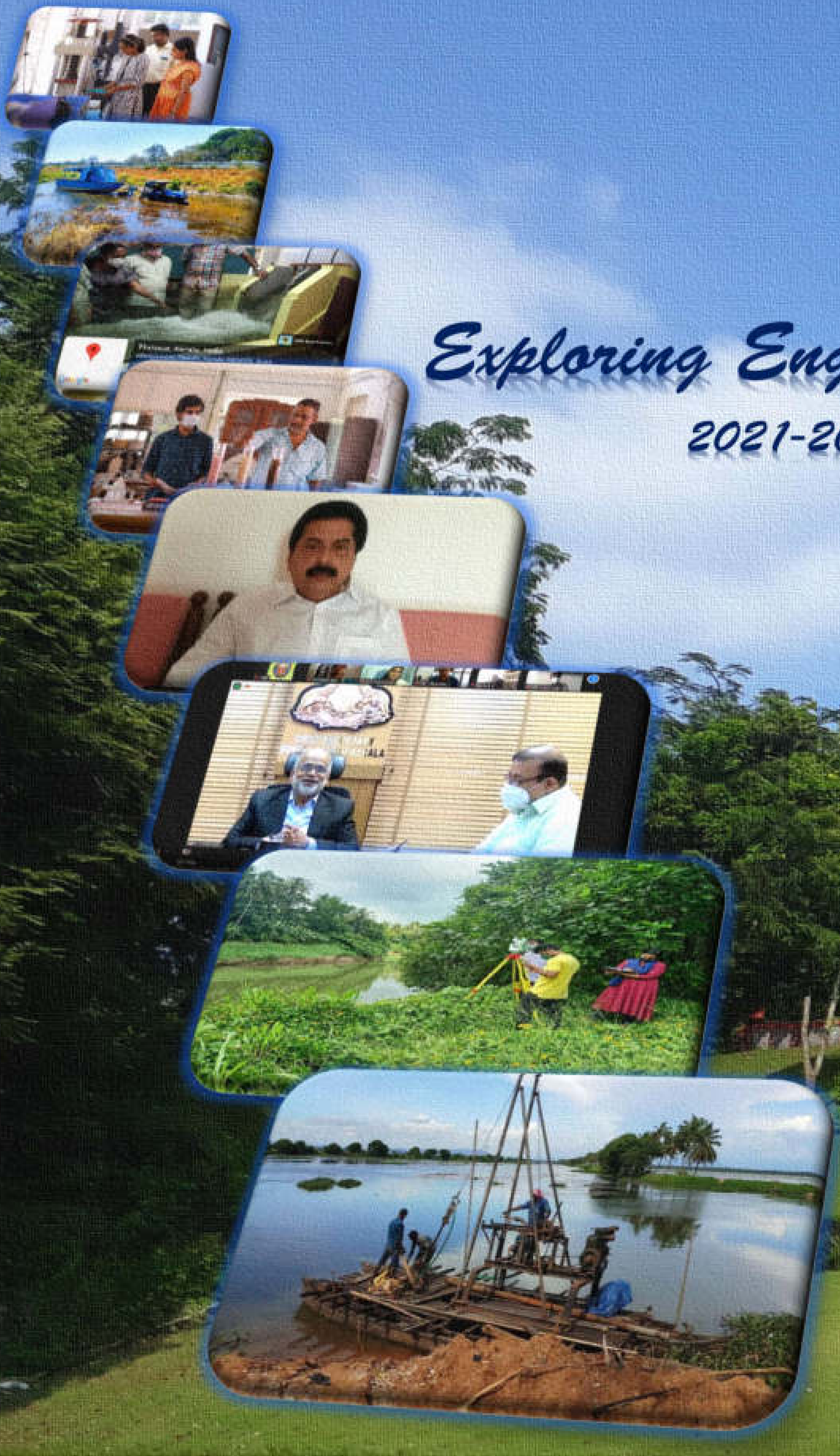
KERALA ENGINEERING RESEARCH INSTITUTE

കേരള എഞ്ചിനീയറിംഗ് റിസർച്ച് ഇൻസ്റ്റിറ്റ്യൂട്ട്

Peechi - Thrissur

An Institution of Irrigation Department Under Ministry of Water Resources, Govt. of Kerala



Exploring Engineering ...

2021-2022

ACKNOWLEDGEMENT

"Appreciation is the highest form of prayer, for it acknowledges the presence of good wherever you shine the light of your thankful thoughts" Alan Cohen

At the very outset of this report, I would like to express my profound gratitude to all of the individuals who have assisted me in these endeavours. I would not have progressed without their proactive advice, assistance, cooperation, and encouragement.

I am eternally grateful to Sri. Roshy Augustine, Kerala's Minister of Water Resources, for his vision and worthwhile outlook towards KERI.

Building bridges between theory and practice is becoming increasingly important. The collaborative approach that effectively uses the increasing pool of knowledge in the science and technology sector will result in practical technologies that boost up the prosperity of the people's society and lives. I thankfully acknowledge Sri. V. P. Joy (IAS), Chief Secretary, Government of Kerala for the incredible support and inspiration deliberates towards KERI.

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I am grateful to the members of my department's personnel and friends who assisted me in completing these accomplishments successfully.

As John F. Kennedy rightly said, "We must find time to stop and thank the people who make a difference in our lives", let me thank you all once again,Thank you.

DIRECTOR

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EXECUTIVE SUMMARY

The establishment of research centres in numerous sectors is critical to a nation's development. Every centre plays a vital role in its specific field. Considering India is an agrarian economy, research centres focusing on effective water resource management and the creation of reliable irrigation systems are critical to the country's infrastructure development. The Kerala Engineering Research Institute in Peechi is one of our country's first research institutes of its sort.

The Kerala Government established the Kerala Engineering Research Institute, Peechi, five decades ago, in recognition of the role of engineering and technology in nation building initiatives. Institute is located on the beautiful foothills of the Western Ghats, near to the Peechi dam, on a 25-hectare site surrounded by evergreen forests. In April 1958, the State Government approved a plan to establish a research institute. On April 26, 1958, the then Prime Minister of India, Pandit JawaharLal Nehru (who referred to the dams as "temples of modern India") laid the foundation stone for the main building in the presence of Smt. Indira Gandhi and Shri. E.M.S. Nambuthiripad, the Chief Minister of Kerala.

The building took two years to complete, and the institute was made to functioned in 1960. The Governor of Kerala, Shri. B. Ramakrishna Rao, formally inaugurated it on June 13, 1960. Many eminent engineers from the state have served this institute, including Er. K.K.N Nambiar, Er. G. Thomas, Er V.K. Vasudevan, Er. John. J. Erattupuzha, Er. N.S. Mani, Er. P.R. Sahasranayanan, Er. K.S. Narayanan, Er. M. Parameswaran Nair, Er. V. Laxmanan, Er. San. At its golden periods, this prestigious institution was well known not just in India but also internationally.

It is important in both basic and practical research in the field of Civil Engineering. The institute was founded to address a variety of issues that arise during the planning and execution of major development projects in the fields of irrigation, navigation, flood control, and buildings, among others. The Institute

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is located in the centre of the state, allowing it to serve people from all around the state. On the separation of PWD, the Institute became part of the Irrigation Department and has been operating under the Chief Engineer, Investigation, Design, and Research Board (IDRB).

The research institute is connected to water resources in the state of Kerala, which is a rare and unique trait. The current flood scenario has brought attention to concerns in the field of water resources engineering, necessitating solutions through research investigations. The prevailing climate and rainfall patterns have greatly exacerbated the urgency of the situation. The KERI grew to take on the challenges of R&D in the field of construction, especially construction of irrigation, hydropower, and other significant hydraulic projects in the State, along with other State Government engineering research institutes including GERI, MERI, and IHH, Poondi.

Harnessing the engineering solutions to solve real world problems is essential for the evolving of a society. As Albert Einstein said "Scientists investigate that which already is; engineers create that which has never been". The emerging problems associated with the change in climate pattern and obsoleted engineering structures are becoming a complexity and huge burden on Government. As an engineering research institution, KERI was entrusted by the government to conduct multiple research engineering projects to solve real engineering problems, and this report summarised the various studies conducted by KERI during the fiscal year 2021-22.

Kerala Engineering Research Institute

VISION

To become a pioneering research centre on par with international standards offering integrated services by fulfilling the needs in the field of Civil Engineering and Water Resources Engineering in particular.

MISSION

To enhance the innate capabilities of the institute by taking up new research projects, partnering with other reputed research institutes to improve the research capacity, imparting training to engineers to facilitate knowledge sharing and harnessing young talent through constructive academic collaboration to attain new perspectives.

HYDRAULIC RESEARCH

a. Hydraulics Division
b. Sedimentation Division
c. Coastal Engineering Division

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HYDRAULICS DIVISION

1. INTRODUCTION

Studies on various problems in Applied Hydraulics, Irrigation Engineering etc..are taken up by Hydraulics division and solutions are proposed by the division for the same. The works on major irrigation and hydroelectric project in the state are undertaken only after doing model /research studies by this division. The studies are conducted on a wide range of parameters related to spillways, sluices, chutes, energy dissipating arrangement, flow condition in tail-race, hydraulic behavior of canal structures, river training works etc. From these studies hydraulically sound and economically viable solutions are provided to various problems associated with projects.

1.1 Meteorological Station, KERI, Peechi

Weather observations are necessary to improve meteorological services in thestateand enhance the predictive capability of short and long-term information for weather forecasts and climatic changes. The weather data is used for the real-time preparation of weather analysis, forecasts and severe weather warnings, for the study of climates, for local weather dependent operations (for example local aerodrome flying operations, construction work on land and at sea) for hydrology and agricultural meteorology and for research in meteorology and climatology. The meteorological Station under K E R I, Peechi is located on the west bank of Peechi Dam, near the Peechi House at a latitude of 10º 31'30'' N, longitude 76º 21' 59'' E and height above MSL +96.03 m. The weather parameters are observed and recorded daily at 8.30 AM.The station is equipped with the instruments for measuring manually the weather parameters namely Atmospheric Pressure, Temperature, Humidity, Rainfall, Evaporation, Wind speed, Wind direction and Bright Sunshine. As part of modernization, an automatic weather station was installed in June 2014. During the period 2020-21 the sensors of the automatic weather station were replaced.

1.1.1 Automatic Weather Station

The meteorological station under the division at Peechi is equipped with Automatic weather station. Time series observations are vital to improve the understanding of weather dynamics and its variability. The automatic weather station (AWS) plays an important role in providing short term and long-term time series weather observations. Automatic weather station is functioning with a solar panel for uninterrupted power supply.

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The Automatic Weather station collects data related to air temperature, air humidity, barometric pressure, ultrasonic wind speed, ultrasonic wind direction, global radiation and precipitation using different sensors. These data can be accessed using a software HYDRAS. The data collected can be used to gauge current weather conditions and to make weather forecasts like temperature high/lows, cloud cover and the probability of precipitation.

1.1.2 Manual Weather Station

Manual measurements of meteorological data are done using the following instruments and the readings are taken every day at 8.30 am.

- Temperature – Max & Min Thermometers & Bimetallic Thermograph
- Relative Humidity – Psychrometer (Dry & Wet bulb) & Hair Hygrometer
- Rainfall – Standard Rain Gauge, Self Recording Rain gauge
- Evaporation – Land Pan Evaporimeter
- Wind Direction – Wind Vane
- Wind Speed – Cup Anemometer
- Bright Sunshine – Sunshine Recorder

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Weather Station- Instruments for manual recordings of weather data

1.2. Initial setup and Physical Model Study of Kuttyadi Dam

Based on the recommendation of the committee on dam safety it was decided to modify the spillway of the dam. Chief Engineer, IDRB, Thiruvananthapuram (Vide Lr.No. No:675/DAMS-AD6/1987/IDRB-Part File I dated 30.04.2018) directed KERI to undertake the physical modelling of the proposed modification of spillway of Kuttiyady dam. The study involves in verifying the flow characteristics of the proposed modification of spillway and stilling basin for energy dissipation in the D/S of dam. The initial setup included water proofing of overhead tank, setting up of water circulation system, underground sump for storing water etc.

MODEL DETAILS

The model of the prototype spillway of the Kuttiyadi dam was constructed to a scale of 1: 60 in the Hydraulics laboratory in Hydraulics Division, KERI. Out of four bays, an undistorted model of two bays was constructed at two different downstream bed levels (having downstream bed level at +15.0 m and +16.5 m) as in prototype. An Ogee type of spillway model with stilling basin and energy dissipater corresponding to the prototype was constructed according to the scaled dimensions in model following the scale ratio. The spillway was also provided with shutters so as to control the flow of water from the reservoir to the downstream. The reservoir with head maintaining facility, facility for discharge measurement, pressure head measurement, flow profile plotting along the spillway flow path also exist in the model. The discharge measurement was done using a calibrated V - notch. The model set up along with elevation of the spillway is shown in Fig. 1, with the piezometer tapings (Sp1 to Sp15) provided to measure the pressure head when the flow occurs over the spillway. The design discharge adopted for the model building of spillway as supplied by IDRB is 1584 m3/s.The initial depth of flow and the sequent depth for the hydraulic jump were measured and the velocity and Froude number at the salient points of jump were estimated. Also a physical observation of the jump in the stilling basin was done to see the flow pattern and energy dissipation.

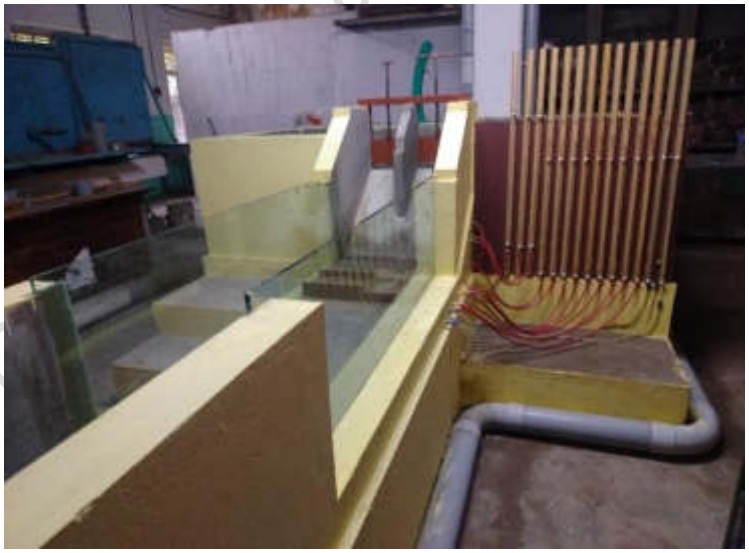


Figure 1: Model details

3D model of Kerala and the building housing the model

The Relief map of Kerala (Kerala model) at K.E.R.I. is a three dimensional model of Kerala and it is a centre of attraction in Peechi, with lot of people visiting daily. 3D model of Kerala painted with colorful paints for distuinguishing each district and marking National Highway, State Highway, Railway Line and Rivers with suitable colours. Two display boards also written on

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walls of building displaying details of rivers in Kerala and Nation Highways passing through Kerala State. Now this building was rectified and beautified and allowing tourist to visit them.It is more informative to the tourists to know about Kerala.



Kerala 3D Model after renovation

1.4 Additional activities

- A Sub group constituted to assist CWRC in finalizing the national institutes for conducting Physical and Mathematical model studies in dams in Cauvery Basin. Director of KERI is one of the members of the subgroup.
- Submitted a brief Perspective on Dam Decommissioning Scenario.

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SEDIMENTATION DIVISION

1. INTRODUCTION

Sedimentation Division in KERI conducts studies to compute the present storage capacity of reservoirs and other water bodies. Such studies are conducted using modern electronic method called 'Integrated Bathymetric System'(IBS). In order to ascertain the underwater profile of the sediment layer another sophisticated instrument called 'Sub Bottom Profiler' is used. From 2004 onwards, this division has completed 52 studies using IBS which includes Kallada Reservoir, Malampuzha Reservoir, Neyyar Reservoir, Mullaperiyar, Vembanad Lake and Kattampally Wetland etc. Sub Bottom profiler was used for 28 of the above studies.

- **Relevance of the study**
  - To estimate the present capacity of the reservoirs
  - To manage the reservoir operations based on the present actual capacity
  - Vital role in the ongoing Desiltation work of reservoirs for the capacity improvement
  - To observe the influence of the heavy flood in 2018 and 2019 in the reservoir sedimentation
  - Assessing the bottom profile of reservoirs and preparing contour map of water body
- **Methodology for Data Collection**

The mobile station consists of the DGPS and its antenna, Echo sounder, Sub Bottom Profiler and the transducers, etc are mounted on the FRP boat. The transducer of Sub Bottom Profiler is permanently fixed at the center of the boat. The transducer of Echo sounder is fixed to the left side of the boat and is detachable. Proper connections are made between this equipment and the laptops for the data collection. The boat is sailed along the planned track with a speed of 3 to 4 knots. The data from the Echo sounder and Sub Bottom Profiler is collected simultaneously through two laptops as shown in fig.

For IBS Survey, the laptop loaded with QINSY survey software is used. There are three modules in the QINSY Software: Data Acquisition, Data Processing and Data export/ import.

The system **SES-2000**(Sediment Echo Sounder) Sub Bottom Profiler is a parametric (non-linear) dual frequency echo sounder. The instrument simultaneously transmits two signals of

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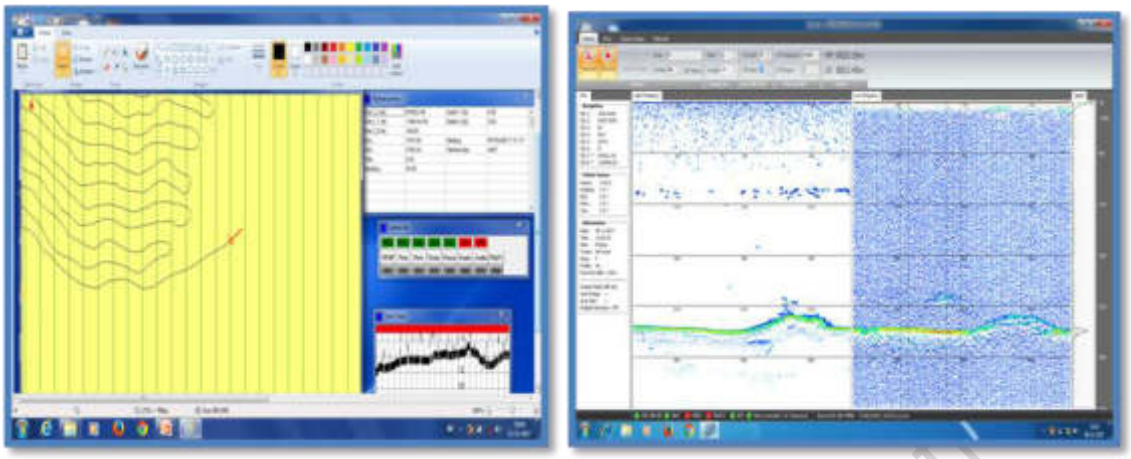
slightly different high frequencies; their interaction creates a new low frequency signal. It has a large bandwidth and a short signal length, which allows good use in very shallow water and results a high (~15 - 20 cm) vertical resolution at acceptable sub-bottom penetration up to 10 m or more. Some favourable near sub-bottom seismic and geological conditions permit to achieve a vertical resolution up to 10 cm.



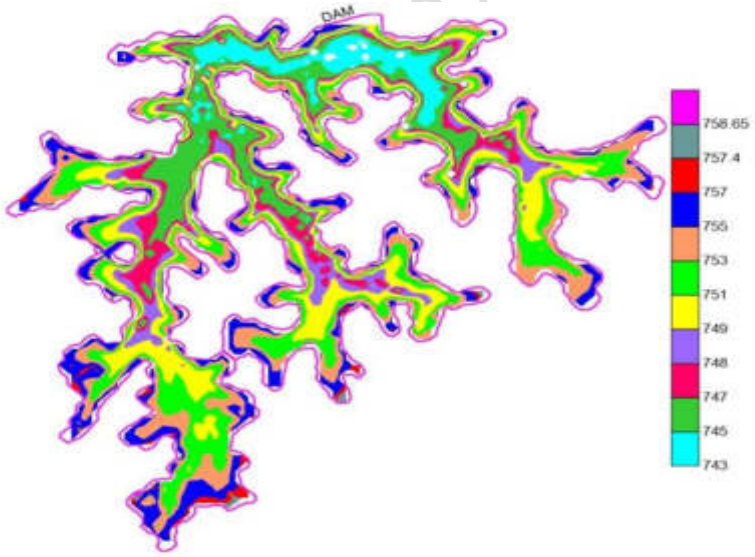
Fig.1 Chart planning for Data collection

Parametric (non-linear) sound generation allows designing acoustical systems with small transducer dimensions and narrow sound beams at low frequencies. An Innomar SES-2000 parametric transducer has an active area of 20 x 20 cm and provides a beam width of less than four degrees (at 3dB), valid for all adjustable low frequencies between 5kHz and 15 kHz. The transmit directivity of the parametric sound beam does not show any significant side lobe characteristic, which reduces ambiguities during the interpretation of individual reflectors. Short transmit signals of single sinusoidal cycles without any ringing and high ping rates of up to 50 pings per second are further advantages. They contribute to a high spatial resolution of this acoustical system and permit to apply it in a shallow basin. Innomar's software tool ISE provides near real-time processing of the collected SES data. The operation procedure can be tuned online. A value of the sound velocity in water is used to convert sound travel time to the depth. The depth values are screened online.

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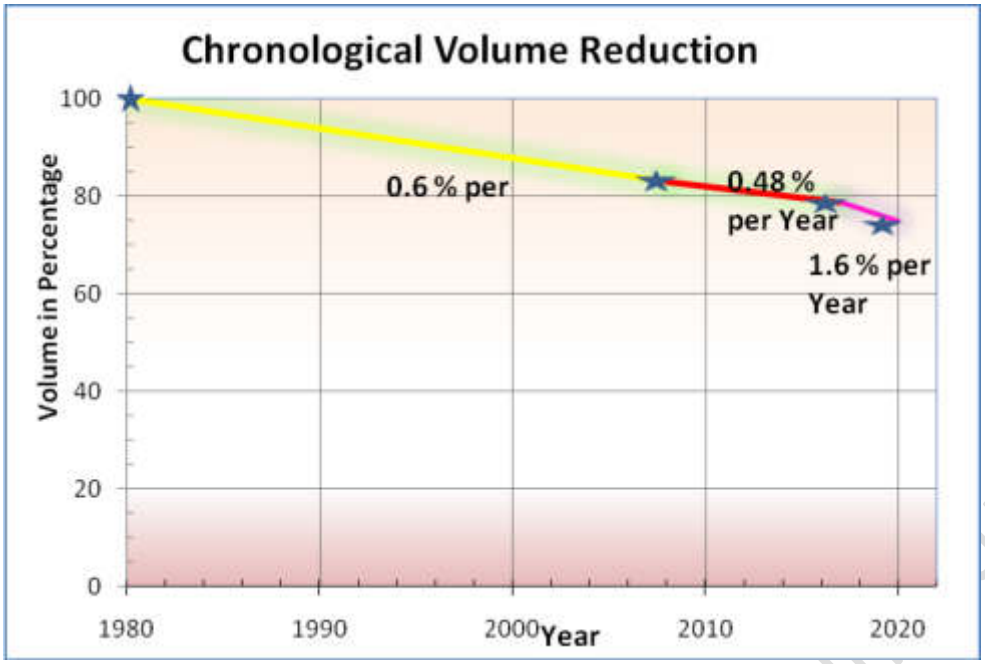


Data collection in IBS and Sub bottom profiler

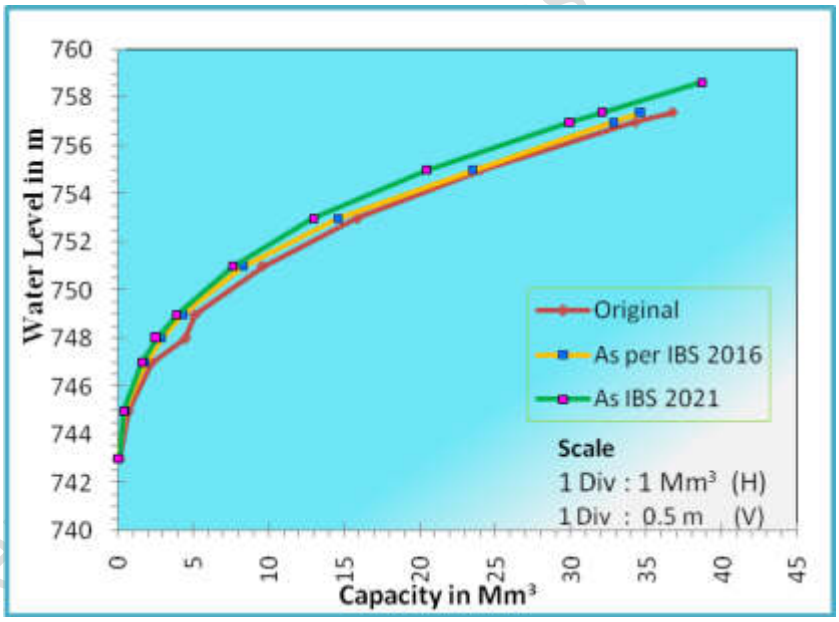


Contour map based on IBS survey

The capacity reduction in the reservoirs in a chronological manner can beassessed by conducting repeated studies.



The capacities at different water levels are computed by processing the collected data using the softwares



2. SEDIMENTATION SURVEYS CONDUCTED DURING THE YEAR 2021-22

During the Financial year 2021-22 this division has conducted the sedimentation study of Kallada and Maniyar reservoirs.

➢ Sedimentation Study of Kallada Reservoir

Study of Kallada reservoir has initially conducted on January 2018 and the repeat study is included in the Action Plan 2021-22 to assess the effects of heavy floods occurred in 2018 and 2019 in the reservoir sedimentation. The study has been started in the month of December 2021 and completed by 20/02/2022.

Salient Features of Kallada Irrigation Project:

1.	Name	:Kallada (Parappar)
2.	Location	
	Longitude	:77^{o} 04’12.149’’E
	Latitude	:8^{o} 57’16.558’’N
3.	Year of starting	:1972
4.	Year of partially commissioning	:24-05-1986
5.	Type of Dam	:Masonry Straight gravity dam with spillway
6.	Length of Masonry Dam	:335 m
7.	Length of Spillway	:42.0 m
8.	Maximum height above deepest foundation	:85.35 m
9.	Top width of Dam	:7.62m
10	Full reservoir level	:115.82m
11.	Maximum water level	:116.77m
12	Dead storage level	:70.25m
13.	Catchment area	:549 Sq.km
14	Gross storage at F.R.L	:504.92Mm^3
15	Dead storage capacity	:17.75Mm^3
16	Water spread area at F R L	:23.00 Sq.km
17	Purpose	:Irrigation

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The data collection of Kallada reservoir using IBS and Sub bottom Profiler has been completed and the data processing and validation is ongoing.



തെന്മല ഡാമിലെ എക്കലിന്റെ അളവ് കണ്ടെത്താൻ പരിശോധന

ആര്യങ്കാവ്: തെന്മല പരപ്പാർ ഡാമിൽ എക്കലിന്റെ അളവ് കണ്ടെത്താനുള്ള പരിശോധന ആരംഭിച്ചു. ഡാമിൽ അടിഞ്ഞിട്ടുള്ള എക്കലിന്റെ അളവും നിലവിലെ ജലാശയവും പ്രത്യേക ഉപകരണങ്ങളുടെ സഹായത്തോടെ കണ്ടെത്തിയാണ് സംഭരണശേഷി കണക്കാക്കുന്നത്.

ജലവിഭവ വകുപ്പിന്റെ പീച്ചിയിലുള്ള കേരള എൻജിനീയറിങ് ഇൻസ്റ്റിറ്റ്യൂട്ടിലെ സെഡിമെന്റേഷൻ ടീമിലെ അഞ്ചംഗ സംഘമാണ് പരിശോധന നടത്തുന്നത്. മഴക്കാലത്ത് ഡാം പെട്ടെന്ന് നിറയുകയും വേനൽ തുടക്കത്തിൽ വെള്ളം കുറയുകയും ചെയ്യുന്നതിനാൽ ഡാമിന്റെ സംഭരണശേഷി എത്രത്തോളം കുറഞ്ഞിട്ടുണ്ടെന്ന് കണ്ടെത്താനാണ് പരിശോധന. 2018 ലാണ് അവസാനമായി പരിശോധന നടത്തിയത്.



ഡെപ്യൂട്ടി ഡയറക്ടർ സി ജെ ദിവ്യയുടെ നേതൃത്വത്തിൽ തെന്മല പരപ്പാർ ഡാമിൽ എക്കലിന്റെ അളവ് കണ്ടെത്താനുള്ള പരിശോധന പുരോഗമിക്കുന്നു

അന്ന് 6.59 ശതമാനം എക്കൽ ഉള്ളതായി കണ്ടെത്തി. ഇപ്പോൾ 113.83 മീറ്റർ വെള്ളമുണ്ട്. ഈ സമയത്ത് നടത്തുന്ന പരിശോധനയിൽ മുമ്പത്തേതിനെക്കാൾ എക്കലിന്റെ അളവ് കണ്ടെത്താനാകുമെന്ന് പരിശോധനക്ക് നേതൃത്വം നൽകുന്ന സെഡിമെന്റേഷൻ ഡിവിഷൻ ഡെപ്യൂട്ടി ഡയറക്ടർ സി ജെ ദിവ്യ പറഞ്ഞു. പരിശോധന പൂർത്തിയാകാൻ ഒരു മാസം വേണ്ടി വരും. അസി. ഡയറക്ടർമാരായ എസ് എസ് രോഷിനി, കെ വി ജയശ്രീ എന്നിവരും സംഘത്തിലുണ്ട്.

- **Sedimentation Study of Maniyar Reservoir**

Maniyar Barrage in Kakkad River is the head works of the Pamba Irrigation Project. It is designed as a diversion barrage with regulators. The water is used for agricultural and water supply purpose and a small hydro electric project is also working to utilize the surplus water available from the reservoir after meeting the irrigation and water supply demand.

Salient Features of the Maniyar Barrage:

Total length of barrage at top : 115.22m

Width of barrage at top	: 5.48m
Height above deepest foundation Level	: 18.29m
Length of bulk heads	: 50.90m
Length of spillway portion	: 64.31m
Crest level	: +29.26m
Average bed level of river	: +20.12m
River Sluice: 2 Nos. Sill level of river sluice	: +21.34m
Level of roadway	: +36.88m
Reservoir Details Catchment area	: 280 Sq. Km.
Maximum Water Level	: +35.35m (MWL)
Full Reservoir Level	: +34.62m (FRL)
Minimum draw down level	: +29.26m
Dead storage level	: +29.26m
Water spread area at FRL	: 1.08 sq. km.
Storage capacity at FRL	: 8.8 Million m^3
Live storage level	: 0.8 Million m^3

Sedimentation study of Maniyar reservoir has been conducted as per the Endt No.DM-AD 6/5/2019 – IDRB dated.19/07/2021 and as per the letter no. D8 – 156/18-G Dated.21/05/2021 of the Superintending Engineer, Project Circle, Piravom. They have reported that the storage capacity of Maniyar reservoir has been reduced considerably due to accumulated silt and decayed vegetation after the August 2018 flood. Hence the study has been conducted to assess the present storage capacity of the reservoir and the quantity of sediment deposition. Data collection work was started by 20/02/2022 and completed by 23/02/2022. Quantity of sediments will be assessed after processing the survey data.

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COASTAL ENGINEERING DIVISION

1. INTRODUCTION

Coastal Engineering Division is entrusted with topographic surveying for the design of various hydraulic structures, fixing alignment of irrigation canals, quantification of capacity of water retaining structures, planning of various projects (Micro-Irrigation schemes, Lift Irrigation schemes) and flood related studies. The Division is working under Joint Director, Hydraulic Research, KERI and consist of a Deputy Director, two Assistant Directors and four overseers. The division has also completed important works related with the Irrigation Department such as fixing temporary Bench Mark for Mullapperiyar dam as well as fixing submersible area of proposed Attappady dam. The division is collaborating with NIT Calicut for sand auditing of Chaliyar river which is taken as a pilot project in connection with rejuvenation of rivers in Kerala. This division is equipped with a robotic total station (TS 13), a set of DGPS (GS 18T) and a total station (TS 11). Images of the instruments are shown in the Figures 1 and 2 respectively.Outputs from the surveying works are disseminated in the form of contour maps, cross-sections and layouts.

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Fig. 1: GS14 Base Unit with CS-10 Controller



Fig. 2: Total Station and Prism used for surveying work

2. WORKS EXECUTED DURING THE YEAR 2021-22

The works executed during the year 2021-22 under various head of accounts and the main objective of the same are elucidated in the Table 1.

Table 1: Details of works executed during the year 2021-22

Sl. No.	Name of work	Objective
Head of account: Development of KERI-Stage-II		
1	Cross checking crest level of existing Mullaperiyar dam with Mean Sea Level 2021-22	Fixing crest level of Mullaperiyar dam
2	Topographical investigation for finding out the variations in bed levels in the upstream 600m of Velliyamkallu Regulator at Thrithala - 2021-22	Quantification of sediment deposition and erosion
3	Topographical investigation for Chundampatta Branch Canal of Thathanampully Lift Irrigation Scheme in Palakkad District-2021-22	Fixing alignment of branch canal
4	Load test on Attappally Regulator Cum Bridge-Measurement of deck slab deflection using total station	Measuring deflection of deck slab of bridge during

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	for the year 2021-22	load test
5	Topographical investigation allied with the obstruction to flow of Periyar river near Vallarpadam Railway bridge at Vaduthala-2021-22	Quantification of sediment deposition around Vallarpadam railway bridge
6	Topographic investigation of command area for implementation of Community Micro Irrigation Project in Dasanakkara in PulppallyPanchayath 2021-22	Design of Micro-Irrigation scheme
7	Topographic investigation of Kottoor branch canal from Ch. 16200m of LBMC and three distributaries for the year 2021-22	Fixing alignment of branch canal
8	Topographic investigation of command area for implementing community micro irrigation at Vazhavatta-Cheepram in MuttilPanchayath of Wayanad District.	Design of Micro-Irrigation scheme
9	Topographical investigation of Kayamkulam Branch canal of Kallada Irrigation Project from Ch.0m to 11500m	Fixing alignment of canal
10	Topographic surveying of Peechi Dam Campus including Vallikkayam saddle dam and allied features	Preparation of Master Plan for Peechi dam and KERI campus
11	Conducting Topographic investigation in Kurumali river in connection with rehabilitation of Attappilly Regulator cum Bridge	Design of approach road, protection measures and rehabilitation of Attappilly RCB
12	Routine activities of Coastal Engineering Division Office and Offices of Director, F & AR and Joint Director, Hydraulic Research	Maintenance and upkeep of offices
13	Maintenance of the model area of the Coastal Engineering Division	Maintenance and upkeep of model area
14	Annual Maintenance and purchase of accessories for Smart Station	Maintenance and upkeep of Smart station
15	Purchase of Robotic Total station compatible with Leica GS -18 T DGPS and accessories	
Head of account: Investigation of Major Irrigation Schemes		
1	KIP (RBC) - Kodumon Distributary - Deflection measurement of aqueduct from Ch 7650m to 7850m	Measurement of deflection of aqueduct
2	Engineering investigations allied with the rehabilitation of existing hydraulic structures and various water resources related problems	

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Head of account: Formation of River Basin Organization		
1	Sand Budgeting in Chaliyar River Basin	Quantification of mineable sand from Chaliyar river in a scientific manner

The above mentioned works were carried out using the total station and DGPS instruments available in the division in the departmental execution mode. These are high priority of works of the department and covers wide range of objectives as mentioned in the Table 1. The overall expenditure of the works was 99.62% of the total TS amount.Apart from the above mentioned works, a deposit work from Centre for Water Resources and Development (CWRDM) was done during this year. The work mainly comprises of topographic surveying of Poonoorpuzha for analysing the flood conditions during the monsoon season and planning of protection structures for reducing the damages of floods. The locations affected by the floods during the years 2018 and 2019 have given prime importance during the surveying. The TS amount for the work was 6.65 lakhs. As a part of sand auditing of Chaliyar river, suspended sediment sampling was commenced on the month of September 2021 and ended on February 2022. The samples collected were sent to NIT Calicut for measuring the sediment concentration and using it for the sand auditing works. A training programme on sand auditing was organized by this division from 27-12-2021 to 29-12-2021 in which sessions were handled by Dr.Santosh G Thampi, Head, Department of Civil Engineering, NIT Calicut. In continuation with this, two online training sessions were also conducted on the topic of hydrologic modelling of river basins. The selected images of various works done are given in the Figures 3 and 4 respectively.

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Fig. 3: Topographic surveying work across Periyar river near Vallarpadam Railway Bridge



Fig. 4: Topographic surveying for fixing alignment of Kayamkulam branch canal



Fig. 5: Topographic surveying for Poonoorppuzha and its banks



Fig. 6: Topographic surveying for measuring deflection of bridge slab during load test



Fig. 7: Topographic surveying of downstream of Attappilly RCB



Fig. 8: Suspended sediment sampling of Chaliyar river for sand auditing

Construction Materials & Foundation Engineering

a. Construction Materials Division

b. Soil Mechanics & Foundation Division

c. Instrumentation Division

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CONSTRUCTION MATERIALS DIVISION

INTRODUCTION



Construction Material Division is one of the sub unit of Kerala Engineering Research Institute (KERI) basically engaged in material testing. The division is managed by Deputy Director with the assistance of two Assistant Directors. Testing of construction materials is an essential part for ensuring quality in construction. In addition to the testing of Irrigation dept works, other Government Departments, Central Government Departments, Public Undertakings and various Private agencies are utilizing the facilities of lab for ensuring quality construction. The CM Lab continuing to contribute healthy revenue every year to the Government through various tests conducted for clients. The Lab is also functioning as a training centre of the Irrigation Department and providing training programmes and refresher courses for the benefit of department engineers. The training facility extended to other department engineers also. Now the CM Lab is on the process of getting assessment and accreditation of Testing and Calibration Laboratories by the National Accreditation Board Testing and Calibration Laboratories (NABL) in accordance with the international standards. The accreditation from NABL will boost up the status of the Lab and likely to increase the revenue to Govt. Modernizing the lab will come true through with the addition of modern instruments which is a must for any Material Testing Lab. Modern equipment for ascertaining the strength of concrete structures using Non Destructive Techniques were available and will help to solve the practical problems arising in the field and creating awareness among the engineering fraternity. The lab is equipped with basic NDT instruments like Pile Integrity Test, Rebound hammer, Ultra sonic pulse velocity meter and Core cutter. These nondestructive tests are being conducted to check the strength and deformation characteristics of the existing structures.

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WORKS EXECUTED DURING THE YEAR 2021-22

Construction materials division of KERI deals with testing of construction materials such as cement, aggregates, steel, tiles, bricks, rock, concrete etc and design of concrete mixes. The essentials tests for getting the physical properties of above materials are carrying out at this lab. Two Hundred and fifty four test reports were generated from this division during the Financial year 2020-2021 earning a revenue of **Rs. 9,47,434**/- (Rupees Nine lakhs forty seven thousand four hundred and thirty four only).

Report No	Details of Client	Description of test
CM 01/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 02/21-22	Wapcos Ltd, (Nissy Enterprises)	Tests On Concrete Cubes
CM 03/21-22	Assistant Engineer, Pwd Building Section, Kodungallur	Tests On Concrete Cubes
CM 04/21-22	Assistant Engineer, Pwd Building Section, Kunnamkulam	Tests On Concrete Cubes
CM 05/21-22	Assistant Executive Engineer, Transgrid TC Sub Division, Chalakudy (M/S Tritech RMC, Mannuthy)	Tests On Coarse & Fine Aggregates
CM 06/21-22		Tests On Cement
CM07/21-22	Assitant Executive Engineer, Irrigation Project Section, Velliyankallu, Thrithala	Tests On Concrete Cubes
CM 08/21-22		Tests On Cement
CM 09/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 10/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 11/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 12/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 13/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 14/21-22	Section Engineer, Office Of SSE/W, TCR	Tests On Concrete Cubes
CM 15/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 16/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 17/21-22	Assistant Engineer, Pwd Building Section, Kodungallur	Tests On Concrete Cubes
CM 18/21-22	Project Specific Engineer, Kitco Ltd	Tests On Steel-Unit Weight

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CM 19/21-22	Assistant Engineer, Pwd Building Section, Kodungallur	Tests On Concrete Cubes
CM 20/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 21/21-22	Chief Executive Officer	Mix Design
CM 22/21-22	Executive Engineer, Karapuzha Project Division, Kalpatta, Wayanad	PILE ECHO TEST
CM 23/21-22	Assistant Engineer, Pwd Buildings Section,Kodungallur	Tests On Concrete Cubes
CM 24/21-22	Assistant Engineer, Irrigation Project Section, Velliyankallu,Thrithala	Test On Z Type Hot Rolled Sheet Piles
CM 25/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 26/21-22	Assistant Engineer, Minor Irrigation Section, Tirurangadi	Pile Echo Test
CM 27/21-22	Assistant Engineer, Pwd Buildings Section, Kunnamkulam	Tests On Concrete Cubes
CM 28/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 29/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 30/21-22	Assistant Engineer, Irrigation Project Section, Velliyankallu,Thrithala	Tests On Concrete Cubes
CM 31/21-22	Secretary, Peechi Service Co-Operative Bank Ltd, Pattikkad	Tests On Paver Blocks
CM 32/21-22	Magtech Engineers & Constructions	Tests On Concrete Cubes
CM 33/21-22	Magtech Engineers & Constructions	Tests On Concrete Cubes
CM 34/21-22	Assistant Engineer, Irrigation Project Section, Velliyankallu,Thrithala	Tests On Concrete Cubes
CM 35/21-22	Assistant Engineer, Irrigation Project Section, Velliyankallu,Thrithala	Tests On Steel Bars
CM 36/21-22	Assistant Engineer Quality Control Section,Palakkad	Tests On Steel Bars
CM 37/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 38/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 39/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 40/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 41/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 42/21-22	ASSISTANT ENGINEER, Chamravattam Project Section III, Eeswaramangalam	Tests On Sheet Pile
CM 43/21-22	Assistant Engineer, Pmpar Project Section 3, Marayoor	Tests On Rock Core Samples

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CM 44/21-22	Project Engineer -24, Kiidc, Thiruvananthapuram	Tests On Steel Bars
CM 45/21-22	Assistant Engineer, Minor Irrigation Section, Mala	Tests On Concrete Cubes
CM 46/21-22	Assistant Engineer, Minor Irrigation Section, Kodakara	Tests On Concrete Cubes
CM 47/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 48/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 49/21-22	Assistant Engineer, Minor Irrigation Section, Shornur	Tests On Sand
CM 50/21-22	Deputy Director, Instrumentation Division, Keri, Peechi	Tests On Rock Core Samples
CM 51/21-22	M/S. Mahalakshmi Tiles,Elanthuruthy, Kutanellur	Test On Clay Tiles
CM 52/21-22	Assistant Engineer, Mi Section, Chalakudy	Tests On Concrete Cubes
CM 53/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 54/21-22	Assistant Engineer, Pwd Building Section, Kodungallur	Tests On Concrete Cubes
CM 55/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 56/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 57/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 58/21-22	M/S. Global Constructions, Room No. 1, St. Mary's Complex, Chalakudy	Tests On Concrete Cubes
CM 59/21-22	Assistant Engineer, Pwd Building Section,Chalakudy	Tests On Concrete Cubes
CM 60/21-22	Sri. Lawrance Chummar, Padinjarathala(H), Karuvannur, Thrissur	Tests On Granite Paver Tile
CM 61/21-22	Assistant Engineer Iii, Project Division, Kerala Water Authority,Nattika	Tests On Steel Bars
#REF!	Capital Pavings, Shornur	Tests On Paver Blocks
CM 63/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 64/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 65/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. SOUTH INDIAN CONSTRUCTIONS,KOLLAM)	Tests On Granite
CM 66/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. SOUTH INDIAN CONSTRUCTIONS,KOLLAM)	Tests On Cement
CM 67/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. Hilite Projects Ltd)	Tests On Concrete Cubes
CM 68/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes

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CM69/21-22	Assistant Executive Engineer, Idamalayar Irrigation Project, Angamali	Steel Test
CM 70/21-22	Assistant Executive Engineer, Idamalayar Irrigation Project, Angamali	Tests On Coarse Aggregates
CM 71/21-22	Assistant Executive Engineer, Idamalayar Irrigation Project, Angamali	Tests On Fine Aggregates
CM 72/21-22	Assistant Executive Engineer, Idamalayar Irrigation Project, Angamali	Tests On Cement
CM 73/21-22	Assistant Executive Engineer, Idamalayar Irrigation Project, Angamali	Mix Design
CM 74/21-22	Assistant Engineer, Cdp Section No. 2, Echippara	Tests On Coarse Aggregates
CM 75/21-22	Assistant Engineer, Cdp Section No. 2, Echippara	Tests On Fine Aggregates
CM 76/21-22	Assistant Engineer, Cdp Section No. 2, Echippara	Tests On Cement
CM 77/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Fine Aggregates
CM 78/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 79/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 80/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 81/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 82/21-22	Assistant Engineer, Pwd Cdp Section No.1, Echippara	Tests On Concrete Cubes
CM 83/21-22	Assistant Engineer, Pwd Cdp Section No.1, Echippara	Tests On Concrete Cubes
CM 84/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 85/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 86/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 87/21-22	M/S Uniq Contracting	Tests On Geobags
CM 88/21-22	Assistant Engineer, Cdp Section No. 2, Echippara	Tests On Coarse Aggregates
CM 89/21-22	Assistant Engineer, Cdp Section No. 2, Echippara	Tests On Fine Aggregates
CM 90/21-22	Assistant Engineer, Pwd Building Section, Irinjalakuda	Tests On Concrete Cubes
CM 91/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 92/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 93/21-22	Assistant Engineer, Cdp Section 1, Echippara	Tests On Concrete Cubes

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CM 94/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 95/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 96/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 97/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 98/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 99/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 100/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 101/21-22	Wapcos, Nissy Enterprises	Test On Steel Bars
CM 102/21-22	Assistant Engineer, Pwd Buildings Section, Chalakudy	Test On Concrete Cubes
CM 103/21-22	Assistant Executive Engineer, Sub Regional Store, Electrical Circle, Kseb Ltd.	Test On Ht Stay Wire
CM 104/21-22	Assistant Engineer, Pwd Buildings Section, Kunnamkulam	Test On Paver Blocks
CM 105/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Test On Concrete Cubes
CM 106/21-22	Assistant Engineer, Pwd Buildings Section, Irinjalakuda	Test On Concrete Cubes
CM 107/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 108/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 109/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 110/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Test On Concrete Cubes
CM 111/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Test On Concrete Cubes
CM 112/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. SOUTH INDIAN CONSTRUCTIONS,KOLLAM)	Tests On Cement
CM 113/21-22	Assistant Engineer, Peechi Project Section, Mannamangalam	Tests On Cement
CM 114/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 115/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 116/21-22	Assistant Engineer, Pwd Buildings Section, Irinjalakuda	Test On Concrete Cubes
CM 117/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD (M/S. Hilite Projects Ltd)	Tests On Concrete Cubes
CM 118/21-22	Assistant Engineer, Pwd Buildings Section, Irinjalakuda	Test On Concrete Cubes

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CM 119/21-22	Assistant Engineer, Mi Section, Thrissur	Test On Inter Lock & Terrazzo Tiles
CM 120/21-22	Assistant Engineer, Chimmony Dam Project Section No.1	Test On Concrete Cubes
CM 121/21-22	Assistant Engineer, Pwd Buildings Section No.2, Ayyanthole	Test On Concrete Cubes
CM 122/21-22	Assistant Engineer, Pwd Buildings Section No.2, Ayyanthole	Test On Concrete Cubes
CM 123/21-22	Meleth Constructions	Test On Concrete Cubes
CM 124/21-22	Assistant Engineer, Pwd Buildings Section, Chalakudy	Test On Concrete Cubes
CM 125/21-22	Magtech Engineers & Contractors	Test On Concrete Cubes
CM 126/21-22	Assistant Engineer, Pwd Buildings Section, Irinjalakuda	Test On Concrete Cubes
CM 127/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 128/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 129/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 130/21-22	Assistant Engineer, Peechi Project Section, Mannamangalam	Tests On Cement
CM 131/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. HILITE PROJECTS PVT LTD)	Tests On Cement
CM 132/21-22	Assistant Executive Engineer, IIP Irrigation Subdivision No.2, Angamaly	Cement Test
CM 133/21-22		Mix Trials
CM 134/21-22	ASSISTANT ENGINEER, Chamravattam Project Section III, Eeswaramangalam	Dimensions
CM 135/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 136/21-22	Assistant Executive Engineer, Irrigation Subdivision No.II Chalakudy	MIX DESIGN
CM 137/21-22	Ceecon Ready Mix Concrete Pvt., Ltd.	Test On Coarse Aggregates
CM 138/21-22	Ceecon Ready Mix Concrete Pvt., Ltd	Test On Coarse Aggregates
CM 139/21-22	Ceecon Ready Mix Concrete Pvt., Ltd.	Test On Fine Aggregates
CM 140/21-22	Sri. Nabeel Ahmad, Thrissur	Test On Laterite Blocks
CM 141/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Steel Test
CM 142/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Tests On Coarse Aggregates
CM 143/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Tests On Fine Aggregates

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CM 144/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Tests On Cement
CM 145/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Mix Design
CM 146/21-22	Executive Engineer, Pampa Irrigation Project Division, Chengannoor	Mix Design
CM 147/21-22	Project Specific Engineer, KITCO LTD, KOCHI (M/S Hilite Projects Pvt. Ltd.	Tests On Concrete Cubes
CM 148/21-22	Ae, Pwd Buildings Section, Irinjalakuda	Tests On Concrete Cubes
CM 149/21-22	Ae, Pwd Buildings Section, Kunnamkulam	Tests On Steel Bars
CM 150/21-22	Wapcos Ltd, (Nissy Enterprises)	Tests On Concrete Cubes
CM 151/21-22	Ae, Pwd Buildings Section, Kunnamkulam	Tests On Solid Blocks
CM 152/21-22	Assistant Engineer, Irrigation Quality Control Section, Thrissur	Tests On Concrete Cubes
CM 153/21-22	Assistant Engineer, Irrigation Quality Control Section, Thrissur	Tests On Concrete Cubes
CM 154/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 155/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 156/21-22	Assistant Executive Engineer, Srs Thrissur, Kseb Ltd	Tests On Stay Wire & Rod
CM 157/21-22	Ae, Pwd Buildings Section, Kunnamkulam	Tests On Paver Blocks
CM 158/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 159/21-22	Nirmithi Kendra , Thrissur	Tests On Concrete Cubes
CM 160/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 161/21-22	Assistant Manager, Technical Cell, Penna Cement Industries Ltd.	Mix Design
CM 162/21-22	Sastha Cement Industries, Kannara, Companypady, Thrissur	Tests On Paver Blocks
CM 163/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 164/21-22	Team Leader, Central Zone, Wapcos Ltd, (Nissy Enterprises)	Tests On Cement
CM 165/21-22	Team Leader, Central Zone, Wapcos Ltd, (Nissy Enterprises)	Tests On Cement
CM 166/21-22	Deputy Director, Instrumentation Division, Keri, Peechi	Tests On Rock Samples
CM 167/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. HILITE PROJECTS PVT LTD)	Tests On Cement
CM 168/21-22	Investigation Work, Attappilly Core Samples	Core Testing

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CM 169/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 170/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 171/21-22	Rabeesh Kumar, Quality/Materials Engineer, Cpcpl	Tests On Concrete Cubes
CM 172/21-22	Rabeesh Kumar, Quality/Materials Engineer, Cpcpl	Tests On Concrete Cubes
CM 173/21-22	Rabeesh Kumar, Quality/Materials Engineer, Cpcpl	Tests On Concrete Cubes
CM 174/21-22	Wapcos Ltd , (Nissy Enterprises)	Tests On Concrete Cubes
CM 175/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 176/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. HILITE PROJECTS PVT LTD)	Tests On Cement
CM 177/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. HILITE PROJECTS PVT LTD)	Tests On Cement
CM 178/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 179/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 180/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 181/21-22	Assistant Executive Engineer, Srs Thrissur, Kseb Ltd	Tests On Ht Stay Rods
CM 182/21-22	Sri. Jose P.K, Padayattil House, Okkal P.O	Cement Test
CM 183/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 184/21-22	Assistant Engineer Iii, Trichur Project Division, Cpwd	Tests On WMM
CM 185/21-22	Assistant Engineer Iii, Trichur Project Division, Cpwd	Tests On Gsb
CM 186/21-22	Deputy Director, Instrumentation Division, Keri, Peechi	Rock &Concrete Core Testing
CM 187/21-22	Deputy Director, Instrumentation Division, Keri, Peechi	Rock Core Testing
CM 188/21-22	General Manager, WAPCOS Cochin Special Economic Zone Project Office, CSEZ	Concrete Core Testing
CM 189/21-22	Reo Rinson A, Associate Manager, Lahanti Homes & Infrastructure Pvt. Ltd., Mannuthy.	Tests On Concrete Cubes
CM 190/21-22	Reo Rinson A, Associate Manager, Lahanti Homes & Infrastructure Pvt. Ltd., Mannuthy.	Tests On Concrete Cubes
CM 191/21-22	Assistant Engineer, Irrigation Section, Kunnamkulam	Tests On Concrete Cubes
CM 182/21-22	Assistant Engineer, Irrigation Section, Kunnamkulam	Tests On Concrete Cubes
CM 193/21-22	Team Leader, Central Zone (Nissy Enterprises)	Tests On Concrete Cubes

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CM 194/21-22	Sri. Santhoshkumar K.M, QC Lab, Sobha Ltd. Thrissur	Rock Core Testing
CM 195/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 196/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 197/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 198/21-22	Sri. Arjun M.S, Msc Forestry, KAU,	Tests On WOOD CEMENT COMPOSITE SPECIMENS
CM 199/21-22	Registrar, Kscste- Kerala Forest Research Institute	Tests On Concrete Cubes
CM 200/21-22	Project Specific Engineer, KITCO LTD, KOCHI (M/S Hilite Projects Pvt. Ltd.	Tests On Concrete Cubes
CM 201/21-22	PROJECT SPECIFIC ENGINEER, KITCO LTD(M/S. HILITE PROJECTS PVT LTD)	Tests On Cement
CM 202/21-22	Assistant Engineer, Mi Section, Chalakudy	Tests On Steel Bars
CM 203/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 204/21-22	Thiruvananthapuram Corporation	Pile Integrity Test
CM 205/21-22	Sri. Sojan M.D, Meleth Constructions	Tests On Steel Bars
CM 206/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 207/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 208/21-22	Assistant Engineer, Pampar Project Section No.3, Marayoor	Tests On Steel Bars
CM 209/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 210/21-22	Assistant Engineer, Pwd Buildings Section, Chalakudy	Tests On Concrete Solid Blocks
CM 211/21-22	Assistant Engineer, Pwd Buildings Section, Chalakudy	Tests On Steel Bars
CM 212/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 213/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 214/21-22	Assistant Engineer, Chimmoni Dam Projest Section No.1	Tests On Steel Bars
CM 215/21-22	Assistant Engineer, Chimmoni Dam Projest Section No.1	Tests On Concrete Cubes
CM 216/21-22	Assistant Engineer, Chimmoni Dam Projest Section No.1	Tests On Concrete Cubes
CM 217/21-22	M/S NAVERA Builders Pvt Ltd, 1st Floor Tharappel Complex, Kolazhy, Thrissur	Tests On Concrete Cubes
CM 218/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes

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CM 219/21-22	Project Engineer-39, KIIDC (M/S Paulose George Constructions)	MS Sheet
CM 220/21-22	Assistant Engineer, Lsgd Section, Muriyad Gp	Tests On Paver Blocks
CM 221/21-22	Assistant Engineer, Mi Section, Tripunithura	Tests On Steel Bars
CM 222/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 223/21-22	Assistant Engineer, Pwd Buildings Section, Mg Kavu	Tests On Steel Bars
CM 224/21-22	Registrar, KSCSTE- Kerala Forest Research Institute	Tests On Concrete Cubes
CM 225/21-22		
CM 226/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 227/21-22	Assistant Engineer, Irrigation Section, Enamakkal	Tests On Cement
CM 228/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 229/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Solid Blocks
CM 230/21-22	M/S NAVERA Builders Pvt Ltd, 1st Floor Tharappel Complex, Kolazhy, Thrissur	Tests On STEEL BARS
CM 231/21-22	Assistant Engineer, Public Health Section, Kerala Water Authority, Peechi	Tests On Concrete Cubes
CM 232/21-22	Deputy Director, Instrumentation Division, Keri, Peechi	Rock Core Testing
CM 233/21-22	M/S Builtech Gateway Ventures LLP, Builtech Foundation, Chittur Road, Palakkad	Tests On STEEL BARS
CM 234/21-22		Coarse Aggregates
CM 235/21-22		Fine Aggregates
CM 236/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 237/21-22	Assistant Engineer, Pwd Buildings Section, Kodungallur (Ap Constructions)	Tests On Paver Blocks
CM 238/21-22	M/S Asian Designer Tiles, Pavers & Flyaash Bricks, Coimbatore	Tests On Paver Blocks
CM 239/21-22	M/S Asian Designer Tiles, Pavers & Flyaash Bricks, Coimbatore	Tests On Paver Blocks
CM 240/21-22	M/S Asian Designer Tiles, Pavers & Flyaash Bricks, Coimbatore	Tests On Paver Blocks
CM 241/21-22	Assistant Engineer, Kuttyadi Irrigation Project Operation & Maintenanance Section-A, Peruvannamuzhy	Tests On Steel Bars
CM 242/21-22	Assistant Engineer, Pwd Bridges Section, Thrissur (Contractor: Joji Joseph)	Tests On Steel Bars
CM 243/21-22	Assistant Engineer, Pwd Bridges Section, Thrissur	Mix Design

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CM 244/21-22	(Contractor: Joji Joseph)	Mix Design
CM 245/21-22	Nabeel Ali, Site Engineer, Pmr Constructions	Tests On Concrete Cubes- 7th Day
CM 246/21-22		Tests On Concrete Cubes- 28th Day
CM 247/21-22	Nabeel Ali, Site Engineer, Pmr Constructions	Tests On Concrete Cubes
CM 248/21-22	The Project Engineer-39, KIIDC, Knnur (M/S Paulose George Constructions)	Tests On Sheet Piles
CM 249/21-22	The Assistant Engineer, Irrigation Quality Control Section, Thrissur	Tests On Steel Bars
CM 250/21-22	Sri Ibrahimkutty, Star Plaza Site, Shornur Road, Thrissur	Tests On Concrete Cubes
CM 251/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 252/21-22	Team Leader, Central Zone, Wapcos Ltd, (Fins Engineers & Contractors)	Tests On Concrete Cubes
CM 253/21-22	Assistant Engineer, Pwd Special Buildings Section, M.G Kavu, Thrissur	Tests On Concrete Cubes
CM 254/21-22	Assistant Engineer, Minor Irrigation Section, Kodungalloor	Tests On Concrete Cores

The lab is equipped with NDT instrument for Pile Integrity Test and has done following Pile Integrity Tests.

1. Residential Training Centre at Attukal, Thiruvananthapuram Corporation (124nos).

2. KRP Flood Damage 2018 – Urgent Rectification works of breach at LBMC near Ch:4800m (9nos).

3. LAC-ADS-Construction of a SWE/VCB cum Tractor path across Poorapuzha at Parayil in Parappanangadi Municipality in Malappuram District (9nos).

Nondestructive tests like core compressive strength are being conducted to check the strength of concrete of the existing structures.

1. Testing of existing concrete components at the site Regulator cum Bridge Attappilly, Thrissur.

As part of research, the following works were carried out.

1. Testing of mineral sand collected from Thottappilly spillway
2. Suitability of soil collected from Eri's, Palakkad as fine aggregates for the purpose of concrete.

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SOIL MECHANICS & FOUNDATIONS DIVISION

INTRODUCTION

Soil mechanics Division has been working under the Joint director, Construction Materials and foundation Engineering (CM & FE), KERI headed by Deputy Director. Soil Mechanics & Foundations Division is one of the sub units of Kerala Engineering Research Institute (KERI) basically engaged in soil testing.

Soil, the most unpredictable of all engineering materials also happens to be the all-important material in civil engineering because all structures need to be founded on earth. In addition to being the founding medium, soil is also used as a material of construction. As in the case of other materials, properties of soil cannot be generalized since basically soil is a combination of different constituents having different properties. Therefore the study of the technical and structural aspects of soil is all important.

Major difficulties encountered in foundation work are due to the nature of soil. The investigation for any foundation engineering problem may range from a simple examination of soil to a detailed study of the soil and ground water by means of bore holes and laboratory tests on the materials encountered. The extent of the work depends on importance and foundation arrangement of structures, the complexity of the soil conditions and already available information of existing foundations on similar type of soils.

The physical characteristics of soils can be investigated by means of laboratory tests on samples taken from boreholes or trial pits. Results from lab tests can be used to derive important parameters in the design of substructure. The results of shear strength tests can be used to calculate the ultimate bearing capacity. Soil parameters so obtained by means of investigations can be utilized to design safe structures.

Soil Mechanics Laboratory under K.E.R.I. is fully equipped to determine the index as well as the engineering properties of soil samples. The soil mechanics laboratory undertakes work from Government agency and private agencies.

During investigation, soil samples are collected and tested in the laboratory, for finding out index properties and engineering properties like Maximum Dry Density, Optimum Moisture Content, Permeability, Shear strength parameters, Consolidation and Swelling characteristics and relevant

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parameters are furnished to design the proposed structures. The laboratory is assisted by the Instrumentation Division which is equipped with field testing equipment for boring to collect undisturbed soil samples.

Soil samples received from various projects of Irrigation Department, PWD Roads and Buildings, CPWD, KFRI, Kerala Agricultural University, Panchayati Raj institutions, Power Grid, WAPCOS, CPWD Kerala State Electricity Board, Housing Board and Non-Government bodies are being tested as per the codes of Bureau of Indian Standards.

The Lab contributes healthy revenue every year to the Government through various tests conducted for clients. The Lab is also functioning as a training centre of the Irrigation Department and providing training programmes and refresher courses for the benefit of department engineers. Now the Lab is on the process of getting assessment and accreditation of Testing and Calibration Laboratories by the National Accreditation Board Testing and Calibration Laboratories (NABL) in accordance with the international standards. Also research activities are being conducted at this division.

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Fig. Soil Mechanics & Foundations division office

The important equipments available in the laboratory are

i) **Hydrometer test with accessories**
ii) **Atterberg's limit devices**
iii) **Direct Shear apparatus**
iv) **Automatic Compactor**
v) **Light and Heavy compaction testing apparatus**
vi) **Laboratory CBR test apparatus**
vii) **Digital soil cone penetrometer**
viii) **Constant head permeability test apparatus**
ix) **Variable head permeability test apparatus**
x) **Tri-axial Shear Apparatus**
xi) **Unconfined Compression Test Apparatus**
xii) **Consolidation Apparatus**
xiii) **Sample extruder**
xiv) **Standard set of sieves**

Modernizing the lab will come true with the addition of modern Instruments. This lab is equipped with Engineering Seismograph and is used for subsurface characterization by seismic refraction method. Seismograph is also used for Seismic Tomography Survey to determine compactness in dams.

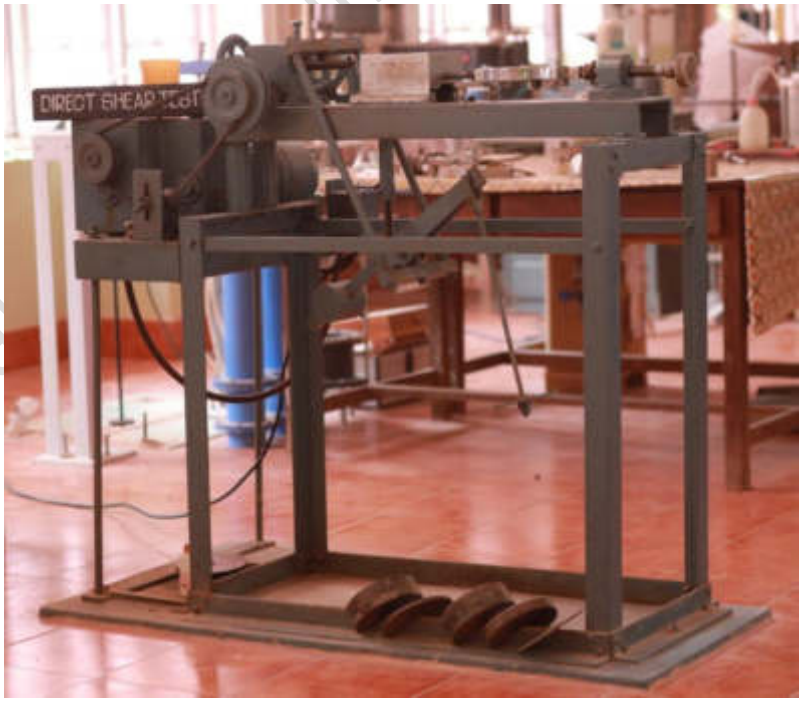


Fig. Direct Shear Apparatus

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Fig. Static Triaxial Testing Apparatus



Fig .Digital Soil Cone Penetrometer

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Fig. Consolidation Test Apparatus

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Fig. Unconfined Compression Test Apparatus

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Fig. Compaction Test Apparatus



Fig. Engineering seismograph

WORKS EXECUTED DURING THE YEAR 2021-2022

Soil samples were tested from various projects of Irrigation department, other departments and private agencies. During the year 2021-22, more than 1000 samples were tested in 30 different works for revenue of about Rs. Seventeen lakh/- (Rs.17,00,000/-) and the details of works are given below.

Sl No	Name of Work
1	Testing of Sand Samples – Greenline Constructions.
2	Soil Investigation for the proposed protection works at Shanmugham Canal in Poommangalam Panchayath, Thrissur Dt.- Handling over soil samples for lab Test.
3	Soil Investigation work for the construction of footbridge to Vattamala Murugan Temple on Kalpathy River in Palakkad Muncipality Ward No.1
4	Desitation in PC Canal from Orumanayoor to Chavakkad Reach
5	IWT-Desilting and side protection of Thiruvanchikulam canal from Ch.0 to 300m in Kodungallur taluk PC canal Ch.243.50 km
6	Soil Investigation work of obstructions to flow of Periyar River at Railway Bridge to Vallarpadam container terminal near Vaduthala, Ernakulam
7	Creation of Basic Infrastructure Facilities for Arts & Science Colleges-reg — Performing various soil tests for Sri. Achutha Menon College, Thrissur

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8	Peechi Scheme - A Permanent solution at breached portion of Left bund main canal bund between ch.19/600 km and 20/600 km -reg (Mannamangalam)
9	Augmentation of infrastructure facilities at Kerala Varma College, Thrissur - Testing of soil sample
10	Soil Investigation for various works of irrigation Department – Soil Investigation for RCB at Attapilly
11	Testing for Geotechnical parameters of Soil Samples – KFRI, Peechi
12	Testing of Sand Samples – Greenline Constructions
13	Desilting Peringad puzha at the downstream of Idiyanchira regulator cum bridge in Thrissur District
14	Testing of soil samples for the construction of Zoological Park at Puthur, Thrissur
15	Soil Investigation for various works of Irrigation Department – Soil Investigation work at Chamravattom
16	Analysing of Geotechnical properties of soil sample collected from Idukki region
17	Testing of dynamic properties of soil samples – KAU – ARS, Chalakkudy
18	Soil Investigation for Pamba River
19	Desiltation of Manimalayar - Topographical Investigation and Soil Investigation
20	Soil Investigation for Meenachilar
21	Soil Investigation for Achankovilar
22	Soil Investigation for Muvattupuzha
23	Soil Investigation for Thatanampully LIS in Kulukkallur GP, Palakkad
24	Soil Testing for dredged material from the premises of IWT Terminal at Maradu
25	Sedimentation study of Maniyar Reservoir using IBS and Sub bottom Profiler – Testing of Soil Samples
26	Sedimentation study of Kallada Reservoir using IBS Sub bottom Profiler – Testing of Soil Samples
27	CEFS- Data Collection of Design Parameters for urgent protection works at Erosion Hotspots along Kerala Coast – Hotspot Kodungallur
28	Soil loss estimation and monitoring in the highland ecosystems of Kerala for effective conservation Planning - Testing of Soil Samples from Thrissur Region
29	Cluster Number – Creation of Basic Infrastructure Facilities for Arts & Science Colleges-reg – Performing Field Density test of Soil. Panambilly Memorial Govt College Canteen Block reg:-

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30	Soil Investigation works to the Reconstruction of Chakkumkandam salt water exclusion sluice in Chavakkad Municipality

In addition to above, Soil Mechanics & Foundations Division has conducted following works during the financial year 2021-22.

1. **Seismic Tomography Study on Dams -** The ageing and degradation of dam structures is an inevitable problem and its consequences on the safety of the structure are important. Seismic Tomography technique is generally used for detecting the deteriorated zones inside the dam (masonry and concrete) body. Seismic tomography survey was conducted at Chimoni Dam on a study basis during March 2022 and data analysis is going on.

2. **Fundamental Studeis on Seismic Refraction Survey for Subsurface Profile Investigation -** Seismic refraction survey is a reconnaissance survey used to determine wave propagation velocities through various soil layers in the field and to obtain the thickness of each layer. This method is based on the fact that seismic waves have different velocities in different types of soils (or rock). It is a widely used method for the determination of bedrock depth. Seismic refraction survey was conducted on a study basis using Engineering Seismograph at Attapilly and Thathanampully site during current financial year. In this study an attempt was made to validate the seismic refraction survey results with borehole data.

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INSTRUMENTATION DIVISION

INTRODUCTION

Instrumentation Division acts as a mobile unit to conducts various soil investigation works under the Construction Materials and Foundation Engineering (CM&FE) Division, KERI Peechi. The most important part of any building or hydraulic structure is foundation which is the lowest part of a structure. It transmits the load to the soil below. So the quality of the soil on which the foundation is resting need to be determined precisely. To understand the soil, soil exploration is need. Site investigation is essential for judging soil suitability for proposed engineering work and preparing adequate design. It also helps for selecting suitable and economic construction materials as well as methods. Site exploration reveals reliable information about soil and ground water which will help the Engineer for an intelligent planning.

Bore hole drilling – Making Bore holes is commonly used method for field investigations and they are executed by various devices ranging from simple hand operated augers to drilling machines. Instrumentation division is in possession of two rotary type, clayx type drilling machines. These machines are used for drilling in soil, soft rock and hard rocks for a depth of 50 m to 60 m. The samples collected are transferred to SM & F Division for carrying out various tests in soil for finding the engineering properties.

Soil samples are taken from sites on request and are transferred to Soil Mechanics and Foundations Division for testing. The following field tests are conducted by this division;

1. Standard Penetration Test.
2. Collection of disturbed and undisturbed soil samples by hand auger and machine boring.
3. In situ Vane Shear test

The important equipments available in the Division are

- Equipments for hand augering.
- In situ Vane shear test apparatus
- Rotary type Diesel boring plant - 2 Nos.

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Fig 1. Boring Using Rotary Calyx Drilling Machine



Fig 2 - Insitu Vane shear Apparatus

WORKS EXECUTED DURING THE YEAR 2021-2022

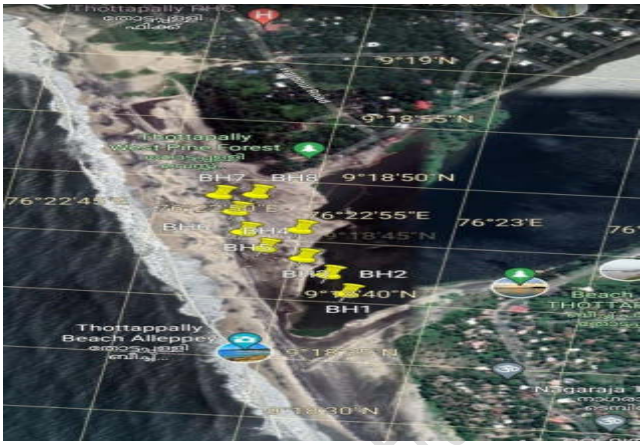
1. Investigation Works At Thottapally Pozhi Mouth

Director, KERI was instructed by the Additional Chief Secretary , to conduct analysis for the mineral sand in the samples received from the Thottapally Pozhi . Sand bar formed at the mouth of

Pozhi Samples were collected from the different locations, from pozhi such that representative samples of the area was collected and transferred to IREL Labs for testing to find the mineral

content and percentage composition of the following minerals Ilemenite, Rutile, Zircon, Silimanite.





2. **Soil Investigation Works of Obstructions to flow of Periyar River at Railway Bridge to Vallarpadam container terminal near Vaduthala Ernakulam** .

To determine the quality of the sediments obstructing the flow of river on either side of Railway bridge to Vallarpadam container terminal near Don Bosco boat jetty at Vaduthala. The samples were collected from an area of 1 Km upstream and 2.20 Km downstream of the Railway bridge. . The undisturbed soil samples were collected in sampler tube of 5m length with end attachments. Out of 30 bores holes, 13 nos. of boreholes were explored in the upstream side and other 17 nos. of bore holes in the downstream side of the river with reference to the railway bridge. One Bore hole using Rotary Calyx drilling machine was carried at the prescribed bund position, which was laid for the construction of railway bridge. The boring was extended up to a depth of 17m. Soil samples were transferred to SM Lab for testing. Work was undertaken using amount in the Action Plan , which was reserved for the soil Investigation of various works for Irrigation department – 1,85,058/-



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3. Soil Investigation for Reconstruction of Sunken Portion of Left Bank Retaining Wall of Chamravattam RCB.

As per the request of the Executive Engineer, Project division, Eswaramangalam dtd. 30/10/2021, Soil investigation work was carried out at the left side downstream of the Chamravattam RCB to investigate the causes of tilt and sink to the existing retaining wall. The retaining wall failure was seen in the left bank (downstream) to an extent of 89.30m from the regulator. Three boreholes at a 30m interval (Approximately) are suggested to be excavated near the sunken retaining wall.Works was taken in action plan of KERI – Soil Investigation of various works of Irrigation department – 1,35,560/- .





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4. Soil Investigation for Attappilly RCB

Attappilly Kadavu regulator cum bridge across Kurumali river connects Mattathur and Varandarappilly Grama Panchayaths of Thrissur district . Road near the left bank approach road of subject work has subsided on 04.06.2021 and subsequently, the bridge was closed for traffic. As per the instructions of the Director, KERI vide email dated 3/11/2021, Soil Investigation works were entrusted to this division. 8 bore holes were located along the various areas along the regulator to investigate the nature of the soil profile . Work was undertaken in Action plan of KERI . Soil Investigation works of irrigation department – 1,78,668/



5. **Soil Investigation for aqueduct of Thathanampully LIS in Kulukkallur GP ,Palakad District** .

As per the request of The Executive Engineer, MI Division, Palakkad vide Lr. No.D3-General/2019-20, the estimate is prepared for the soil investigation for the aqueduct of Chundampetta branch canal of the scheme.In the site there are existing 23 pillars of spacing 4.10 m each. New set of pillars are to be constructed for the new aqueduct proposed between the two canals .19 no of Bore Holes were drilled and soil samples were transferred to SM &FE Division for testing .Work was carried in the head Investigation of major Irrigation Schemes – 4700-80-005-99-02-00-V and total amount expended as 6,31,258/-



6. Desiltation of Muvattupuzha River.

Muvattupuzha River is one of the important rivers in Ernakulam District of Kerala. This river is the union of three rivers - Thodupuzha, Kaliyar and Kothamangalam at Thrivenisangamam at Muvattupuzha. Sediment deposits were found in the Kaliyar river in the following locations, Purapuzha location of Kodikulam Panchayath, Thennathoor Chelakkadavu Bridge of Kodikulam Panchayath. Muvattupuzha town was flooded during the last to floods of 2018 and 2019. Crossection survey of the rivers was carried from Thriveni sangamam to Kayanad check dam.

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Upstream portion from Thrivenisangamam towards kaliyar river and Thodupuzha river Total length of the stretch under study is 8.704 km. Area was surveyed and representative samples were collected and tested for analysis.





7. Investigation works to the reconstruction of Chakkamkandam salt water exclusion sluice in Chavakkad Muncipality under supervision of KERI

Supervision works were carried by KERI, for the reconstruction of Chakkamkandam salt water exclusion sluice. The old sluice has to be demolished and the 4 bore holes were drilled near the existing sluice to get the soil profile of the area. Soil samples were transfeered to SM &FE Division for further testing and analysis.





Think of Solutions

a. Load Testing of Attappilly Regulator cum Bridge
b. Topographic and soil investigation near Railway Bridge to Vallarpadam Container terminal at Vaduthala
c. Possibility of using Bottom Sediments from Periyar River at Vaduthala for Agricultural Applications
d. Proposal for Rectification of Subsided Left Bank Approach Road of Attappillikkadavu Regulator cum Bridge
e. Environmental Management Plan for desiltation of Kambalathara Eri, Palakkad
f. Environmental Management Plan for desiltation of Venkalakkayam Eri, Palakkad
g. Environmental Management Plan for desiltation of Kunnampidari Eri, Palakkad
h. Engineering Investigations for the Rectification of Existing Regulator cum Bridge at Idiyanchira
i. Forensic Engineering Investigations And Proposals For Rectification Of Attappillikkadavu Regulator Cum Bridge
j. Qualitative Assessment Of Sediment Deposits In Rivers Draining Into Vembanad Lake
k. Quantitative Assessment Of Sediment Deposits In Rivers Draining Into Vembanad Lake

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REPORT OF LOAD TESTING OF ATTAPPILLY REGULATOR CUM BRIDGE

ABSTRACT

Attappillykkadavu regulator cum bridge across Kurumaliriver connects Mattathur and Varandarappilly Grama Panchayaths of Thrissur district. Subject work was started on 24-6-2008 as per agreement no. 08/SE/ICC/08-09 dated 12-6-2008. However, the work was terminated without risk and costs vide order no: D6-4373/1995 dated 18.07.2014, since the period of NABARD assistance ended. At this juncture, downstream apron was not constructed. The balance work was arranged as per Agreement no: 10/SE/ICC/2016-17 dated 24.09.2016. This work could not be completed because of the issues in the original terminated work in the year 2014. Meanwhile, road near the left bank approach road of subject work has subsided on 04.06.2021 and subsequently, the bridge was closed for traffic. Then as per the Government meeting held on 16.08.2021, the Additional Chief Secretary, Water Resources Department Govt. of Kerala has directed K.E.R.I. to conduct load test to ensure the serviceability of existing bridge portion of RCB before 31.08.2021. Accordingly, load test was carried outon 25.08.2021 (conforming to relevant IRC Standards and Indian Standards), with the support of Honorable MLA and in the presence and support of Panchayath authorities and public.



Fig.1- Subsidence of Approach road of Attappillykkadavu Regulator cum bridge

METHODOLOGY

Load testing for rating and posting was conducted according to IRC: SP: 37-2010 Guidelines for evaluation of load carrying capacity of bridges. As per section 5.1 of this code, there are three methods for rating of bridges as per IRC: 6-Loading standards for bridges, namely, a) Analytical method, b) Load testing method and c) Correlation method. To check the serviceability aspects, it

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was a requirement to rate the bridge for the maximum load which it can carry and to post for this to regulate the traffic through this bridge. Hence, load testing method as mentioned above was resorted to. Relevant details of IRC code is attached herewith.

Prior to load testing, a theoretical analysis was done to find the deflection of deck slab of the bridge, for serviceability limit state as per IRC:6 and IRC SP:51, and also to compare it with the deflection during testing so as to check for acceptance criteria mentioned subsequently.

Deck slabof the bridge was modelled in STAADPro software with the loading as pe IRC: 6. Applicable loads as per section 201.1 of this code are IRC Class A loading and IRC class 70 R loading.

This bridge has 8 spans with clear span of 6 m and width of pier supporting this slab is 1.5 m. Depth of reinforced concrete portion of deck slab is 500 mm. As per IRC 112-2019, effective span is the smaller of centre to centre distance between supports and the sum of clear span plus effective depth. As the support width is 1.5 m, effective span is the sum of clear span plus effective depth.

Effective span = 6+0.45

= 6.45 m

However, effective span is considered as 6.5 m for the purpose of analysis in STAADPro using plate element.

Various loads are as given below.

Dead loads

Thickness of wearing coat is 100 mm.

Dead load of wearing coat = $0.1\times24 = 2.4 kN/m^2$

Equivalent Dead load of parapet/m = $(0.2\times0.2\times1.2+6\times0.1\times0.15\times0.5)\times25$

=2.3 kN/m

As the length of plate element considered for analysis along span is 0.25 m (Half the depth of reinforced portion of deck slab of 0.5 m), point load on outside edge of plate element = 2.3×0.25

= 0.58 kN

(Parapet consists of a post connected by beams)

Live loads

Live loads are in the form of wheel loads as given below.

There are three types of live loads being checkedfor;

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1) IRC class A loading,
2) IRC class 70R loading, as per IRC 6,
3) The most likely heaviest vehicle that can ply on this road (Here, it is the vehicle load with GVW of 38.65tonnes).

Fig 2 to 4 shows details of loading patterns as per respective IRC codes and Fig. 5 gives the actual most probable heavy weight vehicle being used for load test and the details of loading on the bridge. Similar to this loading, IRC class A and class 70 R loading was applied on to the bridge, ie., point load equidistant from the centre, as per fig.5. However, as for loadings of class A and commercial vehicles, the ground contact area of tyresare known and hence pressure values are applied in STAAD model.

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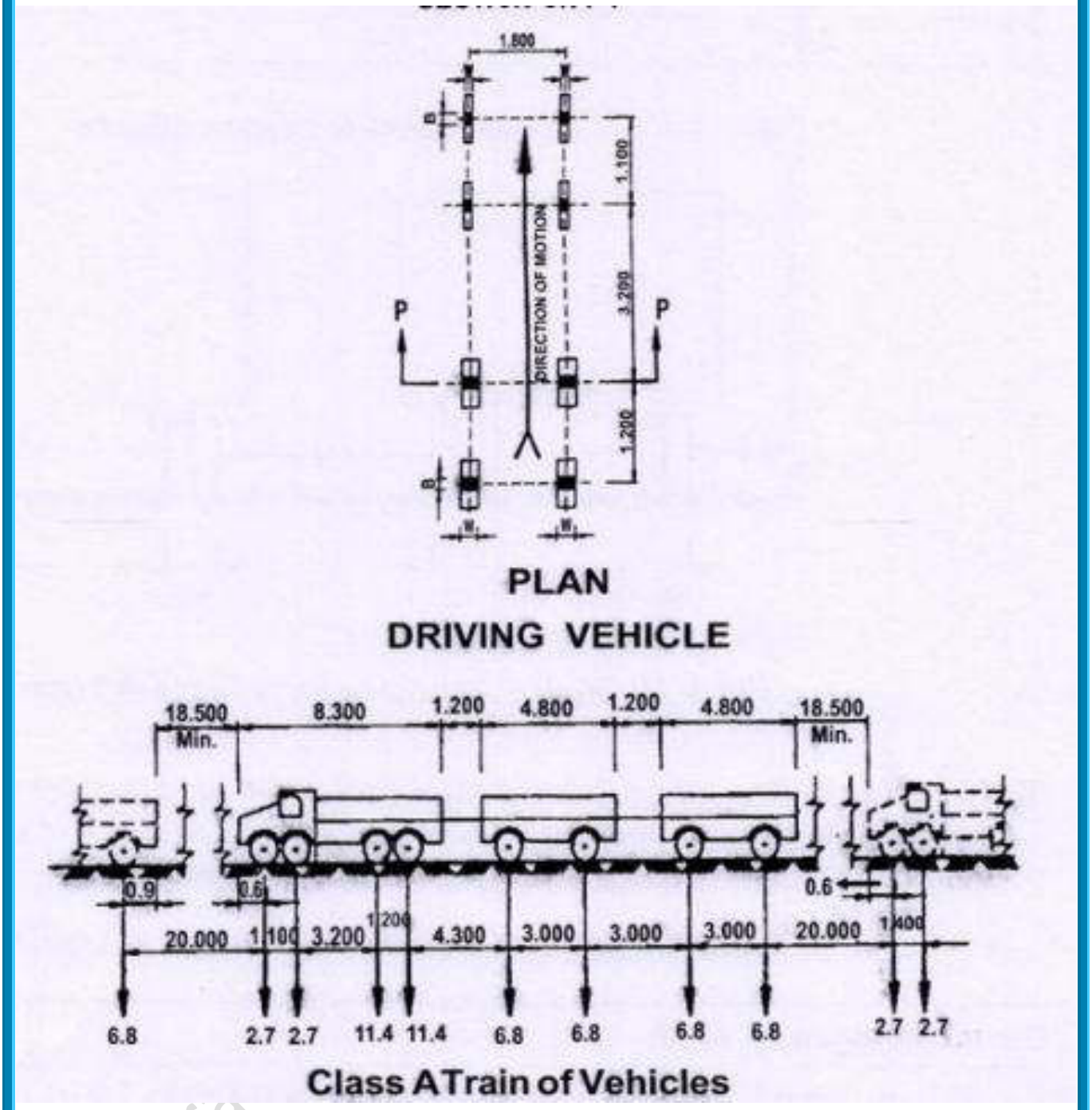


Fig.2- Class A train of vehicles as per IRC loading

Table 2: Ground Contact Dimensions for Class A Loading

Axle load (tonne)	Ground contact area	
	B (mm)	W (mm)
11.4	250	500
6.8	200	380
2.7	150	200

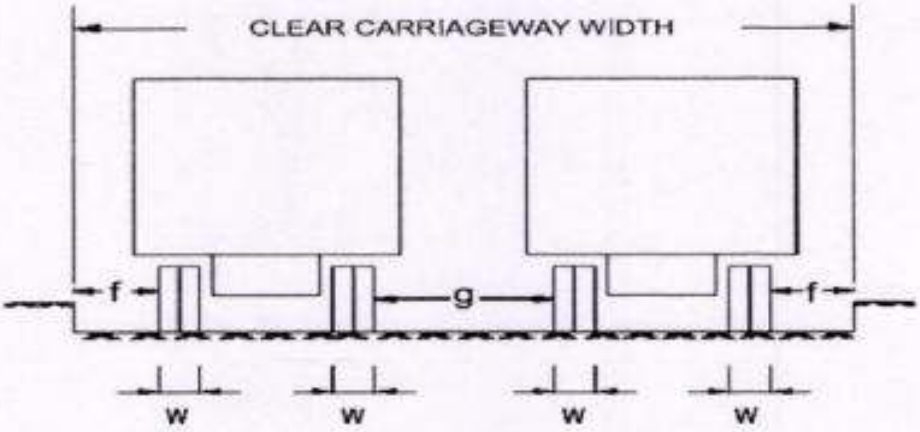


Fig.3: Minimum Clearance for 2 Class A Train Vehicles

5) *The minimum clearance, f, between outer edge of the wheel and the roadway face of the kerb and the minimum clearance, g, between the outer edges of passing or crossing vehicles on multi-lane bridges shall be as given in* ***Table 3****.*

Table 3: Minimum Clearance for Class A Train Vehicle

Clear carriageway width	g	*f*
5.3 m(*) to 6.1 m(**)	Varying between 0.4 m to 1.2 m	150 mm for all carriageway width
Above 6.1 m	1.2 m	

Fig. 3- Ground contact dimensions for IRC class A loading and placement of vehicles on road

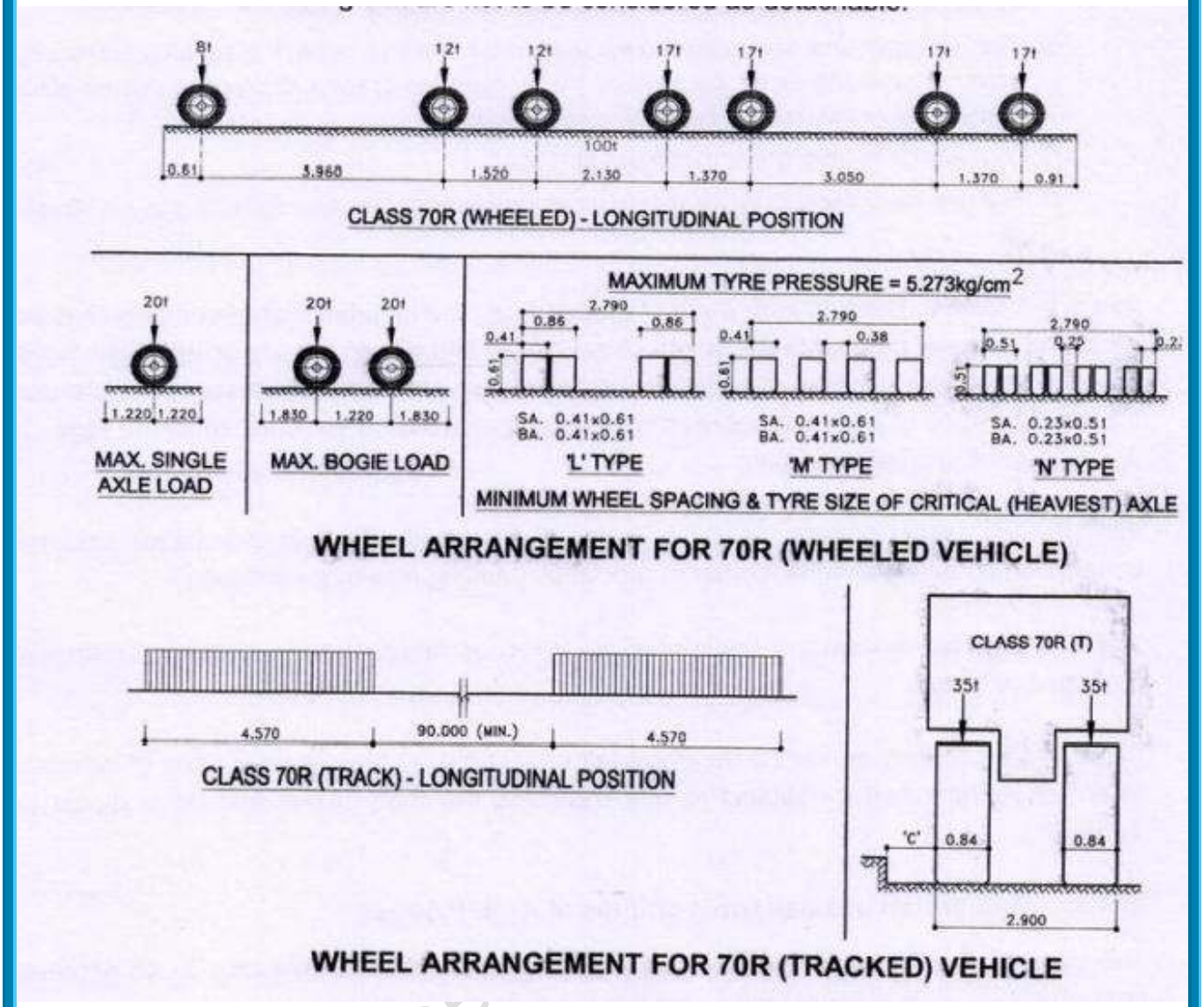


Fig. 4- Details of class 70 R loading as per IRC 6

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All dimensions in m.

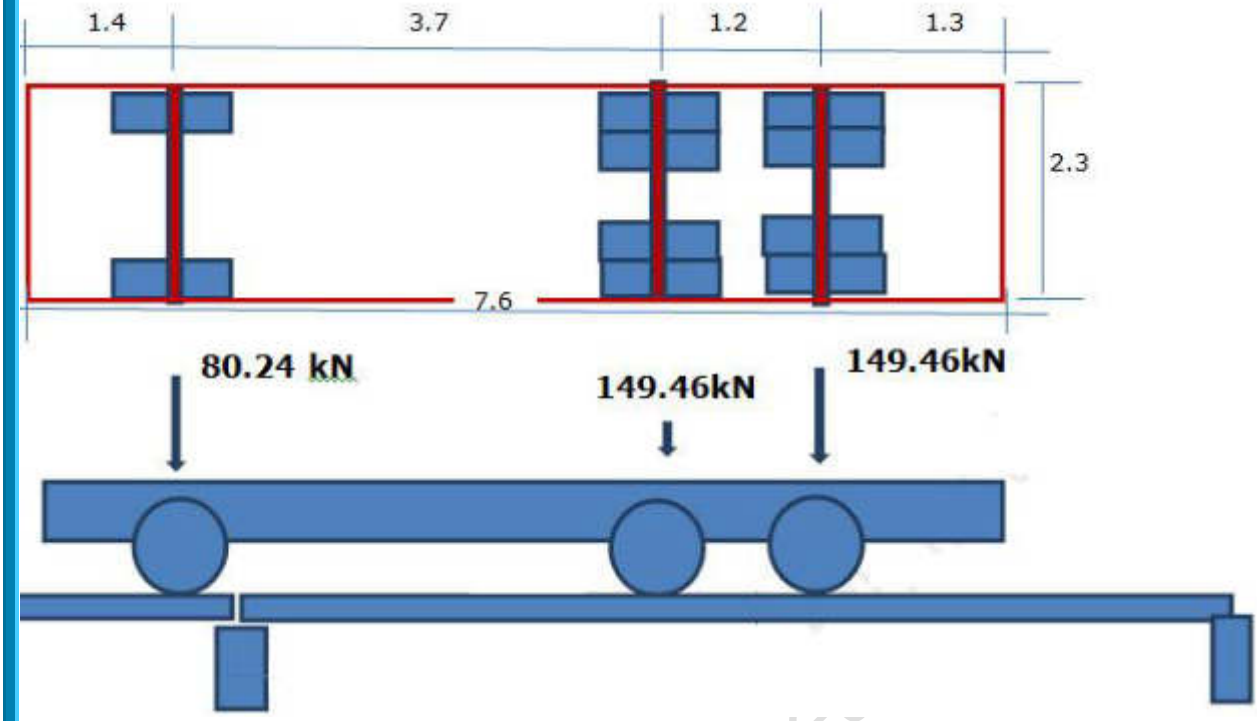


Fig. 5- Details of commercial vehicle used for load test of Attappillykkadavubridge at maximum bending moment case



Fig. 6- Details of Test vehicles used for load test at Attappillykkadavubridge

In class A loading, the axle load of 11.4 t (111.83kN) is applied symmetrical to the centre of the beam as shown in fig. 5., in the STAAD model.

Point load to each wheel of axle = 111.83/2 = 55.91kN

Ground contact area for this load is 0.25×0.5 m from fig. 3.

Pressure to be applied to plate element of STAAD model = 55.91/(0.25×0.5)

= 447.34kN/m^2

Consider IRC Class 70R loading.

Consider maximum single axle load of 20t (196.2kN).

Consider also maximum bogie load of 20t each spaced at 1.22 m apart as seen from fig. 4.

Single point load for L type loading = 196.2/2 = 98.1kN

Single point load for M type loading = 196.2/4 = 49.05kN

Single point load for N type loading = 196.2/4 = 49.05kN

These loads are applied as point loads, sincetyre ground contact length in the direction of motion is not given.

The position of these loads are applied as per fig. 4.

Since loading for M and N types have same position, only M type is considered.

IRC 70R Wheel loading (ref. fig. 4).

Total load on one train = 343.35kN

19 nodes are required to transfer this load to middle 4.57 m of bridge to get maximum bending moment

Load on each node = 343.35/19 =18.07kN

Load details for maximum heavy weight probable to run on the bridge as given in fig. 5are as following.

Gross weight = 38650 kg

Weight considering only front axle = 8180 kg = 8180×9.81/1000 kN

= 80.24 kN

Weight considering only back axles = 30470 kg

= 30470×9.81/1000

= 298.91 kN

(30.47 tonne)

Weight on each of back axle (ref. fig. 5) = 298.91/2

= 149.46 kN Weight on each of wheel of back axle

= 149.46/2 = 74.73 kN

Pressure to be applied to plate element of STAAD model = 74.73/(0.25×0.5)

= 597.84kN/m^2

Above loads were applied to STAAD model.

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Load positions of commercial vehicle loading for load test is given in fig. 7 below.

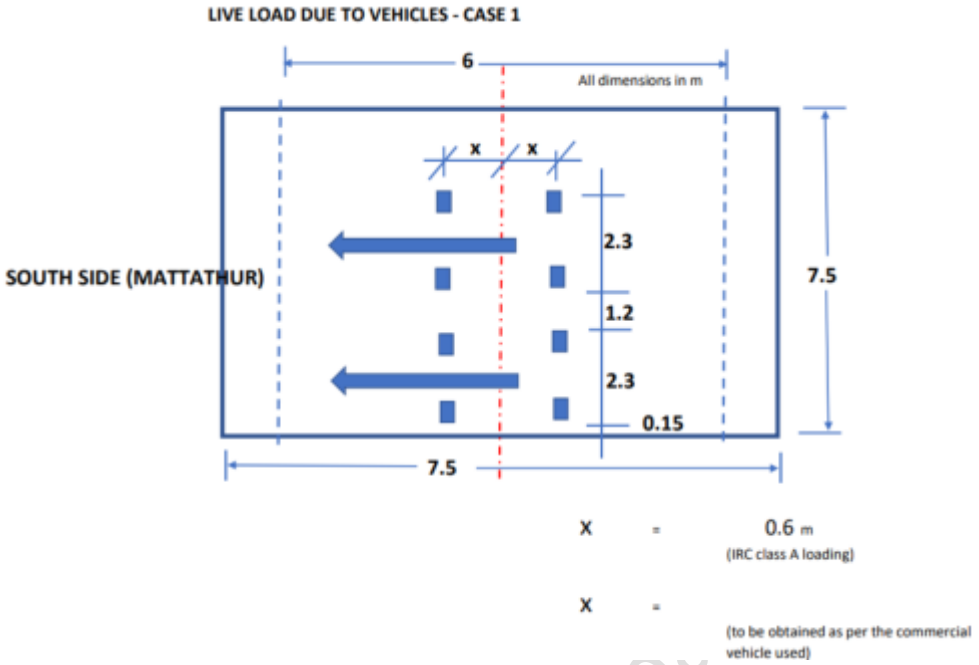


Fig. 7- Load positions for load test considered as per IRC 6

3D model of the plate model is given in fig. 8. Dimensions of the model are given in fig. 9 and a typical loading using IRC class A loading is given in fig. 10.

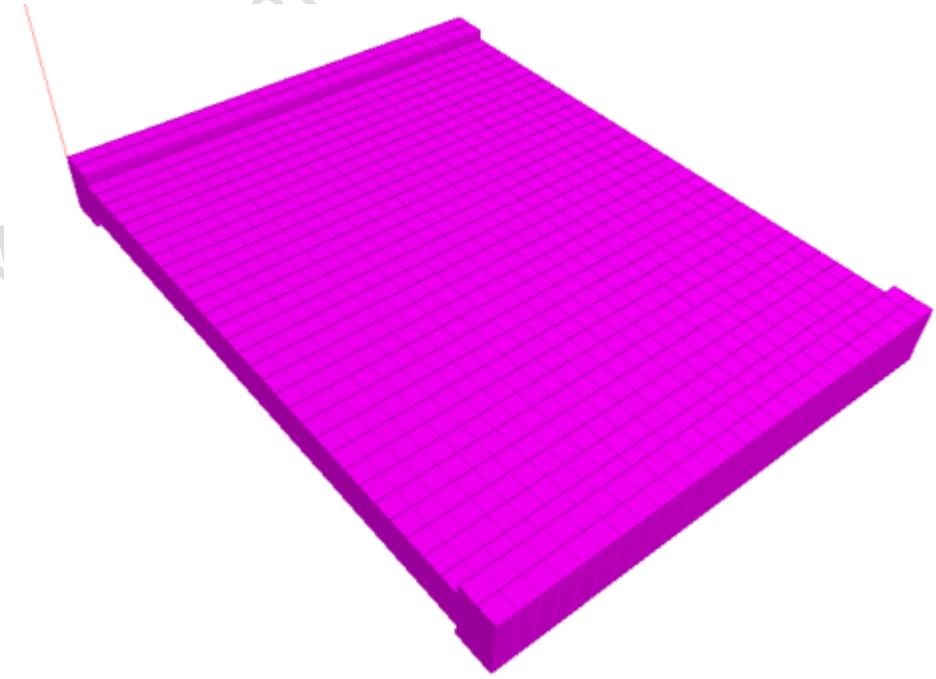


Fig. 8- 3D model of the STAAD model

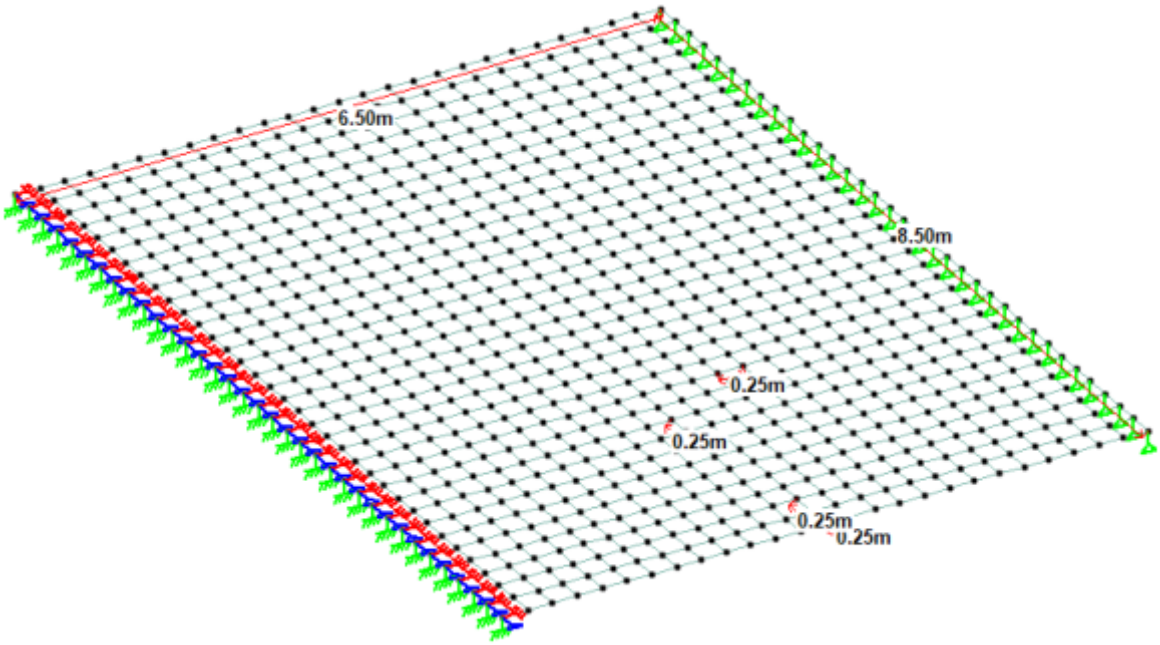


Fig. 9- Dimensions of the model

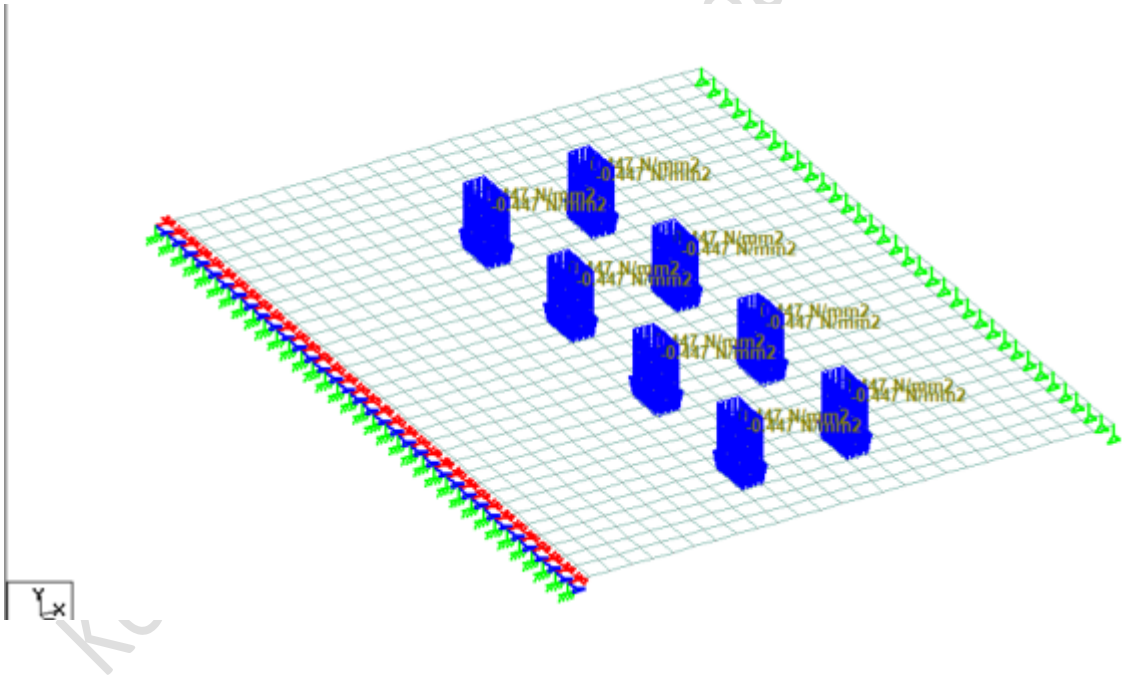


Fig. 10- Typical application of IRC class A loading

Maximum node displacement summary for the commercial vehicle proposed to do load test is given in table 1.

Table 1- Node displacement summary for commercial vehicle of GVW 38.65t

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	1	14:CV -GVW 3	**0.000**	0.000	0.000	0.000	0.000	0.000	-0.000
Min X	1	14:CV -GVW 3	**0.000**	0.000	0.000	0.000	0.000	0.000	-0.000
Max Y	3	15:CV-GVW 3E	0.000	**0.000**	0.000	0.000	-0.000	0.000	0.000
Min Y	340	15:CV-GVW 3E	0.000	**-1.439**	0.000	1.439	0.000	0.000	-0.000
Max Z	1	14:CV -GVW 3	0.000	0.000	**0.000**	0.000	0.000	0.000	-0.000
Min Z	1	14:CV -GVW 3	0.000	0.000	**0.000**	0.000	0.000	0.000	-0.000
Max rX	178	14:CV -GVW 3	0.000	-1.054	0.000	1.054	**0.000**	0.000	0.000
Min rX	772	15:CV-GVW 3E	0.000	-1.054	0.000	1.054	**-0.000**	0.000	0.000
Max rY	1	14:CV -GVW 3	0.000	0.000	0.000	0.000	0.000	**0.000**	-0.000
Min rY	1	14:CV -GVW 3	0.000	0.000	0.000	0.000	0.000	**0.000**	-0.000
Max rZ	380	15:CV-GVW 3E	0.000	-0.000	0.000	0.000	-0.000	0.000	**0.001**
Min rZ	355	15:CV-GVW 3E	0.000	-0.000	0.000	0.000	-0.000	0.000	**-0.001**
Max Rst	340	15:CV-GVW 3E	0.000	-1.439	0.000	**1.439**	0.000	0.000	-0.000

Maximum displacement (deflection of the bridge) obtained is 1.439 mm from table 1.

While doing load test, this displacement is regarded as the baseline for control of loading to avoid failure or excessive deflection of the deck slab, and to ensure safety of the personnel doing the test.

LOAD TEST

Load test is done as per IRC SP: 37 and IRC SP:51. Guidelines are given in the screen shot below, from IRC SP: 37 (Guidelines for evaluating load carrying capacity of bridges).

8.5.4 The test load shall be applied in stages following the given values 0.5W, 0.75W, 0.90W, 1.0W, where "W" is the gross laden weight of the test vehicle.

8.5.5 For each stage, the correspondingly loaded test vehicle shall be brought to the intended/marked position and observation of deflections shall be made immediately on loading and after five minutes.

The test vehicle should be taken off the bridge and instantaneous deflection recovery and deflection recovery 5 minutes after the removal of the load should be noted.

8.5.6 After the load placement, observation shall also be made for development of any new crack and widening of the existing ones.

Important points of load test are given in rectangular boxes. Details of the codal provisions of the test and loading details are given in theattachment.

Test loadis applied in stages as given in cl.8.5.4of IRC SP-37. The following criteria stipulated in IRC SP-37 arefor checking the acceptance of load test for girder bridges (given below as excerpts from IRC SP-37).

IRC:SP:37-2010

8.6.2 *For girder bridges*

The load for rating shall be taken all the least of:

i) The load causing a deflection of 1/1500 of the span in any of the main girders for simply supported spans OR for cantilever spans the load causing a deflection of 1/800 of the cantilever span in any of the main girders. The rotation of pier should be accounted for while calculating the deflection.

ii) The load causing tension cracks of width more than 0.3 mm in any of the girders for normal cases and 0.2 mm for structures exposed to very severe and adverse conditions.

iii) The load causing appearance of visible new diagonal cracks of width more than 0.3 mm for normal cases and 0.2 mm for structures exposed to very severe and adverse conditions or opening/widening of existing cracks close to the supports in concrete girders.

iv) The load at which recovery of deflection on removal of test load is not less than 75 percent for R.C.C. structures, 85 percent for pre-stressed concrete structures. Temperature correction be considered as per provisions contained in IRC:51.

As this bridgeis RCC slab bridge, corresponding clause in IRC SP 51is referred to, since the general provisions of IRC SP 51 is applicable as per cl. 8.5 of IRC SP 37(excerpts of which is given as below).

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6.8 Acceptance Criteria

The acceptance criteria of load test shall be as under:

6.8.1 Measured deflections and strains at critical location of particular structural member/ members shall be equal to or less than theoretical deflections and strains obtained from respective designs.

6.8.2 The percentage of recovery of deflections for various types of bridges after retention of test load for 24 hrs. shall be :

Type of Bridges	Minimum percentage recovery of Deflection at 24 hrs after removal of test load
1. Reinforced Concrete	75
2. Prestressed Concrete	85
3. Steel	85
4. Composite	75

13

IRC:SP:51-2014

6.8.3 The structure shall not show any cracks more than 0.30 mm for (normal) moderate exposure and 0.20 mm for severe conditions of exposure, spalling or deflections which are incompatible with safety requirements, as prescribed in the relevant design codes.

From the above, the following acceptance criteria for slab bridges are deduced.

1. Measured deflection at mid span of slab shall be less than the theoretical deflection obtained from respective designs (Cl. 6.8.1 of IRC SP 51).
2. The recovery of deflection on removal of test load is not less than 75 % (Cl. 8.6.4 (4) of IRC SP 37 and Cl. 6.8.2 of SP 51)
3. The structure shall not show any cracks more than 0.3 mm (Cl. 6.8.3 of IRC SP 51 and cl. 8.6.2 (ii) of IRC SP 37)).
4. Limiting values of deflection under live load as per Cl.12.4.1. (2) of IRC 112 is span/800 = 6500/800 = 8.125 mm

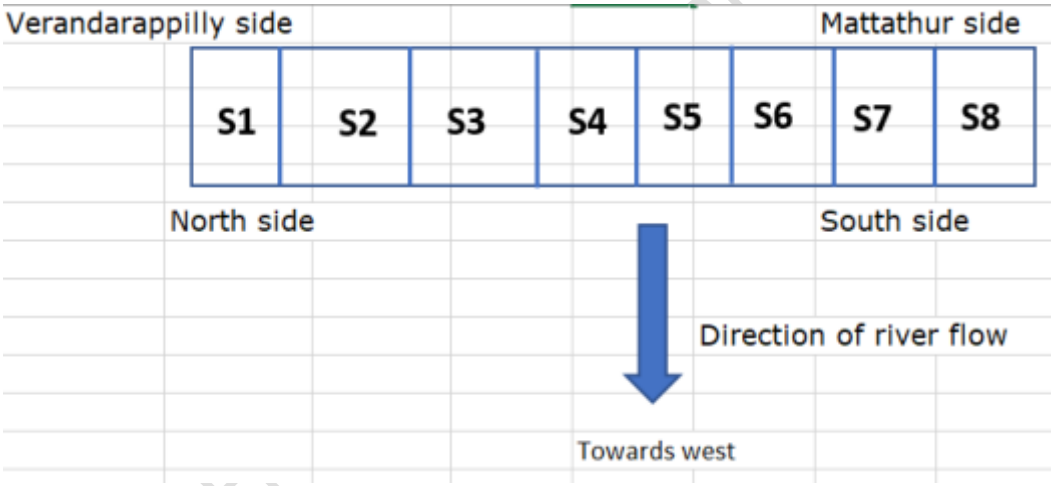
Verification of point no. 1 and 2 above are as following.

Deflections were measured as per applicable clauses in IRC SP-37 as given above and the maximum deflections at each of the spans and the percentage recovery of deflections are given below, in table 3.Deflections were measured using total station of least count 0.1 mm as per clause 6.5.1 f of IRC SP:51.

Table 2- Maximum deflection and recovery of deflection

Slab designation*	Maximum deflection in mm	Deflection in unloading in mm	% Recovery of deflection
S1	0.7	0.1	85.71
S2	0.9	0.1	88.89
S3	0.9	0.1	88.89
S4	0.7	0.1	85.71
S5	1.3	0.2	84.62
S6	1.3	0.1	92.61
S7	0.7	0.1	85.71
S8	1.4	0.1	92.86

*Slab designation is as given below.



Accordingly, the maximum deflection is 1.4 mm and the minimum percentage recovery of deflection is 84.62 % (from table 2). This deflection is less than the maximum deflection from table 1 and hence, acceptable. Also, the percentage recovery aforementioned is greater than that given in point no. 2 of acceptance criteria given above and hence, acceptable. So, clause 1 and 2 of acceptance criteria are satisfied. Photograph of the activity of using total station is given in fig. 11 below.

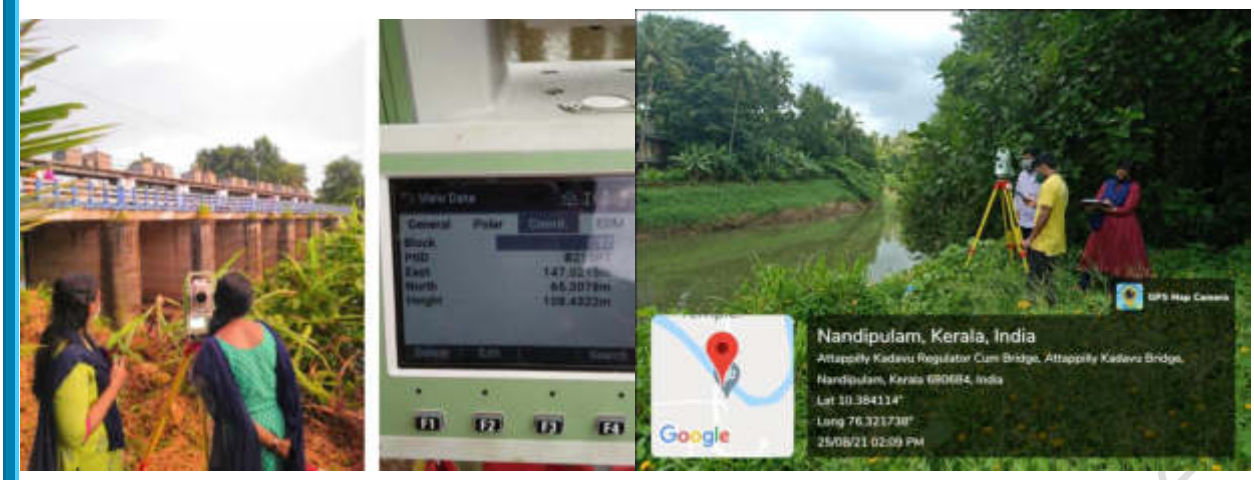


Fig. 11- Photograph of using total station for deflection measurements

Verification of point no. 3 of acceptance criteria mentioned above is explained as following.Crack widths were measured using crack microscope. Photograph of crack width measurement using crack microscope is given in fig. 12 below. Maximum crackwidth obtained was 0.1 mm, for slab S8. This is less than the limiting value as per point no. 3 of acceptance criteria and hence this is also acceptable.



Fig. 12- Photograph of crack measurement using crack microscope

Verification of point no. 4 is as following.

Observed maximum deflection of 1.4 mm is less than the limiting deflection of 8.125 mm, as per point no. 4 above of the acceptance criteria. Hence, point no. 4 of acceptance criteria is acceptable.

Hence, the bridge is deemed to be safe in load rating as per the commercial vehicle of GVW of 379.16 KN (38650 Kg). Since IRC class A loading is of lesser magnitude than the test load (refer fig. 2 and 5), class A loading is also safe to pass through this bridge.

DISCUSSION

Bridge component of Attappillykkadavu regulator cum bridge is load rated for commercial vehicle of GVW 38650 kg as per fig. 5. As IRC class A loading as per fig. 2 is less intense than this load, this bridge is also rated for IRC class A loading.

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TOPOGRAPHIC INVESTIGATIONS AT VADUTHALA

ABSTRACT

Kerala Engineering Research Institute (KERI), Peechi has undertaken an investigation allied with the obstruction to flow of Periyar river near Vallarpadam Railway bridge at Vaduthala as per the verbal instruction of Additional Chief Secretary, KWRD in line with the written letter from Executive Engineer, Irrigation Division, Ernakulum vide Lr.No.A5-23911/2018/WPC dated 12.07.2021. The objective was to determine the quantity as well as quality of the sediments obstructing the flow of river on either side of Railway bridge to Vallarpadam container terminal near Don Bosco boat jetty at Vaduthala. In order to allow free flow of water, materials consisting of sediments, concrete and drain pipes around each pier should be removed. This quantity was calculated as 25769.03 m^3. Sediment deposition was found between 1 Km upstream and 2.20 Km downstream of bridge and the same was quantified to be 2515670.15 m^3. Soil samples taken from 30 bore holes indicate the presence of clayey and silty deposits which are unsuitable for construction and beach nourishment purposes.

METHODOLOGY

Topographic Investigation

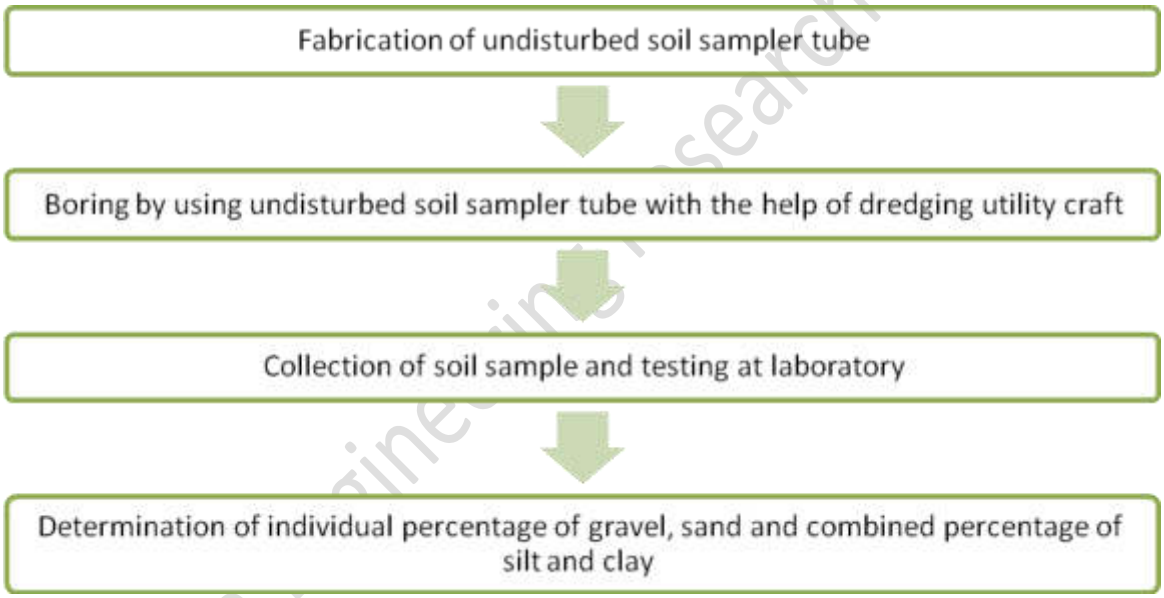
The total station/DGPS surveying was done in a detailed manner from Pathalam Bridge Cum Regulator 17 Km upstream of the Railway bridge to Bolgatty island 4 Km downstream of the Railway bridge. The images related with the surveying process are shown in the Figures 1-10. The Bench Mark was transferred from Bhoothathankettu barrage to the work site using DGPS. The cross-sections were taken at 100 m interval and in each cross-section points were taken at an interval of 20 m for a distance of 1 Km upstream and 2.2 Km downstream of the bridge where significant deposition of sediments were identified during the preliminary inspection of the study area. High resolution data was taken near the Railway bridge (for a distance of 30 m upstream and downstream of the railway bridge) so as to accurately locate the coffer dam provided for the bridge construction. The river bed levels near the bridge were taken at a closer interval of 5m across the river and 2m along the flow direction of river. The river bed levels were then plotted in Autocad Civil 3D and cross-section details were taken at an interval of 100m upstream and downstream of the Railway bridge. In order to quantify the sediment deposition in the study area, original bed level (reference level) is necessary. The bed level of apron downstream of Pathalam Bridge Cum Regulator was considered as the reference level (-2.5m) since the original bed level was not duly obtained from the concerned authorities on request (Letter No. DB-

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890/2021/Vaduthala dated 15.07.2021 of the Director, F&AR, KERI to the Executive Engineer, Irrigation Division, Ernakulam). Moreover, a bed slope of 1/10000 was maintained along the river from 1 Km upstream to 2.2 Km downstream of the bridge for smooth flow of water. Further, the quantity of deposition around the bridge piers consisting of sediments, remnants of concrete piers and drain pipes was also exclusively determined.

Soil Investigation

The methodology adopted for taking soil samples is illustrated in the flow chart given below. The drilling of borehole was advanced with the aid of an undisturbed soil sampler capable of penetrating upto a depth of 5m, which is attached on a DUC. Both disturbed and undisturbed samples were collected from different locations of river bed. The undisturbed soil samples were collected in sampler tube with end attachments, which is fabricated locally in the workshop.



Flow chart for soil investigation

For drilling a borehole in the river bed, the undisturbed soil sampler tube fitted with PVC pipe casing (which is used for collecting the soil sample) is attached on the arm of DUC. Then the tip of the undisturbed soil sampler tube was set up properly at the exact location of borehole. Thereafter, by using the arm of UDC, sampler tube was pushed into the bed of river to make a borehole. After reaching a specified distance of 5m, the sampler tube was taken out from the borehole. Subsequently, the soil samples filled inside the PVC pipe casing were taken out from the undisturbed soil sampler tube, which later cut into 1m pieces for convenience of handling and transportation to conduct laboratory tests on these collected samples. The same procedure is repeated for other the boreholes. The figurative illustration of the above said procedure can be shown below from Figures 11-19. Out of 30 bores holes, 13 nos. of boreholes were explored in

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the upstream side and other 17 nos. of bore holes in the downstream side of the river with reference to the railway bridge. BH 30 was drilled using Rotary Calyx drilling machine at the prescribed bund position, which was laid for the construction of railway bridge as shown in Fig. 19. The boring was extend up to a depth of 17m.

Soil testing

The objective of the investigation is to assess the grain size distribution of the soil deposited in the study area. The assessment is made by analysis after conducting the Grain Size Analysis of the soil collected from limited number of boreholes as per the current Bureau of Indian Standard Specification. Grain size distribution of soil samples has been determined in the laboratory as per IS 2720 (Part 4). In order to get reliable results, wet sieve analysis has been chosen to determine the individual percentage of gravel & sand and combined percentage of silt & clay. Sodium hexa-metaphosphate has been used as dispersing agent for wet sieve analysis. Wet sieve analysis has been conducted in 107 numbers of soil samples collected from 29 boreholes. The soil samples received from the work site are shown in Fig. 20.

DISCUSSION

Topographic Investigation

The bed levels of the river obtained from surveying process were plotted in Autocad Civil 3D and the variations of the same were analysed. The bed levels around the bridge piers were observed up to 0.50m indicating the presence of significant quantity of deposition. These depositions include sediments, remnants of concrete and drain pipes which can be clearly observed during the low tide periods. These depositions surrounding the piers were quantified to be 25769.03m^3 which should be invariably removed from the study area for ensuring smooth flow of water between the Railway bridge piers. Thereafter, the bed levels were found in a range between -0.80m to -1.60m between 1 Km upstream to 2.20 Km downstream of the Railway bridge. These depositions were quantified to be 2515670.151m^3. After the distance of 1 Km upstream as well as 2.20 Km downstream of the Railway bridge, the river bed levels were significantly increased to -5m indicating substantial depth of water. The results of soil tests illustrate that the material comprises mainly of silt and clay which may have transported and deposited as a part of aggradation phenomenon. The river reach under consideration is the last stage of Periyar river before joining with the Arabian sea. This reach is characterized by large bed width and flatter bed slopes which results in smaller depth and lower velocity of flow (Mikhailova, 2008). The lower velocity of flow increases the deposition of sediments in the river

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bed as the sediment carrying capacity of the river is proportional to square of the velocity of flow (Kennedy's theory).

$$\therefore supporting\ capacity\ Q_t = aBV_0^{5/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where : a= Constant

B: Bed width of river

V_0: Critical velocity in the channel

In order to attain smooth and free movement of large ships and passenger boats, National Waterway (NW-3) and Water Metro channels near the right bank of river maintain large depth and higher velocity of flow. This in turn decreases the depth and velocity of flow in the remaining portions of the river leading to huge deposition of sediments as the river always maintains its natural equilibrium condition (Punmia et al., 2009). Moreover, the Railway bridge piers obstruct river flow which results in smaller velocity of flow and higher deposition of the sediments in the river bed. Hence, the sediment deposition in the study area is a natural phenomenon which will continue in the future periods. This fact is confirmed by conducting the surveying in the right side of Island D Cochin towards the Mulavukad Island. The bed levels of the river were in the range between -0.80m to -1.60m till the Water Metro channel indicating the deposition of the sediments in the respective river bed. Therefore, the sediment deposition in the river reaches from left bank of the river to Water Metro channel is a natural phenomenon which occurs due to morphological characteristics of the river mouth and high momentum of flow through NW-3 and Water Metro channels respectively. Hence, the removal of such natural deposits is not a permanent solution for increasing the depth and velocity of water, since such depositions will continue to occur in future and demands periodic dredging process.

Soil Investigation and Soil Testing

Based on the visual inspection of the soil samples brought to the laboratory, red earth soil is only observed in BH 30 up to a depth of 1.50 m from the bed level. Majority of the soil samples brought to the laboratory are of silty and clayey type. Sandy soils are also observed in very few numbers of boreholes. As the majority of samples are of clayey and silty nature, some difficulty were observed while removing finer particles from soil samples even after using dispersing agent. In practical case, soil samples are normally washed with water for separating silt and clay as the use of dispersing agent is too costly. But in this case, as the majority of samples are of clayey and silty nature, it will be very difficult to remove finer particles from soil samples with water alone. From grain size analysis, it is observed that out of 107 soil samples tested, 18 samples contains of sand particles in the range of 50% to 80% and 5 soil samples contain more

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than 80% of sand particles. Remaining 84 soil samples contains less than 50% of sand particles. It is also observed that 61 soil samples contain less than 30% of sand particles. The average depth of sampling is 4 m from the bed level.

As per IS 1498 - 1970, Gravel particles are in the range of 80 mm - 4.75 mm, Coarse sand particles coming in the range of 4.75 mm – 2.00 mm, medium sand particles in the range of 2 mm - 0.425 mm and fine sand particles coming in the range of 0.425 mm to 0.075 mm. Particles finer than 0.075 mm are considered as fine soil which is constituted by silt and clay sized particles. Based on laboratory analysis, it is estimated that the tested soil samples contain 30.82% of sand, 68.95% of silt & clay and 0.23% of gravel on an average. It is also observed that tested soil samples contain an average of 0.40% of coarse sand, 3.43% medium sand and 26.99% fine sand. Suitability of sand contained in various soil samples for construction purposes (concreting, plastering & masonry mortar) is checked based on IS 383: 2016, IS 1542: 1992 and IS 2116: 1980. Suitability of sand for construction purposes is checked herewith purely based on gradation of soil particles obtained by sieve analysis. As the majority of sand particles are fine in nature, sand contained in almost all the soil samples is found unsuitable for construction purposes. Majority of sand present in the coastal areas of Ernakulam has grain size ranging between 600 micron to 300 micron. However the sand separated from the depositions in the study area is characterized mainly by grain size between 300 microns to 75 microns. As the sand used to nourish the coast/ beach should have grain size similar or coarser than the native sand, it is unsuitable for beach nourishment. Possibilities for using the natural depositions for agricultural purpose need further laboratory tests and it needs to be conducted by collaborating with other research institutions since such facilities are not available with KERI.

Based on the inferences obtained from the topographic and soil investigations, following conclusions are achieved.

- To ensure free flow of water, the materials around each bridge pier which includes sediment depositions, remnants of concrete and drain pipes should be removed with immediate effect. The respective quantity was determined to be 25769.03 m^3
- Sediment depositions were found from 1 Km upstream to 2.20 Km downstream of the Vaduthala railway bridge and the same was quantified to be 2515670.151m^3
- Soil samples were taken and tested for 30 boreholes from upstream, downstream and under the Vaduthala railway bridge. Based on laboratory analysis, it is estimated that the tested soil samples contain 68.95% of silt & clay, 30.82% of sand (0.40% of coarse sand, 3.43% medium sand & 26.99% fine sand) and 0.23% of gravel on an average. Results mainly indicate the presence of clayey and silty deposits (Sand contained in the tested soil samples is

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not suitable for the construction purposes and beach nourishment.)

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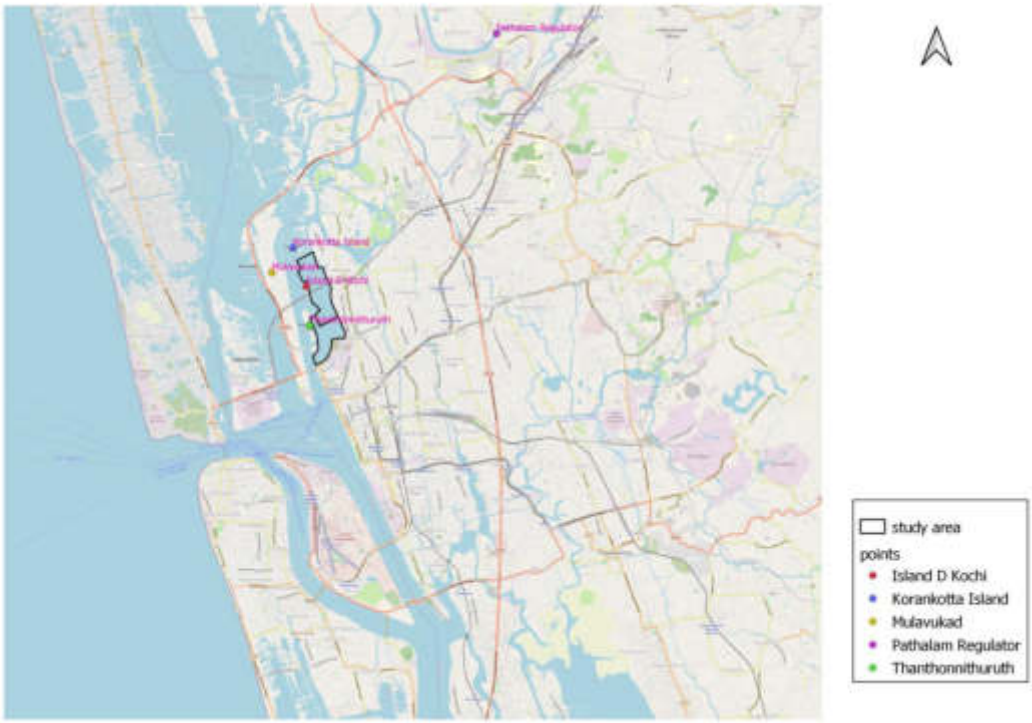


Fig. 1: Study area (upstream of the Periyar towards North direction)



Fig. 2: Situation near the Railway bridge during low tide periods



Fig. 3: Situation near Railway bridge during high tide periods



Fig. 4: Near regions of bridge pillar during low tide periods



Fig. 5: Another view near bridge pillars during low tide periods



Fig. 6: Regions near the bridge pillars during high tide periods



Fig. 7: Remnants of drain pipes near the bridge piers



Fig. 8: Total station surveying in boat



Fig. 9: Total station surveying

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Fig. 10: Total station surveying



Fig. 11: Layout of borehole drawn by using QGIS software



Fig. 12: Setting up of undisturbed soil sampler tube at the exact location of borehole



Fig. 13: Pushing of sampler tube into the bed of river to make a borehole

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Fig. 14: Taking off the soil sampler tube from the borehole after erection



Fig. 15: Lifting the sampling tubes from bore holes

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Fig. 16: Removal of the end attachment of the soil sampler tube to collect soil samples



Fig. 17: Taking out the PVC pipe casing filled with soil sample from sampler tube

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Fig. 18: PVC tubes filled with soil samples



Fig. 19: Boring Using Rotary Calyx Drilling Machine

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Fig. 20: Soil samples received from site

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POSSIBILITY OF USING BOTTOM SEDIMENTS FROM PERIYAR RIVER AT VADUTHALA FOR AGRICULTURAL APPLICATIONS

ABSTRACT

The purpose of this study is to assess the viability of using bottom sediment collected from the Vaduthala river for agricultural purposes. Laboratory tests such as pH, electrical conductivity and heavy metal (Cd, Cr, Pb, and Ni) analysis were performed to investigate the agricultural feasibility of the aforementioned soil. The present study aimed to conduct the feasibility study of collected samples for the use of agricultural purposes as it is a relatively simple approach to deposit sediments on land. As the river bed sample contains mainly high organic matter, heavy metals and so on. The presence of heavy metal could be a deterrent to its use in agriculture. Metals commonly utilised in industry, such as zinc, copper, chromium, cadmium, lead, and nickel, are the most prevalent metals detected in sediment.

METHODOLOGY

The soil sample was collected by using undisturbed soil sampler with the help of dredger utility craft (DUC). The collected samples were tested for pH, EC and Heavy metal determination. he soil samples were collected from 4 different locations from the river bed. The samples from borehole numbers BH 5, BH17,BH 18 and BH 22 were taken for the laboratory analysis. The soil sample from BH5 was labeled as 26540 for convenience in laboratory handling. Similarly the samples from BH17, BH18 and BH22 were labeled 26581, 26585 and 26612.

The collected samples were analyzed at Radiotracer Laboratory, College of Agriculture, Kerala Agriculture university, Thrissur. The parameter like pH Electrical conductivity and the heavy metal were tested. In heavy metal study the presence of Cadmium, Chromium, Lead and Nickel were analyzed. The pH of 1:2.5 soil water suspension is estimated using a pH meter. Electrical conductivity in soil water system is a measure concentration of soluble salts and extent of salinity in the soil and is measured using a conductivity meter. Heavy metal in the soil also affect the plant growth. Metal such as chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni) are toxic to most plants and other organism at higher concentration. The parameters such as Cr, Cd, Pb and Ni are analyzed using Inductively Coupled Plasma (ICP) Emission Spectrophotometer

The following results were observed for characteristics such as pH, Electrical conductivity, and heavy metal based on laboratory investigation of soil samples. The pH value of sample number 26540 is 7.2, indicating that the soil is neutral. And the reported electrical conductivity parameter

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was 4.49 dS m-1, which is significantly greater than the allowed limit of 2 dS m-1. Similarly, the concentrations of heavy metal parameters such as Cd, Cr, Pb, and Ni were found to be 0.023, 2.075, 6.502, and 0.853 ppm, respectively. The Cr and Pb concentrations obtained are higher than the permissible limit. Likewise the results from sample descriptions 26581, 26585, and 26612 are also tabulated and included.

DISCUSSION

Soil sample from Vaduthala river was tested at the Radiotracer laboratory. According to the soil parameter analysis, the soil from boreholes is not suitable for agricultural uses since the parameters examined are higher than the permissible limit of agricultural appropriateness. Some chemical procedures can be used to adjust the pH of the soil sample to an acceptable level. However, the electrical conductivity of all of the soil samples is above permissible limit, which is not ideal for agricultural applications. Heavy metal is also present in greater quantities than the allowed limit for several sample descriptions, which is not suitable to cultivation.



Figure. Method of sample collection



pH meter



Electrical Conductivity Meter



Inductively Coupled Plasma (ICP)
Emission Spectrophotometer

Figure. Different laboratory Equipments used for experimental analysis at the Radiotracer laboratory, KAU

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PROPOSAL FOR RECTIFICATION OF SUBSIDED LEFT BANK APPROACH ROAD OF ATTAPPILLIKKADAVU REGULATOR CUM BRIDGE

ABSTRACT

Attappillykkadavu Regulator Cum Bridge (RCB) across Kurumali River connects Mattathur and Varandarappilly Grama Panchayaths of Thrissur district. The construction work of RCB was started in the year 2008 as per agreement no. 08/SEICC/08-09 dated 12-6-2008 of the Superintending Engineer, Irrigation Central Circle, Thrissur. However, the work was terminated without risk and costs vide order no: D6-4373/1995 dated 18.07.2014, since the period of NABARD assistance ended. At this juncture, downstream apron was not constructed. The balance work was arranged as per Agreement no: 10/SEICC/2016-17 dated 24.09.2016, but still the work was not completed because of the issues in the original terminated work in the year 2014.



D/S View of Attappillykkadavu Regulator cum bridge

Meanwhile, the left bank approach road of Attappilly Bridge has subsided on 04.06.2021 and subsequently, the bridge was closed for traffic. Then as per the Government meeting held on 16.08.2021, the Additional Chief Secretary, Water Resources Department, Govt. of Kerala has directed K.E.R.I. to conduct load test of Attappilly Bridge to ensure the serviceability of existing bridge portion of RCB and also KERI was entrusted to conduct investigations for making the RCB functional and to report the prerequisites for reinstating the traffic through bridge at the earliest.

Fig shows the subsidence occurred in the left bank approach road during the month of June 2021.



Subsidence of Left bank Approach road of Attappillykkadavu Regulator cum bridge



Load Test

In order to make the regulator cum bridge at Attappilly functional, necessary forensic investigations were carried out at site by KERI. Based on the investigations, the proposal for rectification of the left bank approach road is prepared.

METHODOLOGY

Preliminary observation of the cause of this soil subsidence can be hypothecated as follows.

Recently, the left bank approach road has subsided during the month June 2021. Just below the subsidence area, it is the counter fort slab of the abutment, which is resting on a group of piles.

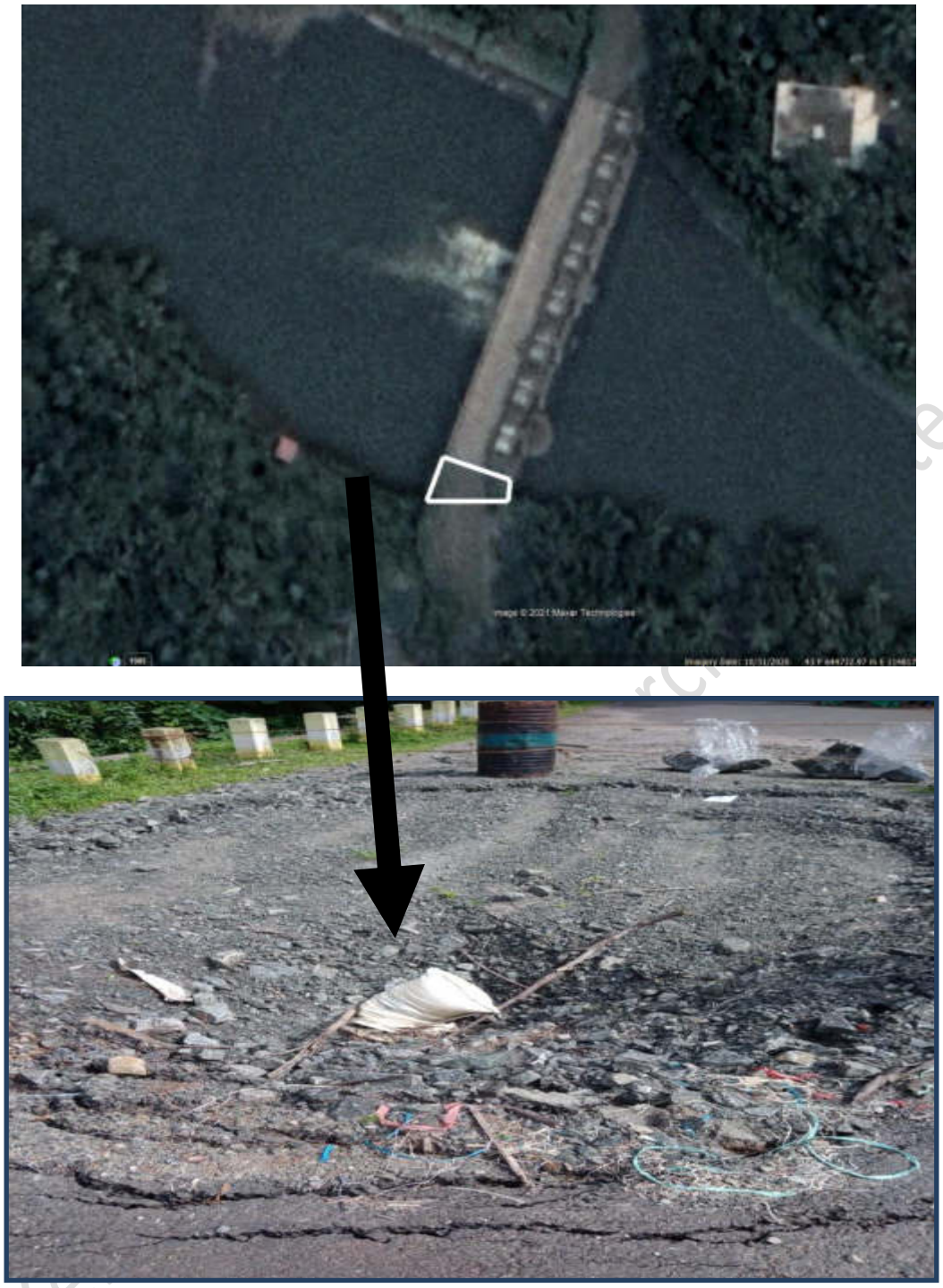
As seen from Fig, the white quadrilateral portion is in the regime of the river itself. Also, there is visible gap between the piles. Hence, there is definitely a flow below the foundation slab. The flow adjacent will automatically induce a negative pressure in the enclosed space of counterforts supporting the left abutment and due to this a force is generated, which will pull the minor soil particles away to river. As the mass of subsoil from bottom eroded away, there will be a cavity which is likely to form. However, the soil above will hold by arch action in between the two adjacent supports. When further the erosion occurs, span of this arch action increases, and it comes to a point that it cannot hold the top soil and it will collapse down. Further, a cave will be formed above, and this process continues until the surface subsides down. This process accelerates, when the water level in the river reduces drastically when a rain comes and goes. It is during this period that the subsidence occurred.

The upstream and downstream retaining walls of left bank (Mattathur side) are not in a straight line. The left abutment is projected into the river which causes a flow through the body of the approach road.



Regulator cum Bridge - photo during construction of left abutment

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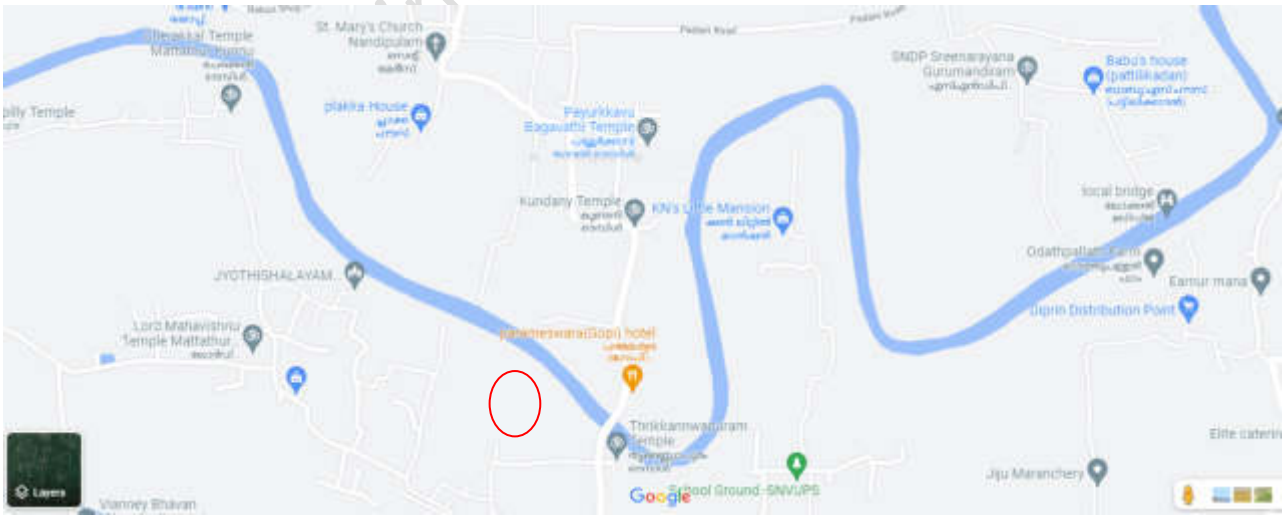


Overall layout of Attappilly regulator cum bridge and photo of subsidence



Overall elevation of Attappilly regulator cum bridge

Also the RCB is located at the curvilinear path of river. Hence the outer side of the curved flow undergoes constant erosion of the bank and erosive forces are generally greater at higher flows causing piping action of soil particles and leads to subsidence.



Location of Attappilly regulator cum bridge



Deposition of sediments on inner bank (Right bank)



പൊന്മാനിക്കുടം മുനയത്ത് ശുദ്ധജലമില്ല

ആറ്റുപിള്ളി പാലത്തിലേക്കുള്ള താൽക്കാലിക റോഡ് തകർന്നു

● ഗൂലേറ്ററിന്റെയും അപ്രോച്ച് റോഡിന്റെയും പണികൾ പൂർത്തിയായിട്ടില്ല

Report of Subsidence of left bank approach road during 2014

VARIOUS ALTERNATIVES FOR REINSTATING THE APPROACH ROAD OF ATTAPPILLY BRIDGE

a. Remove the soil of the approach road upto the rock level and provide Dry Rubble packing with necessary intermediate RCC belts overlaid with Random Rubble masonry and mass concrete with road surface RCC slab. The rough cost estimate of 1.75crores.

b. Provide Under reamed piles with beams and road slab. One end of the approach road slab shall be supported on the left abutment by means of the stiching process using chemical anchor bolts. The rough cost estimated is 1.20crores.

c. Provide under reamed piles to support road slab in such a way that one end of the slab is resting on cantilever beams at the abutment side. The new construction is acting as monolithic, not connected with existing structure. The rough cost estimated of 1.10crores.

d. The Existing upstream retaining wall projected to the river regime shall be reconstructed in line with downstream retaining wall. Left bank abutment (Mattathur Side) shall be modified as pier and construct new abutment aligning with the new retaining wall alignment.(this alternative involves more complications in terms of hydraulic design and economy)

An assessment of feasible solution at site needs to be ascertained by the execution authority of this work, keeping in view of various constraints of construction and demands. Also the site conditions might be changing day by day, the review of suitability of alternatives is required just prior to execution at site. The as built drawings of the structure is not available and while scrutiny of measurement books of the construction of Attappilly RCB, some of the measurement books (MB 185/85-86, 57/04-05, 20/07-08, 23/07-08, 24/07-08) were not made available to KERI. Hence the measurements of the various components of the structure could not be ascertained exactly. In this scenario, by considering the technical viability, economy and speedy execution, third alternative is seems to be better and recommended with detailed design calculation. Since the water level in the river is varying as intimated by the Superintending Engineer, Irrigation Central Circle vide letter no. D6-4597/2015 Vol IV dated 02.11.2021, the temporary bunds may be provided as per the site requirements during the time of execution.

Detailed calculation of third alternative enlisted above is given in subsequent pages.

In this alternative, the approach road slab is supported on beams (cantilever beams on left abutment side) which is resting on under reamed piles. In this calculation note, the design of cantilever option of slab on pile on the approach road (left side) of Attappillykkadavu R.C.B. is performed.

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As a first step, the assessment of loads is made and is given below.

LOADS

As per applicable loads of section 201.1 of IRC 6, vehicle load with GVW of 38T is found to be critical, as given in the report on load test.

Various loads are as given below.

DEAD LOADS

Dead loads is provided in model using its built in comment command.

LIVE LOADS- VEHICLE LOADS

Live loads are in the form of wheel loads. These loads are so arranged in various load cases so that it will result in maximum shear to slab, maximum bending moment to slab and maximum reaction to the pile, as given in the STAAD file.

Maximum spacing of two axles shall not be more than 1.22 m as given in page 11 of IRC 6. This criteria also needs to be satisfied.

Load details for maximum heavy weight probable to run on the bridge are as following.

Gross weight = 38650 kg

Weight considering only front axle = 8180 kg

= 8180×9.81/1000 kN

= 80.24 kN

Weight considering only back axles = 30470 kg

= 30470 ×9.81/1000

= 298.91 kN

(30.47 tonne)

Weight on each of back axle (ref. fig. 4.1) = 298.91/2

= 149.46 kN

Weight on each of wheel of back axle= 149.46/2

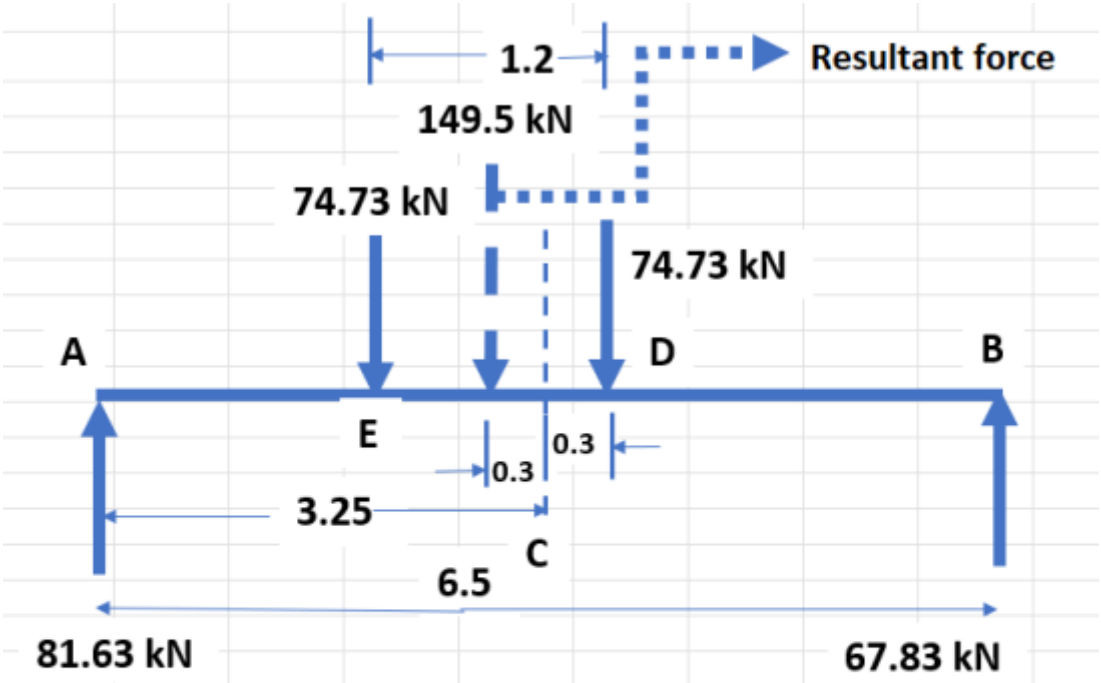
= 74.73 kN

Above loads were applied to STAAD model.

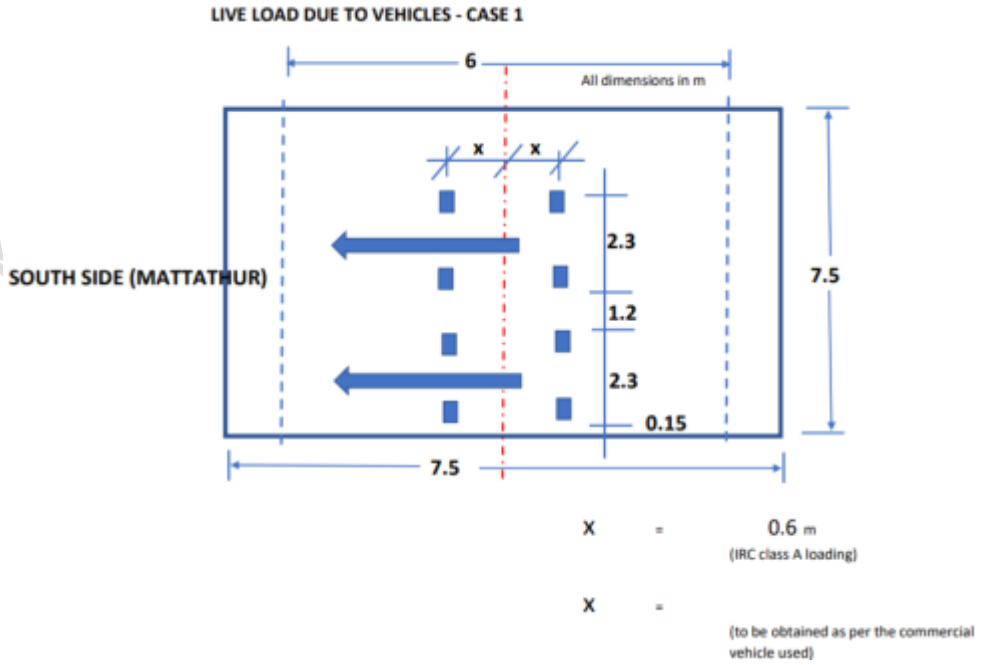
The absolute maximum bending moment under any given concentrated load, which forms part of a train of loads moving across a simply supported beam, occurs when the mid-span point of the beam bisects the distance between the centre of gravity of the load system and the given load.

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As per above directive, the maximum bending moment occurs under 74.73 kN load, as per details shown below.



	Ra	=	(74.73*4.15+74.73*2.95)/6.5
		=	81.6282 kN
	Rb	=	(74.73*2.35+74.73*3.55)/6.5
		=	67.8318 kN
ABSOLUTE MAXIMUM BENDING MOMENT		=	-67.83*2.95
UNDER ANY 74.73 kN		=	-200.1 kNm



Load positions for load test as per IRC 6

As the gross vehicle weight is 38.65T, the minimum spacing between rear and front axles of successive vehicles shall not be less than 4 m (without impact condition) and 20 m (with impact condition) as per relevant clause in IRC 37 given below. This condition is also applied in STAAD. So, the impact load is not added for vehicle spacing of 4 m as mentioned above.

BRAKING, TRACTIVE, FRICTIONAL FORCES

As per cl. 211.1 of IRC: 6, braking force is 20 % of the vehicle loads.

As per cl. 211.3, the force due to braking effect shall be assumed to act along a line parallel to the roadway and 1.2 m above it.

Horizontal force due to braking of commercial vehicle of GVW 38T

For the rear wheel loads = 20/100×298.91

= 59.8kN

As this is 1.2 m above the road, moment due to this = 59.8×1.2

= 71.7kNm

Above loads were applied to each of the points of wheel loads of the vehicle, as above load/4, as there is 2 axles and 4 wheel points.

Horizontal force due to braking of commercial vehicle of GVW 38T for the front wheels

= 20/100×80.24 = 16.05 kN

Moment due to this braking load = 16.05×1.2 = 19.26 kNm

Above loads/moments are applied to each of the wheels.

IMPACT LOAD

Impact factor for class A loading as per cl. 208.2 of IRC 6 = 4.5/(6+L) ----------(3)

Where 'L' is the length in meters of the span = 3.5 m (considering the slab supported on piles and the soil is subsided on a critical case)

= 4.5/(6+6.5)

= 0.36

This is assumed for commercial vehicle of GVW 38 tonne as this load is similar to IRC class A loading.

So, for each rear wheel, impact load = 0.36 ×74.73 = 26.9kN

For each front wheel, impact load = 0.36×40.12 = 14.44 kN

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TEMPERATURE LOADS

Temperature loads shall be found as per section 215 of IRC: 6.

Since the bridge is restrained due to the frictional forces generated owing to resting on top of the pier, temperature effects shall be considered, due to this frictional bearing restraint.

There are separate provisions for temperature effects due to restraint and effects with in superstructure.

Maximum and minimum temperature for calculating effects on restraint as given in fig. 15 and 16 of IRC 6 as 37.5 and 17.5 deg Celsius. This temperature change will cause axial deformation, which is restrained at the supports. Change of temperature = 37.5-17.5 = 20^0C. This load was applied in STAADPRO in the linear deformation mode.

Hence, for axial deformation, a temperature difference of 20^0C is proposed for the bridge and for the flexural deformations and temperature difference between the top and bottom surfaces is given as 15^0C.

LOAD COMBINATION

Load combinations are as per IRC 6 as given below, as snapshots from IRC 6.

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Loads	Ultimate Limit State		
	Basic Combination	Accidental Combination	Seismic Combination
(1)	(2)	(3)	(4)
1. Permanent Loads:			
1.1 Dead Load, Snow load (if present), SIDL except surfacing			
a) Adding to the effect of variable loads	1.35	1.0	1.35
b) Relieving the effect of variable loads	1.0	1.0	1.0
1.2 Surfacing			
a) Adding to the effect of variable loads	1.75	1.0	1.75
b) Relieving the effect of variable loads	1.0	1.0	1.0
1.3 Prestress and Secondary effect of prestress	(Refer Note 2)		
1.4 Back fill Weight	1.5	1.0	1.0
1.5 Earth Pressure			
a) Adding to the effect of loads	1.5	1.0	1.0
b) Relieving the effect of loads	1.0	1.0	1.0
2. Variable Loads:			
2.1 Carriageway Live load and associated loads (braking, tractive and centrifugal) and Footway live load			
a) As leading load	1.5	0.75	-
b) As accompanying load	1.15	0.2	0.2
c) Construction live load	1.35	1.0	1.0
2.2 Wind Load construction during service			
a) As leading load	1.5	-	-
b) As accompanying load	0.9	-	-
2.3 Live Load Surcharge effects (as accompanying load)	1.2	0.2	0.2
2.4 Construction Dead Loads (such as Wt. of launching girder, truss or Cantilever Construction Equipment)	1.35	1.0	1.35
2.5 Thermal Loads			
a) As leading load	1.5	-	-
b) As accompanying load	0.9	0.5	0.5
3. Accidental effects:			
3.1 Vehicle collision (or)	-	1.0	-
3.2 Barge Impact (or)	-	1.0	-
3.3 Impact due to floating bodies	-	1.0	-
4. Seismic effect			
(a) During Service	-	-	1.5
(b) During Construction	-	-	0.75
5. Hydraulic Loads (Accompanying load):			
5.1 Water current forces	1.0	1.0	1.0

Table B.3 Partial Safety Factor for Verification of Serviceability Limit State

Loads	Rare Combination	Frequent Combination	Quasi- permanent Combination
(1)	(2)	(3)	(4)
1. Permanent Loads:			
1.1 Dead Load, Snow load if present, SIDL except surfacing	1.0	1.0	1.0
1.2 surfacing			
a) Adding to the effect of variable loads	1.2	1.2	1.2
b) Relieving the effect of variable loads	1.0	1.0	1.0
1.3 Earth Pressure	1.0	1.0	1.0
1.4 Prestress and Secondary Effect of prestress	(Refer Note 4)		
1.5 Shrinkage and Creep Effect	1.0	1.0	1.0
2. Settlement Effects			
a) Adding to the permanent loads	1.0	1.0	1.0
b) Opposing the permanent loads	0	0	0
3. Variable Loads:			
3.1 Carriageway load and associated loads (braking, tractive and centrifugal forces) and footway live load			
a) Leading Load	1.0	0.75	-
b) Accompanying Load	0.75	0.2	0
3.2 Thermal Load			
a) Leading Load	1.0	0.60	-
b) Accompanying Load	0.60	0.50	0.5
3.3 Wind Load			
a) Leading Load	1.0	0.60	-
b) Accompanying Load	0.60	0.50	0
3.4 Live Load surcharge as accompanying load	0.80	0	0
4. Hydraulic Loads (Accompanying loads) :			
4.1 Water Current	1.0	1.0	-
4.2 Wave Pressure	1.0	1.0	-
4.3 Buoyancy	0.15	0.15	0.15

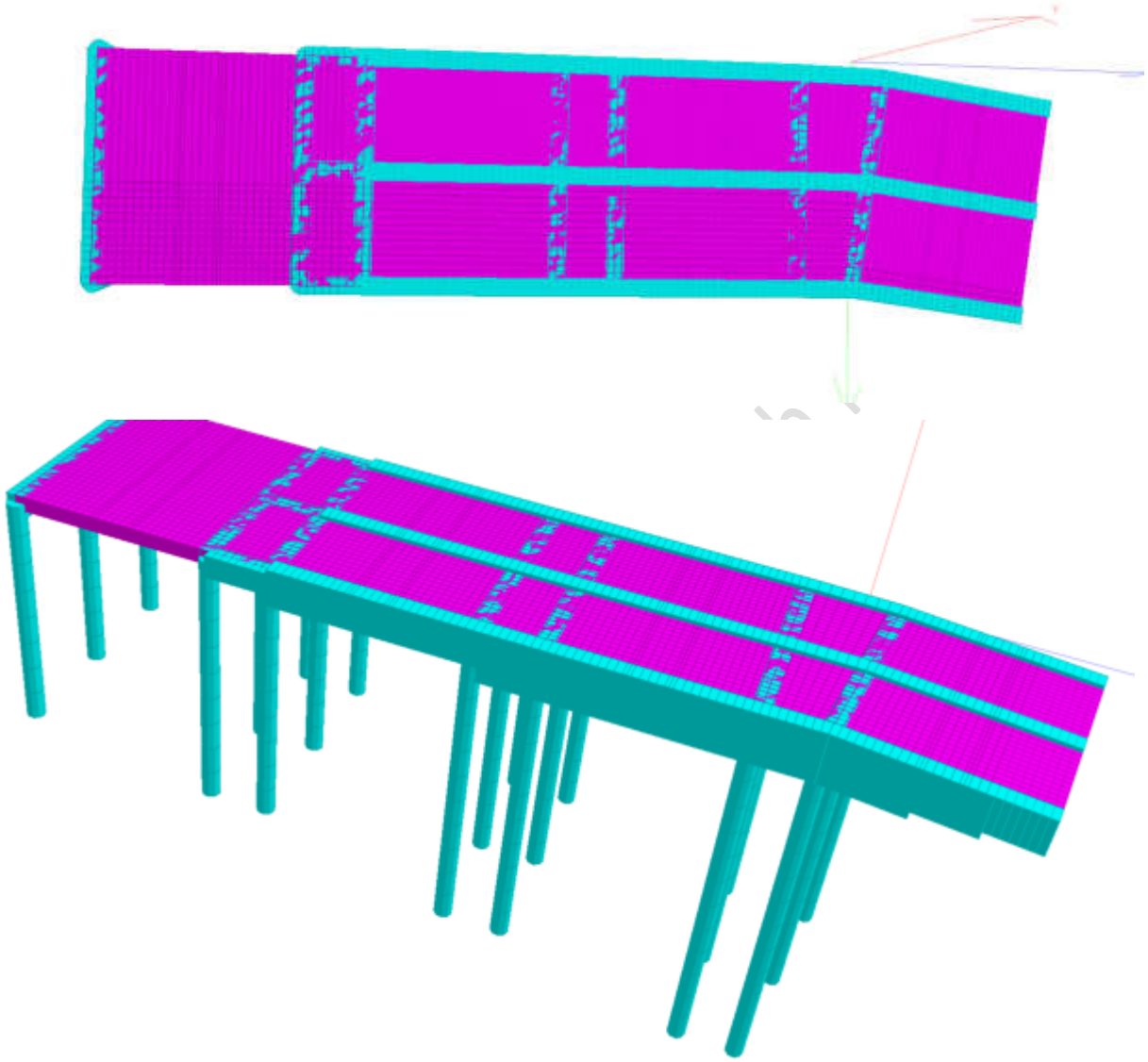
Above load combinations are applied to STAADPRO.

Table B.4 Partial Safety Factor for Checking the Base Pressure and Design of Foundation

Loads	Combination (1)	Combination (2)	Seismic Combination	Accidental Combination
(1)	(2)	(3)	(4)	(5)
1. Permanent Loads:				
1.1 Dead Load, Snow load (if present), SIDL except surfacing and Back Fill	1.35	1.0	1.35	1.0
1.2 SIDL surfacing	1.75	1.0	1.75	1.0
1.3 Prestress Effect	(Refer Note 4)			
1.4 Settlement Effect	1.0 or 0	1.0 or 0	1.0 or 0	1.0 or 0
1.5 Earth Pressure				
a) Adding to the effect of loads	1.50	1.30	1.0	1.0
b) Relieving the effect of loads	1.0	0.85	1.0	1.0
2. Variable Loads:				
2.1 All carriageway loads and associated loads (braking, tractive and centrifugal) and footway live load				
a) Leading Load	1.5	1.3	0.75 (if applicable) or 0	0.75 (if applicable) or 0
b) Accompanying Load	1.15	1.0	0.2	0.2
2.2 Thermal Load as accompanying load	0.90	0.80	0.5	0.5
2.3 Wind Load				
a) Leading Load	1.5	1.3	-	
b) Accompanying Load	0.9	0.8	0	0
2.4 Live Load surcharge as Accompanying Load (if applicable)	1.2	1.0	0.2	0.2
3. Accidental Effect or Seismic Effect				
a) During Service	-	-	1.5	1.0
b) During Construction	-	-	0.75	0.5
4. Construction Dead Loads (such as Wt. of launching girder, truss or Cantilever Construction Equipments)	1.35	1.0	1.0	1.0
5. Hydraulic Loads:				
5.1 Water Current	1.0 or 0	1.0 or 0	1.0 or 0	
5.2 Wave Pressure	1.0 or 0	1.0 or 0	1.0 or 0	
5.3 Hydrodynamic effect	-	-	1.0 or 0	
6. Buoyancy:				
a) For Base Pressure	1.0	1.0	1.0	
b) For Structural Design	0.15	0.15	0.15	

DESIGN

3D model of the deck slab supported on pile is given below.



3D Model of complete approach road resting on pile and not supported on any existing structure

Grouping of various members were made in STAAD and design output for each of the groups were taken and separate design using EXCEL sheets were made, except for the pile foundation, for which the design output has been directly taken from STAAD.

Above details are as given below.

Beam force details summary for 1.75 m deep and 0.6 m wide beam. Depth of the beam from bottom of the 0.5 m thick slab is 1.25 m (Approach slab 50cm thick). However, considering the

beam action, the total depth of the beam 1.25 m depth with 0.5 m deep slab is considered as 1.75 m in STAAD model.

Design of pile foundation

Pile is modelled in STAAD using confinement from sides as per modulus of subgrade reaction as per table 5 of IS 2911 (excerpt shown below).

C-2 STIFFNESS FACTORS

C-2.1 The lateral soil resistance for granular soils and normally consolidated clays which have varying soil modulus is modelled according to the equation:

$$\frac{p}{y} = \eta_h z$$

where

p = lateral soil reaction per unit length of pile at depth z below ground level;

y = lateral pile deflection; and

η_h = modulus of subgrade reaction for which the recommended values are given in Table 5.

Table 5 Modulus of Subgrade Reaction for Granular Soils, η_h, in kN/m³

(*Clauses* C-2.1 *and* C-2.3.1)

Sl No.	Soil Type	N (Blows/ 30 cm)	Range of η_h kN/m³ × 10³	
			Dry	Submerged
(1)	(2)	(3)	(4)	(5)
i)	Very loose sand	0-4	< 0.4	< 0.2
ii)	Loose sand	4-10	0.4-2.5	0.2-1.4
iii)	Medium sand	10-35	2.5-7.5	1.4-5.0
iv)	Dense sand	> 35	7.5-20.0	5.0-12.0

NOTE — The η_h values may be interpolated for intermediate standard penetration values, N.

As the N value ranges from 10-35, a modulus of subgrade reaction of 4000 kN/m^3 was chosen for the analysis and the details of calculated lateral stiffness values are given below in table 9.1.

Table 9.1- lateral stiffness of pile

Depth from bottom of pile cap	Depth, m below ground level	Lateral stiffness (P/Y) (kN/m)
2	2	4800
3	3	7200
4	4	9600
5	5	12000
6	6	14400
7	7	16800
8	8	19200
9	9	21600
10	10	24000
11	11	26400
12	12	28800
13	13	15600

From the compressive strength values of rock ranging from 30 to 50 N/mm2, a bearing capacity value of 1000 kN/m2 can be very safely adopted. Accordingly, modulus of vertical subgrade reaction can be found as following (From the text book of Joseph Bowles).

$k = 40 \times 3 \times 1000 = 120000$ kN/m^3

Vertical spring constant for application to STAAD = $120000 \times 3.14/4 \times 0.6^2$

$= 33912$ kN/m

From the output of STAAD design, the following design for pile foundation can be adopted.

Main rebar is 21 nos. T12 with circular ties of T10-190 centre to centre.

However, provided rebars are 18-T20 with T10-150. Increased rebars are provided to take care of the possible variations at site.

The following maximum vertical load need to be verified for the pile load test of each of the piles of the subject work. The details are given in table 9.2.

Table 9.2- Details of load for pile load test

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Beam Force Detail Summary

Sign convention as diagrams:- positive above line, negative below line except Fx where positive is compression. Distance d is beam end A.

				Axial	Shear		Torsion	Bending	
	Beam	L/C	d (m)	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
Max Fx	6283	22:1.35DL+1.5l	1.000	**1.51E+3**	1.323	0.404	0.000	-0.000	0.000
Min Fx	2379	14:TL-RESTRA	0.000	**-85.317**	9.117	0.380	-0.000	-0.134	12.922
Max Fy	4334	28:1.35DL+1.5l	0.000	580.028	**81.554**	-13.228	-0.000	21.236	133.199
Min Fy	6274	70:1.35DL+1.5l	0.000	1.35E+3	**-42.449**	-3.074	0.000	38.017	-137.093
Max Fz	6271	78:1.35DL+1.5l	0.000	1.05E+3	-6.834	**61.129**	-0.000	-209.636	-114.912
Min Fz	5308	72:1.35DL+1.5l	0.000	961.084	8.346	**-62.924**	0.000	271.266	-65.778
Max Mx	2451	75:1.35DL+1.5l	0.000	846.701	23.951	48.274	**0.000**	141.035	32.960
Min Mx	4332	73:1.35DL+1.5l	0.000	317.930	-30.940	4.915	**-0.000**	-21.152	-136.554
Max My	5308	72:1.35DL+1.5l	0.000	961.084	8.346	-62.924	0.000	**271.266**	-65.778
Min My	6271	84:1.35DL+1.5l	0.000	965.266	-11.192	61.099	-0.000	**-213.575**	-106.492
Max Mz	5371	76:1.35DL+1.5l	1.000	1.27E+3	-20.630	-5.315	0.000	-0.743	**216.174**
Min Mz	6271	70:1.35DL+1.5l	0.000	1.32E+3	-26.474	13.224	-0.000	6.512	**-229.467**

From the above table, the vertical load of 1510kN needs to be verified in the pile load test. As there is an uplift of 85.3kN, a single underream is required at the mid height of each of the piles of subject work. Detail of underream is as given below for 600 mm dia piles where the safe uplift pressure is 21T (206 kN), which is much more than the required one of 85.3kN.Hence, this is deemed to be acceptable.

TABLE 1 SAFE LOAD FOR VERTICAL BORED CAST *IN SITU* UNDER-REAMED PILES IN SANDY AND CLAYEY SOILS INCLUDING BLACK COTTON SOILS

Size		Length		Mild Steel Reinforcement			Compression				Safe Loads in Uplift Resistance				Lateral Thrust	
Diameter of pile	Under reamed diameter	Single under-reamed	Double under-remed	Longitudinal Reinforcement		Rings spacing of 6mm dia rings	Single under-reamed	Double under-reamed	Increase per 30 cm Length	Decrease per 30 cm Length	Single under-reamed	Double under-reamed	Increase per 30 cm length	Decrease per 30 cm length	Single under-reamed	Double under-reamed
cm	cm	m	m	No.	Dia mm	cm	t	t	t	t	t	t	t	t	t	t
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
20	50	3·5	3·5	3	10	18	8	12	0·9	0·7	4	6	0·65	0·55	1·0	1·2
25	62·5	3·5	3·5	4	10	22	12	18	1·15	0·9	6	9	0·85	0·70	1·5	1·8
30	75	3·5	3·5	4	12	25	16	24	1·4	1·1	8	12	1·05	0·85	2·0	2·4
37·5	94	3·5	3·75	5	12	30	24	36	1·8	1·4	12	18	1·35	1·10	3·0	3·6
40	100	3·5	4·0	6	12	30	28	42	1·9	1·5	14	21	1·45	1·15	3·4	4·0
45	112·5	3·5	4·5	7	12	30	35	52·5	2·15	1·7	17·5	25·75	1·60	1,30	4·0	4·8
50	125	3·5	5·0	9	12	30	42	63	2·4	1·9	21	31·5	1·80	1·45	4·5	5·4

As per IS 456- the vertical deflection limits may generally be assumed to be satisfied if the span to depth ratios are not greater than the values as given below.

23.2.1 The vertical deflection limits may generally be assumed to be satisfied provided that the span to depth ratios are not greater than the values obtained as below:

a) **Basic values of span to effective depth ratios for spans up to 10 m:**

Cantilever	**7**
Simply supported	**20**
Continuous	**26**

In the case of the cantilever part, the span to depth ratio = 6500 /1750 = 3.7, which is much less than the value of 7 above and hence, O.K.

Before construction, the working drawings need to be made depending up on the then site conditions and then applicable construction procedures.

DISCUSSION

Bridge approaches provide a smooth and safe transit of vehicles from pavement to structure and vice versa. The subsidence of bridge approaches not only causes inconvenience to public but also increases maintenance cost. It was imperative to find the cause of failure through forensic studies and to make immediate measures to restore the traffic. The soil samples were collected from the Attappilly Bridge site by the Instrumentation Division and its properties were checked in the Soil Mechanics laboratory. Concrete Core samples were extracted from the left abutment and the rock samples were collected from approach road and tested for its compressive strength at the Construction Materials Testing Laboratory. The total station survey was conducted by the Coastal Engineering Division. Based on the site investigations, analysis and forensic studies, four proposals were formulated by Kerala Engineering Research Institute, Peechi. Among the proposals, most economical and feasible third alternative (Provide under reamed piles to support road slab in such a way that one end of the slab is resting on cantilever beams at the abutment side)is recommended for execution, after getting necessary approval from the concerned authority. The longitudinal gradient of approach road shall be consistent with the gradient of existing road. The worsening nature of damages at site necessitates review of design prior to construction.

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ENVIRONMENTAL MANAGEMENT PLAN (EMP) FOR THE DESILTATION OF KAMBALATHARA ERI

ABSTRACT

'Eri' the word derived from Tamil, which means large pond having a greater area. There are three Eris associated with the Chitturpuzha project viz. Kambalathara, Venkalakkayam and Kunnampidari. The chief controlling element of the Chitturpuzha project, Moolathara Regulator diverts the PAP water received from Manakkadavu weir to left bank, right bank and other river systems. Kambalathara Eri is act as a balancing reservoir for the left bank canal system Water collected in this Eris is very crucial to meet water demand at time when there is no sufficient supply of water from Aliyar. Moreover, it helps to maintain ground water level in the adjoining drought prone areas and plays significant role in ecological balance too.

The storage capacity of the regulator is only 0.5488 Mm3. Water diverted to Left Bank Canal system flows through a feeder canal (referred as High Level Canal) for about 7 Km to reach the Kambalathara Eri and gets stored. From the other side of Eri the left bank main canal is continuing for a length of 24.40 Km. Kambalathara Eri is act as a balancing reservoir for the left bank canal system, having an ayacut area of 8210 Ha. This Eri has a storage capacity of 3.00 Mm3 spread in an area of 81 Ha. Water stored in this Eri is released to Venkalakkayam Eri and to the Left Bank Canal system as per demand of ayacut. The total length of the earthen Bund portion comes to 960m.



Fig.1.1 Location Map of ERIs

The Kerala Irrigation Department planned to desilt the kamabalathara Eri in order to increase its storage capacity. As instructed in G.O. (MS) No. 79/2017/WRD dated

Thiruvananthapuram 26/09/2017, Environment Management Plan (EMP) is to be carried out for the deepening process. As directed by the Empowered Committee meeting held on 7/10/2021, Superintending Engineer, Siruvani Project Circle, Palakkad has requested KERI to prepare the Environmental Management Plan vide letter no D6-1277/2017/Eri's dated 7/10/2021. This study is being developed in order to assess the project's environmental impact and, as a result, to develop an Environmental Management Plan for the project. During the de-silting activities, the Environmental Management Plan (EMP) serves as an important link between anticipated consequences and mitigating actions. The EMP lays out the mitigation, monitoring, and institutional measures that will be implemented during and after the de-silting operations to minimise or mitigate negative environmental consequences, as well as the steps that will be taken to put them in place. The project's anticipated effects on numerous environmental components have been identified, and mitigation strategies have been proposed. In order to enhance the storage capacity of the kamabalathara Eri, Irrigation department of Kerala decided to perform the desilting operation. This report is prepared in view of assessment of environment impact and thus to make an Environmental Management plan for the proposed project.



Fig.1.2 Kambalathar Eri

Scope of EMP includes the following

- Conducting Environmental Impact Assessment Study, which includes data collection of parameters related to air, water and noise environment, soil characteristics, aquatic life, flora and fauna, etc and prediction of probable impacts on the environment and ecology due to the entire desiltation, separation and transportation operations.
- Preparation of Environment Management Plan (EMP) based on the Comprehensive EIA study which includes the recommendations of mitigation measures to minimise the adverse impacts of pollution on environment and ecology due to entire desiltation, separation and transportation operations, disposal of separated material etc.

Objectives of EIA include the following:

- Assessment of the existing status of air, water, land, biological, climatic, socioeconomic, health and cultural component of environment.
- Identification of potential impacts on various environmental components due to activities envisaged during the desilting operations

- Preparation of environmental impact matrix based on the identification and evaluation of impacts. - Delineation of environmental management plan (EMP) outlining preventive and curative strategies for minimising adverse impacts during the de-silting operations along with the cost and time-schedule for implementation of EMP.
- Formulation of environment quality monitoring programme for de-silting operations to be pursued by the project proponent.

Bathymetric study

A detailed Sedimentation study and Topographic survey was conducted in Kambalathara Eri for the assessment of the quantity of earth to be removed for enhancing the storage capacity of Eri. The sedimentation study using Integrated Bathymetric system (IBS) was conducted by KERI, Peechi 2010. The original capacity of the Kambalathara Eri is 3.00Mm^3 at FRL of 181.08 m with respect to MSL. At the time of IBS study the water level was +178.930m and the corresponding capacity calculated as 1.887 Mm^3. The contour map of water spread area is shown in Fig.2.2 at an interval of 0.50 m. The elevation capacity values are shown in table 2.1 and the corresponding curve is plotted in figure 2.2.

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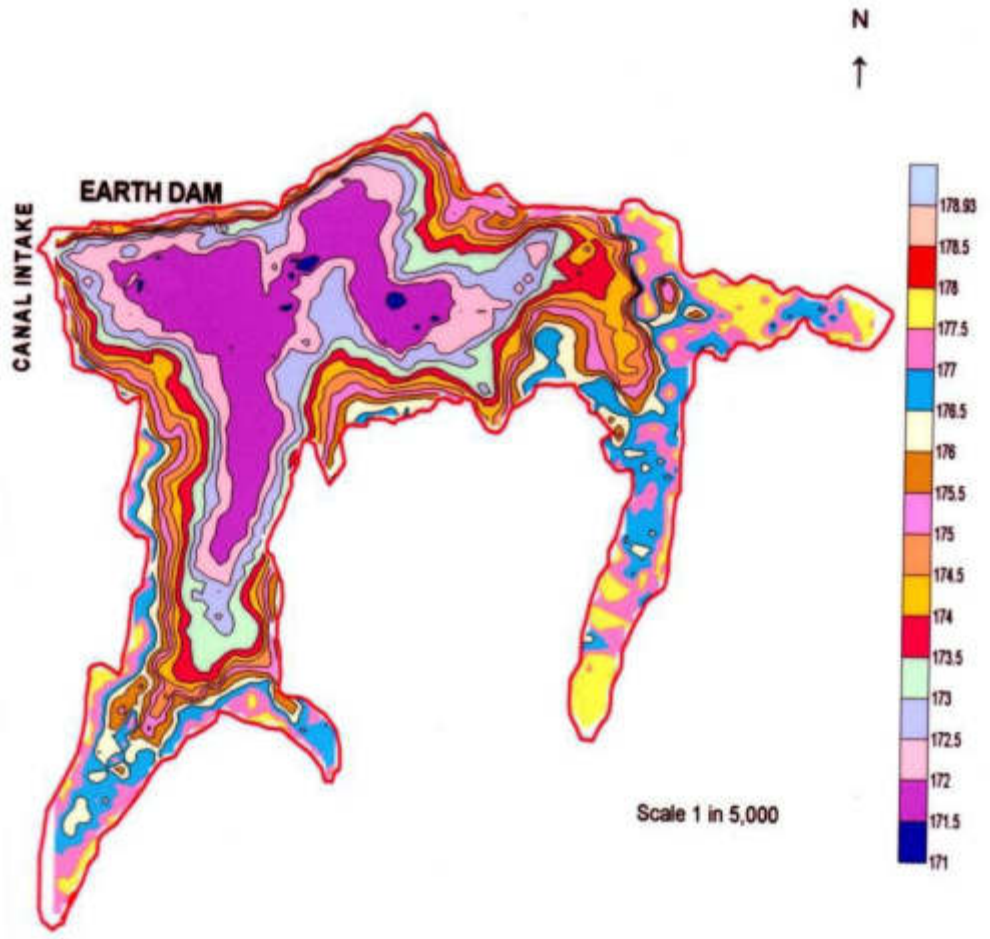


Fig. 2.2: Contour map of Kambalathara Eri based on IBS Survey

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METHODOLOGY

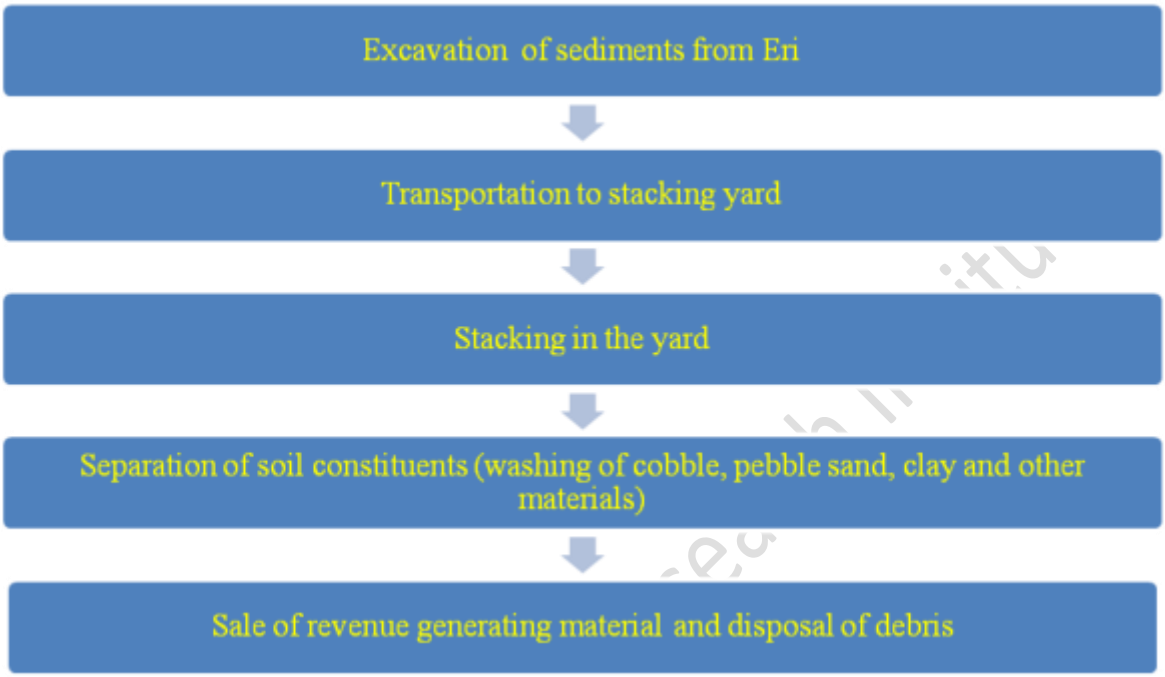
The methodology to be followed for the EIA study is delineated below:

- Onsite collection of data relevant to physical, chemical, biological and socioeconomic factors
- Interactions with the Assistant Executive Engineer, Assistant Engineer, Overseers and Eri watchmen
- Identification of road network for transport of the de-silted sediments
- Biodiversity assessment of the study area
- Interactions with the local people
- Identification of the monitoring locations for analyzing the various environmental parameters.
- Prediction of impacts (positive and negative) on the various attributes due to the proposed de-silting operations
- Suggesting suitable impact mitigation measures

- Proposing appropriate environment monitoring plan

Desilting Methodology

The entire process consists of excavation, stacking of the materials, separation of material into gravel, sand, clay etc, stacking and packing of separated material and transportation of separated materials. The various steps are shown in the flow chart below.



Environmental Management Plan (EMP)

The Environmental Management Plan (EMP) provides an essential link between predicted impacts and mitigation measures during the de-silting operations. EMP outlines the mitigation, monitoring and institutional measures to be taken during and after the de-silting operations to avoid or mitigate adverse environmental impacts, and the actions needed to implement these measures. The likely impacts on various components of environment due to the project have been identified and measures for their mitigation are suggested. The EMP lists all the requirements to ensure effective mitigation of every potential biophysical and socio-economic impact identified in the EIA. For each attribute, or operation, which could otherwise give rise to impact, the following information is presented:

- A comprehensive listing of the mitigation measures
- Parameters that will be monitored to ensure effective implementation of the action
- Time schedule for implementation of the action to ensure that the objectives of mitigation are fully met

1. EMP for De-silting Operations

The EMP comprises of a series of components covering direct mitigation and environmental monitoring, an outline of waste management plan and a project site restoration plan. Therefore, environmental management plan has been prepared for each of the above developmental activities. The management plan for each of the environmental component consists of adopting the mitigation measures proposed for them depending on the anticipated impacts. The mitigation measures for all the anticipated impacts are detailed in Chapter 5, in section 5.4. The mitigation measures shall be meticulously followed to ensure efficient environmental management during the de-silting operations.

Land Environment

- Demarcation of excavation area with pillars and geo-referencing should be done prior to start of de-silting.
- Carry out earthwork excavation of ERI by keeping 15m wide embankment along the periphery and maintain a side slope of 1:1 for the earth cutting.
- The excavation should be carried out without affecting the stability of the existing structures such as earthen dam(bund with stone pitching), high level canal from Moolathara regulator, distribution canal, sluice and so on.
- The depth of de-silting should be limited to the existing impervious layer or the original bed level of the reservoir, as per the direction of departmental officials at site.
- Catchment area treatment may be prioritized.
- The debris and the topsoil shall be stacked separately and used for bund formation.
- Burning of wastes on site shall be prohibited
- The debris from dredging shall be properly disposed off
- Restricting cutting of trees and site vegetation clearance to the minimum needed to provide adequate & safe working space for all activities which will be carried out on site
- Green belt/plantation shall be developed to arrest dust.
- On completion of de-silting operations all machinery and equipment, surplus materials and wastes should be completely removed. Stockpiles if any should be provided with gentle slopes
- A waste management plan should be prepared and complied with.

Water Environment

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- Settling tanks and purifying facilities should be established for reducing turbidity. Harmless coagulants used for drinking water treatment such as alum or poly electrolyte can be used as coagulation aids for assisting the sedimentation. The scheme of wastewater treatment proposed shall include detention ponds with geo-membrane liner, coagulant dosing and primary settling tank and ponds for filtration. The filtration ponds shall have geo-membrane liner and graded sand as filtration media. The scheme for wastewater management is depicted in Figure 6.1.



Fig 6.1: Proposed Treatment Scheme for the Wastewater

- Excavation shall be done only in the dry season to avoid any disturbances affecting the water quality in the Eri's water.
- Laborers should be provided with adequate quantity of drinking water of potable quality.
- Sufficient and appropriate sanitary facilities should be provided in order to maintain hygienic conditions. Septic tanks followed by soak pits shall be used for disposal of sewage.
- Area for maintenance of vehicles should be so located that contamination of Eri's water or surface water by accidental spillage of oil can be prevented. Such areas shall be provided with an impermeable base and drainage systems which discharge through efficient oil and grease traps.
- Storm water management shall be done by providing adequate drainage facilities.

Air Environment

- The transporting vehicles shall not be over loaded.
- Repair and maintenance of the roads shall be done as and when required.
- Water sprinklers shall be used to minimize the air borne dust emissions on haul roads and all the haul roads shall be paved with bitumen to prevent any dust generation.
- PUC certified vehicles shall be used for transportation.
- Vehicles and equipment should be well maintained in fuel efficiency and anti idling.
- If DG sets are used as source of power or back up, they shall be as per CPCB prescribed standards for emission and stack heights.

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- Any waste oil generated shall not be incinerated and will be sold to authorized waste oil recyclers
- The storage and handling of soil, sub-soils, top-soils and materials shall be carefully managed to minimize the risk of windblown material and dust
- Engines and exhaust systems of all vehicle and equipment shall be maintained so that exhaust emissions do not exceed statutory limits and that all vehicles and equipment are maintained in accordance with manufactures' manuals. Periodic monitoring of this shall be undertaken to ensure compliance.
- Ambient air quality with respect to SPM, RPM, SO_2, NO_x, H_2S and CO monitoring shall be continued at appropriate locations.

Noise and Vibration

- Earth movers and other machinery with low noise levels shall be used. Acoustic barriers and silencers should be used in equipment wherever necessary.
- Periodic maintenance of various machinery and transportation vehicles should be undertaken.
- Onsite workers should be provided with noise protection devices such as ear plugs/ muffs wherever necessary and their proper usage will be ensured for eardrum protection of the workers.
- Periodic monitoring for the noise levels within the project site and along the outside project boundary shall be undertaken to ensure compliance as per the standards set by CPCB.
- De-silting operations shall not be carried out in the late night hours.
- Monitor job and location specific noise levels for compliance with HSE regulations by verifying acceptability of noise levels caused by the project activities and comparison with noise criteria.
- Feedback from the monitored noise levels at sensitive locations shall be taken to ensure that the impact due to high noise levels is practically minimized.

Biological Environment

- The region does not have dense vegetation which requires clearance. The vegetation in the processing location needs to be cleared.
- Many spawning habitats require a specific sediment size and too fine of sediment can end up smothering the eggs and other benthic creatures. Too much sediment deposition can also bury habitats and even physically alter a waterway. Excessive levels of suspended load tend

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to have negative impacts on aquatic life. Suspended sediment can prevent light from reaching submerged vegetation and clog fish gills. These suspended sediments will also reduce the DO, which adversely affect the life of aquatic species.

- No washing, crushing, screening, stockpiling, or plant operations should occur at or below the stream's "average high water elevation". Similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish and benthic flora and fauna.
- Development of green belt with carefully selected plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation/assimilation and for providing food and habitat for local micro fauna.

Socio Economic Environment

- Even though the de-silting operations do not require huge quantities of power or water, the only likely impact on infrastructure would be on the roads, for transporting the excavated/processed sediments. Considering the high traffic emanating during the transportation of processed sediments, an effective traffic management scheme should be developed to avoid congestion on the nearby and local roads.
- Local persons will get employment due to the de-silting operations
- Socio-cultural conflicts between the workforce and local communities can be avoided, if the majority of the operators and workforce are local inhabitants.
- Employing local labour will avoid the requirement of providing onsite accommodation to the workforce.

Health and Safety

- Proper signage shall be used at excavation site as well as the transportation route.
- The movement of heavy equipment should be done with proper precaution to prevent any accidents on the road or at the execution site or processing locations.
- Occupational risk should be minimized at the project site through implementation of a proof safety system.
- Safety training should be provided to all construction workers on operation of equipment. Security should also be extended during non-working hours to ensure there is controlled access to the machinery and equipment.

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- The contractors should also be vigilant to detect workers showing symptoms of communicable diseases. All illness and incidents shall be reported and recorded

Environmental Monitoring Programme

The suggested Environmental Monitoring Programme for the de-silting operations is given in Table 6.1. Besides this a base line data should be collected just before the commencement of the project and restoration data after the completion of the project. The expenditure incurred for the same is also included in the table.

Table 6.1: Suggested Environmental Monitoring Programme

Sl no	Type	No of locations	Parameters	Period and frequency	Total no of tests proposed	Cost
1	Ambient Air quality	5	Criteria Pollutants: SO_2. NO_2. PM_{10}. PM_{25} ,CO.	Once in a month	40	4,00000
2	Ambient Noise	5	dB (A) levels.	Once in a month	40	40000
3	Water quality in open well	2	As per IS 10500 potable water standards.	Once in 6 months	12	15000
4	Reservoir water quality	1	pH, Temp., Salinity, TDS,TSS. DO. BOD, Hardness, Alkalinity, Chlorides, Turbidity. Conductivity, Oil and Grease. Heavy Metals	Twice in a month	12	40000
5	Soil quality	1	Organic matter. CH. N. Alkalinity. Acidity, heavy metals and trace metal. Alkalinity. Acidity.	Once in 6 months	6	7000
6	Sediment quality	1	Organic C. Organic N. heavy metals	Once in 6 months	6	7000
Total						**5,09,000**

The proposed ambient air, noise, water, soil and sediment quality monitoring locations are found and sketched in the figure below.

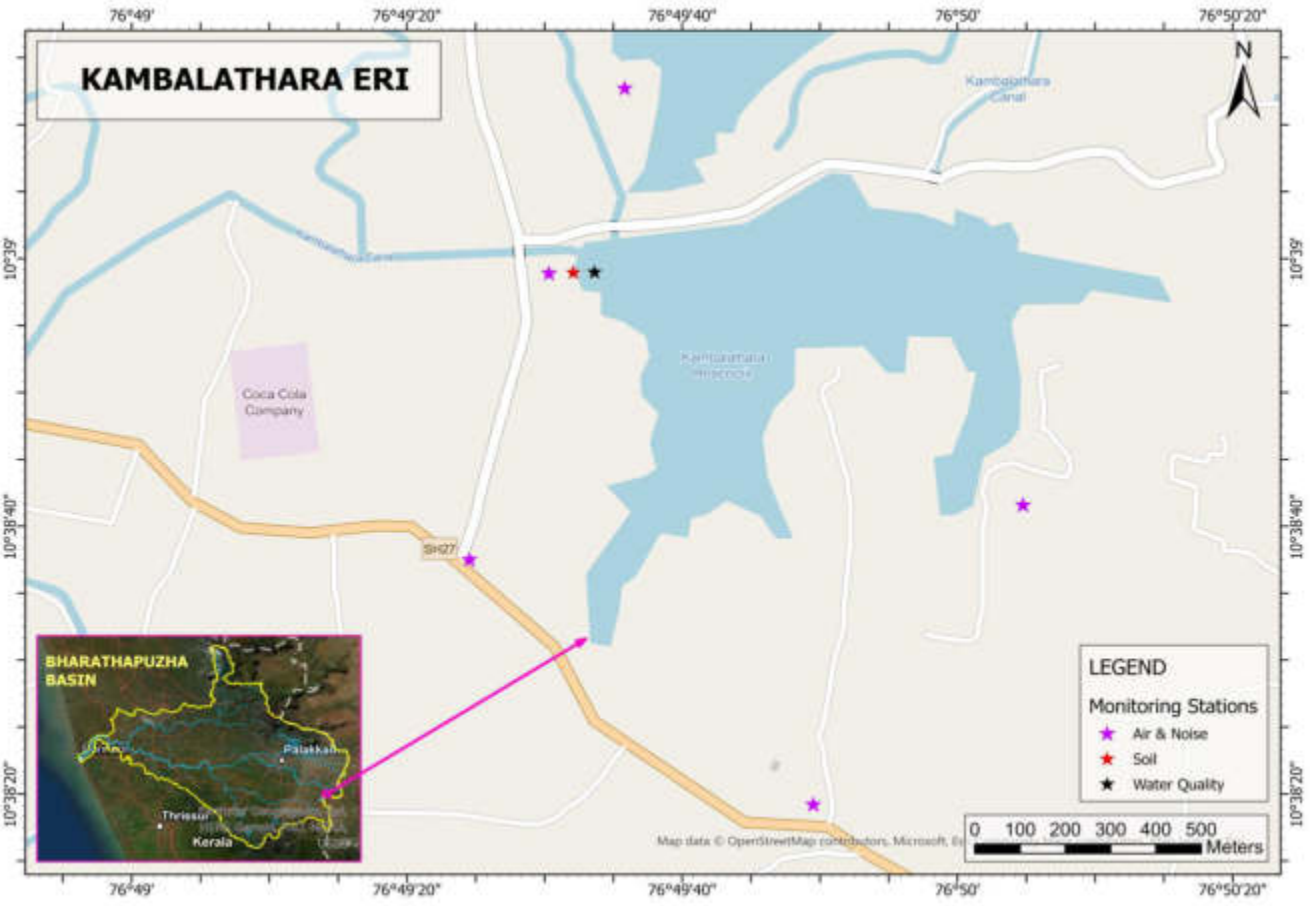


Fig.6.2 Monitoring locations of different parameters

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Environment Management Cell (EMC)

EMC's overall responsibility is the co-ordination of actions required for environmental management and mitigation, and for monitoring the progress of the proposed management plans and subsequent actions to be taken. The EMC will prepare a formal report on environmental management on regular intervals. The EMC will also be responsible for the following:

- To implement the environmental management plan effectively
- To identify risks and control environmental problems
- To assure regulatory compliance with all relevant rules and regulations
- To minimize environmental impacts by strict adherence to the EMP
- To initiate environmental monitoring as per approved schedule
- To maintain documentation of good environmental practices and applicable environmental laws as ready references.
- To do coordination with regulatory agencies, external consultants, monitoring laboratories etc.
- To address all environment-related aspects as a dedicated group and will be responsible for the compliance to all environmental requirements
- To manage post project-monitoring plan as per approved EIA & EMP.
- To develop & maintain green belt

The EMC shall have all basic environmental management data of the project that includes:

- Environmental Management Plan
- All valid and up to date statutory clearances
- All latest environmental legislations, standards, policies, codes and manuals for ready references
- Contact details of all emergency rooms (Police, Hospital, Fire brigade etc)

DISCUSSION

- Depth to which materials can be removed should be pre-determined and a clear de-silting plan may be worked out
- Identification of sites of sand deposits, estimation of thickness of the sediment layer and grain size distribution along the depth are important pre-requisites for the excavation of the exposed sediments.

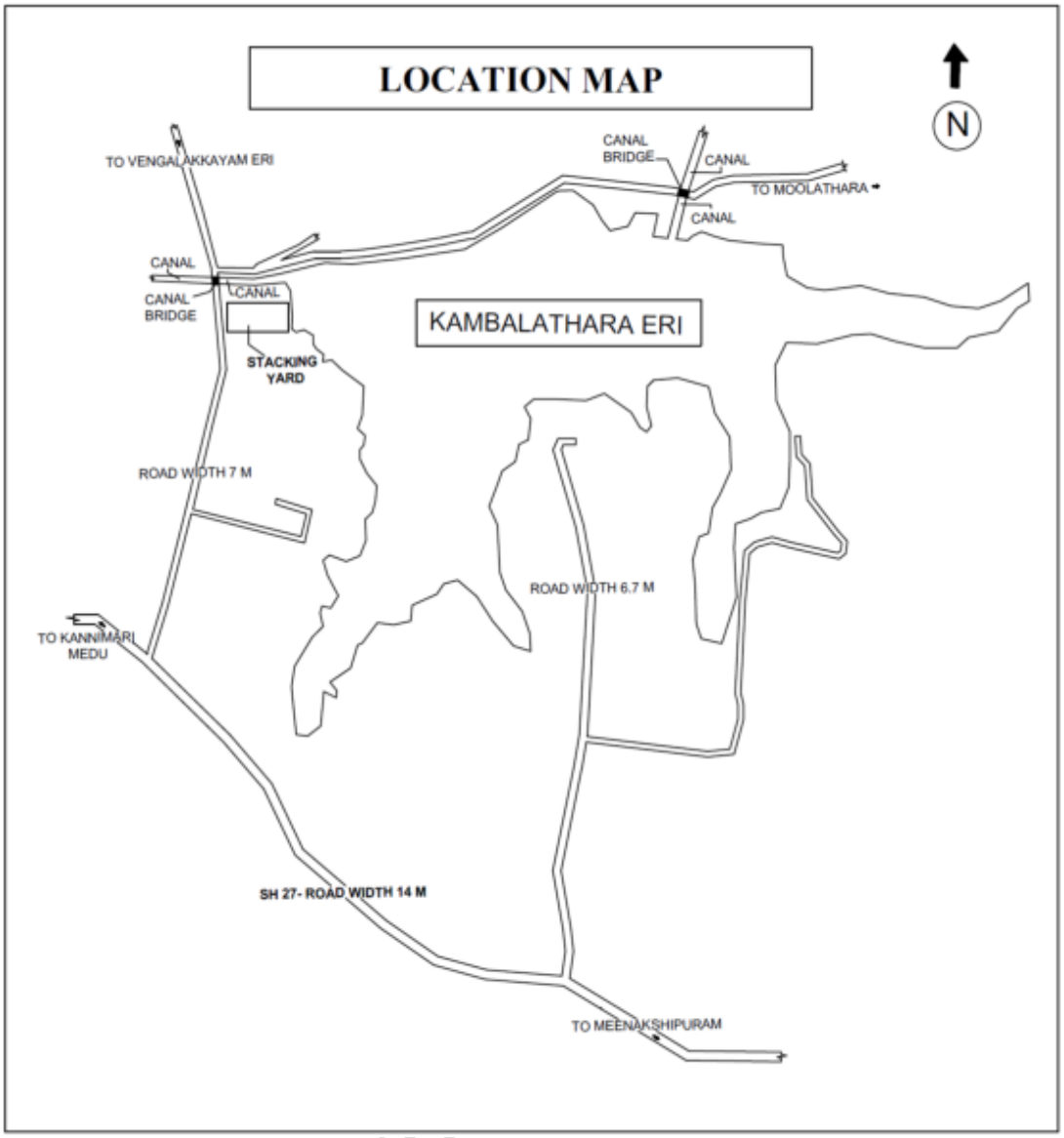
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- The mitigation measures identified for the environmental impacts and the EMP shall be meticulously followed. The environment management cell shall oversee and ensure this.
- During implementation of the project, there is always the possibility that unforeseen issues could arise, the EMP should therefore be revised where necessary to mitigate the unanticipated impacts.

Recommendations

- An Environmental monitoring committee (EMC) comprising of professionals and various stakeholders should be constituted to oversee the entire operation with full transparency.
- Local area development plan to be formulated in consultation with the revenue officials, village and Panchayats.
- The silting of an Eri is an unavoidable process which cannot be totally eliminated; it can be slowed down and controlled by employing a variety of soil conservation practices and by modifying agricultural practices in the catchment area.
- Use of proper land and water management practices can reduce the rate of siltation.
- Coir Rolls or geotextile mats which are cost effective organic living revetments that provide erosion control and rapid vegetation establishment can be an excellent technique for establishing marginal vegetation around Eri edges.
- Training and human resource development is an import link to achieve sustainable operations and environmental management.

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Location Map



Fig. Site visit conducted by KERI team



Fig. Survey Regarding Flora and Fauna

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ENVIRONMENTAL MANAGEMENT PLAN (EMP) FOR THE DESILTATION OF VENGALAKKAYAM ERI

ABSTRACT

Sedimentation is a process whereby soil particles are eroded and transported by flowing water or other transporting media and deposited as layers of solid particles in water bodies such as reservoirs, Eris and rivers. Sedimentation of the reservoir/ Eri is of utmost concern as it reduces the storage capacity thereby reduces the life of the reservoir/Eri and defeats the major purpose such as irrigation for which these were planned. De-silting of reservoirs/Eris is the engineering practice which makes use of various sediment removal techniques and technologies, thereby aiming to restore fully or partially, the storage capacity lost due to the siltation process occurring in the reservoir/Eri basins. De-siltation of reservoirs/Eris can be done by hydraulic or mechanical de-silting techniques.

G.O. (MS) No. 79/2017/WRD dated Thiruvananthapuram 26/09/2017 recommends to prepare an Environment Management Plan (EMP) for the deepening process. As directed by the Empowered Committee meeting held on 7/10/2021, Superintending Engineer, Siruvani Project Circle, Palakkad has requested KERI to prepare the Environmental Management Plan vide letter no D6-1277/2017/Eri's dated 7/10/2021. This study is being carried out in order to assess the environmental impact due to the project execution and, as a result, to develop an Environmental Management Plan for the project. During the de-silting activities, the Environmental Management Plan (EMP) serves as an important link between anticipated consequences and mitigating actions. The EMP lays out the mitigation, monitoring, and institutional measures that will be implemented during and after the de-silting operations to minimize or mitigate negative environmental consequences, as well as the steps to be taken to put them in place. The anticipated effects on numerous environmental components have been identified, and mitigation strategies are proposed.

In order to enhance the storage capacity of the Venkalakkayam Eri, Irrigation department of Kerala decided to perform the desilting operation. This report is prepared in view of assessment of environment impact and thus to make an Environmental Management Plan for the proposed project.

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Fig.1.2 Venkalakkayam Eri

METHODOLOGY

The methodology to be followed for the EIA study is delineated below:

- On-site collection of data relevant to physical, chemical, biological and socioeconomic factors
- Interactions with the Assistant Executive Engineer, Assistant Engineer, Overseers and Eri watchmen
- Identification of road network for transport of the de-silted sediments
- Biodiversity assessment of the study area
- Interactions with the local people
- Identification of the monitoring locations for analyzing the various environmental parameters.
- Prediction of impacts (positive and negative) on the various attributes due to the proposed de-silting operations
- Suggesting suitable impact mitigation measures
- Proposing appropriate environment monitoring plan

Environmental Management Plan (EMP)

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The Environmental Management Plan (EMP) provides an essential link between predicted impacts and mitigation measures during the de-silting operations. EMP outlines the mitigation, monitoring and institutional measures to be taken during and after the de-silting operations to avoid or mitigate adverse environmental impacts, and the actions needed to implement these measures. The likely impacts on various components of environment due to the project have been identified and measures for their mitigation are suggested. The EMP lists all the requirements to ensure effective mitigation of every potential biophysical and socio-economic impact identified in the EIA. For each attribute, or operation, which could otherwise give rise to impact, the following information is presented:

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- Time schedule for implementation of the action to ensure that the objectives of mitigation are fully met

EMP for De-silting Operations

The EMP comprises of a series of components covering direct mitigation and environmental monitoring, an outline of waste management plan and a project site restoration plan. Therefore, environmental management plan has been prepared for each of the above developmental activities. The management plan for each of the environmental component consists of adopting the mitigation measures proposed for them depending on the anticipated impacts. The mitigation measures for all the anticipated impacts are detailed in Chapter 5, in section 5.4. The mitigation measures shall be meticulously followed to ensure efficient environmental management during the de-silting operations.

Land Environment

- Demarcation of excavation area with pillars and geo-referencing should be done prior to start of de-silting.
- Carry out earthwork excavation of ERI by keeping 15m wide embankment along the periphery and maintain a side slope of 1:1 for the earth cutting.
- The excavation should be carried out without affecting the stability of the existing structures such as earthen dam(bund with stone pitching), high level canal from Moolathara regulator, distribution canal, sluice and so on.
- The depth of de-silting should be limited to the existing impervious layer or the original bed level of the reservoir, as per the direction of departmental officials at site.
- Catchment area treatment may be prioritized.

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- The debris and the topsoil shall be stacked separately and used for bund formation.
- Burning of wastes on site shall be prohibited
- The debris from dredging shall be properly disposed off
- Restricting cutting of trees and site vegetation clearance to the minimum needed to provide adequate & safe working space for all activities which will be carried out on site
- Green belt/plantation shall be developed to arrest dust.
- On completion of de-silting operations all machinery and equipment, surplus materials and wastes should be completely removed. Stockpiles if any should be provided with gentle slopes
- A waste management plan should be prepared and complied with.

Water Environment

- Settling tanks and purifying facilities should be established for reducing turbidity. Harmless coagulants used for drinking water treatment such as alum or poly electrolyte can be used as coagulation aids for assisting the sedimentation. The scheme of wastewater treatment proposed shall include detention ponds with geo-membrane liner, coagulant dosing and primary settling tank and ponds for filtration. The filtration ponds shall have geo-membrane liner and graded sand as filtration media. The scheme for wastewater management is depicted in Figure 6.1.



Fig 6.1: Proposed Treatment Scheme for the Wastewater

- Excavation shall be done only in the dry season to avoid any disturbances affecting the water quality in the Eri's water.
- Laborers should be provided with adequate quantity of drinking water of potable quality.
- Sufficient and appropriate sanitary facilities should be provided in order to maintain hygienic conditions. Septic tanks followed by soak pits shall be used for disposal of sewage.
- Area for maintenance of vehicles should be so located that contamination of Eri's water or surface water by accidental spillage of oil can be prevented. Such areas shall be provided with an impermeable base and drainage systems which discharge through efficient oil and grease traps.

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- Storm water management shall be done by providing adequate drainage facilities.

Air Environment

- The transporting vehicles shall not be over loaded.
- Repair and maintenance of the roads shall be done as and when required.
- Water sprinklers shall be used to minimize the air borne dust emissions on haul roads and all the haul roads shall be paved with bitumen to prevent any dust generation.
- PUC certified vehicles shall be used for transportation.
- Vehicles and equipment should be well maintained in fuel efficiency and anti idling.
- If DG sets are used as source of power or back up, they shall be as per CPCB prescribed standards for emission and stack heights.
- Any waste oil generated shall not be incinerated and will be sold to authorized waste oil recyclers
- The storage and handling of soil, sub-soils, top-soils and materials shall be carefully managed to minimize the risk of windblown material and dust
- Engines and exhaust systems of all vehicle and equipment shall be maintained so that exhaust emissions do not exceed statutory limits and that all vehicles and equipment are maintained in accordance with manufactures' manuals. Periodic monitoring of this shall be undertaken to ensure compliance.
- Ambient air quality with respect to SPM, RPM, SO_2, NO_x, H_2S and CO monitoring shall be continued at appropriate locations.

Noise and Vibration

- Earth movers and other machinery with low noise levels shall be used. Acoustic barriers and silencers should be used in equipment wherever necessary
- Periodic maintenance of various machinery and transportation vehicles should be undertaken
- Onsite workers should be provided with noise protection devices such as ear plugs/ muffs wherever necessary and their proper usage will be ensured for eardrum protection of the workers.

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- Periodic monitoring for the noise levels within the project site and along the outside project boundary shall be undertaken to ensure compliance as per the standards set by CPCB
- De-silting operations shall not be carried out in the late night hours.
- Monitor job and location specific noise levels for compliance with HSE regulations by verifying acceptability of noise levels caused by the project activities and comparison with noise criteria
- Feedback from the monitored noise levels at sensitive locations shall be taken to ensure that the impact due to high noise levels is practically minimized

Biological Environment

- The region does not have dense vegetation which requires clearance. The vegetation in the processing location needs to be cleared.
- Many spawning habitats require a specific sediment size and too fine of sediment can end up smothering the eggs and other benthic creatures. Too much sediment deposition can also bury habitats and even physically alter a waterway. Excessive levels of suspended load tend to have negative impacts on aquatic life. Suspended sediment can prevent light from reaching submerged vegetation and clog fish gills. These suspended sediments will also reduce the DO, which adversely affect the life of aquatic species.
- No washing, crushing, screening, stockpiling, or plant operations should occur at or below the stream's "average high water elevation". Similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish and benthic flora and fauna.
- Development of green belt with carefully selected plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation/assimilation and for providing food and habitat for local micro fauna.

Socio Economic Environment

- Even though the de-silting operations do not require huge quantities of power or water, the only likely impact on infrastructure would be on the roads, for transporting the excavated/processed sediments. Considering the high traffic emanating during the transportation of processed sediments, an effective traffic management scheme should be developed to avoid congestion on the nearby and local roads.
- Local persons will get employment due to the de-silting operations

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- Socio-cultural conflicts between the workforce and local communities can be avoided, if the majority of the operators and workforce are local inhabitants.
- Employing local labour will avoid the requirement of providing onsite accommodation to the workforce.

Health and Safety

- Proper signage shall be used at excavation site as well as the transportation route.
- The movement of heavy equipment should be done with proper precaution to prevent any accidents on the road or at the execution site or processing locations.
- Occupational risk should be minimized at the project site through implementation of a full proof safety system.
- Safety training should be provided to all construction workers on operation of equipment. Security should also be extended during non-working hours to ensure there is controlled access to the machinery and equipment.
- The contractors should also be vigilant to detect workers showing symptoms of communicable diseases. All illness and incidents shall be reported and recorded

Environmental Monitoring Programme

The suggested Environmental Monitoring Programme for the de-silting operations is given in Table 6.1. Besides this a base line data should be collected just before the commencement of the project and restoration data after the completion of the project. The expenditure incurred for the same is also included in the table.

Table 6.1: Suggested Environmental Monitoring Programme

Sl no	Type	No of locations	Parameters	Period and frequency	Total no of tests proposed	Cost
1	Ambient Air quality	3	Criteria Pollutants: SO_2. NO_2. PM_{10}. PM_{25} ,CO.	Once in a month	33	3,33,000
2	Ambient Noise	3	dB (A) levels.	Once in a month	33	33,000
3	Water quality	2	As per IS 10500	Once in 6	8	10000

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	in open well		potable water standards.	months		
4	Reservoir/Eri water quality	1	pH, Temp., Salinity, TDS,TSS. DO. BOD, Hardness, Alkalinity, Chlorides, Turbidity. Conductivity, Oil and Grease. Heavy Metals	Twice in a month	19	65000
5	Soil quality	1	Organic matter. CH. N. Alkalinity. Acidity, heavy metals and trace metal. Alkalinity. Acidity.	Once in 6 months	4	6000
6	Sediment quality	1	Organic C. Organic N. heavy metals	Once in 6 months	4	6000
Total						**4,43,000**

The proposed ambient air, noise, water, soil and sediment quality monitoring locations are found and sketched in the figure below.

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Fig.6.2 Monitoring locations of different parameters

Environment Management Cell (EMC)

EMC's overall responsibility is the co-ordination of actions required for environmental management and mitigation, and for monitoring the progress of the proposed management plans and subsequent actions to be taken. The EMC will prepare a formal report on environmental management on regular intervals. The EMC will also be responsible for the following:

- To implement the environmental management plan effectively
- To identify risks and control environmental problems
- To assure regulatory compliance with all relevant rules and regulations
- To minimize environmental impacts by strict adherence to the EMP
- To initiate environmental monitoring as per approved schedule
- To maintain documentation of good environmental practices and applicable environmental laws as ready references.
- To do coordination with regulatory agencies, external consultants, monitoring laboratories etc.
- To address all environment-related aspects as a dedicated group and will be responsible for the compliance to all environmental requirements

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- To manage post project-monitoring plan as per approved EIA & EMP.
- To develop & maintain green belt

The EMC shall have all basic environmental management data of the project that includes:

- Environmental Management Plan
- All valid and up to date statutory clearances
- All latest environmental legislations, standards, policies, codes and manuals for ready references
- Contact details of all emergency rooms (Police, Hospital, Fire brigade etc)

DISCUSSION

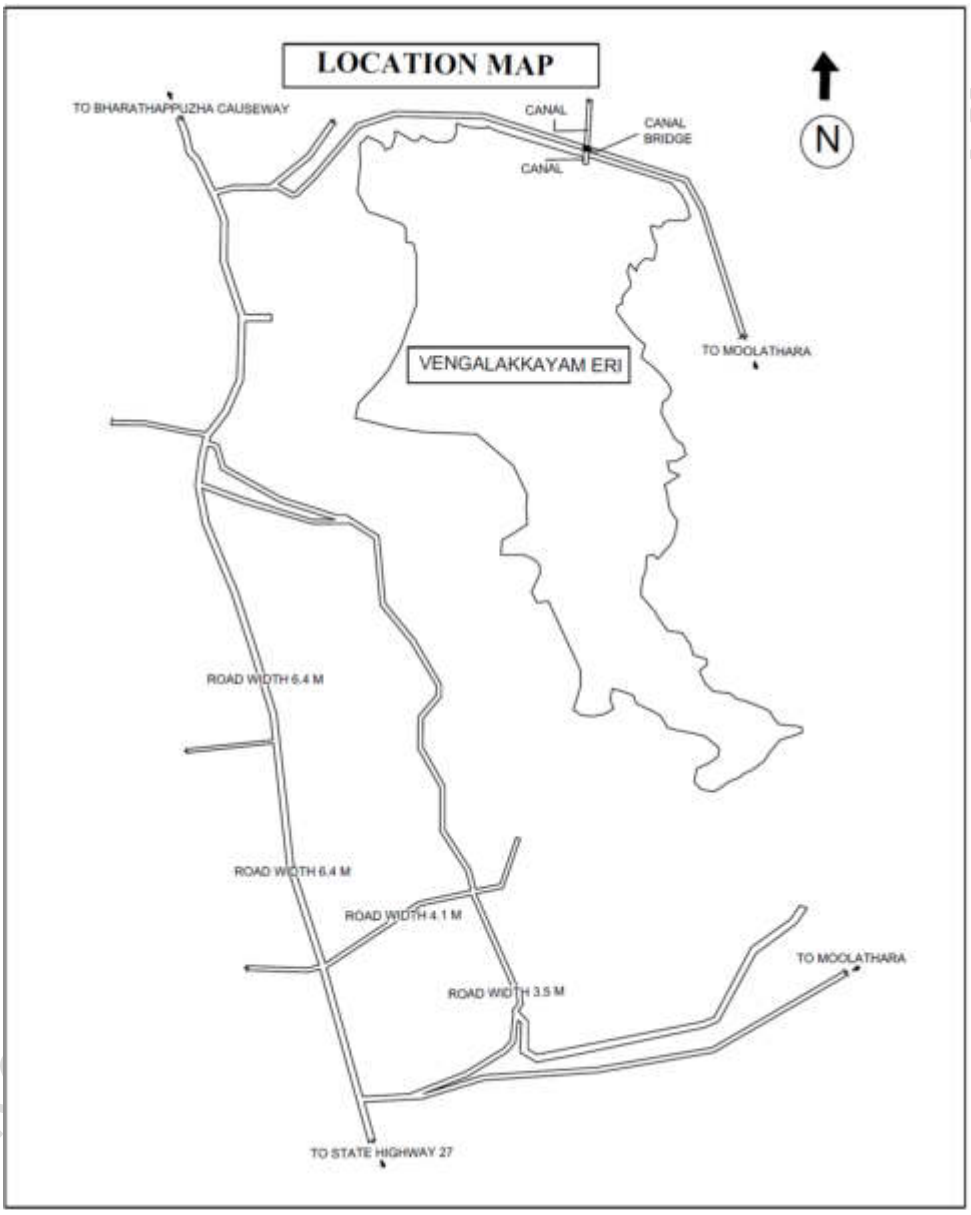
- Depth to which materials can be removed should be pre-determined and a clear de-silting plan may be worked out
- Identification of sites of sand deposits, estimation of thickness of the sediment layer and grain size distribution along the depth are important pre-requisites for the excavation of the exposed sediments.
- The mitigation measures identified for the environmental impacts and the EMP shall be meticulously followed. The environment management cell shall oversee and ensure this.
- During implementation of the project, there is always the possibility that unforeseen issues could arise, the EMP should therefore be revised where necessary to mitigate the unanticipated impacts.

Recommendations

- An Environmental monitoring committee (EMC) comprising of professionals and various stakeholders should be constituted to oversee the entire operation with full transparency.
- Local area development plan to be formulated in consultation with the revenue officials, village and Panchayats.
- Silting of an Eri is an unavoidable process which cannot be totally eliminated; it can be slowed down and controlled by employing a variety of soil conservation practices and by modifying agricultural practices in the catchment area.
- Use of proper land and water management practices can reduce the rate of siltation.

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- Coir Rolls or geotextile mats which are cost effective to organic living revetments that provide erosion control and rapid vegetation establishment can be an excellent technique for establishing marginal vegetation around Eri edges.
- Training and human resource development is an import link to achieve sustainable operations and environmental management.



Location Map



Fig. Site visit conducted by KERI team



Fig. Survey regarding Flora and Fauna

ENVIRONMENTAL MANAGEMENT PLAN (EMP) FOR THE DESILTATION OF KUNNAMPIDARI ERI

ABSTRACT

Kunnampidari Eri is a mini reservoir located at Valiavallampathy village of ChitturTaluk and is fed through a sluice of Right Bank Canal at Ch.9/700 km. The storage of this Eri is being utilized to cater the additional need of Kunnamkattupathy System by connecting the Kunnamkattupathy main canal at Ch.14/200km.

Sedimentation of the reservoir/ Eri is of utmost concern as it diminishes the storage capacity, thus reducing their life and defeating the primary objectives such as irrigation, drinking water supply etc. Desilting of reservoir/ eri is an engineering technique that utilizes a variety of sediment removal techniques and technologies with the goal of restoring full or partial storage capacity lost owing to the siltation process.

G.O. (MS) No. 79/2017/WRD dated Thiruvananthapuram 26/09/2017 recommends to prepare Environment Management Plan (EMP) for the deepening process. As directed by the Empowered Committee meeting held on 7/10/2021, Superintending Engineer, Siruvani Project Circle, Palakkad has requested KERI to prepare the Environmental Management Plan vide letter no D6-1277/2017/Eri's dated 7/10/2021. This study is being carried out in order to assess the environmental impact due to project execution and, as a result, to develop an Environmental Management Plan for the project. During the de-silting activities, the Environmental Management Plan (EMP) serves as an important link between anticipated consequences and mitigating actions. The EMP lays out the mitigation, monitoring, and institutional measures that will be implemented during and after the de-silting operations to minimise or mitigate negative environmental consequences, as well as the steps to be taken to put them in place. The project's anticipated effects on numerous environmental components have been identified, and mitigation strategies are proposed.

Kunnampidari Eri is a mini reservoir located at Valiavallampathy village of Chittur Taluk and is fed through a sluice of Right Bank Canal at Ch.9/700 km. The storage of this Eri is being utilized to cater the additional need of Kunnamkattupathy System by connecting the Kunnamkattupathy main canal at Ch.14/200km. Geographic allocation of the Eri's at 10°42'14.00"N, 76°49'55.00"E. It is situated at the 6thmile of Kozhinjamapra Panchayath near Chittur-Gopalapuram Road. The satellite image of the Eri is shown in the figure 1.1

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Fig.1.1 Satellite image of Kunnampidari Eri

In order to enhance the storage capacity of the Kunnampidari Eri, Irrigation department of Kerala decided to perform the desilting operation. This report is prepared in view of assessment of environment impact and thus to make an Environmental Management plan for the proposed project.

METHODOLOGY

The methodology to be followed for the EIA study is delineated below:

- On-site collection of data relevant to physical, chemical, biological and socio economic factors
- Interactions with the Assistant Executive Engineer, Assistant Engineer, Overseers and Eri watchmen
- Identification of road network for transport of the de-silted sediments
- Biodiversity assessment of the study area
- Interactions with the local people
- Identification of the monitoring locations for analyzing the various environmental parameters.
- Prediction of impacts (positive and negative) on the various attributes due to the proposed

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de-silting operations

- Suggesting suitable impact mitigation measures
- Proposing appropriate environment monitoring plan

The entire process consists of excavation, stacking of the materials, separation of material into gravel, sand, clay etc, stacking and packing of separated material and transportation of separated materials. The various steps are shown in the flow chart below (figure 2.4)

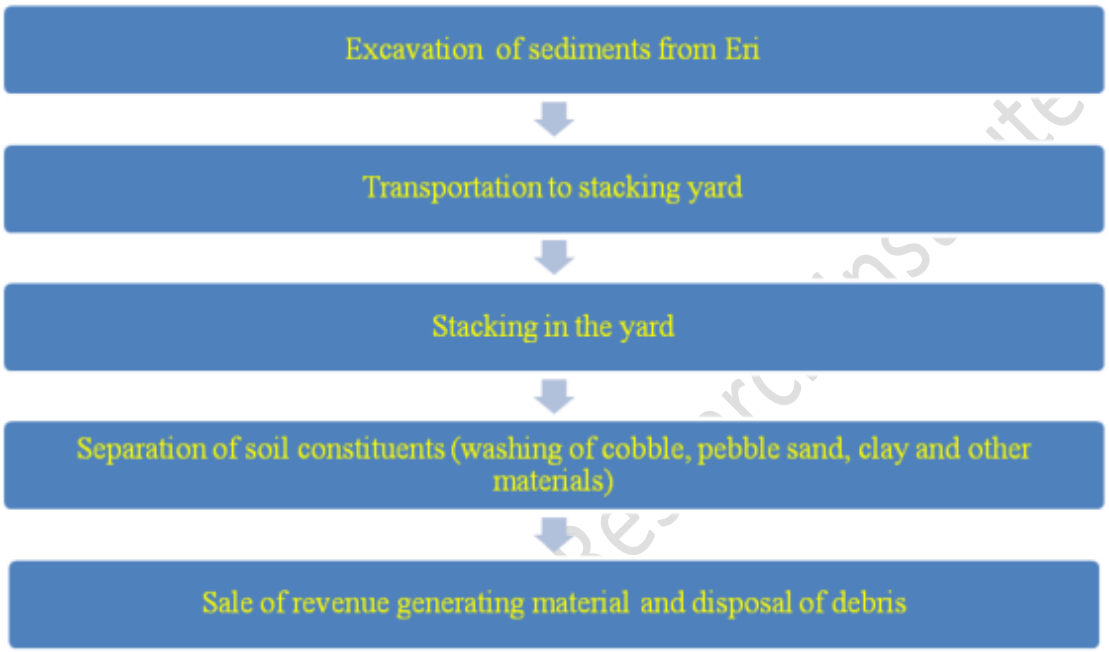


Fig. Flow Chart of Desilting steps

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management Plan (EMP) provides an essential link between predicted impacts and mitigation measures during the de-silting operations. EMP outlines the mitigation, monitoring and institutional measures to be taken during and after the de-silting operations to avoid or mitigate adverse environmental impacts, and the actions needed to implement these measures. The likely impacts on various components of environment due to the project have been identified and measures for their mitigation are suggested. The EMP lists all the requirements to ensure effective mitigation of every potential biophysical and socio-economic impact identified in the EIA. For each attribute, or operation, which could otherwise give rise to impact, the following information is presented:

- A comprehensive listing of the mitigation measures
- Parameters that will be monitored to ensure effective implementation of the action
- Time schedule for implementation of the action to ensure that the objectives of mitigation

are fully met

EMP for De-silting Operations

The EMP comprises of a series of components covering direct mitigation and environmental monitoring, an outline of waste management plan and a project site restoration plan. Therefore, environmental management plan has been prepared for each of the above developmental activities. The management plan for each of the environmental component consists of adopting the mitigation measures proposed for them depending on the anticipated impacts. The mitigation measures for all the anticipated impacts are detailed in Chapter 5, in section 5.4. The mitigation measures shall be meticulously followed to ensure efficient environmental management during the de-silting operations.

Land Environment

- Demarcation of excavation area with pillars and geo-referencing should be done prior to start of de-silting.
- Carry out earthwork excavation of ERI by keeping 15m wide embankment along the periphery and maintain a side slope of 1:1 for the earth cutting.
- The excavation should be carried out without affecting the stability of the existing structures such as earthen dam.
- The depth of de-silting should be limited to the existing impervious layer or the original bed level of the reservoir, as per the direction of departmental officials atsite.
- Catchment area treatment may beprioritized.
- The debris and the topsoil shall be stacked separately and used for bundformation.
- Burning of wastes on site shall beprohibited
- The debris from dredging shall be properly disposedoff
- Restricting cutting of trees and site vegetation clearance to the minimum needed to provide adequate & safe working space for all activities which will be carried out onsite
- Green belt/plantation shall be developed to arrestdust.

On completion of de-silting operations all machinery and equipment, surplus materials and wastes should be completely removed. Stockpiles if any should be provided with gentleslopes

A waste management plan should be prepared and compliedwith.

Water Environment

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- Settling tanks and purifying facilities should be established for reducing turbidity. Harmless coagulants used for drinking water treatment such as alum or poly electrolyte can be used as coagulation aids for assisting the sedimentation. The scheme of wastewater treatment proposed shall include detention ponds with geo-membrane liner, coagulant dosing and primary settling tank and ponds for filtration. The filtration ponds shall have geo-membrane liner and graded sand as filtration media. The scheme for wastewater management is depicted in figure6.1.



Fig 6.1: Proposed Treatment Scheme for the Wastewater

- Excavation shall be done only in the dry season to avoid any disturbances affecting the water quality in the Eri'swater.

- Laborers should be provided with adequate quantity of drinking water of potablequality.

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- Storm water management shall be done by providing adequate drainage facilities.

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- The transporting vehicles shall not be overloaded.

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- Earth movers and other machinery with low noise levels shall be used. Acoustic barriers and silencers should be used in equipment wherevernecessary
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- Socio-cultural conflicts between the workforce and local communities can be avoided, if the majority of the operators and workforce are localinhabitants.
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- Proper signage shall be used at excavation site as well as the transportationroute.
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3	Water quality in open well	2	As per IS 10500 potable water standards.	Once in 6 months	8	10000
4	Eri/Reservoir water quality	1	pH, Temp., Salinity, TDS,TSS. DO. BOD, Hardness, Alkalinity, Chlorides, Turbidity. Conductivity, Oil and Grease. Heavy Metals	Twice in a month	19	65000
5	Soil quality	1	Organic matter. CH. N. Alkalinity. Acidity, heavy metals and trace metal. Alkalinity. Acidity.	Once in 6 months	4	6000
6	Sediment quality	1	Organic C. Organic N. heavy metals	Once in 6 months	4	6000
				Total		**3,29,000**

The proposed ambient air, noise, water, soil and sediment quality monitoring locations are identified and sketched in the figure 6.2 below. The soil quality in the dumping yard must be also determined.

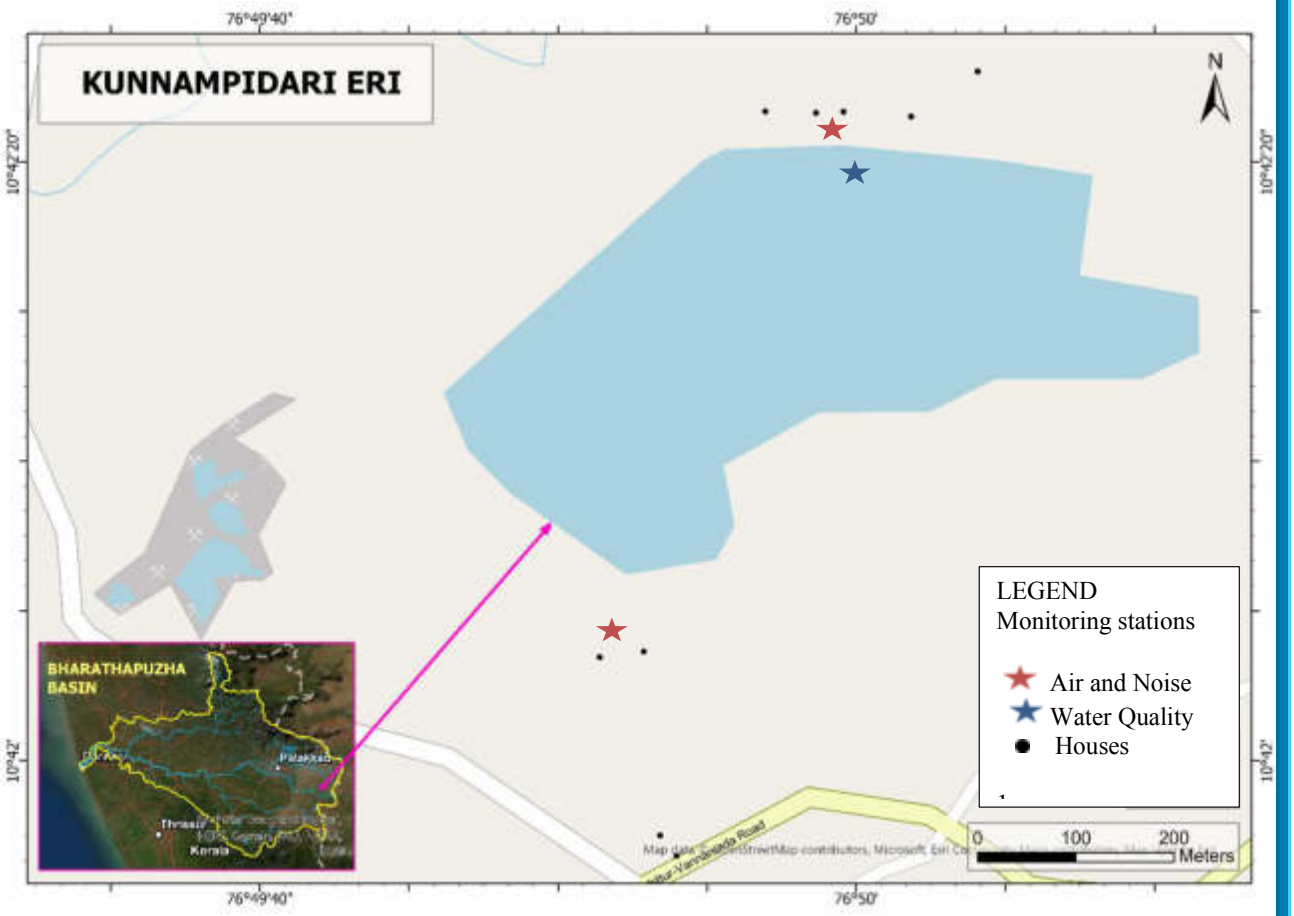


Fig.6.2 Monitoring locations of different parameters

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EMC's overall responsibility is the co-ordination of actions required for environmental management and mitigation, and for monitoring the progress of the proposed management plans and subsequent actions to be taken. The EMC will prepare a formal report on environmental to implement the environmental management planeffectively

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- To minimize environmental impacts by strict adherence to theEMP
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- To address all environment-related aspects as a dedicated group and will be responsible for the compliance to all environmentalrequirements
- To manage post project-monitoring plan as per approved EIA &EMP.
- To develop & maintain greenbelt

The EMC shall have all basic environmental management data of the project that includes:

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DISCUSSION

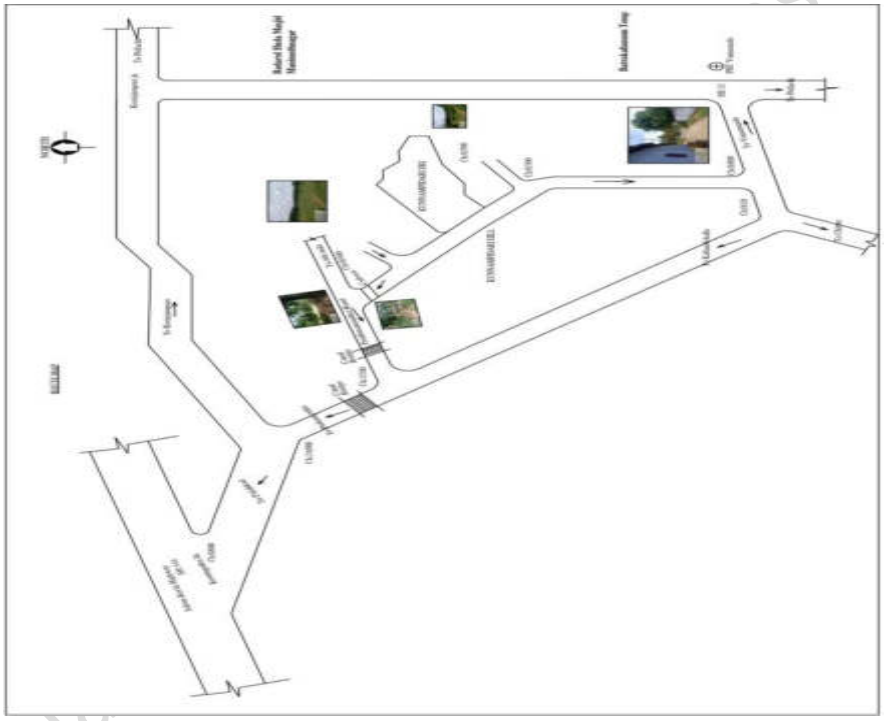
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- During implementation of the project, there is always the possibility that unforeseen issues could arise, the EMP should therefore be revised where necessary to mitigate the unanticipatedimpacts.

7.1. Recommendations

- An Environmental monitoring committee (EMC) comprising of professionals and various stakeholders should be constituted to oversee the entire operation with fulltransparency.
- Local area development plan to be formulated in consultation with the revenue officials, village and Panchayats.

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- The silting of an Eri is an unavoidable process which cannot be totally eliminated; it can be slowed down and controlled by employing a variety of soil conservation practices and by modifying agricultural practices in the catchment area.
- Use of proper land and water management practices can reduce the rate of siltation.
- Coir Rolls or geo textile mats which are cost effective organic living revetments that provide erosion control and rapid vegetation establishment can be an excellent technique for establishing marginal vegetation around Eri edges.
- Training and human resource development is an import link to achieve sustainable operations and environmental management.



Location Map





Fig. Site visit conducted by KERI team



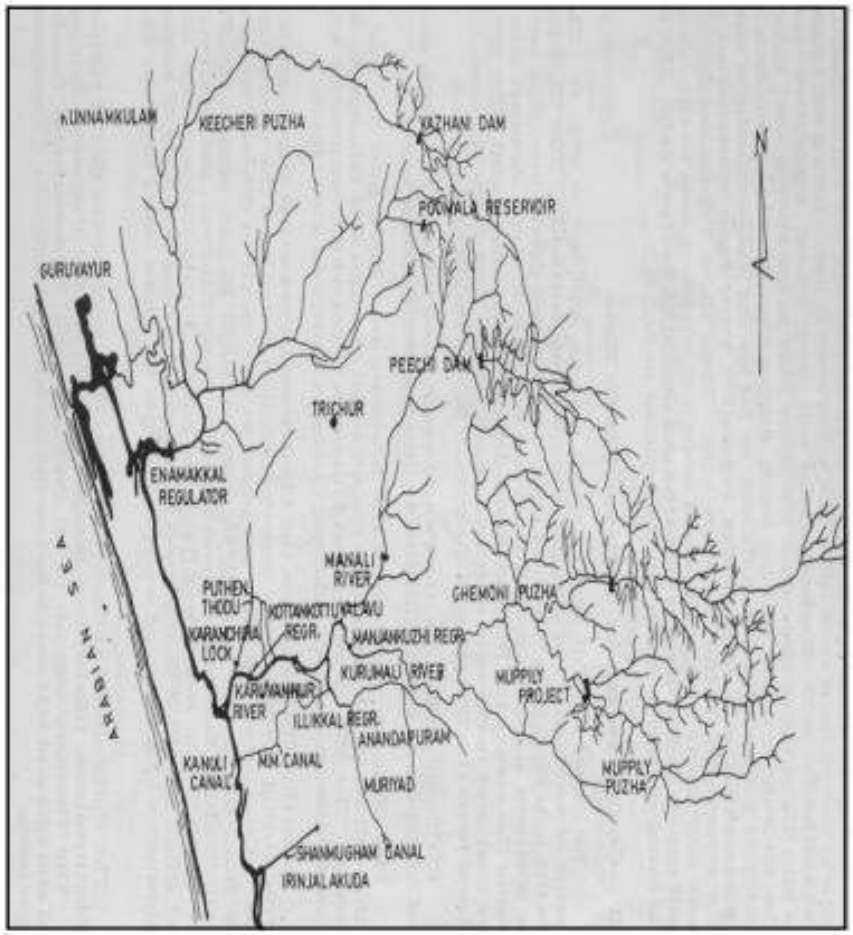
Fig. Survey Regarding Flora and Fauna

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ENGINEERING INVESTIGATIONS FOR THE RECTIFICATION OF EXISTING REGULATOR CUM BRIDGE AT IDIYANCHIRA

ABSTRACT

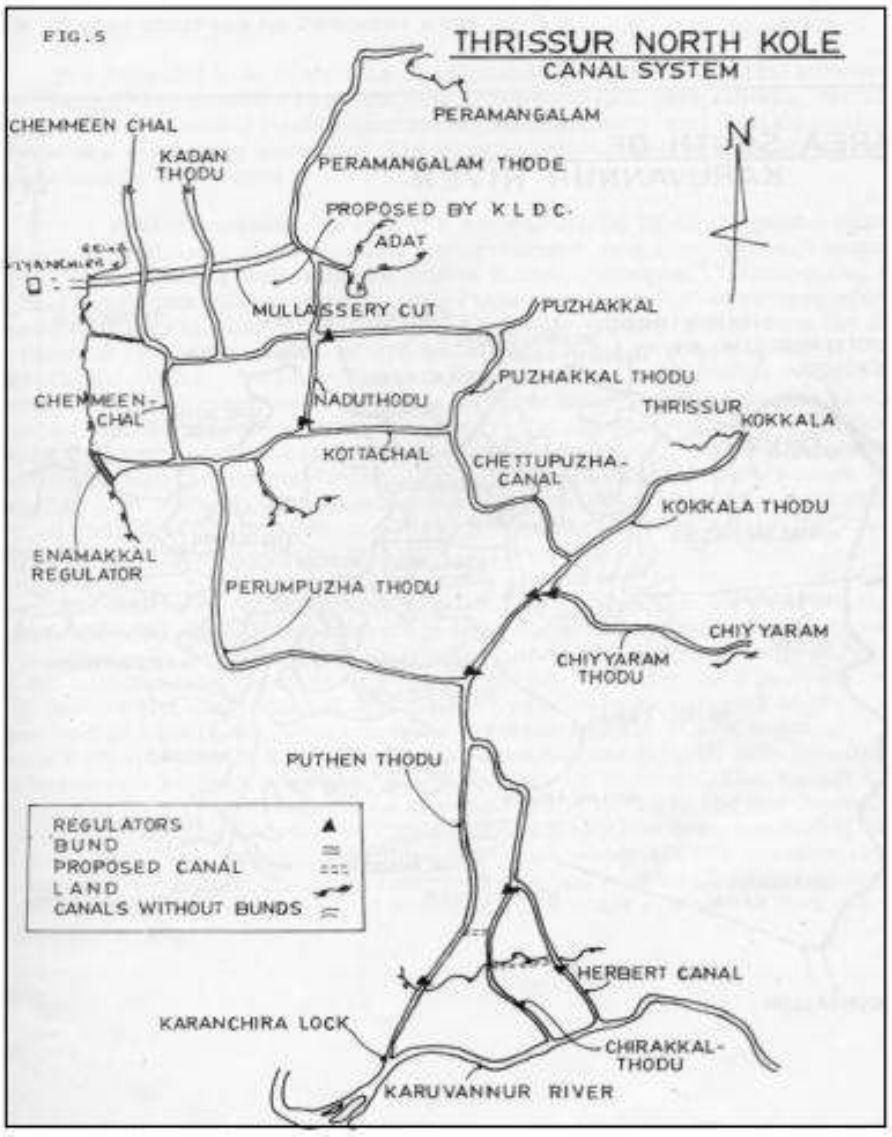
Enamakkal and Idiyanchira regulators are two important structures in the Kole wetland system. These regulators prevent salt water intrusion into the Kole lands during summer months and helps in discharge of flood waters during monsoon. These regulators serve to divert flood waters of northern Kole to the backwaters through *Kanoli* canal and subsequently to the sea through *Chettuva azhi*.



Kecheri and Karuvannur River system

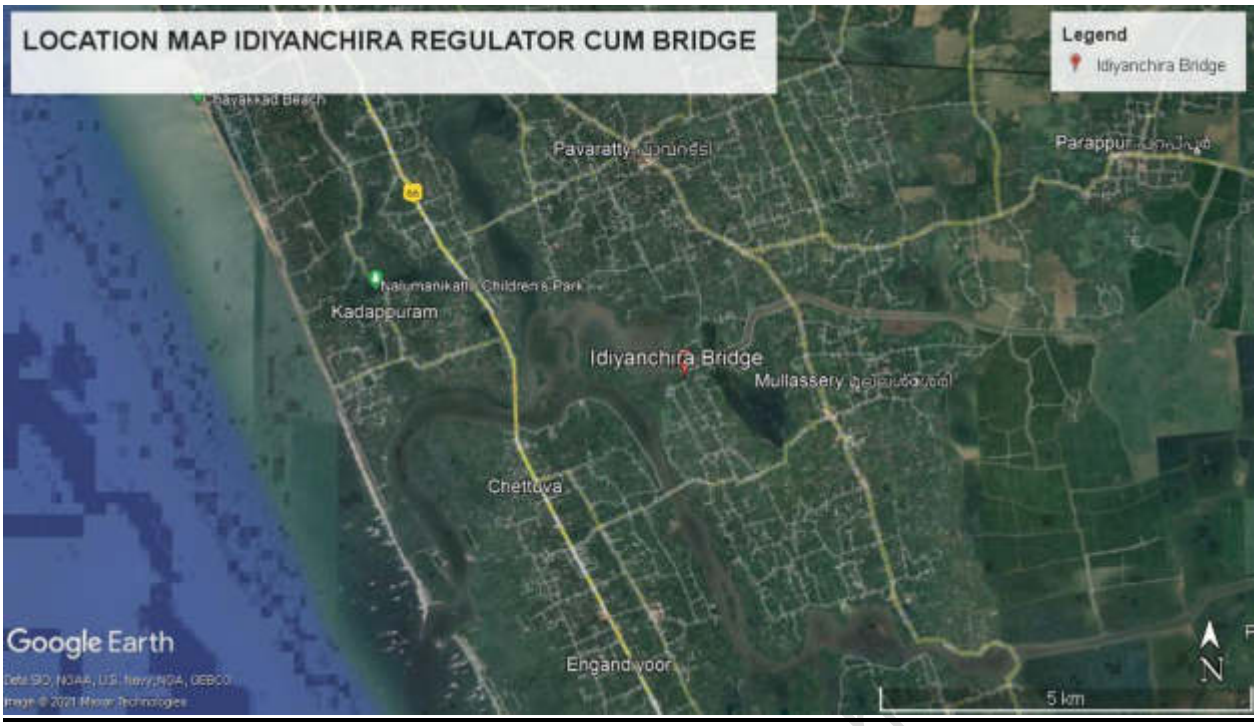
Kole lands mainly refer to a group of low-lying wetlands in the western part of Thrissur district, most of which are located below mean sea level ranging from 0.5m to 2.5m. In Thrissur district, 13000 Ha of kole land are extending between Kechery River and Karuvannur River. Majority of the kole land in Thrissur Taluk is lying very near to sea. As these lands are low lying areas, a day long rain is enough to bring the land under flood. The regulators play a crucial role in

preventing salt water intrusion into the Kole lands during summer months and discharging flood water during rainy season.



Thrissur North Kole canal system

Presently it is reported that the Enamakkal and Idiyanchira regulators are not water tight and are in need of an overall maintenance. As the structure is not watertight, a temporary bund has been constructed every year to prevent salt water intrusion into Kole lands, which has to be demolished during monsoon to facilitate exit of flood water. This incurs expenditure for an amount of 37 lakhs every year which can be avoided by the proper upkeeping of the regulators.



Location Map – Idiyanchira RCB

As per Lt no. WP2-7186/2018/D2/GL dated 29.04.2021of the Chief Engineer Project II and Lt no. D6-4927/2018 (2) dated 29.04.2021 of SE ICC; it was entrusted to carry out investigation works of Regulator cum Bridge located at Idiyanchira to upgrade the structure in terms of structural and hydraulic aspects so as to meet the current requirements.

Idiyanchira regulator cum bridge located in Mullassery Canal is one of the important structures in the Kole wetland system of Thrissur District. The concrete structure was constructed in 1990s by Kerala Land Development Corporation Ltd to prevent salt water intrusion into the Kole lands during summer months and helps in discharge of flood waters during monsoon. As per Lt.No.D6-4927/2018 dated 15.09.2021 and 20.07.2021, the Superintending Engineer, Irrigation Central Circle (ICC), Thrissur has reported that structure was constructed in the year 1990 by KLDC and later handed over to the Irrigation Department.

The structure has 33 vents for the flow of water and the shutters are manually operated now. Concrete deck is provided over the concrete piers for vehicular traffic. Presently the regulator is not water tight and every year huge fund is required to put earthen bund in the upstream of regulator to prevent salt water intrusion. Hence it is required to perform various investigations to make the structure functional.

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View of Idiyanchira Regulator cum Bridge

METHODOLOGY

The investigations of old concrete structures are proposed to identify the deficiencies that potentially affect the safety and functionality of the structure. Hence the investigation shall include data collection and review, assessment of existing structural condition etc. The methodologies of investigations carried out are described in detail in the subsequent part of this report.

Review of data and records

First, an assessment of the background, design, construction and performance history of the Regulator cum Bridge is conducted to understand the following details of the structure using available data with the Major Irrigation wing which includes the details transferred by KLDC.

1. Design calculations specifying the load distribution and type of loads along with IS code references used for design and construction
2. Contract drawings / built up drawings
3. Site records of construction
4. Soil Investigation data before and during construction
5. Material tests and load test data
6. Contract specifications
7. Post construction inspection and maintenance records
8. Details of repairs or strengthening work carried out till date
9. Hydrological, seismic and environmental data including changes if any.

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10. Other natural hazards identified if any.

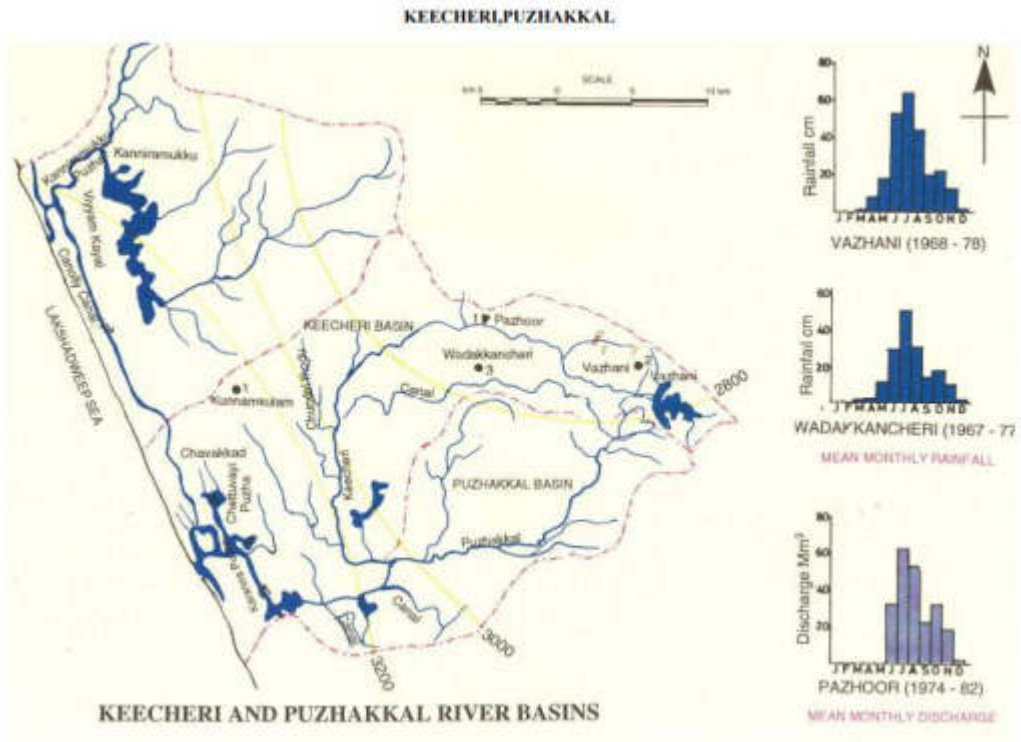
Design calculations specifying the load distribution and type of loads along with IS code references used for design and construction

The hydraulic design details and structural design details used for the design of structure by KLDC as per records transmitted from Irrigation Central Circle, Thrissur are described below.

1. Bed width of canal – 90.00m
2. Design discharge - 382 m3/sec
3. Velocity of flow - 1.26m3/sec
4. Retention level - +1.50m
5. Downstream HTL (max) - +1.20m
6. Downstream LTL (min) -+0.00
7. Bed slope of river - 1 in 24000
8. Bed level of river - -1.80
9. Top of Bund - +2.60
10. Top of Shutter level -+1.65
11. Top of cut water - +2.00
12. Bottom of Bridge -+2.70
13. Bottom of operating platform -+5.95
14. Loading - IRC Class A

The design discharge adopted for the design of hydraulic components of the Idiyanchira Regulator is 382m3/sec. It was the flood discharge recorded at Pazhoor gauge station in the year 1968. The recent floods in the year 2018 and 2019 might have changed the above hydraulic particulars and the hydraulic design is to be verified according to the new parameters and in conform to the current IS standards (IS: 6966 (Part 1) -1989) Hydraulic design of barrages and weirs -Guidelines, Part 1: Alluvial Reaches [WRD 22: River Training and Diversion Works] **.**

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Location of Pazhoor gauge station

(Source: KERALA ENVIS website viewed on 26.10.2021)

Contract drawings / built up drawings

The drawing of the existing visible components of Regulator cum Bridge was transmitted to KERI by the Executive Engineer, Irrigation Division.

Site records of construction

Idiyanchira regulator is located in Mullassery canal and originally constructed by Kerala Land Development Corporation Ltd for the purpose of salt water prevention to Kole lands and exit of flood water.

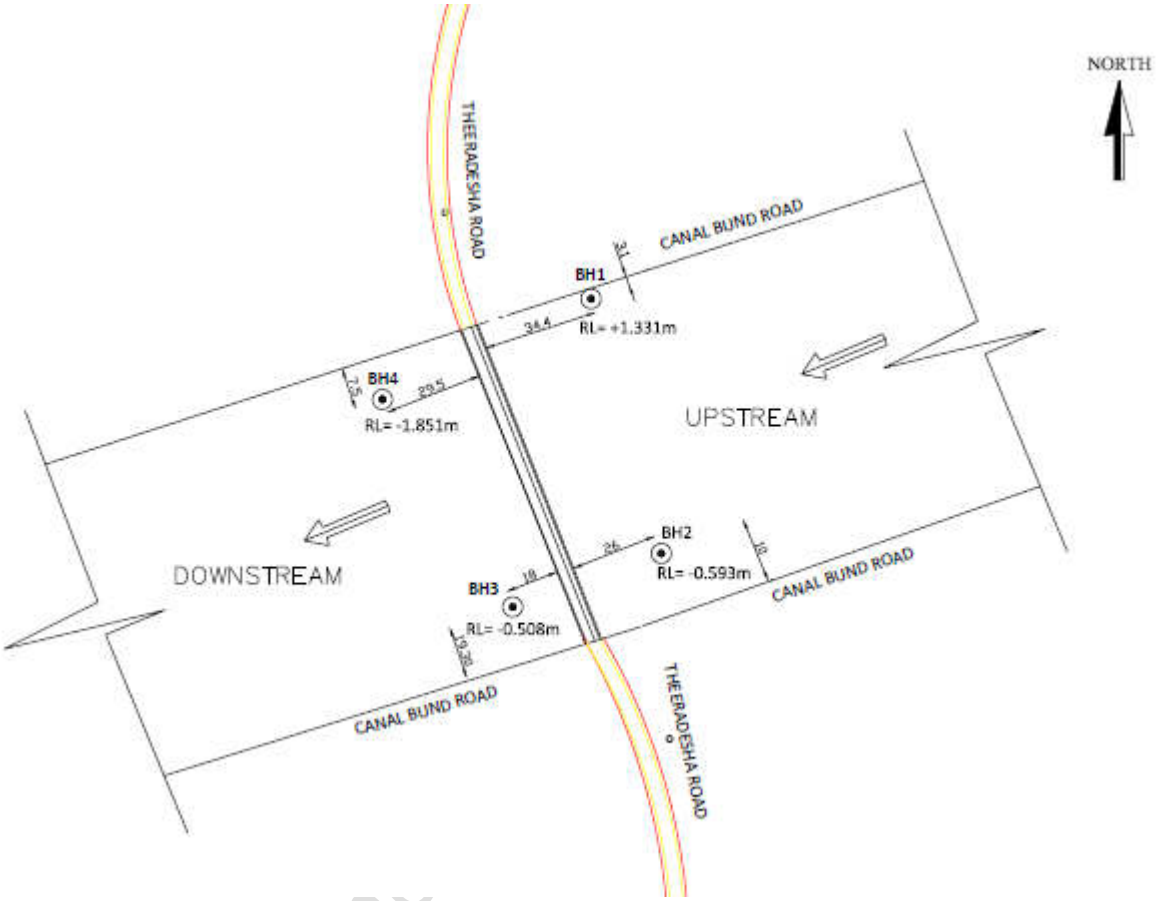
Soil Investigation data before and during construction

As per the records of KLDC, borings at five places were conducted along the alignment of the regulator prior to the construction. Laterite and coarse sand are available in the first three borings. Lime shell and sand are met with 4th and 5th bore holes.

Soil Investigation by KERI

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As part of the investigations done for the rectification of Idiyanchira Regulator, soil investigations were carried out by the Instrumentation Division, KERI during 06.07.2020 to 15.09.2020 and the Four bore holes were explored at site, two bore holes at upstream and two bore holes at downstream of regulator.



Borehole details and locations (Soil Investigation by KERI, 2020)

Site observations of conditions

The careful examination of the surface and all parts of the structure was carried out to assess and document current conditions. Site inspections were conducted out jointly from team from KERI, Irrigation Division Thrissur and experts from Government Engineering College, Thrissur and experts in the relevant field on 18.06.2021 and jointly with experts from NIT, Kozhikkode on 18.09.2021.

Through examination, the signals of damages or deterioration occurred to the structure are observed and the photographs are attached herewith.





Upstream and downstream view of Structure

Structural problems are indicated by cracking, exposure of reinforcing bars, large areas of broken-out concrete, misalignment at joints, undermining and settlement in the structure. Rust stains that are noted on the concrete may indicate that internal corrosion and deterioration of reinforcement steel is occurring.

Concrete deterioration is a progressive reduction in properties that may make concrete no longer serviceable for its intended use. This may be a physical "removal" of materials from the surface of the structure leading to a reduced cross section or an internal change in strength, modulus of elasticity, Poisson's ratio, or density that reduces its overall structural load-carrying capacity. The reduced cross section increases the stresses of the remaining section proportionately to the amount of material removed. Scaling, spalling, pitting, corrosion are different types of deterioration occurs to concrete.

Scaling is the flaking or peeling away of the concrete or mortar surface. Scaling also results in susceptibility to further deterioration of the structure. Scaling is a milder form of disintegration.

Spalling is the loss of larger pieces of concrete (usually flakes or wedge-shaped pieces) from a surface, often at edges, caused by a sudden impact, external pressure, weathering, internal pressure (e.g.corroded rebar near the surface), expansion within the concrete mass, or fires built on or against structures. It often occurs in concrete on exposed surfaces at corners or at joints. Pitting is the development of small cavities in the concrete surface caused by localized disintegration. Once pitting begins it usually continues to worsen.

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Corrosion typically results in an increase in the volume of the reinforcing metal that causes cracking and spalling of overlying concrete. Visible signs of metal corrosion include straight, uniform crack lines above reinforcing, rust stains on the surface, spalling, exposed reinforcing, and deterioration of concrete next to unprotected aluminum fish ladders, hydraulic pumps, gates, and guard rails.



Spalling of Concrete and exposed bars in piers



Deterioration of concrete in gate openings (view from U/S)

The cracking, spalling, loss of material from the concrete structure components are seen from the photographs. The reinforcement bars are seen exposed and corroded. Also, the gate opening

channel portions in the piers are seen deteriorated and reinforcement exposed. The exposure to saline water may aggravate the corrosion and deterioration of materials.

Bridge bearings are structural equipment or devices installed between bridge substructure and superstructure to transfer the applied load including earthquake loads; wind loads; traffic loads; and superstructure self-weight. The delay in the rehabilitation of the bearings will affect the performance of bridge and deck slab as it designed for IRC class A loading.



Distressed conditions of bearings

Under Water Investigations

Bridges or Hydraulic structures that cross waterways often have foundation and substructure elements located in water to provide the most economical total design. Inspection of underwater components is usually not easy and economical compared with inspection of the structure above the water surface. However, underwater inspection is a major part of underwater structure assessment to specify whether the structure meets design requirements, future performance and safety.

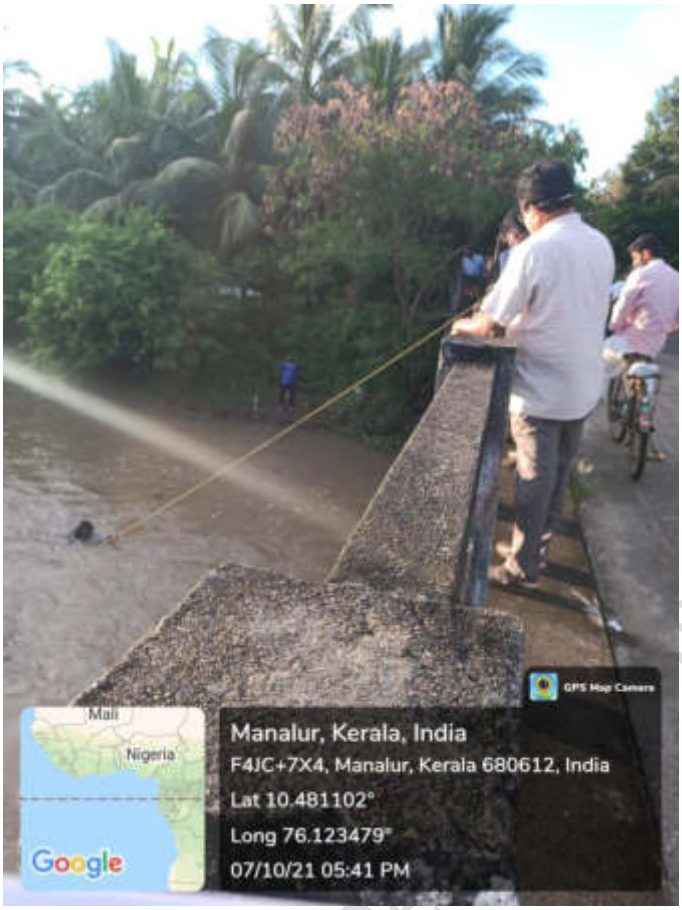
Uunderwater inspection by surface supplied air diving method is carried out at Idiyanchira Regulator cum Bridge site to confirm as-built conditions of the components, to find out obvious deterioration or damage that might be occurred as a result of the impact overstress corrosion or biological attack. The inspection was carried out on 07.10.2021 by M/s AigleTech Diving & Engineering Services Co., Cherpu, Thrissur. Surface supplied air diving is well suited for waterway inspection with adverse conditions, such as high stream flow velocity up to a maximum of 4 m/s polluted water, and long duration requirements.



Preparation for underwater inspection at upstream side



Underwater inspection at upstream side



Underwater inspection at downstream side

Observations

Every year temporary bund is constructed in the upstream side of Idiyanchira Regulator to prevent salt water intrusion. Through underwater inspection, it was noticed that the river bed and apron are got affected due to deposit of suspended sediments. Both of this may cause adverse effect on structure in terms of stability and forces. The velocity of water and presence of sediments causes erosion of construction material. Sometimes the air bubbles present in the turbulent water strikes the structure and bursts, this acts as tiny hammer which causes cavitation or loss of material from the structure.

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Cavitation of concrete Pier

The aquatic life in the water body causes deposition on the surface of apron which interferes with the inspection of apron and piers.



Aquatic plants growth in between piers from D/S

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Due to the growth of aquatic plants and sediment deposition, the entire portion of waterway could not be inspected during underwater inspection. Out of the 33nos ventways, 4,5,6,7 vents from left abutment are filled with the aquatic plants making obstruction to flow and interfering under water inspection. Also the vents 7,8,13,14,15,16, 17 are also in the same condition with the roots of plants extending upto the bed level.



Aquatic plants in between Jack piers from U/S

The visible portions of apron are found in distressed condition during underwater inspection and the aggregates separated. As provided in the design papers given by KLDC to Major Irrigation, the underwater inspection confirms the presence of apron at upstream and downstream of structure.

Limitation of Visual Inspection Method for Underwater RCC Structures

Even though underwater inspection is considerably quick to conduct but there are conditions that may restrict this inspection technique which involves strong waves that decrease diver capacity, turbid water which decline visibility and marine growth that cover structural defects. Diver skills and experiences largely affect restriction related to the diver.

DISCUSSION

Every artificial obstruction constructed across a river course can be a potential hazard to downstream life and property. As many existing hydraulic structures are reaching or passing their design life spans, which required to be upgraded to the latest standards to make it functional as it intended. The risks associated with the up gradation can be minimized through application of sound technical engineering practices, but risks increase substantially without proper maintenance. It is not only necessary but essential to include quality control and sound

technology before and during construction, regular preventive maintenance, routine visual inspections, and identification of problems in their early stages and after their completion.

The Idiyanchira Regulator cum Bridge was constructed by Kerala Land Development Corporation Ltd in 1990s and later handed over to Irrigation Department. A worst flood which had ever seen in Kerala occurred in the year 2018 and repeated in the year 2019. Based on the investigations carried out by KERI, the conclusions and recommendations to improve the structure are as follows.

1. As per the records, solid apron was constructed for 4.5m length on upstream side and 9m length on downstream side and the thickness provided for both upstream and downstream was 1m. Top 30cm M200, Bottom 70cm M100.
Loose apron was provided on both upstream and downstream. Sheet pile M200, 15cm thick. The underwater inspection confirms the provision of solid apron, but the deposition of sediments and aquatic growth restricted the complete inspection of apron. Also the concrete provided for the visible parts of apron is seen deteriorated. Due to lacking of proper sealing of shutters, the operational difficulties of small gates fixed on Jack piers and small ventways creates requirement of reinstallation of gates and reconstruction of Jack piers. Due to the above reasons, reconstruction of apron is recommended. However during rehabilitation stage, when dry working space is created, if any part of the existing apron is found in good condition, that parts may be retained after necessary quality tests like core tests. Being a hydraulic structure having issues of salt water intrusion, the apron may be reconstructed after redesigning based on the latest soil investigation, latest flood parameters and as per IS 6966-1989. The tidal effect may also take into account to the revised design of apron.

2. Main piers 10nos (7.25mx1.00m), with 11nos span 8.4m width, Main Pier M200 (with temperature reinforcement1:11/2:3), Two jack piers Waterway 2.06m, Concrete piles M200 for piers 10m length 35x35cm with nominal reinforcement. Material deterioration is visible for both concrete and steel. Hence the main piers are required to rehabilitate in accordance with IRC SP 40 - 2019.The stability analysis may be carried out for piers as per the current loads as per IRC 6-2016.

3. Two Jack piers with ventway 2.06m are provided in between main piers. By considering the climate change, rainfall pattern and flash floods, afflux, the ventways are to be redesigned so as to facilitate immediate exit of flood water. The design discharge provided was 382m3/sec as per the flood recorded in the year 1968 at Pazhoor station. The hydraulic design is to be confirmed compatible to the new hydrologic parameters and in conform to the current IS

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standards IS: 6966 (Part 1) -1989 Hydraulic design of barrages and weirs -Guidelines, Part 1: Alluvial Reaches [WRD 22: River Training and Diversion Works]**.**

4. The reconstruction of jack piers is to be carried out in accordance with the redesign of ventways.

5. The width of the roadway provided is 4.25m and thickness of deck slab 60cm with IRC Class A Loading design. The bearings provided for deck slab are completely deteriorated condition. Hence the deck slab is required to rehabilitate in accordance with IRC SP 40-2019 and recommended to carry out load test after completing rehabilitation.

6. The concrete parts of the structure are seen deteriorated. The deteriorated portions are to be strengthened and repaired with modern repair materials. Expert solution in the field of Modern repair materials of concrete may be obtained before execution.

7. The strengthening of the existing structure shall be made after checking the hydraulic design and structural design.

8. The details of maintenance or improvements executed for the structure during the past years and in future are to be recorded for ready reference.

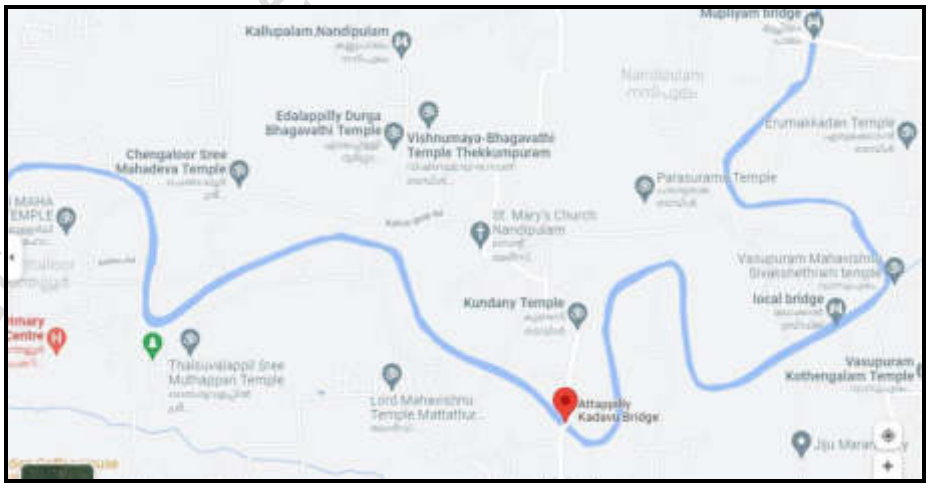
9. The river training works shall be carried out in accordance with IRC SP 89-2019 Guidelines for Design and construction of river training and control works for Road Bridges.

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FORENSIC ENGINEERING INVESTIGATIONS AND PROPOSALS FOR RECTIFICATION OF ATTAPPILLIKKADAVU REGULATOR CUM BRIDGE

ABSTRACT

Proposal for construction of Regulator cum Bridge at Attappillykadavu was taken up under NABARD RIDF –XI Scheme. The work was started in the year 2008 as per agreement no. 08/SEICC/08-09 dated 12-6-2008 of the Superintending Engineer, Irrigation Central Circle, Thrissur. Heavy flow during the rainy season and the release of water from Chimony dam to Kole land during lean season created an unconducive atmosphere in the construction site. The working season gets shortened due to the above reasons. The afflux developed by the construction of temporary check dams across Kurumali River in the downstream of Attappally RCB also decelerated the construction process. As per the records from Major Irrigation, the land required for the approach road was not available and later made it available only in the year 2012. Since the period of NABARD assistance ended in 2014, the work was terminated without risk and cost vide order no: D6-4373/1995 dated 18.07.2014 based on GO(Rt) No.614/2014/WRD dated 23.06.2014. At this juncture, downstream apron, side protection works, approach road and regulator shutters were not completed.



Location of Attappilly regulator cum bridge

The balance work was arranged as per Agreement no: 10/SEICC/2016-17 dated 24.09.2016. Yet the work could not be completed because of the issues in the original terminated work.

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View of Attappillykkadavu Regulator cum bridge

Meanwhile, left bank approach road of Attappilly Bridge has subsided on 04.06.2021 and subsequently, the bridge was closed for traffic. The failures are seen as progressive in nature and threatening within a short span of time.



Subsidence of Left bank Approach road of Attappillykkadavu Regulator cum bridge

Considering the concerns at Attappilly RCB site, a meeting was held at Government level on 16.08.2021, the Additional Chief Secretary, Water Resources Department, Govt. of Kerala has directed Kerala Engineering Research Institute (KERI), Peechi to conduct load test of Attappilly Bridge to ensure the serviceability of existing bridge portion of RCB. KERI was also entrusted to conduct necessary investigations for making the RCB functional and to report the

prerequisites for reinstating the traffic through bridge at the earliest. The present report was prepared by KERI based on the decisions of the above meeting held on 16.08.2021.

METHODOLOGY

The discipline that deals with investigation of failures and performance problems in the built environment is known as Forensic Engineering. This includes the application of engineering principles and methodologies for scientific evaluation of the structure to uncover the reason something went wrong or stopped working. Failure need not always mean that a structure collapses. It can make a structure deficient or unserviceable in usage. It may even cause secondary adverse effects like Safety failure (Injury, death, or even risk to people), Functional failure (Compromise of intended usage) and Ancillary failure (Adverse effect on schedules, cost, or use).

Before establishing cause of failure it is necessary to investigate the condition of the site and record the preliminary observations (Reconnaissance Survey) in order to arrive at the cause of failure. Original soil investigation reports, analysis and design of the structure should be verified and the engineers involved in planning, design, construction and performance monitoring are to be explored in order to know the design methods, sequence of construction, problems during construction and specifications of the material used for construction. Certain field and laboratory tests are conducted to characterize the ground and assess the cause of distress in the structure. The data required for the investigation include topography of the site, soil investigations at the site, hydrological investigations, underwater investigations, results of field and laboratory studies etc. Nondestructive testing of the certain elements is also conducted to evaluate quality of construction.

With a view to improve the performance / life of the Attappilly Regulator cum Bridge structure, the following investigations are performed by Kerala Engineering Research Institute and are explained in detail in the subsequent sections.

LOAD TEST

Load test of Attappilly Bridge was carried out on 25.08.2021 conforming to relevant IRC Standards and Indian Standards. The most likely heaviest vehicle (GVW of 38.65T) that can pass through this road is used as the test vehicle. Fig 3.1 shows the loading arrangement. During testing deflection of all eight spans were measured and percent recovery of deflection were calculated. The maximum deflection of 1.4mm and maximum crack width of 0.1 mm are

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observed in the 8th span, i.e. span near the Mattathur bank. The bridge satisfies all the acceptance criteria as per the IRC provisions i.e.

(i) Measured deflection at mid span of slab is less than the theoretical deflection obtained from respective designs.

(ii) Crack width formed (0.10mm) is less than the permissible value 0.30mm

(iii) Min. percentage recovery of deflection (84.62%) is more than codal provision of 75%.

(iv) Observed maximum deflection of 1.4mm is less than the limiting deflection of 8.125mm (Span/800).

Hence, the bridge is deemed to be safe in load rating as per the commercial vehicle of GVW of 379.16 kN (38650 kg). Since IRC class A loading is of lesser magnitude than the test load, class A loading is also safe to pass through this bridge. The report of load test on bridge was submitted to CE IDRB on 15.09.2021 for onward submission to Government.



Load Test at Attappilly

RECONNAISANCE SURVEY/ TRANSECT WALK

The transect walk was conducted to obtain information which will help to conduct/interpret the forensic engineering investigations of the Attappilly RCB. The transect walk was performed mainly in the upstream part of the regulator which is benefited by the head of water impounded by the regulator. The concerned member of Panchayath was accompanied with the KERI team during the transect walk to clearly indicate the channels (thodu) provided to carry the water from upstream part of the RCB to the agricultural lands. There are several channels existing in the upstream part of the RCB to transport the water to the agricultural fields. Nandipulam thodu, Kunjakkara thodu, Mupliyam thodu and Karayampadam valiya thodu are some of the channels or thodus at upstream of RCB. The former Nandipulam thodu has comparatively smaller capacity as compared to the other channels. It has approximately 1m base width and 1.5m height. The remaining channels are larger (approximately 2-3m base width and 2m height) and capable of carrying sufficient quantity of water to the fields. When the shutters of Attappilly RCB are closed, water will get stored in the upstream region and the same will be carried to various agricultural fields through these channels. Since, the Attappilly RCB is not operational, water is not carried through these channels to the fields.

Vasupuram Chira, Karukulam Chira, Thottumugham Chira and Kannattupadam Chira are temporary barriers in river constructed by Major Irrigation wing and this is put up and maintained for the period from December to June every year. These Chiras are provided in the upstream part of the RCB to impound the water and to carry the same for domestic and agricultural purposes. These temporary bunds are constructed every year at the starting of summer season and demolished at the beginning of South-West monsoon season. However, these temporary bunds can be avoided if the Attappilly RCB is made operational. Apart from the agricultural demands, water from upstream part of RCB is taken for meeting various domestic and drinking water demands. Several Lift Irrigation schemes and drinking water supply schemes of Kerala Water Authority are functional for these purposes. Swajaldhara drinking water scheme at Varandarappally panchayath, Vasupuram-Kunjakkara Lift Irrigation scheme at Mattathoor panchayath and KWA-WGDP-Parakkadavu Water Supply scheme are major projects among the LI and drinking water schemes working in the upstream of the Attappilly RCB..

From the transect walk performed, it can be inferred that superior demand of water for agricultural, drinking and domestic purposes are present in the panchayaths surrounding the Attappilly RCB. The proper operation of the RCB is inevitable for carrying water through the canals to the agricultural fields as well as to get appropriate head for lifting the same during the

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summer season. Temporary bunds can be avoided for heading up the water if the RCB is made to operating condition.



Nandipulam thodu



Kunjakkara thodu



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Mupliyam thodu



Karayampadam valiya thodu staring portion



Location of Vasupuram chira



Location of Thottumukham chira

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Vasupuram-Kunjakkara LI scheme



Swajaldhara drinking water scheme



KWA-WGDP-Parakkadavu Water Supply scheme

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Checking the whirlpool at u/s

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REVIEW OF MEASUREMENT BOOKS

34 measurement books were made available to KERI for examination by Irrigation Division, Thrissur for the work Construction of RCB at Attappillykadavu. But some of the MBs (MB 185/85-86, MB 57/04-05, MB 20/07-08, MB 23/07-08, MB 24/07-08) as recorded in the Final bill (MB No. 134/07-08) were not made available to KERI for review. Assessments of measurements were made based on the examination of available measurement books.

SOIL INVESTIGATIONS

Soil Investigation or geotechnical investigation is a procedure that determines the relevant physical properties of the soil and rock underlying the area of work. Soil exploration studies at Attappilly regulator cum bridge site was started on 28/10/2021 using the Rotary calyx boring plant. The first borehole (BH1) was dug fairly close to the depression that had formed on the approach road, at a distance of 11m from abutment. Drilling is carried out at 15 locations out of which 7 attempts failed due to various reasons.

Rock formation exhibits a downward slope from left bank to right bank (referring to BH1 and BH5B (along the centre line of the regulator), BH3 and BH6 (downstream of the regulator), BH4 and BH7 (upstream of the regulator). Soil and rock core samples are entrusted to SM&FE Division and CM Division of KERI for further laboratory analysis.



Soil Investigation at the approach road

SEISMIC REFRACTION SURVEY

Seismic refraction survey is used to determine the thickness of each soil layer using wave propagation velocities through various soil layers in the field. It is a widely used method for the determination of bedrock depth. Seismic Refraction Survey was conducted using 12 numbers of geophones spaced at 3 m aligned in a linear array. 5 shot points were used for the survey; 2 direct, 2 indirect and 1 central. Seismic refraction data are analyzed using PS Lab software. The results of seismic refraction survey at Attappilly are somewhat matching with the bore-log chart..



Seismic Refraction Survey at Attappilly

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SOIL TESTING

The objective of the study is to determine the index properties such as Grain size, Specific Gravity, Atterberg's Limits of the given soil samples. 17 numbers of soil samples in disturbed condition are tested on 05/11/2021. The test for specific gravity has been conducted as per IS 2720 (Part 3), both sieve analysis and hydrometer analysis per IS 2720 (Part 4) and liquid limit and plastic limit tests have been conducted as per IS 2720 (Part 5). From the grain size analysis, it is observed that 14 soil samples contains more than 50% of coarser particles.

CONCRETE AND ROCK CORE TESTING

Core samples are taken from the RCB components like left abutment, weir and apron and tested its compressive strength. The concrete core samples collected from weir having extensive voids and honeycombing. But the tested core samples have compressive strength in the range of 21N/mm2 to 33N/mm2. Core samples from left abutment have compressive strength in the range 23N/mm2 to 27N/mm2. The compressive strength of rock samples from BH1, BH2, BH3, BH4 having the range 29 to 219 N/mm2.

As part of soil investigations, rock core samples were collected from the subsurface by Instrumentation Division and tested at Construction Materials Testing Lab for compressive strength. Concrete core specimens were also drilled out during the exploration in the apron portion. The concrete core samples collected from BH7 (upstream apron) have compressive strength ranging from 14N/mm2 to 20N/mm2 whereas the samples from BH5B ranges from 26N/mm2 to 34N/mm2. The compressive strength of rock samples from BH5B, BH6, BH7 having the range 46 to 115 N/mm2.



Concrete core samples collected from Attappilly RCB and preparing for testing

TOPOGRAPHICAL INVESTIGATIONS

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Topographic survey is conducted during the period 07.12.2021 to 14.12.2021 to find out the existing bed levels in the upstream and downstream locations of Attappilly RCB, using RTK method, by fixing the base station at Chimmony dam (Leica GS18-T with GNSS receivers and Leica TS- 11 total station). Existing Bench Mark available at Chimmony dam (value of BM +79.60m above MSL) is taken as the reference Bench Mark. Downstream bed level as per the approved drawings is +2.10m whereas the existing level ranges from -0.24 m to +2.10m. River bed level of two spans close to left abutment is not taken as these locations are not accessible due to heavy water currents created due to flow under the weir and abutment. Existing levels of various structural components of the RCB and weir are taken.

HYDROLOGICAL INVESTIGATIONS

The Kurumaly River exhibits meandering behaviour from a distance of 5 Km upstream of Attappillykadavu RCB. The river course adopts a sinuous curved pattern and coupled erosion and deposition occurs in the river. The sediments erode from the outer concave bank and sediment deposits in the inner convex bank. The zone within which a meandering stream periodically shifts its channel is known as a meander belt. It typically ranges from 15 to 18 times the width of the channel (around 1 Km upstream and downstream of Attappillykadavu). Over time, meanders migrate downstream, sometimes in such a short time as to create civil engineering challenges for local self-government attempting to maintain stable roads and bridges. The river migrates back and forth across the axis of flood plain. The scouring at outer bank makes the structure unsafe as regular scouring makes the failure of foundation.

Significance of hydrologic investigation for design of Regulator Cum Bridges (RCB)

The RCBs are constructed across the rivers to impound sufficient quantity of water to meet the various demands (agricultural and domestic) and to enhance the communication facilities between the two banks on either sides of the bridge. Proper understanding of the behaviour of river in the vicinity of the RCB is extremely important for effective planning, design, execution and maintenance of the structure. However, such hydrologic investigation of the site is not taken as a serious factor as compared to structural and hydraulic aspects of the structure. This may not cause an immediate impact or structural failure of the RCB constructed across the rivers. But the river regime may be critically affected due to inadequate consideration of hydrologic aspects leading to high afflux, sediment deposition, flow instability, river meandering, bank erosion and outflanking which can cause lot of damages and demand huge cost for controlling and training the river.

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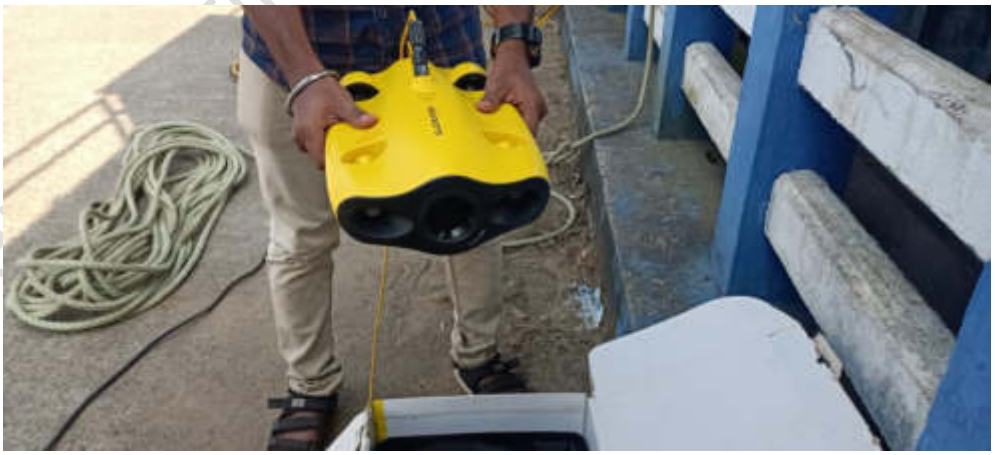
From the google earth images, meandering nature of the river can be clearly understood. The topographic investigations exhibit lower reduced levels upstream and downstream of RCB and nearly flat terrain. The bore hole analysis clearly indicates flow of river beneath the outer bank (left bank) of the river. Hence adequate river training works are required to protect the structure.

Discharge

Based on the enquiries to get the maximum discharge details at Attappilly RCB site, it was reported from Field Studies Circle, Thrissur that maximum gauge in the Kurumali River was observed on 16.08.2018 as 6.4m during the flood in the year 2018 and the discharge is 879.9m3/sec. The Superintending Engineer, Irrigation Central Circle, Thrissur have reported that the water level at Attappilly RCB lowers to a depth of 80cm during March, April, May months. The discharge from Chimony dam to Kole land through Kurumali River is 1.75Mm3 per day. The daily expected discharge through Attappilly RCB during summer comes to 2Mm3 to 3Mm3.

Underwater inspection by surface supplied air diving method is carried out at Attappilly Regulator cum Bridge site. The diver captured the video to assess the as-built condition of the components and thereby to find out the deterioration or damage that might have occurred as a result of the impact, overstress, corrosion or biological attack. The inspection was carried out on 20.12.2021 and 20.01.2022 by M/s AigleTech Diving & Engineering Services Co., Cherpu, Thrissur using **Remotely Operated Vehicle (ROV).**

UNDERWATER INVESTIGATIONS



ROV used for Under water inspection





Various snaps of Underwater inspection at Attappilly

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OBSERVATIONS/DIAGONOSTIC ANALYSIS OF PROBLEM

The existing structure has the following issues which are to be addressed to rectify the structure. The issues are listed below.

1. A weir was constructed at the site which was originally not included in the approved drawings by IDRB. The top of well cap and weir is at the same level.



View of weir and raised well cap



View of weir and raised well cap (During construction)

2. Even though the excavation for the downstream apron was carried out, the construction of downstream apron was not executed at the site but left the site in excavated condition. This creates hydraulic head more than design considerations, which lead to seepage problems and piping process. When the hydraulic gradient of the flowing water near the downstream floor known as exit gradient, is high the water rises above the ground surface with a high velocity. The associated high seepage pressure removes some of the fine soil particles near ground level forming a hole.

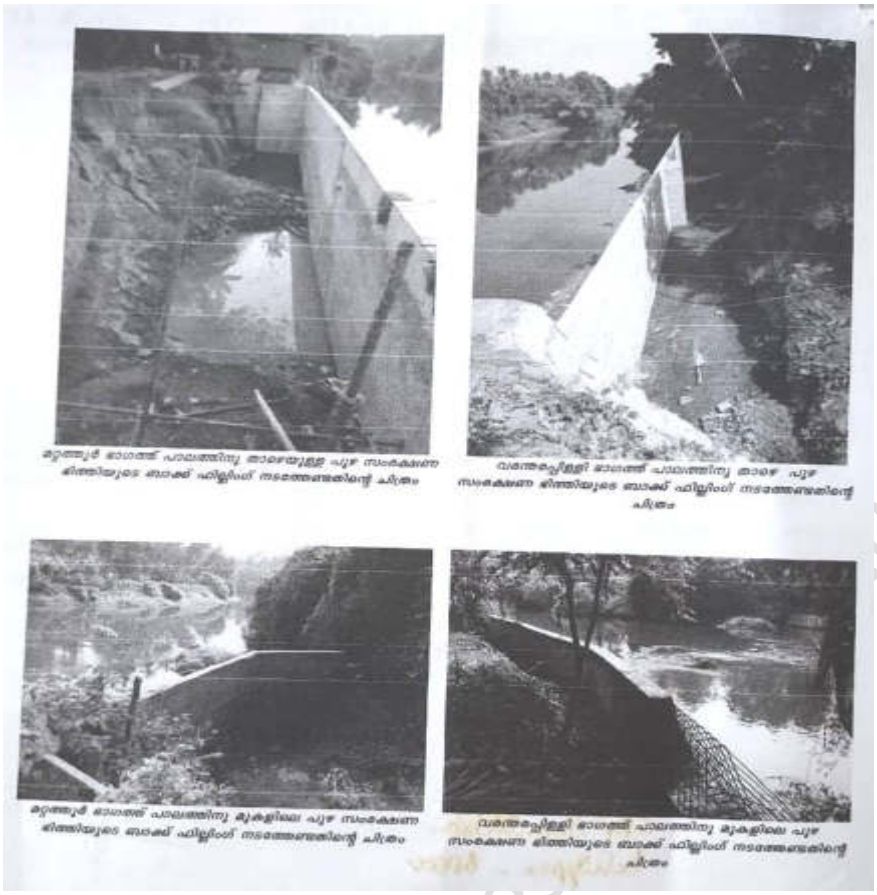
3. The structure is located at the outer bank of the curved river portion and erosion is higher in the outer bank of curve.

4. The upstream and downstream retaining walls of left bank (Mattathur side) are not in a straight line. The left abutment is projected into the river which causes a flow through the body of the approach road. The change in the alignment of construction of upstream protection and downstream portion , projected left abutment into river on Mattathur side (left bank) and the outer bank of the curved river where the erosional forces of flow are higher creates serious threats to the structure on left side.



Regulator cum Bridge - photo during construction of left abutment

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Regulator cum Bridge - photo during construction of retaining walls

5. The concrete apron on upstream side is in dilapidated condition with tunnel like holes to a depth about 6m (rock level) are formed in the apron (1st and 2nd vent from left side) prolonging through beneath the weir to downstream and extending below the left bank approach road.

6. Concrete apron is not seen at various places during underwater inspection and only rubbles are seen at the bed level.

7. No energy dissipation arrangements provided when a weir was additionally constructed.

8. A gap for a height of 1m is seen during underwater inspection in between the left side upstream protection wall and bed level.

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Foundation of Retaining wall during construction

9. The concrete recoveries from bore hole drilled from BH 5A and BH5B in the apron portion of first vent from right side abutment have a depth range of 34cm to 73cm. Beyond that depth, only coarse aggregates are seen during the bore hole exploration. Wide gaps are seen between the end of apron at downstream side and the bed level.

10. Spalling of concrete and cracking are seen on the well foundations at downstream side during underwater inspection.



Drilling bore hole and recovery of concrete (BH5B)

PROPOSAL FOR RECTIFICATION OF RCB

With the approved design particulars, the following rectification measures are proposed to complete Attappilly RCB adhering to the above approved design of IDRB and as per the site conditions. Since the construction of RCB is in partially completed stage, the additional rectification measures apart from the provisions of approved drawings issued by IDRB are only proposed.

1. There are huge hollow spaces developed beneath the 1st and 2nd vent ways from left abutment extending from upstream apron to downstream to a depth upto rock level (approximate 6m). The hollow space extends to the left abutment also. During under water inspection, it was noticed that the sand bags deposited to the bed level to arrest the seepage flow through the left abutment (during the subsidence of left bank approach road occurred in June 2021) were resting on the settled upstream apron and hollow spaces noticed beneath the settled hanging upstream apron. The investigation reveals that the structure failed due to piping. The upstream cut off wall is also a failure as there is considerable flow in the downstream.

A concrete cut off wall in the upstream should be provided in such a way that it should be embedded in the rock to a depth of 30cm. It should also extended into the banks on both sides as per IS 6966 Part 1 clause 1.1.

2. The settlement of apron created cracks in the other locations of apron and even concrete apron portions are not seen at some locations. Upstream apron is in dilapidated condition with huge holes and cracks. Moreover some of the pieces of the apron got dislocated or washed away. In short, the very purpose of apron is defeated due to the crevices formed.

The arresting of flow at one place will creates another path through some other weaker zones. It is inevitable to make the upstream apron impermeable at the bottom of any water retaining hydraulic structure.

An upstream apron is used to lengthen the path of the water that is seeping through beneath the st ructure and to reduce the uplift on the bottom of the structure. If an upstream apron is rovided, the velocity and flow rate of the water that seeps through are reduced, and there by minimized the danger of destruction of the base of the structure by the seepage flows. Here the upstream apron constructed during the first phase (2008) is in deteriorated condition with holes, cracks and settlements as observed during the underwater investigation. Due to the curved shape of the river, the erosional forces higher at the left side aggravate the situation.

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It is inevitable to make the water retaining structure safe against seepage. The river bed should be made even by proper packing and a concrete floor of thickness provided in the approved drawing shall be provided as upstream apron.

The hollow spaces in the two vent ways are to be repaired by filling with concrete mix to prevent the later scouring. After filling the hollow spaces and making the river bed, the two vent ways with apron are to be reconstructed to make the upstream apron impervious.

3. Bore holes were drilled in the first vent from right abutment (BH5A & BH5B) and recoveries of concrete apron is available. The concrete core recovery has a depth ranging from 34 cm of 73cm and beyond that depth only coarse aggregates are seen. As per the original approved design by IDRB, the depth of concrete apron at the bore hole drilled portion is 2.65m. Hence it is to be inferred that the constituents of concrete except coarse aggregates were washed off beyond the depth range of 34 cm to 73cm. The stabilization of this part of apron is mandatory to increase the creep length. Similar situation exists for apron for the other vents also.

The nondestructive tests like core tests conducted at the weir portion and apron portion reveals extensive voids and honey combing in the concrete components. The underwater inspection validated the presence of holes not only on the surface of apron, abutments but also on the surface of weir. Since the upstream face of the weir is vertical and this shape led to the formation of cavitation on the surface due to water pressure. The stabilization process of existing weir with extensive voids, holes, cavities will not ensure the water tightness as the water will find its way through the weakest zones present on the structure. Since there is level difference between the bed level (+2.10) and the crest level of weir (+4.20), the required slope as stipulated in IS 6966 1989 (Part 1) has to be provided but the same was not provided during the construction stage. This may be the reason for the cavities developed in the upstream face of weir.



Inside view of vent – Attappilly Regulator cum Bridge

Also the raised height of weir (+4.20) from the bed level (+2.10) is creating hydraulic jump at the downstream portion. The hydraulic jump thus formed will have the potential to threaten the integrity of structure. Hydraulic jump is the jump or standing wave formed when the depth of flow of water changes from supercritical to subcritical state. The hydraulic jump is necessarily formed to reduce the energy of water while the discharge downfalls and the hydraulic jump is generally known as the dissipator of extra energy of water. It becomes necessary to reduce its energy and maintain stable velocities, that phenomenon is called energy dissipation in hydraulic structures. If the jump formation happens within the pier portion, it will adversely affect the structure. Hence to protect the structure from the adverse effect of jump and to get benefit from the jump formation by preventing the scour action on downstream side of the structure, the position of the jump is to be provided at the downstream of piers.

Two sluices existing in two ventways are required to be made operational by providing mechanized operating system. So repair works are required for these two vents also.

The stabilization and leak proofing of existing weir and existing apron except the first and second bays can be done by using polymer based grouting agents with self-compacting concrete and also by providing an extra solid concrete cut off wall upto the depth of existing downstream side apron (2.65m) and by erecting sheet pile upto rock level. But due to the failures observed at site, this method cannot not be ensured the leak proofing. Since this is a water retaining structure, water will emerges out if any leak zones persist.

Due to the reasons mentioned above, a weir with crest width 4.5m and by providing a glacis 2:1 slope at upstream of weir and glacis 3:1 to 5:1 slope at downstream side as stipulated in IS 6966 may be constructed. A slope 5:1 for the downstream glacis allows the hydraulic jump formation outside the pier portion which will reduce the impact of jump on piers.

A concrete floor of thickness as provided in the approved drawings of IDRB is to be provided below the weir and glacis.

Hence the reconstruction of apron and weir is recommended in tune with the above recommendations and in consideration of the economical and functional benefit.

The whole structure (cutoff, u/s apron, weir, d/s apron and d/s cutoff) is to be constructed monolithically. 0.5m width of the weir portion and the u/s slope is to be constructed to the upstream of the piers.

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4. The downstream portion excavated for apron construction is to be stabilized to the original level by dry rubble packing and then provide the downstream apron, downstream cut off as per approved drawing.

Downstream cut off, which is supposed to go beyond the rock level, should be provided upto the rock level so as to release the seepage water.

5. A gap having size of approximately 1m from bed level was developed at the bottom of upstream side left bank concrete retaining wall. This indicates the high scour formations at that side.

It is proposed that the existing upstream left bank retaining walls are to be dismantled and counterfort retaining walls upto scour depth is recommended for 21m length and further cantilever retaining wall is recommended upto the rock exposed portions. Also a sheet pile cut off wall is proposed along the upstream counterfort retaining wall upto rock level (from the downstream face of the left abutment to the end of upstream counterfort retaining wall).

6. The structure is located at the outer bank of the curve and erosion is high in this region. The upstream and downstream retaining walls of left bank (Mattathur side) are not in alignment with the abutment. The downstream retaining wall is away from the left abutment face. Seepage resulted in formation of a flow passage through the body of the abutment, below the approach road leading to the erosion of filled earth. A channel (approx.2.5m size) was formed under the left side abutment extending from upstream to downstream by exposing the piles of abutment.

Flow of water through the abutment can be arrested by providing sheet piles extending upto rock level as mentioned above, along the exposed faces of the abutment and by stabilizing the gap between the piles using suitable packing materials.

Guiding of river is essentially required to restore the original regime. Already guide walls have been provided in the upstream and downstream side as retaining walls. The downstream retaining wall and upstream retaining wall is to be constructed in the same alignment.

7. There are two sluices provided in the weir with shutter operating facilities manually. This cannot be operated during high flows or when the shutter is closed. The sluices can be retained if necessary by providing pipes with mechanically operated valves which can be controlled from top.

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8. The cavities and cracks formed in the well foundations are to be repaired during the construction of downstream apron.

9. The grades of concrete shall be provided as per the exposure conditions stipulated in IS 456-2000.

10. The water level in the river is fluctuating throughout the year due to monsoon and due to the release of water from Chimony Dam. Since the dam and the release is under the control of Major Irrigation and the water level will be reduced to 80cm as reported by the Major Division authorities, the provisions of ring bund may be suitably provided depending on the site conditions. Hence ring bund provisions are excluded from the estimate.

11. Total estimate cost for the above rectification proposals for completing the Attappilly RCB work comes to 9crores excluding the provisions of ring bund construction and bailing out of water.

DISCUSSION

The Forensic Engineering investigation report with proposal to complete Attappilly Regulator cum Bridge was prepared based on the decisions of Government meeting on 16.08.2021. The completion of Attappilly Regulator cum Bridge is a challenging task due to the peculiar issues of site. Once the structure is completed of structure will help to regulate the flow of water through Kurumali River and thereby meeting the demand of water. Also the bridge connects two Panchayaths namely Varandarappilly and Mattathur. To accomplish the professional and social necessity, systematic investigative studies of failures are conducted and the rectifications measures are to be proposed in accordance with the forensic engineering investigations studies. Every hydraulic structure involves more complexities in their interaction with site hydrology regardless to the size and type. The changing climate pattern and frequent cyclones recently experienced in Kerala aggravates the situation of existing hydraulic structures. Water normally has the tendency to seep through the week zones and no one can predict the path of seepage. Hence the entire hydraulic components are to be constructed monolithically. Delays associated with execution of Government projects is to be taken care of in case of hydraulic structures. Otherwise the partially constructed hydraulic components create more problems and failures at site which cannot be rectified at every time. The solution will become a trial and error process. In the above circumstances, it shall highly recommend to complete the hydraulic structure monolithically.

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QUALITATIVE ASSESSMENT OF SEDIMENT DEPOSITS IN RIVERS DRAINING INTO VEMBANAT LAKE

ABSTRACT

As part of the urgent project envisaged by Water Resources Department for desiltation of rivers, the Soil Mechanics and Foundation Division of KERI conducted grain size analysis on sediment samples collected from 5 rivers namely Pamba, Achankovil, Manimala, Meenachil and Muvattupuzha. All these rivers are draining into Vembanat Lake and there is considerable sediment deposition since the 2018 floods. Hence de-silting these rivers before the oncoming monsoon had become very essential for maintaining proper flow in the rivers and into the backwaters. The task of testing the sediment samples on a swift basis was assigned to this division. Accordingly Grain size analysis was conducted on more than 750 collected from these five rivers in an urgent basis.

METHODOLOGY

Kerala has a total of 44 rivers, which plays a crucial role in discharging the rainwater into the sea. Earlier mining of sand from these rivers were permitted. Hence sediment deposition in rivers was not an issue. However after the ban of sand mining from the rivers, sediments have been depositing in all the rivers. After the floods in 2018 and 2019, lot of sediments accumulated in many rivers, causing obstruction to the smooth flow of water. Hence an urgent project was envisaged for identifying the main areas of sediment deposition across various rivers and desilting them before the oncoming monsoon.

Accordingly the responsibilities of desiltation of rivers were assigned to various executive engineers of Irrigation department. The quantity and quality of sediments had to be estimated before proceeding into the desiltation work. KERI has been entrusted with the task of conducting grain size analysis on sediment samples collected from 5 rivers namely Pamba, Achankovil, Manimala, Meenachil and Muvattupuzha. All these rivers are draining into Vembanat lake and desilting these rivers were crucial.

Sediment samples were collected from the rivers and brought to the lab in a fast manner. A large number of soil samples had to be simultaneously tested and analyzed. Accordingly various arrangements were made in the lab for delivering the results in a timely basis.

Grain size analysis was used for arriving the quality of sediments deposited. The samples were initially dried in a Thermostatically Controlled Hot Air Oven at 105 °C to 110 °C. For samples

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with silt and clay fractions, suitable dispersing agents were used to separate the clay and silt adhered to the gravel and sand. Most of the samples were then analysed by wet sieving. The percentage of Coarse, Medium and Fine sand in each sample was determined. The suitability of the sand in each sample for different construction purposes were also assessed based on the gradation of sand.



Fig.1 Soil samples being numbered and prepared for Grain size analysis



Fig.2 Samples mixed with dispersing agents before sieving



Fig.3 Sieves used for grain size analysis

DISCUSSION

Samples received from the 5 rivers namely, Pamba, Achankovil, Manimala, Meenachil and Muvattupuzha were tested and reports were submitted in a fast track basis. The percentage of Gravel, Sand, Silt and Clay on each of these samples was determined. Also the sand fraction was further analyzed for coarse, medium and fine sands. The suitability of sand for construction purposes was also analysed. The results were also tabulated on a Panchayat basis for quick reference. These efforts made by the division made a significant contribution in assessing the value of the sediments deposited in the rivers which was necessary for proceeding into the desiltation work.

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QUANTITATIVE ASSESSMENT OF SEDIMENT DEPOSITS IN RIVERS DRAINING INTO VEMBANAD LAKE

ABSTRACT

The rivers Pamba, Meenachil, Manimala, Achancovil and Muvattupuzha are the major rivers in Kerala which enter the Vembanad lake before emptying into the Arabian sea. The Pamba River is the third longest river in Kerala after Periyar and Bharathappuzha. The basin of this river extends over an area of 2,235 square kilometres (863 sq mi) with the entire catchment area within Kerala state. The River Pamba which is 176 km long, enriches the lands of Pathanamthitta District and the Kuttanad area of Alappuzha District before emptying into Vembanad lake. The Meenachil River which flows through the heart of Kottayam district is 78km long, it originates from the Western Ghats near Wagamon, flowing westward through the city of Kottayam and other towns like Poonjar, Teekoy, Erattupetta, Bharananganam, Pala, Mutholy, Cherpunkal, Kidangoor and Kumarakom before emptying into the Vembanad Lake. The Meenachil has a watershed area of 1208.11 km². Manimala River is a 92 km long river which flows through South and Central Kerala. The river has a catchment area of about 847 km2. The river passes through the districts of Kottayam, Pathanamthitta and Alappuzha before reaching Vembanad lake.

The rivers Pamba, Meenachil and Manimala have a major role in causing floods in Kuttanad region. The 2018 flood in Pamba, four consecutive floods (2018 to 2021) in Manimala & Meenachil and 2021 land slide in Manimala have significantly reduced the carrying capacity of these rivers. Big rock pieces, boulders, debris and soil particles are deposited in the rivers. The river course has changed in some reaches. The bed level has gone up. Deltas are formed. The river has become more prone to flooding. People who live near the river and its tributaries indeed are deeply concerned about the decline in the water carrying capacity of the rivers. There is acute shortage of water in summer. The mighty rain-fed river turns almost completely dry in summer. Unless some serious and immediate efforts are taken, frequent floods and droughts will occur in these catchments, affecting lakhs of people who depend on these rivers.

Desilting is the process of removal of fine silt and sediment that has accumulated in a river in order to restore its natural capacity, without widening or deepening of the river. Desiltation works have the potential to improve the hydraulic performance of a river and to reduce the chance of flooding. Topographical survey by RTK method has been conducted in the critical locations, which were identified by the Executive Engineers in charge of these riversto determine the accurate quantity of sediments to be removed from the river. The quantity of sediments deposited in each river is calculated panchayath wise and submitted to Executive Engineers.

METHODOLOGY

Topographical survey has been conducted in the critical locations, which were identified by the Executive Engineers in charge of these rivers. Methodology of the work is briefly described below.

Topographical Survey

The methodology of topographical survey adopted for rivers is explained below.Topographical survey is conducted in 32 locations identified by Executive Engineer in charge of the river. These locations fall in 13 Panchayaths namely Perunad, Vechoochira, Naranamoozhy, Ayroor, RanniAngadi, RanniPazhavangadi, Ranni, Cherukol, Kozhenchery, Thottapuzhaserry, Mallappuzhassery, Aranmula and Pandanad. Levels are transferred from CWC BM at Malakkara using DGPS. Topographical survey is conducted using Total Station and DGPS. River cross sections are taken at upstream and downstream of each location for determining natural gradient of the river. The panchayath wise quantity of sediments deposited in the river is computed using Autodesk Civil 3D software.

About 36 locations are identified by the Executive Engineer in charge of the river in the stretch of river Menachil from Mathirancheribhagom to Moonnilavubhagom for performing desilting activities. Total Station and DGPS are used to conduct topographical survey along the river stretch. The levels are transferred from BM at Kalariamakkal check dam using DGPS. River cross sections were taken at upstream and downstream of each location for determining natural gradient of the river. Surveying is conducted in MoonnilavuBhagom for a continuous stretch of about 2 km and river cross sections were taken at 100 m interval in this region. The panchayath wise quantity of sediments deposited in the river is computed using ESurvey CADD and ESurvey Section softwares.

About 14 locations are identified by the Executive Engineer in charge of the river in the stretch of river Manimala from Njarikkadubhagam-u/s of Yendhayar Bridge to Prayattukadavu Bridge for performing desilting activities. Njarikkadubhagam toChappathcheckdamat Koottickal stretch is surveyed continuously for 8 km length and cross sections were taken at 100 m intervals. Total Station and DGPS are used to conduct topographical survey along the river strech. The levels are transferred from available TBM at Koottickal near panchayath building and cross checked with other TBM‘s in the river stretch using DGPS. The cross section details at 100 m intervals of the above 8km region are available from previous survey records conducted in 2018 June. Therefore cross sections are taken at same sections for quantity calculation. River cross sections are taken at

upstream and downstream of other locations for determining natural gradient of the river. The panchayath wise quantity of sediments deposited in the river is computed using ESurvey CADD software.

Disturbed soil samples are collected from each locations using JCB or manual excavation at ground level, 1m, 2m and at a maximum depth of 3m from ground level. The collected soil samples are tested in KERI, Peechi for qualitative analysis of the soil. Grain Size Analysis of the soil samples is obtained using Sieve Analysis. Wet Sieve Analysis is used for fine grained soils and Dry sieve analysis is adopted for coarse grained soil.

DISCUSSION

The Panchayath wise quantity of the sediments deposited in each riveris calculated and submitted to Executive Engineers in charge of these rivers. An offset of 2m is provided from the river boundary for desilting process and excavation should be carried out at a slope of 1:1 in order to protect river bank. The quantity of the sediment deposit has been computed as follows:

Sl No.	Name of the river	Quantity in m^3
1	Pamba	13,92,134
2	Meenachil	2,59,343
3	Manimala	1,67,092
4	Muvattupuzha	1,54,856
5	Achankovilar	801862

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The sampling process and soil samples collected are shown below.









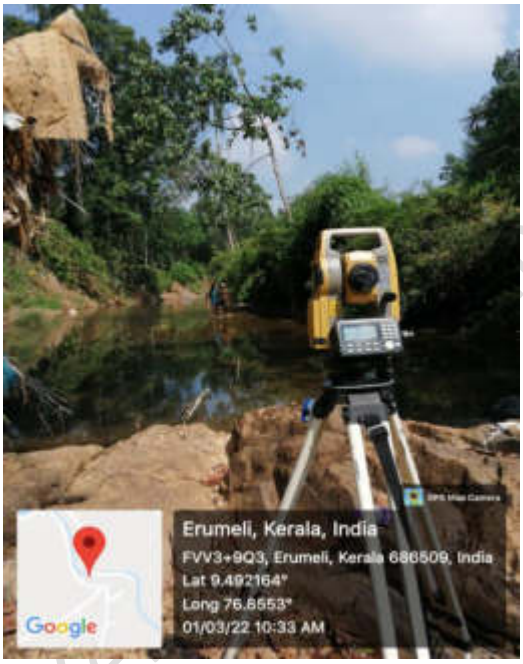


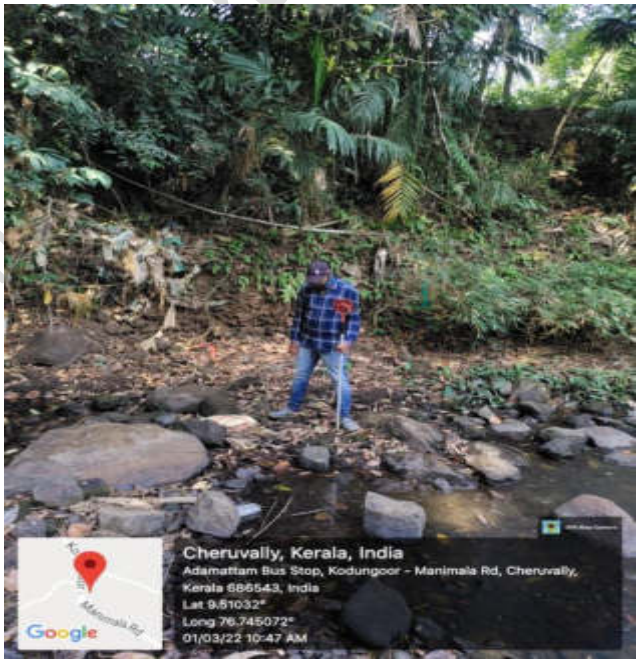


The surveying process in rivers is shown in the figures below.

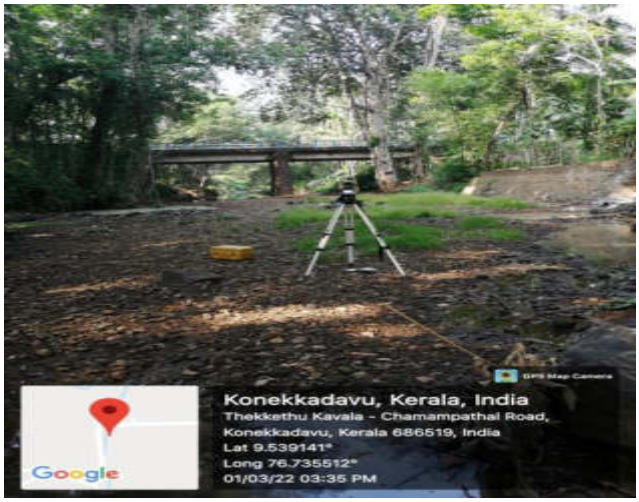












Muvattupuzha River

ABSTRACT

Muvattupuzha River is one of the important rivers in Ernakulam District of Kerala. This river is the union of three rivers - Thodupuzha, Kaliyar and Kothamangalam at Thrivenisangamam at Muvattupuzha. Sediment deposits were found in the Kaliyar river in the following locations, Purapuzha location of Kodikulam Panchayath, Thennathoor Chelakkadavu Bridge of Kodikulam Panchayath. Muvattupuzha town was flooded during the last to floods of 2018 and 2019.

METHODOLOGY

Crossection survey of the rivers was carried from Thriveni sangamam to Kayanad check dam. Upstream portion from Thrivenisangamam towards kaliyar river and Thodupuzha river Total length of the stretch under study is 8.704 km. Area was surveyed and representative samples were collected and tested for analysis.

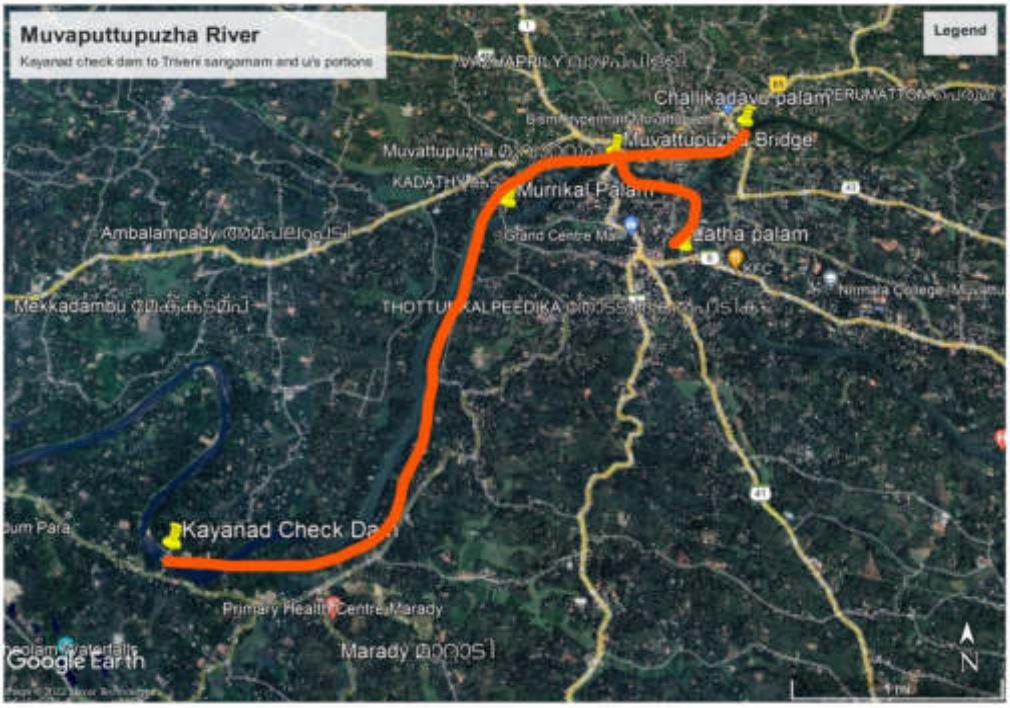


Fig. Reach of Muvattupuzha river where the cross section to be taken (orange line indicate the surveyed reach)

The soil investigation works were conducted at Parappuzha, Thennathoor region and the corresponding figures of collection of soil samples are attached as below.





Fig 1 Desiltation in parapuzha & Thenathoor Region

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DISCUSSION

The total quanity of sediments to be removed from different areas of Muvattupuzha river was calculated and tabulated as below

Name of Muncipality - Muvattupuzha
Name of River - Muvattupuzha

Details of Sediment

Serial No	Name of Location	Latitute	Longitude	Quanitity of Sediment (m^3)	Grain Size Distribution of Sediments		
					Gravel %	Sand %	Silt & Clay %
1	U/s Of Muvattupuzha Bridge to Triveni Sangamam	9° 59 ' 18 "N	76 ° 34 ' 4 "N	18,474.00	Qualitative analysis of the samples can be conducted in consulation with River Incharge .		
2	Downstream side of Muvattupuzha Bridge to Murrikal Bridge	9° 58.2 ' 54.2 "N	76 ° 34 ' 2 "N	26,634.88			
3	Thodupuzha River	9° 59 ' 02 "N	76 ° 35 ' 6 "N	14,000.00			
4	Kaliyar River	9° 59 ' 28.8 "N	76 ° 35 '19.5 "N	31,000.00			
5	Downstream side of Muriikkal Bridge to Kayanad Check Dam	9° 57 ' 19.2 "N	76 ° 32 '46 "N	20,000.00			
	Total quantity of sediment to be removed			110108.88 m^3			

Name of Panchayath - Kodikulam
Name of River - Muvattupuzha

Details of Sediment

Serial No	Name of Location	Latitute	Longitude	Quanitity of Sediment (m^3)	Grain Size Distribution of Sediments		
					Gravel %	Sand %	Silt & Clay %
1	Purapuzha	9°59'3.6"N	76°43'50.9"E	31350	3	76	21
2	Thennathoor Chelakkadavu Bridge	9°59'12"N	76°45'23.4"E	9600	1	63	36

Total quantity of sediment to be removed 40950 m^3

Name of Panchayath - Karumannoor
Name of River - Muvattupuzha

Details of Sediment

Serial No	Name of Location	Latitute	Longitude	Quanitity of Sediment (m^3)	Grain Size Distribution of Sediments		
					Gravel %	Sand %	Silt & Clay %
1	Thommankuthu Chappath	9.94804	76.81415	3,798.00	Qualitative analysis of the samples can be conducted in consulation with River Incharge .		

Total quantity of sediment to be removed 3798.00 m^3

ACHANKOVILAR

ABSTRACT

Siltation in rivers may reduce carrying capacity of the river and thus may cause flooding in nearby areas. By considering the frequent floods faced by Kerala during last few years, it is necessary to remove these deposits from river course to avoid overflowing of river. For the desiltation of Achankovilar, topographical and soil investigations were carried out at various locations in the river. Achankovil is a 128 km long west flowing river, which flows through Kollam, Pathanamthitta, and Alappuzha districts. The river drains vast tract of fertile plains of Upper Kuttanad in the Alappuzha and Pathanamthitta districts. Achankovilar has a catchment area of about 1,484 km^2. The river has its origin in the peak Devar Mala of the Western Ghats at an altitude of about 700 m above sea level (MSL) situated in the Konni Reserve Forest.

Topographical and soil investigations were carried out at 9 locations in Achankovil River and quantity of deposits formed were found out.

METHODOLOGY

Topographical and Soil investigations were carried out at 9 locations in Achankovil river such as Pattathilkadavu, Ambellur Kadavu, Thoppil laksham veedu colony Kadavu, Check dam bhagam, Valanchuzhi Bhagam, Chalelimannil Bhagam,Omalloor, Mathoor bhagam and Karippoor.Topographical survey was done at these locations using Total station and DGPS. Initially a temporary base station was fixed for determining the position of the location. The Bench Mark connected with MSL was transferred from CWC Station, malakkara to the work site using DGPS and to take fly levels and provision has been given for establishing TBMs. Total Station Survey was conductedwith 1 m contour intervals, with 5mx 5m intervals and quantity of deposits formed were calculated. Cross sections at U/S and D/S of every deposits were taken by usingDGPS.Disturbed soil samples were collected from each location to a depth depending upon bed conditions at an interval of 50 cm or 1 m to a depth of 3 m as per the site conditions and samples were tested at Soil mechanics Laboratory, KERIand composition of samples were determined.

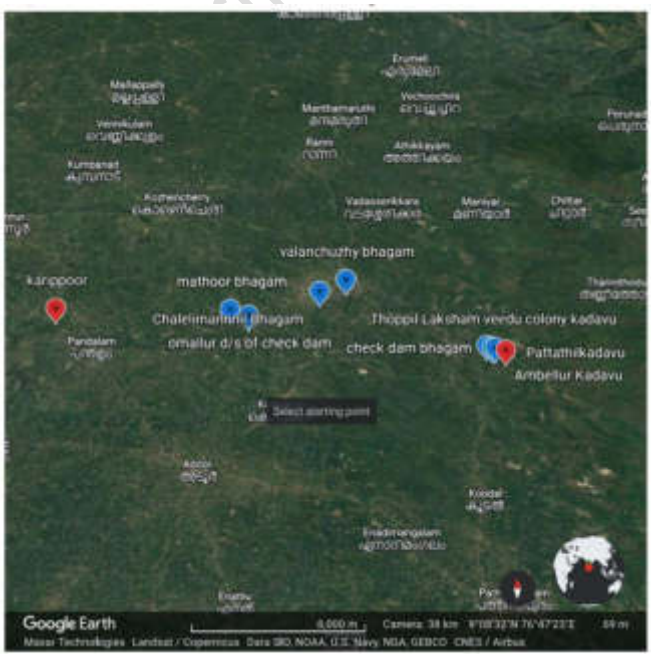


Fig.1 Locations for survey



Fig.2Pattathilkadavu

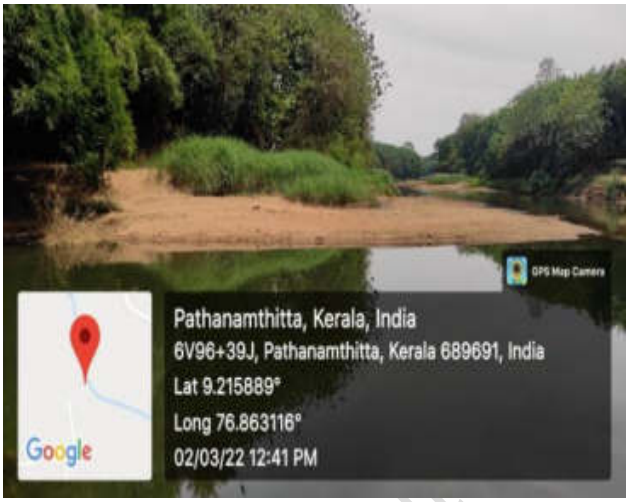


Fig.3 Check dam bhagam



Fig4. Omalloor- D/S of Check Dam



Fig.5 Mathoor Bhagam

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DISCUSSION

Volume of Deposit formed at various locations were obtained as follows:

District	Constituency	Sl. No.	Location	Co-ordinates	Volumeof Deposit (Cu.m)
Pathanamthitta	Aruvapulam Panchayath	1	Pattathilkadavu	9.212 N, 76.87375 E	5988.29
		2	Ambellur kadavu	9.2135 N, 76.86894 E	2221.930
		3	Thoppil laksham veedu colony kadavu	9.21395 N,76.867544 E	1779.270
		4	Check dam bhagam	9.21508 N, 76.865138 E	4012.21
	Pathanamthitta Municipality	5	Valanchuzhi Bhagam	9.259722 N, 76.8 E	18595.88
	Pramadom Panchayath	6	Chalelimannil Bhagam	9.251149N,76.786947 E	10133.080
	Omalloor Panchayath	7	Omallur- D/s of check dam	9.2347222 N, 76.752777 E	33889.49
	Vallikkodupanchayath	8	Mathoor Bhagam	9.238806N,76.743579 E	3120.140
	Kulanada Panchayath	9	Karippoor	9.239769 N, 76.658839 E	1121.63

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Research Activities

a. Investigation works at Thottappally Pozhi
b. Physical Model Study of Kuttyadi Dam
c. Survey of Chandragiri River
d. Sand Budgeting of Chaliyar River
e. National Green Tribunal - Pollution abatement study of Kecheri River
f. Study of suitability of fine aggregates collected from ERI, Palakkad for concreting purposes

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INVESTIGATION WORKS AT THOTTAPALLY POZHI

ABSTRACT

Every year during the monsoon season, the water level of the rivers Achavon kovil, Pamba, and Manimala rises abnormally, causing heavy flooding in the Kuttanad region's low-lying areas. Excess flood water should be drained out by cutting the sand bar formed at the mouth of Thottappally Pozhi to protect the leaves and properties of these in habitations in the Kuttanad region. A study was carried out to determine the mineral content of the sand bar deposited at Thottapally Pozhi.

METHODOLOGY

Samples were collected from sand bar formed at the mouth of Pozhi from pit. Each pit having length of 350 m and width 100m. 9 Samples were collected from the different locations, from pozhi such that representative samples of the area were collected. From each of the pits samples were taken at the ground level, and at a depth of 0.5m to a maximum depth of 2.5 m. Excavation of open pits were conducted using hydraulic excavator. Laboratatary Testing was conduted on two numbers of samples at IREL Labs and the following results were obtained .

Sl.No	Minerals	BH4	BH7	Average (%)
1	Ilemenite	32.66	25.84	29.25
2	Rutile	2.62	1.78	2.20
3	Zircon	0.76	0.64	0.7
4	Silimanite	12.1	13.1	12.6

The comparison of results obtained from IREL with the values obtained from KMML are shown below .

	Minerals	KMML Results %	IREL Results 12/5/21 (%)		
			BH4	BH7	AVG
1	Ilemenite	17	32.66	25.84	29.25
2	Rutile	0.27	2.62	1.78	2.2
3	Zircon	0.12	0.76	0.64	0.7
4	Silimanite	3.5	12.1	13.1	12.6

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DISCUSSION

The samples collected by using open pit excavation from Thottapally Pozhi was tested at Indian Rare Earths Limited (IREL) and compared the same with Kerala Minerals and Metals Ltd (KMML).









Figure. Collection of samples from Thotapally Pozhi and open pit locations

MODEL STUDY OF SPILLWAY OF KUTTYADI DAM

ABSTRACT

Studies on various problems in Applied Hydraulics, Irrigation Engineering etc..are taken up by Hydraulics division and solutions are proposed by the division for the same. The works on major irrigation and hydroelectric project in the state are undertaken only after doing model /research studies by this division. The studies are conducted on a wide range of parameters related to spillways, sluices, chutes, energy dissipating arrangement, flow condition in tail-race, hydraulic behavior of canal structures, river training works etc. From these studies hydraulically sound and economically viable solutions are provided to various problems associated with projects.

Based on the recommendation of the committee on dam safety it was decided to modify the spillway of the dam. Chief Engineer, IDRB, Thiruvananthapuram (Vide Lr.No. No:675/DAMS-AD6/1987/IDRB-Part File I dated 30.04.2018) directed KERI to undertake the physical modelling of the proposed modification of spillway of Kuttiyady dam. The study involves in verifying the flow characteristics of the proposed modification of spillway and stilling basin for energy dissipation in the dam. Based on their technical advice an initial set up for conduction physical model study of dam was constructed in the hydraulics lab. The initial setup included water proofing of overhead tank, setting up of water circulation system, underground sump for storing water etc.

Model details

The model of the prototype spillway of the Kuttiyadi dam was constructed to a scale of 1: 60 in the Hydraulics laboratory in Hydraulics Division, KERI. Out of four bays, an undistorted model of two bays was constructed at two different downstream bed levels (having downstream bed level at +15.0 m and +16.5 m) as in prototype. Among the two bays, the centre bay is at +15.00 m and end bay is +16.50 m as in Fig. 1, following the Froude's model law, for scaling the parameters in order to achieve dynamic similarity between the model and prototype. An Ogee type of spillway model with stilling basin and energy dissipater corresponding to the prototype was constructed according to the scaled dimensions in model following the scale ratio. The spillway was also provided with shutters so as to control the flow of water from the reservoir to the downstream. The reservoir with head maintaining facility, facility for discharge measurement, pressure head measurement, flow profile plotting along the spillway flow path also exist in the model. The discharge measurement was done using a calibrated V - notch. The model set up along with elevation of the spillway is shown in Figure, with the piezometer tapings (Sp1 to Sp15) provided to measure the pressure head when the flow occurs over the spillway. The

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design discharge adopted for the model building of spillway as supplied by IDRB is 1584 m3/s.Based on the details supplied by the Irrigation Design and Research Board (IDRB) on the modified design of the spillway, the physical model of the prototype spillway was simulated in the hydraulics laboratory of KERI, and the performance of the model was analysed. The details pertaining to the spillway model building, model observations, analysis are discussed.

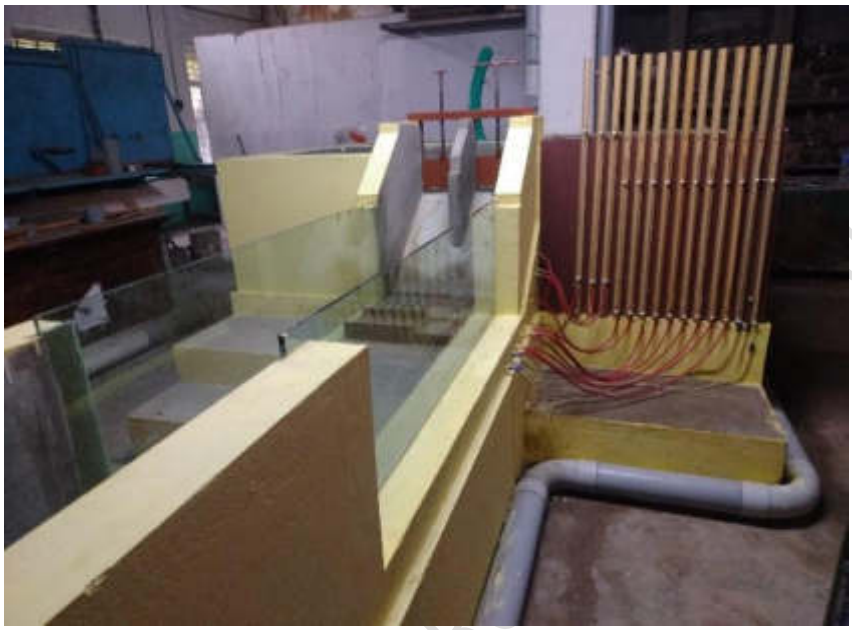


Figure 1:The model set up



Figure 2: Model details

METHODOLOGY

The flow simulation through the Ogee spillway was carried out for different discharges between the minimum to the maximum corresponding to the maximum water level in the prototype. Several trials were done and flow characteristics were observed. The details of the pressure head values recorded in the piezometer tapings .The actual discharge corresponding to different head water over the spillway crest was measured using the calibrated V notch. For the spillway having effective length Le and the head over the crest H, the discharge co-efficient C in the discharge equation for the spillway $Q = C\ Le\ H^{3/2}$ were estimated for different discharges. Based on the theoretical and the actual discharge values corresponding to different water levels, the co-efficient of discharge of the spillway is estimated.The initial depth of flow and the sequent depth for the hydraulic jump were measured and the velocity and Froude number at the salient points of jump were estimated.

DISCUSSION

By simulating site conditions, a physical observation of the jump in the stilling basin was done to see the flow pattern and energy dissipation. A discussion about model study with CWC officials conducted on 25/03/2022 along with other work details.



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SURVEY OF CHANDRAGIRI RIVER

ABSTRACT

The objective of the present work is to perform topographical investigation for preparing a comprehensive water management policy exclusively for Kasaragod District to reduce water crisis in summers as well as the rest of the year of 9 rivers in Kasaragod District using Smartstation - a highly advanced surveying system.The proposal for the investigation is submitted to Govt of Kerala for an amount of Rs. 170 lakhs. During the meeting of Departmental Working Group held on 25.11.2015 in the chamber of Additional Chief Secretary to Government, Water Resources Department, it has been decided to recommend to accord Administrative Sanction for the Topographic Survey of Chandragiri River having length 105km and average width 110km using Smartstation only at an estimate cost of Rs. 45.60 Lakhs and AS has been accorded vide order no. G.O (Rt) No.13/2016/WRD dated 13.01.2016 Thiruvananthapuram under the H/a 4700-80-005-99-Investigation of Irrigation Schemes. Technical Sanction for this work has been accorded by Director, F&AR as per TS No. 02/2015-16/DR/F&AR/KERI dated 15/02/2016 for an amount of Rs. 45 lakhs.

METHODOLOGY

Scope of the work includes taking cross sections at 100m interval including survey of both banks at same interval for a width of 50m on either sides of the river each and preparing the contour plan at 1m interval. Result of this investigation can be utilized for preparing a comprehensive water management policy and to optimize the design of water retaining structures in Chandragiri River which will bring economic feasibility. In addition, 30 numbers of permanent Bench Mark stones have been laid along the banks of Payaswini and Chandragiri River.

GNSS based RTK survey and Total station survey has been used to accomplish the investigation. RTK survey is a relative positioning technique which measures the position of two GNSS antennas relative to each other in real-time. The Reference receiver antenna which is mounted on a previously measured point with known coordinates is known as the Reference Receiver or Base Station. When the receiver is switched on it will start tracking satellites. Because it is a known point, the reference receiver can estimate very precisely what the ranges to the various satellites should be. The reference receiver can therefore work out the difference between the computed and measured range values. These differences are known as corrections. The reference receiver is usually attached to a radio data link /Multiband GSM/UMTS/LTE which is used to broadcast

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these corrections. RTK rover is used for determining the position of unknown points. The rover receiver has also a radio data link/Multiband GSM/UMTS/LTE attached to it that enables it to receive the range corrections broadcasted by the Reference Receiver. The rover receiver tracks the same satellites that are being tracked by the base unit receiver. Since the rover receives the satellite signals directly and also the correction factors from the base station for each satellite it can calculate the correct position. Total station surveying has been used for taking cross sections of river banks by setting up the instrument over a known point established by GPS Rover. Bench Mark embedded in the front veranda of office of the Sub Registrar, Kasargode in the compound of Taluk office has been taken as the reference for the survey and the value is 17.0529m.

DISCUSSION

The first phase of survey of Chandragiri river of Kasargode district for a length of 19km having an average width of 130m has been completed in the financial year 2015-16. The work was done under the H/A 4700-80-005-99-Investigation of Irrigation Schemes for an amount of Rs. 10,01,958/- Scope of the work was to take c/s at 100m interval including the survey of both banks at the same interval for a width of 50m each, upwards from the railway bridge (ie. approximately 1 km awayfrom sea mouth). During 2016-17, nearly 11 km of the river u/s of last year's work towards Payaswini branch of Chandragiri river has been conducted under the same Head of account. Estimate for the survey of remaining 75km of Chandragiri River was submitted under the H/A 4701-80-800-88-00-00-00-V Formation of river basin organization in 2019-20. Detailed estimate of Rs.43 Lakh was prepared and submitted for financial sanction (Price ID-2019/279/IDRB). Financial sanction has been accorded by Chief Engineer, IDRB on 26/09/2019. (FS ORDER No.HRKERIPi/2019/279/IDRB dated 26.09.2019). As per the direction of Chief Engineer, IDRB it has been decided to carry out the Survey as a Tender work so as to avail fund during the desirable working period and to complete the project satisfactorily.Estimate has been revised as tender work and accordedAS and TS as per order No. HRKERIPi/2019/279/IDRB dated 15.02.2020 and HRKERIPi/2019-2020/2019/279/IDRB dated 18.2.2020 respectively.

Joint Director, HydraulicResearch, KERI, Peechi executed agreement with JAI Groups, Digital Land Surveyors, Maradu P.O. Ernakulam as per Agreement No.3/2019-2020/JD-HyR/KERI, PEECHI dated 20.03.2020 for an agreed PAC of Rs.28,77,045/- . The work was started on 30.11.2020 and completed successfully on 17.03.2021. The main inferences obtained from the surveying work are given below:

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- Survey has been conducted both in Chandragiri river (Kudumboor river) and Payaswini river which are the main tributaries of Chandragiri river by taking cross sections at 100m intervals.
- River banks have also been surveyed for ascertaining enough bankheight for water retaining structures.
- Extend of Survey of Chandragiri river and Payaswini river are 44.80 km and 36.531 km respectively from Karnataka border. 456 Ha of river and 299 Ha of bank area have been surveyed in Chandragiri river whereas 407 Ha of river and 301Ha of river bank have been surveyed in Payaswini river.
- Plan, Cross sections, longitudinal sections and contour maps at 1m interval have been prepared. Roads, bridges, check dams, buildings and other permanent structures have been plotted.
- Bench mark stones laid along the banks of Chandragiri river and Payaswini river have been marked in the layout plan.

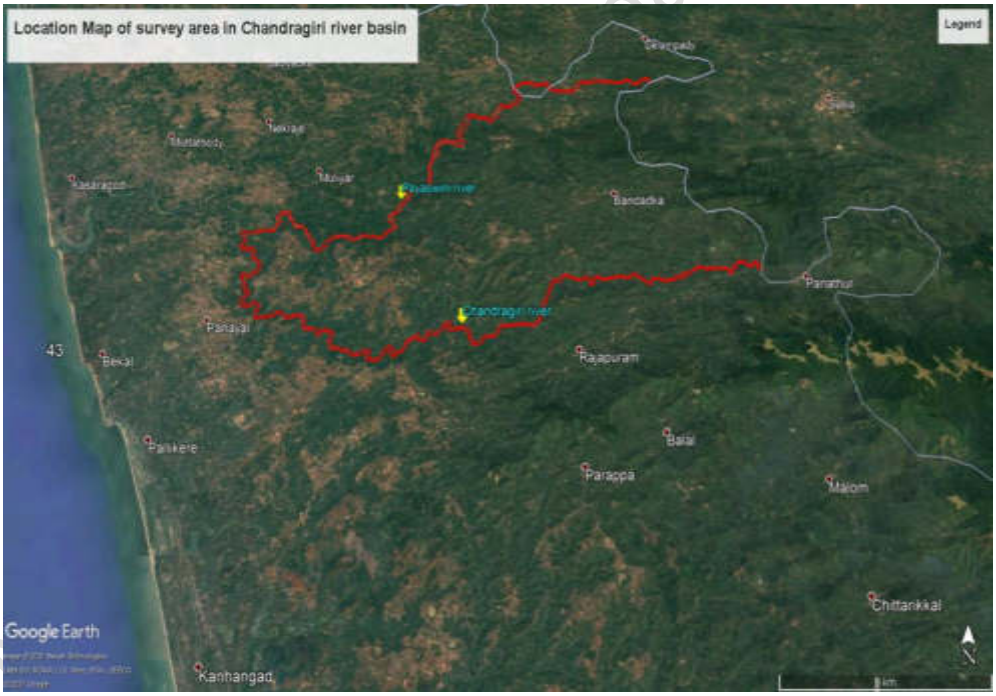


Fig. 1: Study are delineated in google earth

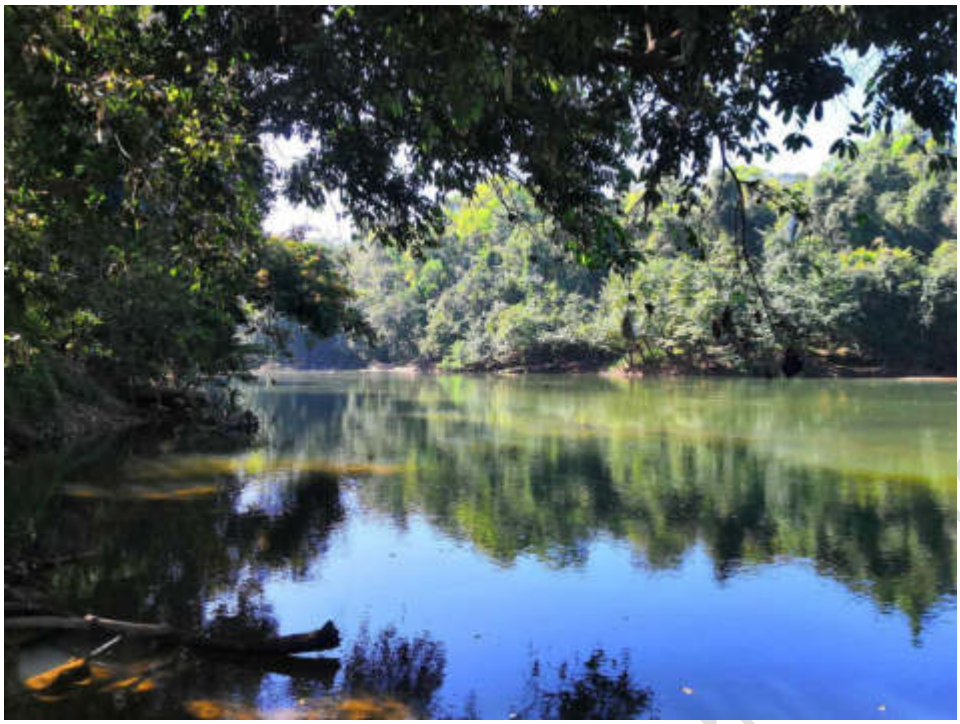


Fig. 2: View of Chandragiri river

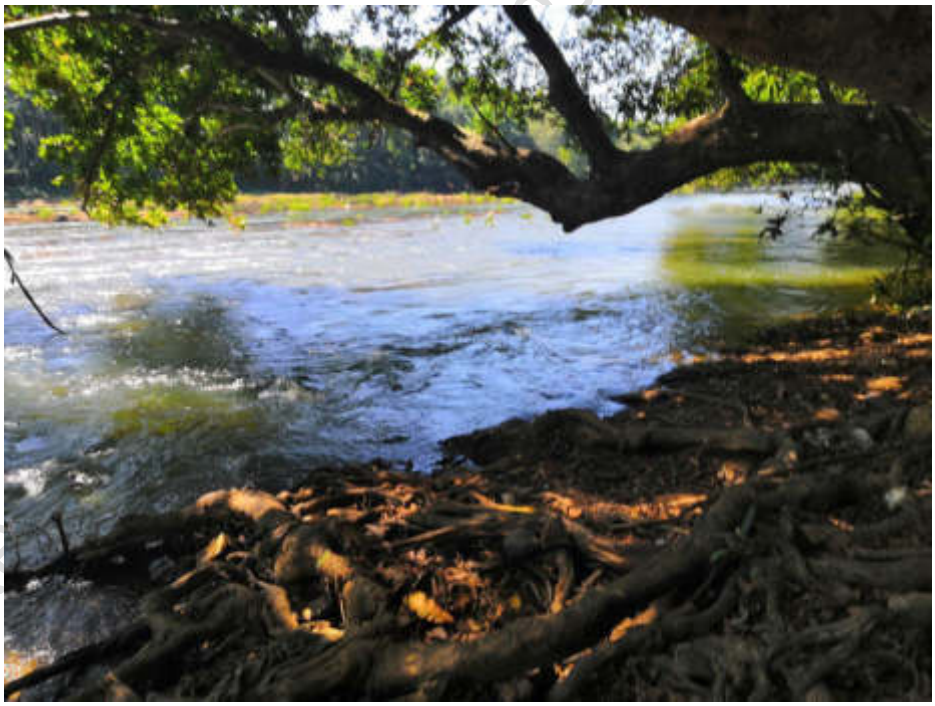


Fig. 3: View of Payaswini river



Fig. 4: Surveying process



Fig. 5: Surveying process



Fig. 6: Surveying process



Fig. 7: Surveying process



Fig. 8: Laying of survey stones in the banks of river

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SAND BUDGETING OF CHALIYAR RIVER

ABSTRACT

Sand Auditing is the procedure to evaluate the process of sand mining in a river or part of the river after a specific period of mining- with an aim to maintain the overall environmental quality of the river. The volume of sand being extracted is having a major impact on rivers, deltas and coastal and marine ecosystems. These include river bank erosion, river bed degradation, river buffer zone encroachment and deterioration of river water quality. Very often, over-mining occurs which jeopardises the health of the river and the environment in general. Extraction has an impact on biodiversity, water turbidity, water table levels and landscape and on climate. There are also socio-economic, cultural and even political consequences. The problem is now so serious that the existence of river ecosystems is threatened in a number of locations, damage being more severe in small river catchments.

Taking a serious note on the impact of river sand mining, The Government of Kerala enacted the legislation "The Kerala Protection of River Banks and Regulation of Removal of Sand Act 2001" to protect the river environment from large scale dredging of sand, The act also envisages provisions for periodical sand auditing in order to assess the feasibility of sand mining in rivers of Kerala. During a meeting convened by at Secretary's (Water Resources) chamber on 05.12.2016 for reviewing the methods available to assess the quantity of silt/sediment etc being deposited in the river beds and for assessing the quantity that can be allowed to be mined, Director, KERI opined that the sand auditing being conducted by the NGOs for Department of Revenue is not scientific as it is based merely on the level of water without taking into consideration the reduction in bed levels. Hence the volume of sand accounted for mining is not correct. Direction has been given to Chief Engineer, IDRB and Director, KERI to submit a proposal specifying the technical method by which an assessment of the quantity of sand available in the river bed, the quantity of sediments being deposited and hence the quantity that can be allowed for mining. KERI has also been directed to undertake quick assessment of the reduction in the level of riverbeds in Kerala over the last 10 years.

The ultimate aim of the present proposal is the development of a scientific method for sand auditing for rejuvenation of all 44 river basins in Kerala State. The method suggested in this proposal has to be validated before projecting it to all the river basins for avoiding unnecessary financial implication. Sand Auditing in Chaliyar River Basin can be taken as a pilot project.

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DISCUSSION

One of the principal causes of environmental impacts from in-stream mining is the removal of more sediment than the system can replenish. Coarse material transported by a river (bed load) commonly is moved by rolling, sliding, or bouncing along the channel bed. Some researchers believe that environmental impacts from in-stream mining can be avoided if the annual bed load is calculated and aggregate extraction is restricted to that value or some portion of it. To accurately limit extraction to some portion of bed load, the amount of sediment that passes the in-stream mining site during a given period of time must be calculated. There is a large amount of uncertainty in the process of calculating annual rates of bed load transport. How much coarse material is moved, how long it remains in motion and how far it moves depends on the size, shape, and packing of the material and the flow characteristics of the river. Because bed load changes from hour to hour, day to day, and year to year, estimating annual bed load rates is a dynamic process involving careful examination. A methodology which takes care the dynamic nature of the bed load is adopted in this proposal. The methodology adopted by Department of Revenue for the sand auditing purpose doesn't take the sediment transport features into consideration and hence results in erroneous calculation of mineable sand. The methodology framed by the Department of Revenue is as follows:

- The river channels are divided into segments based on natural and administrative considerations and profiles are taken across the river at an interval of twice the width of the river or 500m, whichever is less.
- Mineable quantity of sand in each segment is estimated. Mineable quantity of sand means the resource upto a specific depth, ie. less than 2m from the summer water level.
- Sand deposits available in the prohibited areas such as notified biological hot spots, reaches with economical minerals, reaches affected by bank sliding, reaches need protection etc are deducted.
- The quantity of sand that can be mined in a year is estimated by dividing the total mineable sand in the segment by the number of years mining can be permitted in the river, tentatively fixed as 20 years.

7.1 Mapping of the river channel: Mapping of river channel and associated natural features (riparian vegetation, sand bars, pools, eroded banks) and manmade structures (bridges, protective embankments, dams) in a suitable scale. The river channels has to be divided into segments

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based on natural and administrative considerations and profiles has to be taken across the river at an interval of twice the width of the river or 500m, whichever is less. The mapping of the rivers can be performed by using modern equipments in Kerala Engineering Research Institute. River survey can be carried out by using **Integrated Bathymetric System (IBS)** and **Sub bottom Profiler** and banks can be surveyed by **Smart Station**.

The system SES-2000 sub-bottom profiler, which is a mobile parametric sediment sounder, is used for bathymetric and sub-bottom profiling survey. IBS system consists of Differential Global positioning system (DGPS), Echo sounder, Fibre Reinforced Plastic Boat (FRP boat) etc. NAVISOFT software collect the data including position and depth in IBS and SESWIN is used in Sub bottom profiler data collection. Processing software such as SURFER, ISE etc are used for analysing the collected data both in IBS and Sub bottom profiler.

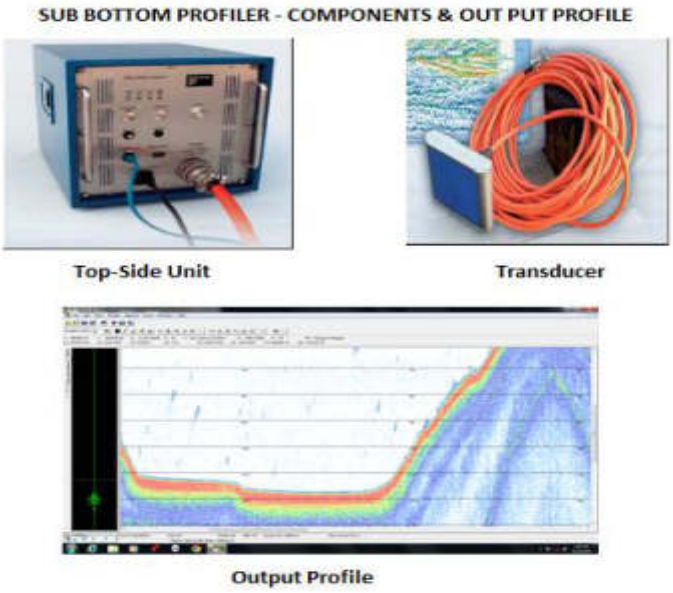


Fig. 1: Components and output profile of sub bottom profiler

Smart station is a new revolutionary surveying system which is more advanced than a conventional total station, in which a high performance total station and powerful GPS receiver is perfectly integrated. With Smart station there is no need to set up the machine over control points, run traverses, or resect the position. We simply set up the instrument wherever it is convenient and determine the latitude, longitude and altitude. These position coordinates are recorded in a memory card which can directly be plotted using any drawing software such as AutoCAD, LisCAD etc.



Fig. 2: Components of smart station

Since the draft of boat using for bathymetric survey is at least 1m, river surveys can be planned in monsoon seasons for a better result and survey of 80% of the area can be done using Sub bottom Profiler. The remaining 20% can be completed using Smart Station. Since the data collected using both Sub bottom profiler and smart station are globally positioned with latitudes and longitudes, the surveys using both equipments may easily be combined to develop the profile at a particular point.

The quantity and quality of sediment transported to the river depends on the rainfall pattern, agricultural activities, type of soil, land use pattern, geomorphology, type of developmental activities etc in the catchment area. These data are available in maps with various agencies such as Kerala State Land Use Board, Kerala State Remote Sensing and Environment Centre, Department of Soil Survey and Soil Conservation, Geological Survey of India etc. Catchment Characteristic Survey can be conducted by applying GIS techniques and field verification of representative areas in catchment. The missing data may be collected from field and mapped using GIS techniques.

7.2 Ascertaining Pristine Condition of the Rivers: For assessing the impact of sand mining, it is necessary to ascertain the pristine condition of the river. Since record of the original river profiles are not available, it can be derived using GIS tools.

Triangulated Irregular Network (TIN) is a vector based three dimensional surface representation derived from irregularly spaced sample points and break-line features. GIS software has specific modules and algorithms to generate TIN models. The algorithm tries to create a surface formed

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by triangles of nearest neighbour points. TIN consists of nodes that store elevation values, connected by edges to form contiguous, non-overlapping triangular facets. In the present study the TIN model of the project area can be derived using Survey of India GTS maps. First step of TIN generation is to create error free vector database of contours of the region. Each contour is represented using line feature in the database. The elevation value of every contour line is attached in the attribute table of the vector database. TIN Model can be used to generate and analyze longitudinal profile and cross profiles of the river.

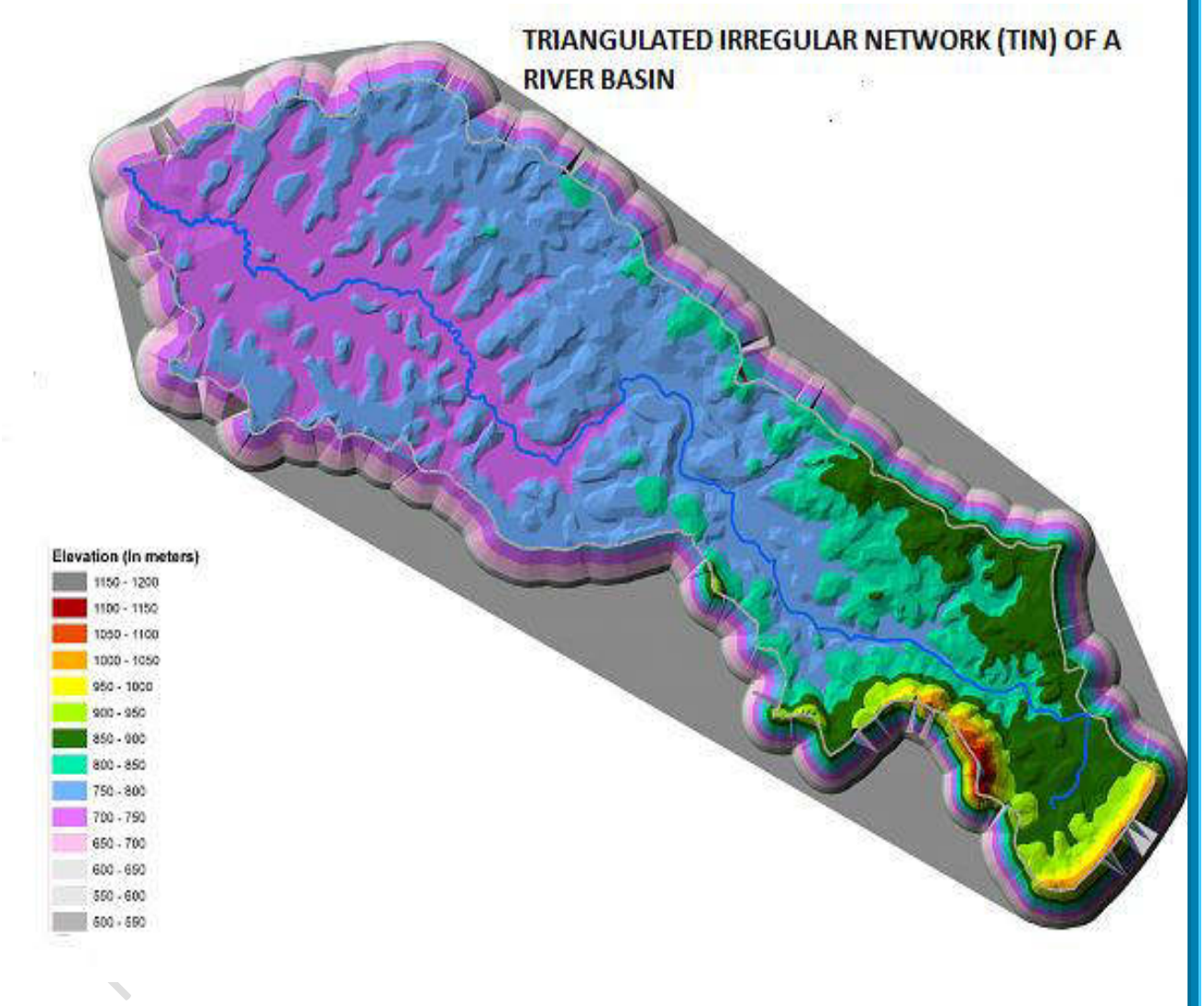


Fig. 3: Sample TIN generated for a river basin

The Digital Elevation Model (DEM) of the study area can be derived from contour corrected TIN model. DEM is used to derive contours of the project area.

7.3 Sediment Sampling: The sediment sampling should include the determination of the nature of bed material and bed material load. KERI has the facilities for sediment sampling. For

collecting the soil sample a floating arrangement which is available in KERI can be used and this arrangement can be rowed to each location for sample collection. Four anchors has been used for keeping the arrangement steady. Soil samples collected from different locations can be analyzed in KERI laboratory to find out its characteristics.

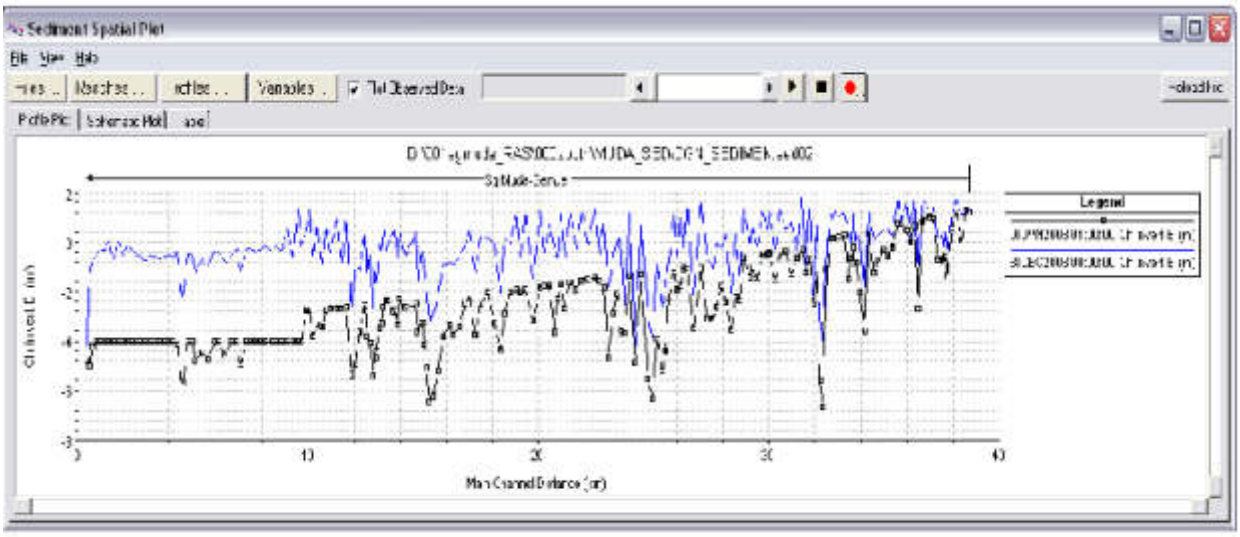


Fig. 4: Collection of soil samples from river

7.4 Sediment Transport Modelling: Sediment transport modelling methods are aimed at providing information regarding the movement of sediment within hydrodynamic systems. Outputs from a sediment transport model include estimates of suspended sediment concentrations, rates of sediment erosion and deposition and sediment transport pathways. The majority of sediment transport models are based on either outputs from hydrodynamic models or solve both hydrodynamic and sediment related equations at each time step of the model simulation. In both cases predictions of water levels and currents, driven by tidal, discharge, wave and meteorological forcing are used in the numerical solving of the equations describing sediment movements. Because of the variety of sediment types, sizes and transport mechanisms, a range of mathematical equations are required to simulate the sedimentary processes. In different models, varying formats and types of sediment transport equations are solved. Different equations are needed to deal with the differences between transports of cohesive or non-cohesive material. Hence different models are often used when modelling sand and mud sediment.

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Sediment Transport Models such as Hydronia / HEC-RAS /MIKE or any other suitable model can be used for this proposal. At present KERI has no expertise in Sediment Transport Modelling and this portion of the proposal may be outsourced to any research organizations. The Directorate has already initiated this study with the help of NIT Kozhikode as pilot proposal using the researchers at their Institution using MIKE software. The geometrical, hydrologic and sediment details collected using the methods explained above will be the input for the models. A series of simulation based on different scenarios should be carried out to determine the most acceptable output for extraction purposes. After the model has finished the computations the user can view the output. Output is available in a graphical and tabular format. The current version of the program allows the user to view Sediment Cross Section Plot, Sediment Time Series and Sediment Spatial Plot which can be used to determine reaches suitable for sand extraction, starting date and last date of sand extraction activities, duration for the sand extraction, the allowable volume of sand to be extracted etc.



SEDIMENT SPATIAL PLOT FOR A RIVER CROSS SECTION

Fig. 5: Sample output of sediment deposition pattern across a river cross-section

7.5 Monitoring Plan: Monitoring will provide data to evaluate the effects of sand and gravel extraction activities, and long-term changes. A brief report summarizing the annual results of the physical and biological monitoring should document the evolution of the sites over time, and the cumulative effects of sand and gravel extraction. The summary should also recommend any maintenance or modification of extraction rates needed to minimize impacts of extraction. In addition to local monitoring for replenishment at specific mining sites, monitoring of the entire reach through the rivers will provide information on the cumulative response of the system to sand and gravel extraction.A repeat study may be conducted once in 5 years to assess the transformation of each river.

The Chaliyar River is an essential element of life in Malappuram and Kozhikode Districts of Kerala State sustaining unique biotic assemblages, human communities, industry, and agriculture. It is the fourth longest river in Kerala having a length of 169 km and a total drainage area of 2,923 sq km out of which 2,535 sq km is in Kerala and the rest in Tamil Nadu. It originates in the Western Ghats range at Elambalari Hills located near Cherambadi town in the Nilgiris district of Tamil Nadu and empties into the Arabian Sea. The river has a few prominent tributaries: Cherupuzha River, Iruvanjippuzha River, Kuruvanpuzha River, Neerppuzha River etc.Chaliyar is one of the rivers which doesn't get dried up in the drought season. Many other rivers in Kerala get dried up during March and April. This river was in the news a few years ago because of the ecological damage caused by a pulp factory at Mavoor that released effluents into the river and affected the marine life. The purpose of this study is to provide a rigorous scientific foundation that quantifies the association between sand mining and equilibrium of riverbed in Chaliyar River Basin. The long term goals expected from the study are elucidated below:

1. A realistic estimation of the sand resource in a given stretch by mapping the present condition of river channels, ascertaining pristine condition of the rivers etc.
2. To assess sustainable level of sand miningby scientific methods such as sediment transport modelling to maximize the health and functions of the river and bringing back rivers to its pristine conditions.
3. To minimize the negative ipacts of sand mining by maintaining riverbed equilibrium
4. Evaluation of the performance of mining activities during the period of auditing

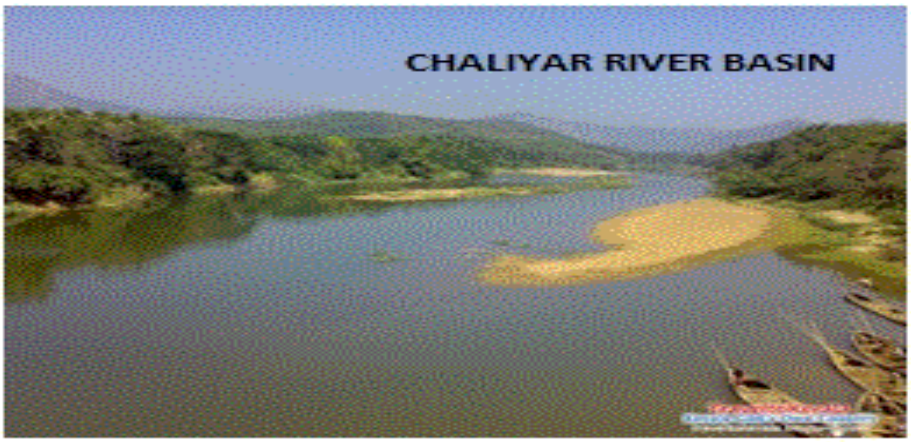


Fig 6 Chaliyar River

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NGT-ABATEMENT OF POLLUTED STRETCH OF RIVER KECHERY FROM KECHERY TO PULIYANNUR

ABSTRACT

The National Green Tribunal (NGT) passed a landmark order on 20 September 2018 about increasing polluted river stretches in the country (NGT 2018). It ordered all states and union territories to prepare action plans within two months to improve the quality of polluted river stretches to "at least bathing purpose" within six months of the finalization of the plans. The tribunal distinctly stated that the chief secretary of each state and the administrator of each union territory will be responsible for the preparation of the action plan. The polluted river stretches have been divided into five priority categories i.e., I, II, III, IV, V depending upon the level of BOD. 351 polluted river stretches have been noted by the Central Pollution Control Board (CPCB). In Kerala total of 21 rivers - only 1 in Priority I list; remaining in IV and V.

As per NGT's recommendations, the Water Resources Department (WRD) of Govt. of Kerala started the formulation of the action plans for abating pollution in the critically polluted rivers of the State. As a first step, it was decided to collaborate with Engineering Colleges so that the domain knowledge of the faculty, the spirit of scientific inquiry of the students and the experience of the officers of WRD can be utilized to develop and implement innovative and effective solutions for the abatement of pollution in these rivers.

The Kerala Engineering Research Institute has selected Kecheri river for the pollution abatement study in collaboration with SCMS School of Engineering and Technology, Karukutty, Ernakulam (SSET) as per G.O.(Rt)No.70/2021/HEDN Dated, Thiruvananthapuram, 13/01/2021 in which the list of rivers and institutions associated with are given.

Kechery River or KecheryPuzha also known as Wadakancherypuzha is a west flowing river which has its origin at Machad hills in Thrissur District. The river is 51 Km in length and empties to Arabian sea at Chettua Lake. The river irrigates 3560 Hectares of land in Thalappilly taluk in Thrissur District through Vazhani irrigation Project. The river coming under priority No:IV as per NGT norms and the most polluted stretch assigned is from Puliyannur to Kechery.

METHODOLOGY

The Kechery River is one of the smallest rivers of Kerala. It is linked with backwaters at Enamakkal. ChoondalThodu, Peramangalamthodu and Chetupuzha are the tributaries of this river. It flows through different areas of Eranellur, Cheranallur, Paranur, Choondal, etc. Its basin

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area is 401 km2. The river irrigates 3560 hectares of land in Thalappilly taluk in Thrissur District through the Vazhani irrigation project. It's not a navigable river. One important project in the river is Parannurchira, it serves irrigation purposes of the villages around it. It is surrounded by Perumala hill in the east, Choondal hill in the south, Choondal rock in the west and Pattikkara backwater and Parappoor backwater in the north. Nowadays ParannurChira is getting more popular for tourism and film shooting. The present study includes a part of this river from Puliyannur to Kechery bridge only.

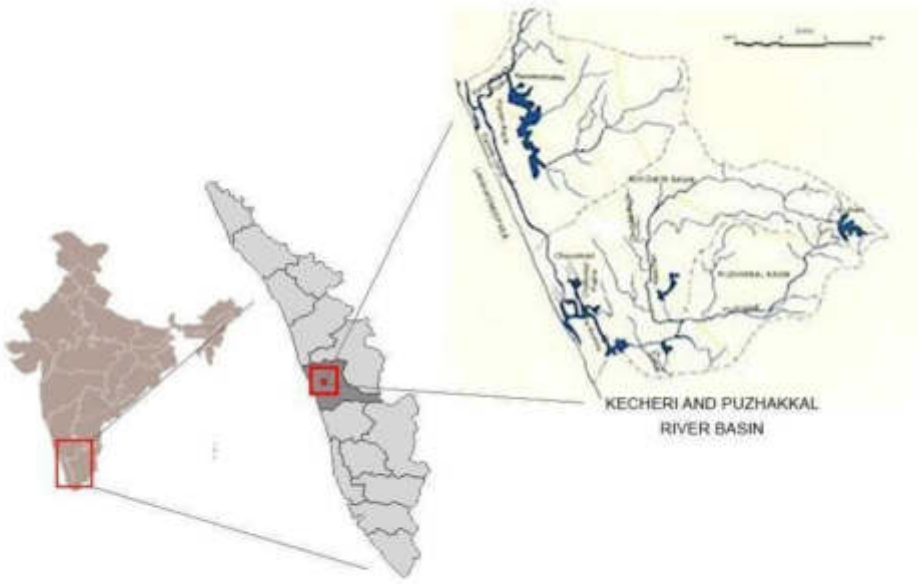


Figure 2: Geographical location of the Kecheri river basin

- **Meteorological parameters**

The climate of the surrounding area is classified as tropical. Most months of the year are marked by significant rainfall. The short dry season has little impact. This climate is considered to be Am according to the Köppen-Geiger climate classification [Note: *Am* = Tropical monsoon climate ; driest month (which nearly always occurs at or soon after the "winter" solstice for that side of the equator) with precipitation less than 60 mm (2.4 in).]. The average annual temperature is 27.6 °C or 81.7 °F. April is the hottest month of the year. The lowest average temperatures in the year occur in July when it is around 25.7°C (78.3°F). The average annual rainfall near the river basin is 3000 mm and the average annual stream flow is around 1024 Mm3. Precipitation is the lowest in January, with an average of 2 mm (0.1 inches).The greatest amount of precipitation occurs in July, with an average of 760 mm (29.9 inches). Between the driest and wettest months, the difference in precipitation is 758 mm (30 inches). The variation in temperatures throughout the year is 4.2 °C (39.6 °F).

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The average wind speed in Thrissur is 2.7 m/s with a maximum wind speed of around 9 m/s. The average relative humidity remains around 79.4%, varies from 35.9% to 98.5%. The station pressure varies from 986 hPa to 979 hPa, averaged around 993 hPa. Windrose of Thrissur shows that predominantly wind blows from the WNW - about 17.99% of all wind directions.

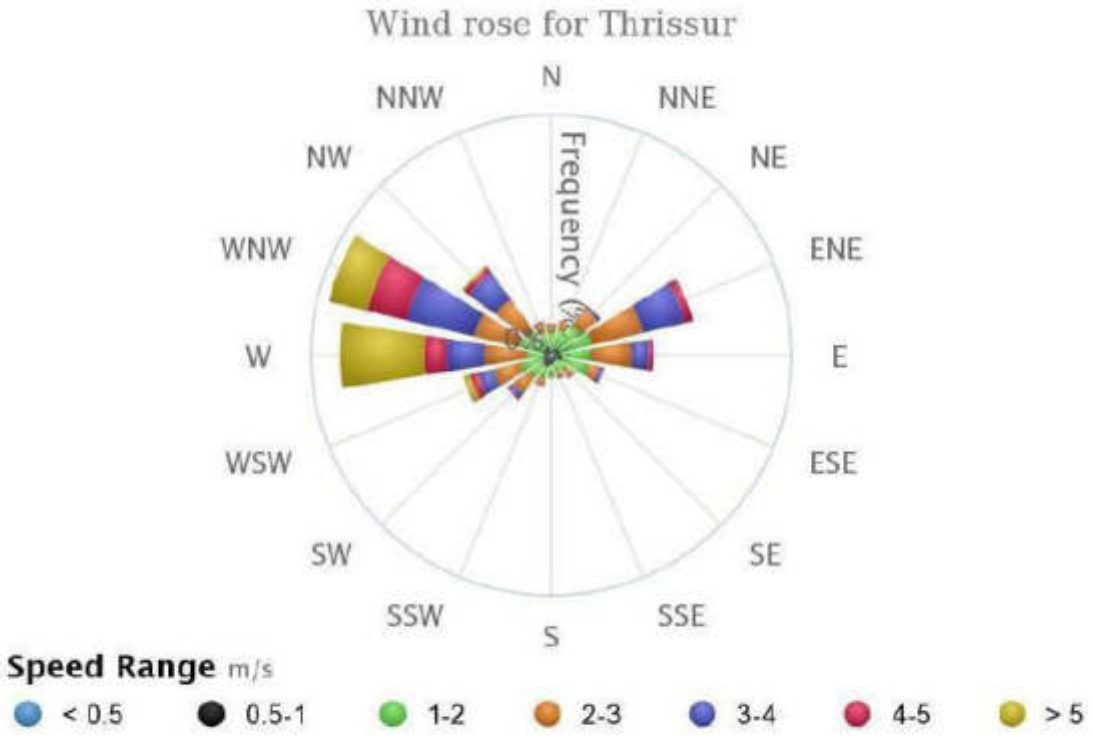


Figure 1: Wind rose of Thrissur

No other drains or rivers are joining the Kechery river. Vazhani dam is located along this river

- **Ecological aspects of the river**

Vazhani dam (which is one of the biggest clay dams of Kerala) is located across Kecheri river. It is one of the tourist attractions of the Thrissur district. The Peechi Vazhani sanctuary is located between the dams of two rivers - Peechi and Vazhani of Trichur. It has one of the richest collections of flora and fauna. These attract a great variety of birds, reptiles and other animals. Also, there is presence of Kole lands along the banks of Kecheri. Geologically, Kole is a low lying area with alluvium deposits brought down by the Kechery and Karuvannur rivers. It is a basin with a saucer shape flanked by laterite hills in the western and eastern margins. Some

portion of the Kole area exhibits a lacustrine 21 environment and contains black carbonaceous clay with many plant parts and in some places withered tree trunks. (Johnkutty and Venugopal,1993).

The Thrissur Kole can be divided into North and South Koles. The Thrissur North Kole is a stretch of low lying lands extending from the Karuvannur River in the south to Kaiparamba in the north. The Thrissur North Kole is divided into three basins, namely the north covering Kechery, Peramangalam and Chemmen basins, the center comprising of PuzhakkalNaduthodu, Chiyyaram and Kokkala basins and the south consisting of Puthenthodu, Herbert Canal and Chirakkalthoudu basins. The main exits for the flood water that enter the Kole fields are Enamakkal and Idiyanchira regulators. These regulators also serve as salt barriers and divert part of the floodwaters of northern Kole to the backwaters through the Kanoli canal and subsequently to the sea through Chettuvaazhi.

- **Environmental concerns**

In 2018, a project to rejuvenate the river was readied with the coordination of people's representatives, officials, voluntary organizations and the public. An action plan to clean up the river was prepared. The action plan mainly focused on three steps - removing encroachments, stopping waste dumping and cleaning the river. The Kerala Institute of Local Administration (KILA) coordinated the rejuvenation project. An expert team was formed at KILA to give necessary guidelines for the panchayat-level team for the conservation of the river. The panchayats were asked to submit projects for the repair of small bunds in the river.

Polluted Stretch of the River

The stretch of Kecheri river from Puliyannur to Kecheri bridge is taken for pollution abatement.The length of this stretch is 8.5 km.

Causes of pollution:

Apart from the fluctuation in water availability during the lean season, pollution is caused byvarious other factors. Urbanization, change in land use pattern, use of excess chemical fertilizers,change in lifestyle, unscientific waste disposal system including that of letting out sewerage towater bodies are some of the main reasons to be highlighted with. The pollutants mostly includewater from households and shops. Various study reports suggest that a large number of wastes arelet out to rivers from hotels, markets, slaughterhouses, colonies, workshops,

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etc. Also, along thecurves in the rivers, meandering has resulted in the formation of small island portions thatobstruct the flushing out of pollutants, something even resulting in a change in the river course.Encroachments and filling-up of rivers for commercial purposes have also resulted in pollution.Hence, there is an urgent need to regulate and control the above-said actions which significantlycontribute to the pollution of water bodies.

- **Water quality data**

Samples were collected from 12 points during three seasons and water quality was analyzed,12 sampling points are:

- Vazhani dam
- Virippakkamanalitharappalam
- Wadakanchery bridge
- Kanjirakodu
- Erumapetti
- Pathramangalam bridge
- Koompuzhapalam
- Kecheri bridge
- Mukollichira
- Kadanthodu
- Koombulli bridge
- Idiyanchira

The heavy metal contamination status of Kecheri river was found out and all the metals (Lindane, Aldrin, DDD, Endo-alpha, Endo-beta, Dieldrin and DDE) were found to be within the limit. For pesticide residue analysis 3 samples were taken from Vazhani dam, Erumappetti and Mukollichira. Chlorinated pesticides were detected during the post-monsoon season whereas in the pre-monsoon and monsoon seasons the values were found to be below the detection limit (BDL). Aldrin was detected in Vazhani dam and Mukollichira. Endo beta was detected in Erumappetti.

Irrigation water quality parameters were calculated based on Sodium Absorption Ratio (SAR), Magnesium Hazard Ratio (MHR), Kelly's ratio (KR) and Soluble Sodium Percentage (SSP). From the calculated values, it was found that all the surface samples of Kecheri river possess excellent irrigational water quality as per SAR, KR and SSP except for the sample from

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Idiyanchira. But as per MHR, the majority of the surface water samples were unsuitable for irrigation purposes.

As per Central Pollution Control Board (CPCB), all 12 samples from Kecheri river are classified as Class C, which indicates that river water can be used as a drinking water source after conventional treatment and disinfection.

Class C criteria:

- Total Coliforms organism MPN/100 ml shall be 500 or less
- pH between 6-9
- DO 4mg/l or more
- BOD 5days at 20 0 C 3 mg/l or less

Canadian Council of Ministers of Environment (CCME) Water Quality Index (WQI) has been worked out for Kecheri river and the index is based on a combination of 3factors:

- The number of variables whose objectives are not met (scope)
- The frequency with which the objectives are not met (Frequency)
- The amount by which the objectives are not met (Amplitude)

In Kecheri, most of the WQI is between 45 – 64.9 which indicate that the water quality often violates criteria to be used as a drinking water source by a considerable margin) and one station showed poor water quality (value less than 45; indicates that water quality does not meet any criteria to be used as a drinking water source).

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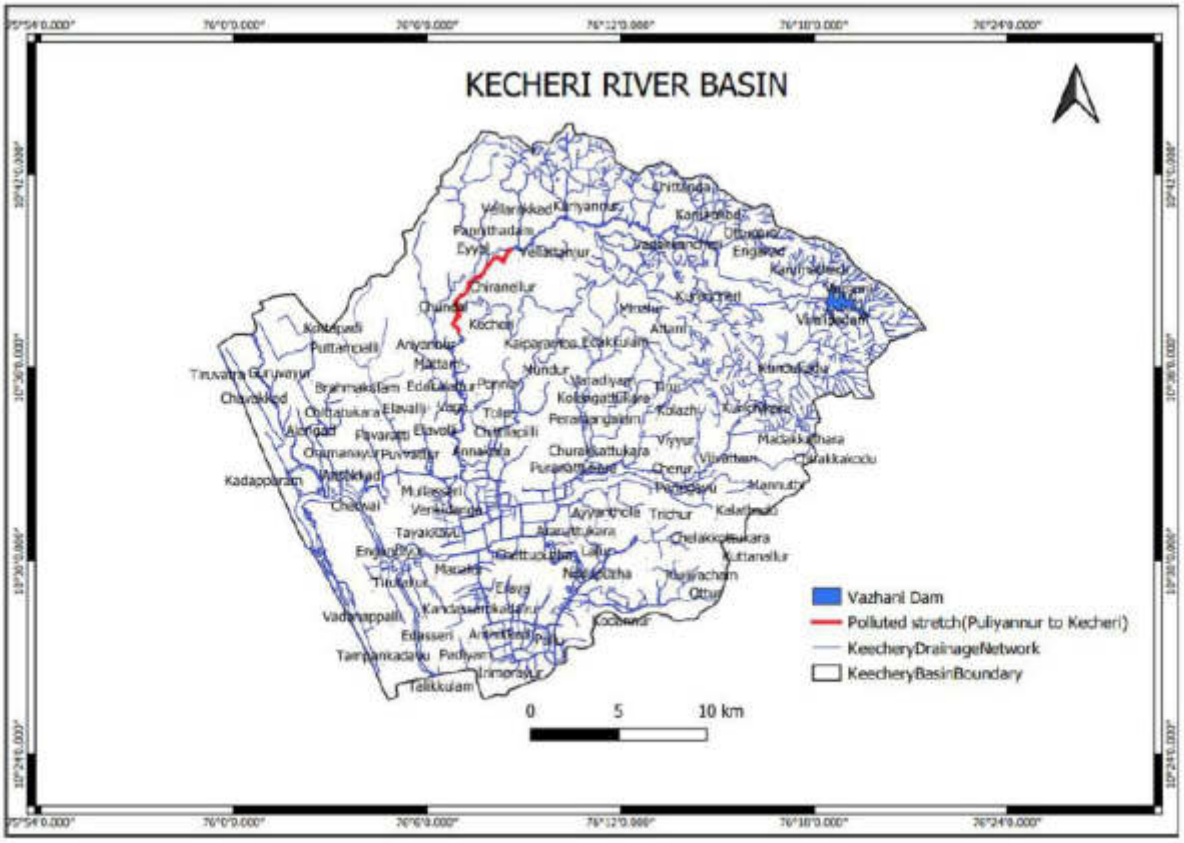


Figure 3: The polluted stretch of Kecheri river

DISCUSSIONS

The main objective of the Action Plan is to restore the water quality of priority IV polluted stretch of Kecheri river (Puliyannur to Kechery) to Class B (IS 2296:1992).

The outcomes envisaged after the implementation of the Action Plan include:

- Enhancement in river water quality to Class B
- Maintenance of minimum environmental flow
- Improvement in river biodiversity

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Pollution Inventory:

- **Details of Drains Contributing Pollution**

The source of pollution could be Pig farm located along the banks of Kechery river. But the BOD values reported till January 2020 are less than 3.

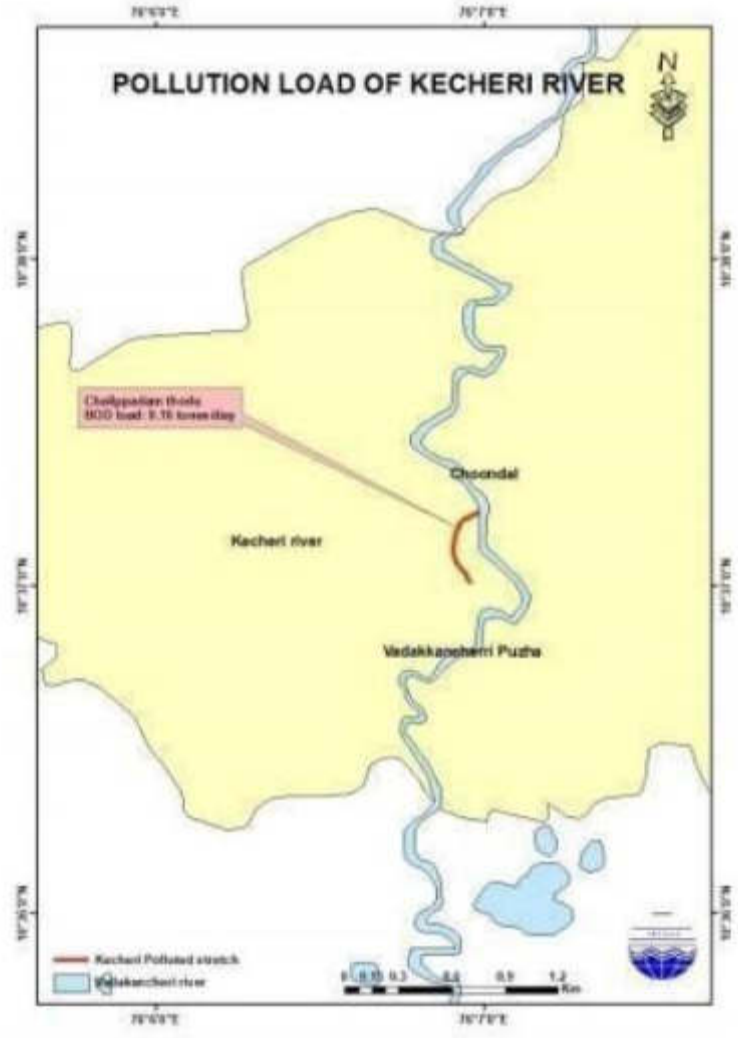


Figure 4: Location of drains

- **Details of Sewage Pollution Sources and Treatment Systems**

There are no significant sewage pollution sources and treatment systems identified in the given stretch of river.

- **Details of Waste Management**

Municipal Solid Waste: There are no significant municipal solid waste identified in the given stretch of river except a flat building near Kechery Bridge



Flat near Kechery Bridge

Bio-medical Waste: There are no significant bio-medical waste sources identified in the given stretch of river

Hazardous Waste: There are no significant hazardous waste sources identified in the given stretch of river

E-Waste: There are no significant e-waste sources identified in the given stretch of river

- **Details of Industrial Pollution Sources**

There are no significant industrial pollution sources identified in the given stretch of river

- **Sources from Agricultural Areas**

Kechery river plays a vital role in irrigating the nearby area. Presence of paddy fields and other agricultural lands have been noted. Locations are shown in the land use map. So there are chances that the fertilizers used may leach into the river and thereby causing pollution.

- **Any Other Sources**

The pig farm located near Kechery river can be a pollution source.

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- **Status of Groundwater**

Total 18 groundwater samples were collected from Kecheri. Analysis of the heavy metals indicate that the ground water samples are free from heavy metals (All results are ND, except the maximum value of iron, which is equal to 0.0085 mg/l).

Monitoring of Pollution Sources:

- **Monitoring of Drains**

There are no drains joining the Kechery river.

- **Monitoring of River**

Samples were taken from 4 locations and anslysed for water quality.

- **Monitoring of Polluting Industries**

There are no industries near by the Kechery river.

Action Plan for Restoration of Polluted River Stretch:

- **Short term action plan**

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Sl. No.	Action	Timeline	Implementing Department / Agency	Remarks
Component I: Sewage Management				
1	Surveillance to prevent flow of sewage /effluent to river	Dec 2019	Choondal GramaPanchayat	
Component II: Industrial Waste Management				
1	Stoppage of effluent from residential apartment and pig farm into the river.	-	Choondal GramaPanchayat	
Component III: Solid Waste Management				
1	Fixing Boards	Dec 2019	Choondal GramaPanchayat	
2	Installation of CCTV in different locations along river side	Dec 2019	PWD electronic division	

- **Long term Action Plan**

Sl No	Action	Timeline	Implementing Department /Agency	Remarks
Component V: Others				
1	Side protection by fixing coir geo nets	Not Reported	Choondal Grama Panchayat	Protection of Kechery river
2	Survey process of Kechery river portion belongs to ChoondalGrama Panchayat tomark the boundary and encroachment.	Not Reported	Revenue Department	On Going
3	Laying of survey station	Not Reported	Choondal Grama Panchayat	On Going
4	Digital mapping and seminar on pollution control	Not Reported	Forestry College, Vellanikkara	On Going

- **Third Party Monitoring and Evaluation**

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Monitoring of the performance indicators by means of result based logical framework analysis andevaluation of the effectiveness of project implementation to be done for each activity/component.

Activity/Component	Performance Indicators	Means of Verification	Frequency of Monitoring
Surveillance to prevent flow of sewage /effluent to river		Inspection to the site	-
Stoppage of effluent from residential apartment and pig farm into the river.		Laboratory testing of water samples	Once in a year
Side protection by fixing coir geo nets		Inspection to the site	-
Digital mapping and seminar on pollution control		Office work	-

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STUDY OF SUITABILITY OF FINE AGGREGATES COLLECTED FROM ERI, PALAKKAD FOR CONCRETING PURPOSES

ABSTRACT

Eri's means large pond having a greater area. There are three Eris associated with the Chitturpuzha project viz. Kambalathara, Venkalakkayam and Kunnampidari. Palakkad District is one of the major districts in Kerala facing severe water crisis in the summer season every year. Most of the years, the district faces drinking water scarcity and agricultural loss due to non-availability of water and experiences drought-like situation. The Eris plays a significant role in the entire water distribution system of Chitturpuzha Irrigation project. The impounded water stored in these Eris reduces severity of drought and scarcity of drinking water. By enhancing the storage capacity of the above Eri's through desilting, the capacity will be raised for stabilizing the discharge of water to left bank canal for irrigation and drinking purpose without any major environmental problems. The individual components extracted from sediments such as sand, gravel and clay residue can be sold to generate revenue to Government.

Two samples of sand soil collected from Palakkad Eri's were brought to the Construction Materials Laboratory by the Deputy Director, Instrumentation Division, KERI, Peechi to conduct necessary tests of fine aggregates and to assess the suitability of these samples for using concrete mixes.

METHODOLOGY

Experimental studies were conducted on 19/04/2021 in one of the Eris (Kamabalathara Eri) for a comparison between the results obtained in the lab (samples collected during the soil investigation works in the Eris) and samples was wash. The study was carried out by digging a trial pit to a depth where the soil profile changes to hard strata or soft rock.

Test Pit 1 First Trial Pit was dug around near the Portion where Bore Hole No 15 is located .Trial pit was dug to a depth of 2.6 m from GL .First 0.80m layer is of soil, which cannot be washed to sand and rest 1.80 m was soil which can be washed and converted to sand . A known quantity of sand (1 cu ft) was taken and washed and sieved as per the sizes available in market , mainly to the size of sand Used for Concrete(size 4.75 mm -150 micron)and sand used for Plastering (150 micron-2.36 mm) and the rest Oversize Gravel to the following results were obtained .

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Type of Sand	Percentage (%)
Sand (150 micron-2.36 mm) – Plastering sand	40 %,
Sand (4.75 mm -150 micron)- Concreting Purpose	7%,
Oversize Gravel	12% ,

Second Trial Pit was dug around near the Portion where Bore Hole No 7 is located .Trial pit was dug to a depth of 2.5 m from GL .First 1.00 m layer is of soil , which cannot be washed to sand and rest 1.50 m was soil which can be washed and converted to sand . A known quantity of sand (1 cu ft) was taken and manually washed and sieved as per the sizes available in market, mainly to the size of Sand (Used for Concrete size 4.75 mm -150 micron)and Sand (Used for Plastering 150 micron-2.36 mm) and the rest oversize Gravel to the following results were obtained.

Type of Sand	Percentage (%)
Sand (150 micron-2.36 mm) – Plastering sand	65 %,
Sand (4.75 mm -150 micron)- Concreting Purpose	6%,
Oversize Gravel	3% ,

From the Observation we could infer that the top layer of the Eris is soil for a depth of 1- 1.5 m average , which cannot be converted to sand , whereas the soil below the top layer has good components of sand , which can be washed and processed . The washing of the samples indicated that sand can be profitably extracted practically and can be used in the construction industry .





The tests conducted in the laboratory are explained in detail and were performed as per the relevant IS codes.

a. Grading of fine aggregates

Grading is the particle-size distribution of an aggregate as determined by sieve analysis. If all the particles of an aggregate are of uniform size, the compacted mass will contain more voids whereas aggregate comprising particles of various sizes will give a mass with lesser voids. The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles. The whole procedure of sieve analysis is to determine the particle size distribution of the fine aggregates and determine whether it is suitable to use in concrete mixing.

As per IS 383:2016, fine Aggregates used for Concrete can be categorized into following types based on sizes as below: Grading zone - Zone I / Zone II/ Zone III/ Zone IV. Fine aggregates grading becomes progressively finer from zone I to zone IV. It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions. The tests for gradation have been conducted as per IS 383-2016 and IS 2386-1963 (Part I&III). The results are shown below

Table 1: Test Results of Sieve Analysis- Test pit 1

IS sieve Designation	Mass retained in grams	Percentage retained	Cumulative % retained	Percentage passing	IS limits (IS 383-2016) of % passing for Zone II
10 mm	0	0	0	100	100
4.75 mm	0	0	0	100	90-100
2.36 mm	0.4	0.04	0.04	99.96	75-100
1.18 mm	159.4	15.94	15.98	84.02	55-90
600 micron	296	29.6	45.58	54.42	35-59
300 micron	506.5	50.65	96.23	3.77	08-30
150 micron	33.7	3.37	99.6	0.4	0-10
Finer than 150 micron	1	0.1			
The Grading of sand belongs to Zone II with fineness modulus 2.57					

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Fineness modulus of fine aggregate is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and divided by 100 gives the value of fineness modulus.

Table 2: Test Results of Sieve Analysis- Test pit 2

IS sieve Designation	Mass retained in grams	Percentage retained	Cumulative % retained	Percentage passing	IS limits (IS 383-2016) of % passing for Zone II
10 mm	0	0	0	100	100
4.75 mm	0	0	0	100	90-100
2.36 mm	4	0.4	0.4	99.6	75-100
1.18 mm	132	13.2	13.6	86.4	55-90
600 micron	289.8	28.98	42.58	57.42	35-59
300 micron	489.1	48.91	91.49	8.51	08-30
150 micron	75.1	7.51	99	1	0-10
Finer than 150 micron	3.4	0.34			
The Grading of sand belongs to Zone II with fineness modulus 2.47					

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b. Specific gravity of fine aggregates

The specific gravity of an aggregate is considered as the measure of strength or quality of the material. Specific gravity is defined as the ratio of weight of a given volume of aggregate to the weight of equal volume of water. Aggregates having low specific gravity are generally weaker than those with aggregates having high specific gravity. This property helps in a general identification of aggregates. The specific gravity of aggregates normally used in construction

ranges from about 2.5 to 3.0 with an average value of about 2.68. The tests for specific gravity have been conducted as per IS 2386-1963 (Part III).

- **Specific Gravity : 2.598 for Test Pit 1**
- **Specific Gravity : 2.575 for Test Pit 2**

c. Compressive Strength of Concrete cubes

The compressive strength of hardened concrete is generally considered to be an index of its other properties like quality and quantity of cement, water and aggregates, batching and mixing, placing, compaction and curing. The grading of aggregates influences the mix proportions for a specified workability and water-cement ratio.

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. In the designed mixes, the performance of the concrete is specified by the designer and the mix proportions are determined by the producer of concrete with minimum cement content. IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm^2

The suitability of the fine aggregates collected from Eri's were tested by preparing design mixes and the 28^{th} day compressive strength was checked. The design mixes are prepared based on IS 10262 -2019. The properties of cement, fine aggregates and coarse aggregates are given in Table-3.

Table 3: Details of Constituents used for design mix

Description	Test Pit 1	Test Pit 2
Design water cement ratio	0.55	0.55
Type of cement used	Sanker OPC 53 grade	Sanker OPC 53 grade
Specific gravity of Cement	3.15	3.15
Consistency of cement	29%	29%
Compressive strength of cement 7^{th} day	46N/mm2	46N/mm2
Compressive strength of cement 7^{th} day	57.5N/mm2	57.5N/mm2
Initial setting time	90minutes	90minutes

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Final setting time	260minutes	260minutes
Specific gravity of Coarse aggregates	2.72	2.72
Specific gravity of Fine aggregates	2.598	2.575
Percentage of Coarse aggregates	54.9	54.9
Quantity of water/m3 concrete	165litre	165litre
Cement content/m3 concrete	300kg	300kg
Grading of Coarse aggregates 20mm & 12mm	50:50	50:50
Loose density of Coarse aggregates	1560kg/m3	1560kg/m3
Loose density of fine aggregates	1363 kg/m3	1353kg/m3
Grade of Design mix	**M15**	**M15**
Characteristic Compressive strength	**15N/mm2**	**15N/mm2**
Target Strength	**20.775N/mm2**	**20.775N/mm2**

Compressive strength test results of trial cubes of M15concrete at 28 day are furnished in Table 4 and 5. The tests have been performed as per IS 516 – 1959.

Table 4: Test Results of Compressive strength- TEST PIT 1 SAND

W/C	Sl. No	Weight	Breaking Load	Compressive Strength	Average Compressive Strength	Remarks
		Kg	*KN*	*N/mm²*	*N/mm²*	
0.55*	1	8.400	516.19	22.94	24	**>Target strength**
	2	8.290	576.05	25.60		
	3	8.210	526.83	23.41		

**Quantity of Materials per cubic meter of concrete*

Cement (SANKER OPC 53) : *300 kg.*

Fine Aggregate : *866.778 kg*

Coarse Aggregates : *1055.94 kg.*

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Water : *165 lit*

Ratio by Weight:- 0.55 : 1.00 : 2.89 : 3.52

Table 5: Test Results of Compressive strength - TEST PIT 2 SAND

W/C	Sl. No	Weight	Breaking Load	Compressive Strength	Average Compressive Strength	Remarks
		Kg	*KN*	*N/mm²*	*N/mm²*	
0.55**	1	8.510	722.24	32.10	32	**>Target strength**
	2	8.370	702.47	31.22		
	3	8.280	705.11	31.34		

*** Quantity of Materials per cubic meter of concrete*

Cement (SANKER OPC 53) : *300 kg.*

Fine Aggregate : *859.104 kg*

Coarse Aggregates : *1055.94 kg.*

Water : *165 lit*

Ratio by Weight:- 0.55 : 1.00 : 2.86 : 3.52

DISCUSSION

The results of various tests conducted on the two samples shows that the samples brought to the lab after washing and cleaning indicate the properties of fine aggregates and can be used for concreting. The compressive strength of concrete cubes prepared by using the above sand samples as fine aggregates indicates strength more than the required target strength.



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Reports on current issues

a. A Brief On Dam Decommissioning Scenario
b. Intense Rainfall Related Landslide and Flooding in Kerala in October 2021
c. Study of Activities Of Various Engineering Research Institutes in India
d. Sustainable Coastal protection Plan

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BRIEF PERSPECTIVE ON DAM DECOMMISSIONING SCENARIO

Decommissioning can be defined as dam removal which includes the full or partial removal of an existing dam and its associated facilities (Guidelines for Dam Decommissioning Projects, United States Society on Dams). The decision to remove a dam should be based on the careful evaluation of a wide range of alternatives to solve a specific problem at an existing facility, including dam safety concerns, high repair costs, high operation and maintenance costs, or significant impacts on aquatic resources and water quality.

In some cases, the problem can be solved by partial removal of the dam rather than by full removal of the dam and project facilities. For partial removal, the dam height and storage capacity should be reduced to the point that the structure no longer presents a downstream hazard. It includes lowering the normal maximum reservoir level in order to permanently reduce the loads on the dam, or to reduce potential downstream consequences in the event of dam failure. Lowering the height of the dam and reducing the maximum storage capacity change its hazard classification. Lowering the normal maximum reservoir level may also be accomplished by non-structural methods, such as permanently opening gates from the spillway and/or outlet works. Full or partial removal of any type of dam requires the consideration of a wide variety of technical, environmental, social, political, and economic issues.

The decommissioning process involves initially meticulous and judicious scrutiny of all the available options and their possible outcomes in deciding whether to maintain or decommission a dam. The decision to remove a dam should be based on a careful evaluation of a wide range of potential structural and non-structural alternatives, which will typically include dam rehabilitation or repair, dam replacement, dam removal, reservoir re-operation and maintaining statuesque. Once it is decided to decommission a dam, project cost, available technology, the impacts of decommissioning on hydrology, river morphology, social and economic conditions, environment etc are analysed in detail. Based on the analysis the best alternative for decommissioning is selected.

The primary factors in a decision to pursue a dam decommissioning project depend upon the type of dam and also include:

- Public Safety (implications of potential dam failure or recreational hazards)
- Public Benefits
- Economics, Project Funding
- Environmental Impacts

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- River Restoration
- Fish Passage and Aquatic Migration

Engineering for dam decommissioning projects, which includes planning, design, and implementation, is an evolving science. The overall site restoration goals and project objectives should be well established when designing a dam decommissioning project. Natural physical and biological processes of the river should be incorporated to the extent possible to facilitate final site restoration. The application of current technologies and engineering practices by competent and experienced design engineers increases the likelihood of site-appropriate designs, realistic cost estimates, reduced risk and uncertainty, and optimum results (Aspen, 2002).

Dam decommissioning projects typically include the following design stages or elements, some of which may occur concurrently depending upon the size and scope of the project. The design stages include the following sections feasibility Study, preliminary and final design.

Sediment management

Sediment management is often a critical issue related to dam decommissioning when the reservoir sediment volume is greater than the mean annual sediment load (Shuman, 2002). Sediment-related impacts following dam removal can occur in the reservoir and in the river channel upstream and downstream from the project site. Depending on the local conditions and the removal methods and rates, the degree of impact can range from negligible to significant. For example, removing a small diversion dam that had trapped only a small amount of sediment would not have much impact on the downstream river channel. Furthermore, if the upper portion of a dam is removed in such a way that very little of the existing reservoir sediment is released downstream, the impacts to the downstream river channel would be related only to the future passage of sediment from the upstream river channel through the remaining reservoir. If dam removal results in a large quantity of sediment being released downstream, then the impacts to both the upstream and downstream channels could be significant (Greimann, 2004).

Disposal of removed materials

Materials removed from a dam and its appurtenant structures may include concrete, reinforcing steel, mechanical and electrical equipment, instrumentation, miscellaneous metalwork, masonry, asphalt, earth materials, timber (treated or untreated), and various other building materials. The volume of material in an earth or rockfill dam is normally much greater than that required for a concrete dam of the same height, but excavation and disposal of the earth and rockfill materials

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is usually much easier. Suitable waste disposal sites should be identified in the specifications within a reasonable haul distance for all waste materials.

List of Decommissioned Dams

Sl. No.	Name of dam	Name of river	Year of removal	Objective
	Elwha and Glines Canyon Dams	Elwha River, Washington	2012-2014	Largest dam removal project in history Elwha ecosystem restoration
	Great Works Dam	Penobscot River, Maine	2012	Penobscot River Restoration Project
	Brown Bridge Dam	Boardman River, Michigan	2012	Boardman River Dams Ecosystem Restoration Project
	Veazie Dam	Penobscot River, Maine	2013	Penobscot River Restoration Project
	San Clemente Dam	Carmel River, California	2015	The dam was found to be unsafe and not serving the intended uses such as power generation and water supply
	Boardman Dam	Boardman River, Michigan	2017	Boardman River Dams Ecosystem Restoration Project and decommissioning of hydropower generation
	Sabin Dam	Boardman River, Michigan	2018	Boardman River Dams Ecosystem Restoration Project and decommissioning of hydropower generation

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INTENSE RAINFALL RELATED LANDSLIDE AND FLOODING IN KERALA IN OCTOBER 2021

From 2018 onwards state of Kerala is experiencing, heavy rainfall in the monsoon period. This year, at the onset of north east monsoon, there is intense rainfall in the state from October 15 onwards, due to the low pressure formations in the Bay of Bengal and Arabian sea regions. This torrential rainfall triggered landslides and flooding in the high altitude areas of Idukki and Kottayam districts leading to loss of life and extensive damages to infrastructure and properties.

High intensity rainfall in Kerala - October 2021

A low pressure system has been formed in the east-central Arabian sea on October 14 and moved to the Kerala coast leading to extreme rainfall conditions. Due to this low pressure system, heavy rainfall and extremely heavy rainfall was experienced in the various districts of the state especially in the southern districts. The high intensity rainfall of more than 5 cm received within two hours indicate the possibility of mini cloud bursts (Deshpande et al., 2018) which has eventually lead to casualties, damages and loss of properties in many regions of Kerala. Indian Meteorological Department (IMD) defines the cloud bursts as the intense rainfall not exceeding 10 cm within duration of 1 hour. The Idukki and Kottayam districts have badly affected by this intense rainfall due to cloud bursts which has resulted in severe loss of lives and properties. In order to analyse the aspect of mini cloud bursts, hourly rainfall data of Peerumed station (Idukki), Cheruthoni station (Idukki) and Poonjar station (Kottayam) were considered. The data has been obtained from the website of IMD. The hourly variations of rainfall of Peerumed station, Cheruthoni station and Poonjar station on 16-10-2021 are shown in Figs. 1-3 respectively.

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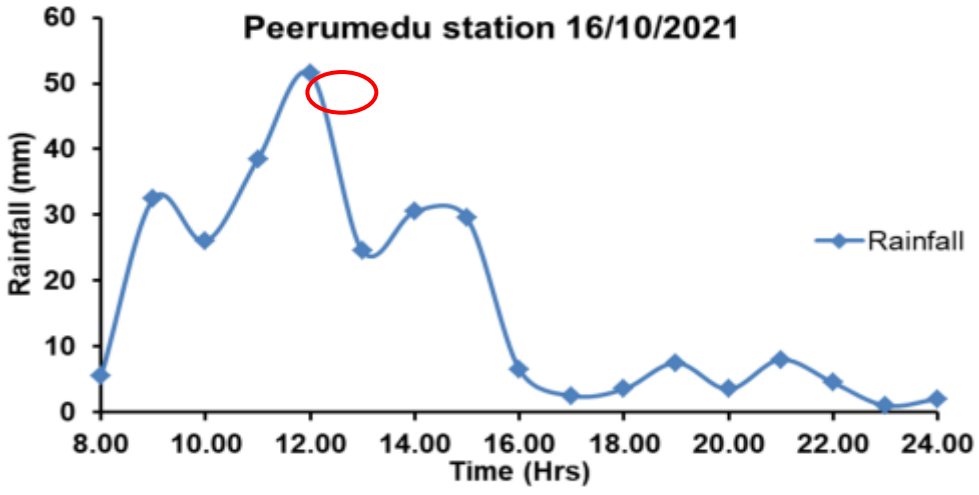


Fig. 1: Hourly rainfall variation of Peerumed station on 16-10-2021

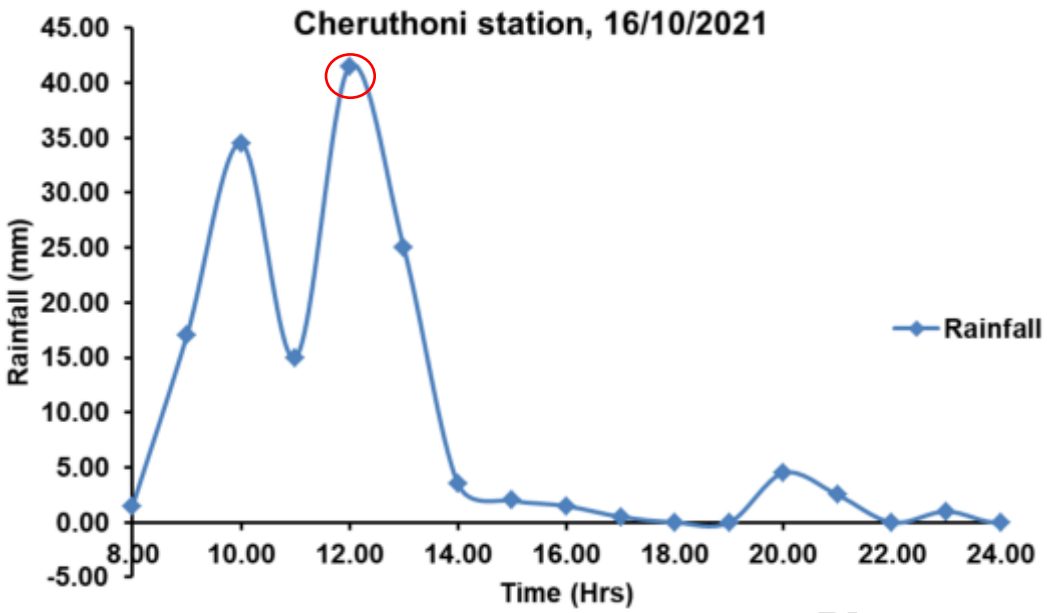


Fig. 2: Hourly rainfall variation of Cheruthoni station on 16-10-2021

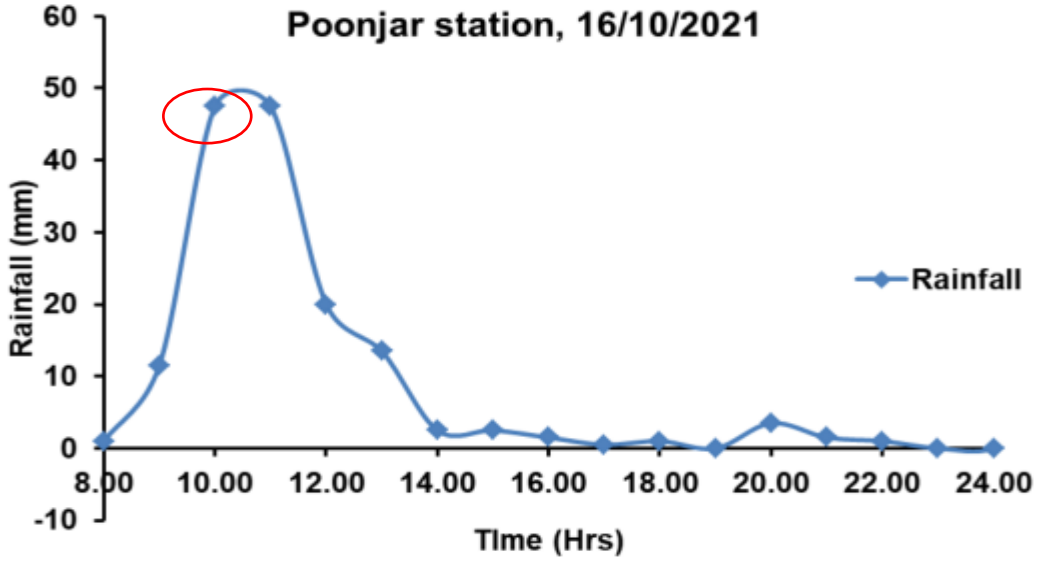


Fig. 3: Hourly rainfall variation of Poonjar station on 16-10-2021

In the Figs. 1-3, more than 5 cm of rainfall has been observed within two consecutive hours (between 9:30 AM to 11:30 AM) on all the three stations on 16/10/2021 indicating the occurrence of mini cloud bursts. Moreover, high magnitudes of rainfall can be seen from 9:30 AM to 1:30 PM on the same day. The continuous high intensity rainfall can increase flows in the river and inflows into the reservoir resulting in the flash flood conditions. In addition to this, hourly variation of rainfall in the Poonjar station on 21/20/2021 is shown in the Fig. 4.

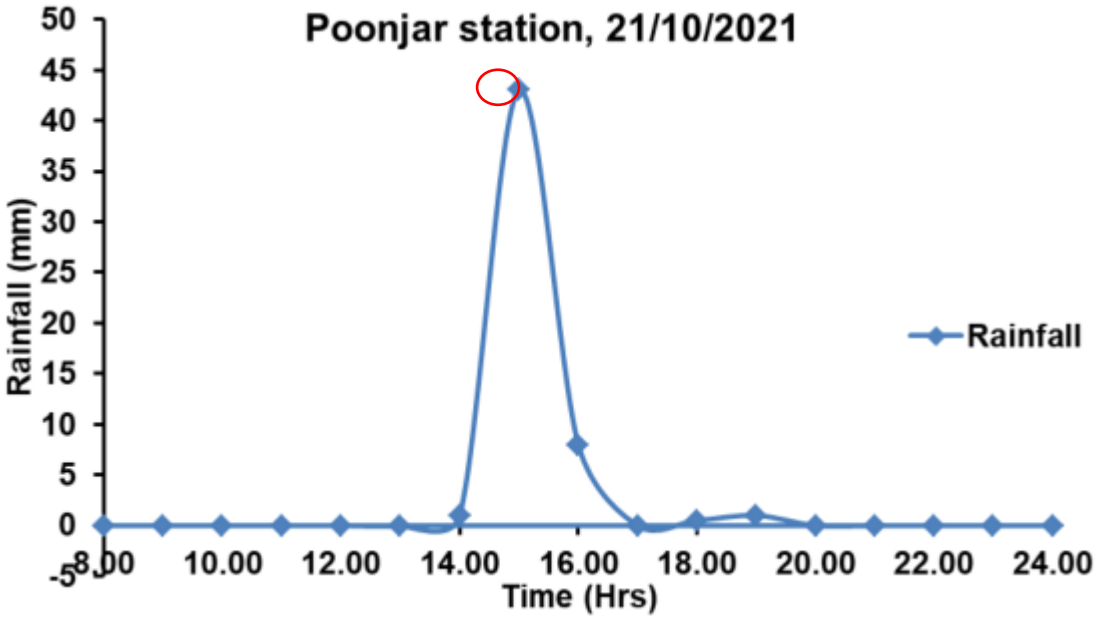


Fig. 4: Hourly rainfall variation of Poonjar station on 21-10-2021

It can be observed from the Fig. 4 that, localized high intensity rainfall occurs during a particular time period (2:30 PM to 3:30 PM) in a day. This high intensity rainfall causes sudden increase in the water levels in the rivers and reservoirs. The occurrence of localized high intensity rainfall also poses challenges in managing the water levels in rivers and reservoirs.

Disastrous impacts of Torrential rain fall

This intense spells of rainfall has resulted in 'flash floods' and landslides in many places in the state and often posed challenges in regulating water in the reservoirs and rivers. Idukki and Kottayam districts have witnessed worst effect of such flash floods and landslides. Roads and buildings were damaged and trees were uprooted during landslides in the mountainous regions. Also, the low lying areas of the city were flooded with water resulting in huge loss in the life and property of the society. Eleven people were died in Idukki district and another fourteen people in Kottayam district. Around 100 relief camps were started in those districts to accommodate thousands of people evacuated from the areas subjected to flooding. The Indian Air Force, National Disaster Relief Force and fisherman in the coastal regions of the state have provided superior efforts in rehabilitating the people trapped in the floods. Their rescue operations to find the missing people in heavy rain were remarkable in Koottikkal as well as Kokkayar localities in Kottayam and Idukki districts respectively. Other districts such as Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Ernakulam and Thrissur have also faced the scenario of flash floods and landslides. This rainfall event is entirely a localized phenomenon which is unusual in the weather pattern of Kerala.

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Rainfall as triggering mechanism of landslides

In our state, around 1500 km^2 in Western Ghats is identified as major land slide prone areas. Recent intense rainfall has acted as a triggering mechanism for landslides in the prone areas. During the monsoon period, the occurrence of landslides is reported every year. Also rapid urbanisation due to population growth and related unscientific construction activities in landslide prone areas can increase the possibility of landslides in Kerala.

Rain fall related flooding

This heavy rainfall for short duration generates huge run-off which is beyond the safe carrying capacity of the rivers and at the same time increases the inflow to the reservoirs. The sudden rise in the water levels of reservoirs has resulted in the necessity of lifting the shutters and thereby to spill the excess water to the river downstream of the dams. All the major dams were opened due to this intensified rainfall conditions. It is beneficial to construct guide banks and bunds (of required height) to the sides of rivers so as to guide the flow through the river, thereby avoiding the flooding conditions in the nearby low lying areas. This method is much useful for rivers passing through the metro cities of the state. Also, the encroachments in the river banks need to be strictly evicted to increase the carrying capacity of rivers during high flow seasons, thereby reducing the chances of flooding. Moreover, urban drainage systems need to be maintained and inspected in a regular fashion so as to properly collect and dispose the run-off into an appropriate place. Also, protective measures shall be provided in the locations prone to the landslides to avoid the slippage of earth. The landslides aggravate the flooding conditions since the trees and other materials carried by the flow will be deposited in rivers and reservoirs which in turn increase the water levels.

Landslide and Flood Mitigation during intense rainfall

As the heavy rainfall is major reason for the disastrous landslide and flooding in the state, it is required to prognosticate these extreme rainfall events in spatial and temporal domain with increased accuracy level.

The weather pattern of our state is witnessing a deviation from traditional weather pattern and frequency of abnormal climatic events such as torrential rainfall is on the high. These phenomena are multi-disciplinary in nature involving climatology, geology, seismology,

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hydrology etc. A well coordinated effort from various departments and agencies is required to develop a comprehensive and holistic mitigation strategy to increase the effectiveness in prevention, preparedness, risk reduction and emergency management of theses disasters. A multi faceted approach using latest technology such as landslide forecasting systems and flood zone mapping can be used to predict and manage these disasters effectively.

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STUDY OF ACTIVITIES OF VARIOUS ENGINEERING RESEARCH INSTITUTES IN INDIA

Activities undertaken by various engineering research institutes in India such as Karnataka Engineering Research Station (KERS), Gujarat Engineering Research Institute (GERI), National Environmental Engineering Research Institute (NEERI), Maharashtra Engineering Research Institute (MERI),Institute of Hydraulics and Hydrology(IHH), Structural Engineering Research Centre(SERC) are as follows:

KARNATAKA ENGINEERING RESEARCH STATION (KERS)

Karnataka Engineering Research Station (KERS) was established in the year 1944, as a small research unit which was functioning as a wing of the Karnataka State Water Resources Department. KERS has diversified its research fields in Irrigation Structures Hydraulics, Soil Mechanics & Foundation Engineering, Coastal Engineering and Technical Services. KERS is also imparting training for capacity building to in-service engineers and administrative staffs of State Water Resources Department, Karnataka Public Works, Ports & Inland Water Transport Department and other State departments. In addition to the research activities, KERS has also been offering the guidance to the students from different Engineering colleges along with lab facilities to enable them to complete their project works as part of their curriculum.The Research station has a well-equipped Laboratories supported with computer facility and library for conducting the research activities.

Organisational Setup

The Karnataka Engineering Research Station is headed by the Director of the rank of Chief Engineer who is assisted by 4 Chief Research Officers (Executive Engineers), 19 Research Officers (Assistant Executive Engineers) and 62 Assistant Research Officers (Assistant Engineers) and 19 Junior Research Officers (Junior Engineers) who are working under the different research divisions of KERS. Dam Safety Cell 1 and 2, which are headed by Assistant Executive Engineers for monitoring and evaluating the safety measures of existing dams as per the central water commission’s guidelines is also functioning under the Director’s office.

Research Fields

1. HYDRAULICS DIVISION

Hydraulic division is headed by the Chief Research Officer (Executive Engineer). This division was formed mainly to provide the solutions to the intricate problems related to Hydraulics Structures, specially the Energy Dissipating Arrangements of various Dams, Gate operation schedules, IBS Hydrography Survey of Reservoir, gauging of canals, carrying capacity of canals, calibrating the current meters and water quality analysis of surface water samples from the Rivers. This division also provides the solutions to the hydraulic problems arising at the time of dam operations, construction and improvements as and whenreferred by the Project Authorities.



Fig.1 Boat for Sedimentation Survey



Fig.2. Current meter gauging in canal



Fig.3 Current meter rating Facility

Various subdivisions under hydraulics Division are:

❖ **SILT AND SEDIMENTATION SURVEY SUB-DIVISION**

The Silt and Sedimentation Survey Sub-division is headed by Research Officer (Assistant executive Engineer). This sub division is equipped with the Navitronic NS 415 bathymetry survey grade Eco sounder, Leica MX 9250 DGPS reference Station, Leica MX 420 DGPS Mobile Station, sound velocity profiler SVP 15 along with the necessary accessories like FRP Boat with arrangements for the bathymetry survey, Navisoft Survey software, data loggers, display units for live display of conducting the Integrated Bathymetry Surveys (IBS) for reservoirs and rivers.

Main Objectives:

- To Assess the total capacity of reservoir at FRL.
- To assess the water spread areas at different water storage levels using software provided with IBS at the level at which the survey was conducted.
- Supplement the water spread areas for the uncovered levels using the appropriate technique.
- Compare the results of the Present study with that of the Pre- impoundment survey.
- Evaluate the present water storage capacity of reservoir at different water levels and estimate the difference in storage capacities with comparison to the pre-impoundment surveys

The Water Quality Lab level-II:

Along with conducting the IBS survey for reservoirs and rivers, this subdivision has a well-equipped water quality lab level II, which established in the year-2002 under National Hydrology Project. The laboratory has entrusted with the analysis and testing of the surface water samples received from 7 different irrigation projects from North Karnataka i.e downstream side of Tungabhadra River, Ghtaprabha River, MalaprabhaRiver,Manjra River Bhima River, Krishna River and Done River.Water samples from these reservoirs wereanalysed at laboratoryfor 28different parameters related to the water quality including Physical, Chemical and bacteriological parameters.

❖ **LAND & WATER MANAGEMENT STUDIES BRANCH**

The Basic Research Branch is one of the five branches functioning under Hydraulics Division of Karnataka Engineering Research Station which was established in the year 1972.

This branch is responsible for:

- Conducting the canal water gauging operations at main canals and distributaries of the major and medium irrigation projects of Karnataka.
- In house calibration (rating) of the current meters, which will be used for the canal gauging. The calibration of current meters will be made for current meters arriving from all over the India.
- Conducting the studies related to the seepages of canals upon the request from the project authorities.
- Conducting the studies related to the canal lining i.e., carrying capacity, efficiency etc.,
- Canal gauging will also be conducted for hydraulic Discharge to the hydroelectric power generation projects for both government and private projects.

❖ **HYDRAULICS BRANCH-I &II**

Hydraulics Branch I, is one is the five branches functioning under the hydraulics division of Karnataka Engineering Research Station. This branch was established in the year 1972.The main objective of this branch is to carry out the studies related to the spillways, outlets, energy dissipaters, tunnels, chutes etc. for economic, reliable and optimal design of various elements by conducting the physical model studies.

Also this branch takes up the studies related to the adequacy of spillways for discharging capacity through the crest gates, performance of Stilling basin, and calibration of gates to arrive the actual discharge at different storage level of reservoirs by in house construction of 2D and 3D physical models to the suitable scale.

Capabilities & Major Functions:

- The hydraulics branch I, can take up the studies for the design of hydraulic structures related to dam and allied Structures like Spillways, Energy Dissipaters, Canal Regulators etc. with the aid of 2D & 3D Model Studies.
- This branch also provides the interim designs by taking up the desk studies for projects through experience and backup knowledge.
- The Study and analysis related on the Suggestions of Dam Safety review panel on the existing projects will also be taken up by this branch.

❖ **MODEL AND PROTOTYPE CONFORMITY STUDIES BRANCH**

Model and Prototype Conformity Studies Branch is one of the five branches functioning under Hydraulics Division of Karnataka Engineering Research Station which was established in the year 1972.The main objective of this branch is to verify the model study reports and inspect the prototypes at the field for the verifying and confirming the hydraulic parameters checked at the models and parameters that incorporated in the prototypes are in concurrence.

Main functions of this branch are:

- Compare the Model Study results with prototypes for performance and to verify the degree of comparability with the model study for hydraulics parameters of major and medium reservoirs in Karnataka.
- Conducting studies for present carrying capacity of Canals after implementing the Modernization works to the existing old canals, upon the request from the project authorities of the major and medium irrigation projects of Karnataka.

2. TECHNICAL SERVICES DIVISION

Various activities under this division are:

❖ Analysing the quality of Construction materials.

❖ Providing mix Proportions for various grades of Cement Concrete.

❖ Evaluation of compressive strength and quality of hardened concrete at site using non-destructive technique.

❖ Analysis of surface water samples from the rivers of southern Karnataka for the 27 parameters in the Level-2 Water Quality Laboratory at Krishnarajasagara established under National Hydrology Project.

❖ Analysing the effect of fertilizers on quality of ground water in irrigated lands of Pandavapura and Srirangapatna taluk.

❖ Regional flood frequency studies in Southern Karnataka.

Various branches under this division are:

❖ **CONCRETE AND POZZOLANA BRANCH**

The Concrete and Pozzolana Branch (C & P) headed by Research Officer (AEE), was established in the year 1982 to carry out the studies related to concrete and pozzolana. This branch works under Technical Services Division headed by the Chief Research Officer. At

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Present, National Water Quality Laboratory Level II and Meteorological section of krishnarajasagara is running under this branch.

Water Quality Laboratory Level-II

The Water Quality Laboratory was upgraded under National Hydrology Project with the help of World Bank Assistance, Under Hydrology Project. The Water Quality lab is well equipped with pH meters , Electrical Conductivity meter, Titration equipments , Incubators, COD digester , Flame Emission Photometer, UV Spectrophotometer, Nepheloturbidity meter, Laminar air flow equipment, Hot air Oven, Autoclave, Electronic balance.

The water samples from ten different locations of rivers from South Karnataka are tested bi-monthly for 27 water quality parameters. The data and result of the water quality test will be sent periodically to Chief Engineer, Water Resources Development Organization, Bangalore.The water & silt samples received from different reservoirs in Karnataka and private agencies will be analyzed for its suitability purposes like drinking, irrigation, concreting.

❖ **STRENGTHENING OF SURFACE WATER BASE ORGANISATION SUB DIVISION**

The Strengthening of Surface Water Base Organisation or SSWBO Sub Division is one of the sub-division under Technical Services Division of Karnataka Engineering Research Station which was formed in 1982 and providing services in the field of surface water hydrology. The Sub division is headed by a Research Officer of rank of Assistant Executive Engineer who in turn is supported by both technical and administrative staff.

The sub division was formed mainly to do the research work related to surface water hydrology. Software such as ERDAS Imagine, Arc-GIS, Q-GIS, ILWIS, HEC-HMS, HEC-RAS, Arc-SWAT are used for the research activities of the sub division. The technical staffs in the sub division are well trained with these softwares.

The sub division is taking up studies pertaining to;

- Hydrologic review of large dams and reservoir routing.
- Development of lumped and distributed catchment models for estimation of inflow flood hydrographs at a given outlet point on the stream.
- Rainfall analysis and preparation of isopluvial maps for different return periods.

- Flood frequency analysis and regionalisation of river basins to develop regional flood equations.
- Dam break analysis to estimate dam break floods.
- Preparation of inundation maps for various scenarios of dam break.
- Capacity evaluation of reservoirs using remote sensing and GIS technique.
- Other research activities pertaining to surface water hydrology.

3. SOIL MECHANICS AND FOUNDATION ENGINEERING DIVISION

Various activities under this division are:

- Analysis of Safe Bearing Capacity of soil for foundations of various structures.
- Analysis of California Bearing Ratio (CBR) for roads.
- Analysis of soil samples for various embankment works.
- Studies of ornamental stones
- Feasibility studies on the materials used in road works namely, coarse aggregate, Bitumen and etc.,
- Studies regarding construction of low-cost roads.
- Construction of experimental roads.

Various branches under this division are:

❖ SM& FE BRANCH 1 & 2

Soil mechanics branch 1 &2 were formed under the Soil Mechanics and Foundation Engineering Division in the year 1972. Subdivision mainly conducts studies related to evaluation of the engineering properties of soil which are very essential for the safe and economical designs for construction of engineering structures. Apart from determining engineering properties of soil, they take up the basic and applied studies related to the soil for behavioural strength and classification aspects.

Various activities under this branch are:

❖ Conduct the field quality control checks like degree of compaction of soil for embankment purposes used in construction of roads, highways, earth fills for dams etc.

❖ Determination of safe bearing capacity of soils for foundations of buildings, bridges, irrigation projects and other costly structures

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❖ Conducting studies related to the seepage and permeability analysis for minor and medium irrigation tanks as and when requested by the project authorities.

Soil mechanics branch 1 and 2 has a well-equipped soil testing lab, which is capable of conducting the tests related to the engineering and index properties of soil including tri-axial shear load tests, direct shear, and automatic compactors for heavy and light compaction of soils.They have conducted an extensive research studies on swelling characteristics, strength parameters and consolidation parameters of black cotton soil by using chemical additives as referred by CBIP (Central Board of Irrigation & Power)

❖ ROAD RESEARCH BRANCH

The Road Research Branch (RRB) was established in the year 1959 and is functioning under Soil Mechanics & Foundation Engineering Division headed by the Chief Research Officer. The main objective of this branch is to conduct applied and basic studies to ascertain quality of materials and to improve the characteristics of various parameters by conducting the necessary tests on sub grade, Sub base, base course and surface course of Road pavements. This Brach has a well-equipped laboratory which houses Thermostatically Controlled Drying Ovens, Mechanical Sieve Shaker, CBR apparatus, Compaction Test Apparatus, Impact Testing Machine, Crushing Value apparatus, Specific Gravity apparatus for soil and Aggregates testing, Viscometer, Penetration apparatus, Ring and Ball apparatus, Flash and Fire apparatus, Ductility testing Machine for conducting tests on bitumen, Marshall Stability Test apparatus, Centrifugal Extractor, Temperature measuring Gun for testing of the bitumen mixes etc.

They are doing testing of stability of materials in the construction of roads, i.e., Soil, Aggregates, Bitumen, Emulsion etc, and investigation of Roads for new construction, improvement or up-gradation of existing roads. They are conducting various tests on materialslike Mechanical Analysis, Atterberg Limits, Specific Gravity, Compaction (Light and Heavy), In situ Density and In situ Moisture Content, CBR Test on Soils, Gradation Test on Aggregates, Penetration Test, Specific Gravity Test, Ductility Test, Flash and Fire Point Test, Softening Point Test, Bitumen Content Test, Viscosity Test on bitumen and Surface Deflection of Pavement by Benkelman Beam Test etc. This branch also provides Bitumen Mix Design for SDBC pavements.

This branch has also conducted the following studies:

- Research activities like laying experimental stretches in water logged areas, Usage of Geo textile materials & performance of anti-stripping agents etc.

- study of traffic density of roads
- The Branch in association with CRRI New Delhi was involved in conducting pavement performance study of experimental reaches of NH-14.
- Comparative study of soil parameters for its influence on the CBR values and studies on Change in characteristics of fine / course grain soils by adding stone dust (Quarry Dust).
- Basic Study on Stabilization of BC soil by adding lime & Rock Dust has been done & Report Submitted to IRC New Delhi
- Improvements of C.B.R value of B.C soil by adding RBI Grade -81 compound as an Admixture & Report Submitted to IRC New Delhi

❖ ROCK MECHANICS BRANCH

The Rock Mechanics Branch is one among the four branches functioning under Soil Mechanics & Foundation Engineering Division. This branch was established in the year 1972. The principle objective of this branch is to study and assess structure &behaviour of rock masses, for evaluating the structural properties of rocks, which are necessary for design of important engineering structures like Dams, Anicuts, Bridges& Power Houses etc. The rock mechanics branch has a well-equipped laboratory for conducting various tests on collected rock samples for True Specific gravity, Apparent Specific gravity, Porosity, Water absorption, Compressive Strength, Transverse Strength, Durability, Weathering, Punching Shear, SBC tests for Hardened Soft rocks.

This branch has catered the needs of the project authorities in conducting studies for evaluation of structural properties of rock samples coming under different major Irrigation projects, like Hemavathy, Karanja, Bennithora, Kabini etc. The studies related to the physical and structural characteristics of Building stones available in Karnataka was started in 1982. The physical & structural characteristics studies for 334 different samples collected from different parts of the Karnataka state were completed, codified & published by Bureau of Indian Standards. They also conduct field investigation for rock masses for Deformability, Bearing Capacity, Shear Parameters, Passive Resistance, Residual stress, Anchor strength, Efficacy of Foundation Treatment and Plate load test on rocks at site.

Completed Research Studies includes:

- Correlation of static &dynamic methods of testing of rocks.
- Rock classification by Hardness test.
- Correlation of compressive strength of rocks with Longitudinal wave velocity

- Effects of High pressure on Mechanical Properties of rock.
- Correlation of compressive strength with Point load.
- Studyon physical and structural characteristics of Building stones available in Karnataka, pertaining to the present 30 Districts

4. COASTAL ENGINEERING DIVISION

The Coastal Engineering Division was formed in the year 1978, which is headed by Chief Research Officer.

Karnataka has a west coast line of about 300Km which stretches from Karwar to Mangalore, broken up with a number of estuaries formed due to draining of large number of rivers joining the Arabian Sea. These rivers carry heavy floods during the monsoon. A number of minor ports mostly for fishing activities have been developed along the coast, at the river mouths. The beaches being narrow in most parts are not very effective in protecting the adjoining fertile garden lands and properties.

Roles and Objectives of Division:

- Identification of the problematic Areas, pertaining to the erosion at open beaches, River Mouths etc.,
- Coastal Engineering Division office acts as a link between the director's office and sub-divisions in terms of collection, assessing and compilation of the coastline data and providing solutions to the erosion prone regions
- Collection of the Erosion Site Details and intensity of the erosion.
- To carry out works entrusted by technical experts committee on flood control and ASE works constituted by Government of Karnataka as a member of the committee.
- Conducting the monthly review meeting of subdivisions for the progress achieved.
- Periodical visiting of the on-going and completed permanent sea wall sties for the evaluation of the performance of the sea walls for Tidal Actions.
- Identified the chainages of the coast line villages, by procuring the maps from district NRDMS
- Calling of Tenders pertaining to the Beach Profile surveys and Offset Surveys.

Strengths

- Coastal Engineering Division has capable of carrying out the research activities and data collection pertaining to the coastal region of Karnataka.

- Can take up the Pre and Post Dredging survey operations at the ports
- Beach Profile Survey data comparison for the assessing the beach contour movement, sand volume estimates and average beach profile line establishment.

❖ COASTAL ENGINEERING SUB DIVISION, BHATKALA

Coastal Engineering Sub-Division, Bhatkala is one of the sub divisions functioning under Coastal Engineering Division. This office is headed by Research Officer, and based in the Bhatkala Town of Uttara Kannada District. The sub division has a jurisdiction of about 160km of west coast line Uttara Kannada District of Karnataka.

Main Regulatory functions are:

- Monthly Monitoring of the sea protection works at Uttara Kannada districts which are under progress.
- Monthly collection of the beach data for the sea erosion affected sites.
- Collection of the Pre and Post Monsoon monitoring data for completed sea protection works at Uttara Kannada District to know the general behaviour and to evaluate their performance for the tidal actions.
- Collection of the beach offset data, for the purpose of the establishing the beach line movement.
- Conducting the Beach profiles Survey with the agency at the pre identified critical erosion prone sites at post monsoon period.
- Co-ordinating with the Port Authorities for acquiring the data for getting up of the master plan for the six minor port development of Karnataka.
- Coordinating with the divisional office for the site visits of the on-going and completed sea walls.
- Carrying out the detailed independent research studies independently or as referred by the project authorities.

❖ COASTAL ENGINEERING SUB DIVISION, MANGALORE

Coastal Engineering Sub-Division, Mangalore is one of the sub divisions functioning under Coastal Engineering Division. This office is headed by Research Officer, and based in the Mangalore City. The sub division has a jurisdiction of about 140 kms of west coast line of Karnataka which is spread across two revenue districts ie., 40 Kms in Dakshina Kannada & 100Kms in Udupi District.

Main Regulatory functions are:

- Monthly Monitoring of the sea protection works at Dakshina Kannada & Udupi districts which are under progress.
- Monthly collection of the beach data for the sea erosion affected sites.
- Collection of the of Pre and Post Monsoon monitoring data for completed sea protection works at Dakshina Kannada & Udupi Districts to know there general behaviour and to evaluate their performance for the tidal actions.
- Collection of the beach offset data, for the purpose of establishing the beach line movement.
- Conducting the Beach profiles Survey with the agency at the pre identified critical erosion prone sites at post monsoon period.
- Co-ordinating with the Port Authorities for acquiring the data for getting up of the master plan for the six minor port development of Karnataka.
- Coordinating with the divisional office for the site visits of the on-going and completed sea walls.
- Carrying out the detailed independent research studies independently or as referred by the project authorities.

❖ COASTAL ENGINEERING SUB DIVISION, KRISHNARAJASAGARA

Coastal Engineering Sub Division, Krishnarajasagara is one of the sub divisions functioning under the Coastal Engineering Division, which is headed by Research officer, this Sub-Division is based at krishnarajasagara. The main objective of this branch is to provide site specific designs along with the model study for the permanent sea wall, which will be constructed by the port and fisheries department authorities of Karnataka.



Fig.4 Model studies related to sea wall construction

Strengths:

- Coastal Engineering Division has capable of carrying out the research activities and data collection pertaining to the coastal region of Karnataka.
- Can take up the Pre and Post Dredging survey operations at the ports including calculation the dredging volume preparation of 3D- Bathymetric maps.
- Beach Profile Survey data comparison for the assessing the beach contour movement, sand volume estimates and average beach profile line establishment.

5. STATE LEVEL DAM SAFETY COMMITTEE

❖ DAM SAFTEY CELL 1:

The Dam Safety Cell-1,attached to the Director, Karnataka Engineering Research Station, comprising of One Assistant Executive Engineer, including 4 Assistant Engineer's and 1 Record Keeper has been created by the Government is assisting the Member Secretary, State Level Dam Safety Committee (SLDSC) in Karnataka, is carrying out the following functions since 01-12-1987.

- Communicating the deficiencies observed in the Health Status reports of Large dams to the Chief Engineers, concerned.
- Preparation of Health Status Report of Large Dams in Karnataka to place the same before the State Level Dam Safety Committee in Karnataka.
- Finalization of the draft compliance for the minutes of the National Committee on Dam Safety.

Pursuing the Chief Engineers in-charge of Large dams to send the following.

- Pre/Post monsoon Inspections reports of Large dams
- Compliance to the minutes of the NCDS.
- Other details keeping in view the proceedings of NCDS / SLDSC and the "Terms of reference of SLDSC".

❖ **DAM SAFTEY CELL 2:**

The Dam Safety Cell-2, attached to the Director, Karnataka Engineering Research Station, comprising of One Assistant Executive Engineer, including 3 Assistant Engineer's, 3 Junior Engineer's and supporting administration staff has been created by the Governmentis assisting the Member Secretary, State Level Dam Safety Committee (SLDSC) in Karnataka, is carrying out the following functions since 01-06-2009.,

- To prepare the Agenda Notes for the meetings of the State Level Dam Safety Committee (SLDSC) before the meeting and to prepare the Draft Proceedings after the meeting and to submit the same to the Government for confirmation
- Communicating the copies of the approved proceedings to all the concerned and to pursue them for communicating compliance.

- To pursue with all the concerned to communicate the "Technical Preparedness" of the zone / organization (as appropriate) for the Dam Safety Bill and to place the same for discussions before the special meeting of State Level Dam Safety Committee (SLDSC) to finalise the Technical Preparedness of the whole State for the "Dam Safety Bill".

6. ENGINEERING STAFF COLLEGE

The Engineering Staff College was established in the year 1971 as a commemoration of the Silver Jubilee of the Karnataka Engineering Research Station with the aim of imparting training to the in-service Engineers as well as newly appointed Assistant Engineers and Junior Engineers of Public Works and Water Resources Departments in updating their knowledge to tackle the problems encountered in their respective fields. The Engineering Staff College is working under the administrative control of Director, KERS.

The college is headed by Principal & Joint Director, of the rank of Superintending Engineer, who also functions as Joint Director of KERS. The Principal is supported by Professors (Executive Engineers) and Assistant Professors (Assistant Executive Engineers) and Lecturers (Assistant Engineers) and Junior Engineers.

A separate building for Engineering Staff College has been constructed by utilizing the grants allotted to KERS under the strengthening of Research Station.

The Engineering Staff Training College conducts following types of training programmes.

A) Institutional Training Programmes:

- Orientation courses of duration six weeks for newly appointed Asst. Executive Engineers and four weeks for the newly recruited Asst. Engineers and Junior Engineers of the Department.
- Refresher courses of 5-6 days duration for in-service Engineers in various Engineering subjects like, Quality Control & Instrumentation, Design construction &maintenance of roads, Canals, operation & maintenance of Reservoirs, Earthquake resistance structures maintenance of vehicles.
- Basic Computer course (training duration 12 days) etc., Training on administrative subjects will also be conducted by the college.

B) Continuing Education Programme Training:

Short term courses of 5 days duration under Continuing Education Programme (C.E.P) at selected 8 Engineering Colleges of State (i.e., Mysore, Hassan, Surathkal, Dharwad, Davangere, Belgaum, Bagalkot and Shimoga) with aim of imparting training in Engineering subjects to the technical personnel of Public works & Water Resources Department who work in and around these centers.

Engineering Staff College is equipped with 2 classrooms, One Computer laboratory and other training equipment's such as slide projector, overhead projector, LCD projector, Gauging equipment's for demonstrations etc., The ESC is conducting nearly 30 Institutional courses and 24 CEP courses per year. In addition to this, special courses are also being conducted on request of various State & Central Government agencies. The EngineeringStaffCollege is also equipped with a Hostel with Boarding & Lodging facilities to cater to about 100 trainees at a time.

GUJARAT ENGINEERING RESEARCH INSTITUTE (GERI)

Gujarat Engineering Research Institute (GERI) is one of the leading state research institutes in the country. The institute aims at providing research and development inputs to the activities of Gujarat State in the fields of Water Resources and Roads and Buildings. The activities of the institute are centredon investigation and testing of Construction Materials, Research and Development, consultancy and training in various areas of Material Testing, Soil Mechanics,

Geo-mechanics, Engineering Geology, Hydraulic Model Study, Sedimentation Survey and Road research Study.

Organisational Setup:

GERI is working under the Narmada Water Resources & Water Supply Department of Government of Gujarat. The institute is headed by 'Chief Engineer & Director' an officer of the rank of the State Chief Engineer. Two joint Directors of the rank of State Superintending Engineer and one Superintending Engineer assist the Chief Engineer & Director. The Research works in various divisions/units are organized by Research Officers of the rank of Executive Engineers with the supporting engineering & scientific staff.

SERVICES OFFERED BY GERI

1.0 SOIL MECHANICS AND FOUNDATION ENGINEERING

Soil Mechanics Division is fully equipped for doing all the tests on foundation soil in laboratory as well as in field. In-situ tests like Dynamic Cone Penetration test, Static Cone Penetration test, Standard Penetration test, Plate Load test and Pile Load test can be conducted in the field. Facilities for collecting undisturbed samples are also available. The Soil Mechanics laboratory is fully equipped to conducts all laboratory tests on samplesreceived from borrow areas as well as from foundation of structures.

1.1 GEOTEXTILE AND REINFORCED SOIL

Geotextile is a permeable textile natural or synthetic material used in foundation of soil, rock, earth or any other geotechnical engineering. It is specially designed to be used as constructional material in conjunction with other geotechnical materials like soil & rock.Geosynthetic / Geotextile can be used for separation, filtration, drainage, reinforcement etc. for Civil Engineering purposes.Testing of Geotextile is necessary for deciding its suitability for specific purpose & for quality control.

The institute has recently installed UTM-100KN specially for Geotextile Laboratory. It has the capacity to test the following properties of Geotextile as per ASTM.

(1) Mass per unit area.
(2) Thickness
(3) Wide width tensile strength.
(4) Puncture Resistance (Index/CBR)
(5) Trapezoid Tear Strength
(6) Grab Strength

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Important Application Made

- Dharoi dam
- Medha creek

Reinforced Soil

Reinforced soil is a composite construction technique in which the strength of soil is enhanced by addition of tensile reinforcement in the form of strips, anchors and geosynthetics which involves generation of frictional force between the soil and the reinforcement. Reinforced soil possesses many noble characteristics which render it eminently suitable for construction of engineering structures.Institute has made an excellent application of reinforced soil technique in construction of a water tank. Other applications of reinforced soil technique are retaining wall, bridge abutment, road embankments etc.

Important Applications Made

- Slope protection at Gandhar
- Command area roads
- Runway of Ahmedabad air port

Important Studies Conducted

- Creep study
- Anchor pull out study
- Improvement in bearing capacity
- Earth pressure on retaining wall
- Construction of water tank
- Model / Proto scale study on
- R. E. Retaining wall

2.0 HYDROLOGY PROJECT

Hydrology Project envisages the surface water resources assessment and monitoring in term ofquantity and quality. Main objective of Hydrology Project is to develop Hydrological Information System (HIS) by creating facilities and standardized procedures for Data collection, Data compilation, Data processing and Data storage for data use in further development and future scope.The quantity assessment and monitoring, network establishment and sampling for

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water quality are covered, under the activities of WRIC (Water Resources Investigation Circle) of Government of Gujarat. The surface water samples collected from network stations are sent to GERI for testing and the test results after primary validation are sent to SWDC for storage and dissemination. For the above study three laboratories are established at Gandhinagar (level -II) Vadodara (level -II) and Rajkot (level –II).

Hydrology Project phase-I (HP-I) was implemented during the period 1995 to 2003. Wherein, Government of Gujarat has established a regular monitoring of 154 sites encompassing the entire state and all the major river basin and reservoirs of the State.

As an extension to the HP-I,HP-II was conceived to include more agencies in the Project to establish facilities for hydrology information system(HIS) and to further strengthen the HP activities by addition of 23 Nos. locations were selected in 2006, and continue the study along with 154 locations of HP-I.
Following three PDS (Purpose Driven Studies) were carried out under HP-II

- To study the trend in water quality locations identified as Hot spots.
- Study of water quality fluctuations in river Viswamitri
- Study of water quality fluctuation in river Sabarmati.

Hydrology Project-II is completed with all achievement of objectives on June 2014.

3.0 ROCK MECHANICS

Rock Mechanics Laboratory is equipped for evaluating following properties of rock samples.

Physical Properties

- Water Absorption
- Density & Porosity
- True Specific Gravity
- Slake Durability Index

Engineering Properties

- Point load strength index
- Brazilian tensile strength
- Unconfined compressive strength
- Triaxial shear strength

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In addition to laboratory testing in-situ tests for evaluating following rock mass properties are conducted.

- Deformability
- Joint shear strength
- Pull-out resistance of anchors
- Foundation Pull-out Tests

Important Investigation Undertaken

- Foundation Pull-out test at 400 kV Transmission Line Towers Solapur - Sangli (Maharashtra).
- Plate load test at Panchana Irrigation Scheme, Karauli (Rajasthan)
- Bearing capacity test at Ranganadi Hydro-electric Project, Yazadi, (Arunachal Pradesh)
- Anchor pull out test at Indira Sagar Project, (Madhya Pradesh)

Important Research Studies Undertaken

- Effect of asperity on shear strength of jointed rock
- Evaluation of static and dynamic elastic properties of rocks met with in Gujarat.
- Geo- mechanical model studies to understand behaviour of jointed rocks.
- Evaluating pullout capacities of the anchors installed in the stilling basin bay - 3 of SSPGujarat.
- Effect of water on unconfined compressive strength of limestone.

4.0 CONSTRUCTION MATERIALS TESTING

Conventional Materials

Facilities of testing conventional construction materials such as Cement, Lime, Fly Ash, Aggregate, Water, Stone, Tiles, Bricks, Steel and C.C. cubes are available. In addition to this, facility for concrete mix design is available.

New Materials

Facilities of testing new materials such as Curing compound, Hollow bricks, LDPE film, Epoxy mortar and Timberare also available.

Following methods are followed for assessing quality of concrete

- Ultrasonic pulse velocity - Non destructive test
- Hammer test - Non destructive test
- Core testing - Destructive test

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Concrete Mix Design

Facilities are available for proportioning concrete mixes as per the provisions &guidelines of IS viz., 456:2000(Reaffirmed 2005), 10262:2009 (First revision) etc. and IRC guideline section 1700 structural concrete for bridges using the basic materials used for manufacture of concrete inclusive of other supplementary material. The proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete & durability requirements.

4.1 Non Destructive Testing Of Concrete

Facilities for conducting Non destructive test of concrete (NDT) is available for:

1) Estimating compressive strength of concrete
2) Estimating uniformity and homogeneity of concrete
3) Detection of presence or absence of cracks, voids, discontinuities
4) Quality of concrete

Instruments available at GERI are:

1) Ultrasonic Pulse Velocity Apparatus (UPVA)
2) Rebound Hammer
3) Profo Scope

4.2 Destructive testing of Concrete

Core Test :

Core test is carried out as per IS 456:2000, IS 516:2008 & 1199-2008. The parts from which cores are to be taken and the number required shall be as per direction of the Engineer in charge and shall be representative of the whole of concrete concerned. In no case, however shall fewer than three cores be tested. Cores shall be prepared and tested as per IS 516:2008.
Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength of the

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grade of concrete specified for the corresponding age & no individual core has strength less than 75 percent.

4.3 Fiber Reinforced Concrete

Facility is available for concrete mix design with fibers as reinforcing materials. The bondingbetween the fibers and the concrete has to be good to withstand the changing environment.

5.0 PETROGRAPHIC ANALYSIS

Engineering Geology Division deals with petrographic examination of rocks and natural aggregates.

5.1 Petrographic Examination:

- Megascopic and Microscopic examination of rocks, mineral constituents and their characteristics study is carried out
- Petrographic analysis of coarse, crushed and fine aggregates to identify the chemically deleterious and physically poor constituents which affect the quality of concrete andmortar
- I.S. No 2386-1963 (part -VIII) and I.S. No 383-1970 are used for carry out above test
- Petrological polarizing microscope and stereo microscope are the main equipments used fortesting
- Petrological Trinoculor polarizing microscope with micro photographic equipment and connectivity to monitor via CCD camera along with CCTV and image grabbing card including computer is used for microscopic examination of rock.

Important Studies in Petrological Laboratory:

- Identification of rocks and minerals
- Quality of aggregate from all major & minor rivers of Gujarat

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5.2 Seismological Investigation

Seismological investigations are carried out by establishing seismological observatorieslocated at and around major Irrigation Projects in the state. Some works carried out are:

1) World Bank assisted DST, New Delhi's project for seismological studies in Peninsular shield region.

Under this project out of 10 seismological observatories in peninsular shield region of India, one observatory is established at Dharoi Irrigation Project in north Gujarat. The earthquakes are being recorded at Dharoi Broad Band seismological observatory and the same is beingtransmitted to National Geophysical Research Institute, Hyderabad through VSAT communication system.The data is further processed and analysed at GERI, Vadodara

2) Establishment and monitoring a network of Seismological Observatories around proposed

Kalpasar project

The project will be comprising of establishment of 8 Seismological observatories (each comprising of Broad Band Seismographs and Strong Motion Accelerographs), monitoring and study the seismicity around the Kalpasar project for 5 years. All the 8 observatories are planned to be connected with VSAT communication system for online data transmission to Central Data Centre at GERI, Vadodara. The seismic noise survey for finalization of quiet site for observatory buildings at various propose sites has been carried out in association with Indian Institute ofTechnology, Roorkee.

5.3 Engineering Geological Investigation

The unit mainly deals with Geological investigation as well as the geological execution work of various water resources schemes of Vadodara, Panchmahals and Dahod districts.The geological investigation works include the preparation of reports, geological drawings and geological log sheets of various schemes.

6.0 SEDIMENTATION OF RESERVOIR

Release of bed load and deposition of suspended materials carried by inflow in the reservoir comprise the sedimentation process. Sedimentation is a phenomenon due to which capacity of

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reservoir reduces with lapse of time. This Phenomenon of sedimentation mainly depends upon area, topography, rainfall, agriculture pattern and forest in catchments area. The sediment deposition has adverse effect such as reduction in storage capacity, increase in back water level andformation of shoals. For effective planning and use of stored water optimally it is necessary to find the actual rate of sedimentation and revised capacity of reservoirs. Therefore hydrographic survey (sedimentation survey) is to be carried out periodically for every reservoir.

Following techniques are used to determine the storage capacity of reservoirs.

(A) Conventional Method:
(B) Integrated Bathymetric System (IBS)
(C) Remote Sensing Technique

7.0 HYDRAULIC MODEL STUDIES

The physical model studies on scale models are been carried out at Gotri campus in Narmada Hydraulic Division GERI,Gotri Vadodara.Gotri Campus of GERI is having extensive infrastructure facilities of Hydraulic Research Studies on Physical models. The campus area about 140 acres is being utilized for constructing, running and operating the required size of scale models. About 100 physical models of various projects are existing in the campus. The infrastructural facilities were established 35 to 40 years back includes feeder canal, return canal,HR gates, OTs, Tube wells, various flumes, channels, standing wave flumes and model trays since these are being constantly in use. This is the only campus in Gujarat state where such type of site specific hydraulic research studies are been carried out on physical models. Some outstanding and remarkable studies were carried out at the campus in the past and accordingly GERI is known as one of the best hydraulic research station in India. Some important hydraulic model studies conducted by this division are:

- Bhadbhut Barrage on Narmada River, sectional (2D) model studies for capacity, scour andgate operations.

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- Bhadbhut Barrage on Narmada River, composite (3D) model studies for flow pattern,inundation and banks spell over on bank area without Barrage, Orientation of Barrage and guide bunds, Assessing effective flood protections embankment on both the banks with Barrage structure and performance of Barrage with different gate opening. This model covers 67 km River stretch from Sukaltirth to sea and 6 km sea portion for simulation of tide





- Tapi River model (3D)

This is the largest physical model from Ukai dam to sea for 140 km length of tail reach of TapiRiver for studying the effective flood protection works on the banks to protect Surat city from flood of any magnitude



- Balloon Barrage on Tapi River (3D) model

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This is the first Balloon Barrage in India of 500 m length across River Tapi to create additional storage reservoir of sweet water near the sea. The studies are being carried out for effective performance and effect on flood levels due to construction of Balloon Barrage with different tide conditions.

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- SardarSarovarNavagam 3D model

Geometrical similar scale 1:150 mobile bed truncated spill way model is being utilized forstudying upstream reservoir characteristic, down stream flow pattern, effective energydissipation arrangements, performance of training walls and performance of auxiliary spill way.





- Garudeshwar sectional (2D) model study

The reservoir capacity in terms of water level, effective energy dissipation arrangements and scour in the down stream of the structure are being assessed. The reservoir will be utilized forrunning the turbine in reversible mode of SardarSarovar Dam.





- Garudeshwar composite (3D) model

Geometrical similar scale 1:150 mobile bed spill way model is being utilized for studying upstreamreservoir characteristic, down stream flow pattern, effective energy dissipation arrangements,performance of training walls and sloping length of apron.





- Nabhoi and Rinza village flood protection (3D) model

This is the part model of Sabarmati River for assessing effective flood protections work on bank of River.

- Rajgadh (2D) model (Rajasthan)

This model is being utilized for reservoir capacity in terms of water level, effective energy dissipation arrangements and scour in the down-stream of the structure. The length of apron was optimized as per the flow conditions observed on the model.

- Heran River composite (3D) model

This model is constructed to assess the flow pattern in the meander shape of River near theNarmada main canal syphon structure crossing the River. The flow was diverted using spur onleft bank to protect the protection work provided on the bank.



- Parvan Dam sectional (2D) model

This model is being utilized for reservoir capacity in terms of water level, effective energydissipation arrangements and scour in the downstream of the structure. The length of apron wasoptimized as per the flow conditions observed on the model

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- Parvan Dam composite (3D) model

From the model study it was suggested to trim the up stream topography in front of three gates from left side so as to achieve uniform flow on the spillway. It was also suggested to raise the height of training wall and the level of trunion axis.

- Flood protective work on the bank of River Watrak near village Vautha

A 3D model of G.S.Scale 1: 100 was constructed to assess the inundation on the right bank andthe flow velocity on the bank so as to decide the type of protection work and its orientation.

- Ukai spillway composite (3D) model

A 3D model with G.S.scale 1:100 was utilized for assessing the performance of tail channel,combination of different gate opening and the performance of divide wall and guide bunds with and without operation of power channel for different discharges .

7.1 METEOROLOGICAL OBSERVATORY

The main purpose of meteorological observatory is to access the net availability of water and plan its optimum utilizations for irrigation. A model meteorological observatory is established in 1970 at Gotricampus, GERI. The main instruments installed in the observatory are as under.

(1) Rain Gauge
- Non recording
- Self Recording

(2) Thermometers
- Maximum
- Minimum
- Dry Bulb
- Wet Bulb

(3) Open Pan Evaporimeter

(4) Anemometer

(5) Wind Vane

(6) Sunshine recorder

(7) Barometer

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Wind - Tunnel

Accurate measurement of wind speed is very important in irrigation, shipping transport, aerodynamics etc. The instrument used for this purpose is three cup anemometer. Anemometer requires periodical calibration. For calibration purpose a wind tunnel is installed at Gotri, GERI. The tunnel having two test sections operates at maximum speed of 100 km/hr.

8.0 DAM SAFETY

There are 632 large dams in Gujarath stateand out of that 207 are major and medium dams and 425 areminor dams. The major and medium dams are regularly inspected by Dam Safety Organisation (DSO) team once in 2-3 years whereas all minor dams are regularly inspected once in 10 years. The gated dams in the state are inspected by Civil as well as Mechanical and Electrical teams of DSO. During inspection an overall view of health status of each dam and its performance is reviewed and remedial measures are suggested by Central Design Organisation where ever required. DSO publishes annual health status report incorporating activities of dam safety organisation every year. It also organises workshops in different regions of the state to educate the project officers for the various requirements of dam safety aspects.

9.0 ROAD RESEARCH AND TRAFFIC STUDIES

There is a separate Road Research set up under GERI headed by a Joint Director (R). The activities are as follows:

Field Investigations:

Facilities for following field investigations are available

- Field density and field moisture content by conventional methods
- Evaluating overlay thickness by Bankleman Beam Deflection method
- Unevenness measurement by bump integrator unit
- Measurement of cracks, ruts, depressions, pot holes etc by visual rating
- Pavement performance study
- Junction Design
- Traffic Survey

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Laboratory Testing:

Following testing facilities are available

- Soil
- Aggregate
- Bitumen
- Emulsion
- Modified Bitumen
- Antistripping agent
- Binder content by centrifuge method
- Asphalt mix design
- Flexible pavement design
- Retro-Reflectometer for measuring the reflection property of road sign boards

Traffic Survey

- Speed flow
- Traffic count survey
- Origin-destination survey
- Traffic and transportation management study
- Road safety audit study

10.0 SOIL SURVEY

There is a separate soil survey organization under GERI headed by a Superintending Engineer (Soil, Drainage and Reclamation). There are three soil survey division headed by Soil SurveyOfficers working in different parts of the state.

Important Activities Undertaken:

- Reconnaissance soil survey and detailed soil survey(such as Monitoring sub soil,Monitoring salinity and water logging conditions,Special surveys etc.) in command areas of Water Resources Projects
- The pre-irrigation reconnaissance soil survey at feasibility stage and detailed soil survey at execution stage is required to be taken up for irrigation project to make interpretation of

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irrigation suitability of land and cropping pattern, intensity of irrigation, sizing of canal etc. are decidedbased on such data. These data forms base line for future monitoring.

- Post-irrigation soil surveys are carried out after irrigation potentials are created, to monitor the change in soil properties due to effect of irrigation and to identifying the changes and problems (positive and negative impacts).
- The Sub Soil Water Table (S.S.W.T.) observations in the command areas of various majorand medium irrigation projects in the state are taken twice in a year i.e. pre-monsoon (May- June) and post-monsoon (Oct.-Nov.). Open cum dug wells are allocated for observation andS.S.W.T is measured and samples are collected from fixed wells for the study of quality of well water in relation to irrigation purpose.

11.LIBRARY FACILITIES:

A library plays a very vital role in research works. GERI therefore has progressively developed a huge and a rich library since 1960. It has now reached in to the 6th decade. It possesses about 35000 books, proceedings, standards, etc.

Publications, Circular (Downloads):

GERI publishes Annual report, Navnirman Magazine (Technical Magazine), Health status report of irrigation structures etc.

MAHARASHTRA ENGINEERING RESEARCH INSTITUTE (MERI)

The Maharashtra Engineering Research Institute (MERI) was established in the year 1959. It is the prime institute of Maharashtra state under Water Resources Department. It is entrusted with the work of applied research in various disciplines of civil engineering like soil mechanics, construction material studies, testing, highway, coastal, remote sensing & GIS, seismology, hydraulic model studies, reservoir sedimentation studies etc.

It is largely dealing with field problems of applied research pertaining to various projects. Being the state research institute, its jurisdiction is spread over the entire Maharashtra state covering the water resources and public works Department while under taking research studies, their application in the field are concerned. In addition to self-sponsored research works referred by the field officers, the institute tackles research problem sponsored by the central government through the Central Board of Irrigation and Power (CBIP), Ministry of water resources (MoWR),

Ministry of Surface transport (MOST), Indian National Committee on hydraulic research (INCH), Department of Science & technology (DST) etc. In addition to this, testing of all construction material, soils and water quality etc. is also done by the institute. The institute also works as a nodal agency for Earthquake monitoring for Maharashtra State. The institute also undertakes consultancy works for other states, other departments of GoM, Local bodies and private agencies.

The five divisions working in the institute are as follows:-

- Soil Mechanics Referral Laboratory
- Material Testing Referral Laboratory
- Highway Research Division
- Resource Engineering Center
- Civil Works Maintenance Division

Material TestingReferral Laboratory

Tests carried out under this department are:

(1)	Cement (Physical and Chemical test)	(15)	Timber
(2)	Coarse Aggregate	(16)	Glazed Tiles
(3)	Fine Aggregate	(17)	Lime
(4)	Mortar	(18)	Hollow Blocks
(5)	Concrete	(19)	Calibration
(6)	Large size cores (0.90m dia)	(20)	Leached Material
(7)	Fly ash / Surkhi (Phy and Chem test)	(21)	Gravel
(8)	R.C.C.Pipes	(22)	Sand
(9)	A.C. Pipes	(23)	Soil
(10)	A.C.Sheets	(24)	T.C.L.Powder
(11)	Metals	(25)	Alum
(12)	Bricks	(26)	Paver Block
(13)	Manglore Tiles	(27)	FRP Needle
(14)	Flooring Tiles	(28)	Seepage water

Technical Committe

1. Concrete Hand Book Chapter Committee

- This committee was formed as per instructions of Director General, MERI, Nashik

- Chief Engineer, CDO, Nashik was the chairman of the committee and Scientific Research officer, Material Testing R.L. was the Member Secretary of this committee.
- Committee had finalized the three chapters as 1) Ready Mix Concrete, 2) Placement of Concrete and 3) Self Compacting Concrete.
- These 3 draft chapters had been submitted to Government of Maharashtra for approval and committee had been dissolved.
- Out of these three chapters, two chapters has been finalized by Government of Maharashtra. They are

PWD Handbook No. 40 Ready Mix Concrete
PWD Handbook No. 41 Placement of Concrete

These chapters have circulated in Public Work Department and Water Resource Department, Maharashtra Government.

2. Colgrout Review Committee

- This committee is constituted as per the instructions of Director General, MERI, Nashik.
- CE, CDO, Nashik is the chairman of the committee and Scientific Research officer, Material Testing Referral Lab is the Member Secretary of this committee.

Final Report on Colgrout construction work is submitted to Director General, MERI, Nashik.

3. Ferro- cements Committee.

- This Committee is formed vide GR of Govt. of Maharashtra, dtd. 03-01-2015.
- CE, CDO, Nashik is the chairman of the committee and Scientific Research officer, Material Testing Referral Lab is the Member Secretary of this committee.
- Uptill now six meetings of this committee are conducted by this division.
- At the end of sixth meeting, the final draft of ferrocement technology is prepared.
- This draft chapters had been submitted to Government of Maharashtra for approval vide letter no. 18 dated 29/12/2017.
- The said chapter on ferrocement has approved by Government of Maharashtra vide letter dated 14/6/2018 and given the permission to publish a draft.

It is WRD Handbook No. 01 Ferrocement Construction.

4. B.I.S. Committee

- Scientific Research officer, Material Testing Referral Lab is the Member of following three committees of B.I.S., New Delhi.

Sr. No.	Committee Number	Name of committee
1	WRD 9	Dams & Spillways Sectional Committee.
2	CED 2:1	Cement, Pozzolana & Cement additives Sub sectional Committee.
3	CED 53	Concrete Pipe Committee

- Cement, Pozzolana & Cement additives Sub sectional Committee CED 2:1Under BIS New Delhi has formulate Specification Standard, named as **IS 16714:2018 Ground Granulated Blast furnace slag for use in Cement, Mortar and concrete-Specification.** As Scientific Research Officer and Assistant Research Officer of this division are Principle member and Alternate member of the above committee respectively, the committee send the complimentary copy of IS 16714:2018 to this division.Every year, BIS New Delhi conducted the committee meetings.

Research Works:

Some completed research works

- Use of crushed stone sand in view of natural sand
- Generating the bill on computer for testing
- Compatibility of chemical admixture with cement
- Properties of concrete made from blending of natural and crushed stone sand
- Calibration report on data compilation of compression testing machine
- Study of mix design for high performance concrete
- Compilation of compressive strength of cement of various brands
- Interpretation of test result of colgrout cores from 45 project located in different parts of Maharashtra
- Use of plastic in concrete
- Study of excess amount of calcium content in leached material in various dams in Maharashtra

- ❖ Compilation of test result data of various types leached material of dams in Maharashtra

Soil Mechanics Referral Laboratory

Soil investigation work for construction of major, medium and minor earth structures and its related laboratory and field tests; foundation, earth dam and canal problems aretackled by this wing. Necessary soil tests are conducted as per IS code 2720(part-III and part IV) and PWD hand book chapter 33 (Quality control part-III earthwork). The soil samples are to be tested in the laboratory for determining soil properties.

Highway Research Division

Activities under this division are

- Design of new roads.
- Various problems suggested by P. W. D. Maharashtra regarding Roads and different Research Schemes for highways are being handled by this division.
- Pavement design for new & existing roads.
- Investigation & suggesting remedial measures for road works.
- Determination of roughness index for roads by automatic road unevenness recorder(ARUR)
- Studying new techniques by using locally available material for road construction
- Various tests related to road materials. (Californiya Bearing Ratio, Soil, Aggregate)
- Steel testing –Tensile strength and elongation of steel is tested in this division.
- Rock testing-Water Absorption, Specific gravity test and compression test
- Non Destructive test (Non Destructive test and core testing)
- Schmid hammer test To detect compressive strength of building without destructing columns or beams

Resource Engineering Center

Activities under this division are

- Assessment of reservoir sedimentation by SRS
- Sugarcane crop mapping.
- Banana crop mapping

- Grape crop mapping
- Green cover mapping
- Land use land cover mapping study
- Hydro cover mapping study
- Urbanization in command area of Major Projects
- Capacity assessment of reservoir by DGPS
- Survey of canal and command by DGPS
- Validation of Benchmarks/TBM/PBM by DGPS
- Training to WRD officers
- Updating information on Bhuvan web portal
- Presentation of papers in conferences
- Consultancy Works
- Knowledge transfer programme for UG/PG/PhD Engineering students.

Civil Works Maintenance Division

Activities under Civil Works Maintenance Division are

(A) Technical

- Watch and ward of MERI premises
- Maintenance and repairs of residential and non residential buildings in over all MERI premises including water supply etc.
- Management and Maintenance of MERI Land Assets
- Issues related to MERI Land in Bombay High Court

(B) Activities under maintenance sub division

- Water and ward of MERI premises
- Maintenance and repairs of non residential building in overall MERI premises.

(C) Account and other related matter of MERI Institute

- Providing service to all divisions under MERI regarding financial matters (Financial transactions and payment etc.) submitting account to A.G.

CSIR-NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE (NEERI)

The CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) is a research institute created and funded by Government of India.NEERI comes under the Ministry of Science and Technology (India) of central government. It was established in Nagpur in 1958 with focus on water supply, sewage disposal and communicable diseases and to some extent on industrial pollution.NEERI is a pioneer laboratory in the field of environmental science and engineering and is constituent laboratory of Council of Scientific and Industrial Research (CSIR) and it has five zonal laboratories at Chennai, Delhi, Hyderabad, Kolkata and Mumbai.

Quality Objectives

NEERI strives to achieve excellence and continual improvement through activities leading to scientific and technological innovations, technical solutions, sharing knowledge and expertise for enabling government, industry, and society to improve quality of environment.

Enhanced R&D performance resulting in:

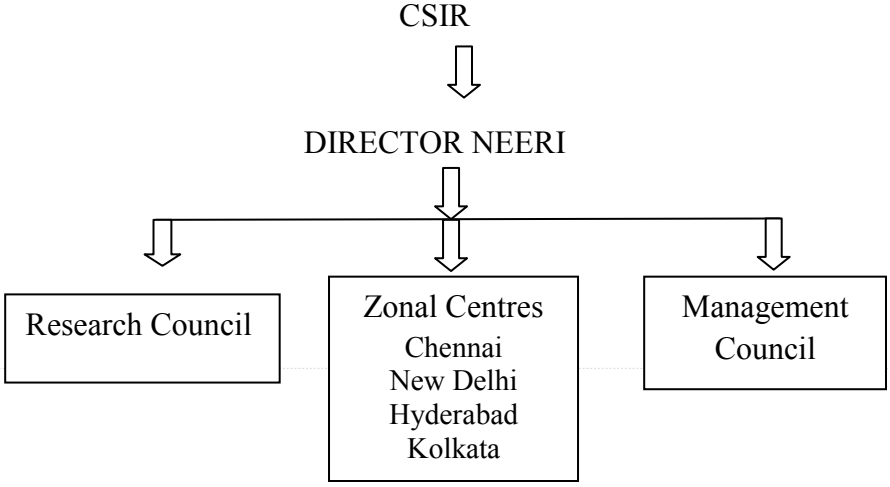
- The sustainable improvement will be realised in terms of:

- Publications (Number in SCI Journals and CIF)
- Patents (Number)
- ECF generation (Growth in %)

- Enhanced customer satisfaction (CS Index)
- Technologies developed and Transferred (Nos.)

- Environmental information dissemination in terms of Website, NEERI Journals, Publications, Reports, Newsletters, Databases, etc.
- Participation of scientists in societal missions and decision making in Government and industry

Organisational Setup



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Achievements of CSIR – NEERI

National Environmental Engineering Research Institute (NEERI), Nagpur is a constituent of Council of Scientific & Industrial Research (CSIR), New Delhi and has a nation-wide presence with its five zonal laboratories at Chennai, Delhi, Hyderabad, Kolkata and Mumbai.

The mandate of NEERI is:

- To conduct research and developmental studies in environmental science and engineering
- To render assistance to the industries of the region, local bodies, etc. in solving the problems of environmental pollution through S&T intervention
- To interact and collaborate with academic and research institutions on environmental science and engineering for mutual benefit
- To participate in CSIR thrust area and National mission projects

R & D Thrust Areas

R & D thrust areas are Environmental Monitoring, Environmental Modelling, Optimisation, Environmental Impact & Risk Assessment, Environmental Policy, Environmental Biotechnology, Genomics and Virology, Environmental Health, Water and Wastewater Technologies, Solid and Hazardous Waste Management and Environmental Materials.The clientele involves Industries, Central Government Ministries/Boards, State Government Ministries/Boards, Judiciary.

CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) has initiated various R&D activities for effective environmental monitoring in the country, which include mission projects such as “National Clean Air Mission”, “Clean Water: Sustainable Options”, “Waste Utilization and Management (COE)” and “Quantification and Mitigation of Persistent Organic Pollutants (PoPs) under Stockholm Convention”. Besides various R&D activities are in progress to deliver environmental solutions through development of cost-effective and resource recovery based technologies suitable to socio-economic conditions prevailing in the country.

CSIR-NEERI has initiated vital outcome-driven R&D activities under CSIR-800 programme to benefit rural people of India in terms of water pollution control, air pollution control and waste to wealth. The Institute is attempting to develop environmental materials which will be instrumental in preventing environmental pollution. The Institute has taken up R&D activities related to carbon dioxide sequestration and valorisation for reducing the increasing levels of CO_2 in the atmosphere. As part of paradigm shifts, CSIR-NEERI is committed to focus on carrying

capacity based developmental planning to ensure sustainable development in the country instead ofconventional environmental impact and risk assessment

The Institute will continue to provide solutions to various environmental problems faced by government, industry and the society. The Institute will also continue its output driven R&D activities in terms of technology development and transfer, research publications, patents, networking with academic and R&D Institutions in India and abroad.

Achievements

- CSIR-NEERI has successfully transferred two technologies, viz. Phytorid wastewater treatment technology to 15 MSME entrepreneurs and Solar Electrolytic Defluoridation technology of water to 9 MSME entrepreneurs. CSIR-NEERI entered into several agreements with various Agencies/Organizations for technology transfer/ implementation of R&D projects / academic collaboration.
- CSIR-NEERI has developed indigenous “Electronic Nose (e-nose)”, in association with C-DAC Kolkata, which has a potential to substitute imported “e-nose”. This e-nose consisting of 8 arrays of sensors (metal oxide) is useful in monitoring of sulphurous odorants in pulp & paper industry, tannery and distillery.
- The Institute provided a technological solution to M/s Mahindra Vehicle Manufactures Limited (MVML), Pune for treatment and safe disposal of its effluent using high rate transpiration system. The HRTS model designed by the Institute was implemented in the field at M/s MVML, Pune. The HRTS design consists of filter media which provides more surface area for interaction of pollutants and also removes the suspended solids present in the wastewater was prepared.
- Hand pump attachable Iron Removal (IR) plants based on the CSIR-NEERI’s technology were installed at 66 locations by Public Health Engineering Department, Chhattisgarh in Rajnandgaon, Durg and Kanker districts. These plants helped to bring down the iron concentrations in water from 3-8 mg/L to less than 0.1 mg/L. Capacity of each plant is about 1000 L/hr.
- Electro-oxidation technology developed by CSIR-NEERI was implemented at Nandesari Industries Association, Vadodara on pilot scale for effective treatment of recalcitrant chemical industry wastewater. The first ever CETP scale electro oxidation plant has been designed in India for treatment of highly recalcitrant chemical industry effluents, based on the technology developed by CSIR-NEERI. This technology helps to meet the effluent discharge norms (COD of 250 mg/l) with low foot print area (4m x4 m per reactor) and is easy to install, operate and cost-effective.

- CSIR-NEERI has taken up Carrying capacity based developmental projects such as "carrying capacity based planning for proposed development in Sambalpur-Jharsuguda region, Odisha"; "Tourist impact assessment and carrying capacity study for environmental protection of world heritage sites – TajMahal, Agra and Ajanta Caves, Aurangabad".
- The Institute provided 100 units each of NEERI-ZAR water filters to the Uttarakhand and J&K Government to provide safe drinking water for flood affected people.
- A multi-fuel domestic cook stove has been developed and tested for its high thermal efficiency and reduced emissions. Village women have shown encouraging response to this product.
- A Mobile Laboratory for Toxic Emission Monitoring and Flue gas treatment is developed for application in Small and Medium Scale Industries. Low cost water recycle and reuse Nawatech Natural Water Technologies (Field demonstration two in Pune and two in Nagpur) and Phytoremediation technology (Three Field Demonstration) under Water4crops project are under implementation.
- A Technology Park to showcase processes and products of 12th Five Year Plan projects on Waste to Energy is under construction stage.

Technology Demonstrated

- Electro-oxidation technology implemented at Nandesari Industries Association, Vadodara on pilot scale for effective treatment of recalcitrant chemical industry wastewater.
- Technological solution to M/s Mahindra Vehicle Manufactures Limited (MVML), Pune for treatment and safe disposal of its effluent using high rate transpiration system.

Societal Projects

- As a part of societal missions, based on the technology developed at the Institute, solar energy based electrolytic defluoridation plant has been constructed and commissioned at a fluorite mine of Maharashtra State Mining Corporation, located near village Dongargaon, about 100 km away from Nagpur city. The plant with a designed capacity of 600 L / batch is providing fluoride free safe water to the workers of the fluorite mine.
- The Institute has evolved US EPA assisted water safety plan for Hyderabad city and demonstrated UNIDO assisted full scale grey water recycle in Madhya Pradesh. NEERI has developed a process for recovery of essential oils from waste peels of citrus fruits for rural community.

- Several low-cost catalysts have been designed and synthesized for the control of CO, VOCs and PM emissions from the solid fuel combustion. These catalysts have been characterized and evaluated for their catalytic activity towards CO, VOCs and PM oxidation with a view to control indoor air pollution in rural areas.
- NEERI has designed and developed sustainable remediation process for mitigation of fluoride contamination in groundwater and its field application for domestic use. Hand pump attachable iron removal plants were developed and installed at various places in the country.

SCHEMES

Considering different environmental factors, CSIR-NEERI conducts R&D studies for the different geographical area under its sponsored/funded Research and Development (R&D) program. While carrying out such studies Institute generates valuable data, which may be further published in the public domain by means of research article, reports, and project findings or by means of some information system (Software). Such data may be published on the website on case to case basis to carry out further research studies or for the health management program. Similarly, Institute also publishes public-awareness videos, articles, software module applicable in nature conservation on its official website. Along with, Institute widely publishes its developed technologies, which can be adopted by industries/corporations for clean pollution-free environment.

SERVICES

- Institute publishes general useful notification like: Training program, workshops, symposiums, and seminars on emerging environmental issues on its official website, which is helpful for the research-scholars, students, employee, and businessmen so as to participate in such programs.
- **Promoting Govt. Schemes & Websites:** Under the wide information dissemination program, Government website and Government scheme widely published on the website.

INSTITUTE OF HYDRAULICS AND HYDROLOGY (IHH) POONDI

Institute of Hydraulics and Hydrology, Poondi was established as an Irrigation research station in 1944 at Poondi, Tamilnadu. There was uniform growth from 1944 to 1995 in the development activities. But after the implementation of Water Resources Consolidation Project from 1996 onwards, there is rapid growth not only in providing infrastructure facilities but also in research activities.

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The service rendered by Er. P. KUMARASWAMY in bringing this Institute to International standard is unforgettable one. Remarkable development made during the year 1998-2003 in the history of Institute of Hydraulics & Hydrology is the establishment of different infrastructure facilities under WRCP.

Organisation and Objective

This institute is headed by a Director (Special Chief Engineer or Superintending Engineer) and is a wing of Water Resources Organisation of Public Works Department, Tamilnadu under the control of Chief Engineer (Designs Research & Construction Support), Chennai. This Institute is carrying out both applied and basic research.

There are two Divisions under this institute headed by Deputy Directors (Executive Engineers). One Division namely Hydraulics Division at Poondi, to carryout model studies and another Division is Water Shed Management Board (WSMB) at Pollachi, to Carryout sedimentation survey works including watershed management studies in reservoirs and major tanks of Tamilnadu.

Infrastructure Facilities

- Right Flank Laboratory area 4.2 ha (10.4 acres)
- Left Flank Laboratory area 9.8 ha (24.2 acres)
- Research Library over 30,000 Technical Books, Reports and Magazines.
- Reprographic section consists of photography, reproduction, Binding section and a printing press.
- Full-fledged workshops such as mechanical, electrical along with carpentry section.
- Exhibit section for preparing the relief models.
- Glass flumes for flow studies.
- Fully furnished weather station.
- 25 KVA and 55 KVA power generators for supplying power during power failure.
- Collector well for catering the drinking water.
- A well equipped conference hall.
- Coastal model trays equipped with wave paddle generators for studying Coastal problems.
- Three Hangars (50 m X 20 m size) have been built newly for conducting model studies. This will accommodate all the instruments including computers, etc. under one roof and study can be made round the clock under all monsoon periods.

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- Computers with latest software technology have been procured for studying all problems.
- Latest electronic instruments for measuring velocity, water level, etc. both for model and field studies have been procured.
- Regular tie up arrangements is being made with Indian Institute of Technology (IIT-Madras) and ICMAM for solving Coastal problems.
- By these arrangements, latest technological advancement in this field is incorporated in our model studies availing the expertise of Senior Professor from Indian Institute of Technology (IIT).
- An Inspection Bungalow with A/C suites is attached to this Institute to fulfil the need of visitors from other Institutes, Govt. officials and dignitaries.

Activities

- Hydraulic Model Studies
  - Model trays available
- Coastal Model Studies
  - Facility for 2D and 3D Physical model study
  - Mike-21 for numerical model studies
- Observation of Beach width along the coast
- Sedimentation survey of reservoirs

Outstanding Achievements:

Total number of reports submitted by Hydraulics Division so far from 1944 is around 750. Out of these studies some of the outstanding achievements are as under.

- Tee block design evolved for Energy Dissipation in lower Bhavani Dam spillway got International recognition.
- Flip bucket type energy dissipator for Parappalar dam.
- Grid corner method evolved for computing capacity of storage reservoir.
- Silt exclusion and proportionate distribution of water in Palar anicut (A peculiar study successfully completed recently after 20 years of research).
- Duck bill weir for Sathanur canal.
- Godbole falling shutters.
- Roller bucket for Panchana Irrigation Project of Rajasthan.

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- Offshore Dis-continuous breakwater for North Chennai Coast
- Tamilnadu Road Development Corporation (TNRDC), Tamilnadu Electricity Board (TNEB), SHAR Centre, Sriharikota model studies

Numerical Model Study

- Mike 21 and Litpack softwares purchased to analyse river and coastal problems.
- Autocad and GIS Software purchased under WRCP

Coastal Process Sub division, Chennai

There are four coastal processes sections functioning under this sub division.

1. Coastal Process Section @ Chennai
2. Coastal Process Ssection @ Nagappattanam
3. Coastal Process Section @ Kanyakumari

There are 37 observation sites under coastal observation from Chennai to Kanyakumari. There are 312 observation reference points located in 37 observation sites covering a distance of 89 km along the coast.

Observations of the long term shoreline changes in the coastal areas from Chennai to Kanyakumari for the total coastal length of 906 km have been done. The data collected are also analysed and the annual reports of coastal studies are also prepared and kept in Institute of Hydraulics & Hydrology library for reference and future use. The collected data from the above observation can be utilised for the model studies like erosion problems, fishing harbour problems, protection of monuments, etc.The required funds for these sub division activities are met by the Government of Tamilnadu.

Water Shed Management Board, Pollachi

The Watershed Management Board Division with its Headquarters at Pollachi has been formed as per GO. Ms. No. 857 dt 26.5.73. This Division is engaged in undertaking sedimentation and watershed management studies in selected reservoirs/tanks in Tamilnadu for arriving upto date reduction in capacity due to sedimentation. Assess the useful life of reservoir and to suggest the remedial watershed management measures to be undertaken in order to arrest the sediment entry into reservoirs from the watershed.

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Integrated Bathymetric System:

Integrated Bathymetric System has been obtained from MOWR, GOI using Hydrology Project Funds of World Bank.By using this system, the survey studies were carried out in Reservoirs.

Structural Engineering Research Centre (SERC)

Structural Engineering Research Centre (SERC), Chennai, India is one of the national laboratories under the Council of Scientific & Industrial Research (CSIR), India. SERC has built-up excellent facilities and expertise for the analysis, design and testing of structures and structural components. Services of SERC are being extensively used by the Central and State Governments and public and private sector undertakings. Scientists of SERC serve on many national and international committees and the Centre is recognized at the national and international levels as a leading research institution in the field of structural engineering.

Kerala Engineering Research

SUSTAINABLE COASTAL PROTECTION PLAN

ABSTRACT

As per the minutes of the meeting on 28-05-2021 chaired by Dr.K M Abraham CFA, Chief Principal Secretary, O/o the Chief Minister, Kerala Engineering Research Institute (KERI) has been directed to take up a pilot project in association with Kerala Forest Research Institute (KFRI) to place 100 number of tetrapots with different varieties of mangroves and to identify the type of mangrove that can grow at the particular location. It has also been directed to formulate plans for various investigations and studies required for implementation of soft solutions and tetrapot with mangrove combination etc. Further to that joint site inspection has been conducted by KERI and KFRI at specified sites. Soil and water samples have been collected and tested. Based on that the suitable mangrove varieties have been identified. A proposal with the budget for establishing nursery, planting and maintenance cost for five years and the timeline for various activities has been submitted to the Chief Engineer (I & A) and the Chief Engineer (IDRB).

METHODOLOGY

- After a set of discussions with KFRI officials regarding the subject matter, a joint field visit by KERI, KFRI officials and LSG authorities was conducted on **30-09-2021** at following sites in Thrissur district
  - Thambakkadavu Arappa beach, Thalikkulam Grama panchayath
  - Snehatheeram beach,Thalikkulam GP
  - Thiruvathra beach,Chavakkad municipality
  - Periyambalam beach, Punnayoorkkulam GP

a) Suitable locations to plant the mangroves has been identified

b) Soil and water samples has been collected from the sites

KFRI submitted the report by concluding that "In general, the conditions are unsuitable and soil conditions have to be suitably modified to enable mangrove growth."

- On **01-10-2021**, a team from KFRI, KERI, Irrigation department of Kerala and Travancore Titanium products limited visited sites Poovar, Onnampalam and Idava zones of Trivandrum district and Lakshmi, Mukkam and Thanni beaches of Kollam district
- Tetrapot design has been obtained from IDRB
- **On 17-12-2021** KFRI submitted a report with cost estimate for planting and planting time schedule and submitted to CEs

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- **On 18-12-2021**, additional comments of KFRI on the design of tetrapot and its suitability has been submitted to CEs
- As part of associating with other institutes KERI had expressed our interest to associate with the Integrated Rural Technology Centre (IRTC) for the site-specific study of coastal zone management of Kerala Coast for the preparation of a master plan
- In order to create a system for utilising the innovative capabilities of students, KERI is planning to include students from Arts and Science colleges especially from Botany department in this project

The budget for establishing nursery, planting and maintenance cost for 5 years and the timeline for various activities has been submitted by KFRI and the proposal has been submitted to Chief Engineer (I & A) and CE (IDRB).



Site visit at proposed sites by KERI and KFRI team

Start Up Project

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START UP PROJECT

ABSTRACT

India has designated the years 2010-2021 as the "Decade of Innovation." Kerala towards the end of this decade is witnessing a wave of innovative and entrepreneurial efforts from discrete sectors. Startups in Kerala are creating solutions in new and better ways than ever before as they experiment with futuristic technology. In order to address the needs of the Irrigation Department, Kerala Engineering Research Institute (KERI) has committed to promote startups. The institute plans to construct an automatic water level prediction system in canal water distribution system to the irrigation department's needs.

METHODOLOGY

A preliminary discussion to provide viable solutions to the problems faced by the irrigation department was conducted between the officials of Innovation & Entrepreneurship Development Center, Sreepathy Institute of Management and Technology (SIMAT), Vavanoor during the first week of January 2022. Subsequently, a prototype of automatic water level prediction system to monitor the water level of Peechi dam in real time was designed by the students of the Electrical and Electronics Engineering Department, SIMAT. The prototype needs to be modified for canal automation and it is proposed to deploy the same in any one of the canal branch of Peechi irrigation system. If the pilot deployment is successful, the project will be developed for the entire canal branches under the Peechi irrigation system. An android application for the real time monitoring was developed and the working view of the application can be shown as below.

DISCUSSION

As part of KERI's startup initiative, a prototype for automated real-time water level monitoring was developed. After the prototype has been corrected through regular checks, it can be used to monitor water levels in canal systems in real case.

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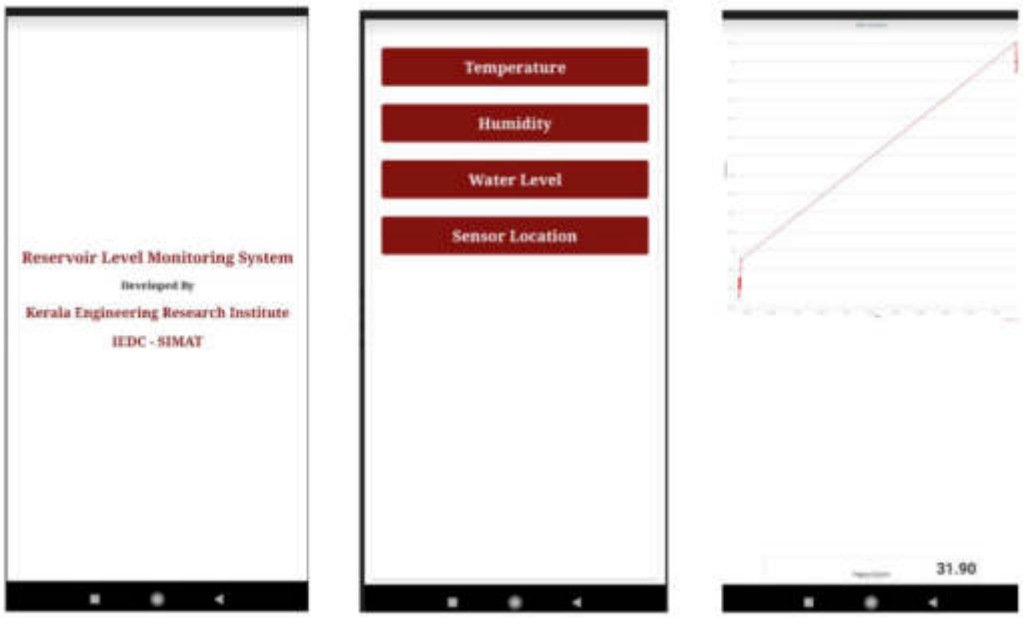


Fig. Android application for real time monitoring



Fig. SIMAT students submitting Real Time Reservoir Water Level Monitoring System to Director, KERI

Technical Collaborations

a. Association with National Institute of Technology, Kozhikode in Sand Budgeting study
b. Association with CWRC in model study of Banasurasagar Dam
c. Association with College of Engineering, Thiruvananthapuram Hydraulic Model Study
d. Report of Member participation of KERI in various technical committees

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ASSOCIATION WITH NATIONAL INSTITUTE OF TECHNOLOGY, KOZHIKODE IN SAND BUDGETING STUDY

Unscientific sand mining has been one of the burning issues in the state Kerala which has caused ecological/environmental imbalances. As sand is used extensively in construction, the amount being mined is increasing exponentially. Lack of proper scientific methodology for river sand mining, monitoring systems, regulatory policies and environmental impact assessments have led to indiscriminate mining, triggering severe damage to the environment and related ecosystem services.

Sand Auditing is the procedure to evaluate the process of sand mining in a river or part of the river after a specific period of mining- with an aim to maintain the overall environmental quality of the river. The sand auditing being conducted by the NGOs for Department of Revenue is not scientific as it is based merely on the level of water without taking into consideration the reduction in bed levels. Hence the volume of sand accounted for mining is not correct. Under these circumstances, Director, KERI had issued orders to submit a proposal specifying the technical method by which an assessment of the quantity of sand available in the river bed, the quantity of sediments being deposited and hence the quantity that can be allowed for mining.

The Chaliyar River Basin has been selected for a pilot study.It is the fourth longest river in Kerala having a length of 169 km and a total drainage area of 2,923 sq km. The objectives of this study are:

1) To ensure that sand and gravel extraction is carried out in a sustainable way
2) To maintain the river equilibrium with the application of sediment transport principles in determining the locations, period and quantity to be extracted.

Detailed Project Report has been submitted and financial sanction has been accorded by Chief Engineer, IDRB for an amount of Rs.28 Lakhs.

The methodology followed for sand auditing in these rivers includes Mapping of the river channel, Ascertaining Pristine Condition of the Rivers, Sediment Sampling, Sediment Transport Model, Model Simulation, Result Analysis includes Sediment Spatial Plot, Sediment Time Series, Sediment Cross section Plot and Monitoring Plan.

Since KERI is new to the field of Sediment Transport Modelling, this portion of the proposal was decided to be outsourced. NIT Kozhikode has already been involved in such studies using

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HEC/MIKE software. Our Institute had discussed with NIT Kozhikode and they expressed their willingness to collaborate with our Institution for a pilot study, which includes capacity building of our Engineers. MoU has been signed with NIT Calicut to undertake the study using HEC and ArcGIS software.

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ASSOCIATION WITH CWRC IN MODEL STUDY OF BANASURASAGAR DAM

ABSTARCT

The meeting held with CWRC Sub group to conduct the "Mathematical and Physical model studies to verify the veracity and relevance of the present procedures and coefficients adopted for computation of discharge through the river sluices and spillways, etc in the designated dams of Cauvery Basin" on 10.12.2021 at 11.30 AM. Meeting started at 11.30 AM. The members of subgroup such as Sri.Mohan Murali, Director, CWRC Bengaluru, Smt.Saji Samuel, Joint Director CWRC Bengaluru, Sri.R.Thankamani. Superintending Engineer, CWC Bengaluru, Smt.Suprabha N, Director KERI Peechi, Sri.Rajasekhar, Superintending Engineer Puducherry, Sri.Ravisankar, Joint Director KERS, Sri.Divakar, Deputy Director IHH Poondy, Sri. Suresh Babu, Assistant Director IHH Poondy and are attended the meeting. Convenor of the subcommittee Sri.Mohan Murali, Director CWRC Bengaluru makes a presentation about the proposals submitted by various institutes, requirements of CWRC, Terms of Reference and Course of Action etc. After the presentation there is a discussion within the members of subgroup.

METHODOLOGY

The details of 1 to 9 should be provided by the subgroup:

1. A common guideline can be formulated by the sub group to assist CWRC for the referenceof consultants.
2. The hydraulic structures for which the modeling (numerical and physical models) to be done should be identified. List to be prepared by concerned states with available details. (eg: Name of river/dam/reservoir/location including the State). Also show it in a layout figure/map of basin.
3. The details of data on the structures that are available with the respective organizations who are custodians of those structures should be provided. This can include the features of the structure (eg: dam/spillway/sluice/conduit for taking water like a tunnel/weir or barrage) as the case may be. Also details of the river/reservoir at the site to which the structure belongs to should be provided.
4. The details to be modeled for each structure or part of structure should be provided. It includes whether the structure is to be modeled independently; or in association/combination with other structures, what are the parameters have to be determined (eg: co-efficient of discharge, discharge versus head relationship,

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maximum discharge capacity, Pressure variation connected with flow, gate discharge etc.)

5. They should provide the conditions regarding the modeling study: Concerned with physical or/and numerical modeling of structures.

   a. Provide the details of Structures requiring Physical modeling only : Name of structure,2D/3D modeling, Scale used etc.

   b. Provide the details of Structures requiring Numerical modeling only : Name of structure,2D/3D modeling, and modeling platform/software to be used etc.

   c. Provide the details of Structures requiring both physical and numerical modeling : details similar to above

6. Input data for the Study:

A list and details of available data for each structure should be prepared with respective user organizations/collected by user organizations and should be given to consultants.

7. Desired outputs of study should be Specified with respect to each structure, by giving a list of the details of specified structure.
8. Preliminary aspects to be decided in selection of Consultants for the study: (a) Whether a single/multiple consultant is required for physical and numerical modeling of different structures.

a) Whether a single/multiple consultant is required for physical modeling of different structures.

b) Whether a single/multiple consultant is required for numerical modeling of different structures.

c) Whether a single/multiple consultants is required for physical andnumerical modeling of all structures in a particular state/under the control of a particular agency.

d) Any other criteria to be followed in preliminary aspect for consultant selection : State/Jurisdiction etc.

9. The subgroup should select common software for mathematical model study.

On the basis of the above points the sub group should conduct a preliminary discussion with all consultants about the details of study, requirement, expected time etc. then only a common format can form from subgroup side.

10. After the discussion get detailed proposal from the consultants in a common format indicating the requirement desired from study : expertise/modeling strategy used, duration of study, Estimated cost for study, Typical physical/numerical model

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studies doneearlier, additional cost if any for additional data collection (To be specified by consultants).

11. The proposals submitted by the consultants should be scrutinized by

    1. sub group

    2. The agency/CWMA/CWRC/ CWC.

12. Based on the proposals obtained from consultants final selection of proposals should be done by the sub group based on the parameters cost, duration of study, expertise in physical/numerical model studies etc. /any other conditions can be incorporated.

13. (a) MOU with the selected consultants for undertaking the study. (b) Payment procedures in the consultancy work (like advance, stage wise payment, final payment etc) and associated guidelines to be formed with the agencies selected (both for consultancy work and Scrutiny of the report) (c) Scrutiny of reports and modification on the basis of it etc.

As per the meeting conducted on 17/01/2022 by CWRC with the subgroup members, a standard format was identified for the model study of 8 designated dams in Cauvery basin .Ithas been decided to conduct brainstorming session with selected institutes for the requirements needed by them.The brain storming sessions were conducted as follows:

- IIT Madras- 25/01/2022
- CWPRS, Pune- 01/02/2022
- Irrigation Research Institute, Roorkee- 08/02/2022
- IISc Bangalore- 18/02/2022
- IIT Delhi - 22/02/2022
- IIT Roorkee- 25/02/2022

By incorporating the inputs received from all brainstorming sessions and the reviews from the subgroup members, the standard format was finalized for submitting the final proposals. The first part of the standard format with the comments from the side of KERI has been mailed to CWRC on 09.03.2022. The second part with the details of model studies to be conducted (which has been submitted by the Banasurasagar project authorities) was sent to CWRC on 16.03.2022. After receiving the proposals from the selected institutes, CWRC and subgroup members will select the institute to conduct the study.

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DISCUSSION

Salient features of the Banasurasagar dam and the details of discharge outlets have been sent to CWRC. No other data has been shared. CWRC informed that the additional data if any required by the institutes to submit the proposal will be requested later. If it is available with the project authorities, it will be intimated then. Otherwise, it is the duty of the selected institute to collect the data from the site at their own cost.

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ASSOCIATION WITH COLLEGE OF ENGINEERING, THIRUVANANTHAPURAM IN HYDRAULIC MODEL STUDY OF KUTTIADY DAM

Kuttiady Dam is built across Kuttiady River at Peruvannamoozhi in Chakkittapara Grama Panchayath in Kozhikkode District. It was constructed as part of Kuttyadi Irrigation Project. The project consists of a masonry dam across Kuttiyady River and 13 earth dams to maximize the storage of the reservoir. The construction of this project started in 1962 and was commissioned in 1973. Based on the recommendation of the committee on dam safety it was decided to modify the spillway and stilling basin of Kuttiyadi dam. The Chief Engineer, IDRB, Thiruvananthapuram (Vide Lr.No. No: 675/DAMS-AD6/1987/IDRB-Part File I dated 30.04.2018) directed KERI to undertake the physical modelling of the proposed modification of spillway of Kuttiyadi dam.

The physical model study of Kuttyadi dam was accomplished through collaboration with College of Engineering, Trivandrum. The technical collaborations are relationships of great mutual benefits which foster the academic and institutional development. These eminent alliances with renowned academic institutions will help to acquire knowledge, exposure skills and aptitude in the relevant field. The comprehensive application of conceptual with practical aspects of technology will inculcate the culture of rapid problem-solving and innovative thinking.

A mutual agreement (MOU No.02/2018-19/DIR/ KERI dated 16.5.2019) was executed between KERI and ITC &SR (Centre for Industrial training consultancy and sponsored research), CET. The model formulation, simulation of experiments was done under the guidance of Prof. Dr. Jairaj P G and Prof. Thulasidharan Nair, Department Civil Engineering, College of Engineering Trivandrum. The study involves in verifying the flow characteristics of the proposed modification of spillway and stilling basin for energy dissipation in the dam.

A comprehensive and geometrically similar model of Kuttiady dam project and its spillway was constructed in the hydraulics lab. Spilling part of the model was constructed with pressure points to measure piezometric heads. The model was performed under different operating conditions of the spillways.

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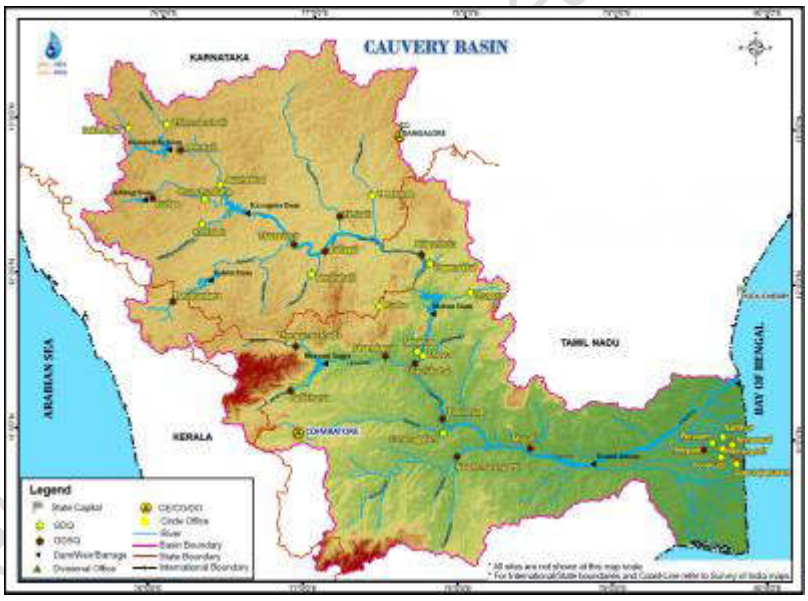
Based on the details supplied by the Irrigation Design and Research Board (IDRB) on the modified design of the spillway, the physical model of the prototype spillway was simulated in the hydraulics laboratory of KERI, and the performance of the model was analysed.

REPORT OF MEMBER PARTICIPATION OF KERI IN VARIOUS TECHNICAL COMMITTEES

Kerala Engineering Research Institute is functioning under Kerala Irrigation Department as a Research and development wing of the department. Being an Engineering Research Institution, the institute is nominated to various technical committees of Government formulated for different purposes. The participation of such committees is described as follows.

1. Proposal to conduct physical and mathematical model studies for computation of discharge through river sluices and spillways in 8 designated dams in Cauvery basin

The sharing of waters of the Kaveri River has been the source of a serious conflict between the two Indian states of Tamil Nadu and Karnataka. Being an interstate water dispute, Supreme Court pulled out to establish Cauvery Water Management Authority. The Authority will be assisted in the discharge of its functions by a Regulatory Committee known as Cauvery Water Regulatory Committee (CWRC).



The Cauvery basin extends over states of Tamil Nadu, Karnataka, Kerala and Union Territory of Puducherry. The total length of the river from origin to outfall is 800 km. Its important tributaries joining from left are the Harangi, the Hemavati, the Shimsha and the Arkavati whereas the Lakshmantirtha, the Kabbani, the Suvarnavati, the Bhavani, the Noyil and the Amaravati join from right. The Kabini is an important tributary of the Cauvery. it is a perennial river, 150 to 200 M. wide and has a course of about 240 Kms. It rises in the Western Ghats in North Wynad in Kerala State as two streams i.e. the Mannantoddy puzha and Panamarampuzha. About 16 km below their confluence, the

Kabini forms border between Kerala and Karnataka for about 12 km before entering Karnataka state. It joins the Cauvery at Tirumakudalu Narasipur (T.N.Pur).

Cauvery Water Regulation Committee (CWRC) proposes to conduct mathematical and physical model studies to verify the veracity and relevance of the present procedures/coefficients adopted for computation of discharge through river sluices and spillways, etc in the eight designated dams (Harangi, Hemavathy, KSR, Kabini, Mettur, Bhavanisagar, Amaravathy, and Banasurasagar) of Cauvery basin. In pursuance of the decision taken in the 53 rd/55 th meetings of CWRC, a subgroup has been constituted including Director KERI in order to assist CWRC in finalizing the national level research organizations /institutes for carrying out the proposed Physical and Mathematical Model Studies of the eight designated dams in Cauvery basin as per office order No.3/1//CWRC/2021/2077-99 dated 25.11.2021 of the Member Secretary, Cauvery Water Regulation Committee. The members of the Subgroup are

1. Director, CWRC (Convenor)
2. Principal / Joint Director, Karnataka Engineering Research Station (KERS), Karnataka (Member)
3. Superintending Engineer, WRD, Institute of Hydrology & Hydraulics, Poondi, Thiruvallur District, Tamilnadu (Member)
4. Director, KERI, Peechi, Thrissur, Kerala (Member)
5. Superintending Engineer, Circle III, PWD Karaikkal Region, Puducherry (Member)
6. Superintending Engineer, CSRC, CWC, Bangalore (Member)

2. Technical Sanction of Irrigation works under KIIFB funding

∗ Kerala Government has given utmost importance and priority for mitigating coastal distress and ensures coastal protection through financial assistance from KIIFB. As per GO(Rt) No.435/2021/WRD dated 28/08/2021, a committee was constituted by the Government for issuing Technical Sanction for irrigation works financed by KIIFB for a period of one year particularly pertaining to coastal protection works undertaken by KIIDC. The Chief Engineer IDRB has forwarded a proposal through the letter no. IDRB/3641/2021/CS/PBD Dated 06/09/2021, requesting to reconstitute the technical committee including following more members, Chief engineer (I& A), Director, KERI, Chief Project Examiner, KIIFB. As per the

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Government order GO(Rt)No.527/2021/WRD dated 08/10/2021, Government had modified GO(Rt) No.435/2021/WRD dated 28/08/2021 and included Director, KERI
In the technical committee constituted for the above purpose.
The members of the committee constitutes are

1. Chief Engineer, KIIDC
2. Chief Executive Officer, KIIDC
3. Chief Engineer (I&A), Irrigation Department
4. Chief Engineer. IDRB, Irrigation Department
5. Director, KERI, Irrigation Department
6. Chief Project Examiner, KIIFB

3. Desiltation of Reservoirs in Kerala

The siltation has reduced the capacity of dams in Kerala significantly. Through desiltation of reservoirs, storage of the dams could be enhanced and the water need not be drained to sea during rainy season. Desiltation is considered as one of flood risk management activity which reduces susceptibility of flood damages. Government of Kerala has constituted a technical committee for the desiltation of reservoirs in Kerala as envisaged in the Standard Operating Procedure. The 9th empowered committee on desiltation decides to reconstitute the technical committee constituted for the desiltation of reservoirs in Kerala with external experts from premier institutions. Chief engineer I &A has furnished proposal as per letter No.PL1(A) Mon/12539/2003 Dated 03.09.2021, for reconstituting technical committee including Director KERI along with other experts from premier institutions such as IITs, NITs, also Assistant Chief Technical Examiner under finance department. Government have examined the matter in detail and reconstituted technical committee as per order GO (Rt)No.491/2021/WRD dated 20.09.2021. The reconstituted committee members are

1. Chief Engineer (I&A), Irrigation Department (Chairman)
2. Chief Engineer in charge of the Project (Convenor)
3. Chief Engineer , Mechanical, PWD (Member)
4. Director, Mining & Geology Department (Member)
5. Chief Hydrographer (Member)
6. Superintending Engineer in charge of Project (Member)
7. Dr. Divya P.V, Assistant Professor, Geo Technical Engineering Division, IIT Palakkad (Member)

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8. Dr. S. Chandrasekharan, Professor, HAG, Civil Engineering Department, NIT Kozhikkode (Member)
9. Sri. Hariram N, Technical Examiner, Office of the Chief Technical Examiner (Member)
10. Smt. Suprabha N, Director, Director, KERI, Peechi (Member)
11. Smt. Smitha Balakrishnan, Assistant Engineer,Dam Section, Mangalam (Member)

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Technical Events

a. Induction training programme to newly recruited Assistant Engineers of Irrigation Department

b. Training programme on Significance of Quality Control and Quality monitoring of Irrigation works

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REPORT OF INDUCTION TRAINING PROGRAMME TO NEWLY RECRUITED ASSISTANT ENGINEERS IN THE YEAR 2021 OF IRRIGATION DEPARTMENT

ABSTRACT

In the year 2021, a new batch of 75 Assistant Engineers was inducted into the Irrigation Department. Kerala Engineering Research Institute planned and conceived induction training for new Engineers in accordance with the directions of Hon'ble Additional Chief Secretary, and the order no.PL6 (B) 17308/2021 dated 16/08/2021 of Chief Engineer, Irrigation & Administration, Thiruvananthapuram. The induction training was held in order to provide newly recruited assistant engineers in the irrigation department with an opportunity to learn about their new role in the department. The induction training began on August 17, 2021, and ended on September 14, 2021, with a total of 42 sessions using the Zoom platform. The training curriculum covers a wide range of topics, including irrigation project research, hydraulic structures, hydrology, coastline protection, and the Harithakeralam Mission. This training also covers a variety of general topics, such as department procedures, office management, and personality development. The training also aims to create awareness and understanding of the various activities of the department and government procedures required for project implementation. Accordingly a comprehensive curriculum covering all these aspects was prepared by KERI and suitable resource persons were assigned for delivering the sessions. It was also planned to create a basic awareness about the various other departments, the role of irrigation department in various other sectors and collaborative projects etc.

METHODOLOGY

The training programme was delivered online through the Zoom Platform. Shri. Roshy Augustine, Hon'ble Minister for Water Resources, inaugurated the induction training on August 17, 2021, in the presence of Chief Secretary Shri. V P Joy, IAS, and Additional Chief Secretary Shri. T K Jose, IAS. Dr.V P Joy, IAS, Hon'ble Chief Secretary, was welcomed by Shri. Alex Varghese, Chief Engineer, I & A, to address the trainees and gave an encouraging discourse to the young engineers. The department was lucky to have Dr. E Sreedharan, "Metro man," communicate with the trainees on the first day. Dr. E. Sreedharan was introduced to the session by Shri. Biju D., Chief Engineer, IDRB.

The Chief Engineer, Kuttanad Package & Inland Navigation, also conducted a session. Another session on "Overview and Activities Undertaken by KERI, various facilities, etc." was held by the Director of KERI and team. The various sessions of the induction training were conducted by 22 resource persons from the irrigation department and 28 external resource individuals. On the

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14th of September 2021, a Valedictory session of the training programme was held with special sessions by Sri. K Jayakumar IAS (Rtd.), Director, IMG on the topic "Reading - A Gateway to Personal and Professional Development" and Sri. Dr. Alexander Jacob IPS (Rtd) on the topic "Engineering – Lessons From History."

To assess the effectiveness of the sessions, an online evaluation was conducted on daily basis, and participants' feedback on the sessions was also collected. The trainees were instructed to attend the three online courses (Financial Engineering, Data Analysis, and Python) and all have undergone the same. Certificates were awarded to those who successfully completed the training programme based on evaluation and attendance. 74 certificates were distributed.

As part of the programme, district-wise site visits were also held to provide the engineers with hands-on experience in the field. On 13th September 2021(Kasargod, Palakkad, Thrissur, Ernakulam, Idukki, and Kollam) and 3rd November 2021 (Kozhikode) as part of the induction training, site visits were conducted on a district basis to give the trainees practical experience on the execution and operation of major irrigation projects such as dams and other irrigation structures. Candidates got the opportunity to visit and inspect the key irrigation structures in their area, as well as their areas of interest. Due to Covid 19 pandemic situations the site visit was arranged in 7 groups . The following paragraph describe about the site visit.

The first group of 13 people went to the Kallada (Parappar) dam on September 13, 2021. The second batch, made up of 17 persons (11 freshly appointed Assistant Engineers and 6 coordinators from the Quality Control Subdivision in Kottayam), was assigned to two locations in the Idukki district. Munnar Check Dam and the Pattissery Dam construction site. The next team consisted with 7 participants and 4 departmental staffs visited Boothathankettu barrage and Malankara dam on the same day. The other group visited Chimoni dam as part of their site visit during induction training programme with eight number of participants. Further, Palakkad district team visited two destinations; Malampuzha dam in Palakkad district and a Community Micro irrigation project at Karadippara, Chittur, Palakkad. A team of 14 new Assistant Engineers from Palakkad and Malappuram districts joined in the visit. Then another team Visited to Peruvannmuzhi Dam Site, Koovapoyil UT & Chittarikadavu RCB. The team consisted of 16 people, 13 newly appointed Assistant Engineers and 3 coordinators from Quality Control Subdivision Kozhikode. Kasargod district team had visited to irrigation structures in Kasargod district, consisted of 6 participants from Kannur and Kasargod district.

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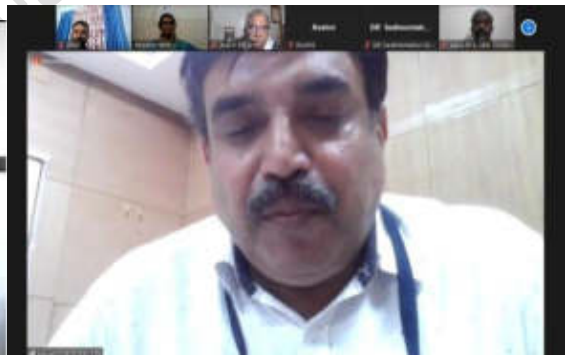
DISCUSSION

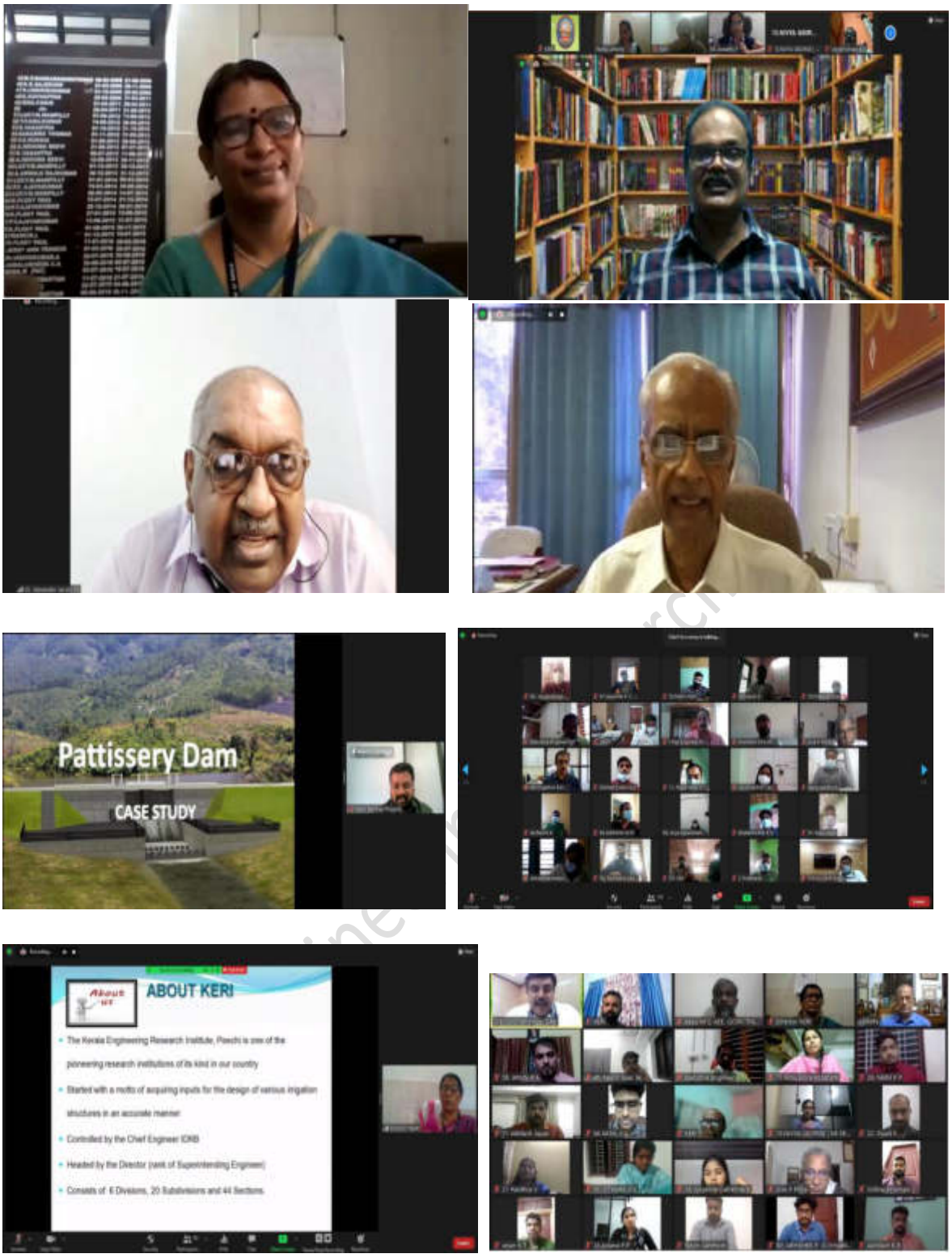
With the help of an online induction training programme organized by Kerala Engineering Reasearch Institute , 75 Assistant Engineers were inducted into the Irrigation Department. Based on the feedback received, it was comprehensible that the training was extremely beneficial in raising awareness and understanding of the department's various activities as well as the government procedures required for project implementation in the department. Continuous training on modern methodology and trends in the construction field has to be regularly carried out. Furthermore, the site visits conducted during the programme was an opportunity to get anextensive knowledge that will be extremely useful in their field practices in the coming days.











Figures. Photos of Induction training programme on online Platform



Figures. Photos of Site visit during induction training programme

Training programme on Significance of Quality Control and Quality monitoring of Irrigation works

Quality control wing under Irrigation Department was formed in the year 1995 as a separate mechanism to ensure the quality of works undertaken by the department. In whatever we do, the one and only response which we cannot ignore is the quality aspect. Ensuring quality is not a onetime affair. It is a continuous process, transcending the boundaries of time and space. The job of Quality Control wing of Irrigation department is also not different. The periodical training accelerates the effective implementation of works. Also transferring of updated technical details is essential in the field of quality assurance. The lack of awareness about PWD manual, PWD quality control manual and various IS Codes in connection with quality control and quality assurance of Irrigation works are affected the improvement of the quality of works undertaken by the department.Considering this aspect, under the aegis of KERI, Peechi, a Herculean task of training the majority of technical professionals of Irrigation Department was embarked upon. Hence it was decided to organize state wise trainings for Quality monitoring and Quality control of irrigation works and related IS codes for all technical field staffs (Overseers to Assistant Executive Engineers) under the department.

Considering the constraints of COVID lockdown and related restrictions, the trainings were scheduled in online mode. Total estimated participants were from Overseer to Assistant Executive Engineer level including Major/Minor/ Hydrology/ Coastal / Addtional Irrigation/IDRB and Projects wings of Irrigation Department. Training got started in the month of October 2021 and IDRB set up an ambitious target of finishing the training before March 2022. A dedicated team at KERI, under the leadership of Director Smt.Suprapha.N got into the task in a brisk and efficient manner to arrange all the required technical support, scheduling the training programs and communicating with prospective participants. Assistant Executive Engineers of Quality Control wing identified the participants in the respective districts and a separate Whatsapp group was created for each scheduled training program and subsequent communication regarding training was effected through these groups. Interactions, feedbacks and post training tests were also effectively coordinated through these groups.

KERI has identified 2 internal resource persons for conducting these trainings. The identified resource persons are Er.Babu M.S, AEE, Quality Control Sub Division Thrissur and Er. Merin Thomas, AEE, Quality Control Sub Division, Kottayam were given an orientation training arranged by KERI.

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Total 13 training programs were conducted within a span of 4 months. Each training was of one day duration and on completion 1988 nos participants were trained. Course completion certificates were also issued to the trainees. Learning materials were also shared through Whatsapp groups. Online training programs were conducted through Zoom platform.

Details of Quality Control & Monitoring Training 2021-22

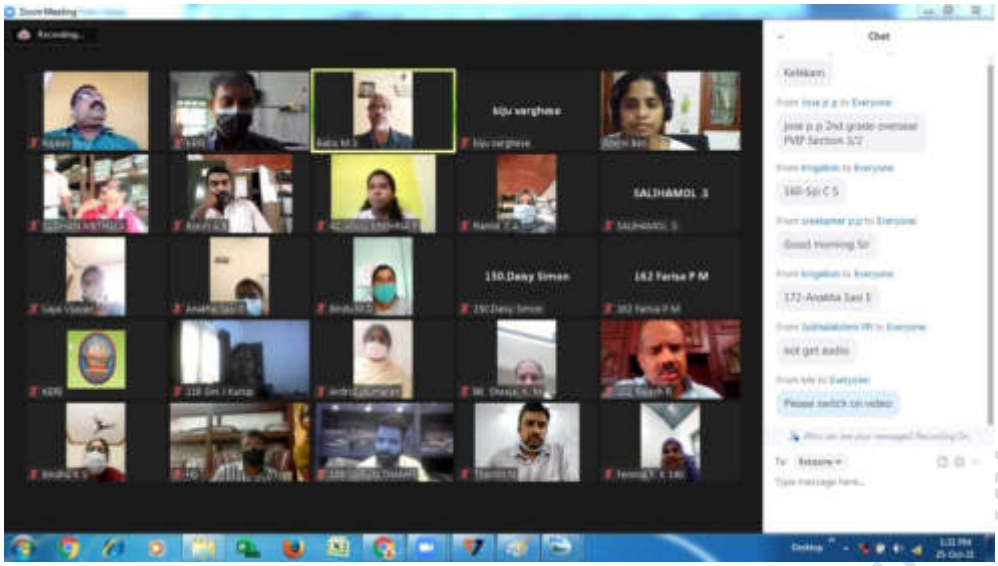
Sl No	Month	Date	Participants
1	Oct-21	21-10-2021	80
2	Oct-21	23-10-2021	89
3	Oct-21	25-10-2021	95
4	Nov-21	15-11-2021	70
5	Nov-21	17-11-2021	71
6	Nov-21	19-11-2021	76
7	Nov-21	24-11-2021	82
8	Nov-21	29-11-2021	52
9	Nov-21	30-11-2021	79
10	Dec-21	22-12-2021	200
11	Dec-21	28-12-2021	470
12	Feb-22	09-02-2022	221
13	Feb-22	11-02-2022	403
		Total	**1988**

Following sessions were handled in the training program.

FN session- Significance of Quality Assurance and Quality Control in Irrigation works by Er.Babu.M.S

AN session - Introduction to PWD Quality control Manual and related IS codes by Er.Merin Thomas.







Trainings were well received by participants and excellent feedbacks were really motivating for trainers and KERI team. It is also mooted that all new recruits will be trained at regular intervals on these topics. The training sessions were highly interactive and many practical situations were brought into discussions and thoroughly brainstormed and practical solutions arrived. The results of training programs are already visible in the field situations and marked improvements are being observed in execution process.

Thoughts are already on, in bringing out a comprehensive Quality Control Manual exclusively for Irrigation department, considering the diverse nature of works being executed.

Sophisticated Instruments / Facilities / Tests

a. Seismic refraction survey using Engineering Seismograph
b. Seismic Tomography
c. Pile Integrity Tests
d. Sedimentation survey using IBS and Sub Bottom Profile
e. Smart Station
f. Technical Library

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SEISMIC REFRACTION SURVEY USING ENGINEERING SEISMOGRAPH

ABSTRACT

Seismic refraction survey is a reconnaissance survey used to determine wave propagation velocities through various soil layers in the field and to obtain the thickness of each layer. The seismic refraction method is based on the measurement of the travel time of seismic waves refracted at the interfaces between subsurface layers of different velocity. This method is based on the fact that seismic waves have different velocities in different types of soils (or rock). It is a widely used method for the determination of bedrock depth. Seismic refraction survey was conducted on a study basis using Engineering Seismograph at Attapilly and Thathanampully site during current financial year. In this study an atempt was made to validate the seismic refraction survey results with borehole data.

METHODOLOGY

In this method, seismic waves are produced by mechanical blow with a sledge hammer on a metallic plate at the ground surface. The seismic waves propagate into the subsurface at a velocity dependent upon the elastic properties of the material through which they travel. When the waves reach an interface where the density or velocity changes significantly, a portion of the energy is reflected back to the surface and the remainder is transmitted into the lower layer. Where the velocity of the lower layer is higher than that of the upper layer, a portion of the energy is also critically refracted along the interface. Critically refracted waves travel along the interface at the velocity of the lower layer and continually refract energy back to the surface. Receivers (geophones) laid out in linear array on the surface, record the incoming refracted and reflected waves. The geophones convert the ground vibrations into electrical impulses and transmit them to a recording apparatus (seismograph). The seismic refraction method involves analysis of the travel times of the first energy to arrive at the geophones. These first arrivals are from either the direct wave (at geophones close to the source), or critically refracted waves (at geophones further from the source).

Seismic refraction data were analyzed using PS Lab software. PS Lab allows simple processing of seismic data in SEG2 format. Through a guided path, program enables to get a detailed report of the survey, accompanied by graphics and tables, starting from field data. For surface seismic analysis, identification of depth of each layer is based on generalized reciprocal method (GRM),

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which requires a minimum of three energizations along the array and calculates depth below each geophone and average velocity of compression waves (P Wave) through seismic layers. When first arrival times identification has been performed, directly on seismograms with different graphic aids or with manual entry in a table, the analysis of travel time graphs is made simply by an intuitive approach which provides attribution of observed times to each refractors by means of a simple mouse-click. Calculation of Vp (P wave velocity) velocity is based on interval method (ie. Based on measurements of the time interval between initiation of a seismic wave and its arrival at detectors). Program calculates velocity for each layer by analysis of travel time.

DISCUSSION

Seismic refraction survey was conducted on a study basis at Attapilly and Thathanampully site during current financial year. Results (such as bedrock depth and thickness of subsurface layers) of the above sites obtained after analysis with PS Lab software was then compared with the borelog data. Results of seismic refraction survey at both the above sites are pretty much matching with the borelog chart of the respective sites.



Fig. Apparatus used for Seismic Refraction Survey



Fig. PS Lab software interface



Fig. Seismic refraction survey at Attapilly



Fig. Seismic refraction survey at Thathanampully

Kerala

SEISMIC TOMOGRAPHY SURVEY AT CHIMONI DAM

ABSTRACT

The ageing and degradation of dam structures is an inevitable problem and its consequences on the safety of the structure are important. Seismic Tomography technique is generally used for detecting the deteriorated zones inside the dam (masonry and concrete) body. Seismic tomography survey was conducted at Chimoni Dam on a study basis during March 2022.

METHODOLOGY

Seismic tomography surveys are generally conducted across vertical upstream-downstream cross sections. Seismic tomography was carried out with the help of a sledge hammer by hitting on the downstream face of the dam while the seismic wave arrivals were picked up by different detectors (geophones and hydrophones) placed on the upstream face of the dam at different intervals. The seismic arrivals were amplified and recorded on a 24-channel signal enhancement seismograph.

In vertical planes taken across the dam axis, 12 geophones and 12 hydrophones spaced at different intervals were placed on the upstream face of the dam and various hammer points spaced at 1 m was used for generating acoustic waves on the downstream face of the dam. In order to obtain seismic velocities along longitudinal section of the body dam, it was installed a geophones chain on the ceiling of the gallery at the bottom of the dam, with spacing of 5m. Then energizations were made with a triggered sledgehammer each at 2m spacing on top of the dam.

The travel times of these arrivals were measured from the seismic record on which a time scale is maintained. From the measured time of first arrival of the seismic waves and the distance between source (hammer point) and the receiver (geophone), the average velocity of propagation of the elastic wave for that distance iss calculated. The recorded wave arrival data is analyzed by seismic ray tomography (using Reflexw software) which enables the imaging of the velocity distribution within the sampled area.

Typically, tomography images are analysed to look at the velocity changes within the masonry or concrete. Areas with lower velocity correspond to weaker, less dense concrete/masonry, while those with higher velocities are considered to be sound concrete/masonry. The results also can show areas with cracking damage or other discontinuities.

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DISCUSSION

Geophysical Techniques can use for Quick assessment of subsurface conditions of Dams in non-destructive manner. These techniques are important tool for health check of dams, regular monitoring and pre & post rehabilitation inspections. In this study, Seismic Tomography Survey is conducted at Chimoni Dam and the data analysis is going on.



Fig . Seismic Tomography Study at Chimoni Dam

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Fig . Seismic Tomography Study at Chimoni Dam

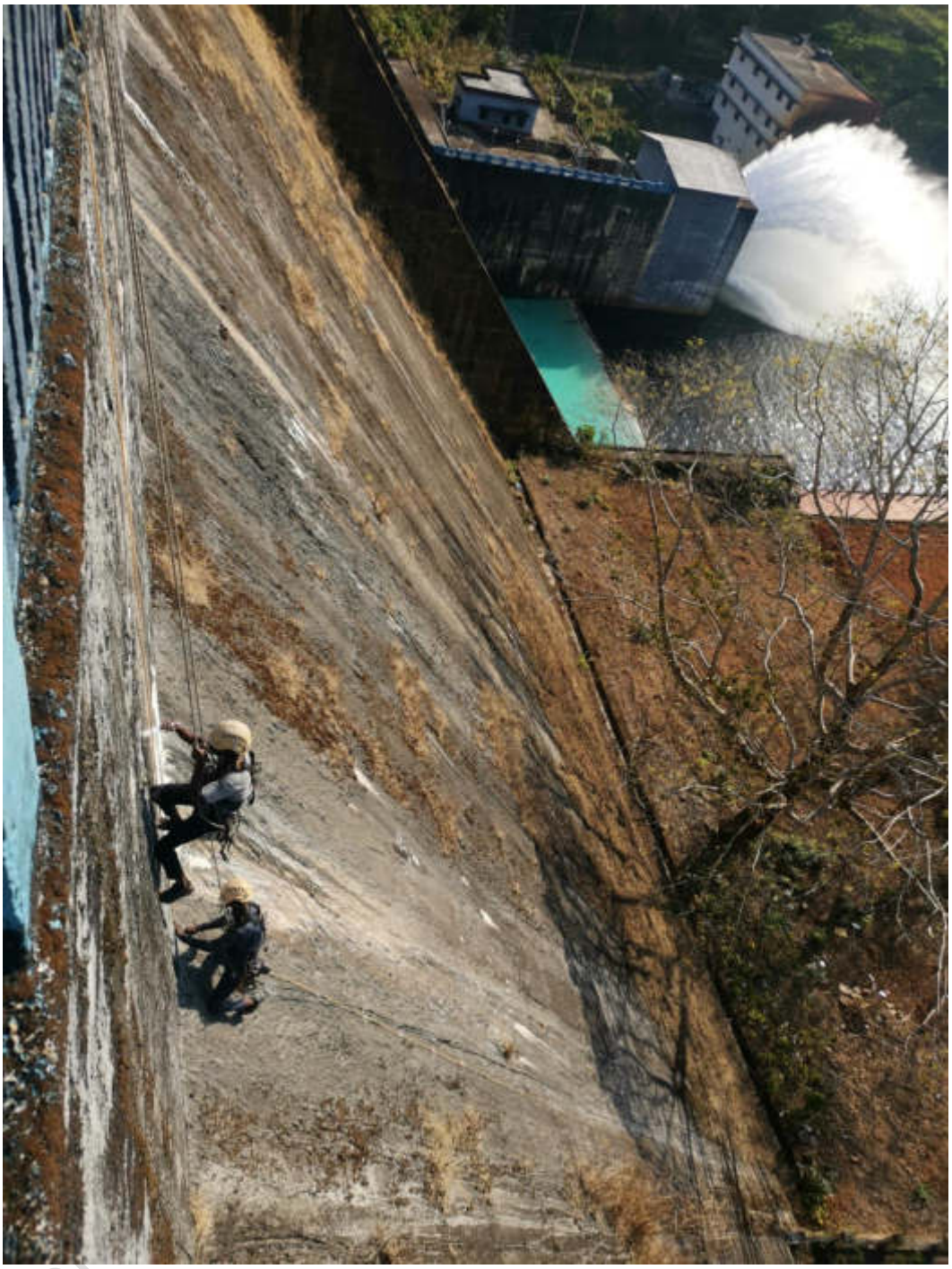


Fig . Seismic Tomography Study at Chimoni Dam

PILE INTEGRITY TESTS

ABSTRACT

Pile Integrity testing is a nondestructive testing conducted on piles as per IS 14893:2001. This is a method usually employed for the evaluation of the physical dimensions such as cross sectional variations, length, discontinuity etc. Impulses or vibrations are applied to the pile and converted using transducers and wave arrival times are used for computing the length and the wave shape gives an indication of the shape of the shaft. The equipment being used by KERI is PET (USB version).

The hardware part consists of an accelerometer which has an inbuilt amplifier and ac/dc converter and microcontroller. The hardware is connected to a PC using the USB. A hammer is also part of the equipment which is used for imparting vibrations to the pile shaft.

The software is installed in the computer which is connected to the accelerometer. To turn the raw data into an acceptable reflectogram, the PET software performs several operations.

TESTS CONDUCTED 2021-22

a. The Superintending Engineer, Thiruvananthapuram Corporation has requested to conduct Pile Echo Test (PET) on the pile group pertaining to the work ***Residential Training Centre at Attukal, Thiruvananthapuram Corporation.*** There are 124nos piles were trimmed cleaned and the site was equipped for testing. Accordingly, the test was performed on 17.12.2021 and 18.12.2021.



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124 no. of piles as per drawing given by the Superintending Engineer, Thiruvananthapuram Corporation vide Lt. E13/UPA/214/03 dated 07.10.2021 were tested.

These identification numbers are as per the above drawing available at site. The grade of concrete was reported as 1:2:4 as per Lt. E13/UPA/214/03 dated 11.03.2019. The casting of piles was carried out during the period 28.04.2007 to 12.01.2008. A velocity of 3300 m/s was chosen from the software.

b. The Executive Engineer, Karappuzha Project Division, Kalppetta, Wayanad vide letter no D1-1874/18 dated 27.03.2021 has requested to conduct Pile Echo Test (PET) on the pile group pertaining to the work ***KRP Flood Damage 2018 – Urgent Rectification works of breach at LBMC near Ch:4800m.*** Nine no. of piles namely P2-1, P3-1, P3-4, P4-1, P4-3, P5-1, P5-2, P5-5, P6-1, P7-1, P8-1.These identification numbers are as per drawings available at site. Since the grade of concrete was M30, a velocity of 4000 m/s was chosen from the software.





c. The Assistant Engineer, Minor Irrigation Section, Tirurangadi vide letter no AE/TGD1/2019/174/IA dated 22.03.2021 has requested to conduct Pile Echo Test (PET) on the pile group pertaining to the work LAC-ADS-Construction of a SWE/VCB cum Tractor path across Poorapuzha at Parayil in Parappanangadi Municipality in Malappuram District. Nine no. of piles namely A1-3, P1-2, P2-2, P3-3, P4-4, P5-4, P6-1, P7-2, A2-2. These identification

numbers are as per drawings available at site. Since the grade of concrete was M30, a velocity of 3750 m/s was chosen from the software.

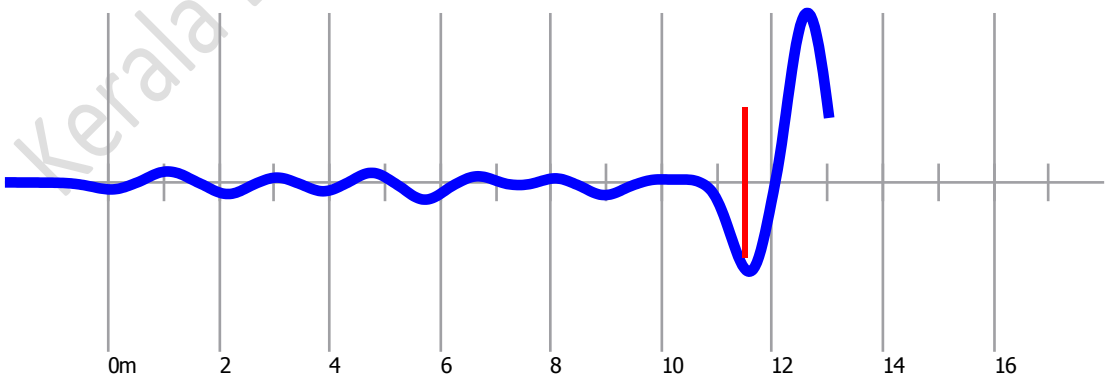




METHODOLOGY

The piles at the site were tested using PET and analysed at office using the PET software. On each pile, hammer blows were imparted till ten similar blows with 6% convergence was obtained. During processing errand waves were deleted to obtain a sharp and clear reflectogram to pick up the first reflection.

Pile testing requires two inputs the target length and the wave velocity calculator.



Sample Reflectogram for P4-4 (Note that the length of pile obtained is 11.5m), Parayil VCB

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Assumptions

The field officers were asked to report the following.

- Type of cement used
- Water Cement ratio and Mix proportions.
- As per IS14893 the velocity lies between 3000-4000m/sec depending on the grade of concrete (M20-M25).
- As per the standards described in the software velocity assumed accordingly for the each set of pile.
- Generally no contractor will construct piles more than the design length.

DISCUSSION

- *The entire result is based on the authenticity of the length of each pile reported by the site engineer.*
- Results are affected by the condition of the pile head, noise level during the test, moisture content and other factors.
- Load carrying capacity and strength parameters of the pile cannot be found using this test.
- Only an indication of length of the pile can be obtained from this test, which is based completely on the reported length of the each pile and reflectogram obtained during the pile test.
- Comments regarding the shape of the piles are based on field experience.
- *The length reported for piles will be (+/-) 10% variation due to the limitation of the Instrument (NDT) used.*

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MODERN SOPHISTICATED INSTRUMENTS USED FOR SEDIMENTATION SURVEY

INTEGRATED BATHYMETRIC SYSTEM

Traditionally reservoir sedimentation has been studied by carrying out bottom topographic survey using boat, sextant, ranging rods, echo-sounder etc. Naturally, this is very time consuming and the outcome was susceptible to human error because of the monotony of work.

Integrated Bathymetric system has been found to be an ideal solution to all the above rigorous work. The system consists of modern sophisticated electronic equipment. Data collection, processing and calculations are done by means of computer software. The results are more accurate than the conventional survey methods.

EQUIPMENTS USED

- ***Sub Bottom Profiler***

The system SES-2000 sub-bottom profiler, which is amobile parametric sediment sounder, was used for bathymetric and sub-bottom profiling survey. The SES- 2000 hardware component and transducers are shown in figure. The compact design with a user-friendly control unit allows the survey even in small and shallow waters with all the advantages of the parametric acoustics. The system offers the possibility to store data digitally and gives reliable results during online data processing. The system is primarily designed for shallow geophysical surveys. The tolerance of the system for 100 kHz frequency is 0.02 m + 0.02% of water depth and for 10 kHz it is 0.04 m + 0.02% of water depth. The compact design without integrated industrial PC components results in an affordable and reliable instrument for sub bottom profiling applications.



Top- side Unit **Transducer**

Fig.1 Sub Bottom Profiler

Both the primary high frequency (HF) signal (100 kHz) and the secondary low frequency (LF) signal (6–12 kHz) are recorded. Penetration can reach up to 50 m in soft sediments. Advantages

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of the parametric acoustic system include: (i) narrow beam width at low frequencies; (ii) deep penetration of sediment layers and objects with high resolutionand (iii) accurate depth measurements with the high frequency signal. The variant SES-2000 compact is designed for shallow water depth applications near the shore and inland waters down to 400 m.

- ***DGPS SIMRAD MX-610***

DGPS MX- 610 is a highly reliable system and it receives correction from a permanent reference station which is approved by Govt. of India, Dept. of Light house and Light ship. It can track up to 12 satellites to achieve maximum positional accuracy. The received position is transferred to Echo Sounder and Sub Bottom Profiler.



Fig. 2 DGPS SIMRAD MX-610

- ***MIDAS Surveyor Echo-sounder***

The MIDAS Surveyor is a revolution of small boat survey work with an integral GPS receiver. It logs and displays DGPS position data in WGS 84 Coordinate system or Local Grid. This Echo-sounder is designed to measure under water depth up to 1200m. Accuracy of instrument is 1cm. A dual frequency echo-sounder is specified to distinguish between fluffy top depth and the consolidated bottom. The high frequency (200 KHz) is used to detect the top of the mud/sediment. Under favorable conditions the low frequency signal (33 KHz) can penetrate in to the bottom and reveal information about the bottom soil structure.

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Fig.3 MIDAS Surveyor Echo Sounder

- **Survey Boat**

A Fiber Reinforced Plastic (FRP) boat with two 60 HP petrol out board engines is used as the Survey Boat. The boat has dimension of 7.50m x 2.66m x 1.20m and 8 persons capacity with the equipment. The boat with all the survey equipment is referred as the 'mobile station'. For the power supply, two solar panels of 260 watts each are mounted on the roof of the boat.



Fig.4 FRP Boat



Fig. 5 Equipment set up inside the Boat

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SOFTWARES USED

- **QINSY SOFTWARE**

This software is used for data collection and processing in IBS survey. The Bathymetric software supports NMEA 0183 compatible devices. Local grid UTM (WGS-84) is the projection supported by this software.

- **SESWIN**

This software is used for the data collection in Sub Bottom Profiler.

- **I.S.E. 2.9.2**

This is the post processing software used for analyzing the data collected from sub bottom profiler.

- **Surfer software**

Surfer is a graphic program used for calculating the volume based on the logged data from the IBS and Sub Bottom Profiler.

SMART STATION

KERI is equipped with modern survey equipment called Smart Station for carrying out topographical survey in which Terrestrial Positioning System (TPS) and Global Positioning System (GPS) are perfectly integrated. With Smart Station, there is no need to search for and set up over control points, run traverses, or resects the position. This instrument is a versatile tool for speedy survey work. Smart Station comprises of Base station GNSS and Smart Antenna. It is a GS14/GS18 satellite receiver. It receives signals from US GPS satellites, Russian GLONASS satellites with integrated 4G LTE and UHF external radio RTK modems. The radio modem is HPR2 satelline – EASY Pro 35W high power radio, 403-473MHz RX/TX radio, GS 18T is immune to magnetic disturbances.



Fig. 1: GS14 Base Unit with CS-10 Controller

GS-18T RTK Rover with Pole, Antenna and CS20 Field Controller (Smart Pole): RTK (Real

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Time Kinematic) Rover is a GS18T satellite receiver integrated with Cinterion cellular modem that supports LTE (4G) as well as all existing networks and UHF RTK modem which is set up at an unknown point using a carbon-fibre telescopic pole. The Pole is GLS30 GNSS telescopic pole with maximum height of 2m. RTK rover with pole and field controller is known as Smart Pole. The CS20 field Controller is connected to both Base and Rover via Bluetooth and the entire operations are done in the Controller. The controller is with full VGA touch display, 4GB internal storage, 2GB SD RAM, CF/SD card slot and 5MP camera. It includes Bluetooth, numeric keypad, stylus etc.



Fig. 2: GS18-T Rover with CS-20 Controller

Due to the tilt compensating function, it is not required to hold the survey pole in vertical position, that is there is no need to level the bubble for measuring and staking of points. In this the sensor accurately and reliably measures the pole tilt and together with RTK or Smart Link, provides an accurate tilt compensated position.

Total station with back sight Tripod kit: It is a TS 11, 5" (1.5mgon) total station with reflector less R500 EDM, electronic guide light (EGL5), 1GB internal flash memory, laser plummet, Keyboard with full VGA colour touch screen, Bluetooth /RS232/USB/SD card interface.

Leica Geo Office Software: This software is used to import and combine data from both total station and GPS and process it to produce the final results. It is mainly used for processing the

position values (latitude, longitude and altitude) of the base station.



Fig. 3: Total Station and Prism

METHODOLOGY

RTK method is used for transferring the levels from a known Bench Mark connected with MSL. It is a relative positioning technique which measures the position of two GNSS antennas relative to each other in real-time. All GPS positions are based on measuring the distance from the satellites to the satellite receiver on the earth. This distance to each satellite can be determined by the receiver. The basic idea is that of resection. If distance to three points relative to our own position is known, our position relative to those three points can be determined. From the distance to one satellite, we know that the position of the receiver must be at some point on the surface of an imaginary sphere which has its origin at the satellite. Since, the topographic surveying was conducted at the same river reach three years back, top level of the Thrithala RCB from the past report of the work was used for starting the present surveying work.

Setting up of Base Station or Reference receiver: The Refrence receiver antenna is mounted on a previously measured point with known coordinates. The receiver that is set at this point in survey mode is known as the Reference Receiver or Base Station. The receiver is switched on and begins to track satellites. The reference receiver estimates the ranges to various satellites in a precise manner since the respective position is already known. The reference receiver can thereof rework out the difference between the computed and measured range values. These differences

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are known as corrections. The reference receiver is usually attached to a radio data link/Multi band GSM/UMTS/LTE which is used to broad cast these corrections.

RTK rover is used for determining the position of unknown points. The rover receiver has a radio data link /Multiband GSM/UMTS/LTE attached to it that enables it to receive the range corrections broadcasted by the Reference Receiver. The rover receiver tracks the same satellites that are being tracked by the base unit receiver. The correct position can be calculated by the rover receiver based on the signals from the satellites which are tracked by the base station and the correction factors obtained from the base station. Multiple Rover Receivers can receive corrections from one single Reference.

Total station Survey: Project area where direct GPS connection cannot be established can be surveyed using total station. Total station is set up at a known point established by GPS Rover and survey can be continued from this point using Total Station.

Advantages of Survey using Smart Station

- There is no need to search for and set up over control points, run traverses, or resect the positions
- Lesser man power is needed
- Consistent high accuracy
- Lesser time for surveying
- Since GSM which can transmit signals to a longer distance is used for transmitting signals, number of base stations can be reduced which will minimize the errors

Limitations of Survey using Smart Station

Though the instrument is fast and efficient to use, it needs an open view of the sky in order to receive the satellite signals. RTK is best in wide, open areas with clear sky. RTK cannot be used to determine the details of points under trees and bushes, in city canyons etc. Various error influences, particularly those relating to ionospheric delays, tropospheric delays and satellite orbits affect the satellite signals. Daily out turn of the survey work depends on various unpredictable factors such as availability of satellite signals, quality of available satellite signals, cell quality (3G/4G), climate conditions etc.

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TECHNICAL LIBRARY

ABSTARCT

The Kerala Engineering Research Institute's information bureau is sited in a technical library operated by the publication wing. The library which houses roughly 10,000 (ten thousand) books and a handful of latest periodicals, this wing delivers essential technical knowledge to all staffs of this Institute. This department organizes lectures and training programmes for the benefit of staff of the Institute. The wing also organizes training and refresher courses for the Irrigation Department's employees as well.

METHODOLOGY

The technical library is kept up to date by adding new publications on topics of interest to researchers, students, and employees, among others. The library is being used by many technical persons in different Government Departments and also by a number of students from different Engineering Colleges and Polytechnics. Books are issued to officers attached to KERI using Library software.The card system is also being maintained.Facilities are also extended to Engineers working in various Departments and Institutions for referring the books. Aparts from theses, Many Indian periodical such as Indian Geotechnical Journal, Concrete Journal, Electronics for You, Indian Journal of Power & River Valley Development, Civil Engineering and Construction Review, Down to earth



Fig. View of Library

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Various trainings have been conducted in the financial year 2021-2022 under the perview of technical library to improve the skills and technical knowledge of engineers and other technical staff . The List of various trainings conducted is listed as below.

Sl. No.	DATE OF TRAINING	TOPIC	PRESENTER	TARGET AUDIENCE	NO OF PARTCIPANTS
1	24-02-2021	Coastal Structure Design & Contruction.	Chief Engineering Manager & Head, Engineering Design & Research Centre - Ports and Harbours , L&T ,Construction , Chennai	Engineers of Major Irrigation Division's and (Coastal Engineering & Field Studies (CEFS),	90
2	14-05-2021	SUBSOIL INVESTIGATION FOR IRRIGATION STRUCTURES	Sri. Saju Varghese. DD, Instrumentation division, KERI, Peechi. Sri. Sreedev. M. S AD, Instrumentation division, KERI, Peechi.	IWR Engineers /Overseers /KERI Engineers	76
3	03-06-2021	Basics on Coastal Engineering	Mrs Paravathi MM , Assistant Director , IDRB , Tvm	online training for the departmental Engineers of Coastal Engineering & Field Studies (CEFS)	37
4	07-06-2021	Oceanographic Field Instruments	Neeraj Prakash Project Scientist ,NIOT ,Chennai	CEFS,KERI	30
5	09-06-2021	Introduction to Ocean Engineering	Prof. Balaji Ramakrishnan, Department of Civil Engineering, IIT Bombay	CEFS. KERI , MAJOR IRRIGATION DIVISIONS	75
6	11-06-2021	Discussion on Coastal Protection using Tetrapots	Discussion with KFRI	KERI, CEFS	60
7	25-06-2021	Coastal Erosion and the Impact of Anthropegenic Activities	Dr L Sheela Nair, Head Marine Geoscience group, NCESS	KERI, CEFS	64
8	30-06-2021	Introduction to PWD Quality Control Maual and related IS Codes	Baiju P B, AEE Bridges Sub Div, Kozhikhode	Quality control, KERI Engineers	60
9	17-08-2021	Inaugural Session	Shri. Roshy Augustine, Hon. Minister for Water Resources	Newly appointed AE's	84
10	17-08-2021	Special Session	Dr.V.P.Joy (IAS), Chief Secretary, Government of Kerala	Newly appointed AE's	84
11	17-08-2021	Special Session - Qualities of a Professional Engineer	Dr. E. Sreedharan, The Metro Man	Newly appointed AE's	84
12	17-08-2021	State of the art in Project Management - Sharing strategies	Shri.Jose P Philip, National Vice President, Indian Institute of Welding, Kolkata	Newly appointed AE's	84

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		and techniques of successful practices in Project Management			
13	18-08-2021	Overview of Kerala Irrigation Department	Er. Alex Varghese, Chief Engineer (Irrigation & Administration)	Newly appointed AE's	84
14	24-08-2021	Planning & Execution of Major Irrigation structures	Er.Binu Baby, Executive Engineer, Irrigation Division, Alappuzha	Newly appointed AE's	84
15	24-08-2021	Planning & Execution of Minor Irrigation structures	Er.Susheela R, Executive Engineer, MI Division, Kottayam	Newly appointed AE's	84
16	25-08-2021	Planning of Sustainable Coastal protection strategies	Dr.Joseph Mathew, ADB Consultant	Newly appointed AE's	84
17	25-08-2021	Overview of Project Wings (Project I & II)	Er.Sandheep V, Executive Engineer Karapuzha Irrigation Project Division, Kalpetta, Wayanad & Er.Balasankar K, Superintending Engineer, Project Circle, Piravom	Newly appointed AE's	84
18	26-08-2021	Overview of Irrigation Design and Research Board (IDRB)	Er.Biju D, Chief Engineer, IDRB	Newly appointed AE's	84
19	27-08-2021	Applications of Hydrology in Irrigation	Er.Sandhya S G, Joint Director, Hydrology & Investigation, IDRB	Newly appointed AE's	84
20	27-08-2021	Applications of Hydrology in Irrigation	Er.Shibu George, Assistant Executive Engineer, Hydrology Division, Thrissur	Newly appointed AE's	84
21	28-08-2021	Engineering Investigations and Design of Hydraulic Structures	Er.Shamsudheen K H, Chief Engineer (Retd), Irrigation Department	Newly appointed AE's	84
22	28-08-2021	Guidelines on Finanacial Aspects in Irrigation Works	Shri.Salil T B, Divisional Accountant, Harbour Engg, Kozhikkode	Newly appointed AE's	84
23	28-08-2021	Art of Professionalism in Engineering	Er.Jose Andrews, Assistant Engineer(Retd), Irrigation Department	Newly appointed AE's	84
24	30-08-2021	An outline to Kuttanad Package	Er.Syam Gopal, Chief Engineer, Kuttanad Package & Inland Navigation	Newly appointed AE's	84
25	30-08-2021	Perspectives of Inland navigation waterways in Kerala	Er. Arun K Jacob, Director, Inland Navigation Directorate, Kollam	Newly appointed AE's	84
26	30-08-2021	An awareness on the activities of Harbour Engineering Department	Er.Kunhimammu P, Superintending Engineer, Harbour Engg. North Circle, Puthiappa, Kozhikkode	Newly appointed AE's	84

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27	30-08-2021	Ventures of Kerala Public Works Department	Er. Baiju P.B, Assistant Executive Engineer, PWD Bridges Sub Division, Kozhikode	Newly appointed AE's	84
28	31-08-2021	Introduction to KSR	Shri.K.Sundaran, Administrative Assistant (Retd), Agriculture Department	Newly appointed AE's	84
29	31-08-2021	Significance of quality control in Irrigation works	Er.Babu M S, Assistant Executive Engineer, Quality Control Subdivision, Thrissur	Newly appointed AE's	84
30	01-09-2021	Overview on PWD Manual	Shri.K B Manoharan,Senior Finance Officer(Retd), Finance (Estt. B) Irrigation Department	Newly appointed AE's	84
31	01-09-2021	Law aspects related to Irrigation Department	Shri.Mohanachandran M S, Deputy Secretary to Govt, Law Department	Newly appointed AE's	84
32	02-09-2021	Concepts of Micro Irrigation	Dr.Sushanth, Scientist (Retd),CWRDM	Newly appointed AE's	84
33	02-09-2021	Office Administration Procedures	Sri. B. Madhusoodanan Pillai, Senior Superintendant (Retd.), Irrigation Department	Newly appointed AE's	84
34	03-09-2021	Introduction to QGIS and Mapping	Er.Chanchal Mary Peter, Assistant Engineer, Irrigation Section, Tirur	Newly appointed AE's	84
35	04-09-2021	Departmental Procedures for Execution of works	Er. N. Pradeep Kumar, Assistant Engineer (Retd) LSGD (Pradeepan Thoolika) & Er. Shamsad U C, Assistant Executive Engineer, Minor Irrigation Circle, Kozhikkode	Newly appointed AE's	84
36	04-09-2021	Conflicts Management of Works	Shri. Harilal M, Divisional Accountant, Kerala State Transport Project, Kottarakkara	Newly appointed AE's	84
37	06-09-2021	Soft Solutions in Coastal Protection	Dr. T V Sajeev, Scientist E-1, Kerala Forest Research Institute, Peechi	Newly appointed AE's	84
38	07-09-2021	Implementation of River Basin Management plans	Dr. E J James Pro Vice Chancellor, Karunya Institute of Technology and Sciences(Deemed university), Coimbatore	Newly appointed AE's	84
39	07-09-2021	Disaster Management- Case Studies	Er. Sunil Raj D, Superintending Engineer, Irrigation South Circle, Thiruvananthapuram	Newly appointed AE's	84
40	08-09-2021	Harithakeralam Mission	Shri.Renukumar, Programme Coordinator, KILA, Thrissur	Newly appointed AE's	84

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41	09-09-2021	Basic awareness of Mechanical components in Irrigation schemes	Er. Satheesh Chandran, Assistant Engineer (Mechanical), Malampuzha/ Er. Nibu Andrews, Asst. Executive Engineer, PWD,Mechanical Sub Division, Thiruvanathapuram	Newly appointed AE's	84
42	09-09-2021	Basic awareness of Electrical components in Irrigation schemes	Er. Seeja K.R, Assistant Executive Engineer, Elecrical Wing, Aluva	Newly appointed AE's	84
43	10-09-2021	Catch a Glimpse of KERI	Er.Suprabha N, Director, KERI & Team	Newly appointed AE's	84
44	10-09-2021	Role of Irrigation Department in Agricultural Sector	Smt. Sherly Zacharia, Assistant Director, Agricultural Department, Kottayam	Newly appointed AE's	84
45	10-09-2021	Monitoring softwares in Irrigation Department	Sri. Alex H.T, HOD, Automation Department, C DIT	Newly appointed AE's	84
46	11-09-2021	Dam Management under KSEB	Er. M K Parameswaran Nair, Member Civil (Retd), KSEB (Ex Chairman, Mullapperiyar Special Cell,Govt of Kerala)	Newly appointed AE's	84
47	11-09-2021	Concept of Environmental Flow	Dr. Sudheer Padikkal, Superintending Engineer (Retd), Irrigation Department	Newly appointed AE's	84
48	11-09-2021	Strategies for Reservoir Operation	Dr.Jasmine I, Assistant Director, IDRB	Newly appointed AE's	84
49	11-09-2021	Projects in collaboration with Engineering Colleges	Dr.Priya K L, Asst Professor, TKM College of Engineering, Kollam	Newly appointed AE's	84
50	12-09-2021	Chronological Review of ongoing Dam construction - Pattissery Dam	Er. Isaac P George, Assistant Engineer, Pampar Project Section-3, Marayoor	Newly appointed AE's	84
51	13-10-2021	Office Administration Procedures	Sri. B. Madhusoodanan Pillai, Senior Superintendant (Retd.), Irrigation Department	Promoted AE's	74
52	22-10-2021	Overview on PWD Manual	Er. Shamsad U C, Assistant Executive Engineer, Minor Irrigation Circle, Kozhikkode	Promoted AE's	74
53	26-10-2021	Overview of Minor Irrigation structures	Er.Susheela R, PA to SE, KD Circle, Kottayam	Promoted AE's	74
54	27-10-2021	Basic awareness of Mechanical components in Irrigation schemes	Er. Satheesh Chandran, Assistant Engineer (Mechanical), Malampuzha & Er. Nibu Andrews, Asst. Executive Engineer, PWD,Mechanical Sub Division,	Promoted AE's	74

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			Thiruvanathapuram		
55	28-10-2021	Overvirew of Irrigation projects .	Er.Balasankar K, Superintending Engineer, Project Circle, Piravom & Er.Sandheep V, Executive Engineer Karapuzha Irrigation Project Division, Kalpetta, Wayanad	Promoted AE's	74
56	29-10-2021	Strategies for Reservoir Operation	Dr.Jasmine I, Assistant Director, IDRB	Promoted AE's	74
57	30-10-2021	Familirisation of Design Indent and IS Codes .	Er. Athulya Das A S, Asst Director, Canals, IDRB	Promoted AE's	74
58	01-11-2021	Investigation works for Irrigation structures .	Er. Saju Varghese, Deputy Director, Instrumentation Division, KERI, Peechi & Er. Suffera O B, Asst . Director, Coastal Engineering Division , KERI, Peechi	Promoted AE's	74
59	02-11-2021	Applications of water resources in Hydrological perspective .	Er.Jigi M.O, Executive Engineer , Hydrology Div ,Thrissur & Er.Shibu George, Assistant Executive Engineer, Hydrology Division, Thrissur	Promoted AE's	74
60	03-11-2021	Basic awareness of Electrical components in Irrigation schemes	Er. Younas M S, Assistant Engineer, Electrical Lift Irrigation Section, Ramamangalam	Promoted AE's	74
61	05-11-2021	Introduction to QGIS and Mapping ,Hands on session on QGIS and Mapping	Er.Bismi Shafna, Asistant Engineer, Irrigation Investigation Section No.2, Aluva & Er.Raji Thampan, Deputy Director , Coastal Engineering Division, KERI, Peechi	Promoted AE's	74
62	21-10-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	AE's & AEE's	73
63	23-10-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	96
64	25-10-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	91
65	15-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	AE's & AEE's	70

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66	17-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	67
67	19-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	77
68	24-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	AE's & AEE's	83
69	29-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	51
70	30-11-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	78
71	22-12-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	AE's & AEE's	171
72	28-12-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	419
73	09-02-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	AE's & AEE's	183
74	11-02-2021	Online Training Programme for Quality Monitoring and Quality Control of Irrigation Works	Er. Babu M S, AEE, QC Subdivision, Thrissur & Merin Thomas,AEE, QC Subdivision, Kottayam	Overseers	322

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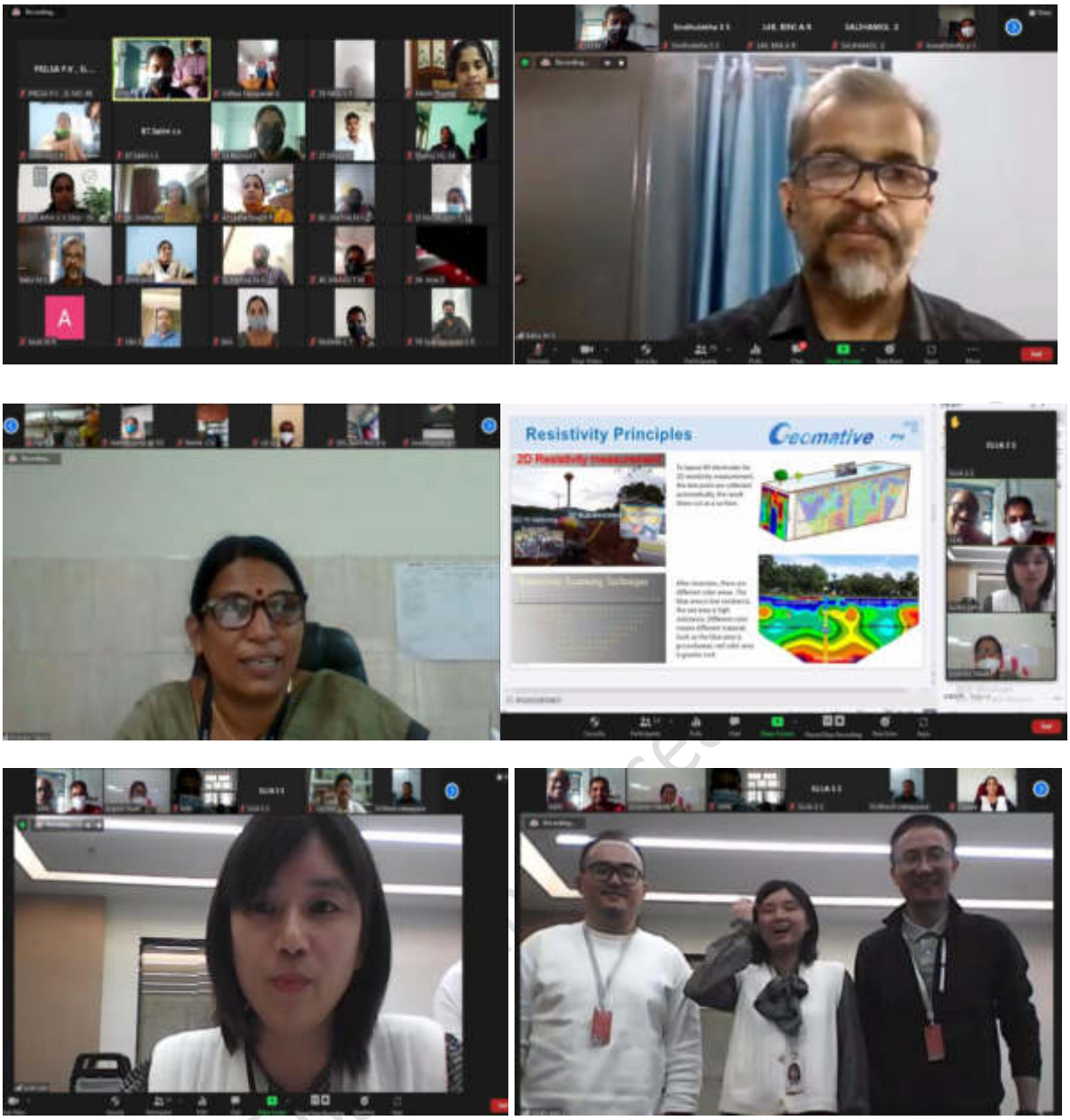


Fig. Photos of online training programmes

DISCUSSION

The technical library disseminates information through technical books, e-journals, printed journals, previous study reports, and other means. The training also provides an opportunity to advance the knowledge of employees in the department. As part of the library's upgrade, it is proposed that it operate in a digitilised mode, so that the entire department can take advantage of the technical abilities at their finger tips.

Annual Plan 2021-22

Kerala Engineering Research Institute

Annual Plan 2021-22					
	H/A 4701-80-800-99-00-34-03 Development of KERI-Stage -II				
Sl. No	**Head of Account/ Name of the Project**	**FS amount/ Project Cost (Rs. Lakhs)**	**Work Status: Completed (C) or Ongoing (OG)**	**Expenditure* (Rs Lakhs)**	**Expenditure %**
I	**Joint Director CM &FE, KERI, Peechi**				
A	**Instrumentation Division (Sub Division Office)**				
1	Routine Works of Instrumentation Division	1.80	C	1.78919	**99.40%**
2	Revamping and Modernization of Instrumentation Division	3.00	C	2.99780	**99.93%**
3	Soil investigation of various works for Irrigation Department	5.00	C	4.99285	**99.86%**
4	Routine Works Of Publication wing like conducting seminars and trainings etc	2.50	C	2.49902	**99.96%**
	Total	**12.30**	**(C)**	**12.27886**	**99.83%**
B	**Soil Mechanics And Foundation Division (Sub Division Office)**				
5	Upkeep and Routine activities of SM lab	3.00	C	2.89435	**96.48%**
6	Charges for NABL Acreditation	2.00	C	1.38460	**69.23%**
7	Painting works of SM Lab in connection with NABL Accreditation	1.50	C	1.57524	**105.02%**
8	Fundamental Studies on Seismic refraction survey for subsurface profile investigation	0.50	C	0.42034	**84.07%**

9	Seismic tomography study on dams	5.00	C	4.11925	**82.39%**
10	Fundamental Research on Geotechnical Engineering	1.00	C	0.92393	**92.39%**
11	Procurement of Static Triaxial Testing Machine	12.00	C	9.79323	**81.61%**
12	Procurement of IT equipments	1.07		0.00000	**0.00%**
	Total	**26.07**	**7(C)**	**21.11094**	**80.98%**
C	**Construction Materials Division(Sub Division Office)**				
13	Routine Activities of CM lab	3.50	C	2.78921	**79.69%**
14	Buoyancy balance- Specific gravity and water absorption test apparatus	1.20	C	1.17381	**97.82%**
15	Ultrasonic Pulse velocity tester	7.20	C	6.96200	**96.69%**
16	NABL Accreditation Process to CM Lab	2.60	C	2.45703	**94.50%**
17	Upkeep and procuring IT equipments	1.50	C	1.44555	**96.37%**
18	Attending trainings organised by BIS for getting NABL Accreditation	1.00	C	1.00000	**100.00%**
	Total	**17.00**	**C**	**15.82760**	**93.10%**
	TOTAL- Joint Director CM &FE, KERI, Peechi (Division office)	**55.37**	**17(C)**	**49.21740**	**88.89%**

II	**Joint Director, Hydraulic Research, KERI, Peechi**				
A	**Sedimentation Division (Sub division office)**				
19	Routine actitivies of Sedimentation Division including maintenance of survey equipments and accessories	2.00	C	1.94	**96.93%**
20	Purchase of new echo sounder and transducer and quinsy software for the use in the Small Boat for the study of Small rivers and canals	19.00	C	18.70	**98.44%**
21	Purchase of new laptop, solar panel, Battery for use in small boat for the study of small rivers and canals	3.30	C	3.30	**100.00%**
22. A	Sedimentation study of Kallada reservoir using IBS and Sub Bottom Profiler	4.25	C	4.02	**94.68%**
22 B	Sedimentation study of Maniyar reservoir using IBS and Sub Bottom Profiler	1.15	C	1.14	**99.20%**
	Total	**29.70**	**C**	**29.11**	**98.00%**
B	**Coastal Engineering Division (Sub division office)**				

23. A	Fundamental studies using Smart Station for the year 2021-22- Cross checking crest level of existing Mullaperiyar dam with Mean Sea Level 2021-22	0.85	C	0.836	**98.33%**
23. B	Topographical investigation for finding out the variations in bed levels in the upstream 600m of Velliyamkallu Regulator at Thrithala - 2021-22.	1.6	C	1.598	**99.86%**
23. C	Topographical investigation for Chundampatta Branch Canal of Thathanampully Lift Irrigation Scheme in Palakkad District- 2021-22	1.11	C	1.100	**99.08%**
23 D	Load test on Attappally Regulator Cum Bridge- Measurement of deck slab deflection using total station for the year 2021-22	0.27	C	0.268	**99.08%**
23 E	Topographical investigation allied with the obstruction to flow of Periyar river near Vallarpadam Railway bridge at Vaduthala- 2021-22	2.38	C	2.318	**97.41%**
23 F	Topographic investigation of command area for implementation of Community Micro Irrigation Project in Dasanakkara in Pulppally Panchayath 2021-22	1.5	C	1.495	**99.66%**

KERALA ENGINEERING RESEARCH INSTITUTE

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Peechi - Thrissur

An Institution of Irrigation Department Under Ministry of Water Resources, Govt. of Kerala







Exploring Engineering ...

2021-2022







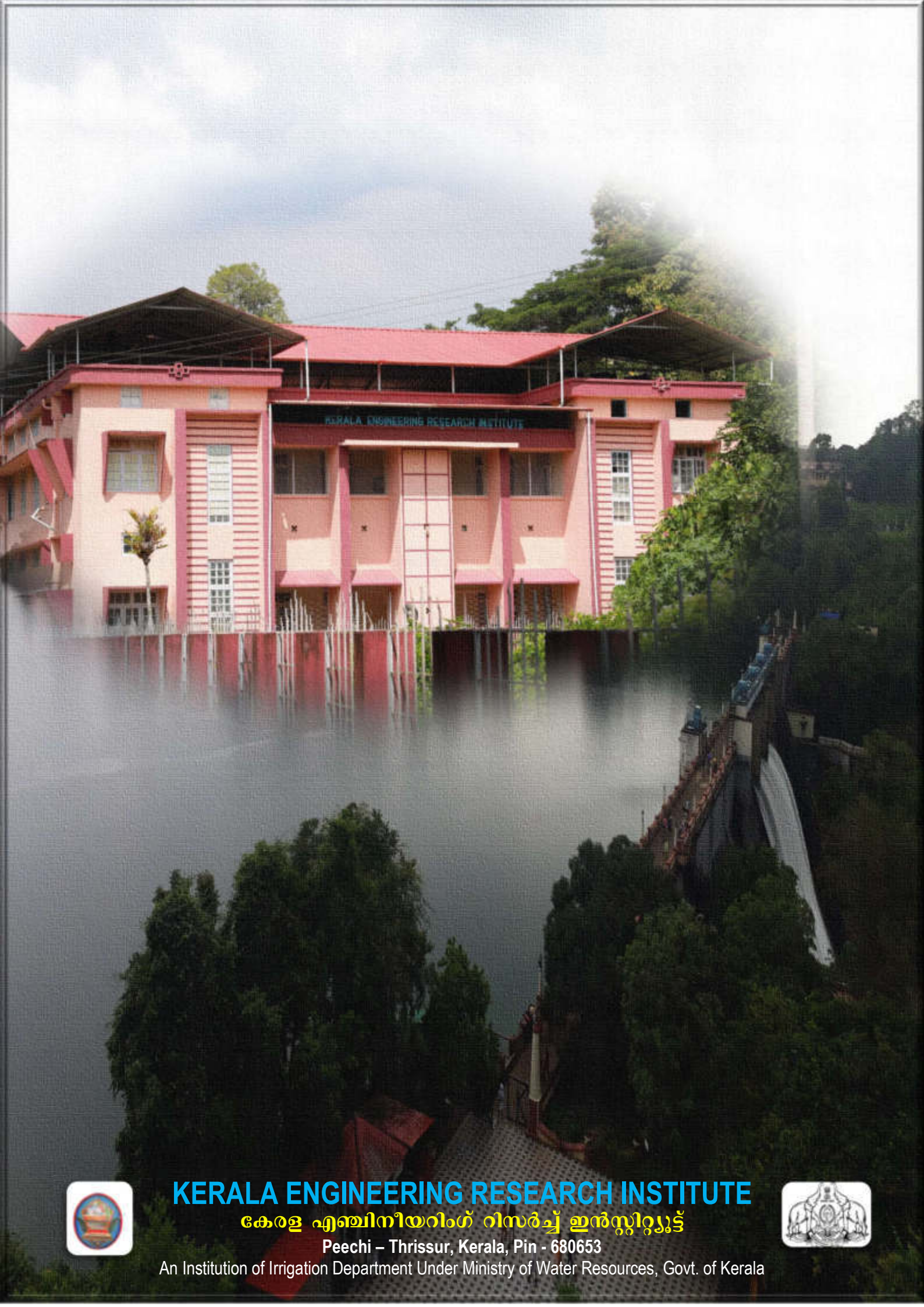


23 G	Fundamental studies using Smart Station for the year 2021-22- Topographic investigation of Kottoor branch canal from Ch. 16200m of LBMC and three distributaries for the year 2021-22	3.33	C	3.322	**99.76%**
23. H	Fundamental studies using Smart Station for the year 2021-22- Topographic investigation of command area for implementing community micro irrigation at Vazhavatta-Cheepram in Muttil Panchayath of Wayanad District.	3.35	C	3.346	**99.89%**
23. I	Fundamental Studies using Smart Station for the year 2021-22 - Topographical investigation of Kayamkulam Branch canal of Kallada Irrigation Project from Ch.0m to 11500m	2	C	2.000	**99.99%**
23 J	Topographic surveying of Peechi Dam Campus including Vallikkayam saddle dam and allied features	2.32	C	2.319	**99.97%**
23 K	Conducting Topographic investigation in Kurumali river in connection with rehabilitation of Attappilly Regulator cum Bridge	1.29	C	1.258	**97.55%**
24	Routine actitivies of Coastal Engineering Division Office and Offices of Director, F & AR and Joint Director, Hydraulic Research	2.00	C	2.00	**100.00%**

25	Maintenance of the model area of the Coastal Engineering Division	0.50	C	0.489	**97.77%**
26	Annual Maintenance and purchase of accessories for Smart Station	1.50	C	1.499	**99.94%**
27	Purchase of Robotic Total station compatible with Leica GS -18 T DGPS and accessories	17.93	C	17.924	**99.97%**
	Total	**41.93**	**C**	**41.77**	**99.62%**
C	**Hydraulics Division (Sub division office)**				
28	Model study of Kuttiyadi Dam Phase II	0.50	C	0.48	**95.05%**
29	Renovation of Model Area I and II	2.15	C	2.11	**98.09%**
30	Upgradation of Hydraulics Lab	3.00	C	2.71	**90.24%**
31	Maintenance of Instrumentation workshop building for using as a model lab Phase II	10.00	C	9.59	**95.86%**

32	Routine maintenance of Meteorological Station for the year 2021 - 2022	1.50	C	1.18	**78.51%**
33	Routine works of Hydraulic Division office for the year 2021 - 22	1.15	C	0.90	**78.05%**
34	Routine maintenance of Kerala model and building housing model for the year 2021 - 22	0.70	C	0.62	**88.47%**
35	Routine maintenance of Model area I and II for the year 2021 - 2022	1.00	C	1.00	**99.53%**
36	Maintenance and yearly charges of FTTH internet connection of KERI Offices for the year 2021 - 22	0.60	C	0.51	**85.05%**
37	Providing wireless internet facility for Director Office and other Offices	2.40	C	2.21	**92.18%**
	Total	**23.00**	**C**	**21.29**	**92.57%**
	Total-Joint Director, Hydraulic Research, KERI, Peechi	**94.63**	**19(C)**	**92.16840**	**97.40%**
	Grand Total - KERI, Peechi	**150.00**	**36(C)**	**141.38580**	**94.26%**

Kerala Engineering Research Institute



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Peechi – Thrissur, Kerala, Pin - 680653

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