters of the Panniar River for Power Development.

Access

The site of Anayirankal dam is about 13 miles (20.93 km) South East of Devikulam and is approachable by a branch road from the Panniar estate taking off from 12th mile of the Devikulam – Kumili Road. The dam site is one mile along the branch road from the Devikulam – Kumili Road and is situated in the Panniar Estate of Harrisons Malayalam Plantations Ltd. The road bridge crossing the Panniar River is located just downstream of the dam site. The dam at Ponmudi is 18 miles (28.98 km) downstream of Anayirankal dam and 2 miles (3.22 km) upstream of the junction of Panniar with Mudirapuzha and 4 miles (6.44 km) from Sengulam Power House. The Power Station is located on the left bank of Mudirapuzha River almost opposite to Sengulam Power Station, but a few metres downstream of it.

The index map and Google map of Panniar HEP are given in **Fig 1.1** and **Fig 1.2**.

Project Benefits:

Panniar project consists of:

1. A Rubble masonry straight gravity Ponmudi dam 31.40 m high above the deepest river bed and 297.04 m long with a gated spillway having 3 spans of 7.62 m each across River Panniar. The dam is 28.98 km downstream of Anayirankal dam and 3.22 km upstream of the junction of Panniar with Mudirappuzha and 6.44 km from Sengulam Power House.

Fig 1.1 Index Map

Fig 1.2 Google Map showing the Project

2. A Composite dam at Anayirankal of 550 ft long Rock fill dam with earthen core and a 307 ft long rubble masonry straight gravity type dam with 32 m height above the deepest river bed and 306 m long at top. An ungated overflow spillway is provided in the masonry portion of this dam.

3. A Power House located at Vellathooval almost opposite to Sengulam Power Station, but a few metres downstream of it, having installed capacity of 30 (2 x 15) MW.

Unit	**Rating**	**Date of Commissioning**
U # 1	15 MW	29.12.1963
U # 2	15 MW	26.01.1964

The Project was commissioned in 1964 and later augmentation schemes viz. Mudirappuzha Diversion Structures across Mudirappuzha River, Parakkadavu Diversion Structures across Parakkadavu thodu and Mullakkanam Diversion Weir across Mullakkanam stream were constructed. The generating units in the station were renovated during 2000 - 2003 period as part of PPSHUP (Pallivasal Panniar Sengulam Hydro Up-gradation project). The power generated is stepped up to 110 kV and taken to 110 kV yard at Sengulam Powerhouse for onward transmission. After Renovation, the installed capacity is increased to 32.4 MW and firm annual generation capability to 158 MU.

Unit after Renovation	**Rating**	**Date of Commissioning**
U # 1	16.2 MW	01.02.2003
U # 2	16.2 MW	23.11.2001

A schematic diagram of the project is outlined below in **Fig 1.3a.** A layout of the augmentations is given i**n Fig 1.3b.**

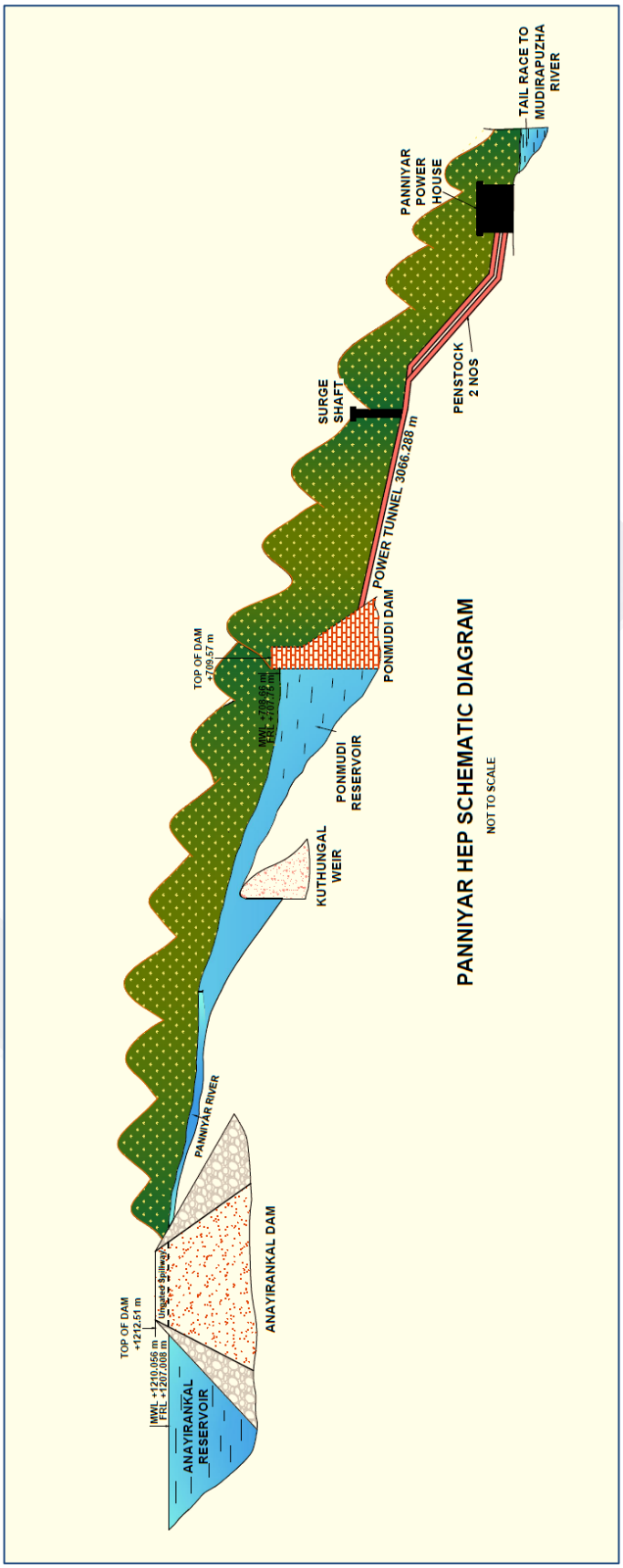


Fig 1.3a Schematic Diagram of the Project

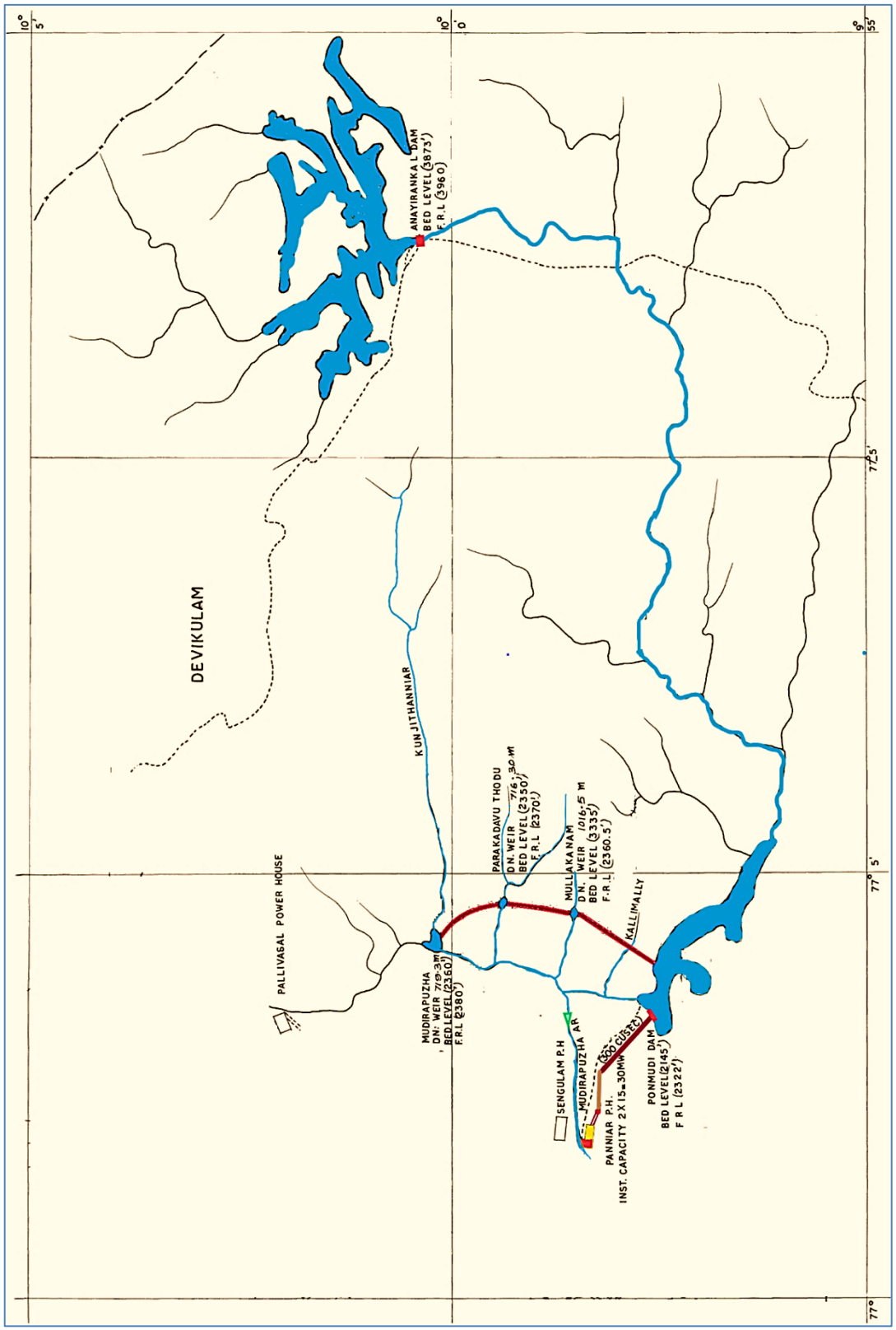


Fig 1.3a Layout of Panniar and Augmentations

SALIENT FEATURES OF THE PROJECT

A	Name of dam	-	Ponmudi dam
	Type of dam	-	Rubble masonry straight gravity dam
	Source of water	-	Panniar River - tributary of Mudirapuzha River
	Catchment area	-	221.75 sq km
	Average rainfall	-	80 inches (2032 mm)
	Gross Storage of reservoir	-	51.536 Mm^3
	Average bed level	-	653.96 m
	Top of dam	-	+ 709.57 m
	Maximum Water Level (MWL)	-	708.66 m
	Full Reservoir Level (FRL)	-	707.75 m
	Minimum Draw Down Level (MDDL)	-	676.65 m
	Height of dam	-	57.60 m
	Width of roadway at top	-	6.0 m
	Length of dam at road level	-	288.8 m
	Max. designed flood through spillway	-	1359 m^3/s
	Volume of masonry	-	181000 m^3
	Outlet sluice	-	6 ft dia. outlet pipe fitted with 4 ft dia disperser (Glenfield & Kennedy make)
B	**Name of dam**	**-**	**Anayirankal dam**
	Type of dam	-	Composite dam of earth core covered by rock fill shoulders for 550 ft and rubble masonry straight gravity type for 307 ft
	Source of water	-	Panniar River - tributary of Mudirapuzha River
	Catchment area	-	64.92 sq km
	Average rainfall	-	67 inches (1701.8 mm)
	Gross storage of reservoir	-	1800 Mcft (50.97 Mm^3)
	Average bed level	-	+3873.00 ft (1180.49 m)
	Top of dam	-	+3978.00 ft (1212.50 m)
	Maximum Water Level (MWL)	-	+1210.07 m

	Full Reservoir Level (FRL)	-	1207.01 m
	Minimum Draw Down Level (MDDL)	-	+1188.10 m
	Height of dam	-	34.13 m above deepest foundation
	Width of roadway at top	-	6.1 m
	Length of dam at road level	-	326 m
	Max. designed flood through spillway	-	343.65 m^3/s
	Volume of masonry	-	2.25 lakhs cft
	Volume of earth core	-	85 lakhs cft
	Volume of rock fill	-	75.67 lakhs cft
	Outlet sluice	-	Outlet tunnel of cross sectional area 72 sq ft in lined portion and 90 sqft in unlined section
C	**Water conduit system**		
a)	**Intake (At Ponmudi dam)**		
	Length of intake pipe including bell mouth	-	45 ft (13.716 m)
b)	**Power tunnel**		
	Length	-	10060 ft (3066.28 m)
	Area of lined section	-	72 sq ft (6.68 m^2)
	Maximum flow	-	600 cusecs (16.99 m^3/s)
	Maximum velocity	-	9 ft/s (2.743 m/s)
	Exit sill level	-	+2157.00 ft (657.45 m)
	Total fall in elevation	-	40.00 ft (12.19 m)
	Number of bends	-	4
c)	**Surge Shaft**		
	Top level of shaft	-	+2418.00 ft (737.006 m)
	Diameter of shaft	-	(i) 22 ft between +2372.00 & +2418.00 (ii) 19 ft between +2222.50 & +2372.00 (iii) 16 ft between +2208.00 & +2222.50
	Depth of shaft	-	256 ft (78.028 m)
	Maximum surge level	-	+2373.00 ft (723.29 m)

	Bottom level of surge gallery	-	+2188.00 ft (666.902 m)
	Area of gallery	-	209.50 sqft (19.46 m^2)
	Length of gallery	-	200 ft (60.96 m)
d)	**Penstocks**		
	Number of pipelines	-	2
	Internal diameter	-	58 inches (1473.2 mm)
	Total length of pipelines (H.P.P)	-	1943 ft (592.23 m)
	Length of pipes in tunnel (L.P.P)	-	330 ft (100.58 m)
	Maximum flow in each pipe	-	300 cusecs (8.495 m^3/s)
	Maximum velocity	-	17 ft/s (5.18 m/s)
	Thickness of pipe	-	20 mm at bottom and 10 mm at top
	Suppliers	-	M/s. Ferrum of Norway
e)	**Butterfly Valves**		
	No. and Type	-	2 nos, 1500 mm Automatic self-closing type
	Suppliers	-	M/s. Neyrpic, France
f)	**Tunnel drain**		
	Length of pipe	-	80.00 ft (24.38 m)
	Internal diameter	-	24.00" (609.6 mm)
	Fitted with sluice valve and energy dissipator		
g)	**Power House**		
	Size	-	100' x 72' (30.48 m x 21.95 m)
	Floor level of generator	-	+1525.00 ft (464.82 m)
	Draft tube sill level	-	+1496.00 ft (455.98 m)
	Gross head available	-	809 ft (246.58 m)
	Turbines (Vertical shaft Francis type reaction turbines	-	2 nos
	No. of generators (Supplied by M/s. HITACHI)	-	2 nos
	Capacity	-	17647 KVA

	Power output	-	2 x 15000 KW
	Voltage of generation	-	11000 volts
	No. of transformers	-	2 nos
	Transformer ratio	-	11/100 KV
	Capacity	-	18 MVA
D	**Panniar Augmentation Scheme**		
a)	**Diversion Structures**		
	Mudirappuzha Diversion Structures	-	FRL – 725.40 m, Across Mudirapuzha
	Parakkadavu Diversion Structures	-	FRL – 722.40 m, Across Parakkadavu thodu
	Mullakkanam Diversion Weir	-	FRL – 719.50 m Across Mullakkanam river
b)	**Diversion Tunnel**		
	Completed Length	-	5171.23 m
	Size and shape	-	8' dia. unlined, circular in shape
	Slope	-	1 in 516
	Maximum velocity	-	5.44 ft/s (1.658 m/s)

Cost and benefits

The Panniar project was estimated to cost 3.24 crores with annual energy generation of 15.60 MW on a firm basis (137 MU) at 100 % load factor at Panniar power house. The station will get connected with the other stations in Mudirappuzha basin viz. Pallivasal, Sengulam and Neriamangalam. The tail waters from the Panniar station will generate additional continuous power at Neriamangalam Station to the extent of about 13 MW at 100% load factor.

1.3 Background Details of the Project

Panniar HE Project is a logical development in harnessing the waters of the Mudirappuzha basin and hence was recommended to be taken up in the second five-year plan. The project brings the Neriamangalam scheme to its maximum utility. Since this station is connected to other stations in Mudirappuzha basin viz. Pallivasal, Sengulam and Neriamangalam, the

flexibility of the grid is very much increased. The Anayirankal dam with storage capacity 50.68 MCM along with the Ponmudi dam downstream yields a firm discharge of 285 cusecs which is diverted through a water conduit system consisting of a power tunnel and penstocks to the power house on the left bank of the Mudirappuzha river opposite to the Sengulam Power Station. The gross head available for power generation is about 809 ft and the annual quantum of power generated is to the order of 137 MU. The Project was later augmented by Mudirappuzha Diversion, Parakkadavu Diversion and Mullakkanam Diversion. The generating units in the station were renovated during 2000 - 2003 period, power generated is stepped up to 110 kV, and the installed capacity is increased to 32.4 MW with firm annual generation capability of 158 MU.

The construction of the project was commenced during 1961 and commissioned in 1965. The design of the project was done by KSEB Ltd.

1.4 Salient Features of Anayirankal Dam

Component Structures

1. Dam & Reservoir	
Type	Composite Earth & Rock fill
Latitude	10^0 00' 35" N
Longitude	77^0 12' 26" E
Lowest River Bed Level	1180.49 m
FRL	1207.02 m
MWL	1210.07 m
Top of Dam	1212.51 m
MDDL	1188.10 m
Length of dam at top	326.00 m
Width at top	6.10 m
Height above deepest foundation	34.13 m
Height above bed level	32 m
Gross storage at FRL	50.68 Mm^3

Live storage at FRL	49.83 Mm^3
Dead storage	0.85 Mm^3
Catchment area at Dam site	64.92 km^2
Reservoir spread area at FRL	4.856 km^2
No. & size of river outlet	1 no., 1.5 m x 1.5 m
Outlet level	1187.19 m at intake 1184.15 m at control shaft bottom
Discharge capacity of river outlet at MWL	28.12 m^3/s
2. Spillway	
Shape	Ogee
No. and size of bays	3 bays, 9.35 m x 4.75 m each
Type of gate	Ungated overflow structure
No. of gates	Nil
Total spillway discharge	343.65 m^3/s
Design Flood (original)	364.00 m^3/s
Design Flood (revised)	894.00 m^3/s
Spillway crest El.	1207.02 m
Length of spillway at crest	28.05 m

Anayirankal Dam:

Anayirankal dam is of composite type consisting of a rubble masonry dam with spillway on the left flank and a zoned earth-cum-rock fill dam at the centre and right flank. The spillway is located in the masonry section and is ungated. A tunnel cum sluice is provided on the left flank/abutment beyond the dam masonry for regulating the flow to the Panniar Power House.

The dam is 34.13 m high above the deepest river bed and 326.00 m long. The top width of dam is 6.10 m. The FRL and MWL of the dam are +1207.01 m and +1210.07 m respectively. The spillway structure has three bays, each of size 9.35 m x 4.75 m and is ungated overflow type structure. The total spillway capacity is 343.65 m^3/s. The reservoir has a gross storage capacity of 50.68 Mm^3 and a live storage capacity of 49.83 Mm^3 at FRL.

Google view of Anayirankal dam is shown in **Fig 1.4**. Photograph showing downstream elevation and upstream elevation of Anayirankal dam are given in **Fig 1.5a** and **Fig 1.5b**.

Fig 1.4a Google map view of Anayirankal dam

Fig 1.4b Google map view of Anayirankal dam

Fig 1.5a Upstream View of Anayirankal Dam

Fig 1.5b Downstream Elevation of Anayirankal Dam

1.5 Assignment of Responsibility

Kerala State Electricity Board Ltd is the owner and has the final authority and responsibility for the operation and maintenance of the dam. Identification of all areas of responsibilities connected with the operation and maintenance of the dam are covered in this section. The officer's responsibilities for the various functions (civil, mechanical, electrical, instrumentation etc.) are identified by their designation and, in particular, the responsibilities of operating personnel are specifically identified including the regularly scheduled duties which staff personnel are required to perform as outlined.

Project Administration Officer in Charge	-	Executive Engineer, Research & Dam Safety Division No. IV, Pambla.
Authorizing releases for hydro power	-	Executive Engineer, Research & Dam Safety Division No. IV, Pambla.
Dam safety surveillance including instrumentation.	-	Executive Engineer, Research & Dam Safety Division No. IV, Pambla.
Routine inspection	-	Assistant Executive Engineer, Research & Dam Safety Sub Division, Kallarkutty.
Maintenance	-	Assistant Executive Engineer, Research & Dam Safety Sub Division, Kallarkutty.
Operations of Equipment at the dam	-	Assistant Engineer, Research & Dam Safety Sub Division, Kallarkutty.
Recording reservoir data	-	Assistant Engineer, Research & Dam Safety Sub Division, Kallarkutty.

1.6 Collection & Reporting of Dam and Reservoir Data

Dam Reservoir Data and vital information as below are collected, recorded and documented for the record.

- Reservoir water surface elevation
- Reservoir inflow
- Spillway outflow
- Irrigation, water supply and hydropower releases
- Weather related data
- Instrumentation data

1.7 Public Utilities and Safety

As safety of Project Staff is of prime concern, safety instructions & protection measures at the dam are to be followed by all staff / project personnel.

The project is located in Idukki District of Kerala State. The nearest airport is CIAL, Nedumbasserry. The distance from airport to Anayirankal dam is 125 km. The nearest rail head is Aluva. It is about 127 km from dam site. The nearest city is Kochi.

Distance to the nearest public conveniences:- For medical assistance a Government Health Centre are available at Rajakumari, 13 km away from the dam. Police station is located at Shanthanpara, 10 km away from the dam. There is an Inspection Bungalow of KSEB Ltd at Vellathooval, 38 km from the dam.

1.8 Restricted Areas

Certain areas of the dam and reservoir are restricted for entry of the general public. The purpose of restrictions is for security of the dam, public safety and uninterrupted safe operation of the dam. Restricted areas include: confined spaces such as spillway approach, chute, energy dissipation arrangements, intake, tunnel, gate operations areas, control rooms etc. Warning boards showing the restricted area are placed at the dam premises.

1.8.1 Dam safety surveillance including instrumentation

Security arrangements are already provided through Ex-service men at the security check posts near dam. Also CCTV surveillance will be provided soon covering the dam and premises.

1.9 Staff position, Communication & Warning System

The number and description of operating unit personnel posted/placed at different locations of the dam are noted in supporting documents and referenced in this Manual. Means of communications both in normal and emergency situations are identified in the Communication Directory. Communication means available include landline, mobile and satellite phones, wireless sets etc. Basic facilities like sirens etc. are available. A hierarchy of organizational structure for the control and safety of Anayirankal dam is outlined below in **Fig 1.6**. Present hierarchy of Controlling officers and their contacts are as below:

Designation and office address	Contact number and e-mail
Chief Engineer Civil (Dam Safety & DRIP), KSEB Ltd, Dam Safety Organization, Pallom, Kottayam	Ph.: 9496018719, 9446008964 e-mail: cedamsafety@kseb.in, cedamsafety@gmail.com
Deputy Chief Engineer, Research & Dam Safety Organization, Pallom, Kottayam	Ph: 9446008492, 0481-2432290, 9496011540 e-mail: dirroplm2@gmail.com
Executive Engineer, Dam Safety Division No. IV, Pambla	Ph: 9446008421, 0486-62206206 e-mail: eerdspambla@gmail.com
Assistant Executive Engineer, Dam Safety Sub Division, Kallarkutty	Ph: 9496011963 e-mail: aeedskty@gmail.com
Assistant Engineer, Dam Safety Sub Division, Kallarkutty	e-mail: aeedskty@gmail.com

Fig 1.6 Dam Safety Organisation Structure for Anayirankal Dam

Spillway flood releases

The own catchment of Anayirankal dam is subject to heavy rainfall during North East monsoon whereas the catchment of Mudirappuzha is subject to heavy rain in South West monsoon. Hence normally this reservoir will not spill during South West monsoon. The reservoir water can be regulated to Ponmudi reservoir through the tunnel cum sluice at the left bank. The overflow is also directed to Panniar River downstream.

Since the reservoir inflow during South West monsoon is less compared to North East monsoon and being an ungated overflow spillway, there is no specific flood release procedure. Both the spill water and regulated outflow through tunnel cum sluice joins in Panniar River downstream and flows to Ponmudi reservoir through the Kuthungal weir and Power House. The flood release if any required is done at the Ponmudi reservoir.

Releases for various purposes like irrigation, water supply, and hydropower

Water from the reservoir is mainly used for power generation at a 2 x 15 MW power house of KSEB Ltd at Panniar. Anayirankal reservoir water is utilized for power generation at Panniar PH when the Ponmudi reservoir is almost depleted. Normally in the summer season i.e. from the mid of March of every year, the control shaft gate will be kept opened and waters would be released at the below mentioned rate and continued for 2 months till the depletion of Anayirankal reservoir. The diversion to Ponmudi reservoir through the tunnel is maintained at 1 Mm^3 per day.

There is a downstream weir and power house at Kuthungal (21 MW) in between Anayirankal & Ponmudi. This is a private sector captive power plant (CPP) for INDSIL Company, Coimbatore, the tail water after generation again joins Panniar River and reaches Ponmudi reservoir. The flow diagram of water utilization is given in **Fig 1.7** below.

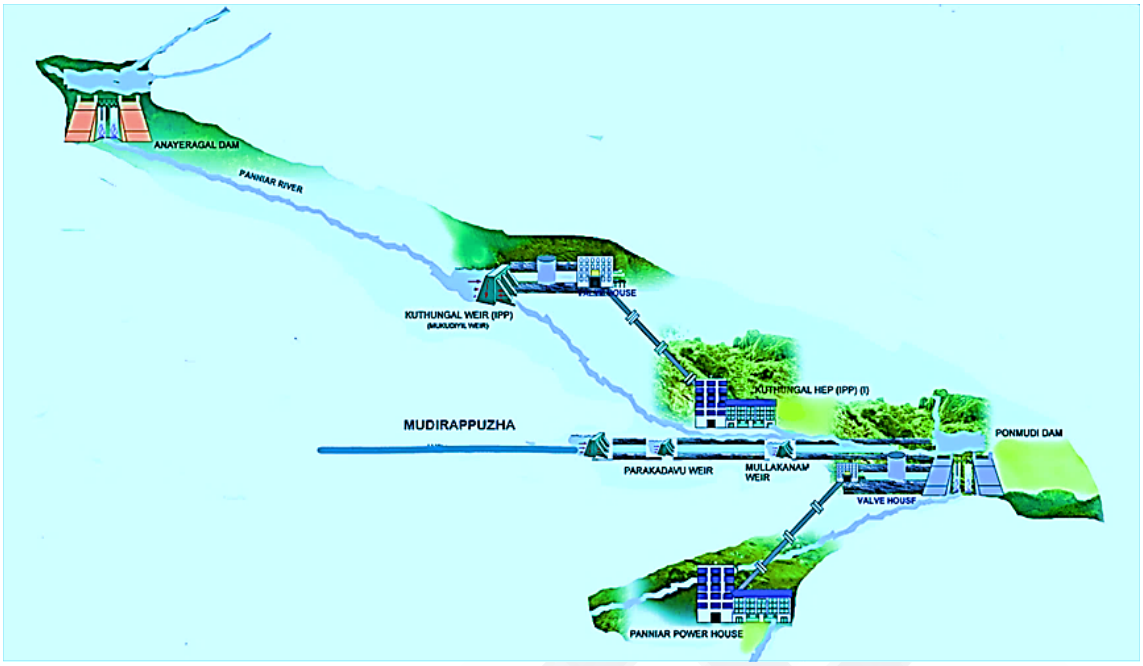


Fig 1.7 Panniar H E Project - Flow diagram

Routine inspection

Usually monthly inspection and quarterly inspections are carried out by the operating / controlling officers. Pre monsoon inspection and Post monsoon inspection as per CWC guidelines are carried out by the respective officers and reports are submitted to higher office and updated in DHARMA web site.

Maintenance

Routine maintenance is carried out for sluice gate, trash rack and control shaft before the onset of monsoon.

1.10 Distribution of Operation & Maintenance Manual

The following officers/field staff at different levels in the Division under the supervision of Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom and administrative control of Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom have been entrusted with the specific responsibility for carrying out O & M activities for Anayirankal dam.

1) Executive Engineer, Dam Safety Division No. IV, Pambla
2) Asst. Executive Engineer, Dam Safety Sub Division, Kallarkutty

3) Assistant Engineer, Dam Safety Sub Division, Kallarkutty
4) Personnel in charge of works of the Dam

The offices/officers to which the O & M Manual of Anayirankal dam is to be distributed are:

1. Dam Safety Division No. IV, Pambla.
2. Dam Safety Sub Division, Kallarkutty.
3. Assistant Engineer in charge of Anayirankal Dam.
4. Office of Deputy Chief Engineer, Research & Dam Safety Organization, KSEB Ltd, Pallom, Kottayam.
5. Office of Chief Engineer, Dam Safety Organization, KSEB Ltd, Pallom, Kottayam.
6. Office of the Director (Generation – Civil), KSEB Ltd, Thiruvananthapuram.
7. Office of the Central Project Monitoring Unit, CWC, New Delhi.

1.11 Supporting Documents & Reference Material

This O&M Manual is the key instruction document. Supporting documents and necessary instructions for all phases of the operation, inspection and maintenance of the dam, reservoir and appurtenant works indicated below are available at the dam control room for reference.

- Detailed drawings of the Project
- Emergency Action Plan (EAP)
- Latest Hydrology Review and DSRP Reports
- Flood forecasting and operating criteria
- Agreements with user agencies
- Power station operation plan
- Administrative procedures
- Gate Manufacturer's manual and drawings
- Regional communication directory
- Instrumentation reports / results

1.12 Typical Schedule of Duties

Schedule of duties/inspections to be carried out for the operation and maintenance of the dam by the concerned official are tabulated below in **Table 1.2**.

Sl. No.	Component/ Duty	Frequency	Personnel
1	Visual inspection of dam including top of dam, upstream and downstream faces, visible portions of foundation, abutments, Spillway and its energy dissipation arrangements.	Daily	Sub Engineer/Dam operators on contract
2	Record water surface elevation.	Daily (Hourly basis during monsoon)	Sub Engineer/Dam operators
3	Record depth of flow over spillway during monsoon.	Hourly basis during monsoon	Sub Engineer/Dam operators
4	Outflow over spillway during monsoon (Estimated from depth of flow over Crest).	Hourly basis during monsoon	Sub Engineer/Dam operators
5	Record meteorological data, Record releases from outlet/sluices if necessitated.	Daily	Sub Engineer/Dam operators
6	Check security and safety devices, Complete logbook / site registers which include the above information.	Daily	Assistant Engineer
7	Record seepage from drainage systems, Gallery drains etc.	Weekly	Sub Engineer/Dam operators
8	Visual inspection of dam including top of dam, upstream and downstream faces, visible portions of foundation, abutments, spillway, energy dissipation arrangements etc.	Weekly	Assistant Engineer
10	Check Drainage systems, Toe drains etc.	Weekly	Assistant Engineer
12	Visual inspection of dam top, upstream and downstream faces, visible portions of foundation and abutments, Spillway, energy dissipation arrangements, Intake shaft etc.	Fort nightly	Assistant Executive Engineer
13	Check drainage systems, Toe drains etc.	Fort nightly	Assistant Executive Engineer

14	Check Sign/Warning display boards near vulnerable locations	Fort nightly	Assistant Executive Engineer
15	Visual inspection of dam including crest, upstream and downstream faces, visible portions of foundation and abutments, spillway, energy dissipation arrangements, control shaft etc.	Monthly	Executive Engineer
17	Check measuring instruments, Security and safety devices, Communication devices, vegetation growth, -rectification, if needed.	Monthly	Executive Engineer
18	Check Sign/Warning display boards near vulnerable locations	Monthly	Executive Engineer
19	Check outlet works, updating operating instruction, check gate air vents, clean gate control switchboxes, check operation of gates & valves, grease gate hanger/dogging	Quarterly	Executive Engineer
20	Check condition of spillway, debris in inlet channel, Check condition of Outlet works & its Energy Dissipation Arrangement.	Quarterly	Executive Engineer
21	Check for damages in spillway glacis, energy dissipation arrangement, d/s area etc.	Quarterly	Executive Engineer
22	Check condition of hydro mechanical components.	Quarterly	Executive Engineer

Table 1.1 Schedule of duties/inspections

1.13 Hydro-Mechanical Inspections / Checks

Frequent inspections/checks for hydro-mechanical components are to be conducted and necessary action to be taken up during maintenance. Routine maintenance is carried out for outlets and hoisting machinery as part of routine maintenance before the onset of monsoon. Details are given under the Chapter **Project Maintenance**.

Chapter 2

Project Operation

The operation of a dam will involve regulation of its reservoir as per project specific requirements, keeping records and ensuring public safety. Proper operation procedures are crucial for normal or day to day operation of a dam for maintaining a safe structure.

2.1 Basic Data

The operation plan for Anayirankal dam consists of instructions for operating the dam and reservoir during routine (normal) and emergency conditions. The operating procedures for normal operations are discussed in this chapter including operating criteria for the reservoir & outlets.

2.1.1 Dam

Anayirankal dam is 326.00 m long at top and the top width is 6.1 m. The deepest river bed level is 1180.49 m and the top of the dam is 1212.51 m. The FRL and MWL of the dam are 1207.01 m and 1210.07 m respectively. The live storage is 49.83 Mm^3. The dam is a composite dam with an Earth cum Rock fill dam between Ch. 0 and Ch. 616, Masonry dam up to Ch. 894 and a core wall portion of length 50 ft at left abutment. There is an approach road at right abutment.

Filter materials of three sizes viz., 0.02 mm to 2 mm, 2 mm to 20 mm and 20 mm to 200 mm were used between the impervious earth core and rock toe. Ordinary rubble blasted from quarry on the right bank of river below dam site was used for the rock fill. Typical cross section of rock fill portion and masonry portion are given in **Fig 2.1a & 2.1b** respectively.

Concrete Key Walls

After excavation and laying concrete up to 2' thickness, the foundation under the key was grouted. The general plan for grouting provided consists of one row of grout holes core-drilled - 2½" in diameter about 20' apart to a depth of 20' to 40' deep. First of all primary holes were drilled and grouted at a spacing of 40' to 80' c/c after which the intermediate holes were drilled. The pressure used was usually as high as allowable without disturbing the surrounding rock.

Filter Blankets

Filter blankets were placed to lines and levels in 1' layers and compacted by power roller. When only hand tamping was possible, the filters were laid in 4" layers. Sometimes, the width of different grades of filter materials were not of required thickness for the operation of the power roller. In such cases, different layers of filter materials were laid to lines and levels side by side and compaction of 3 layers carried out simultaneously. The filter materials were placed in horizontal layers and spread level before the compaction was started.

Typical cross sections and details of the dam are given in **Drg 2.1 & Drg 2.2** of **Annexure 1**.

2.1.2 Spillway

The spillway of Anayirankal dam is an ungated overflow type structure, which has three bay of size 9.35 m x 4.75 m. The spillway structure is constructed in concrete at the left bank of the dam between Ch.750.5 m and Ch. 842.5m. Length of spillway is 372 ft. The elevation of the crest of the spillway is 1207.02 m. A photograph of spillway at Anayirankal dam is given in **Fig 2.2a & 2.2b**. Energy dissipation is done by chute blocks, baffle walls and drops. A section of the dam through the overflow portion of spillway is given in **Fig 2.4**. The spill way plan and details of spillway channel (plan and section) are given in **Drg 2.3 & Drg 2.4** of **Annexure 1**.

2.1.3 Outlet arrangements

There is a river outlet in the left bank which releases water downstream for hydro-power requirements from Anayirankal reservoir to Panniar River and eventually to Ponmudi reservoir. Its regulation is controlled with a gate arrangement. The discharge capacity of the outlet is 28.12 m3/s. RC conduit of dia 6 ft with bottom at El. 3885 ft and length 210 ft (LPP) and a tunnel (HPP) of cross-sectional area 93.38 sq ft joins the Control shaft of dia 14 ft at Ch.397.5 at a distance of 48 ft from the face of core wall from where it enters an outlet tunnel of horse shoe section with 72 sq ft cross sectional area and flows by gravity to the downstream of dam and joins the Panniar River. For letting out water from the reservoir, an emergency gate and service gate of size 1.50 m x 1.50 m are provided in the control shaft. These gates have rubber seals on sides and bottom. The hoisting mechanism consists of wire rope and drum.

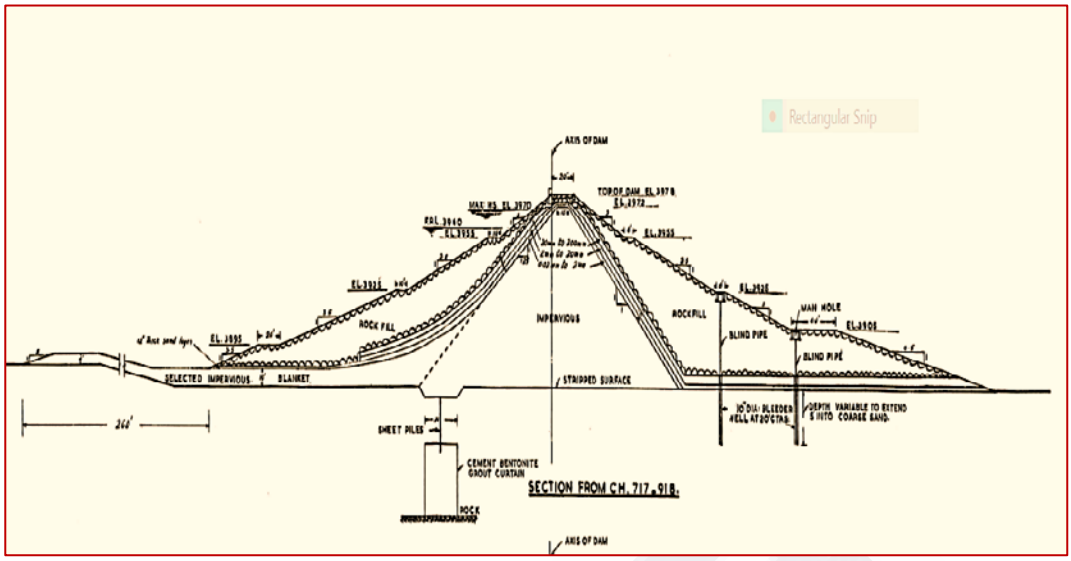


Fig 2.1a Typical cross section Rock fill portion

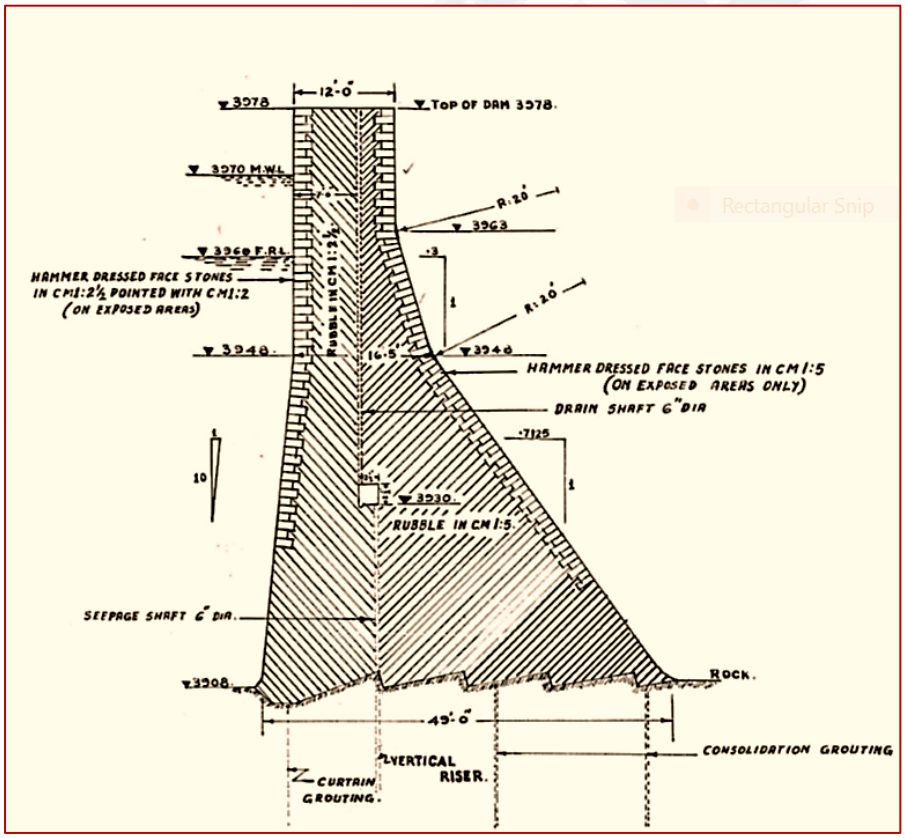


Fig 2.1b Typical cross section Masonry portion

Fig 2.2a Spillway of Anayirankal dam

Fig 2.2b Spillway of Anayirankal dam

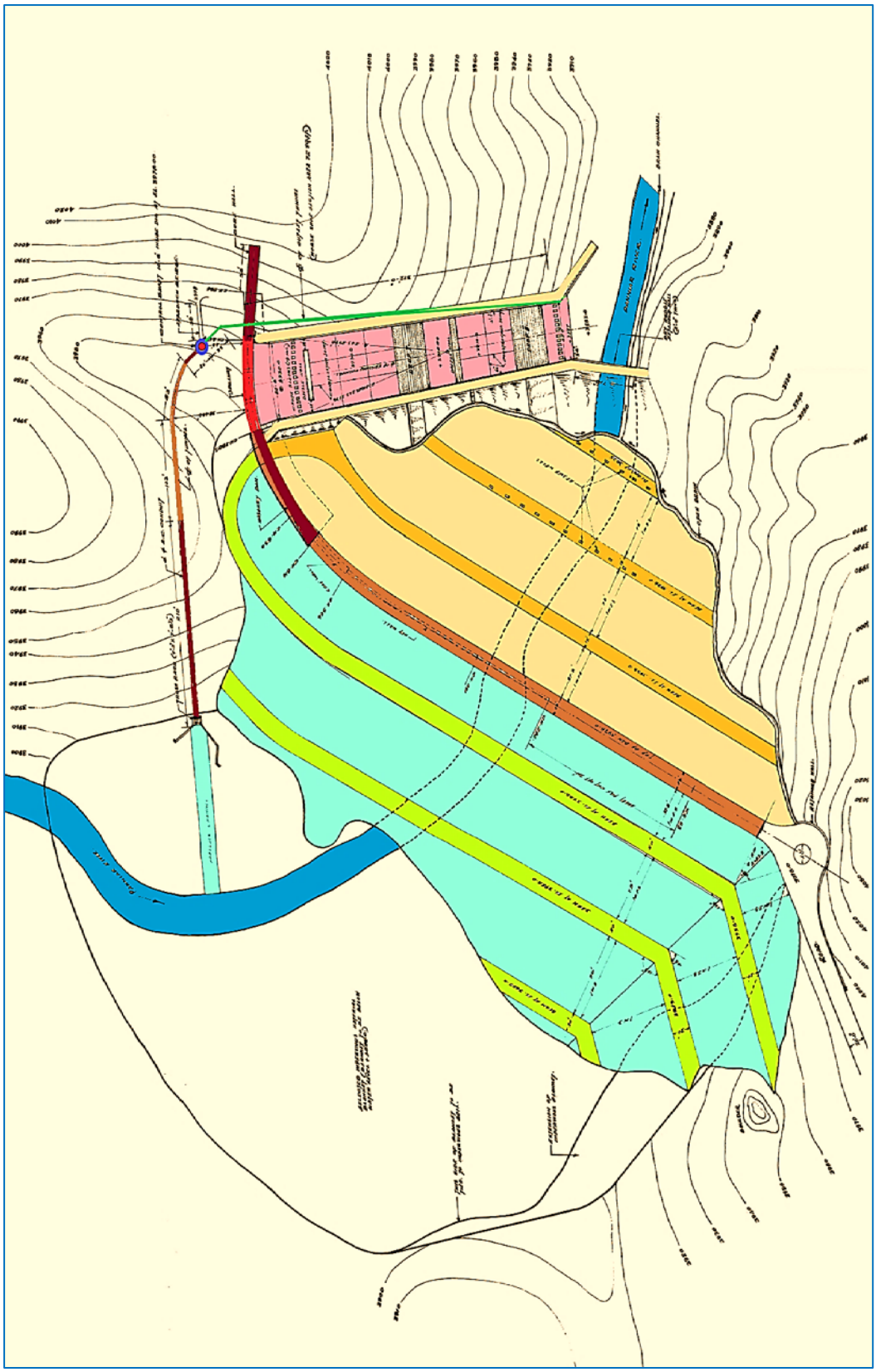


Fig 2.3 Layout of Dam and Outlet Arrangement

Gates are operated manually by rotating the drum with handle. The emergency & service gates and its hoisting system are supplied by M/s Thungabhadra Steel Company Ltd. Pl See Please see **Fig 2.3 & Fig 2.5** for the lay out of control shaft arrangement.

The water stored in the reservoir is released to the river downstream through this outlet arrangement. The controlled release from the reservoir leads to the Ponmudi reservoir, which is then diverted to Panniar power house located on the left bank of Mudirappuzha. Sections of bell mouth and trash rack structure at inlet of power tunnel are given in **Drg 2.5a, 2.5b & Drg 2.6** of **Annexure 1**. The details of control shaft structure and outlet gates are given in **Drg 2.7 & Drg 2.8** of **Annexure 1**.

Photographs of Trash rack and Control shaft building of Anayirankal dam are given in **Fig 2.6, Fig 2.7** and **Fig 2.8.**

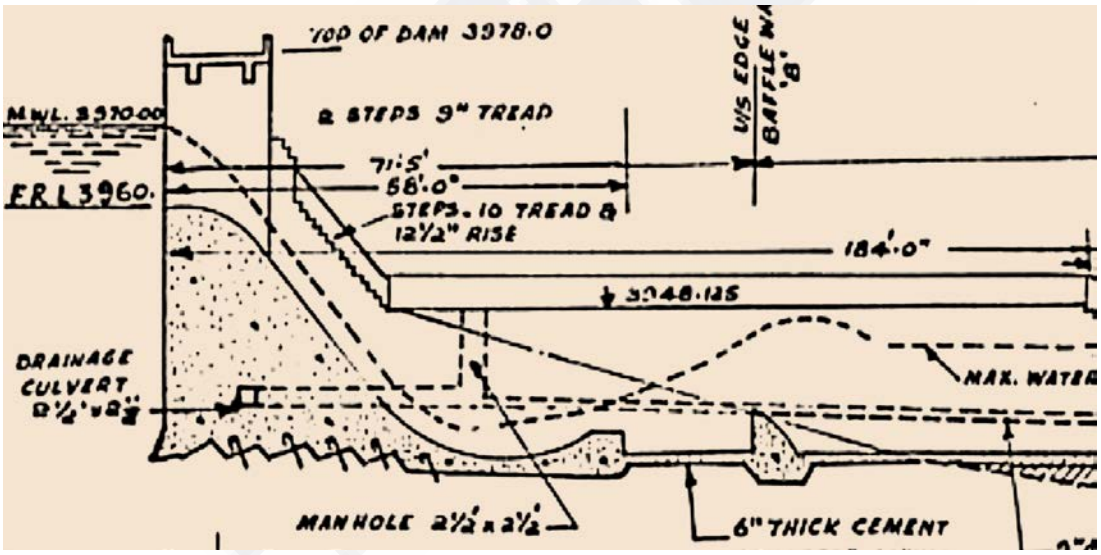


Fig 2.4 Cross-section through the overflow portion of Spillway

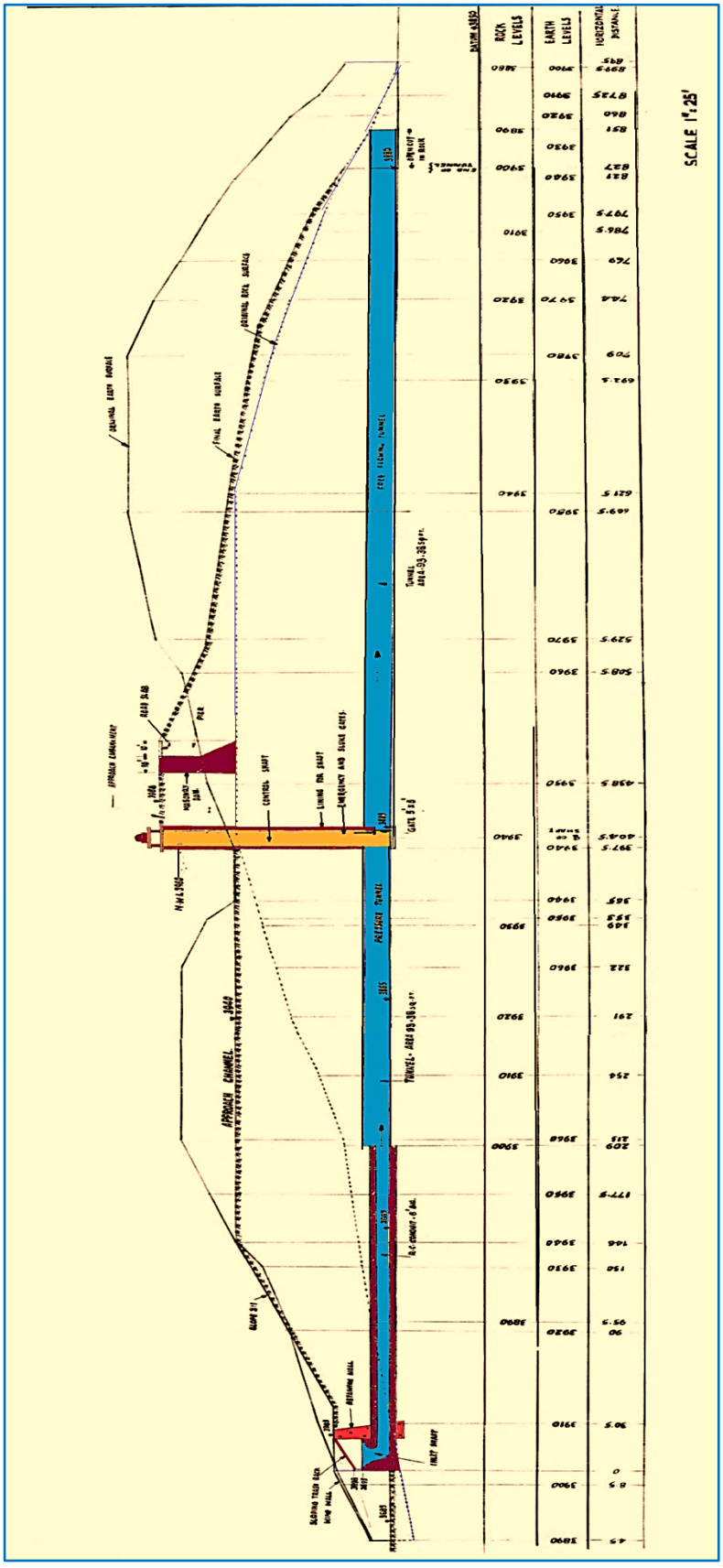


Fig 2.5 Anayirankal dam Outlet arrangement section

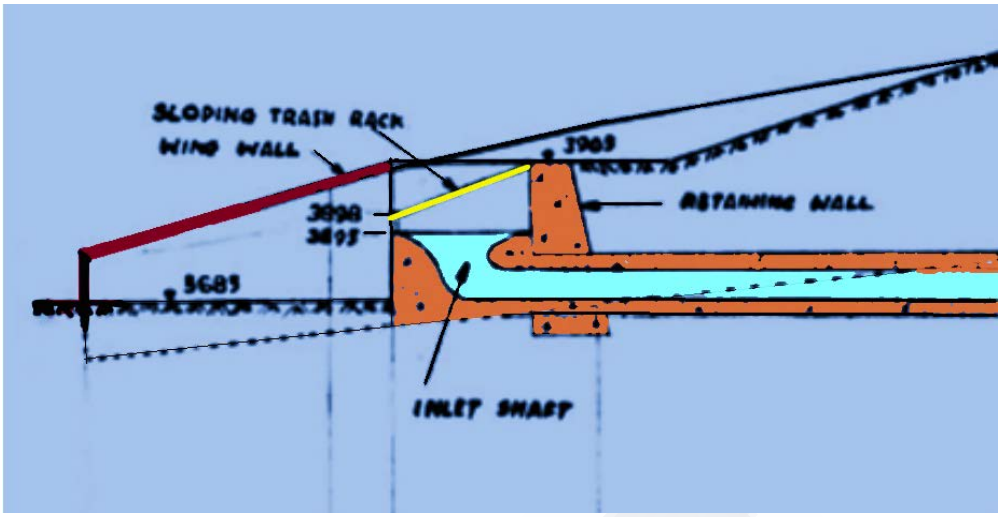


Fig 2.6 Anayirankal dam Sloping Trash rack

Fig 2.7 Anayirankal dam Sloping Trash rack

Fig 2.8 Anayirankal dam Control shaft

2.1.4 Elevation Capacity Curve

Drawing showing Area & capacity vs. storage curve of Anayirankal dam is given below in **Fig 2.9.** The Elevation vs. capacity is tabulated in **Table 2.1** below and plotted as **Fig 2.10.**

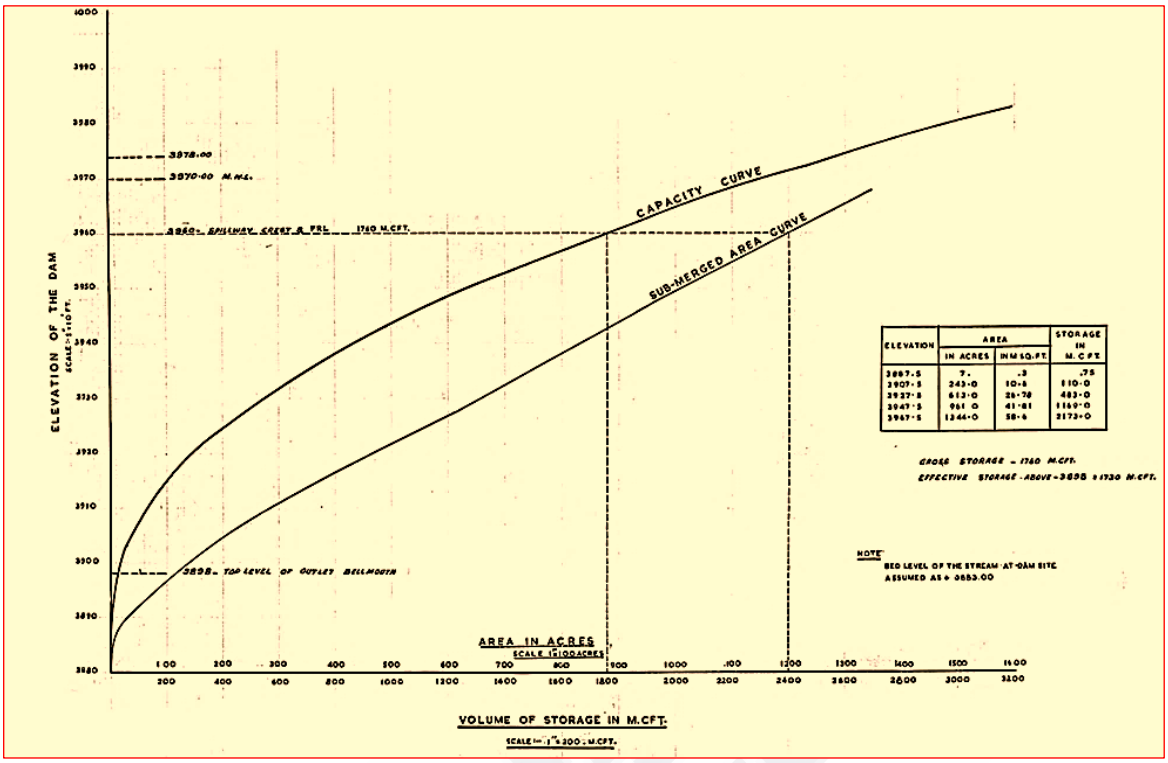


Fig 2.9 Anayirankal Dam Area Capacity Curve

Elevation (feet)	Elevation (m)	Storage in Mcft	Storage in Mm^3	Remarks
3887.50	1184.91	0.75	0.02	
3907.50	1191.01	110.00	3.11	
3927.50	1197.10	483.00	13.68	
3947.50	1203.20	1169.00	33.10	
3960.00	**1207.01**	**1760.00**	**49.84**	**Crest & FRL**
3967.50	1209.29	2173.00	61.53	

Table 2.1 Anayirankal Reservoir Elevation vs. Storage

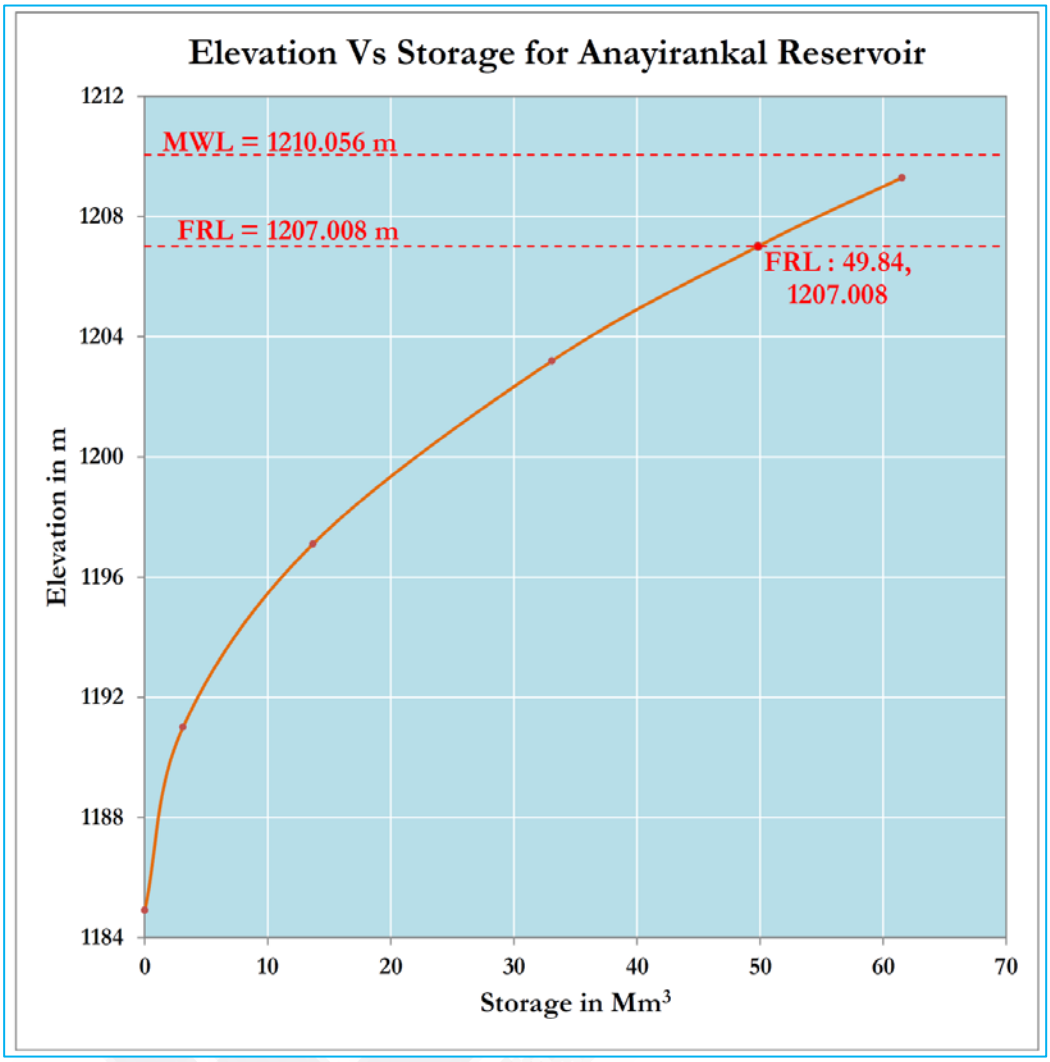


Fig 2.10 Elevation vs. Storage Curve

2.2 Operation Plan

An effective operation plan and schedule is required for safe project operation. The catchment area of Anayirankal dam is subject to heavy rainfall during NE monsoon whereas the catchment of the Mudirappuzha subject to heavy rain in SW monsoon. Hence normally this reservoir will not spill during SW monsoon. The reservoir water can be regulated to Ponmudi reservoir through the tunnel sluice at the left end. The overflow is also directed to Panniar River downstream.

2.2.1 Data of the historic floods

As per historical records, the maximum flood observed in Western Ghats was during 1924. The centre of the storm of the 1-day rainfall of 17th July 1924 and 2-day rainstorm of July 16-

17 was located at Devikulam in Kerala in which rainfall of 484 mm and 751 mm respectively was recorded.

The second historical flood occurred during August 14 to 17 in 2018 which resulted in record inflow in to the reservoir. The SW monsoon of the year 2018 in the State similar to that of 1924 Devikulam storm, Kerala experienced an abnormally high rainfall from 1 June 2018 to 19 August 2018 which resulted in severe flooding in 13 out of 14 districts in the State. It is seen that the 2-day and 3-day rainfall depths of 15-17, August 2018 rainfall in Pamba, Periyar and Bharathapuzha sub-basins are almost comparable to the Devikulam storm of 16-18, July 1924. For the entire Kerala, out of 758.6 mm rainfall from 1 August 2018 to 19 August 2018, about 414 mm rainfall occurred in just three days viz. 15-17, August 2018, which created severe flooding in the State, while the same during 16-18, July 1924 was 443 mm.

2.2.2 Design Flood and Features Related to Safety

Original Hydrology

Anayirankal Dam is constructed across Panniar, a tributary of Mudirappuzha River. Anayirankal has a catchment area of 64.92 km^2. The storage capacity of the reservoir at FRL is 49.83 Mm^3. An over flow arrangement with 3 vents of size 9.35 m x 4.75 m is provided for this dam. The FRL is 1207.01 m and MWL is 1210.07 m. The original design flood of this dam was arrived as 364 m^3/s. The spillway discharge capacity is 343.65 m^3/s.

Hydrology review carried out in DRIP

The revised flood of Anayirankal reservoir is estimated as 894 m^3/s as per FER 5 (a) & (b) published by Central Water Commission and IS - 11223. The original design flood of the project was 364 m^3/s. Flood routing study was carried out with the revised design flood. It was found that the revised MWL comes to El. 1209.20 m and the routed outflow was 238 cumec.

2.3 Normal Operation of the Reservoir

The operating procedures developed for normal or day to day operation of a dam shall include the following:

- Instructions for operating control mechanisms.
- General instructions for the safe operation of the dam and appurtenances.

Site security is a matter of concern at all major dams. This includes terrorism implications and preventing structural damage by vandals and unauthorized operation of outlet or spillway gates. In most cases restricting public access is essential, and in some instances electronic security devices should be considered.

The above aspects in case of Anayirankal dam are discussed in the subsequent paragraphs.

2.3.1 Operation of Control Mechanisms

Panniar HE Project has an upper reservoir at Anayirankal and a lower reservoir at Ponmudi. Water stored in Anayirankal reservoir is released through the river as per requirement to the Ponmudi reservoir. Regulated discharge from Anayirankal dam is used for power generation in Kuthungal powerhouse and the tail water from this power station reaches Ponmudi reservoir. The water stored in Ponmudi reservoir is used for power generation in Panniar power house.

There is a control mechanism for the outflow ie. an inclined trash rack, power tunnel, control shaft and a gravity tunnel leading to the downstream. The scour sluice is operated with a gate arrangement. Emergency and service gates are provided in the control shaft for regulating the flow through the sluice tunnel and are operated **manually**. Emergency and Service gate hoist is given in **Fig 2.11 & 2.12**.

Fig 2.11 Anayirankal dam Emergency & Service gates hoist

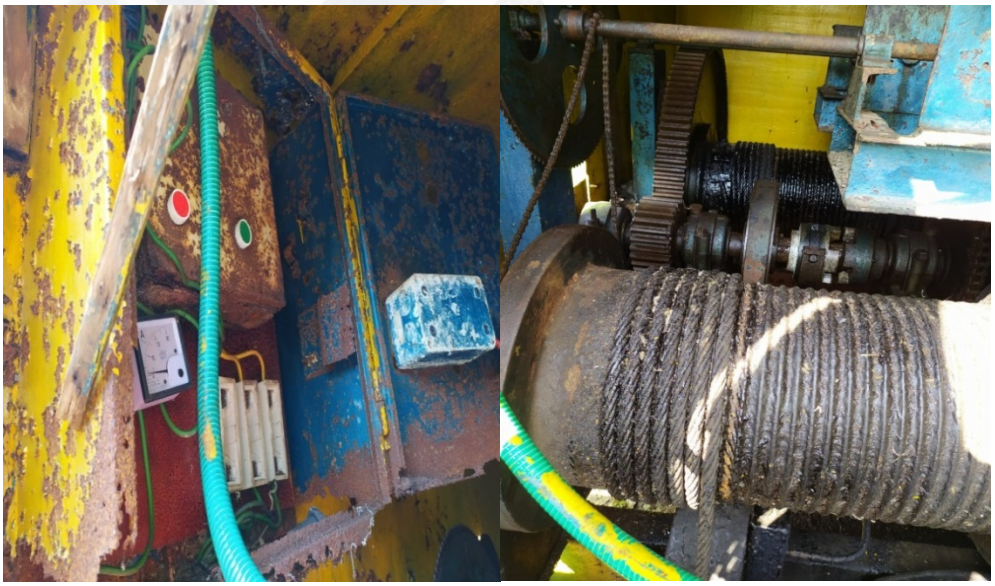


Fig 2.12 Emergency & Service gates hoist mechanism

2.3.2 Operation of the Reservoir

Anayirankal dam has an ungated overflow spillway. The reservoir water will overflow on reaching the Full reservoir Level i.e. 1207.01 m level which is the same as spillway crest level. Discharge through spillway for different reservoir levels above FRL is tabulated in **Table 2.2** and plotted in **Fig 2.13**.

Reservoir water level in m	Head above crest in m	Discharge in m^3/s
1207.008	0.00	0.00
1207.26	0.25	6.44
1207.51	0.50	18.79
1207.76	0.75	34.43
1208.01	1.00	56.32
1208.26	1.25	80.52
1208.51	1.50	108.06
1208.76	1.75	138.41
1209.01	2.00	171.82
1209.26	2.25	208.28
1209.51	2.50	247.48
1209.76	2.75	289.17
1209.91	2.90	315.64
1210.056	3.048	343.65

Table 2.2 Free Spillway Discharge

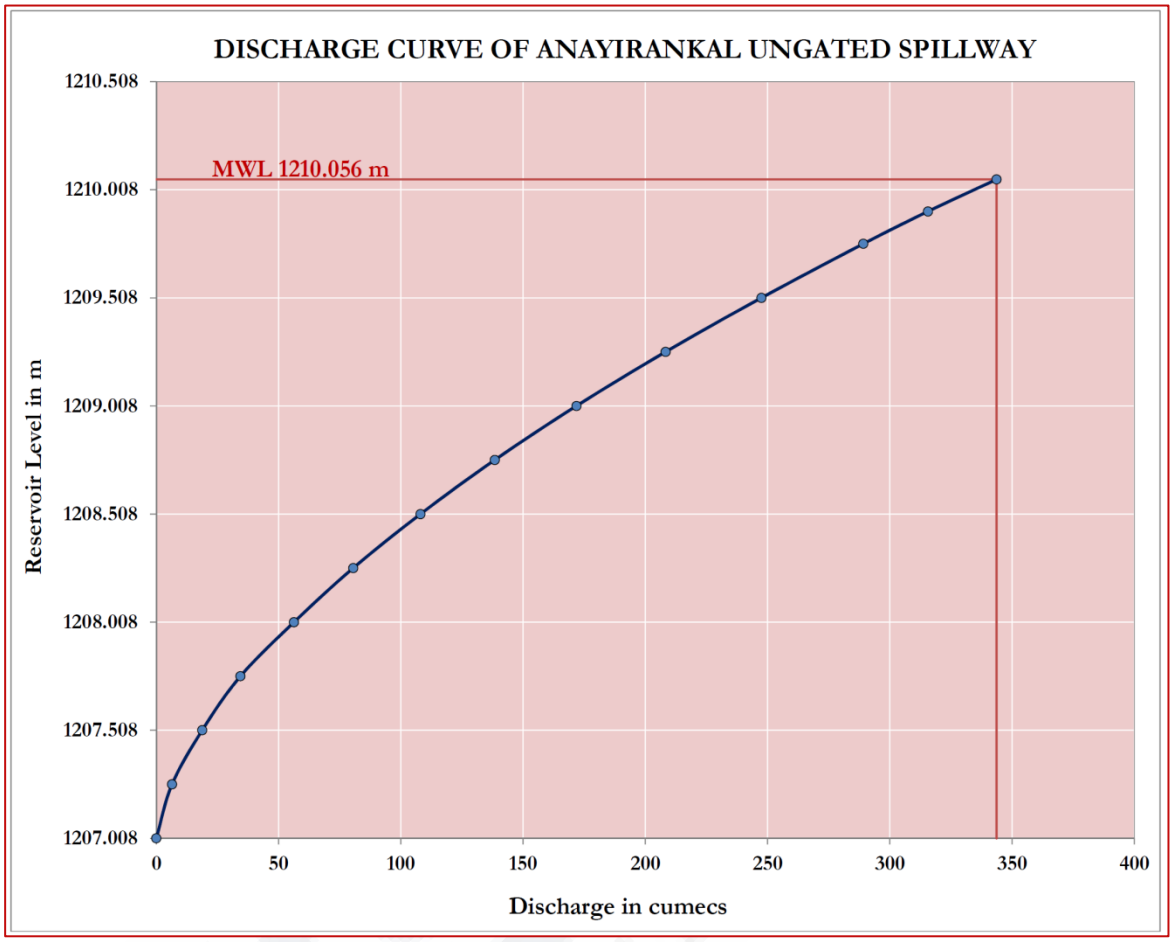


Fig 2.13 Discharge Curve for Anayirankal spillway

2.3.3 Rule Curve

As per the Kerala flood study report of August 2018, CWC has recommended for reviewing the rule curves of all the reservoirs in Kerala. The rule curves need to be formulated for both conservation as well as operations during the flood, particularly for the reservoirs having the live storage capacity of more than 200 Mm^3 in order to create some dynamic flood cushion for moderating the floods of lower return periods particularly in the early period of monsoon. Accordingly, rule curve for major reservoirs under KSEB Ltd have been reviewed considering the historic inflow after the filling of reservoir and the power demand during respective months.

The gross storage capacity of Anayirankal dam is 50.68 Mm^3. It has an ungated overflow spillway and a sluice tunnel to release water to Panniar River. Moreover this reservoir receives more inflow in the NE monsoon. As such no rule curve has been prepared for this dam.

2.3.4 Safety Aspects

The safety and security of dam against the structural damages by vandals, public and unauthorized operation of outlet gates is looked after by deploying security personnel.

2.3.5 Reservoir Capacities

The Gross storage and the Live Storage of the reservoir at FRL are 50.68 Mm^3 and 49.83 Mm^3 respectively and the ungated spill details are given in **Table 2.1.** The reservoir capacity may reduce with time because of reservoir sedimentation. Bathymetric survey of the reservoir may be considered every 10 years.

2.3.6 Climate

Anayirankal catchment is subjected to heavy rainfall during North East. The basin receives rain during South West monsoon also. The weighted average rainfall in the 25 sq miles of catchment area at the dam site for several years is computed to be 67" per year.

2.3.7 Emergency Operation

The Emergency operation will be carried out following the Emergency Action Pan (EAP). The Emergency conditions are outlined in **Chapter 4** under **Cl.4.2.1** on Immediate Maintenance. The EAP together with this Manual will be available at site at all times. Summary of alert conditions during Emergency are given in **Annexure 7**.

2.4 Power Generation

Water from Anayirankal reservoir along with Ponmudi reservoir is mainly used for power generation at a 2 x 15 MW power house of KSEB Ltd at Panniar. As per the project conception, the yield from the upstream catchment is being stored in the Anayirankal reservoir with storage about 50 Mm^3 and regulated discharge is let out to the Panniar river during the months from January to May. This storage is utilized for power generation as the Ponmudi reservoir is almost depleted. The diversion to Ponmudi reservoir through the tunnel is

maintained at 1 Mm^3 per day. Normally in the summer season i.e. from the mid of March of every year, the control shaft gate will be kept open and water released downstream @ 1 Mm^3 per day and continued for 2 months till the depletion of Anayirankal reservoir.

There is a downstream weir and power house at Kuthungal (21 MW) in between Anayirankal & Ponmudi. This is a private sector captive power plant (CPP) for INDSIL Company, Coimbatore, the tail water after generation again joins Panniar River and reaches Ponmudi reservoir.

2.4.1 Initial Filling of Reservoir

The reservoir was initially filled during 1965.

Geology

The project area and its vicinity forms a part of Southern granulite terrain belonging to the Archean age and rock types are Granite gneiss, magmatic gneiss with intrusions of pink granite and grey granite traversed with pegmatite and quartz veins.

Geology of dam site

On detailed investigation, it is found that rock at reasonable depth is not available from the centre to the right bank along the centre line of the dam. At one point viz. chainage 165 the rock level is touched only at a depth of 84' below bed level. Over the rocky strata, clayey-silty-sand is deposited and the rock fill dam is constructed over this foundation soil after stripping the topmost layer of weak clayey soil for a depth of 22'.

2.5 Record Keeping

The records regarding dam and appurtenant structures including detailed drawings and construction details are kept at the field office. Essential documents as per the dam safety guidelines are kept at the dam site office.

Following records of reservoir operations are being maintained:

1. Reservoir levels on daily basis during non-monsoon and hourly basis during monsoon.
2. Spillway outflows during monsoon on hourly basis.
3. Release data through tunnel cum sluice on daily basis.
4. All operating procedures.

Chapter 3

Project Inspection

An effective inspection program is essential to identify problems and to keep a dam in a good and healthy condition. Inspection details and suggestions are kept at field office and reports send to higher offices. The current practice of Inspection at Anayirankal dam includes the Deputy Chief Engineer in presence of Executive Engineer, Asst Executive Engineer & Assistant Engineer at site to carry out pre-monsoon and post-monsoon inspections as per CWC guidelines in the format issued by CWC. The format followed for inspection report as per CWC is now revised during January 2018 and new guidelines issued vide Doc No. CDSO_GUD_DS_07_v1.0, CWC 2018 for Safety Inspection of Dams. Now since the health reports are to be uploaded in DHARMA, the inspection reports are prepared in the new format. The Executive Engineer will upload the inspection report approved by the Deputy Chief Engineer in DHARMA. Detailed description on project inspections is available in the Guideline for Safety Inspection of dams. However an overview of the various types of inspections to be carried out at Anayirankal dam is given below. Note that for uploading Inspection Data into DHARMA, the Inspection Instructions & Forms given in the above mentioned Guideline for Safety Inspection of Dams must be used. This Chapter provides guidance on carrying out other inspections.

3.1 Types of inspections

Four different types of dam safety inspections are carried out at Anayirankal Dam. These include, but are not limited, to the following:

1. Comprehensive evaluation inspections
2. Scheduled inspections (Pre & Post monsoon inspections & other scheduled inspections)
3. Special (Un scheduled) inspections
4. Informal inspections.

The frequency of each type of inspection depends on the condition of the dam, dam safety regulations, etc. Typical inspection elements and the detail of the safety inspections are provided below. More detailed descriptions are given in the 'Guideline for Safety Inspection of Dams' (CWC 2018). A comprehensive health checklist **(Annexure 2)** for recording the status

of each item being inspected and the overall condition of the equipment along with any consequential risks on the health of the dam is required to be maintained.

3.2 Comprehensive Evaluation Inspections

For comprehensive dam safety evaluation for each dam an independent panel of experts known as Dam Safety Review Panel (DSRP) needs to be constituted for determining the condition of the dam and appurtenant works. The panel will undertake evaluation of the dam once in 10 years or on occurrence of any extreme hydrological or seismic event or any unusual condition of the dam or in the reservoir rim. The terms of reference of the comprehensive dam safety evaluation shall include but not be limited to;

- General assessment of hydrologic and hydraulic conditions, review of design flood, flood routing for revised design flood and mitigation measures.
- Review and analysis of available data of dam design including seismic safety, construction, operation maintenance and performance of dam structure and appurtenant works.
- A visual inspection or field examination of the dam, its appurtenant works, and the surrounding areas.
- Review of the instrumentation records and structural behavior reports, if any.
- Evaluation of procedures for operation, maintenance and inspection of dam and to suggest improvements / modifications.
- Evaluation of any possible hazardous threat to the dam structure such as dam abutment slope stability failure or slope failures along the reservoir periphery.

3.2.1 Details to be provided to DSRP before inspection.

All relevant details / data / drawings for the dam project to be examined by the DSRP shall be provided at least 3 months in advance of the proposed visit. This will include

- General information and Scope of the Project
- Emergency preparedness
- Details of key personnel
- Hydrology - (both Original and Latest design flood review study)
- Basic data and Issues related to safety of dam
- Problems if any during construction

- Drawings of dam, spillway, gates and appurtenant structures
- Status of the instrumentation
- Construction History
- Geological Report including Special problems at site and their treatment
- Field Inspection- Observation & recommendation regarding Remedial Measures

3.3 Scheduled Inspections

Scheduled inspections shall consist of Pre-monsoon & Post-monsoon inspection and any other inspections carried out by the State Dam Safety Organisation/any Expert panels constituted by the dam owner. These inspections are performed to gather information on the current condition of the dam and its appurtenant works. This information is then used to establish needed repairs and repair schedules, and to assess the safety and operational adequacy of the dam. Scheduled inspections are also performed to evaluate previous repairs.

Scheduled inspections include the following components as a minimum:

- Review of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as may be required
- Visual inspection of the dam and its appurtenant works
- Preparation of a report or inspection brief, with relevant documentation and photographs. The report should be filed in the dam owner's project files

3.3.1 Pre- and Post-Monsoon Checklist and Example of Report Proforma

Detailed checklists are required to ensure the health of the dam and to ensure that it continues to operate in satisfactory and safe condition. The proforma to be used for inspection should be the one enclosed in the Doc No. CDSO_GUD_DS_07_ v1.0, CWC 2018 on the Guidelines for Safety Inspection of Dams.

Pre-monsoon Inspection to be carried out during	:	April - May
Post-monsoon Inspection to be carried out during	:	December - January
Inspecting Officers	:	Deputy Chief Engineer along with SPMU Executive Engineer, Field Executive Engineer, Concerned Assistant Executive Engineer and Assistant Engineer
Preparation of Inspection Report	:	Executive Engineer, Field (Dam Health Engineer)
Submission of Pre-monsoon Inspection Report	:	Before June 30th
Submission of Post-monsoon Inspection Report	:	Before January 15th
Checking and approval of report	:	Deputy Chief Engineer, SPMU
Uploading corrected document in DHARMA	:	Executive Engineer, Field

3.4 Special (Unscheduled) Inspections

Special inspections may need to be performed to resolve specific concerns or conditions at the site on an unscheduled basis. Special inspections are not regularly scheduled activities, but are usually made before or immediately after the dam or appurtenant works have been subjected to unusual events or conditions, such as an unusually high flood or a significant earthquake. These inspections are to be carried out by teams to be constituted by state DSO after an initial assessment based on informal inspection carried out by project personnel reveal dam safety related concerns like cracking in the dam, damages, erosion/ scour, undermining/ piping/ sink holes/ liquefaction or any such undesirable feature. A special inspection may also be performed during an emergency, such as an impending dam breach, to evaluate specific areas or concerns. They are also made when the ongoing surveillance program identifies a condition or a trend that appears to warrant a special evaluation. Special inspections should focus on those dam components that are affected by the unusual event and should include at least three elements:

1) Review of available relevant files or data,
2) Visual inspection of all components of the project and surroundings, and
3) Report preparation covering status of project and recommendations.

More detailed site investigations / studies may be required (such as drilling, surveys, or seepage flow estimates) if the special inspection reveals the need for the same. Photographic documentation is to be included as part of the inspection.

3.5 Informal Inspections

An informal inspection, is a continuing effort by on-site personnel (dam owners/operators and maintenance personnel) performed during their routine duties. Informal inspections are critical specially to keep an eye on to the proper operation and maintenance of the dam. These inspections consist of frequent observations of the general appearance and functioning of the dam and appurtenant structures.

Operators, maintenance crews, or other staffs who are posted at Anayirankal dam site are supposed to conduct informal inspections on routine basis (See duty schedules in Chapter 1). These people are the 'first-line of defense' in assuring safe dam conditions, and it is their responsibility to be familiar with all aspects of the dam. Their vigilance while walking across the dam for inspection / surveillance, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or even dam failures.

Informal inspections are important and are performed at every available opportunity. These inspections may only cover one or two dam components as the case may be, or they may cover the entire dam and its appurtenant structures in one go. The informal inspections are not as detailed as comprehensive evaluation, scheduled, and special inspections and will only require that a formal report is submitted to the dam owner's project files if a condition is detected that might endanger the dam. Report is to be submitted detailing the condition discovered along with photographs, time, reservoir water level, other features etc.

Chapter 4

Project Maintenance

A good maintenance program is required to protect a dam against deterioration, prolong its life and greatly reduce the chance of failure. Maintenance program for a dam should be developed primarily based on systematic and frequent inspections. Nearly all the components of a dam and its materials are susceptible to damage and deterioration if not well maintained. Moreover, the cost of a proper maintenance is small compared to the costs of major repairs, loss of life, property and litigation. If maintenance of a dam is neglected the consequences and costs could be enormous.

4.1 Maintenance Plan

A basic maintenance schedule for the various monitoring components prepared for Anayirankal dam based on manual of operating parts, frequent inspections, priority, and interval for Anayirankal dam is arrived showing the tasks to be performed and how frequently that is to be inspected/observed and repaired **Annexure 5**.

4.2 Maintenance Priorities

Maintenance activities need to be prioritized. In order of priority they need to be classified under the heads immediate maintenance & preventive maintenance.

4.2.1 Immediate Maintenance

The following conditions are critical and call for immediate attention & reservoir lowering, if warranted. These conditions may include, but are not limited to:

1. Evidence of excessive seepage through the Rock fill dam, exiting on its downstream face or anywhere on the downstream of the dam and increasing in volume.
2. Dam showing signs of piping or internal erosion indicated by increasingly cloudy seepage or other symptoms.
3. An increase in the reservoir level to near the top of the dam.
4. Water overtopping the dam.
5. Rock fill dam about to be breached by erosion, slope failure etc.

An EAP is to be activated when any of the above conditions are noted.

4.2.2 Preventive Maintenance

This can be further classified as Condition based Maintenance and Routine Maintenance.

4.2.2.1 Condition Based Maintenance

The following maintenance should be completed as soon as possible after the defective condition is noted. These include but are not limited to:

- Remove all vegetation and bushes by roots from the dam surfaces, restoring any deteriorated/eroded areas.
- Restore and reseed eroded areas and gullies on embankment.
- Repair of defective gates and valves.
- Repair any concrete or metal components that have deteriorated.
- Cleaning of the choked drainage holes in the dam body/ foundations in masonry dams.
- Repair any damages on spillway glacis, piers, energy dissipaters, training/divide walls, downstream areas etc.
- Repair of the upstream face of masonry dams where the pointing of masonry joints is damaged.
- Repair of the u/s rip-rap of rock fill dams where the rip rap is damaged.
- Controlling any heavy seepage in the foundation/ inspection galleries in Concrete/masonry dams from drainage holes.
- Controlling any heavy seepage through dam body or foundation of Rock fill dam.
- Repairs of any cracks/cavities/joints in concrete/masonry dams/structures.
- However many of these works will require the services of experienced engineers/expert panels.

4.2.2.2 Routine Maintenance

Several tasks should be performed on a continuous basis. These include but are not limited to the following:

- Restoring of deteriorated/ eroded areas and gullies on downstream face of the Rock fill dam and general maintenance including repairs/cleaning of surface drains on downstream face and in the downstream area.

- Any routine repair to concrete or metal component.
- Observation of any springs or seepage areas in shear zones, faults etc., comparing the quantity and quality (clarity) with earlier observations.
- Monitoring of downstream development which could have an impact on the dam and its hazard category.
- Maintaining proper lighting at dam top, galleries of the dam etc.
- Monitoring of seepage from rock fill dam.
- Monitoring/cleaning & removal of leached deposits in porous concrete/formed drains in dam body and foundation drainage holes of masonry/concrete dams.
- Maintenance of all dam roads & access roads.
- Testing of security equipment.
- Testing of communication equipment.
- Any other maintenance considered necessary.

4.3 Maintenance Items

4.3.1 Controlling Vegetation

Keep the entire dam clear of unwanted vegetation such as bushes or trees. Excessive growth may cause several problems such as:

- It can obscure the surface of an embankment and not allow a proper inspection of the dam.
- Large trees can be uprooted by high wind or erosion and leave large holes that can lead to breaching of the dam.
- Some root systems can decay and rot, creating passageways for water, and thus causing erosion.
- Growing root systems can lift concrete slabs or structures.
- Rodent habitats can develop.

All bushes/trees should be as far as possible removed by roots. The resulting holes should be filled with the material of the dam at that location in suitable lesser thickness layers and well compacted. It would be desirable to remove the plants/vegetation at their early stage to prevent their growing into big tree/bushes. In cases where trees and bushes cannot be removed, the root systems should be treated with herbicide (properly selected and applied) to retard further

growth. Use of harmful chemicals should be avoided. Concerned Government Agencies should be consulted for selection of appropriate herbicides & their use for control of vegetation on dam structures.

Further, it is desirable that there are no trees or bushes within 500 m of the toe drain on the downstream side of the dam.

Removal of vegetation around the dam and other premises is done 2 times in a year.

4.3.2 Controlling Animal Damage

Livestock should not be allowed to graze on an embankment surface. They can damage and disrupt the uniformity of the surface. Moreover, livestock tend to walk in established paths and thus can promote erosion. Such paths should be re-graded and seeded, and the livestock permanently fenced out of the area.

4.3.3 Controlling Damage from Vehicular Traffic

Vehicles, except for maintenance, are restricted on the dam top and kept out by fencing or barricades. Any damages are repaired as soon as possible**.** Also vehicles are permitted after security checking at check posts.

4.3.4 Masonry / Concrete spillways

The following important issues / aspects need to be addressed while undertaking the periodic maintenance, but are not be limited to:

- Cracking in concrete (potential causes are alkali – aggregate reaction, thermal stresses because of heat of hydration or temperature variations, foundation problems).
- Damages on spillway glacis, training/divide walls, energy dissipaters, downstream areas (probable causes are cavitation, abrasion, un-symmetrical flows, unfavorable down-stream conditions)
- Vegetation growth in spillways, spill channel, approach channel etc.
- Seepage on d/s face of the dam.
- Excessive seepage in the galleries.
- Status of rectification works undertaken from time to time need to be assessed during periodic maintenance.
- To ensure proper access & lighting.

- To ensure that the dam is behaving as designed based on instrumentation programs.

Periodic maintenance should be performed on all concrete surfaces to repair deteriorated areas following the standard specifications for repair of concrete surfaces and re-pointing of masonry joints etc.

For remedial measures of problems of special nature advice of experienced engineers/ Panel of Experts needs to be obtained.

4.3.5 Outlet Works

The operation and maintenance of service and emergency gates of river sluice are to be regularly carried out. The outlet conduits should be inspected thoroughly once a year.

Painting of metallic components of gates and valves shall be done as explained below. Provision for routine maintenance shall be kept every year including application of cardium compound to wire ropes. If routine inspection of the Hydro-Mechanical Equipment shows the need for maintenance, the work should be completed as soon as possible.

4.3.6 Trash Racks

Trash racks for the inlet to power tunnel may become clogged with debris or trash which reduces their discharging capacity. Maintenance of trash racks includes periodic inspections for rusted and broken sections and repairs are made as needed. Trash racks should be checked during and after floods to ensure that they are functioning properly and to remove accumulated debris periodically as per site requirements.

4.3.7 Vertical lift fixed wheel Gates

Service and emergency gates provided in the river outlet for controlling/regulating the flow are of this type. The main components of these gates are as under;

i). Embedded parts:

- Sill beam assembly
- Top and side seal seats
- Roller track
- Side guide
- Dogging arrangement

ii). Gate Parts:

- Skin plate Assembly
- End Verticals
- Horizontal girders
- Vertical Stiffeners
- Roller assembly
- Seal Assembly
- Side guide assembly
- Lifting Arrangement

The aspects to be inspected and maintained periodically for ensuring proper operation of these gates are as under:

i. The gate slot and bottom platform/sill beam should be cleaned periodically. Scales formed over the embedded parts should be removed. Second-stage concrete should be checked for any development of cracks / leakages and repairs should be attended to immediately.

ii. Rubber seals should be smoothed, if required, for proper alignment. All nuts and bolts fixing the seal to the gate should be tightened uniformly to required torques. Seals, if found damaged or found leaking excessively should be adjusted, repaired or replaced as considered necessary.

iii. The wheel shall be rotated to check their free movement. Gate roller bearings and guide roller bushes should be properly lubricated. Whenever necessary these should be opened for rectifications of defects, cleaning and lubrication and should thereafter be refitted. These may be replaced if repairs are not possible.

iv. Hoisting connection of the gate leaf should be lubricated where necessary and defects if any should be rectified.

v. All nuts, bolts, check nuts and cotter pins of the lifting devices should be checked periodically.

vi. All components should be greased and lubricated. Recommended and approved oils and grease only should be used.

vii. Roller assembly should be adjusted by the eccentricity arrangement to ensure all rollers rest uniformly on the track plates particularly in the closed position of the gate.

viii. Where filling valves are provided as part of the gate structure, all the nuts, bolts, check nuts etc. should be tightened.

ix. All welds shall be checked for cracks/ damages. Any weld that might have become defective should be chipped out and redone following the relevant codal provisions. Damaged nuts, bolts, rivets, screws etc. should be replaced without delay.

x. The filling-in valves allow passage of water when it is lifted by lifting beam & crane due to creation of space between stem seat and exit passage liner. The springs and associated components should be checked periodically for damages and replaced if necessary.

xi. The guide-assemblies, wheel-assemblies and sealing-assemblies shall be cleared off grit, sand or any other foreign material.

xii. The wheel pin shall be coated with corrosion resistant compound.

xiii. All nuts and bolts shall be tightened.

4.3.8 Maintenance of Electrically operated fixed hoists

General Instructions:

a. Never open any bolt or nut on motor, gear boxes, rope drums and other load carrying hoist components when the gate is in raised position. The gate should be fully closed or rested on the gate latches before carrying out any work on hoist components including motor brake and other electrical equipment.

b. The aspects to be inspected and maintained periodically for ensuring proper operation of Rope drum hoists are as under;

   i. Entrance to all hoist platforms shall be kept locked. All keys shall remain with the shift supervisor.

   ii. A cursory daily inspection shall be made of hoist and gate to ensure that there is no unusual happening.

   iii. Clean all hoisting equipment and hoist platform.

   iv. Check oil level in gearboxes and replenish as and when required with oil of proper grade.

   v. Apply grease of suitable grade by grease gun.

   vi. Lubricate all bearings, bushings, pins, linkages etc.

   vii. Check all the fuses on the power lines.

viii. All bolts and nuts on gear boxes, hoist drum and shaft couplings should be checked for tightness.

ix. Check the supply voltage.

x. Drain sample gear oil from each of the gear boxes. If excessive foreign particles or sludge is found, the gear box shall be drained, flushed and filled with new oil.

xi. All the geared couplings shall be greased.

xii. Raise and lower the gate by hoist motor and check for smooth, and trouble free operation of gate without excessive vibration.

xiii. Observe current drawn by motor at the time of lifting and check if it is more than normal. If so, stop the hoist and investigate the cause and rectify.

xiv. Check the condition of painting of various components and remove rust wherever noticed and repaint the portion after proper cleaning as per painting schedule.

xv. All trash, sediments and any other foreign material shall be cleared off the lifting rope and lifting attachment.

xvi. All ropes shall be checked for wear and tear and if broken wires are noticed, the rope shall be replaced.

xvii. All the wire ropes shall be checked and all visible oxidation shall be removed.

xviii. All wire ropes shall be greased with cardium compound.

xix. Check the overload relays for proper functioning.

xx. Check all the nuts, bolts, rivets, welds and structural components for hoisting platform and its supporting structure for wear, tear and damage. All damages shall be rectified. All bolts shall be tightened. The portion with damaged painting shall be touched up.

xxi. Check the pulleys, sheaves and turn-buckles.

xxii. Raise and lower the gate for its full lift several times (at least three to four) and observe the following:

a) Check the limit switches and adjust for design limits.

b) The effectiveness and slip of the breaks shall be checked by stopping the gate in raising and lowering operations. The brakes shall be adjusted if needed.

c) When the gate is operated, there should not be any noise or chatter in the gears.

xxiii. Adjust the rope tension of wires if unequal. Check for all gears and pinions for uneven wear and adjust for proper contact. Grease the gears.

xxiv. Repaint the hoist components, hoisting platform and its supporting structures as per requirement.

xxv. The periodic maintenance of commercial equipment like motors, brakes, thrusts etc. shall be carried out as per manufacturers operation and maintenance manual.

4.3.9 Electrical System

Electricity is typically used at a dam for lighting and to operate the gates, hoists, recording equipment, and other miscellaneous equipment. It is important that the Electrical system be well maintained, including a thorough check of fuses and a test of the system to ensure that all parts are properly functioning. The system should be free from moisture and dirt, and wiring should be checked for corrosion and mineral deposits.

All necessary repairs should be carried out immediately and records of the works kept. Maintain generators used for auxiliary emergency power - change the oil, check the batteries and antifreeze and make sure fuel is readily available.

Monitoring devices usually do not need routine maintenance. Open areas are particularly susceptible to vandalism. As such all electrical fittings like bulbs, lights, loose wires etc. in open areas should be checked routinely and replaced/repaired where needed. The recommendations of the manufacturer should also be referred to.

4.3.10 Maintenance of Metal Gate Components

All exposed, bare ferrous metal of an outlet installation, whether submerged or exposed to air, will tend to rust. To prevent corrosion, exposed ferrous metals must be either appropriately painted (following the paint manufacturer's directions) or heavily greased in respect of moving parts & on surfaces like guides & track seats on which there is movement of gates. When areas are repainted, it should be ensured that paint is not applied to gate seats, wedges, or stems (where they pass through the stem guides), or on other friction surfaces where paint could cause binding. Heavy grease should be applied on friction surfaces to avoid binding. As rust is especially damaging to contact surfaces, existing rust is to be removed before periodic application of grease.

Surface Preparation and Painting of H M Works

i) Protection of painted surfaces is considered essential for protection & enhancement of service life. Gates, their embedded parts, gate leaf, hoists and its supporting structures need to be protected against corrosion due to climatic condition, weathering, biochemical reaction and abrasion etc. This equipment is likely to deteriorate or get damaged to any extent that the

replacement of parts may become necessary and such replacement may become difficult and costly.

ii) Surface preparation & Painting requirements:

Painting for hydro-mechanical works is to be carried out as prescribed in IS 14177 for both newly manufactured as well as old & used gates, hoists and associated works after proper surface preparation. The preparation includes thorough cleaning, smoothing irregular surfaces, rusted surfaces, weld spatters, oil, grease, dirt, earlier applied damaged layers of primers/ paint by use of mechanical tools, by use of solvents, wire brush etc. The sand / grit blasting process is used for surface preparation to a level of Sa 2½ of the Swedish standard.

iii) Surfaces not requiring painting & their protection during surface preparation, painting & transportation process:

a) The following surfaces are not to be painted unless or otherwise specified:
   - Machine finished or similar surface
   - Surfaces which will be in contact with concrete
   - Stainless steel overlay surfaces.
   - Surfaces in sliding or rolling contact
   - Galvanized surfaces, brass and bronze surfaces.
   - Aluminum alloy surfaces

b) The Surfaces of stainless steel, nickel, bronze and machined surface adjacent to metal work being cleaned or painted shall be protected by using sticky protective tape or by other suitable means over the surfaces not to be painted.

c) All embedded parts which come in contact with concrete shall be cleaned as detailed above and given two coats of cement latex to prevent rusting during the shipment while awaiting installation.

iv) Application of primer &finish coats on embedded parts and gates:

a) Embedded Parts:
   - The prescribed primer shall be applied as soon as the surface preparation is complete and prior to the development of surface rusting and within the specified time prescribed by Indian Standards or the Paint Manufacturer. In case there is lapse of considerable

time beyond the prescribed time limit, the surfaces shall be again cleaned prior to priming.

- Two coats of zinc rich primer with epoxy resin shall be applied to all embedded parts surfaces which are not in contact with concrete and shall remain exposed to atmosphere or submerged in water to obtain a dry film thickness of 75 microns.
- This shall be followed by three coats at an interval of 24hours of coal-tar blend epoxy resin so as to get a dry film thickness of 80 microns in each coat. Total dry film thickness of paint shall not be less than 300 microns

b) Gates:

- Primer Coat:

Over the prepared surface one coat of inorganic zinc silicate primer giving a dry film thickness of 70 ± 5 microns should be applied. Alternatively two coats of zinc rich primer, which should contain not less than 85% zinc on dry film should be applied to give a total dry film thickness of 75 ± 5 microns.

- Finished paint:

Two coats of solvent less coal tar epoxy paints. These shall be applied at an interval of about 24 hours. Each coat shall give a dry film thickness of 150±5 microns. The total dry film thickness of all the coats including primer coating shall not be less than 350 microns.

v) Hoist and supporting structure:

a) Structural components:

Primer coats of zinc phosphate primer shall be applied to give a dry film thickness of 40±5 microns.

Final Coats: One coat of alkalized based micaceous iron oxide paint to give a dry film thickness of 65 ± 5 microns followed by two coats of synthetic enamel paint confirming to IS 2932 – 1974 to give a dry film thickness of 25 ± 5 microns per coat. The interval between each coat shall be 24hours. The total dry thickness of all coats of paint including the primer coat shall not be less than 175 microns.

b) Machinery: Except machined surfaces all surfaces of machinery including gearing, housing, shafting, bearing pedestals etc., shall be given:

Primer coats: One coat of zinc phosphate primer paint to give minimum film thickness of 50 microns. Motors and other bought out items shall be painted if necessary.

Finished coats: The finished paint shall consists of three coats of aluminum paint confirming to IS2339 – 1963 or synthetic enamel paint confirming to IS 2932 – 1977 to give a dry film thickness of 25±5 microns per coat to obtain a total minimum dry film thickness of 125 microns.

c) Machined surfaces:

All machined surfaces of ferrous metal including screw threads which will be exposed during shipment or installation shall be cleaned by suitable solvent and given a heavy uniform coating of gasoline soluble removable rust preventive compound or equivalent. Machined surfaces shall be protected with the adhesive tapes or other suitable means during the cleaning and painting operation of other components.

vi) Application of paint:

- Mix the contents thoroughly as directed by paint manufacturer before and during use.
- Painting at shop can be done by any of the three methods namely Brush / roller, Conventional spray, Airless spray etc.

The paint can be made to suit the adopted method. But once the gate and equipment is in erected position the general method adopted is only brush / roller. In case of spray lot of precautions are to be taken.

For More details: Refer IS: 14177 Part (II) – 1971.

Appendix A – Brushing of paint

Appendix B – Spraying of paint

Appendix C – Spray painting defects: Causes and remedies.

Removal of old paint / rust and carrying out fresh painting:

The carrying out of fresh painting is to be considered under the following conditions:

- The rusting is noticed all over the surface or
- Rusting is severe or
- Cracking and blistering has damaged the primer coat exposing the metal and is noticed all over the surface or
- The paint film has eroded badly, scrap off entire paint film to the base metal and carry out fresh painting.

Note: In case of maintenance and renovation: Refer IS 14177 (Part II) – 1971 for checking and repainting.

vii) Removal of old paint for repainting:

Caution should be exercised while removing the old paint. The surfaces shall be de-rusted and de scaled by either mechanically by one or more of the methods, namely:

a) Wire brushing, Scraping, and chipping. Sand papering or cleaning with steel wool or abrasive paper
b) Power tool cleaning
c) Flame cleaning
d) Sand blasting or shot blasting and
e) Chemical rust removal.

Note: The method of application shall be decided based on conditions existing. After cleaning, painting is to be carried out as originally proposed.

Some are painted without removal of old paint and rusting this will amounts to no painting and deteriorate faster than the original one.

viii) Inspection and testing of painting of H. M works:

a) The following steps are involved in inspection of painting:
   - General inspection before and during painting
   - Viscosity test of paints
   - Paint thickness test – using Elco-meter.
   - Inspection of general appearance of finished work.

b) General:

   The aim of inspection and testing is to ascertain whether the recommended practice is being employed correctly during every stage of application and whether the final results fulfill the object of painting. Any test carried out should be of non – destructive nature or, if it is of destructive nature, it should be either restricted to areas which can be restored without marring the general appearances or be such that it is possible to restore easily without necessitating a complete repetition of the work.

c) Inspection of surfaces prior to painting:

   Inspection methods will depend on whether it is to be painted for the first time or is to be repainted.

d) New Works (Not previously painted): The following shall be decided by inspection:
   - The method of pre cleaning feasible or recommended;
   - The intermediate protective treatments to be applied, if found necessary;

- The final painting schedule and the specifications for the paint for ensuring the particular performance;
- The method of application, whether by brush, roller or spray.

e) Old Work (Which requires repainting):

The following shall be decided by inspection:

- Whether the entire existing paint requires removal; and/or
- Whether repainting without paint removal would be adequate.

4.3.11 Access Roads

Access road surfaces must be maintained to allow safe passage of automobiles and any required equipment for servicing the dam in any weather conditions. Routine observations of any cut and fill slopes along the sides of the road should be made. In case of unstable conditions/slopes developing blockage of the road, protective works including retaining walls shall be provided as remedial measures. Drains are required to be provided and maintained along roads to remove surface and subsurface drainage. This will prolong the life of the road. Road surfacing should be repaired or replaced as necessary to maintain the required traffic loadings. The maintenance of all access roads is executed under DRIP.

4.3.12 General Cleaning

For proper operation of spillways, inlet and outlet structures, stilling basin / energy dissipation arrangements, trash racks, debris control devices etc., regular and thorough cleaning and removal of debris is necessary. Cleaning is especially important after large floods, which tend to send more debris into the reservoir. The dam top road and gallery are to be cleaned regularly.

4.4 Materials and Establishment Requirements during Monsoon

Materials required during monsoon period for both immediate maintenance and preventive maintenance must be stocked in adequate quantities for emergency situations that may arise. At Anayirankal Dam, round the clock patrol is to be carried out during monsoon period. Details of manpower are given in below in table.

Following minimum materials are required for handling the situations during monsoon period:

- Gunny Bags
- Sand
- Boulders/Wire crates
- Bamboos/ Balli's
- Baskets
- Ropes
- Petromax Lamps with Spares
- Torches with spare cells
- Kerosene Oil
- Match Boxes
- Rain Coats
- Gum Boots
- Warning sign indicator
- Danger zone lights

Present Manpower		
Designation	**Anayirankal Dam**	**Remarks**
Executive Engineer	1	The dam safety officers and staff concentrate fully on monsoon related dam operation & monitoring works during monsoon period. The dam safety O & M works are generally executed during the non-monsoon period.
Assistant Executive Engineer	1	
Assistant Engineer	1	
Sub Engineer	1	
Security Staff	As mentioned in **Cl.1.8.1**	

4.5 Preparation of O&M budget

The O & M budget for Anayirankal dam should essentially include but not be limited to the following items:

i) **Establishment Cost of Regular Staff** - Salaries and allowances, Bonus, Medical reimbursement, LTC, Leave encashment, Pension benefits, etc. (as applicable).

ii) **Establishment Cost of Work charged Staff** - Salaries and allowances, Bonus, Medical reimbursement, LTC, Leave encashment, Pension benefits, TA and DA , etc. (as applicable).

iii) **Establishment Cost of Daily wage Staff** - Salaries and allowances, TA and DA etc. (as applicable)

iv) **Office Expenses** - Telephone/Mobile/any other Telecommunication bills, Electricity bills, water bills, Office stationery, Day to day office requirements.

v) **Motor Vehicles** - Running and Maintenance cost of inspection vehicles, Cost of hiring of vehicles as required

vi) **Maintenance of Colony** - Maintenance of staff quarters, colony roads, Electricity, Sanitary and Water supply systems etc.

vii) **T&P** - T&P requirements for offices, colony, works etc. as applicable.

viii) **Works**-Painting, oiling, greasing, overhauling of HM equipment's, Repair/replacement of gates seals & wire ropes, Electricity charges and maintenance of Electric systems of dam site, specific requirements for all Civil, H.M & Electrical maintenance works, vegetation removal, maintenance/cleaning of drains in dam, maintenance of access roads & basic facilities, provision for flood contingency works during monsoon, unforeseen events/items (about 10% of the cost of works) etc.

A summary table for the O&M budget is given below in **Table 4.1.**

Sl. no.	Budget item	Previous year cost (Rs)	Current year budget (Yr ___) (Rs)	Remarks
a.	**Establishment**			
1	Salary of regular staff including all other benefits			
2	Travel expenses			
3	Office expenses			
4	Vehicle expenses			
5	Maintenance of office & colony complex			
	Sub-total - a			
b.	**Works**			
1	**Civil works**			

1.1	Earth &Rock fill dam			
1.2	Concrete / masonry dam			
1.3	Sluices in concrete / masonry dams			
1.4	Approach / inspection roads within dam area			
2	**Hydro-Mechanical works**			
2.1	Sluices in concrete/masonry dams – service & emergency gates & hoists			
3	**Electrical works**			
3.1	Electrical fittings, motors, controls for all gate hoists			
3.2	Power supply lines			
3.3	Electrical fittings on dam top, dam galleries, etc.			
4	**Instrumentation**			
5	**Miscellaneous works**			
6	**Salary of work charged staff including all benefits**			
7	**Materials to be stored before monsoon**			
	Sub-total - b			
c.				
1	**Contingency (10%) on Sub-total of a & b**			
2	**Tools & Plants**			
	Sub-total - c			
	Total Annual Cost			

Table 4.1 Summary Table for Annual O & M Budget

4.6 Maintenance Records

Maintenance records are of utmost importance. A record shall be kept for all maintenance activities, both immediate and preventive maintenance works. Information that must be recorded includes, but not limited to, the following:

- Date and time of maintenance,
- Weather conditions,
- The type of maintenance,
- Name of person or contractor performing maintenance,
- Description of work performed,
- The length of time it took to complete the work with dates,
- Equipment and materials used, and
- Before and after photographs.

The data should be recorded by the person responsible for maintenance.

Chapter 5

Instrumentation and Monitoring

A dam's instrumentation furnishes data for deciding if the structure is functioning as intended and provides continuous monitoring to warn of any unsafe developments or phenomena that can lead to dam failure by drawing information from a wide spectrum of instruments and procedures, ranging from simple to complex. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation.

5.1 Instrument Types and Usage

Grouting of the foundation of the dam as in **Fig 5.1** was done during construction. Instruments were not installed for Anayirankal dam during construction except settlement plates and rock targets for deformation study. Plan and section of drainage arrangement provided in the dam is given in **Drg 5.1a & 5.1b** of **Annexure I.** Bleeder wells for relieving excess uplift were provided in the downstream face as in **Fig 5.2.** Total 22 nos of relief wells are provided in rock fill dam of which 17 nos are at berm El. 3925 ft and 5 nos are at berm at El. 3903 ft. Details of Bleeder well and sections are given in **Drg 5.3** of **Annexure I**. It is proposed to provide piezometers and other instruments under DRIP as below

Instrument	Existing	Proposed under DRIP
Automatic Water Level recorder	0	1
V notches	0	2
Automatic weather Station	0	1

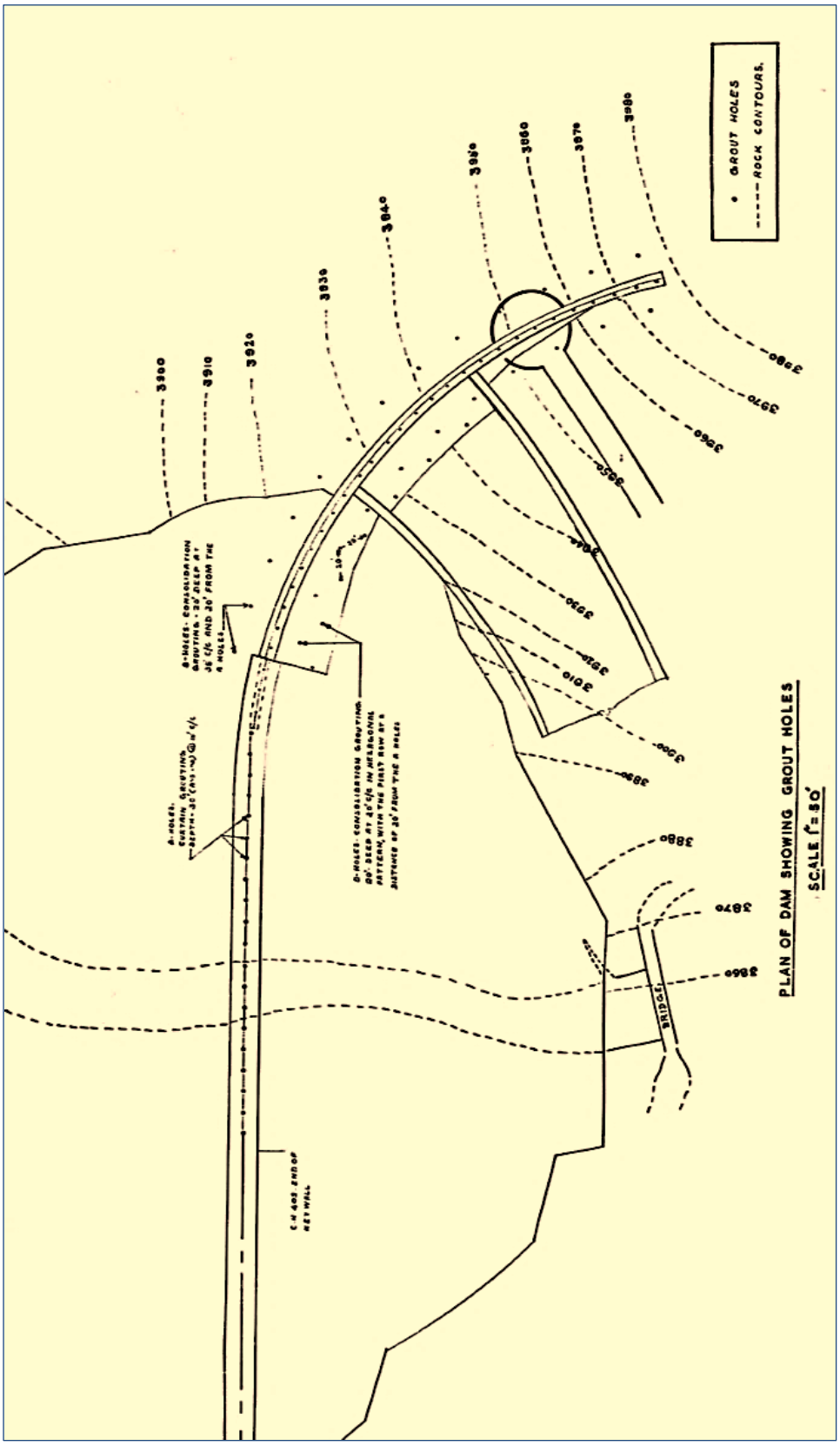


Fig 5.1 Anayirankal Dam – Foundation Grouting Plan

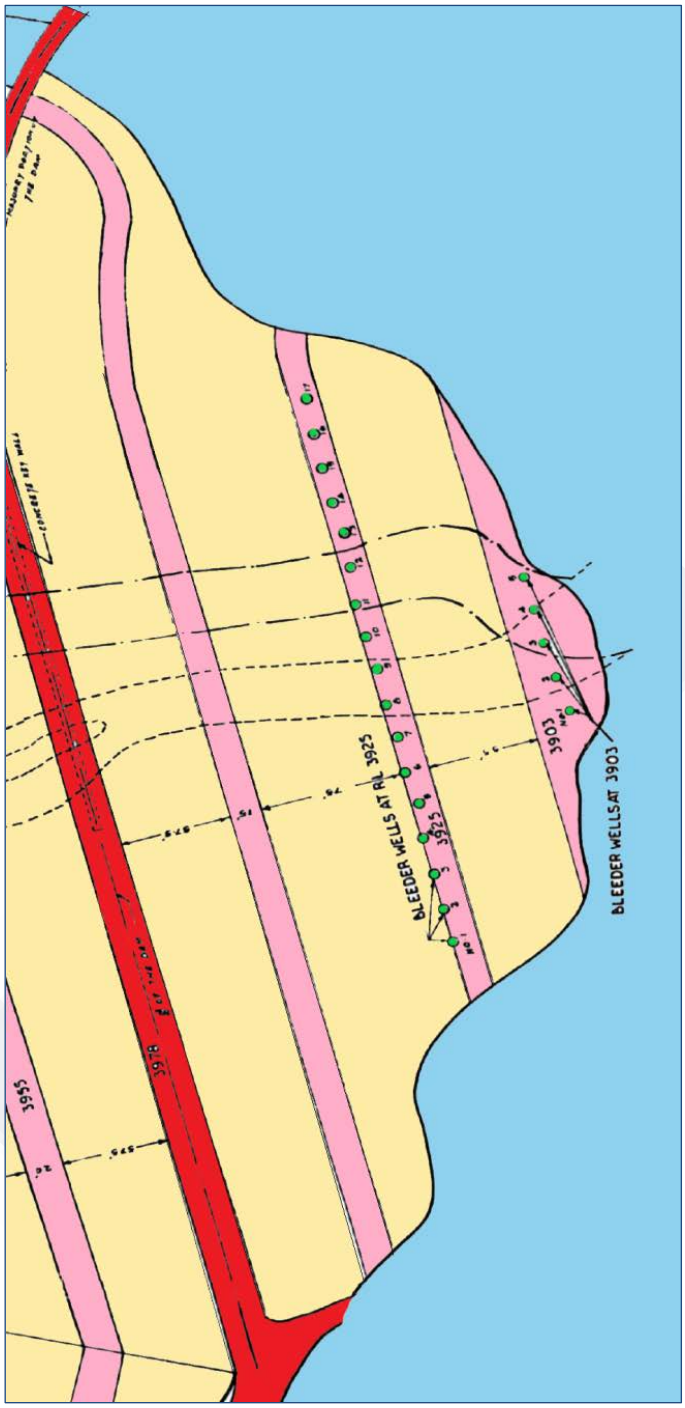


Fig 5.2 Anayirankal Dam – Bleeder Well Locations

5.2 Data Processing, Evaluation, Interpretation reports

The instrumentation monitoring is done periodically and monthly reports are prepared for evaluation. Data interpretation is being done yearly.

Chapter 6

Previous Rehabilitation Efforts

6.1 Issues with the dam

The dam was commissioned in 1965 and no major rehabilitation works were carried out. The Dam was inspected by the DSRP under DRIP. Recommendations were given for works/remedial measures to be attempted for improving the structural safety and security performance of the Dam. Accordingly the works proposed under DRIP were.

- Rubble Pitching for upstream slope protection
- Construction of Security cabin at dam top
- Maintenance of approach road and road to dam top
- Supply and installation of high mast light
- Installation of CCTV camera
- Purchase of speed boat for inspection.
- Improving lighting for external areas of dams

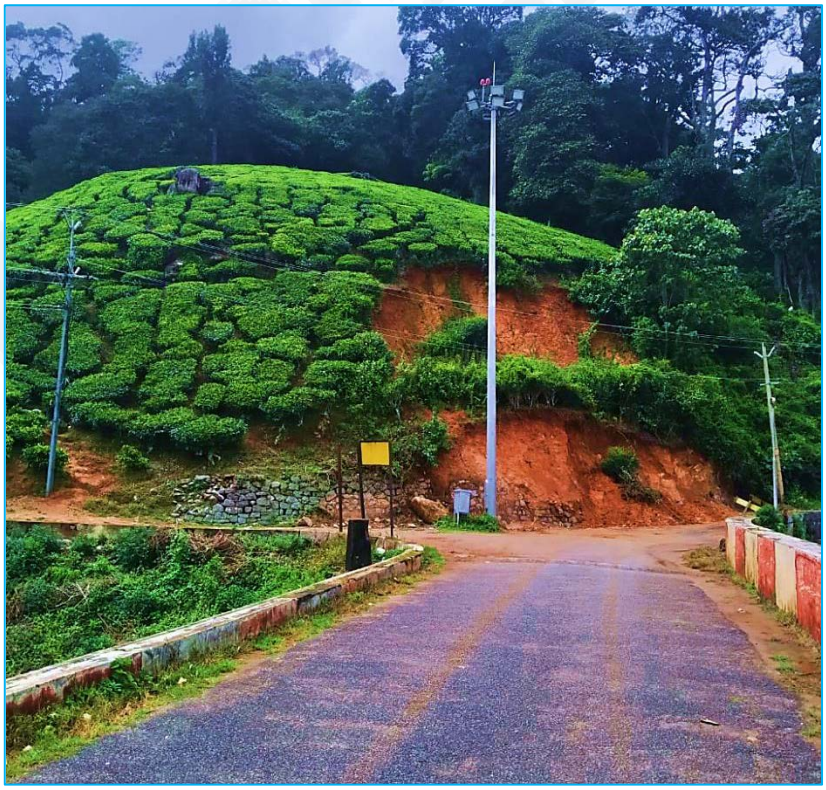
All the above works are carried out except installation of CCTV camera which is under process.

The photographs showing the DRIP works are given below:

Upstream slope protection

Security cabin at dam top

Approach road to dam top



High mast lighting

Chapter 7

Updating the Manual

Whenever features of the dam and appurtenant structures change, the O & M Manual must be edited and portions rewritten to reflect these changes. Updating information in the O & M Manual should be done whenever major changes like construction of an additional spillway, construction of dam on the upstream etc. take place.

Aspects to be considered when updating the Manual must include:

i) Increase/decrease in the frequency of an inspection or the maintenance routine based on additional data/experience acquired,
ii) Changes in the operation and/or maintenance procedures based on additional data/experience acquired,
iii) Alterations to the project data because of changes/modifications in the dam by way of additional spillway etc.

It is recommended that the O & M Manuals may be reviewed/updated after every 10 years by the respective Dam Owners.