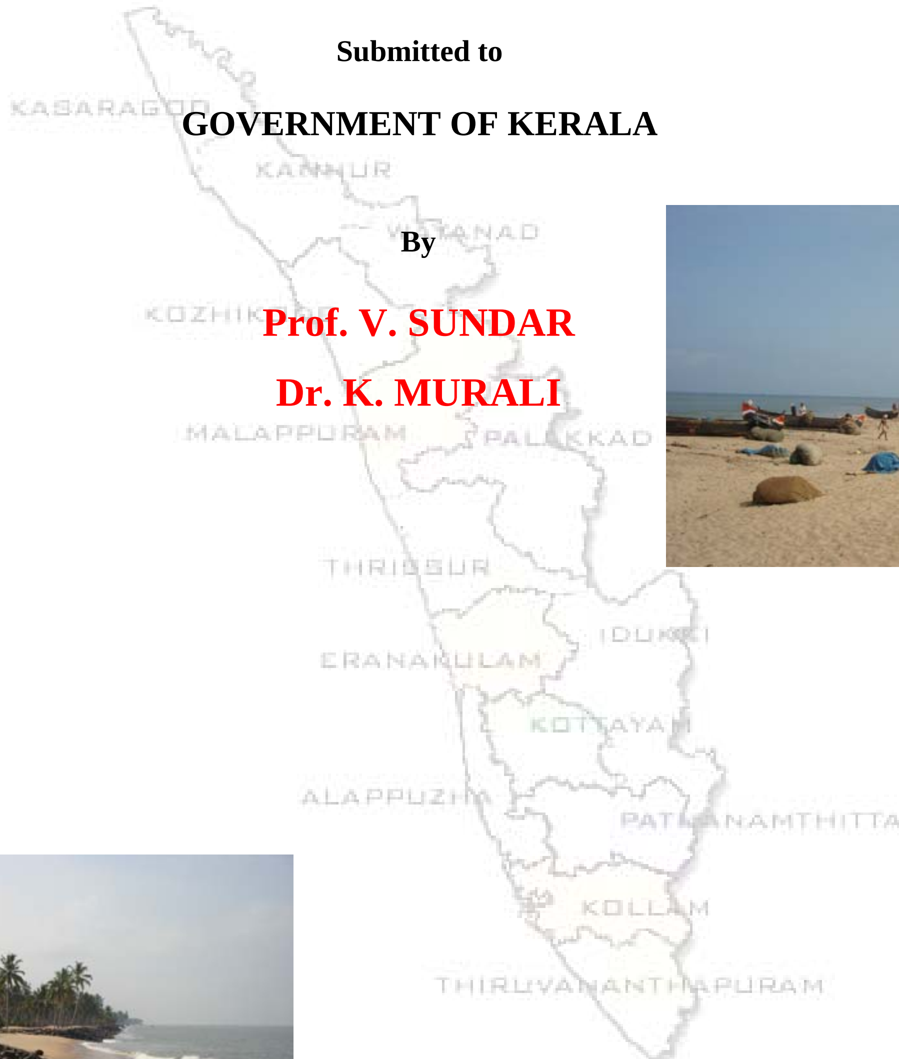
PLANNING OF COASTAL PROTECTION MEASURES ALONG KERALA COAST

Final Report

Submitted to

GOVERNMENT OF KERALA



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EXECUTIVE SUMMARY

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This report presents the outcome of a study conducted for Government of Kerala in order for the state to put forth appropriate plans for the management of its coast from erosion due to waves and flooding events due to extreme waves, storm surges and even tsunamis. The state lies between 8^0 18 ' and 12^0 48 ' north latitude and 74^0 52' and 77^0 22' east longitude. Kerala has about 560 km long coastline of which about 350 km is already protected with sea walls. The government of Kerala is planning to protect the coast of Kerala under the Tsunami Rehabilitation Plan (TRP).

The terms of reference for the present project for Kerala coast excluding the rivers/ drains, estuaries, ports & harbours, fishing harbours, swamps, back waters, etc - will be mainly to identify the stretch of the coast subjected to continuous vulnerable erosion and propose suitable coastal protection measures by taking into consideration the attack due to extreme events. In order to accomplish the project objectives, a team of experts from IIT Madras visited the entire coast of Kerala covered under 3 divisions of Kerala Irrigation Department (KID) in 2 phases. During the field surveys, present status of existing coastal protection mainly seawall, historical behavior of the shoreline, general direction of littoral movement, coastal and beach features, possibilities of short and long term threats to the coastal community, importance of the location/coast etc., have been observed and recorded.

Based on the field survey, various proposals for protection of the coastal stretches are provided in this report. The proposals consist of rehabilitation of existing seawall, construction of groin field, plantations, training walls and application of geo-synthetics like gabions and geo-tubes, etc. Only conceptual layout of the protection scheme for the entire coast has been suggested in this project. The detailed layout could only be arrived after a detail site specific study on the wave climate and littoral drift movement.

Thiruvananthapuram district is the southern most district in Kerala. Panathurakkara has been identified as the most vulnerable stretch in this district. Rehabilitation of seawall with stabilization of the shoreline by means of Groin field has been advised here. Shankumukam, Beemapally, South Thumba (Valiyaveli), Thazhampally and Janarthanapuram / Varkala beach have been identified as vulnerable. The solutions proposed here include rehabilitation of existing seawall, construction of new sea wall (Thazhampalli), groin field (Beemapalli) and geo-tubes (Varkala beach). The other stretches in this district have been identified and placed under moderate priority.

The next district investigated was Kollam. The locations namely, Thanni, Maruthadi, Sraikkadu, Jayanthi Colony, Kayamkulam, Pathiankara are identified as the most vulnerable stretches in this district and placed under high priority. In order to stabilize the coast, transition groin fields are proposed at Thanni, Jayanthi Colony, Pathiankara and Kayamkulam. It is advisable to rehabilitate the seawalls in the other stretches. The stretch of the coast at Kappil, Mukham, Vallavilthoppu have been identified as vulnerable and suitable mitigation measures are suggested for these stretches of the coast. The other stretches in this district have been identified and placed under moderate priority.

Another severely affected district during the Indian Ocean Tsunami and by perennial erosion is the Alappuzha district. The stretch of the coast at Neerkunnam, Punnapra, Vadackal, Kadakkarapally and Andhakaranazhy in this district have been identified as most vulnerable. Except at Vadackal (where a fish landing centre is suggested) and Andhakaranazhy (where a groin field is proposed), rehabilitation of seawall is suggested. Kattoor and the stretch South of Andhakaranazhy are identified as vulnerable areas and appropriate mitigation measures are suggested. The other stretches in this district have been identified and placed under moderate priority.

Ernakulam district was the other severely affected districts of Kerala during the Indian Ocean Tsunami. The stretch of the coast along Gunduparambu, Njarakal, Nayarambulam and Nayarambulam North have been identified as the most vulnerable areas in this district. While rehabilitation of existing seawall will have to be carried out using the cross sections provided in this report, construction of additional groin field at Nayarambulam North is expected to stabilize the beach in the long term. Kandekkadu fishing gap, Edavanakadu (Chathangadu) and Cherai beach are identified to be vulnerable and appropriate measures are provided in these coastal belts. Specifically, submerged geo-tubes will be more attractive to the tourist spot of Cherai beach. The other stretches in this district have been identified and placed under moderate priority.

In the Thirissur district, Achangadi has been identified as most vulnerable and rehabilitation of existing seawall has been proposed for this stretch. The vulnerable areas in this district are North Anchangadi, Koolimuttam, Koorukuzhi and Chettuvai. The mitigation measures are also proposed for these stretches.

The Malappuram district is between Thirissur and Kozhikkodu. Ponnani fishing harbour and Parappanangadi of this district have been identified to be most vulnerable. While a transition groin field is suggested for Ponnani fishing harbour, extension of exiting groins and rehabilitation of seawall is proposed for Parappanangadi. In addition, Cheerankadapuram has been identified vulnerable and appropriate measure is suggested.

Butt Road Beach in the Kozikkodu district has been identified as most vulnerable and a new seawall has been proposed for this stretch. Kallai River mouth, Korapuzha and Poozhithala are identified as the other vulnerable areas and appropriate measures are provided in this report.

In the Kannur district, Kannampuzha has been identified as the most vulnerable area and training walls for a water depth of 5m is suggested. The only vulnerable area in this district is Pettipalem and appropriate mitigation measure is provided.

Kasaba beach in the Kasargod district has been identified as the most vulnerable. A transition groin field has been proposed in this area.

Dr. V. Sundar
&
Dr. K. Murali

CHAPTER 1
INTRODUCTION

1.1 GENERAL

The state of Kerala is situated along the south west coast of India. It stretches along the coast of the Arabian Sea and is separated from the rest of the sub-continent by the steep Western Ghats. The state lies between 8^0 18 ' and 12^0 48 ' north latitude and 74^0 52' and 77^0 22' east longitude. The breadth of the state varies from 32 km in the extreme north and south to over 120 km in the middle. The layout of Kerala state is shown in Fig. 1.1. The government of Kerala is planning to protect the coast of Kerala under the Tsunami Rehabilisation Plan (TRP). This responsibility has been entrusted to Department of Ocean Engineering, IIT Madras vide letter from Ms.Nivedita P.Haran, Principal Secretary, Government of Kerala, No.2774/SLMC3/07/DMD Dt.26-03-2007 addressed to Prof.V.Sundar.

1.2 GEOLOGY OF THE COASTLINE

The coast of Kerala consists of 80% of sandy beaches, 5% of Rocky coast and 15% of Muddy flats. The total length of coastline is about 569.7 km of which about 480.0 km is affected by erosion. (Sanil Kumar et.al., 2006).

1.3 WAVE CLIMATE

The coast of Kerala experiences two distinct seasons based on the wave climate. These are November to April and June to September with May and October as transition months. The period between May and October may be termed as rough weather season for simplicity. The offshore wave data for the grids adjoining Kerala coast is defined in Table.1.1 and Table.1.2 as defined by NIO, Goa for the offshore grids of 6 and 8 as shown in Fig.1.2.

1.4 WIND

The average wind speed during south west monsoon (June to Sept) period is 35kmph, frequently raising up to 45 to 55kmph. The average wind speed during North East monsoon (October to December) prevails around 20kmph. During the cyclonic period wind speed often exceeds 100kmph (Sanil Kumar et.al., 2006).

Table 1.1 Offshore wave data for Grid 6 of Fig.1.2 (6°N 75°E – 10°N 80° E)

Month	Wave Direction w.r.t North	Wave height (m)	Wave Period (sec)
January	50°	1.5	5
February	40°	1.0	5
March	180°	1.0	5
April	180°	1.0	5
May	270°	1.0	5
June	270°	2.0	6
July	270°	2.0	6
August	270°	2.0	5
September	270°	2.0	5
October	270°	1.0	5
November	180°	1.5	5
December	180°	1.0	5

Table 1.2 Offshore wave data for Grid 8 of Fig.1.2 (10°N 70°E – 15°N 75° E)

Month	Wave Direction w.r.t North	Average Wave height (m)	Wave Period (sec)
January	330°	1.25	6.5
February	330°	1.25	6.5
March	330°	1.25	6.5
April	315°	1.25	6.5
May	275°	2.5	7.5
June	260°	2.5	7.5
July	270°	2.75	7.5
August	270°	2.0	7.5
September	290°	1.75	6.5
October	285°	1.25	6.5
November	350°	1.25	6.5
December	350°	1.25	6.5

1.5 TIDES

The tide levels for several locations along the Indian coast as analysed by (Sanil Kumar et.al., 2006) are shown in Fig. 1.3. It is observed that the Highest High Water is about 1.5 m at Kochi.

1.6 LONGSHORE CURRENTS

The current along the Kerala coast varies dramatically as the direction of the current is not constant along the entire coast. Mallik et al. (1987) gave a comprehensive atlas of the nature of the current as reproduced in Fig.1.4. It is observed that the current magnitudes are up to 70 cm/s. It is seen that the direction of the longshore current that dictates the direction of littoral drift for the stretch south of Quilon is southwards. In the stretch north of Quilon the direction of the current is predominantly a northward with reversals at certain locations.

1.7 LITTORAL DRIFT

Littoral drift along the Kerala coast is of varying nature unlike the east coast of India. It is marked with mud banks, a peculiar phenomenon seen only off Kerala. As per the observations of Chandramohan (1988), the quantity and direction of littoral drift at selected locations along the Kerala coast are provided in Table 1.3a. The later work of Sanil Kumar et al (2006) provides alternate estimates of littoral drift and the same are tabulated in Table 1.3b. The estimates of littoral drift provided in the tables including its direction looks quite different and hence a comprehensive study is warranted.

Table 1.3a. Sediment transport rates at different stretches along Kerala Coast (Chandramohan,1988).

S.No.	Location	Net sediment transport rate (in 10^6 m^3/yr)	Net sediment transport direction	Gross sediment transport rate (in 10^6 m^3/yr)
1	Vizhinjam	1.09	South	2.27
2	Thiruvananthapuram	1.01	South	2.24
3	Quilon	0.95	South	2.2
4	Allepey	0.385	North	1.7
5	Manakkodam	0.071	South	1.55
6	Cochi	0.284	North	1.67

Table 1.3b. Sediment transport rates at different stretches along Kerala Coast (Sanil Kumar et.al., 2006).

S.No.	Location	Net sediment transport rate (in 10^6 m^3/yr)	Net sediment transport direction	Gross sediment transport rate (m^3/yr)
1	Kasargod	0.74	South	0.96
2	Kannur	0.019	South	0.56
3	Kozhikode	0.11	South	0.26
4	Nattika	0.19	North	0.66
5	Andhakaranazhi	0.20	South	0.60
6	Allepey	0.017	North	0.063
7	Kollam	0.38	South	0.81
8	Thiruvananthapuram	0.1	North	1.2

1.8 BACKWATERS

The Kerala Backwaters are a chain of brackish lagoons and lakes lying parallel to the Arabian Sea coast (known as the Malabar Coast) of Kerala state in southern India. A map of the backwaters in the Kerala state is presented in Fig. 1.5. The network includes five large lakes (including Ashtamudi Kayal and Vembanad Kayal) linked by 1500 km of canals, both manmade and natural, fed by 38 rivers, and extending virtually half the length of Kerala state. The backwaters were formed by the action of waves and shore currents creating low barrier islands across the mouths of the many rivers flowing down from the Western Ghats range.

Vembanad lake is the largest of the lakes, covering an area of 200 sq km, and bordered by Alappuzha (Alleppey), Kottayam, and Ernakulam districts. The port of Kochi (Cochin) is located at the lake's outlet to the Arabian Sea. Alleppey, "Venice of the East" has a large network of canals that meander through the town. The Vallam Kali (the Snake Boat Race) held every year in August is a major attraction. Ashtamudi Lake is located in Kollam District, and the town of Kollam (Quilon) lies at its outlet.

1.9 RIVERS

There are 44 rivers in the state, of which 41 originate from the Western Ghats and flow towards west into the Arabian sea. A layout of rivers flowing in Kerala state is shown in Fig. 1.6. Three rivers, the Kabani, Bhavani and Pambar rise in Kerala and flow eastwards, Kababi into Karnataka and the other two into Tamil Nadu. As the Western Ghats are nowhere more than 120 kms from the sea, all these rivers are comparatively short. The presence of a large number of rivers has made Kerala rich in water resources, which are being harnessed for power generation and irrigation.

1.10 PORTS IN KERALA

There are 17 Intermediate & Minor Ports in Kerala. The Minor and Intermediate Ports are under the Administration of Government of Kerala. The Ports are administered directly by the Director of Ports who is headquartered at Thiruvananthapuram. There are three regional officers at Neendakara, Alappuzha and Kozhikkode. Besides the Port of Kochi (a Major Port governed by Major Port Trusts Act, 1963), there are 3 Intermediate and 14 Minor Ports in Kerala. They are Neendakara, Alappuzha, Kozhikkode (Intermediate Ports) and Vizhinjam, Valiyathura, Thankasserry, Kayamkulam, Manakkodam, Munambam, Ponnani, Beypore, Vadakara, Thalasserry, Manjeswaram, Neeleswaram, Kannur, Azhikkal and Kasaragode (Minor Ports). The Major Port of Kochi is under the Ministry of Shipping, Government of India while the intermediate and minor ports are under the administration of the Government of Kerala.

1.11 MINERALS

A wide variety of minerals exist in the state of Kerala and the distribution of which is presented in Fig.1.7.

1.12 ECONOMIC SIGNIFICANCE

Connected by artificial canals, the backwaters form an economical means of transit, and a large local trade is carried on by inland navigation. Fishing and fish curing is an important industry. Kettuvallam (Kerala houseboats) in the backwaters are one of the best tourist attractions in Kerala.

1.13 TSUNAMI AFFECTED AREAS IN KERALA

The Indian Ocean tsunami of December 26, 2004, not only affected the coast of India facing the Bay of Bengal but also part of the Arabian Sea coast of India. In particular, the tsunami caused loss of life and heavy damage on some parts of the Kerala coast in southwest India. The tsunami generated at Sumatra, propagated towards west, south of Sri Lanka. Part of the tsunami energy was diffracted around Sri Lanka and the southern tip of India and moved northward into the Arabian Sea. However, tsunami, being a long gravity wave with a length of a few hundred kilometers, has to take a wide turn. In that process, it missed the very southern part of the Kerala coast and did not achieve large amplitudes there. However, further north, the tsunami achieved amplitudes of upto 5 m and caused loss of life and significant damage. The details of the run-up of tsunami are given in Table 1.4.

Table 1.4. Tsunami run-up level along the kerala cost (Prakash et al.,2005)

Location	Run-up level (m)
Nandhi (Kasargod)	1.0
Chootad(Cannanore)	3.0-3.5
Dharmadam (Tellichery)	2.0-2.5
Calicut	1.5-2.0
Ponnani	0.5-1.0
Edavanakad (cochin)	4.0-4.5
Andakaranazhi	3.0-3.5
Allepey	2.5-3.0
Valiayhikkal(Kayamkulam)	4.5-5.0
Azhikkal	4.5-5.0
Thangasseri (Quilon)	2.5-3.0
Paravur	2.0-2.5
Vizhimjam (Trivandrum)	2.0-2.5

1.14 REQUIREMENTS FOR A DETAILED EVALUATION FOR PROTECTION MEASURES

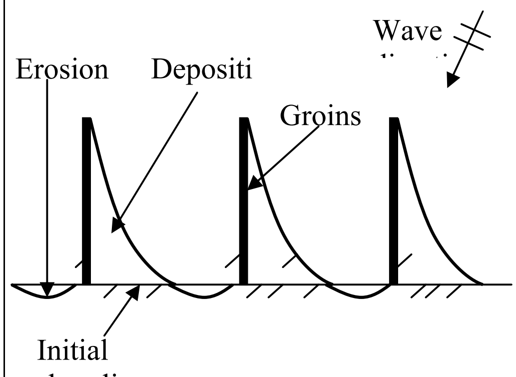
- Collection of seasonal field data and analyse the same critically
- Use old and new satellite imageries to assess the shoreline behaviour
- Use of G.I.S as a tool to map the coastal region of Kerala. This would help in the planning process of coastal protection.
- A field visit along the coast.
- If erosion is observed continuously over a number of years, it is chronic erosion
- If a coast is stable over a long period, but subjected to occasional severe erosion (due to cyclone etc) and then recovers, it is called acute erosion.
- The effect of the recent tsunami on the shoreline should be considered while, detail planning is taken up. This can be accomplished using the techniques of remote sensing and G.I.S.

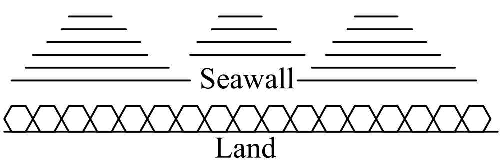
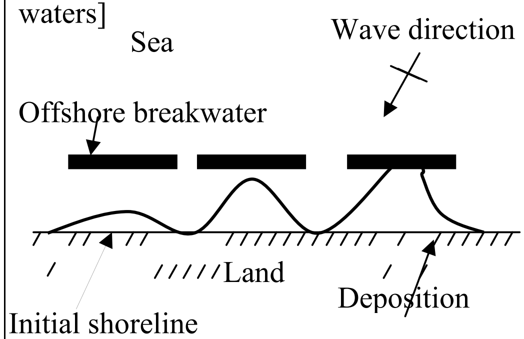
1.15 COASTAL PROTECTION OPTIONS

General

Shorelines are constantly being changed by the interaction between wind, water and land. To protect the coast and properties, there are various methods which are discussed in Table 1. 5.

Table 1.5. Various measures of coastal protection

<table>
<tr><th>HARD MEASURES</th><th>SOFT MEASURES</th></tr>
<tr><td>Normal to the shoreline [groins]

</td><td rowspan="3">Replenishment of coast with sand.
(Artificial beach nourishment)

BIO-SHIELDS</td></tr>
<tr><td>Parallel to the shoreline on shore [seawalls]

</td></tr>
<tr><td>Parallel to the shore[offshore break waters]

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Artificial beach nourishment

Of all the above measures, the method of artificial nourishment deserves special mention due to the following merits:-

- It satisfies the basic need of the material demand and has all the characteristics of a natural beach.

- It increases the stability of not only the beach under protection but also the adjacent shore due to the supply of materials through longshore drift.
- More economical than massive structures as the materials for nourishment may be taken from offshore area and
- Development of the technique of dredging and sand pumping have popularised this method to effect economy.
- Sand dredged from a borrow site is deposited on the eroding shoreline

Dutch design method

- Perform coastal measurements (preferably for at least 10 years)
- Calculate the "loss of sand" in m^3/year per coastal section
- Add 40 % loss
- Multiply this quantity with a convenient lifetime (for example five years)
- Put this quantity somewhere on the beach between the low-water-minus- 1-meter line and the dune foot.

This method is simple and straightforward. It does not require mathematical models and wave (or wind) data, but need good quality measurements.

Placement of sand

Usually the dredged sand is dumped close inshore using split hopper dredger or pumping directly onto the beach using floating and/or submerged pipeline.

Borrow site

Sources of sand for beach nourishment can include upland sand deposits, estuaries, lagoons, inlets, sandy shoals dredged to clear channels for navigation and deposits in the near shore area. The most common source of sand used in nourishment projects is near shore deposits.

Drawbacks

- Once placed on the beach, the quality of sand is often sub-standard or even darker in color, despite assurances otherwise.
- Quality sand sources are becoming more difficult to locate. The problem will only get worse as sources are depleted and quality sand even more expensive.
- Dredging of sand often sucks sea turtles directly off the sea floor, killing them.

- Beach nourishment is a sudden, disruptive and unnatural process.
- It is expensive.

In the Indian context, one successful project on artificial beach nourishment has the coast north of the harbour of Pondichery.

Hard Measures

General

Unfortunately sustainable soft solution is always not possible. In such cases, the choice is either to face the problems or to shift them elsewhere, sometimes if there is a very important land to be protected and if further down the coast there are no important features, the following hard solutions can be used. The above stated shifting the zones of problems can be overcome if the protection measures are carefully planned out.

Seawalls and Bulkheads

Seawalls and Bulkheads are structures placed parallel or nearly parallel to the shoreline to separate the land from water area. The primary purpose of a bulkhead is to retain or prevent sliding of the land, with a secondary purpose of affording protection to the back shore against damage by wave action. The most common and widespread coastal engineering tool for the protection of shoreline is the seawall as a hard measure. Varieties of seawalls / dikes constructed world wide is shown in Fig. 1.8. A typical concrete seawall cross-section is shown in Fig. 1.9. A view of an existing concrete seawall is shown in photo.1.1. Seawall protection is for all practical purposes an irreversible act because the beach in front of it is often removed. The seawall will eventually have to be rehabilitated in constant intervals with bigger size stones as can be seen in photo.1.2. A seawall would not be more effective on coasts that experience predominant littoral drift, like the east coast of India. For example, the seawall along north of Chennai, Visakhapatnam and Paradeep ports have been suffering damages continuously. A strong toe for seawall is very essential as in the case of the seawall for a particular stretch, north of Chennai harbour shown in photo.1.3. In locations, where, large size natural rocks is scanty, gabions (wire net filled with stones of smaller size) as shown in photo.1.4 can be adopted. At locations of abundance of sand (near river mouths which may be dredged as a part of river training works) Geo-bags or Geo-tubes can be adopted as can be seen in photo. 1.5.

Single long groin

When the long shore sediment transport threatens to cause a problem such as siltation of harbour entrance etc., a long groin can be constructed just slightly up drift from the harbour entrance or river mouth. Though, it prevents sediment movement, it can cause erosion on the other side. The different types of configurations of groins are shown in Fig.1.10.

Series of groins

Another way of using groins is to build a series of small groins (groin field) at shorter intervals along the affected coast. This will tend to stabilize the entire coast by keeping the sand trapped between them. Typical shoreline changes due to a single groin and that due to a groin field are projected in Figs.1.11 and 1.12 respectively. The oldest groin in the world in Vissingen, The Netherlands is shown in photo.1.6. The effect of the groin field as a protection measure for the Island of Nordeney, Germany is projected in photo.1.7, while, that of a T-groin field protecting the palm beach area of Florida, USA is shown in photo.1.8. Sometimes unplanned groin works may still be an effective protection measure as in the case of the coast of Cyprus depicted in photo.1.9. Groin fields as a protection measure for Royapuram, Chennai and Kanyakumari district are shown in photos 1.10 and 1.11 respectively.

Off shore Detached Breakwaters

Offshore detached breakwaters are structures designed to protect the beach by dissipating the energy of the incoming waves. They restrict onshore and offshore transport of sand. Typical shoreline changes due to a single offshore breakwater and that due to a series of offshore detached breakwaters are projected in Figs. 1.13 and 1.14 respectively. Although, this measure is the most effective compared to all other hard measures, as it is quite expensive and difficult to construct requiring special construction equipments, further discussion on this measure is not presented.

Plantations

The roots and stems of plants are natural traps for sand particles that would otherwise be carried away by wind, currents and waves. A flat beach is more favourable for such plantation. In addition marsh vegetation acts as a buffer against wave action and tsunami to some extent. Vegetation as a protection can both reduce loads and increase strength. Vegetation has a relatively large resistance to waves and currents, thus reducing the loads. Roots can increase the strength by protecting the grains on a micro scale or by reinforcing them. Fig1.15 shows strength of vegetation with wave load. The outside plants are "front soldiers" and have to withstand a higher load than the inside plants. At the front, due to the high velocities, scour can also occur if the roots are not able to retain the soil. The effect can be that the outside plants are damaged or disappear. As long as the number of soldiers is large enough, the battle can still be won. Vegetation also influences the resistance against sliding. The roots clearly armour the soil, see Fig.1.16 from Schiereck, 2001.

Mangrove forests are the natural vegetation of many tropical coasts and tidal inlets; they form a highly productive ecosystem, a nursery for many marine species. Mangroves are essentially the root systems of trees and shrubs which thrive in the shallows of salt water areas (photo. 1.12). They provide an excellent safe habitat for small marine creatures.

Mangrove trees miraculously thrive in very dynamic circumstances. They can cope with salt water where as most other plants cannot. Seedlings have little opportunity to settle, so mangroves are viviparous, giving birth to an almost complete tree in a capsule that can travel with the tide and can turn into an upright standing young tree within a few days.

1.16 OBJECTIVES OF THE PRESENT STUDY

The objectives of the present project for Kerala coast excluding the river / drains, estuaries, ports & harbours, fishing harbours, swamps, back waters, etc will be as follows.

- Identification of villages affected by inundation due to the recent tsunami
- Identification of the stretch of the coast subjected to continuous vulnerable erosion
- To propose suitable coastal protection works by taking into consideration the attack due to tsunami

Only conceptual layout of the protection scheme for the entire Kerala coast would be suggested in this project. The detailed layout only can be arrived after systematic study on the wave propagation and littoral drift movement at a particular site. Hence, the detailed design of the anti-sea erosion works for the coast said above will not be covered in this project. After the present project report is submitted by the undersigned, on an additional request from the concerned Department, the studies can be taken as individual projects for the detailed coastal protection scheme. Even though, the present project addresses on the overall requirement of the coastal protection along the Kerala coast, a particular site in micro scale (i.e., 1 to 3 km stretch) might behave differently from its neighborhood. This needs further attention through in-depth studies.

1.17 IDENTIFICATION OF VULNERABLE AREAS ALONG THE KERALA COAST

In order to accomplish the objectives set in the study, the discussion is based on the different coastal districts of Kerala covered under 3 divisions of Kerala Irrigation Department (KID). These regions are defined as: South Region including the districts of Thiruvananthapuram, Kollam and Alappuzha; Central Region including Ernakulam and Trissur; and North Region including Malappuram, Kozhikode, Kannur and Kasargode. These districts are shown in Fig.1.1.

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Photo. 1.1 View of a typical concrete seawall

Photo. 1.2. Seawall beyond Ernavur experiencing toe erosion

Photo. 1.3 Seawall with toe protection north of Ernavur

Photo 1.4 Use of Gabions

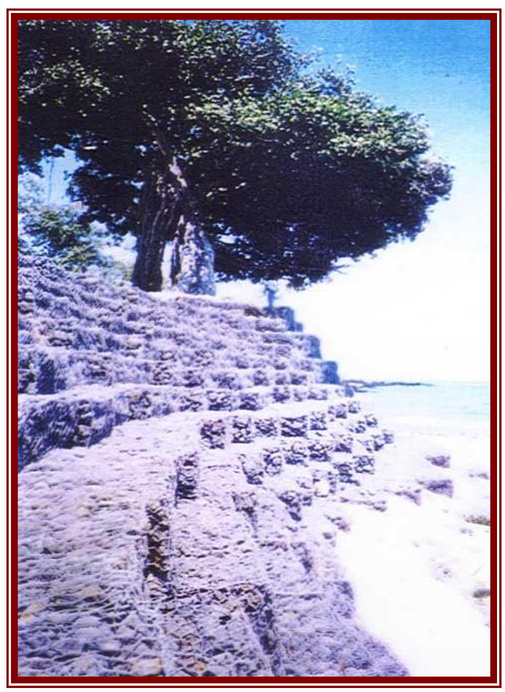


Photo. 1.5 Use of Geo-tubes to protect Island of Sylt, Germany

Photo.1.6 Oldest groins (1503),Vvissingen, Netherlands

Photo.1.7 Groins field protecting the Island of Nordeney, Germany

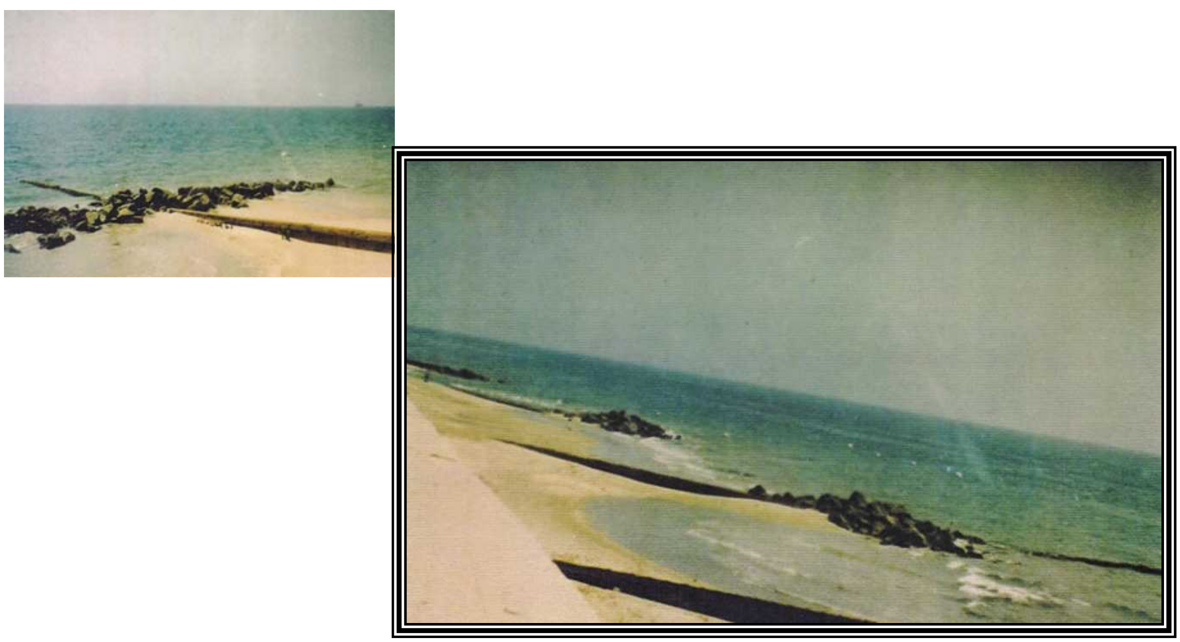


Photo. 1.8 T-Groin field protecting the coast of Florida

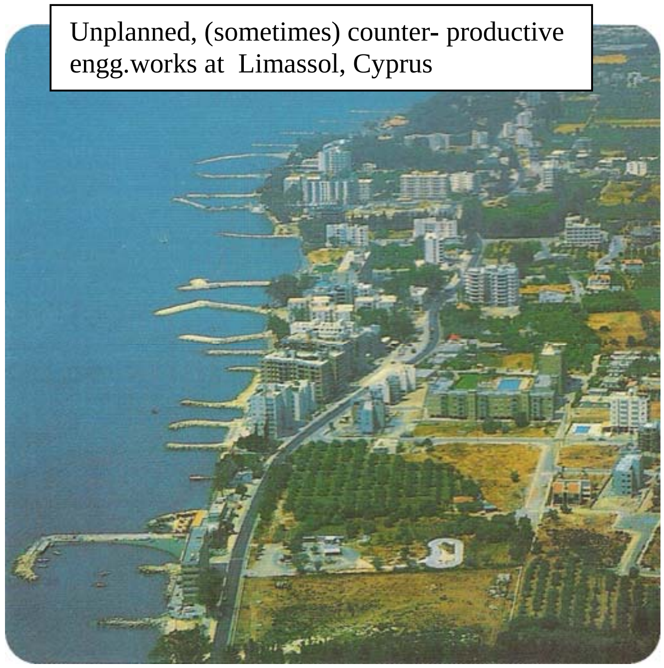


Photo. 1.9 Groins as protection measures

Photo. 1.10. Effect of Groin field in winning the beach (Royapuram, Chennai)

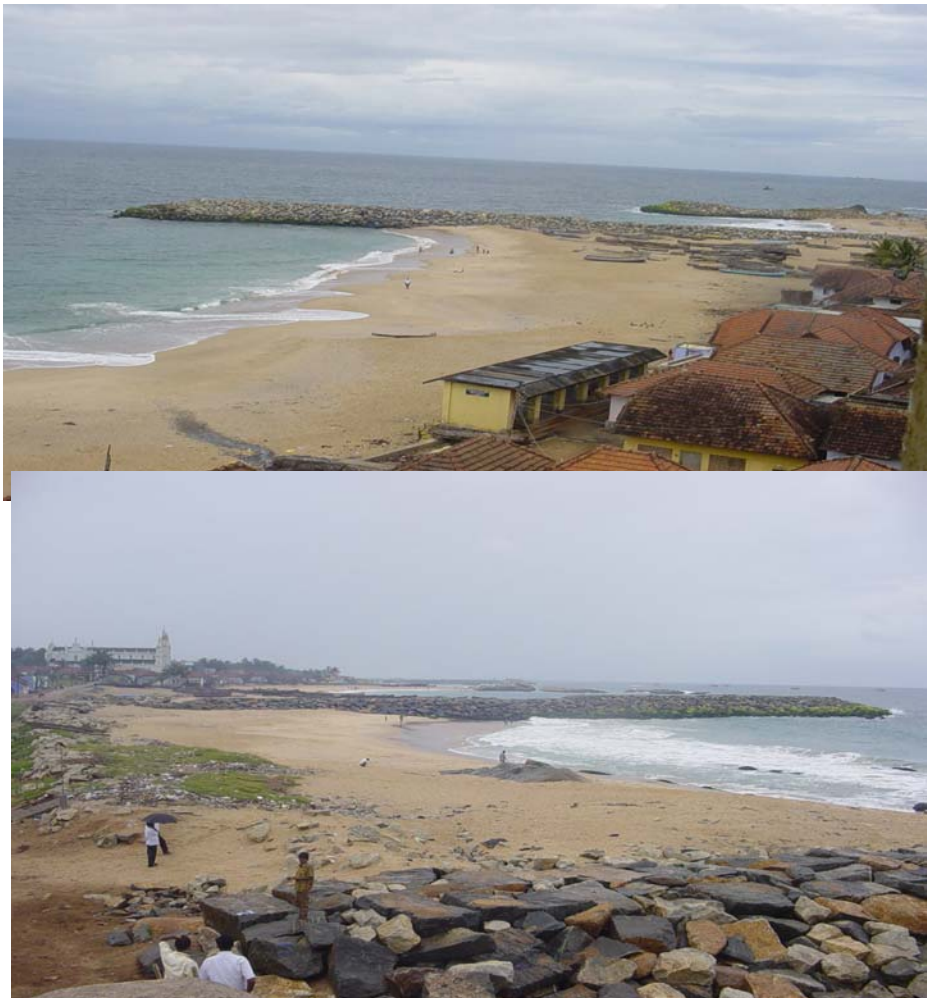


Photo.1.11. Effect of groins as an effective coastal protection measure (Kanyakumari District)

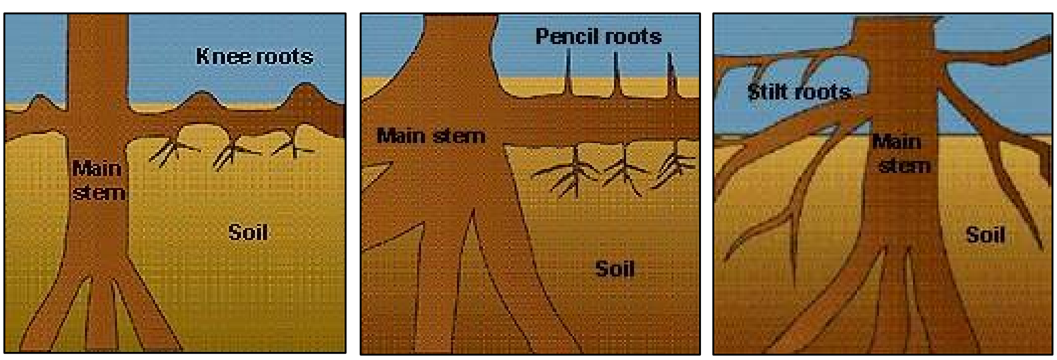


Photo. 1.12 Different root systems of Mangroves that offer resistance to scour.

Fig. 1.1 Layout of Kerala state

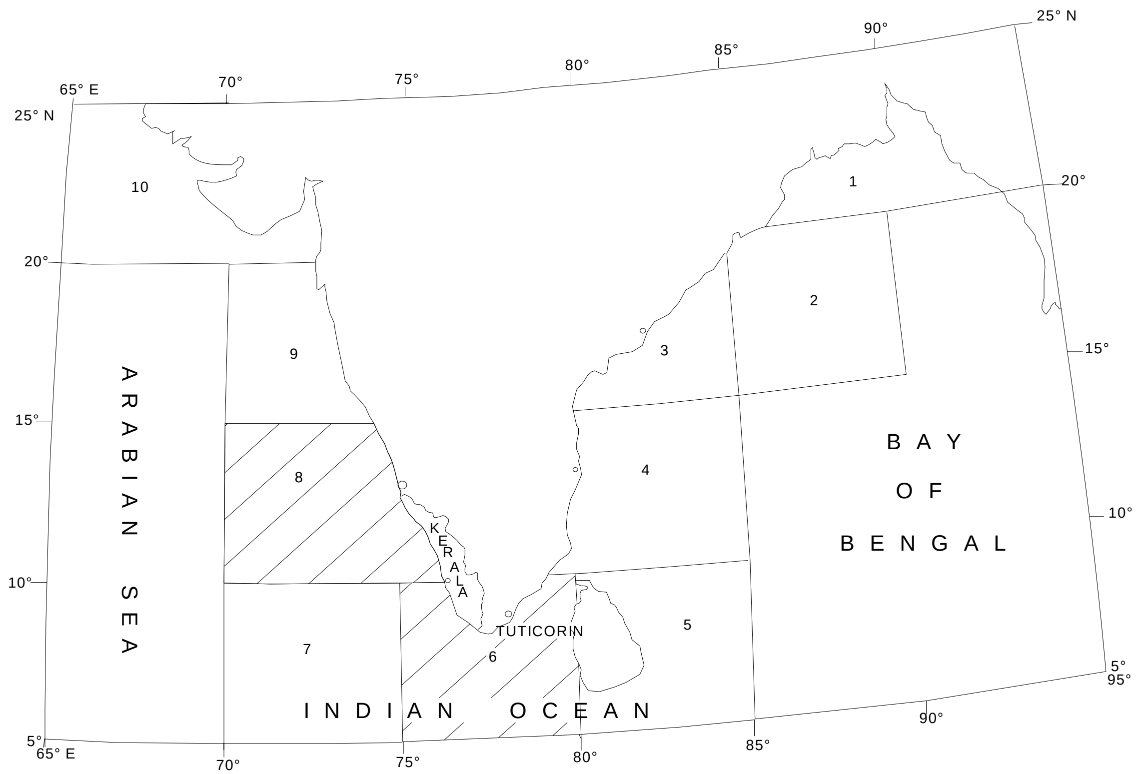


Fig.1.2. Wave Atlas published by NIO

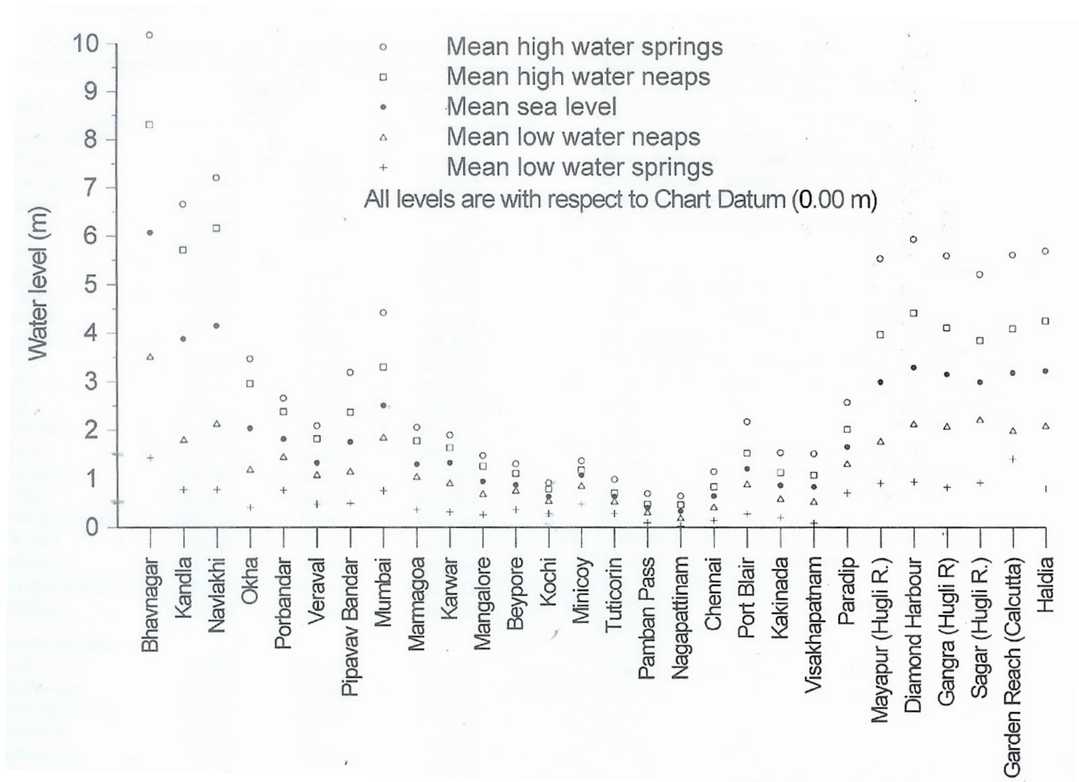


Fig. 1.3. Tidal elevations along the Indian Coast (Sanil Kumar et al. 2006)

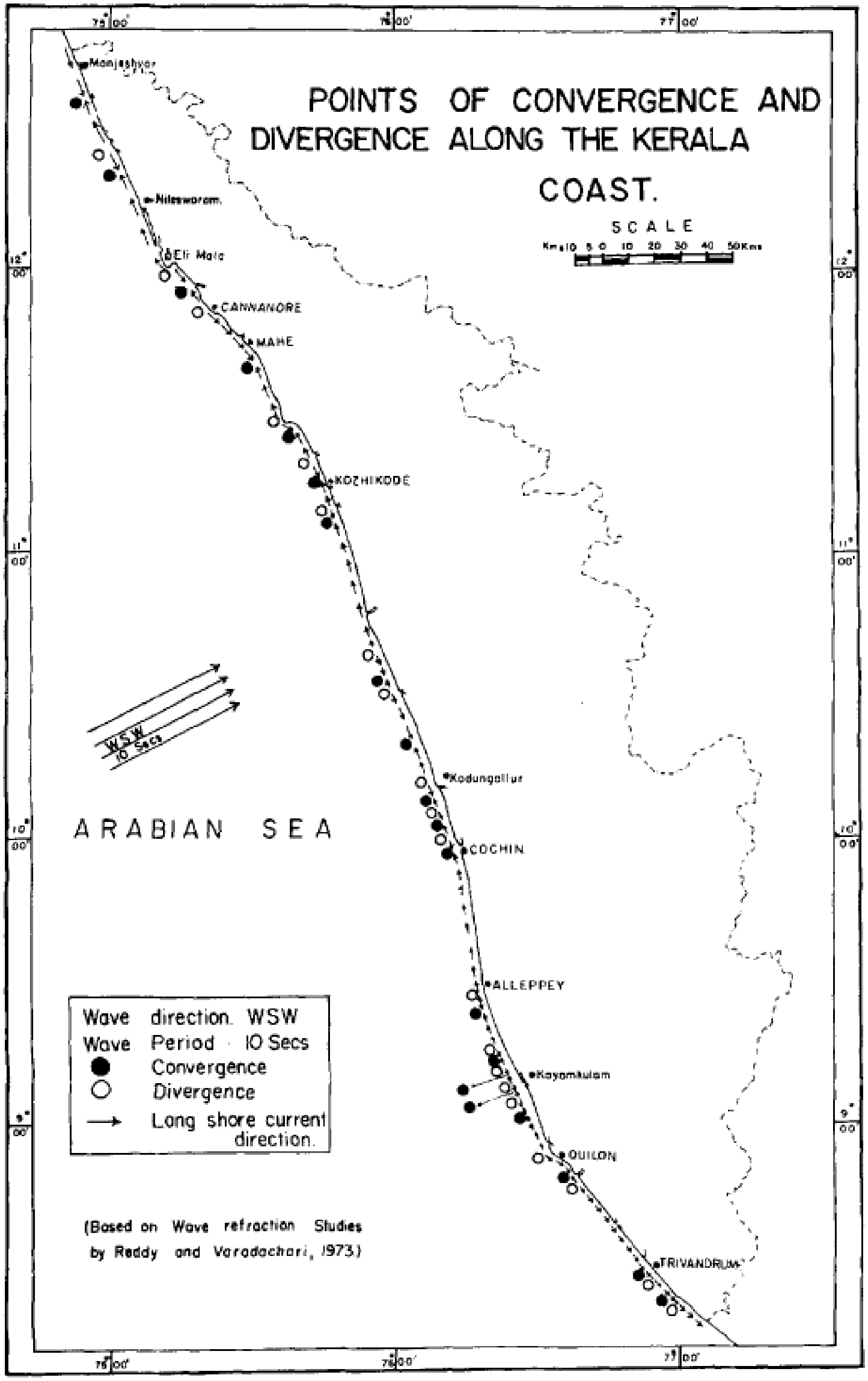


Fig. 1.4. Map showing the longshore currents along the Kerala coast

(Mallik et.al., 1987)

Fig. 1.5. Backwaters in Kerala State

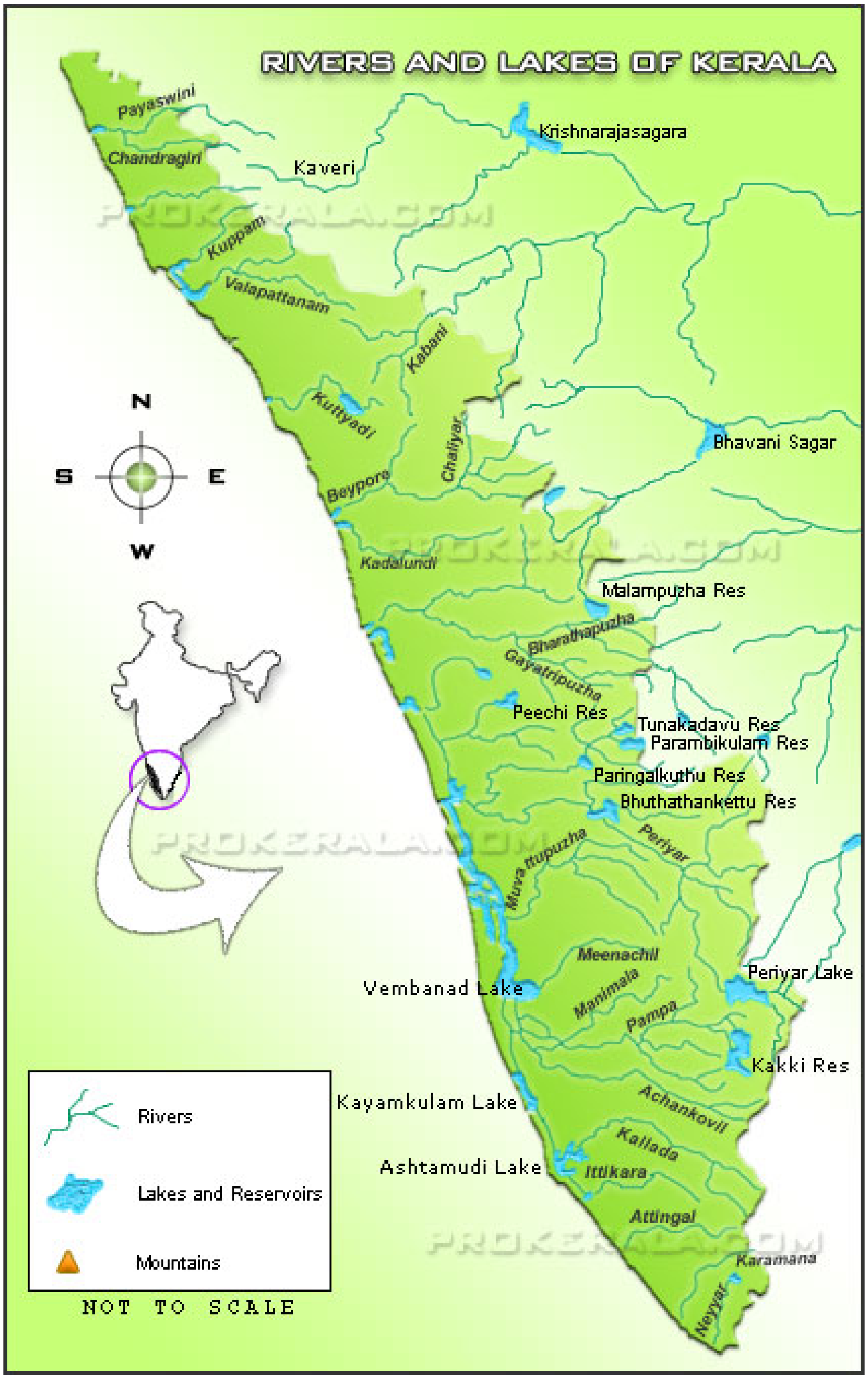


Fig. 1.6. Rivers and Lakes in Kerala State

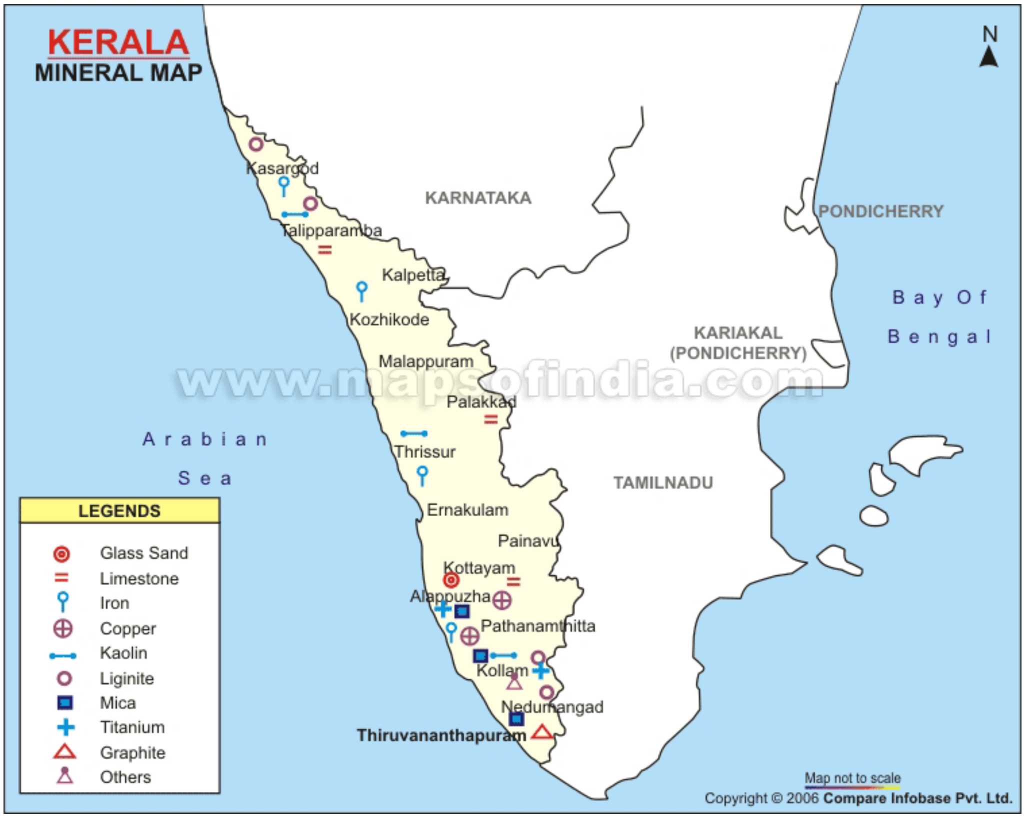


Fig.1.7. Mineral Map of kerala

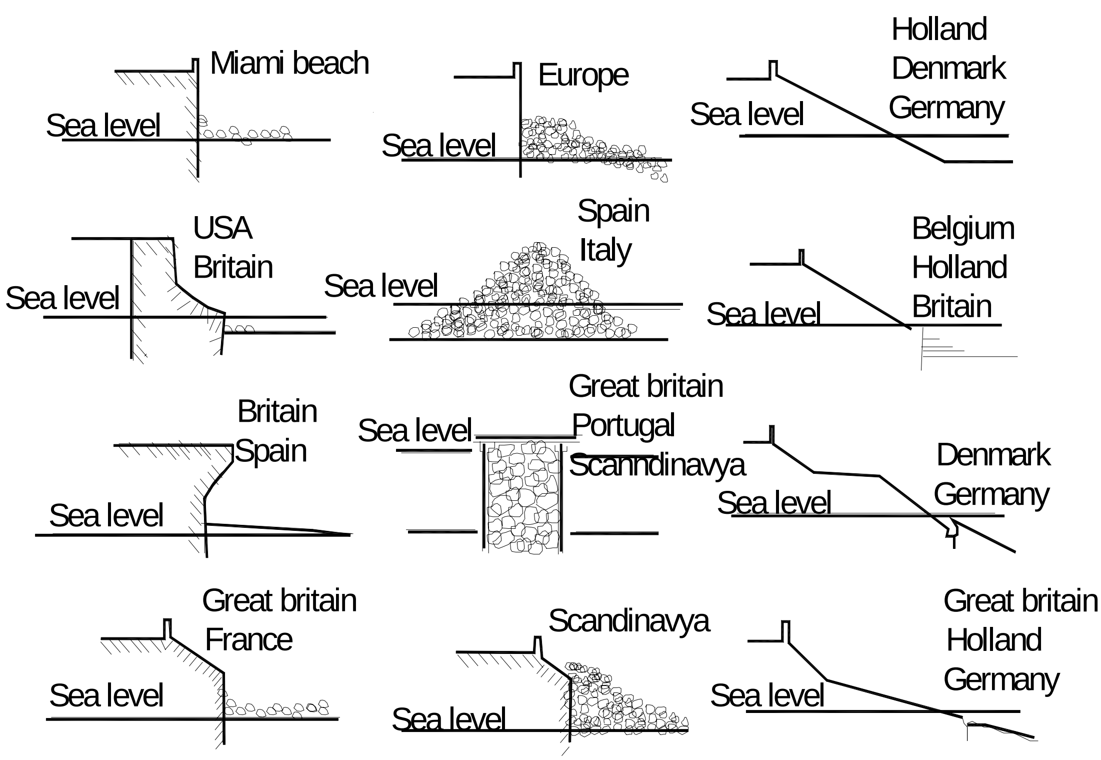


Fig. 1.8 Varieties of seawalls / Dikes

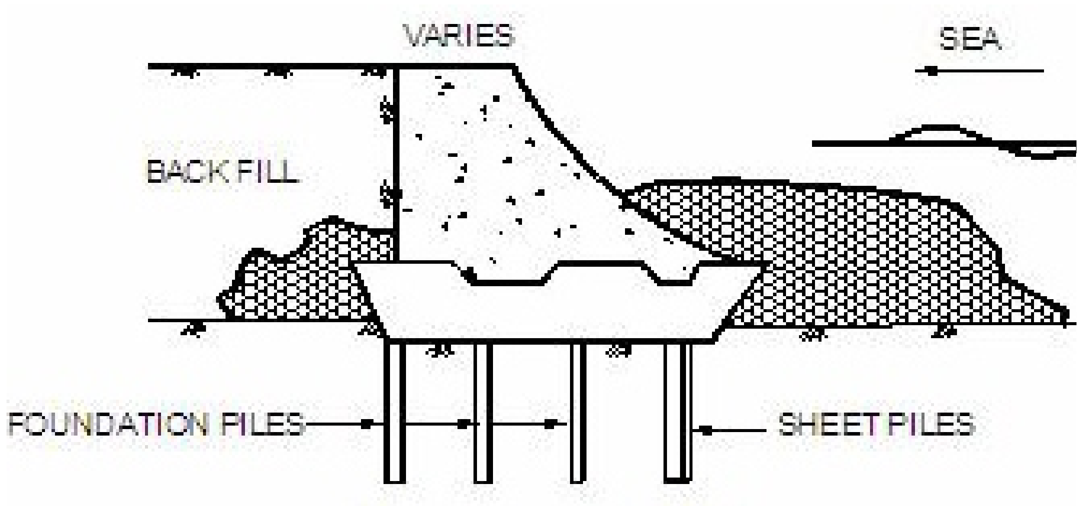
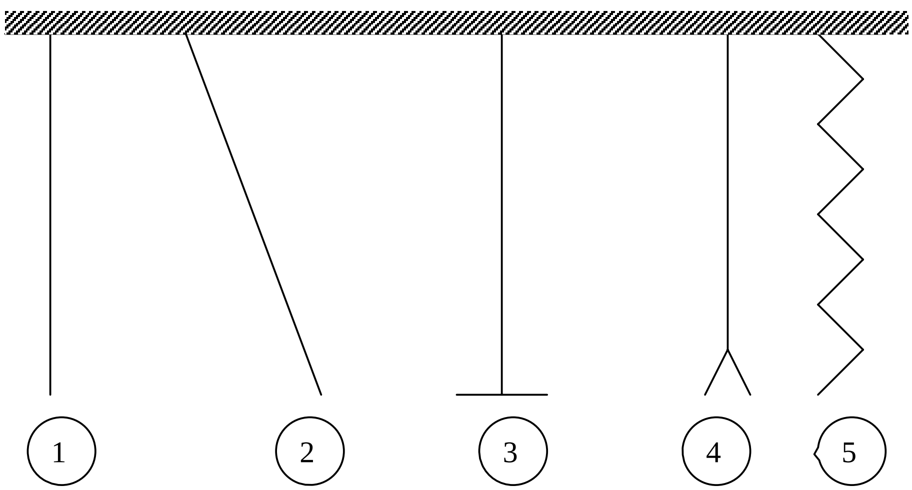


Fig. 1.9 Typical cross section and photo of a concrete seawall



1: Straight groin, 2 : Inclined, 3: T – shaped, 4: Y-shaped, 5: Zig - Zag

Fig. 1.10. Different configurations of groins

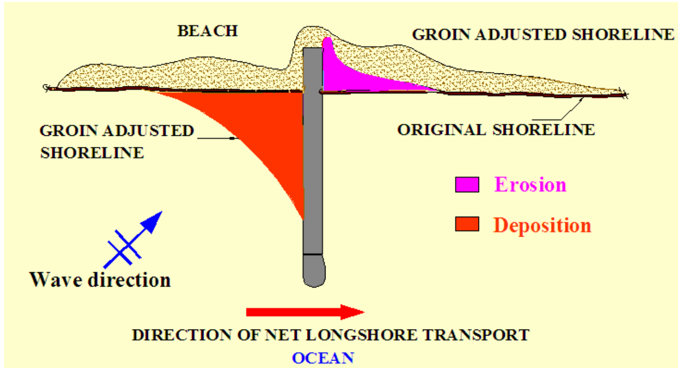


Fig. 1.11. Shoreline Configuration for Single Groin

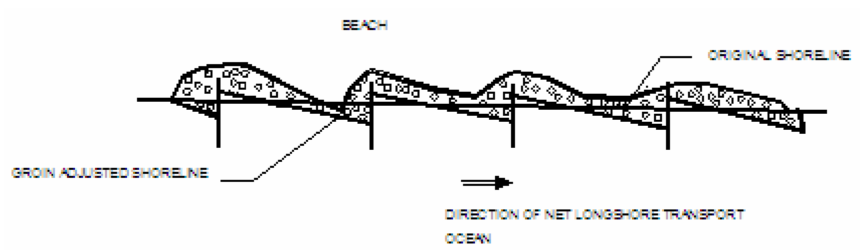


Fig. 1.12. Shoreline configurations for two or more Groins

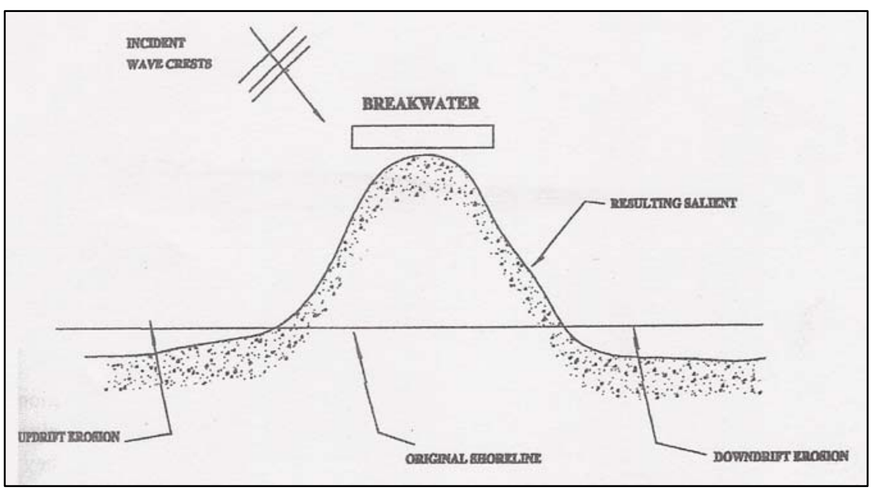


Fig. 1.13 Shoreline Evolution due to the presence of an Offshore Breakwater

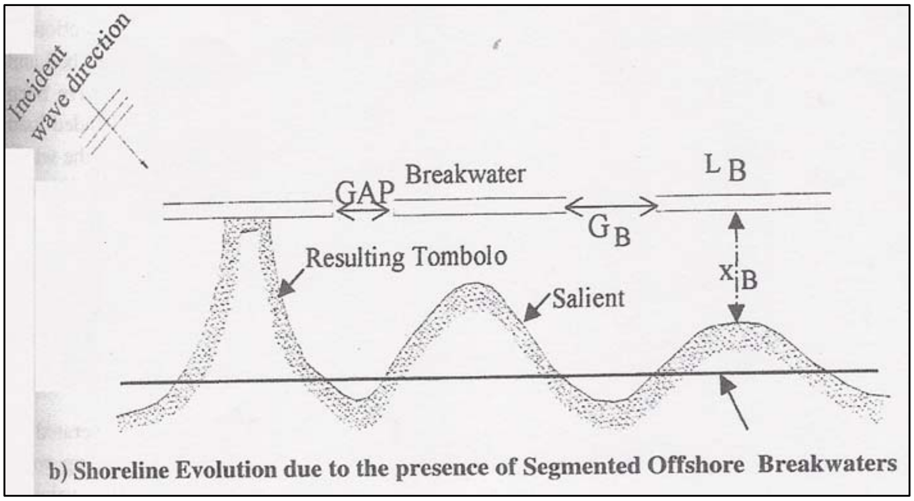


Fig. 1.14 Shoreline Evolution due to the presence of segmented Offshore Breakwaters

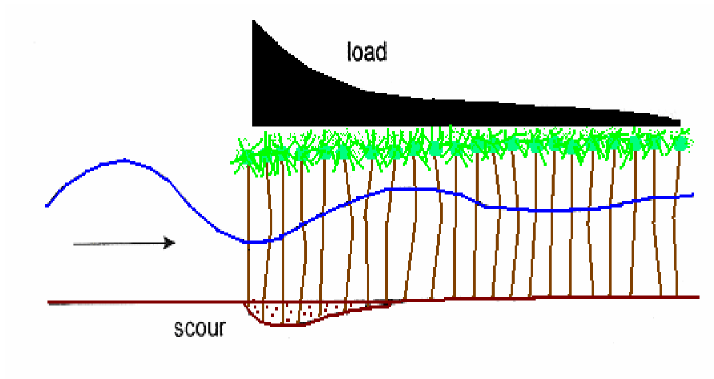
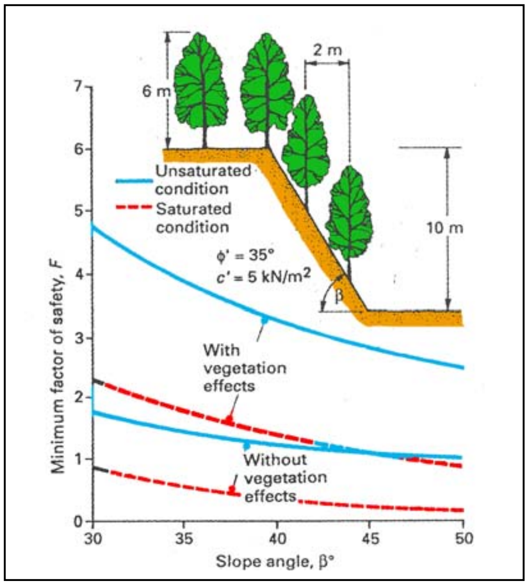


Fig.1.15 Load and Strength



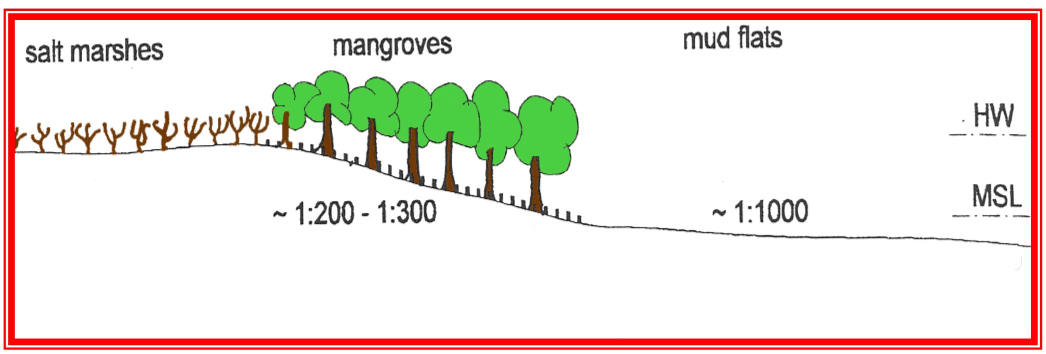


Fig. 1.16 Roots act as armour for the stem and reduces the scour [Schiereck (2001)]

CHAPTER 2

PROTECTION MEASURES FOR THIRUVANANTHAPURAM DISTRICT

2.1 INTRODUCTION

In order to identify the critically eroded areas along the Thiruvananthapuram coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1. Er. P. Anil Kumar (S.E., Irrigation South Circle)
2. Er. Shibu (A.E., Trivandrum division)
3. Mr. Udaya Kumar (A.E., Irrigation Trivandrum subdivision)
4. Ms. Sheela Nair (Scientist E, CESS)
5. Ms. V. Leela (Asst. Director, Coastal Engg IDRB section)
6. Er. M. Rajeev (E.E., HED Vizhinjam)
7. Er. K. Narayana Nair (A.E.E., HED)

The location map of Thiruvananthapuram along with the sites visited is shown in Fig. 2.1. The details of the site visit are presented in the following sections.

2.2 PANATHURAKKARA (8° 24′ 59.8″; 76° 57′ 49.0″)

The views showing North and South of the stretch of the coast is presented in Photos 2.1 and 2.2. Transition groins already proposed by IITM should be taken up. It has already been recommended that two numbers of trial groins at least of 10-15m length should be constructed immediately so as to assess the direction and magnitude of littoral drift in this stretch. Although, IITM has estimated the littoral drift along the above coast, it is important to measure in the field before implementing the project. Until such time, in order to avoid erosion problems in particular during June-July (severe wave overtopping) rehabilitation of the existing seawall could be taken up. The proposal for strengthening the existing seawall until the groin field is completed are provided in Fig. 2.2a to 2.2c.This suggestion is for the coast of length of about 2.65Km starting from CP 5919 to CP 5941. The above said proposals consist of use of natural stones (Fig. 2.2a), use of ploy propylene gabions (Fig.2.2b) or combination of natural stones with gabions as toe protection (Fig.2.2c). The groin field suggested for this stretch of the coast is shown in Fig. 2.3.

2.3 SHANKUMUKAM (8° 28′ 49.2″; 76° 54′ 37.7″)

The stretch of the coast of about 4.0km, up to the mouth of Veli estuary is a virgin beach. A view towards the north from the beach off CP 5864 is shown in Photo.2.3. The erosion is found to be severe during the months of June to August. The scenario of erosion along this thickly populated stretch is shown in Photo. 2.4. The shoreline oscillations for this stretch of coast as observed by Kerala Irrigation Dept. (KID) over a year is shown in Fig. 2.4. This figure exhibits the erosion rate during the year of observation (2005). The KID has proposed to construct a seawall of length of about 4 km of cross section, which is provided in Fig. 2.5.

Two options are suggested for this stretch of the coast. They are listed and explained below:

Option-1: KID design modified by IITM

This option considers coverage of the entire beach width in order to accommodate the width of the seawall as shown in Fig. A6 of Annexure A The figure shows extension of the seawall from the existing seawall (damaged) towards the shoreline for about 21m. It is expected that this proposal will protect the coast during monsoon seasons. However, as the seawall spans the entire width of the beach, the beach would be lost forever. This will be against the interests of Shankumukam which is a favourite tourist attraction.

Option-2: Alternative IITM design

It is proposed that the new design is laid over the remains of the exiting seawall. The new design is given in Fig.A2 of Annexure A. An important feature of this design is that the width of the seawall is considerably reduced meaning that some part of the beach will be available during non-monsoon seasons. During high seasons, the seawall will provide sufficient protection for the properties adjoining the shoreline.

2.4 BEEMAPALLY (8° 27′ 14.7″; 76° 56′ 1.3″)

This site is south of Shankumukam beach and is densely populated. The views towards north and south from the beach are given in Photos 2.5 and 2.6. It has been reported that there is perennial erosion with maximum erosion occurring during the monsoon season of June – September. A stretch of the coast of about 200m along the coast abuts fishing villages and hutments. Due to the erosion problem, the said stretch is under constant threat during high seasons. A seawall with a width of about 18m is proposed along this stretch. The schematic sketch of the proposed seawall is shown in Fig. A5 of Annexure A.

South of the above is a stretch of coastline with an existing seawall constructed by KID for about 1.5km. The present status of this seawall is shown in Photo.2.7. It is recommended that this area be protected by a combination of seawall (rehabilitation of the present seawall as Phase-I) Fig. A4 of Annexure A and groins (after monitoring littoral drift at proposed trial groins at Panathura), as shown in Fig: 2.6.

2.5 SOUTH THUMBA (VALIYAVELI) (8° 51′ 25.3″; 76° 52′ 29″)

This location is north of Veli estuary and south of ISRO. Pictures depicting a view of the beach looking towards north and south are shown in Photos 2.8 and 2.9 respectively. This stretch of the coast is densely populated, affected by tsunami and sufficient beach width is available for construction of a seawall as suggested in Fig. A4 of Annexure A.

2.6 THAZHAMPALLY (8° 38′ 10.1″; 76° 47′ 5.7″)

A coastal stretch of about 300m north of the northern breakwater of the Muthalapozhy harbour is an unprotected virgin beach. Typical view of this stretch of the coast is shown in Photo.2.10. This particular stretch of the coast is exposed to direct wave attack. This coast needs protection and a new seawall with a seaward slope of 1:4 is being proposed. The cross section of the same is shown in Fig. 2.2.

North of the above stretch of the coastline is presently being protected by a seawall (Photo 2.11) which is observed to be breached at several locations due to lack of proper toe-protection. Strengthening the present seawall for a length of about 1km is being proposed. The cross section originally proposed by KID for this stretch of the coast and the existing profile are shown in Fig. 2.7. IIT Madras proposes to strengthen this seawall by a modified cross section as shown in Fig. A4 of Annexure A

The stretch further north of Muthalapozhy harbour (Poothurai) is presently protected by a seawall which is in reasonably good condition. No further protection/rehabilitation is proposed for this stretch.

2.7 JANARTHANAPURAM / VARKALA BEACH (8° 43′ 47.6″; 76° 44′ 25.4″)

The beach is abutted by laterite cliffs on the north and south (depicted in Photos 2.12 and 2.13). KID officials reported that the cliffs have been under continuous erosion during the monsoon seasons. In order to prevent further erosion of the southern cliff, the present practice of KID to drop stones from top of the cliff has not been effective due to the fact that desired slope could not be achieved during implementation of the seawall (shown in photo. 2.13). The present status of the seawall cross section is indicated in Fig.2.8. In order to mitigate this problem, typical cross section of seawall with gabions (2 m high) is proposed as shown in Fig.2.9. There is plenty of scope to convert this location into a tourist attraction point provided the beach formed is conserved, which can be accomplished by providing a submerged breakwater at a certain distance from the shoreline, preferably in 4m to 5m water depth. As usage of stones would hamper the visit of beach lovers, it is proposed to adopt geo-tubes, the scheme as shown in Fig. 2.10.

Table 2.1. Summary of the recommendations by IITM

S. No.	Name of the site	Recommended Protection Measures			Priority
		Seawall	Groin	Other	
1.	Panathurakkara	Rehabilitation (2650 m)			***
2.	Shankumukam	Rehabilitation (4000 m)			**
3.	Beemapally	Rehabilitation (1700 m)	Transition groin field (410 m)		**
4.	South Thumba (Valiyaveli)	New seawall			**
5.	Thazhampally	Rehabilitation (1000 m)		New seawall (300 m)	**
6	Janarthanapuram / Varkala beach	Seawall with gabions		Geotubes	**

*** High Priority
** Medium Priority
* Low Priority

Photo 2.1. North of Panathurakara

Photo 2.2. South of Panathurakara

Photo 2.3. North of Shankumugham

Photo 2.4 Erosion during monsoon seasons at Shankumukam

Photo 2.5. North of Beemapally

Photo 2.6. South of Beemapally

Photo 2.7. Damages to seawall at Beemapally

Photo 2.8. North of Valiyaveli (ISRO seawall)

Photo 2.9. South of Valiyaveli

Photo 2.10. North of Muthalapozhy

Photo 2.11. North of Muthalapozhy NBW

Photo 2.12. North of Janarthanapuram (Varkala Beach)

Photo 2.13. South of Janarthanapuram (Varkala Beach)

Fig. 2.1 Layout of Thiruvananthapuram District

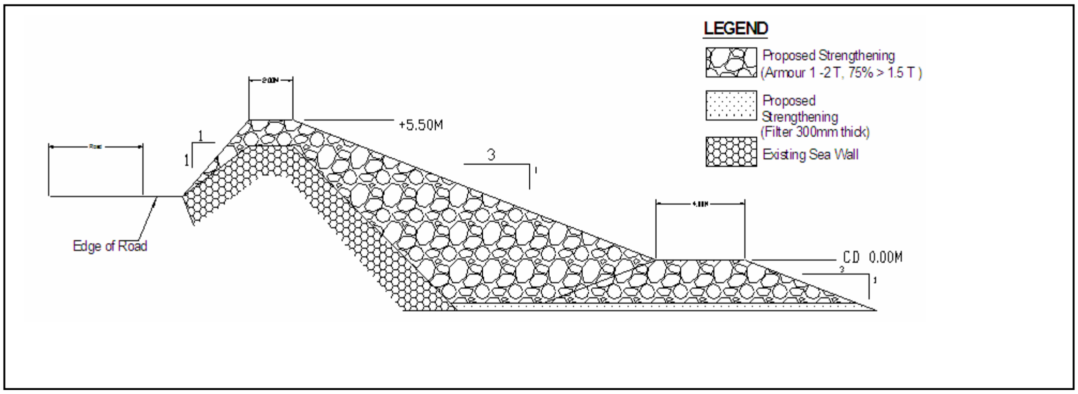


Fig.2.2a. Typical cross section of conventional sea wall

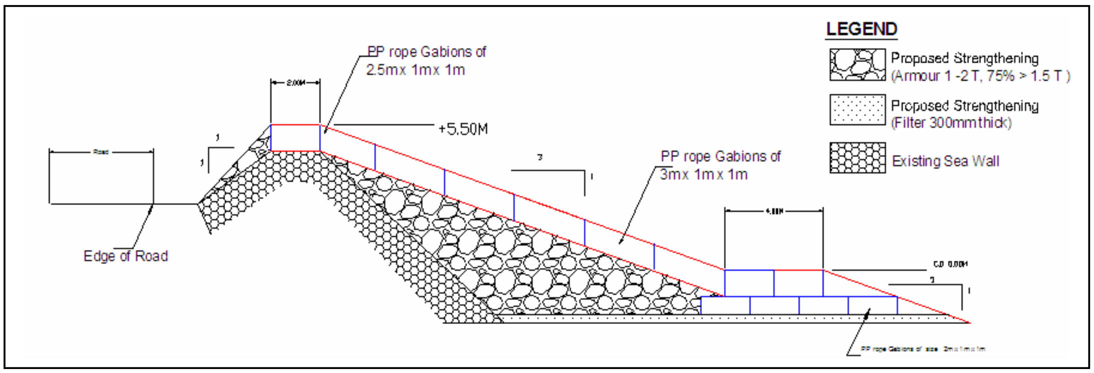


Fig. 2.2b. Typical cross section of sea wall using PP Gabions

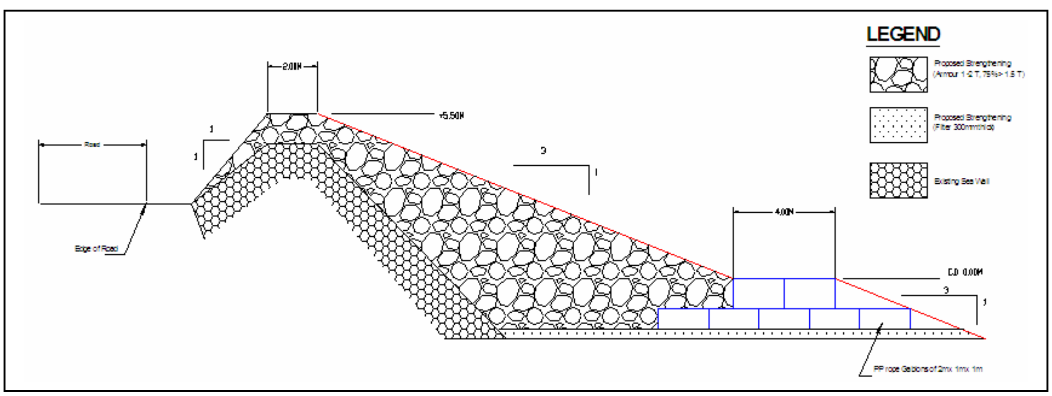


Fig.2.2c. Typical cross section of sea wall with Toe Gabions

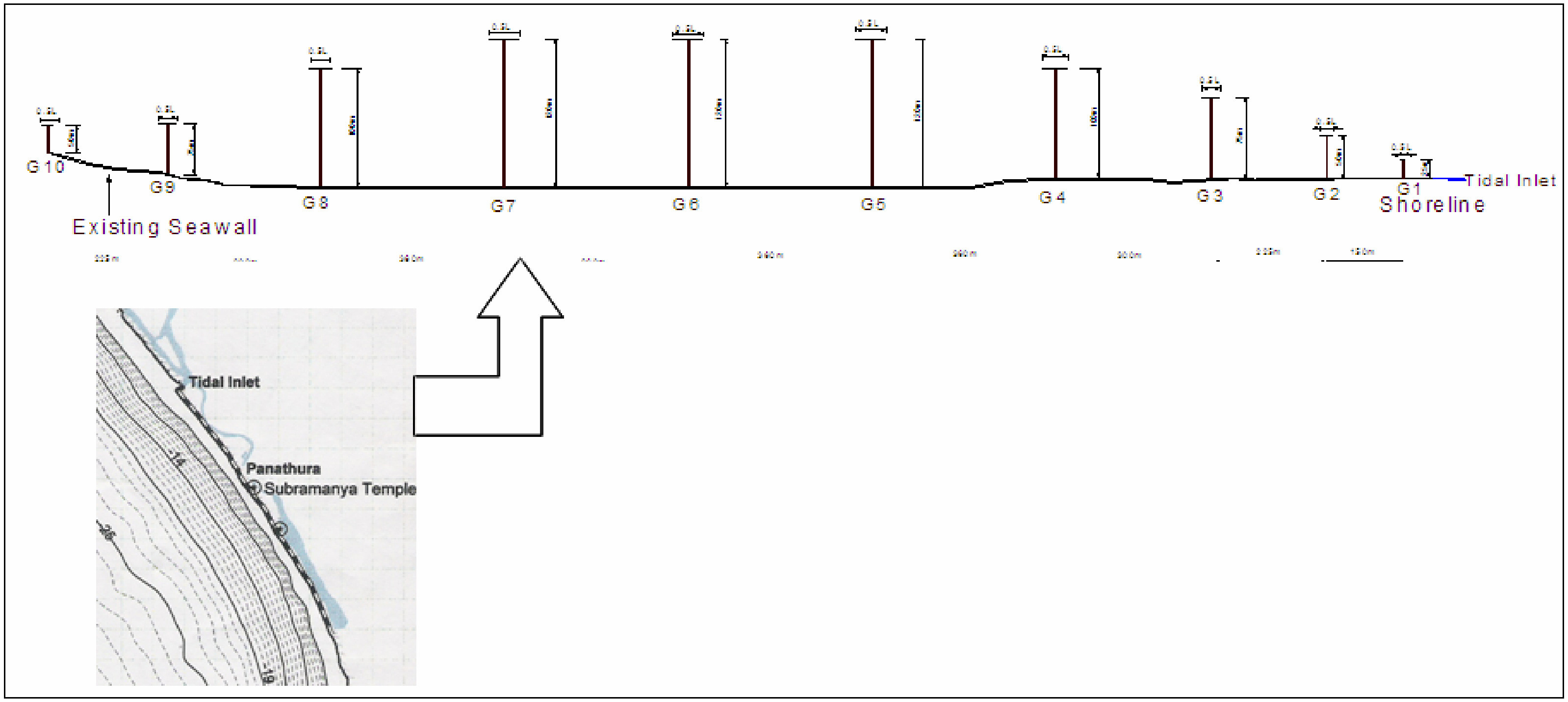


Fig. 2.3 Layout of the Groin field for proposed alignment

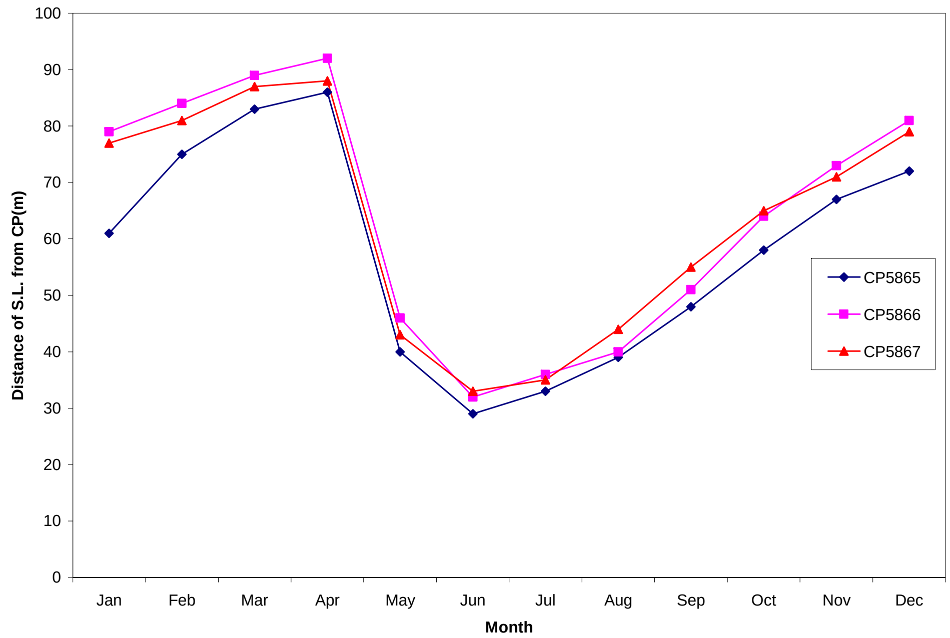


Fig. 2.4. Shoreline Oscillation of Shankumukam in 2005

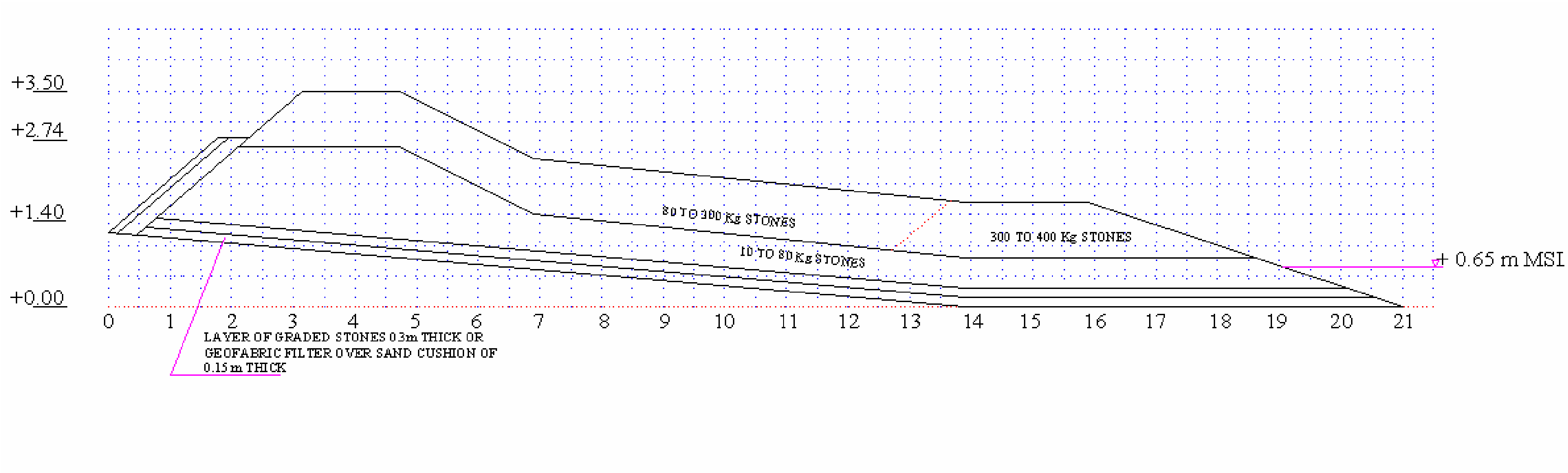


Fig. 2.5. Cross-section of seawall proposed by Kerala Irrigation Division

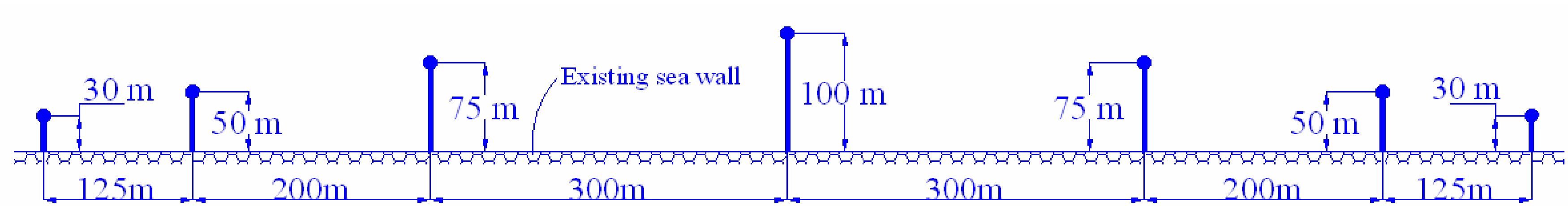


Fig 2.6 Proposed layout of transition groin field at Beemapally

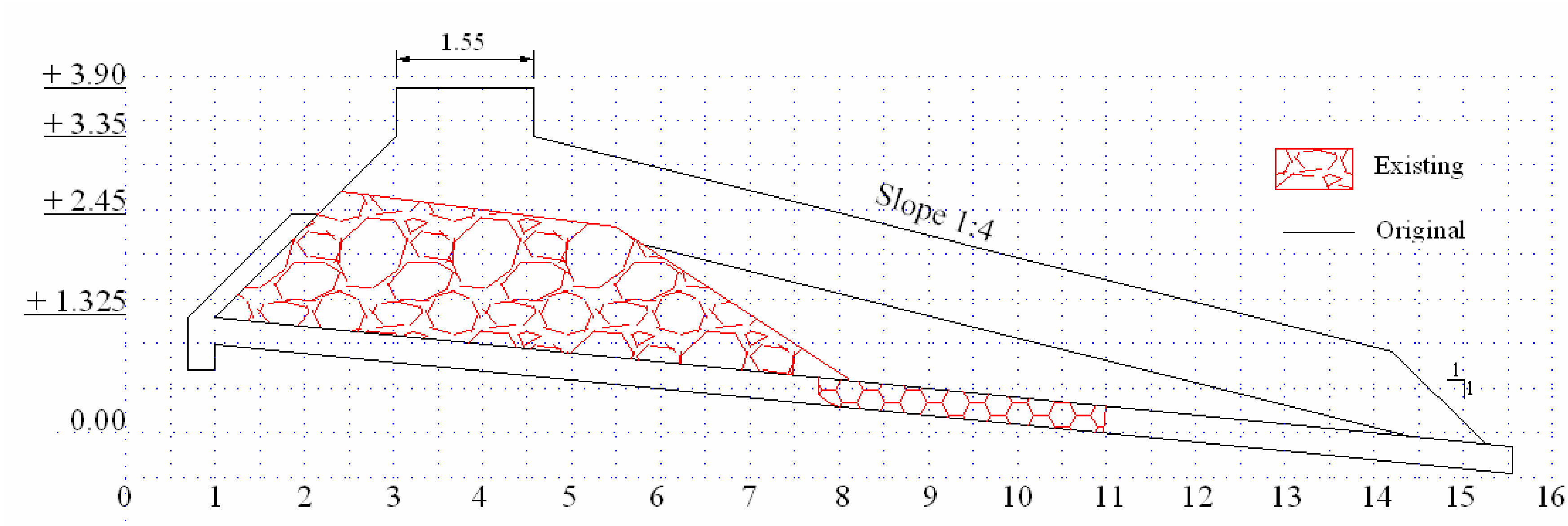


Fig. 2.7. Cross-section of the existing damaged seawall (as per KID) at Thazhampally

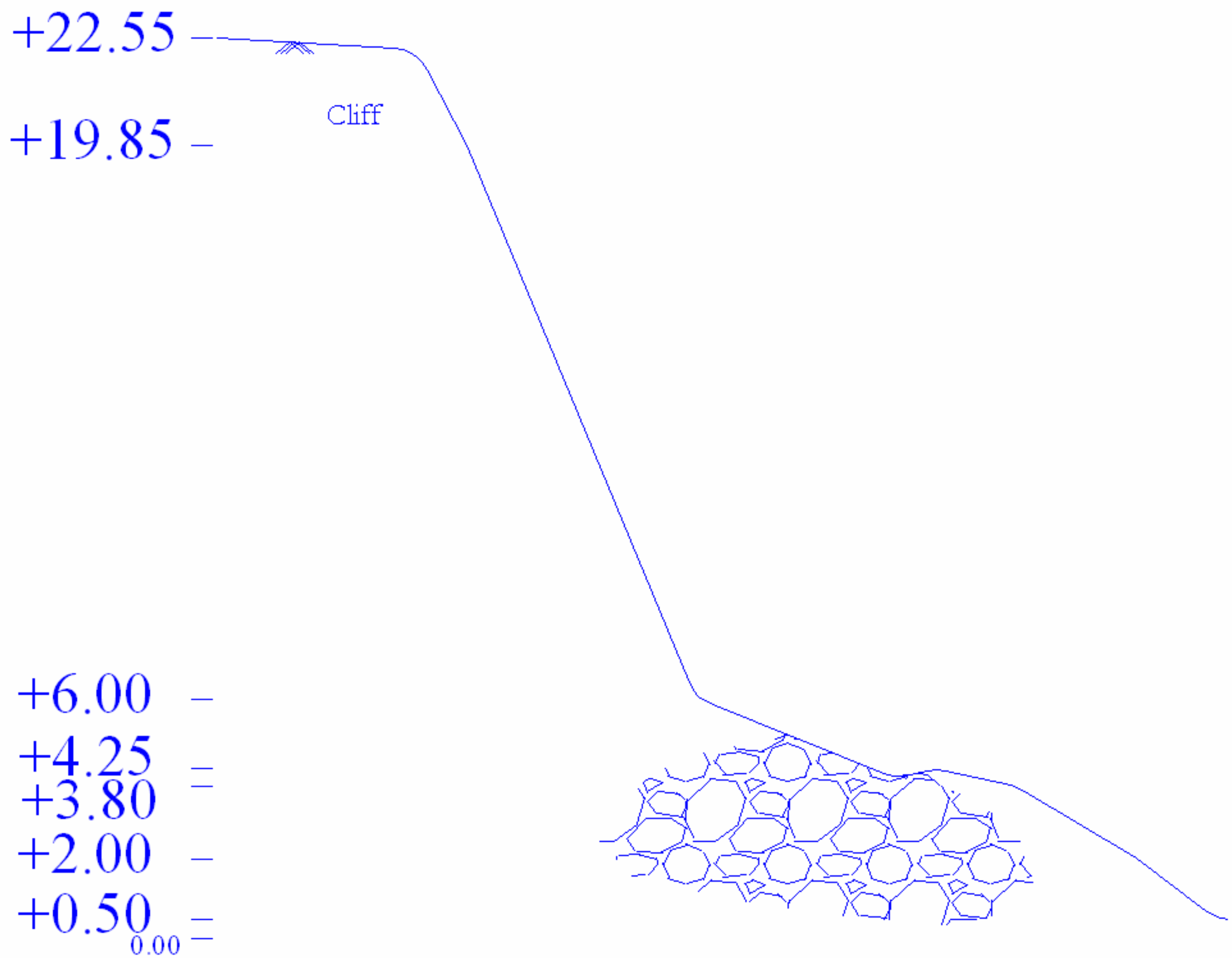


Fig. 2.8. Status of the seawall at Janarthanapuram

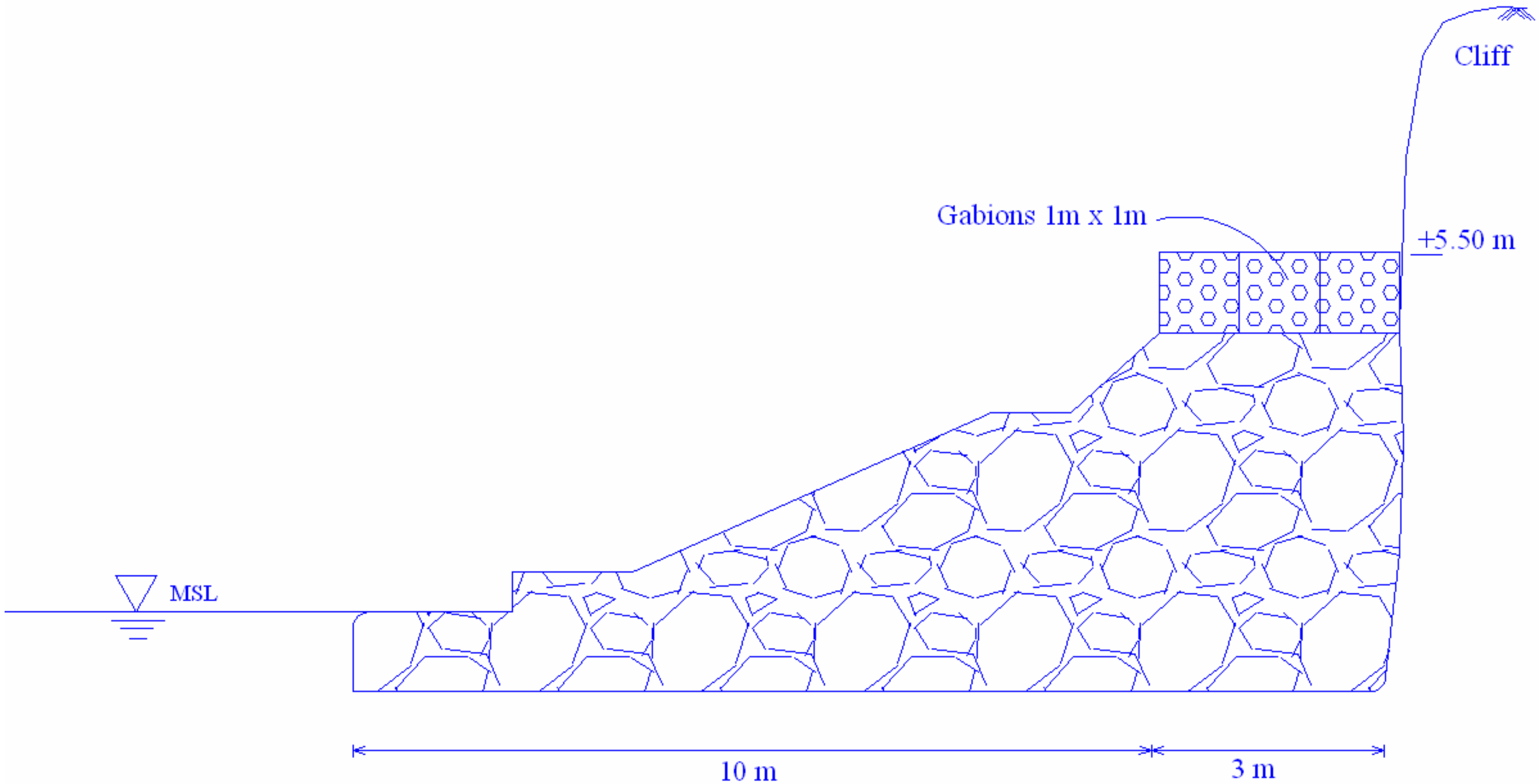


Fig. 2.9.Proposed cross section of seawall with gabions at Janarthanapuram

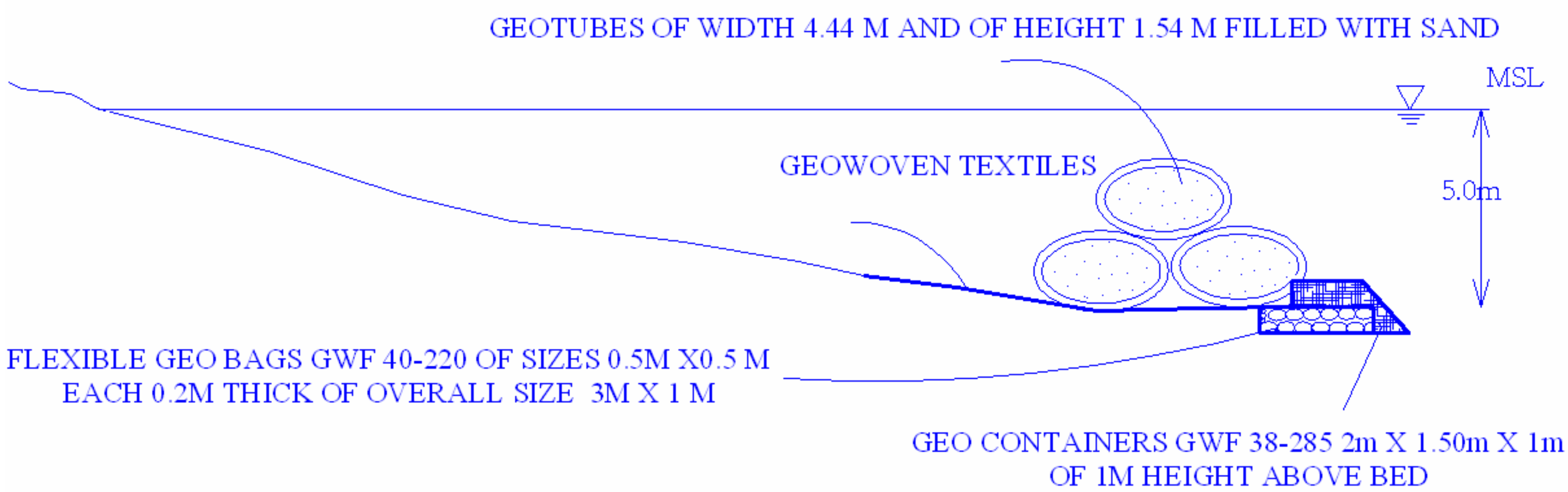


Fig.2.10. Proposed cross-section of geotubes as submerged reef at Janarthanapuram

CHAPTER 3

COASTAL PROTECTION MEASURES FOR KOLLAM DISTRICT

3.1 INTRODUCTION

In order to identify the critically eroded areas along the Kollam coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1. Er. P. Anil Kumar (S.E., Irrigation South Circle)
2. Er. Vinod K. George (E.E., Irrigation Kollam)
3. Er. Jacob Mathai (A.E.E., Kollam subdivision)
4. Ms. Sheela Nair (Scientist E, CESS)
5. Ms. Rema K P (Dy. Director, Coastal Engg Subdivision, Kollam)

The location map of Kollam along with the sites visited is shown in Fig. 3.1. The details of the site visit are presented in the following sections.

3.2 KAPPIL (KOLLAM DISTRICT) (8° 47′ 6.2″; 76° 40′ 14.4″)

The views showing the north and south of this stretch of the coast are given in Photos 3.1 and 3.2. This stretch has been already protected by a seawall and the present status of which along with the originally proposed cross-section is presented in Fig. 3.2. It is proposed that the existing seawall needs to be rehabilitated for a length of about 1.2km with a cross section as presented in Fig. A3 of Annexure A.

3.3 CHILLACKAL (8° 48′ 24.2″; 76° 39′ 11.0″)

This stretch of the coast is characterized by laterite cliffs that are under continuous threat from waves similar to that near Varkala beach. The views towards north and south from top of the cliff are provided in Photos. 3.3 and 3.4. As a temporary protection measure, the KID has been dumping natural rocks from the top of the cliff. This dumping of stones does not withstand the aggravating wave conditions. Hence, it is recommended that for a stretch of about 740m, a seawall with gabion boxes be provided as depicted in Fig. 3.3. The gabion boxes may be placed from top of the cliff by means of cranes. An alternate option for this site could be provision of submerged geo-tubes filled with sand and laid parallel to the coastline in a water depth of about 5m as shown in Fig. 3.4. The details of the exact location and size of the geo-tubes are to be arrived based on detailed numerical model investigation.

3.4 THANNI (8° 50′ 26.0″; 76° 37′ 40.8″)

This stretch of the coast spans between Thangasseri harbour on the north and Paravoor / Pozhikkari on the south. The view from the above location looking towards the harbour is shown in Photo 3.5 and looking towards Paravoor is given in Photo 3.6. A coastal road from Quilon to Paravoor has been proposed to be laid by the state government. Hence, the stretch needs appropriate protection from coastal erosion. The existing cross section of the seawall is shown in Fig. 3.5 which is quite unstable due to the toe erosion. As a short-term measure, the existing seawall needs to be rehabilitated with the cross section shown in Fig. A3 of Annexure A. As a long term measure, in order to also serve as a protection for the proposed road, is the construction of a groin field. The groin field is expected to encourage formation of a beach. Hence, the threat posed by the sea to the road and the shoreline could be nullified. A similar solution to a similar problem north of Chennai port has been proposed by IITM has yielded fruitful results. This information in the form of a technical paper is provided in Annexure-B. In addition, IITM has already proposed a groin field for this stretch of coast Paravoor/Pozhikkarai based on a request from HED. The details of the proposed groin field are provided in Fig.3.6, which need to be taken up.

3.5 MUKHAM (CP 5593) (8° 49′ 23.6″; 76° 38′ 32.9″)

Extensive damages to the existing coastal road have been observed and the same is shown in Photo 3.7. It is also observed that the seawall has a vertical heel and the beach behind the seawall has being undermined. This is possibly due to percolation of water through the seawall from its leeside caused due to wave overtopping and rain water run off. This process will be dominant during monsoon seasons. This aspect is discussed in detail in Annexure-A. The vertical heel has to be modified as discussed in the above annexure.

Further, south of this stretch is a virgin beach of about 150m in between the existing seawalls which is basically a fishing gap. Photo 3.8 depicts the current situation prevailing at this station. Basically two options exist. Option-1: Construction of a seawall designed by IITM as shown in Fig. A2 of Annexure A. Option-2: Develop this site as a fish landing facility by constructing a pair of breakwaters, which will then serve as a protection measure as well as a fish landing centre. The option2 is strongly recommended.

3.6 MARUTHADI (8° 54′ 25.7″; 76° 32′ 42.2″)

The location of this site is north of Kollam and is thickly populated. This is almost a straight and stable stretch of coastline protected by a seawall for about 3.1 km. The seawall is in good condition as indicated in Photos 3.9 and 3.10. The originally adopted and the existing cross sections are given in Fig. 3.7. The major problem, as reported by KID, is the continuous wave overtopping during monsoon seasons. This area has also been flooded by tsunami. No replenishment of the exiting seawall is recommended. However, in order to reduce the overtopping, gabion boxes of size 1m x 1m x 1m should be provided as crown wall.

3.7 VALLAVILTHOPPU (8° 57′ 46.7″; 76° 32′ 33.3″)

Presently, a stable beach with a flat slope exists in this location. This stretch could be developed as a fish landing centre by providing appropriate protection from direct wave attack. The length of the beach stretch is 150m. Photos 3.11 and 3.12 provide an idea of the gap, abutted by the seawalls on the north and south. It is proposed that this virgin beach (Photo 3.12) be protected by a pair of groins as indicated in Fig. 3.8. The length of the groins should be such that the water depth at the head is about 3.0m.

3.8 PANMANA (9° 0′ 38.0″; 76° 31′ 8.8″)

The stretches of the coast north and south of the location are shown in Photos 3.13 and 3.14 respectively. This is an area in which sand is being mined at present by IREL & KMML. The mining is of the order of 1500m^3/day as per KID. The best option for this stretch is to prevent excessive mining and there is no requirement for protection as of now. However, continuous mining carried out in this stretch of coast may lead to over exploitation resulting in the breach of the adjoining TS canal. As of now, no protection measure is suggested as IRE and KMML continue their mining activity in this area. Any suitable measure for this stretch of coastline could only be worked out after knowing proposed mining extent in this area.

3.9 CHERIYAZHEEKAL (9° 3′ 2.3″; 76° 30′ 8.2″)

The status of the existing seawall on the north and south of this location are shown in Photos 3.15 and 3.16. The size of the stones adopted during the execution of the seawall work is found to be small (<200kg). KID has informed the IITM team about the proposal of dredging the sand offshore and building a beach in front of the seawall which is pending since a long time. It is opinion of IITM team that this scheme would not serve as a long term solution, even though; it may be a temporary solution for the fair weather season. It is most likely that the sand deposited could be washed away along and offshore during high seasons. The cross section of the existing seawall is shown in Fig. 3.9. The top level adopted for the present seawall is +3.0m resulting in frequent over topping added to which the flow water on its rear side during monsoon is expected to undermine the structure leading to the instability from its leeside too. The suggested rehabilitation for this stretch of the coast for a length of about 500m is given in Fig. A5 of Annexure A

3.10 SRAIKKADU (9° 3′ 3.3″; 76° 30′ 9.0″)

This stretch of coast is protected by a seawall and the views of which are shown in Photos 3.17 and 3.18. Portion of the seawall on the northern side of this stretch of coast has been breached as can be seen in Photo 3.19. On the southern side of this stretch of coast, the toe of the seawall is being eroded leading to its instability. Moreover, the entire landside of the seawall is vertical with frequent overtopping resulting in undermining of the structure. The present cross-section of the seawall is shown in Fig. 3.10. It is proposed that this stretch of the coast needs to be protected with flexible gabions for a distance of about 700 m. The details of the cross-section proposed are shown in Fig. A5 of Annexure A

3.11 JAYANTHI COLONY (9° 6′ 23.0″; 76° 28′ 27.8″)

During the Indian Ocean Tsunami, maximum number of casualties occurred at this stretch of the coast as per the information provided by KID. A view towards north of this stretch showing the Kayankulam fishing harbour is shown in Photo 3.20. The stretch of coast south of this location is shown in Photo 3.21. This coast is presently protected by a seawall, which was constructed in 2006 and the status of the seawall is shown in Photo 3.22. The top level of the seawall is +3.3 which is unable to prevent overtopping particularly during monsoon seasons.

The original cross-section of the seawall that was adopted and its present status are presented in Fig. 3.11. A transitional groin field is proposed over a 600m length of the coast as significant amount of sand is being moved along this stretch. The groins may be of rubble mound, gabions or geo-bags. The tentative layout of the groin field is shown in Fig 3.12. Further, it is proposed that the rear side of the seawall needs to be protected by gabions as shown in Annexure-A. Further, the top level of the existing seawall should be raised by another 1.0 m (i.e., up to + 4.0 m). It is understood from the KID engineers that during the tsunami its propagation on to the stretch of coast north of the above location (Photo 3.23) has led to a number casualties. Plantations are suggested at this location in between the road and the seawall.

3.12 KAYAMKULAM

This stretch of the coast north of Kayamkulam fishing harbour has been experiencing erosion due to the interception of net northerly littoral drift by the breakwaters of the harbour. Typical views of the coast exhibiting the flatness of the beach are shown in photos. 3.24 and 3.25. The photos also show the ingress of the sea water into the beach that is responsible for the removal of the sand from the shore. The remains of the sewall seen during the site visit is shown in photo. 3.26. Another peculiar behavior is the overtopping of sand over the seawall that prevents the free movement of vehicles as can be seen in photo. 3.27. Prior to the site visit, the KID officials have taken photographs during the attack of storm. The violent wave attack, uprooting of the trees and the wave induced erosion of the seawall are shown in photos. 3.28, 3.29 and 3.30 respectively.

The cross-section that been adopted for this location is not adequate to resist against the wave climate. This cross section is not so easy to rehabilitate as the available width of the beach being far less than what is desired would pose problems in the laying of the stones, as the seaward slope is 1:10. As this slope cannot be achieved, the sizes of the stones of about 500kg would be too small to remain in its position. The cross section need to be re-examined critically. Further, the cross section cannot be the same for all locations as it very much depend on the local wave climate, sediment transport, beach characteristics, etc. At locations of narrow stretches of the beach the cross section that is being adopted by KID should be avoided. The suggested cross sections provided in Fig.3.13a or 3.13b, among which the later section would be preferred.

In regard to long term solution, the problem is quite similar to that along the coast north of Chennai harbour. After a detailed and long deliberation, two groin fields were constructed in mid 2004, which have provided the much needed arresting of erosion. It has not prevented the erosion but also helped in the formation of the beach. Similar solution may be formulated. These details of this project may be obtained in Annexure B. This stretch of the coast is not being starved for sediments as a large quantity is being over topped over the present seawall. This concept should be to tame the waves as well as the sediments in suspension and retain them in a sort of pockets that could be the compartments formed by groins. For efficient retaining, T-groins of shorter length may be considered. In order to finalise the layout, a detailed numerical modeling could be taken up by IIT Madras as a separate consultancy project and cannot be a part of the proposed tsunami rehabilitation project. A long term solution is felt to be absolutely essential. If a positive decision towards the implementation of the long term solution is taken, the rehabilitation of seawall as stated earlier for kayamkulam can be postponed.

3.13 PATHIANKARA (9° 15′ 30.2″; 76° 24′ 26.2″)

This stretch of coast is densely populated and is partially affected by tsunami. The beach along this stretch seems to be of flat slope, which might have encouraged the propagation of tsunami causing damages to the property. Typical views towards north and south of this stretch of coast are shown in Photos 3.26 and 3.27. Hence, a seawall of base width 8m is proposed as shown in Fig. A2 of Annexure A. The local community is thriving with fishing activity with a number of boats as can be seen in Photo 3.28. Hence, a groin field over a stretch of about 750 m is proposed, out of which, one of the groins is bent in order to serve as a fish landing facility. Typical layout for this stretch is shown in Fig. 3.14. The decision on towards which direction the longest groin need to be bent will have to be taken during the course of the construction of the groins, which will clearly demonstrate the direction of littoral drift. A similar successful protection measure as well as landing facility has been adopted for the Alanthalai, Kanyakumari district, Tamilnadu, which has yielded excellent results. The details of which are presented as a form of paper in Annexure C.

Table 3.1. Summary of the recommendations by IITM

S. No.	Name of the site	Recommended Protection Measures			Priority
		Seawall	Groin	Other	
1.	Kappil	Rehabilitation (1200 m)			**
2.	Chillackal	Rehabilitation (740 m)		Submerged Geotubes as offshore breakwater	*
3.	Thanni	Rehabilitation (950 m)	Transition groin field (690 m)		***
4.	Mukham	New seawall (150 m)		Development as a fish landing center	**
5.	Maruthadi	Rehabilitation (3100 m)			***
6.	Vallavilthoppu		Pair of groins (120 m approx)	Development as a fish landing center	**
7.	Panmana				-
8.	Cheriyazheekal	Rehabilitation (500 m)	Groins as Training walls (500 m)		*
9.	Sraikkadu	Rehabilitation (700 m)			***
10.	Jayanthi Colony	Rehabilitation (600 m)	Transition groin field (160 m)		***
11.	Kayamkulam	Rehabilitation	Groin field		***
12.	Pathiankara	Rehabilitation (740m)	Transition groin field (225 m)	Development as a fish landing center	***

Photo 3.1. North of Kappil

Photo 3.2. South of Kappil

Photo 3.3. North of Chillackal


Photo 3.4. South of Chillackal


Photo 3.5. North of Thanni


Photo 3.6. South of Thanni

Photo 3.7. North of Mukham (North of Paravoor)

Photo 3.8. South of Mukham (North of Paravoor)

Photo 3.9. North of Maruthadi

Photo 3.10. South of Maruthadi

Photo 3.11. North of Valavilthoppu

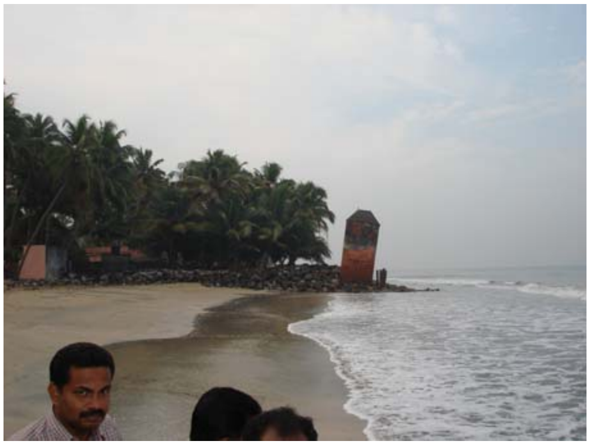


Photo 3.12. South of Valavilthoppu

Photo 3.13. North of Panmana

Photo 3.14. South of Panmana

Photo 3.15. North of Cheriyazheekal

Photo 3.16. South of Cheriyazheekal

Photo 3.17. Status of the seawall north of Srayikadu

Photo 3.18. View towards south of Srayikadu

Photo 3.19. Damages to the seawall due to overtopping at Srayikadu

Photo 3.20. North of Jayanthi Colony

Photo 3.21. South of Jayanthi Colony

Photo 3.22. Status of the existing seawall at Jayanthi Colony

Photo 3.23. Stretch of the coast suitable for plantations

Photo.3.24 Stretch of the coast near Kayamkulam

Photo.3.25 Flooding of the beach by sea water ingress near Kayamkulam

Photo.3.26 Remains of the seawall near Kayamkulam

Photo.3.27 Overtopping of sand over the existing seawall near Kayamkulam

Photo.3.28 Ingress of sea water responsible of the coastal erosion near Kayamkulam

Photo.3.29 Coastal erosion near Kayamkulam during storm

Photo.3.29 damage to existing sewall near Kayamkulam during storm


Photo 3.26. Extent of damage caused to the seawall North of Pathiankara


Photo 3.27. Extent of damage caused to the seawall South of Pathiankara


Photo 3.28. Fishing activity near Pathiankara

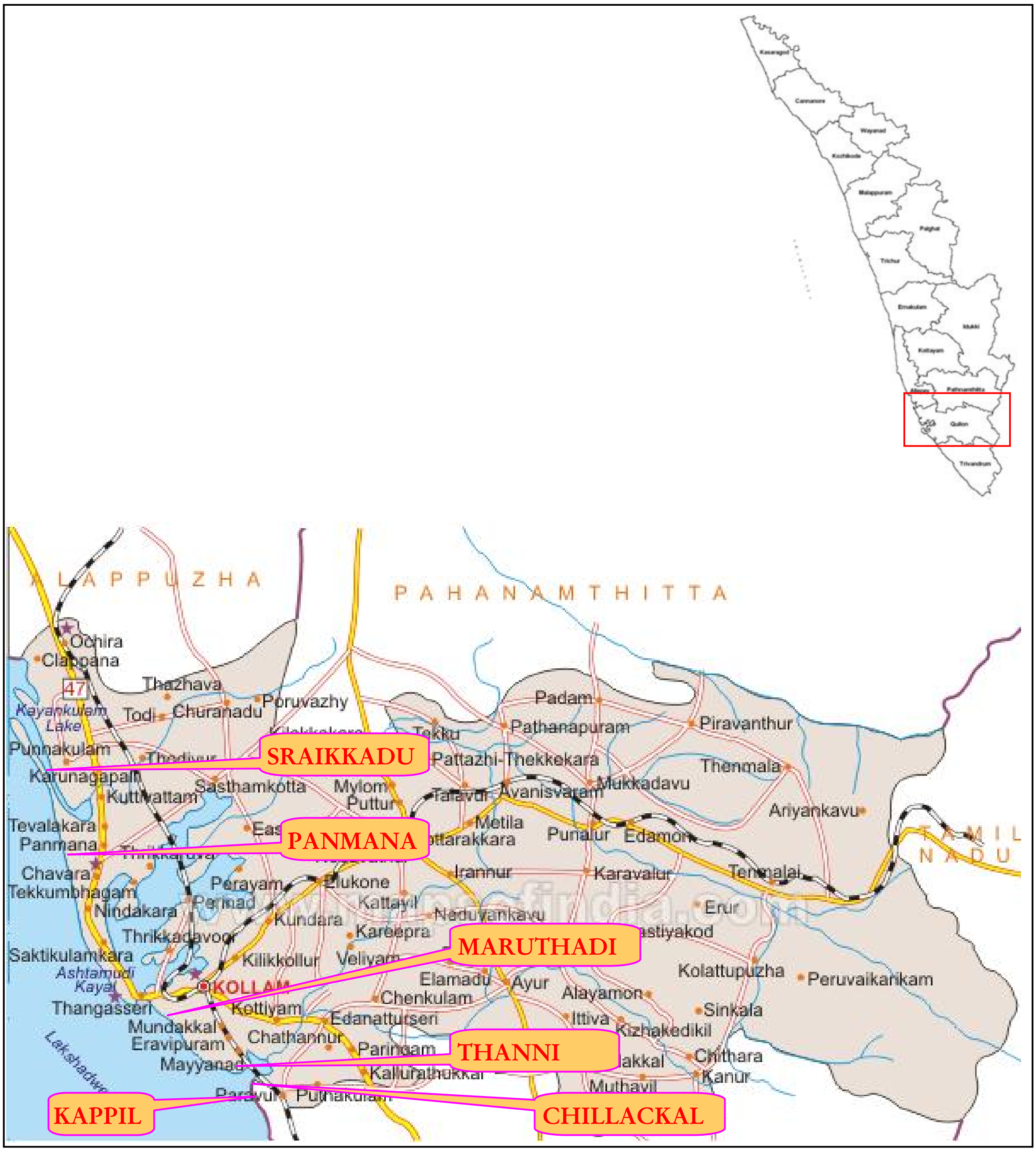


Fig. 3.1. Layout of Kollam District

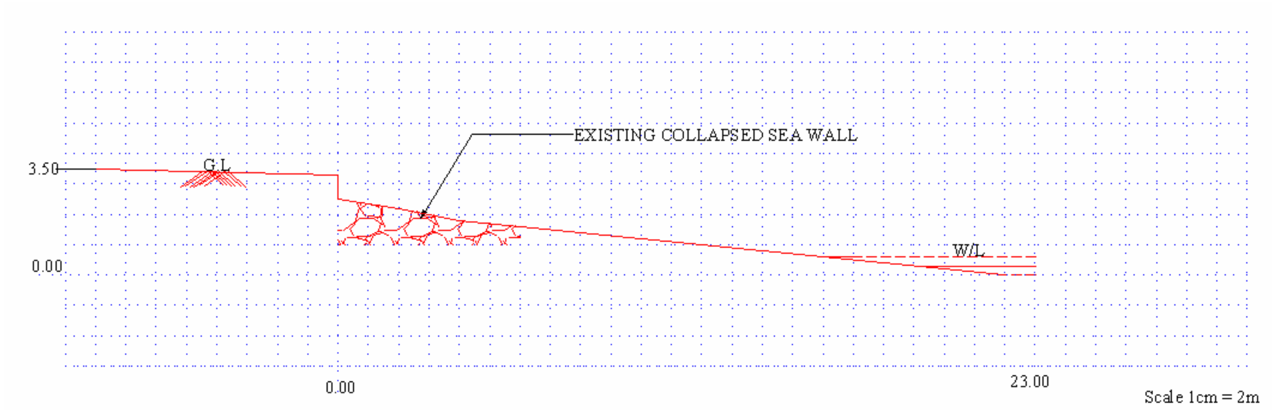


Fig. 3.2. Cross-section of the existing damaged seawall (as per KID) at Kappil

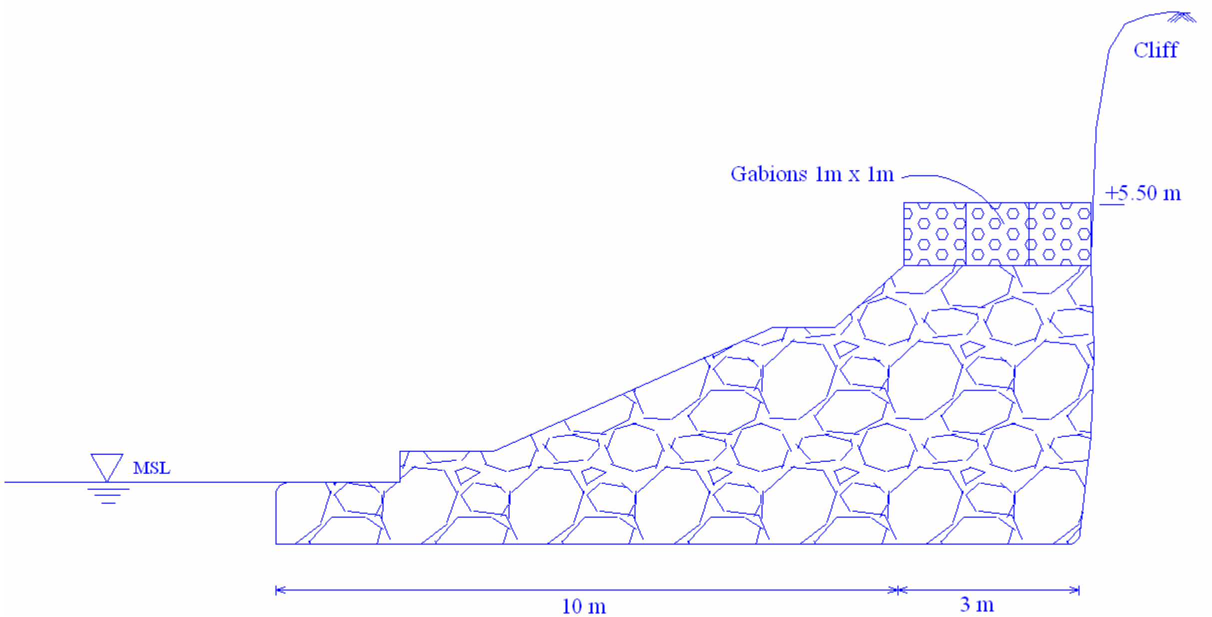


Fig 3.3. Proposed cross-section of Seawall with Gabion Boxes at Chillackal (Option – I)

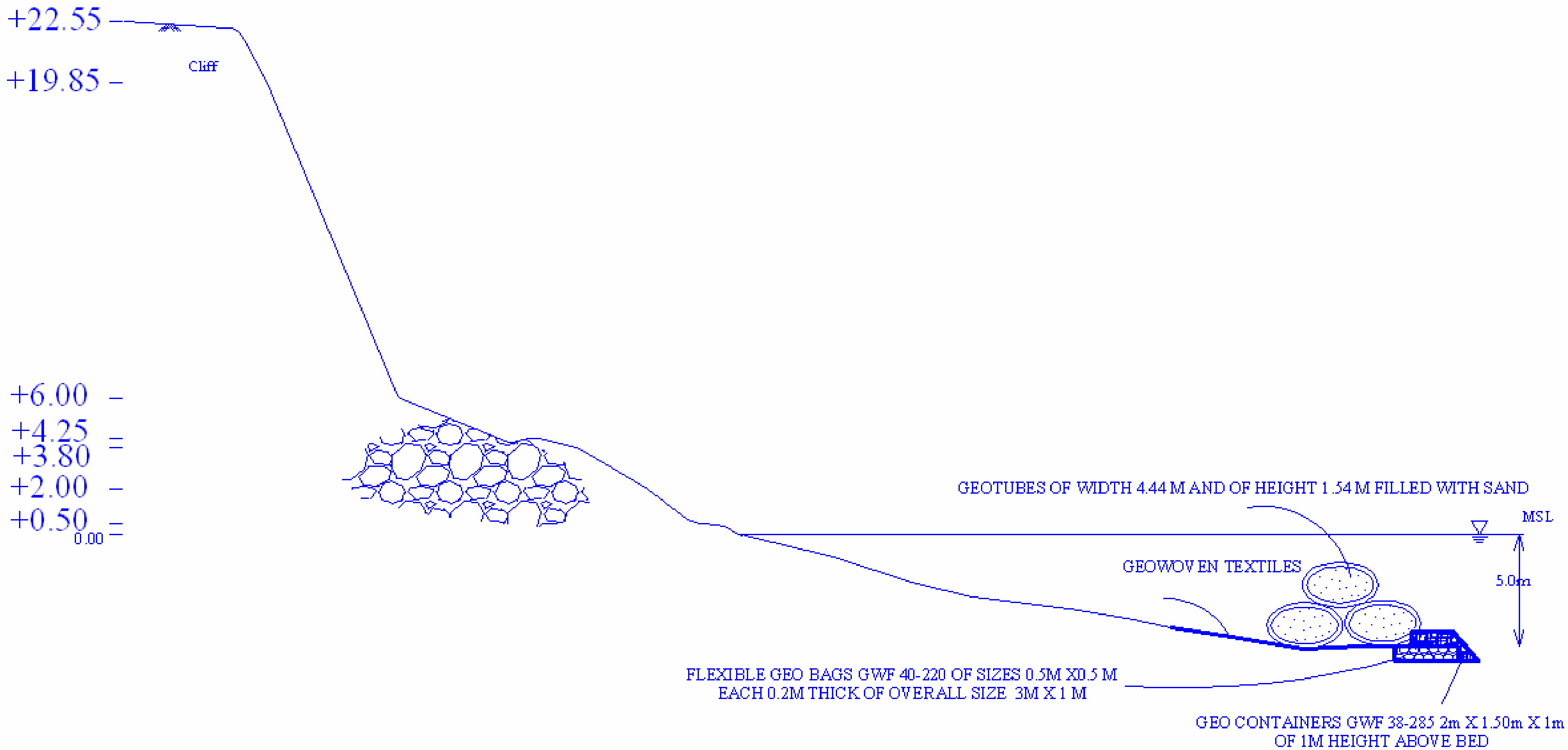


Fig 3.4. Proposed cross-section of geo-tubes as submerged offshore reef at Chillackal (Option – II)

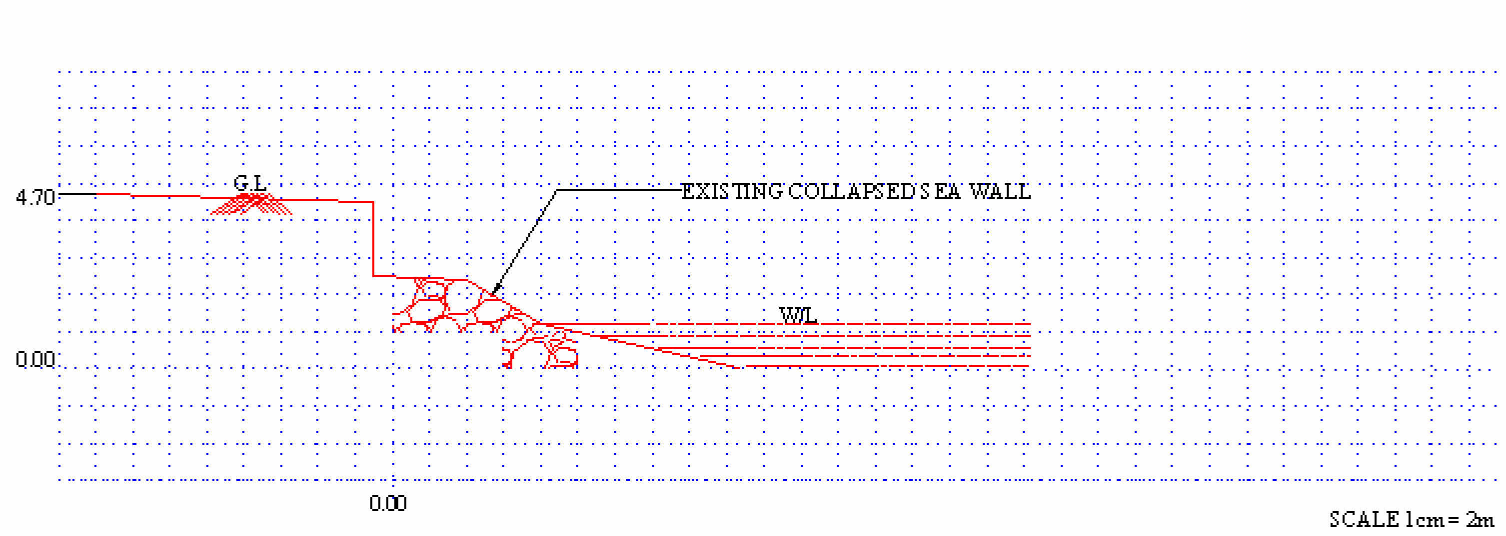
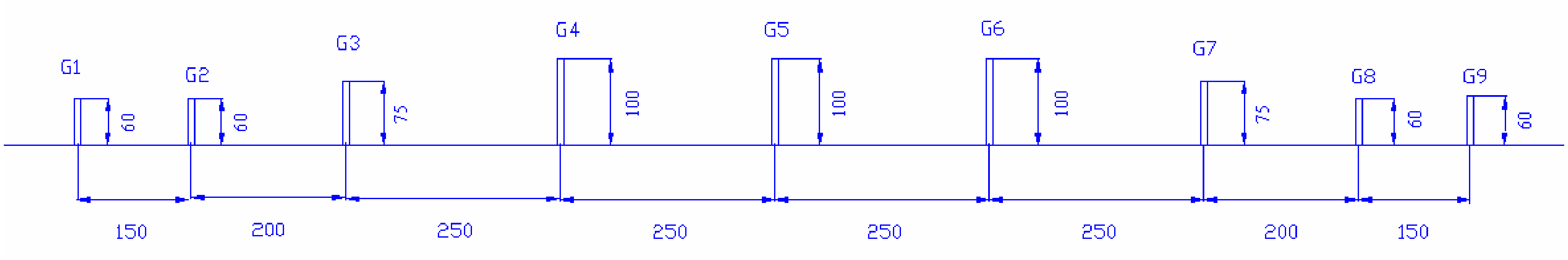


Fig. 3.5. Cross-section of the existing damaged seawall (as per KID) at Thanni



All dimensions are in m

Fig. 3.6. Proposed layout of the groin field for the coast of Paravoor

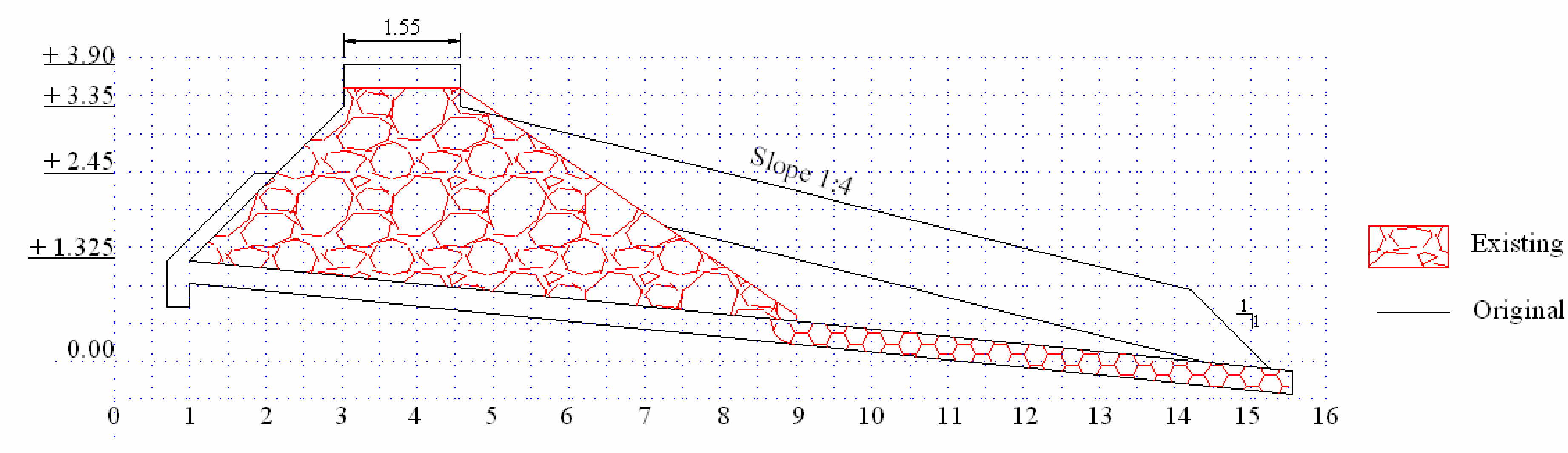


Fig. 3.7. Cross-section of the existing damaged seawall (as per KID) at Maruthadi

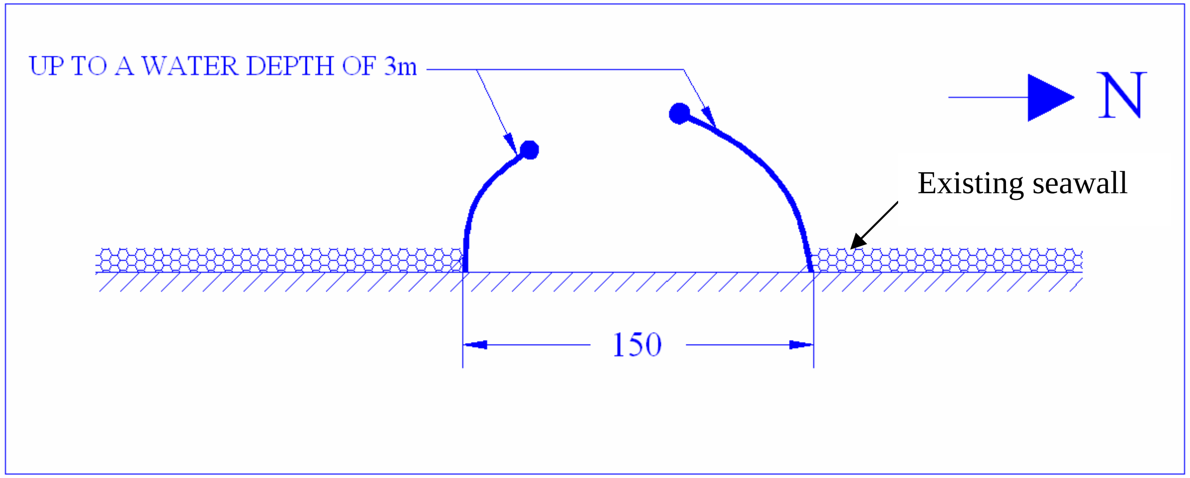


Fig. 3.8. Proposed groins at Valavithoppu

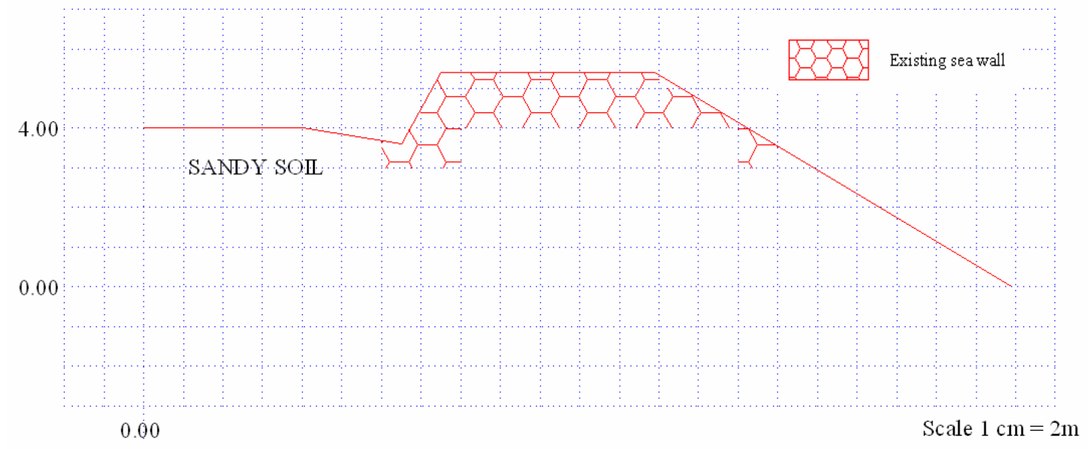


Fig. 3.9. Cross-section of the existing damaged seawall (as per KID) at Cheriyazheekal

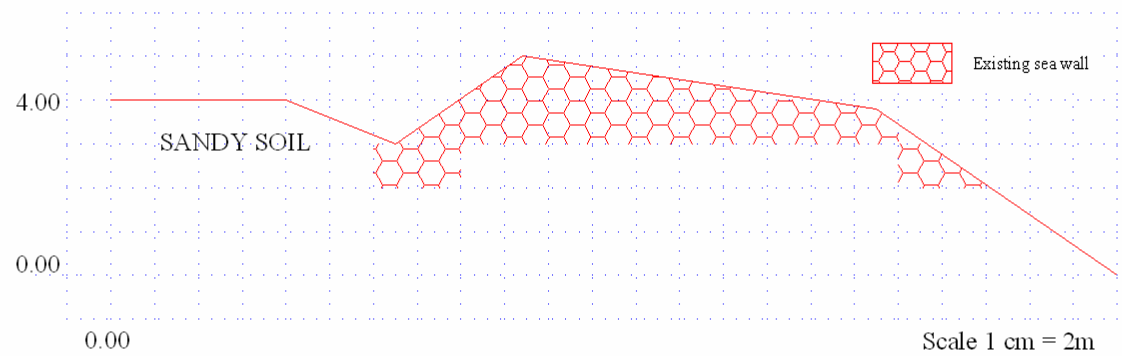


Fig. 3.10. Cross-section of the existing damaged seawall (as per KID) at Sraikkadu

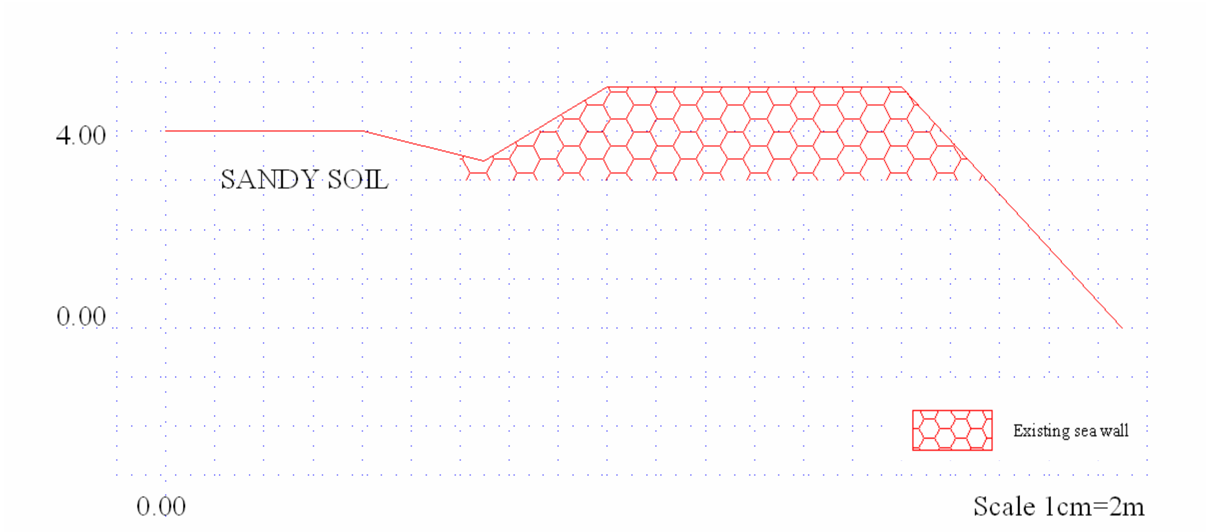


Fig. 3.11. Cross-section of the existing damaged seawall (as per KID) at Jayanthi Colony

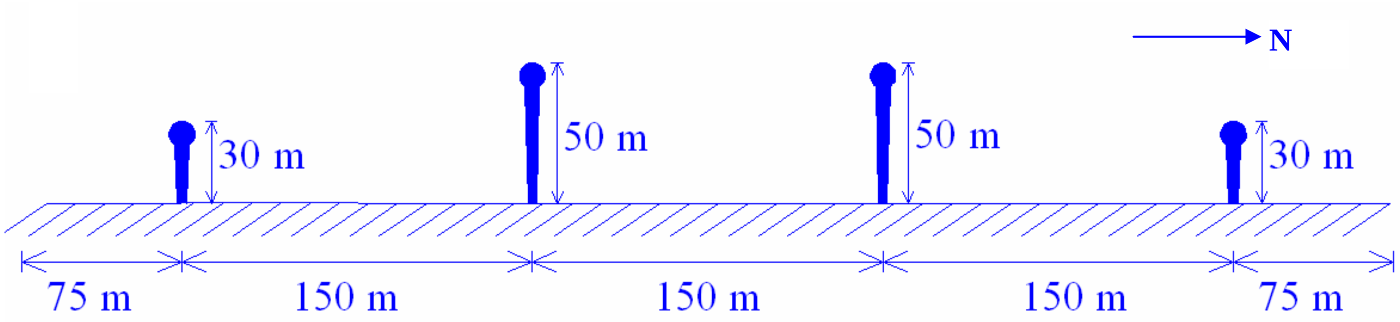


Fig. 3.12.The tentative layout of the groin field for the coast of Jayanthi Colony

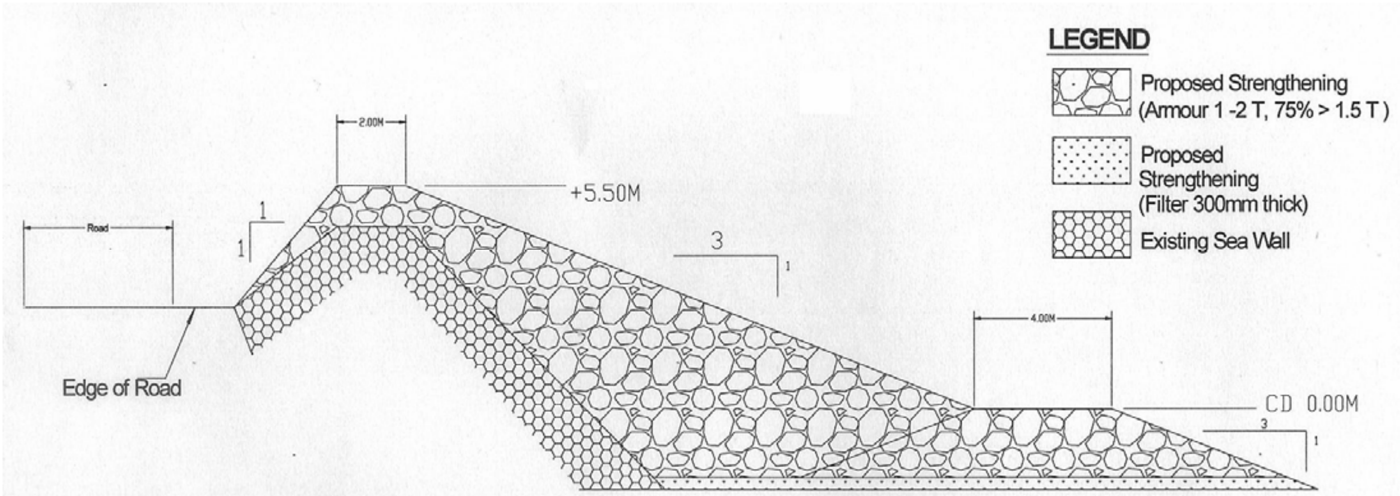


Fig.3.13a. Typical cross section of Conventional Sea Wall

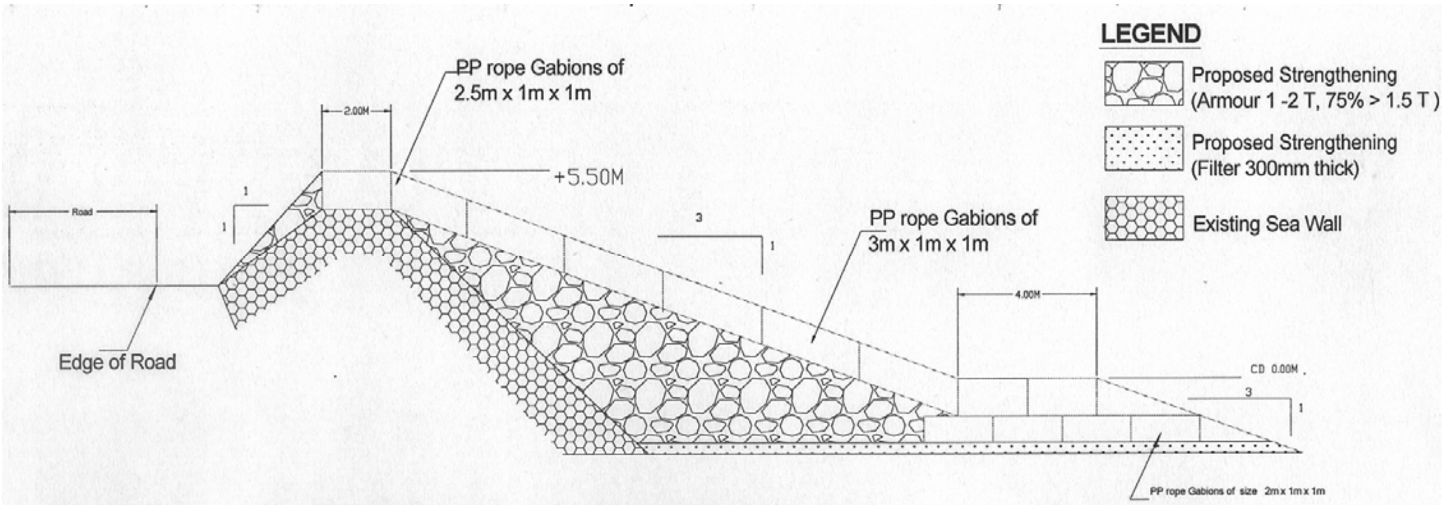


Fig.3.13b. Typical cross section of Sea Wall using PP Gabions

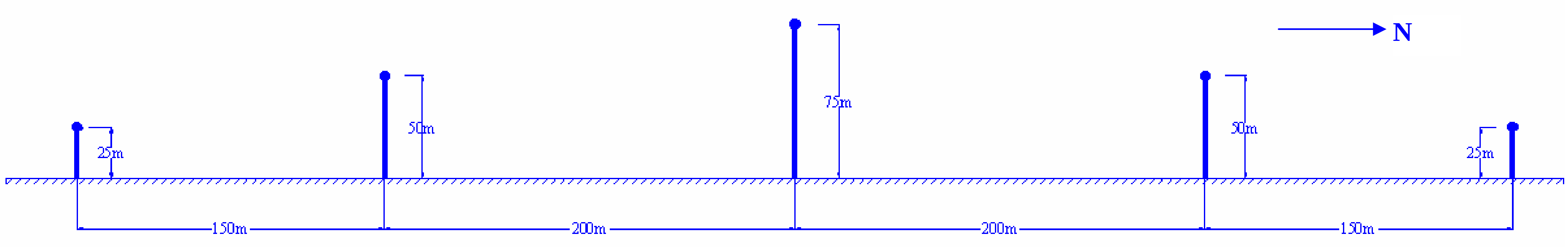


Fig. 3.14.The tentative layout of the groin field for the coast of Pathiankara

CHAPTER 4
PROTECTION MEASURES FOR ALAPPUZHA DISTRICT

4.1 INTRODUCTION

In order to identify the critically eroded areas along the Alappuzha district and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed of KID and HED. The location map of Alappuzha district along with the places visited is shown in Fig.4.1. The details of the site visit are presented in the following sections.

4.2 KAKKAZHAM (9º 23’ 17.8”; 76 º 20’ 53.8”)

This stretch of coast ha been experiencing perennial erosion and a temporary measure of a seawall has not provided sufficient protection against the erosion. The condition of the site is depicted in the views towards north and south of this stretch of coast as shown in Photo. 4.1 and 4.2. The total stretch of coast that is experiencing perennial erosion along this coast is of length about 1.9 km out of which only 60 m will be covered under this plan as the protection measure for the remaining stretch of coast has already been finalized in 12th finance commission plan for which the design has been finalized and work contract is awarded. IITM proposes a new seawall with improved cross-section as shown in Fig. A7 of Annexure A.

4.2 NEERKUNNAM (9 º 24’ 15.4”; 76 º 20’ 34.1”)

This stretch of the coast is being protected by a fairly stable seawall of cross-section shown in Fig. 4.2. Typical views towards north and south of this stretch of coast are shown in Photos. 4.3 and 4.4. A beach of width of about 20 m was found during the site visit as can be seen in above photos, which as per the KID, will be lost during the monsoon seasons. Hence, the existing seawall, for a length of about 350 m has to be rehabilitated with the cross-section designed by IITM and of increased crest level of seawall (+4.3 m) as shown in Fig. A5 of Annexure A.

4.3 VALANJAVAZHI (9 º 23’ 48.3”; 76 º 20’ 43”)

The views towards the north and south of this stretch of coast are shown in Photos. 4.5 and 4.6. The HED has a proposal to develop a fish landing center occupying 700m length of the beach. This is to cater to the needs of the fishermen who are engaged in traditional fishing for the last two decades. An auction hall (Photo. 4.7) is in existence which is being effectively used. At the same time KID has a proposal to construct a seawall for a stretch of coast of length 1.8 Km under 12th finance commission plan. As the work has already been awarded, IITM does not have any real role to play except for the clarifications if any during the course of construction.

4.4 PUNNAPRA (9 º 24’ 56.4”; 76 º 20’ 19.5”)

This stretch of the coast is presently protected by a seawall for a length of about 735 m. However, currently the seawall is completely damaged. The extents of the damages of the seawall are shown in Photos. 4.8 and 4.9. The original cross-section and the present status of the seawall are presented in Fig.4.3. In order to improve the situation, it is proposed that the existing seawall be rehabilitated with the cross-section proposed by IITM as shown in Fig. A4 of Annexure A.

4.5 VADACKAL (9 º 29’ 9.2”; 76 º 19’ 10.1”; CP 4877- 4874)

This is a stretch of unprotected sandy coast of length of about 200m (Photo 4.10 and 4.11). The new cross section of seawall for this 200m stretch has to be selected from Annexure-A based on available beach width at the time of construction.

South of the above site (9 28 44.4; 76 19 17.2), where a seawall has already been constructed, a beach has formed in front of the seawall. A number of country boats operate from this site mainly for fishing (Photos 4.12 and 4.13). This is an ideal site for development of a fish landing centre for traditional fishing. This has already been proposed by HED under TRP. This is strongly recommended as the proposed development of the fish landing centre will improve the livelihood of the local population and will also serve as coastal protection structure.

4.6 KATTOOR (9 º 33’ 48.3”; 76 º 18’ 15.3”)

The length of this coastal stretch is about 1km. Typical views north and south of this stretch of coast are shown in Photos 4.14 and 4.15. The livelihood of the people along this village is fishing. A view of the boats being parked at this stretch is shown in Photo 4.16. Since, a fair amount of littoral sediment is found to be moving along this stretch, Transition groins either with natural stones or gabions are recommended for this stretch of coast. There is an existing fishing gap and hence the protected space in between groins can be effectively used for fishing activities. The details of the suggested protection measure are shown in Fig. 4.4.

4.7 KADAKKARAPALLY (9 º 42’ 56.1”; 76 º 17’ 13.8”) (BLS 183-187)

This stretch of coast is densely populated and is protected by a seawall. Typical views towards north and south of the above site are shown in Photos 4.17 and 4.18.. Reformation of the damaged seawall is not necessary as of now. A beach of width of about 20 m is available at this site. T-groins are suggested for this stretch of coast of length of about 1.0 Km. The details of the suggested protection measure is as shown in Fig. 4.5.

4.8 SOUTH OF ANDHAKARANAZHY (9 º 43’ 46.2”; 76 º 17’ 9.0”) (BLS 189-190)

This stretch of coast was affected to a moderate extent during tsunami. The existing seawall is in a damaged condition (Photo. 4.19). It is proposed that the existing seawall be rehabilitated for a length of 122 m with a modified top level of +4.0 m. The details of the cross-section of the proposed seawall is shown in Fig. A5 of Annexure A.

4.9 ANDHAKARANAZHY (9 º 44’ 53.7”; 76 º 17’ 3.7”)

There is an existing water basin (Photo. 4.20) which is being used by local fishermen as harbour except during the months of June-August. Typical views north and south of the above site are shown in Photos 4.21 and 4.22. Two groins are proposed which will serve as a protection measure against erosion on either side. Further, the groins will also induce erosion in between them both during the southerly as well as northerly drift. Thus, maintaining the mouth free from siltation will facilitate using this location as an effective fishing harbour. However, capital dredging has to be carried out in order to remove the siltation at the mouth. The layout of the proposed groins is given in Fig. 4.6.

Table 4.1. Summary of the recommendations by IITM

S. No.	Name of the site	Recommended Protection Measures			Priority
		Seawall	Groin	Other	
1.	Kakkazham	New seawall (60 m)			*
2.	Neerkunnam	Rehabilitation (350 m)			***
3.	Punnapra	Rehabilitation (733 m)			***
4.	Vadackal	New seawall (200 m)		Development as a fish landing center	***
5.	Kattoor		Transition groins		**
6.	Kadakkarapally		Transition groin field (250 m)		***
7.	South of Andhakaranazhy	Rehabilitation (122 m)			**
8.	Andhakaranazhy		Groins as Training walls (500 m)		***

Photo 4.1. North of Kakkazham

Photo 4.2. South of Kakkazham

Photo 4.3 North of Neerkunnam

Photo 4.4. South of Neerkunnam

Photo 4.5. North of Valanjavazhi

Photo 4.6. South of Valanjavazhi

Photo 4.7. Fish landing center at Valanjavazhi


Photo 4.8. Existing seawall north of Punnapra


Photo 4.9. South of Punnapra


Photo 4.10. Status of the beach at Vadackal North


Photo 4.11. Existing seawall at Vadackal North


Photo 4.12. Fishing boats at Vadackal south

Photo 4.13. Existing fishing gap at Vadackal south

Photo 4.14. View showing north of Kattoor

Photo 4.15. View showing south of Kattoor

Photo 4.16. Fishing activity at Kattoor

Photo 4.17. North of Kadakkarapally

Photo 4.18. South of Kadakkarapally

Photo. 4.19. Breached seawall at Andhakkaranazhy south

Photo 4.20. Water basin used as harbour (non-monsoon seasons) at Andhakkaranazhy

Photo. 4.21. View towards north of Andhakkaranazhy

Photo. 4.22. View towards south of Andhakkaranazhy

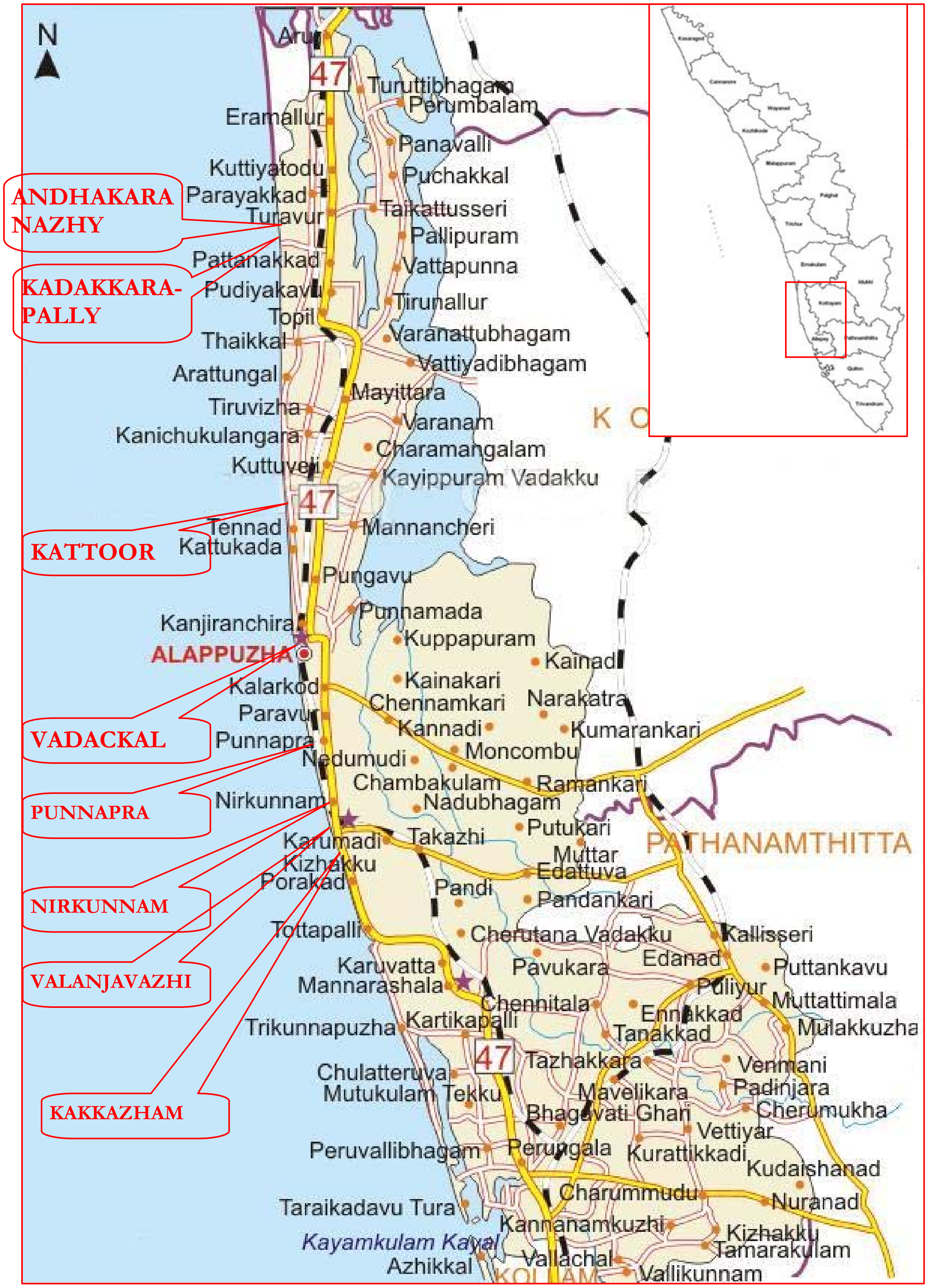


Fig. 4.1. Layout of Alapuzzha district

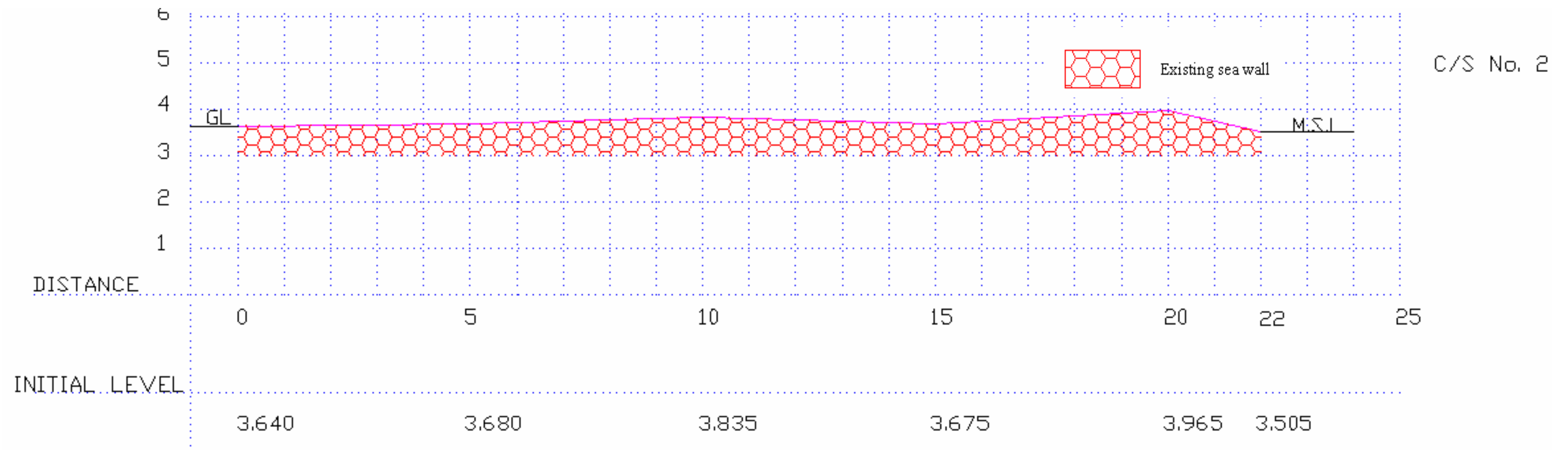


Fig. 4.2. Cross-section of the existing seawall (as per KID) at Neerkunnam

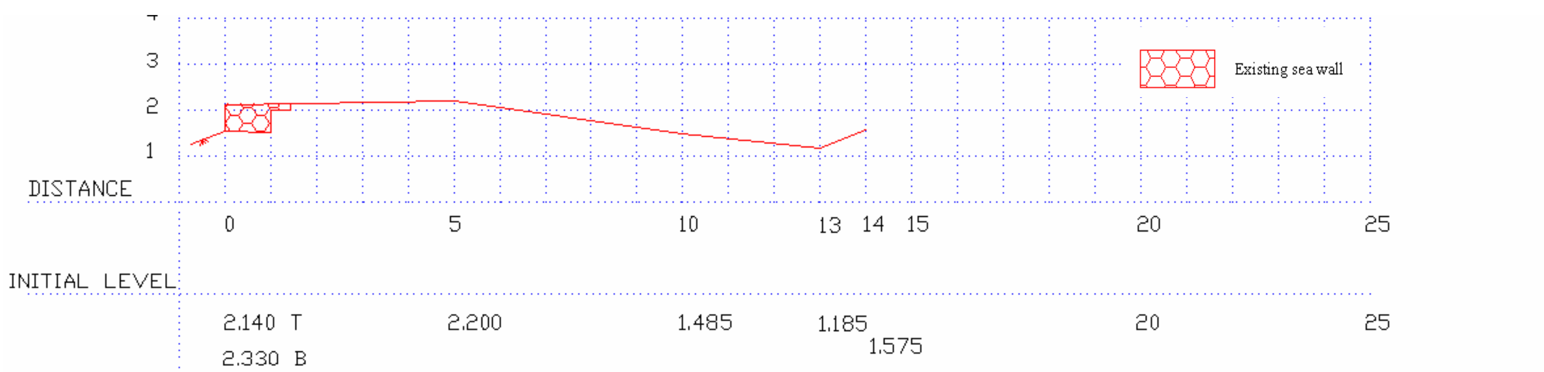


Fig. 4.3. Cross-section of the existing damaged seawall (as per KID) at Punnapra

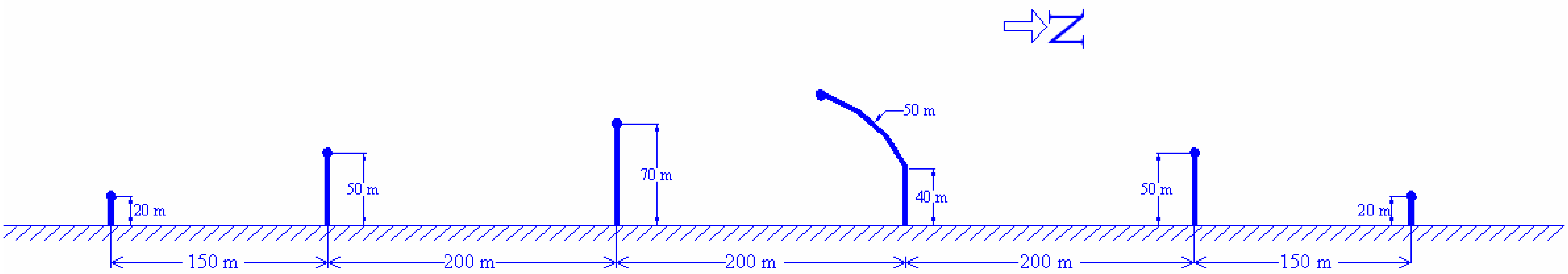


Fig. 4.4. Proposed Transition Groin field for the coast of Kattoor

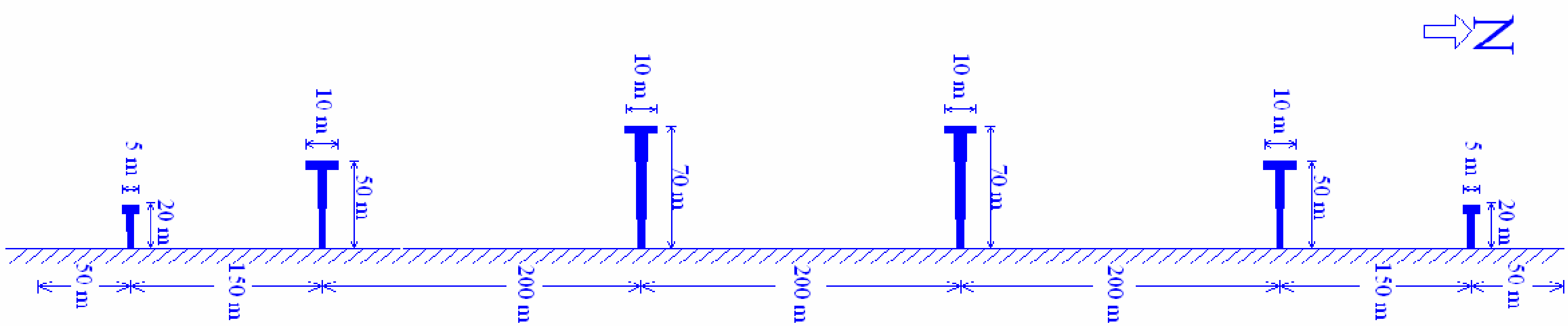


Fig. 4.5. Proposed Transition Groin field for the coast of Kadakkarapally

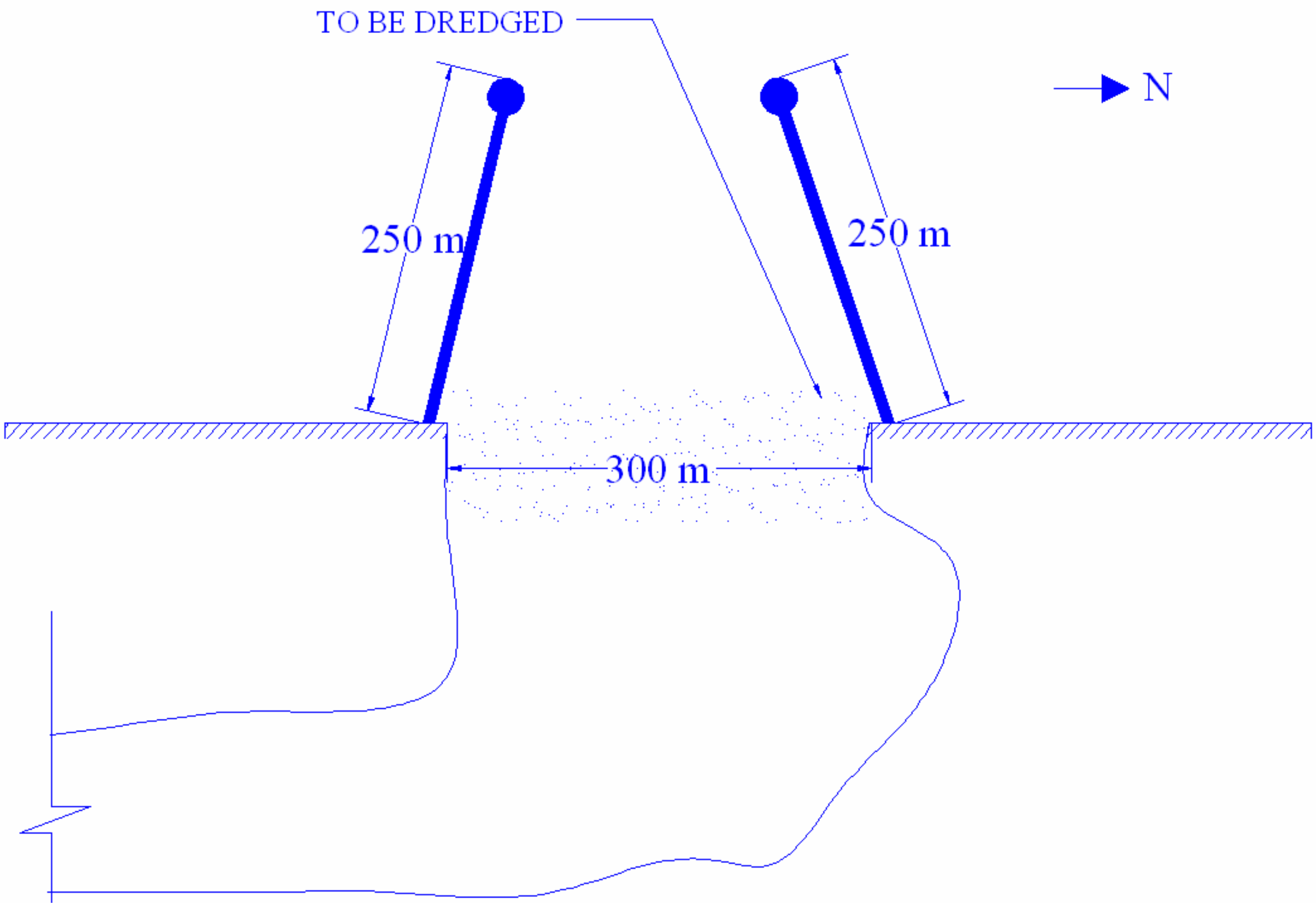


Fig. 4.6. Training walls at Andhakaranazhy

CHAPTER 5

PROTECTION MEASURES FOR ERNAKULAM DISTRICT

5.1 INTRODUCTION

In order to identify the critically eroded areas along the Ernakulam district and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1) Er. R. Unnikrishnan, S.E.
2) Joppan, E.E.
3) Suresh Babu, A.E.E
4) K.V. Jolly, A.E.E
5) Varghese, A.E.
6) Omanakuttan, A.E.
7) Philly Philip, A.E.

The location map of Ernakulam district along with the locations visited is shown in Fig.5.1. The details of the site visit are presented in the following sections.

5.2 GUNDUPARAMBU (9º 48’ 46.0”; 76 º 16’ 23.0”)

This stretch of the coast is thickly populated. The views of this stretch of the coast towards north and south are shown in Photos.5.1 and 5.2. The original cross-section adopted and the cross-section in existence as of now at this stretch are superposed in Fig.5.2. The top level of the existing seawall is +2.8m. This is inadequate protection against the normal waves and in particular against extreme events. It is proposed that the existing seawall be reformed with a new cross-section designed by IITM and shown in Fig. A4 of Annexure A. The top level of the reformed seawall is to be maintained at +4.2m keeping in view the wave attack at this particular stretch of coast.

5.3 KANDEKKADU FISHING GAP (9 º 48’ 3.5”; 76 º 16’ 30.6”)

The views towards north and south of this stretch are shown in Photos. 5.3 and 5.4. The fishing gap between the existing seawall, is under erosion particularly, during monsoon seasons. The waves surge onto the beach in this gap, resulting in unfavorable conditions for the fishing vessels. Hence, it is proposed to protect this stretch with two numbers of groins at a distance of 350 m apart as shown in Fig. 5.3.

5.4 MARAVUKADU (VELANKANNY CHURCH) (9º 49’ 54.5”; 76º 16’ 11.8”)

This stretch of coast is about 300m in length and is already protected by a seawall. The typical views of the existing seawall are shown in Photos 5.5 and 5.6. The original cross-section adopted and the cross-section in existence as of now at this stretch are superposed in Fig.5.4. It is proposed to replenish the existing seawall with a cross-section as shown in Fig. A4 of Annexure A. The top level of the replenished seawall is kept at +4.0 m.

5.5 KANNAMAZHY CP 4329-4332(9 º 52’ 53.7”; 76 º 15’ 39.0”)

The views of the existing seawall protecting this stretch of coast are shown in Photos 5.7 and 5.8. The seawall has breached for a length of about 30 m. The original cross section of the seawall and the cross-section in existence as of now are superposed in Fig.5.5. It is proposed to replenish the existing seawall Fig. A4 of Annexure A. Further south of this stretch, a length of the coast of about 120 m protected by a seawall is in damaged condition. It is proposed to replenish this seawall with a modified cross-section of top level +4.0m as shown in Fig.5.6. Photo 5.9 shows the damages to the seawall protecting the coast north of the above location. This seawall needs to be replenished with a cross-section as shown in Fig. A4 of Annexure A. Further, it is proposed that a groin for a length of about 220 m is to be constructed to protect the fishing gap from sand accumulation.

5.6 NJARAKAL (10 º 01’ 48.3”; 76 º 12’ 35.7”)

From CP 4088 for a distance of about 1.2 km, significant wave overtopping has led to the undermining of the seawall. The views north and south of this stretch are presented in Photo 5.10 and 5.11. The original cross section of the seawall and the cross-section in existence at as of now CP 4088 (Ch 17660 – 18812)are superposed in Fig.5.7. It is proposed to rehabilitate the existing seawall by increased top level of about +4.0 m.

The rear side of the existing seawall needs to be protected with gabions. The details of the suggested protective measure for this problem are presented in Annexure-A. Further, south of the above stretch is a stretch of coast protected by the existing seawall through which the seawater is seeping. The continuous seepage of seawater through the seawall has led to the formation of many streams on the landward side as can be seen in Photos 5.12 and 5.13. Hence, the existing seawall needs to be rehabilitated with a cross-section as proposed by IITM and is shown in Fig. A4 of Annexure A.

5.7 NAYARAMBULAM (10 º 03’ 31.3”; 76 º 12’ 01.3”)

As per the local public, it is understood that during June – August of every year they are forced to be away from their homes and spend in the relief camps due to increase in wave attack during monsoon season. During the tsunami, the public has observed a run-up of about 2m. The seawall which has been constructed by the KID has sunken at a few stretches and the existing cross-section is shown in Fig.5.8. On the leeside of the existing seawall, a beach of width of about 5m backed up by sand dunes with natural vegetation (Adambu) has been implemented by the local public. Typical views north and south of above stretch of the coast is presented in Photos 5.14 and 5.15. Hence, it is proposed that the existing seawall be rehabilitated with a modified cross-section as shown in Fig. A5 of Annexure A, that includes backing up of seawall with gabions. The top level of the suggested seawall should be at +4.00 m. As a long-term measure, a groin field is suggested with details as shown in Fig.5.9.

5.8 NAYARAMBULAM NORTH (10 º 04’ 05.0”; 76 º 11’ 52.3”)

The remains of the existing seawall along this stretch of coast are shown in Photos 5.16 and 5.17. This stretch of coast for a length of about 442 m which is protected by seawall needs to be rehabilitated with a top level of +4.0 m. Further, as a long-term measure, a transition groin field has been suggested as shown in the above figure.

5.9 EDAVANAKADU (CHATHANGADU) (10 º 05’ 20.2”; 76 º 11’ 31.5”)

This stretch of coast has been strongly affected during tsunami. Typical views showing the seawall as well as the adjacent road are provided in Photos 5.18 and 5.19. The newly constructed seawall (Fig.5.10) needs to be rehabilitated with the cross-section proposed by IITM as shown in Fig. A5 of Annexure A. As a long-term measure, groin field as shown in Fig.5.11 is also suggested. Further, Plantations in between the seawall and the adjacent road are recommended.

5.10 CHERAI BEACH (10 º 08' 22.0"; 76 º 10' 44.7")

A clear beach of width of about 10 m with a mild slope is available as shown in Photo 5.20. There is a proposal by the HED/Tourism to develop this stretch of coast as a major tourist attraction. This has to be separately taken up keeping in view of the interests of the above stack holders. One of the concept would be to install a submerged geo-tube beyond the surf width in a water depth of about 5m. As the geo-tube will be completely submerged, the problem of deterioration due to ultra violet rays may not arise. Although, it would involve a major investment, it can attract a lot of tourists.

Table 5.1. Summary of the recommendations by IITM

S. No.	**Name of the site**	**Recommended Protection Measures**			**Priority**
		Seawall	**Groin**	**Other**	
1.	Gunduparambu	Rehabilitation (1200 m)			***
2.	Kandekkadu fishing gap		Groins as breakwaters 350m apart (500 m)		**
3.	Maravukadu (Velankanny church)	Rehabilitation (300 m)			*
4.	Kannamazhy	Rehabilitation (370m)		Development as a fish landing center with groins	*
5.	Njarakal	Rehabilitation (1200 m)			***
6.	Nayarambulam	Rehabilitation (m)			***
7.	Nayarambulam North	Rehabilitation (450 m) as	Transition groin field (120 m) as		***
8.	Edavanakadu (Chathangadu)	Rehabilitation (500 m)			**
9.	Cherai beach			Geotubes as submerged reef	**

Photo 5.1. View towards North of Gunduparambu

Photo 5.2. View towards South of Gunduparambu

Photo 5.3. View towards North of Kandekadu


Photo 5.4. View towards South of Kandekadu


Photo 5.5. View towards North of Maravukadu


Photo 5.6. View towards South of Maravukadu

Photo 5.7. View towards North of Kannamazhy

Photo 5.8. View towards South of Kannamazhy

Photo 5.9. View towards North of North Kannamazhy

Photo 5.10. View towards North of Njarakal

Photo 5.11. View towards South of Njarakal

Photo 5.12. shows continious seeping of sea water through Seawall

Photo 5.13. shows continious seeping of sea water through Seawall

Photo 5.14. View towards North of Nayarambulam

Photo 5.15. View towards South of Nayarambulam


Photo 5.16. View towards North of Nayarambulam North


Photo 5.17. View towards South of Nayarambulam North


Photo 5.18. View towards North of Edavanakadu

Photo 5.19. View towards South of Edavanakadu

Photo 5.20. View of Cherai beach

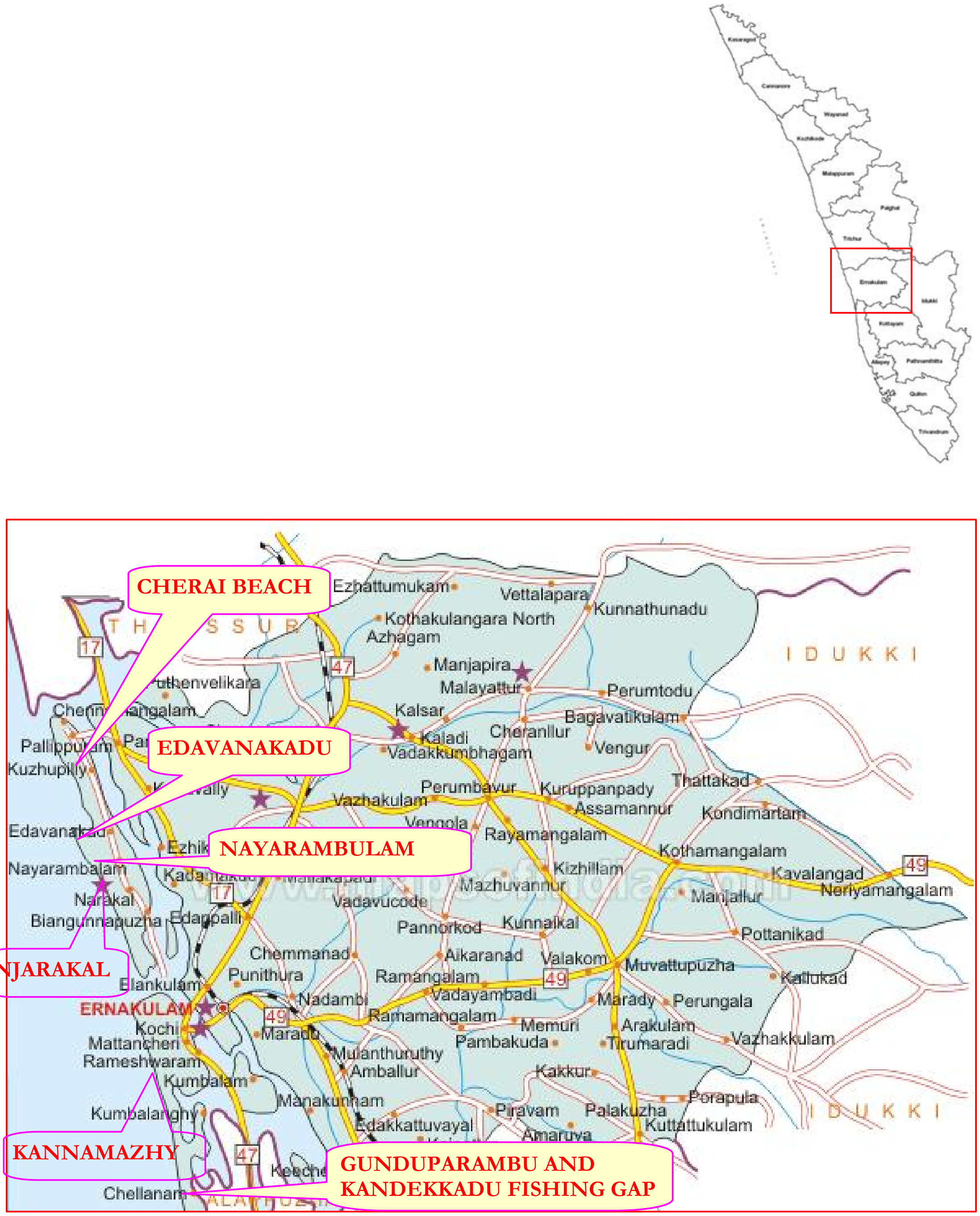


Fig 5.1. Layout of Ernakulam District

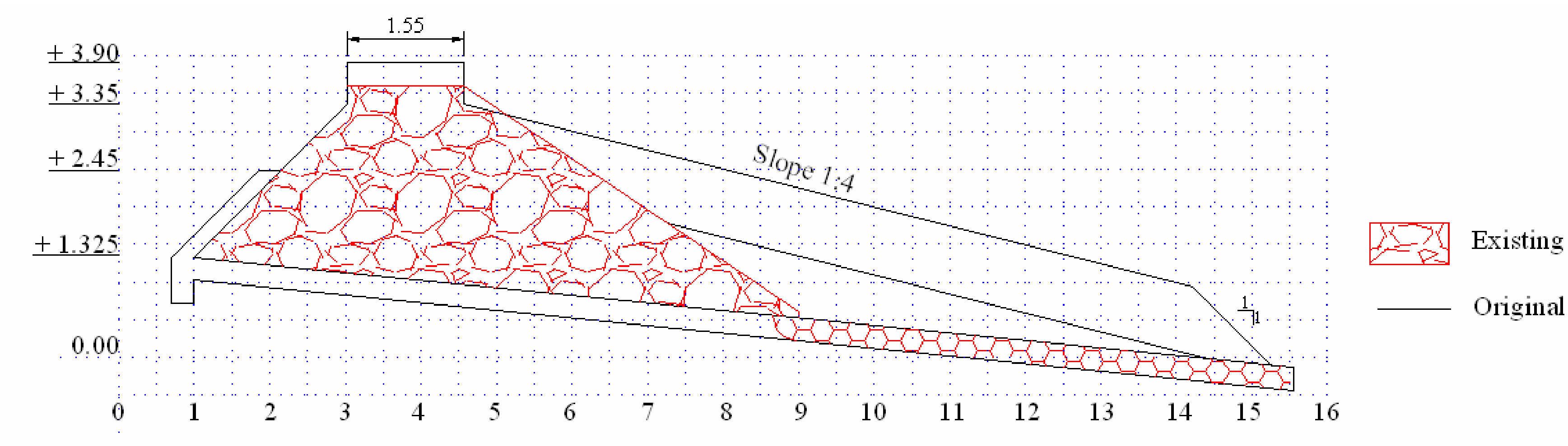


Fig 5.2. Cross-section of existing seawall at Gunduparambu

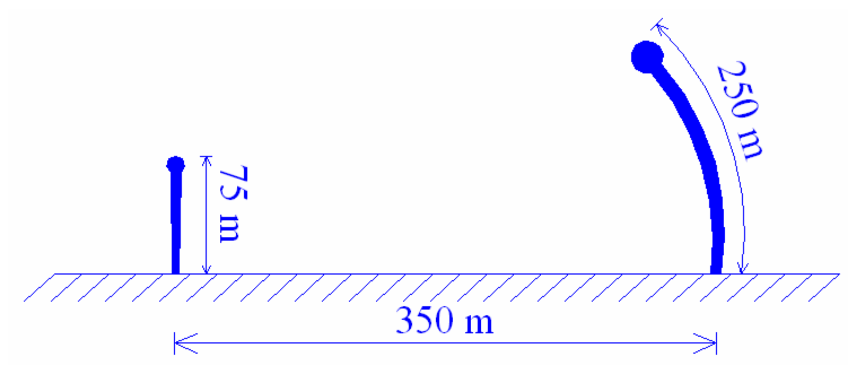


Fig 5.3. Propose groin field at Kandekkadu

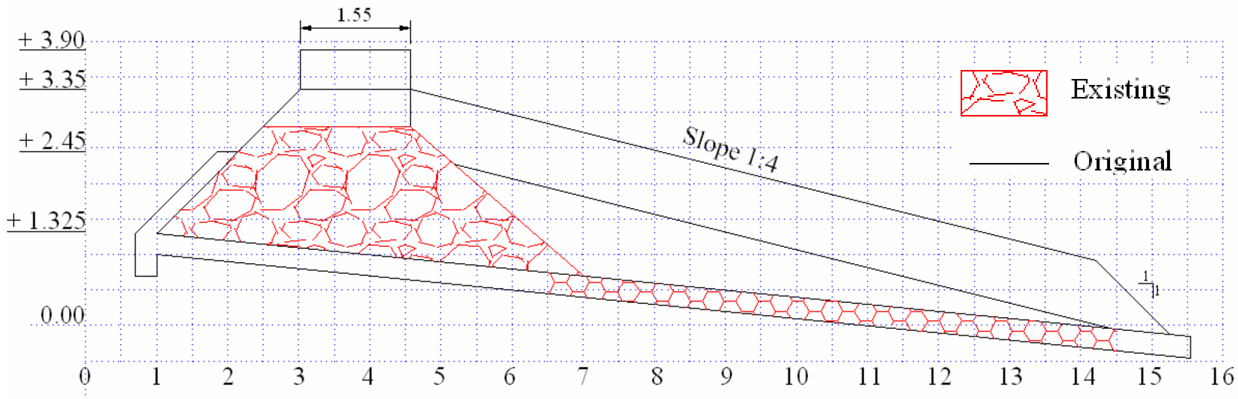


Fig 5.4. Cross-section of existing seawall at Maravukkadu

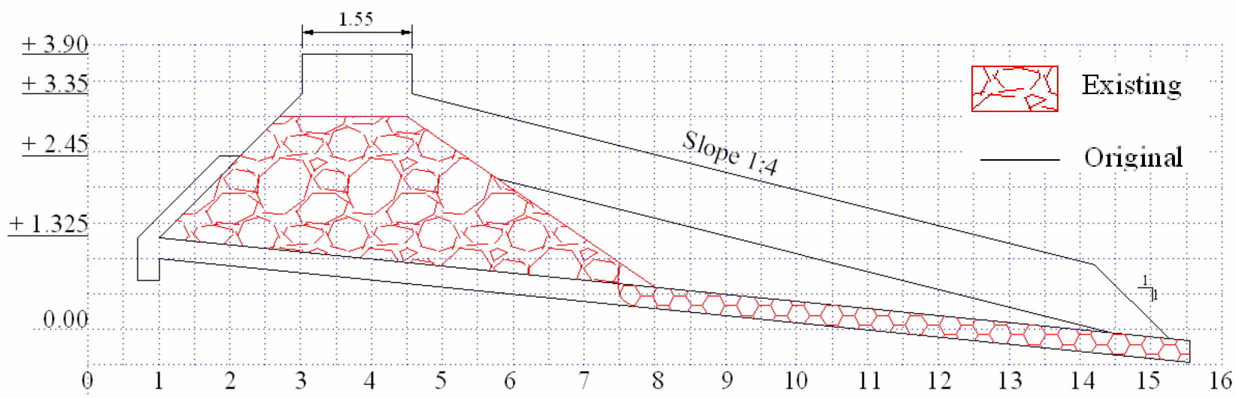


Fig 5.5. Cross-section of existing seawall at Kannamaly

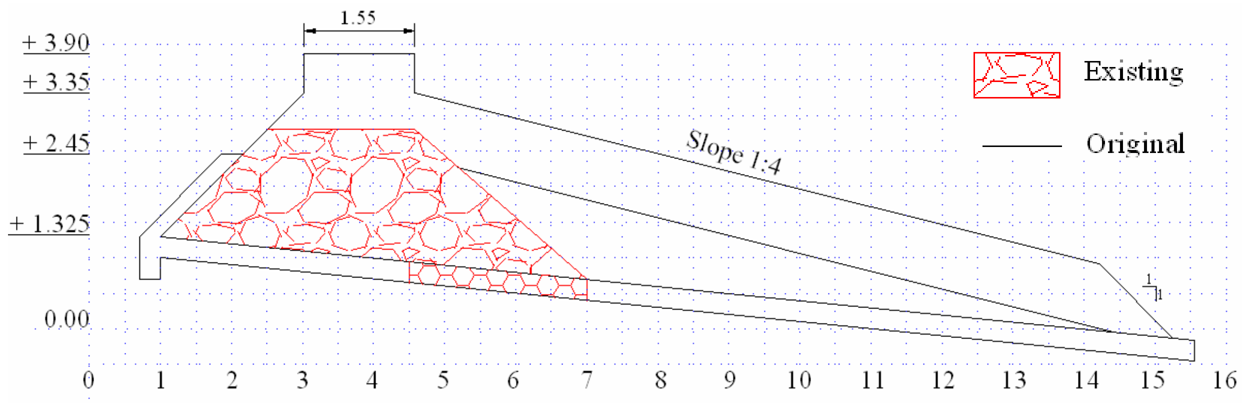


Fig 5.6. Cross-section of existing seawall at Kannamaly

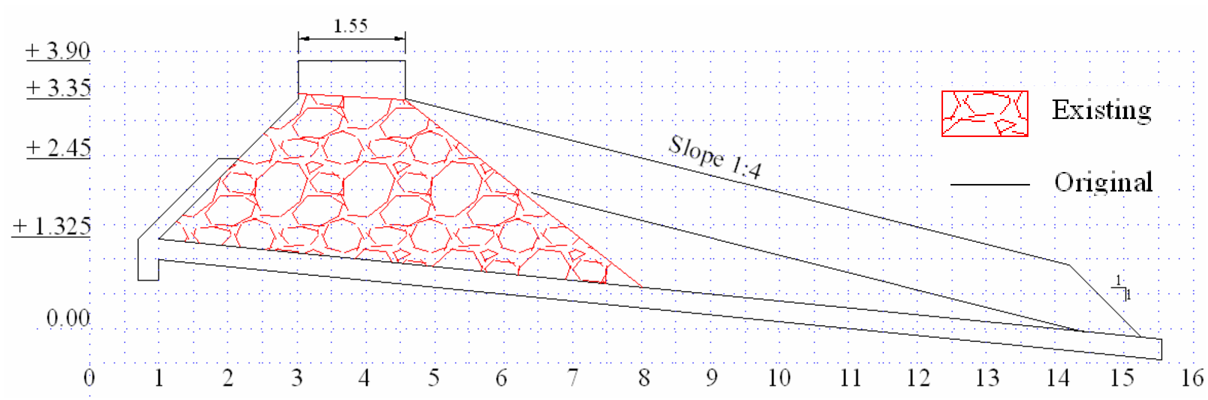


Fig 5.7. Cross-section of existing seawall at Njarakal

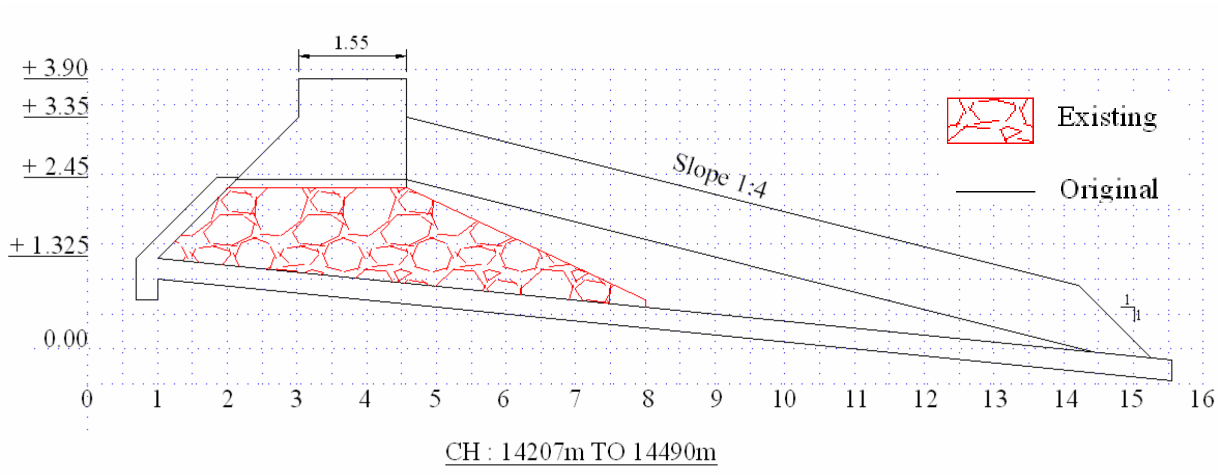


Fig 5.8. Cross-section of existing seawall at Nayarambulam

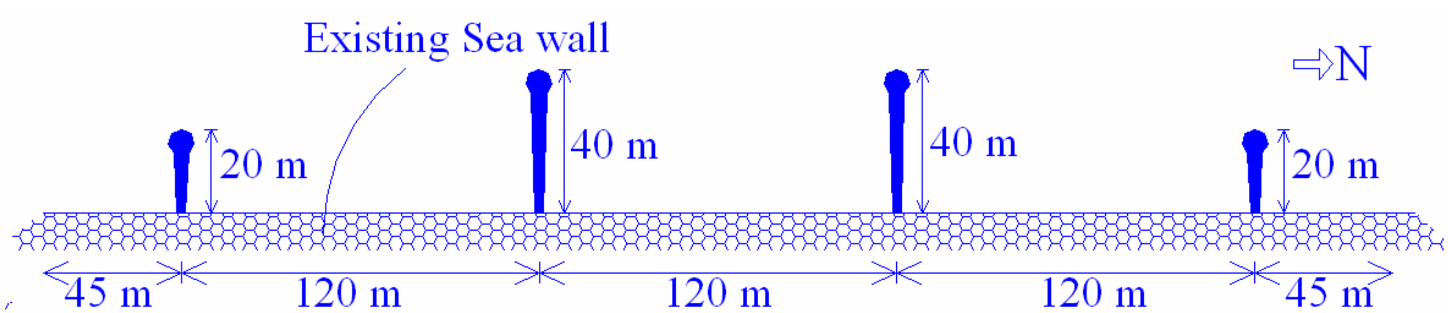


Fig 5.9. Propose groin field at North of Nayarambulam

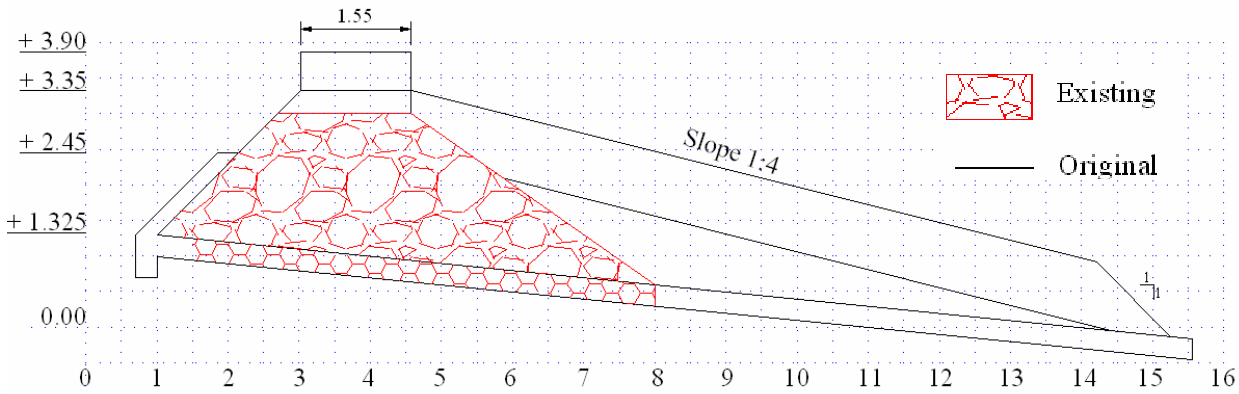


Fig 5.10. Cross-section of existing seawall at Edavanakadu

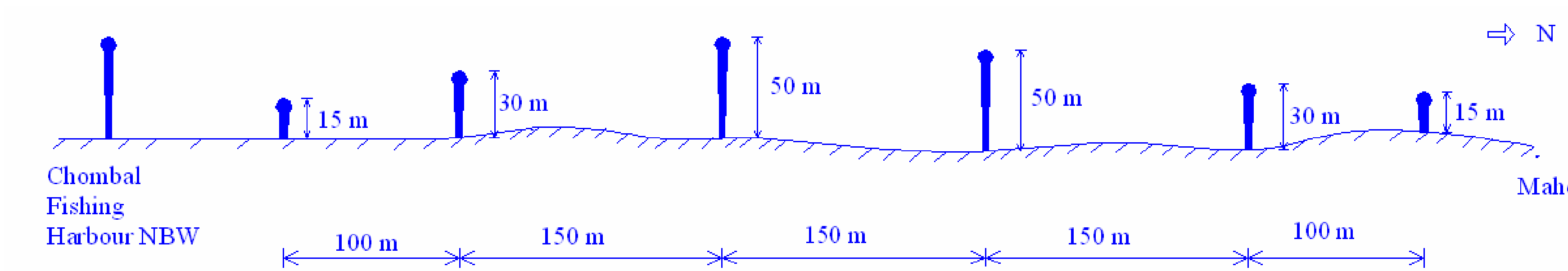


Fig 5.11. Propose groin field at Edavanakadu

CHAPTER 6

COASTAL PROTECTION MEASURES ALONG THRISSUR DISTRICT

6.1 INTRODUCTION

In order to identify the critically eroded areas along the Thrissur coast and to suggest appropriate remedial measures, the team of IITM visited the sites along with the local engineers listed below:

1) Er. Unni Krishnan, Superintendent Engineer
2) Er. A. Valsalan, E.E.
3) Er. P. Mahadevan, A.E.E
4) Er. P.V. Pushparaj, A.E.E
5) Er. A.R. Sundarlal, A.E.
6) Er. A.A. Joseph, A.E.
7) Er. E.P. Luvis, A.E.
8) Er. K.N. Mohan Das, A.E.
9) Er. K.R. Sajith kumar, A.E.
10) Er. S.K. Ramesan, A.E.

The location map of Thrissur along with the places visited is shown in Fig. 6.1. The details of the site visit are presented in the following sections

6.2 ANCHANGADI (10° 14′ 57.2″N, 76° 8′ 25.9″E)

Photo 6.1 shows the existence of beach of width of about 25 m for a length of 1 km. During tsunami as well as during the monsoon period, this stretch of coast has suffered severe damage. The details of which can be seen in Photo 6.2. The original seawall cross-section designed by CWPRS which was adopted for a length of about 100m is shown in Fig. 6.2. The existing cross-section prepared by Kerala Irrigation Department (KID) as well as seen through the earlier photos is projected in Fig. 6.3. It is proposed that the existing cross-section of seawall needs to be reformed with the cross-section designed by IIT Madras for locations with beach width of 20-25m (Fig. A5 of Annexure A). Similarly, the locations along this stretch of coast which are unprotected (for a length of about 50m) should also be covered with the seawall as recommended above.

6.2 NORTH ANCHANGADI (10° 15′ 22.1″N, 76° 8′ 20.3″E)

Further north of the Anchangadi, it is observed that the seawall which was constructed earlier, the cross-section of which is shown in Fig. 6.3 has been reduced to an offshore breakwater. The existing cross-section of the seawall at this location is shown in Fig. 6.3. The view towards north and south of this stretch of coast which is thickly inhabited is shown in Photos 6.3 & 6.4. It is recommended that the existing seawall needs to be modified with a cross-section of Fig.A5 of Annexure A.

6.3 KOOLIMUTTAM (10° 17′ 08.2″N, 76° 7′ 52.1″E)

The views towards north and south of this stretch of the coast are shown in Photos 6.5 and 6.6. The cross-section of the existing seawall is shown in Fig. 6.4. It is recommended that the existing seawall be modified with a cross-section of Fig.A5 of Annexure A as discussed earlier.

6.4 KOORUKUZHI (10° 17′ 08.4″N, 76° 7′ 52.1″E)

This stretch of coast is flourishing with fishing activity. The view towards north and south of this stretch of coast are shown in Photos. 6.7 & 6.8. The photographs indicate the busy fishing activity. It is proposed that this site can be developed as a fishing harbour / fish landing facility. The details of which will have to be worked out later.

6.5 PERINJINAM (10° 17′ 56.6″N, 76° 7′ 37.3″E)

The status of the seawall north and south of this location is given in Photos 6.9 & 6.10. The original cross-section that was adopted and the cross-section at present are shown in Fig. 6.5. It is recommended that the existing cross-section of the seawall needs to be reformed with a cross-section of base width 12 m designed by IIT Madras which is given in Fig.A3 of Annexure A.

6.6 ENGANDIYUR (10° 30′ 24.5″N, 76° 2′ 31.3″E)

Photo. 6.11 shows the damaged portion of the seawall protecting the Island Bangalakadavu near the fishing harbour. A view of the Island Chettuva Azhi is shown in Photo. 6.12. It is proposed to rehabilitate the existing seawall with a cross-section of base width of about 12m designed by IIT Madras as shown in Fig.A3 of Annexure A.

6.7 CHETTUVAI (10° 30′ 19.7″N, 76° 2′ 25.2″E) (CP 3750 – CP 3755)

This stretch of the coast is located south of Chettuva Azhi river mouth. The HED has a proposal to construct a pair of curved breakwaters to facilitate the easy movement of fishing vessels into the Azhi. It is observed during the site visit that, a beach of width of about 20 m is available at this stretch of coast. The present status of the seawall towards north and south of this stretch is shown in Photos 6.13 & 6.14. A seawall with cross-section (base width of 12m) as given in Fig.A3 of Annexure A is recommended. Another option is laying of geotubes filled with dredged sand from the river mouth. The details have to be worked out after a detailed study.

6.8 NORTH OF CHETTUVA AZHI (10° 30′ 41.8″N, 76° 2′ 9.3″E)

Further north of the river Chettuva Azhi is a stretch of coast protected by a seawall, the cross-section of which is shown in Fig. 6.6. Typical views towards north and south of this stretch are shown in Photos 6.15 & 6.16. A seawall with cross-section (base width of 12m) as shown in Fig.A5 of Annexure A is recommended for this stretch.

6.9 ANCHANGADIVALAVU (CP 3732-3734) (10° 32′ 15.7″N, 76° 1′ 24.3″E)

This stretch of coast is protected by a seawall which is in damaged condition. Typical views north and south of this stretch showing the status of erosion are shown in Photos 6.17 & 6.18. The shoreline is at a distance of about 30 m from the adjacent coastal road. Number of dwelling units is present in between the shoreline and the road. Hence, it is proposed to rehabilitate the existing seawall with cross-section designed by IITM of base width 12 m and top level of +3.30m as shown in Fig.A5 of Annexure. A.

Table 6.1 Summary of Recommendations by IIT Madras in Thrissur District

Sl.No	Name of the site	Recommended protection measures			Priority
		Seawall	Groin	Others	
1.	Anchangadi	Rehabilitation (1042 m) + New seawall (50 m)			***
2	North Anchangadi	Rehabilitation (747 m)			**
3.	Koolimuttam	Rehabilitation (695 m)			**
4.	Koorukuzhi			Fishing harbour/ fish landing center	**
5.	Perinjinam	Rehabilitation (280 m)			*
6.	Engandiyur	Rehabilitation (400 m)			*
7.	Chettuvai	Rehabilitation (660 m)		Geo-tubes	**
8	North of Chettuvai	Rehabilitation (670 m)			*
9.	Anchangadivalavu	Rehabilitation (360 m)			*

Photo 6.1. View showing the seawall at Anchangadi

Photo 6.2. Views showing the damages to the private property at Anchangadi

Photo 6.3. View towards north of North Anchangadi

Photo 6.4. View towards south of North Anchangadi

Photo 6.5. View showing the breached seawall at Koolimuttam


Photo 6.6. View towards south of Koolimuttam


Photo 6.7. Fishing activity at Koorukuzhi


Photo 6.8. View towards south of Koorukuzhi

Photo 6.9. View towards north of Perinjinam

Photo 6.10. View towards south of Perinjinam showing the breached seawall

Photo 6.11. View showing the breached seawall at Island Bangalakadavu

Photo 6.12. View showing the Island Chettuva Azhi

Photo 6.13. View towards north showing the existing seawall at Chettuvai

Photo 6.14. View towards south showing the breached portions of seawall at Chettuvai

Photo 6.15. View towards north showing the breached portions of seawall at North of Chettuva Azhi

Photo 6.16. View towards south showing the breached portions of seawall at North of Chettuva Azhi

Photo 6.17. View towards north showing the breached portions of seawall at Anchangadivalavu

Photo 6.18. View towards south showing the seawall at Anchangadivalavu

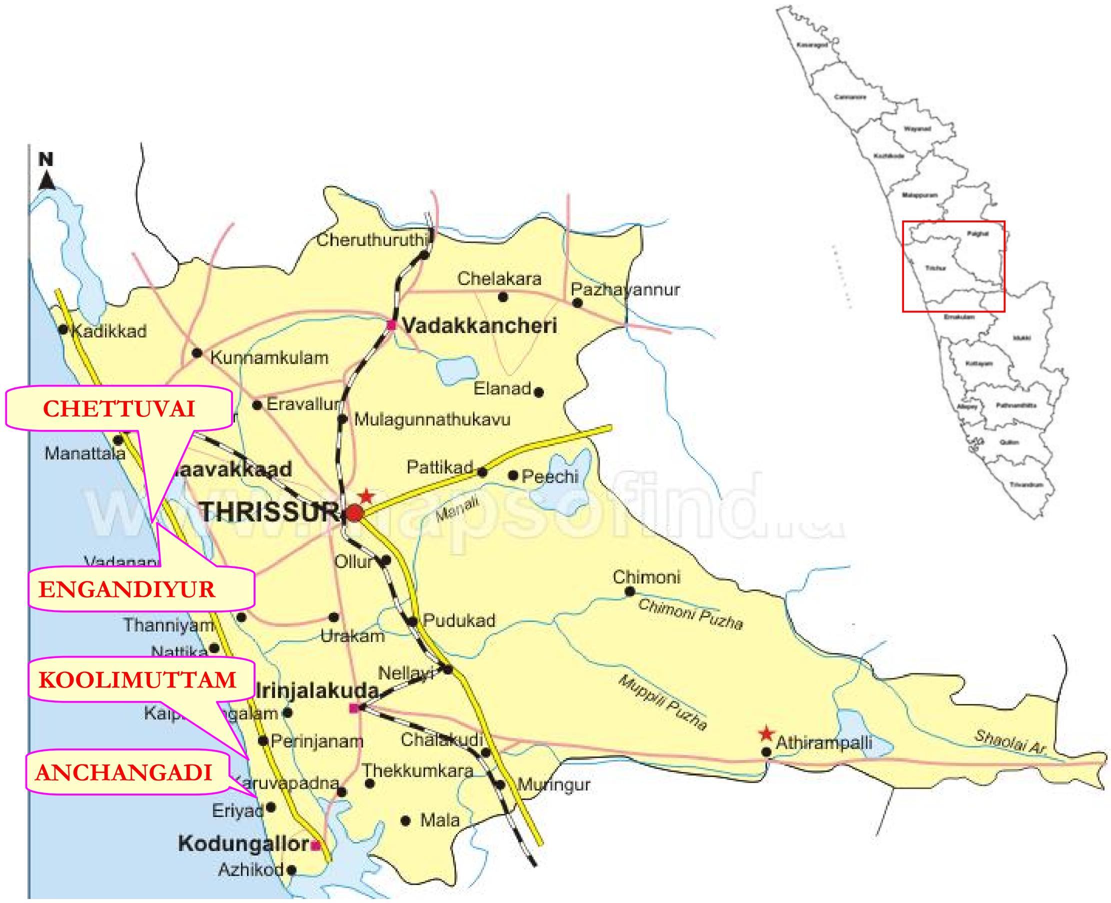


Fig. 6.1. Layout of Thrissur district

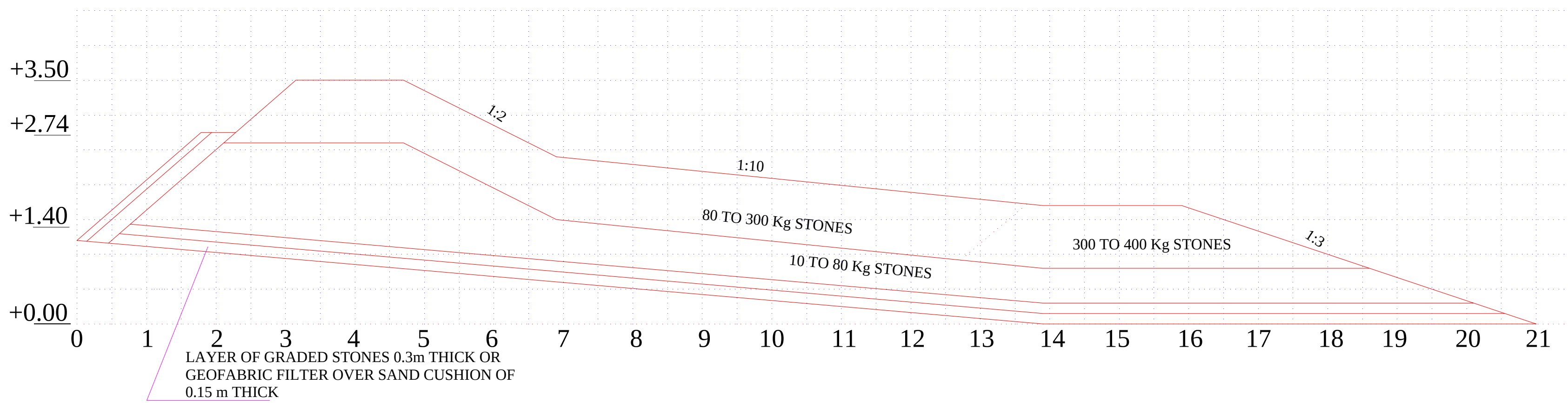


Fig 6.2 Cross Section of Seawall section suggested by CWPRS

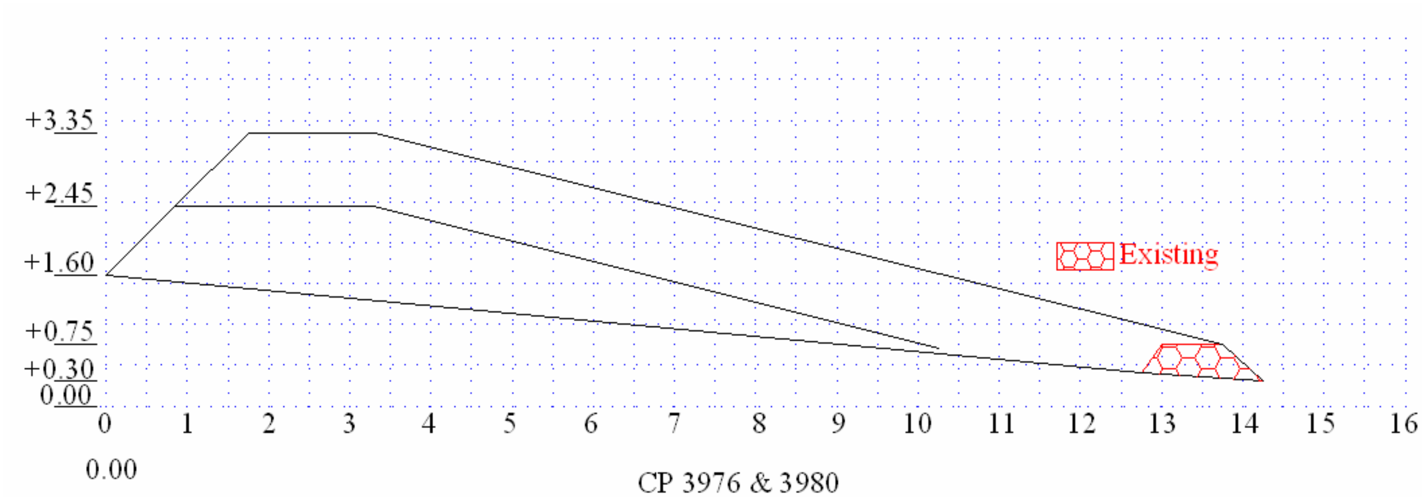


Fig 6.3.Existing and Proposed cross-section by Kerala Irrigation Department in Anchangadi

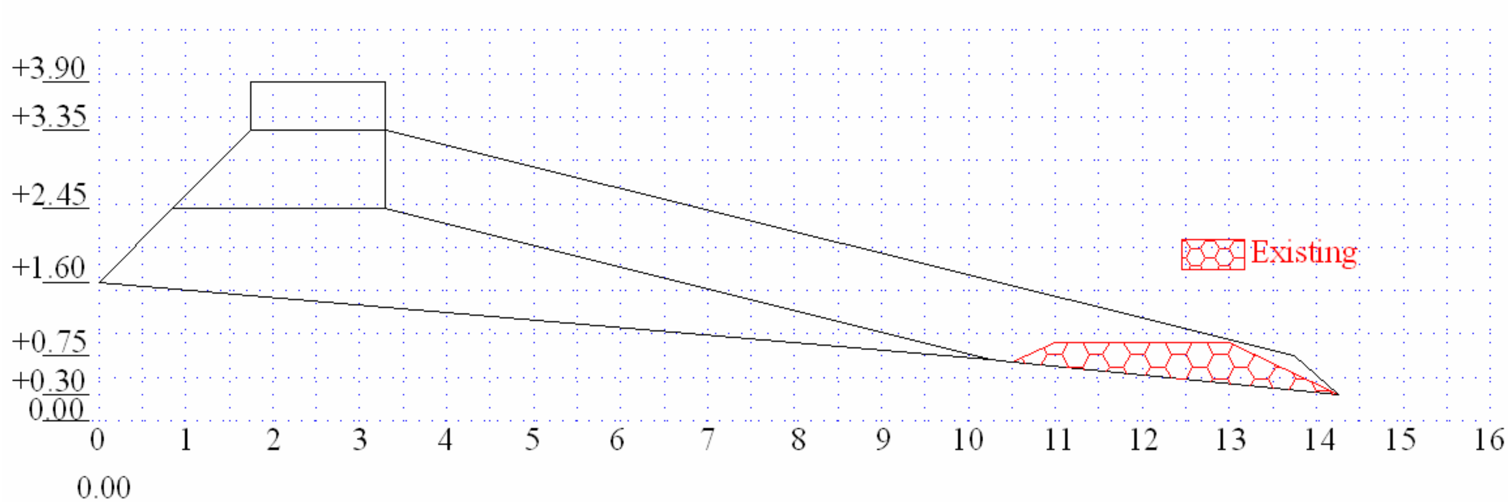


Fig 6.4.Existing and proposed cross-section in Koolimuttam

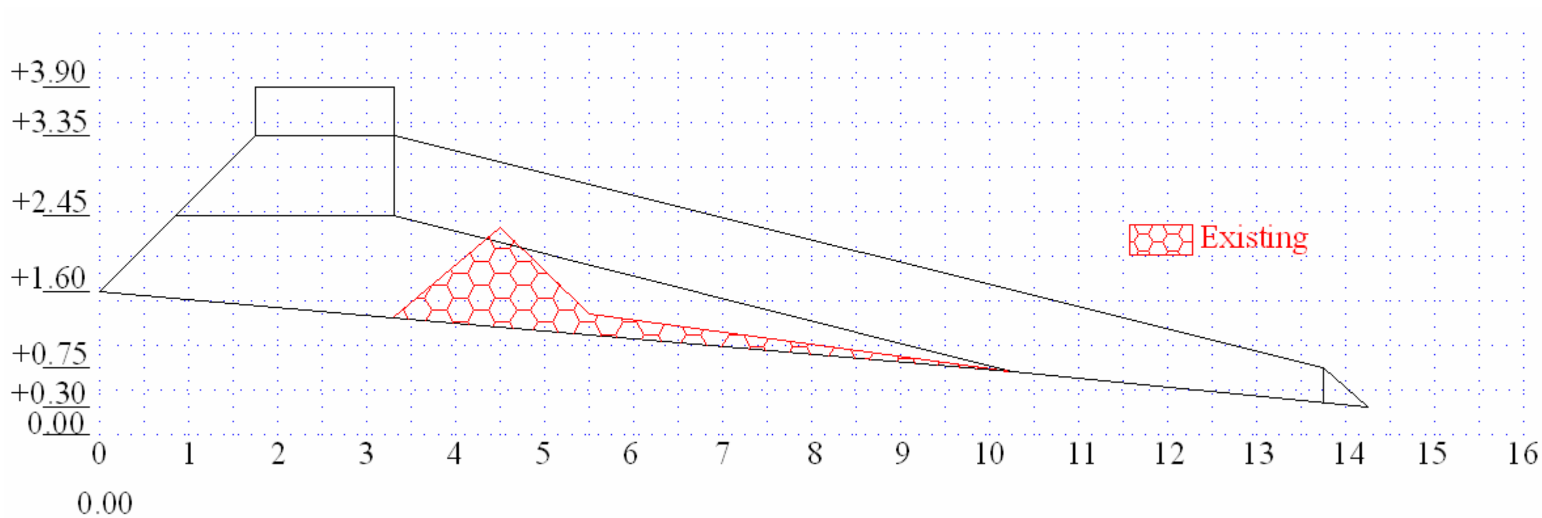


Fig 6.5.Existing and Proposed cross-section in Perinjinam

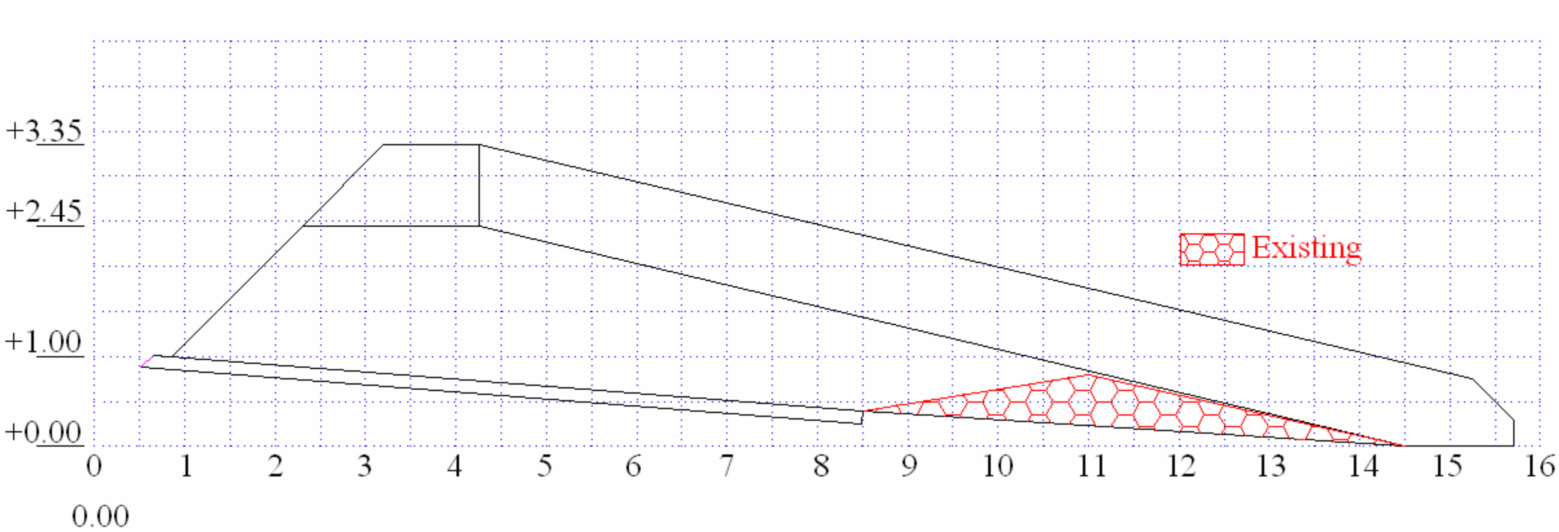


Fig 6.6.Existing and Proposed cross-section in Chettavai Azhi

CHAPTER 7

COASTAL PROTECTION MEASURES ALONG MALAPPURAM COAST

7.1 INTRODUCION

In order to identify the critically eroded areas along the Malappuram coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1) Er. T.S. Naushad	Superintending Engineer,
2) Er. K.K.Sathyan	Executive Engineer
3) Er. M.T.Varghese	Assistant Executive Engineer
4) Er. T.M. Geevarghese	Assistant Executive Engineer
5) Er. Sivanandan	Assistant Executive Engineer
6) Er. Asokan	Assistant Executive Engineer
7) Er. Saifullah. K.P	Assistant Engineer
8) Er. Sudheer	Assistant Engineer
9) Er. C.V. Sureshbabu	Assistant Engineer
10) Er. Asok Kumar	Assistant Engineer
11) Er. Bhaskaran	Assistant Engineer
12) Er. Muraleemohan	Assistant Engineer
13) Er .Musthafa	Assistant Engineer

The location map of Malappuram along with the places visited is shown in Fig. 7.1. The details of the site visit are presented in the following sections.

7.2 KAPPIRIKAD (10° 4′ 23.0″N, 75° 57′ 18.3″E)

This location during the site visit is observed to have 30-40m of beach width. Typical views towards north and south showing the details of available beach are shown in Photos 7.1 & 7.2. The cross-section that was originally adopted by the KID is shown in Fig. 7.2, which is understood to have got sunk leaving only a few stones here and there. This stretch of the coast of length of about 4.0 km experiences littoral drift to an extent of about 0.5 Mm3/year directed towards the south. As the stretch of the coast is quite long and in order to trap the sediments and enable beach building up a T-groin field may be proposed which will be finalized only after a critical study. Added to the above, this will also enhance the socio-economic aspects of the coastal villages as the gap in between the groins will act as fish landing facility. For this stretch the construction of groin field might be quite expensive. The alternate protection measure, although on a lower priority is the construction of a seawall for the entire length of coast. The final details will be worked out later after further careful monitoring of the coast for a minimum period of one year backed by a critical investigation that would include bathymetry and shoreline survey to be carried out by the KID and numerical study by any of the reputed agency/Institute.

7.3 SOUTH OF PONNANI FISHING HARBOUR (10° 46′ 47.7″N, 75° 7′ 52.1″E)

The erosion south of Ponnani harbour is due to the interception of the southerly drift by the breakwaters. The views towards north and south of this location are shown in Photos 7.3 & 7.4. The seawall constructed earlier along this stretch of coast is understood to have sunk as can be seen in the above photos. It is felt that the beach can be conserved as well as can be widened by provision of transitional groin field. The tentative layout of the proposed groin field is shown in Fig. 7.3.

7.4 CHEERANKADAPURAM (CP 3200-3206) (10° 56′ 34.0″N, 75° 52′ 36.1″E)

The existing seawall along this stretch of the coast has completely sunken as can be seen in Photos 7.6 & 7.7. This site is being used for parking a number of boats. The sediment transport along this stretch of coast is towards south of the extent of about 0.2 million m^3/yr. The coastal village is thickly populated and one of the main activities for their livelihood is fishing. Based on the above reasons, a transitional groin field is suggested for this site as shown in Fig. 7.4. The longest groin is fixed as 100 m which can be inclined at an angle of about 15° w.r.t shore normal towards the south. This will facilitate the trapping of sediment and shoreline advancements. The gaps in between the two longest groins may easily serve as a fish landing center.

7.5 ANGADITHODU / THANUR (10° 58′ 36.4″N, 75° 52′ 4.9″E)

Photos 7.8 & 7.9 show a number of boats, mainly fishing vessels being operated at this site. The beach of about 30 m width has been housing the stationary boats. It has been bought to the notice of IITM team that the erosion along this site is only seasonal and not perennial. With the above reasons, it is to be mentioned that this coast may be considered for a development of fish landing center if not a small fishing harbour. Hence no coastal protection is provided. This has been already identified as the development fishing harbour at Thanur by HED.

7.6 PARAPPANANGADI (11° 3′ 8.2″N, 75° 50′ 56.3″E)

Two groins each of length of about 10m with a distance in between them of about 60m which has been constructed are not effective in trapping the sediments. Both the groins have to be extended by an additional length of about 15-20m in order that the groins will be effective in building the beach. Although, the ideal situation would be to construct a groin field for this stretch of coast, as it is thickly populated and handling stones of weight higher than 500 kg is very difficult, this idea is dropped. Instead, the crest level of the existing seawall indicated in shown in Fig. 7.5 has to be fixed at +4.0m in order to avoid overtopping. The rehabilitation of the seawall may be done by superposing one of the typical cross sections designed by IITM of Annexure 1.

Table 7.1 Summary of Recommendations by IIT Madras in Malappuram District

Sl.No	Name of the site	Recommended protection measures			Priority
		Seawall	Groin	Others	
1.	Kappirikad	Rehabilitation (4000 m)	T-groins		*
2.	Ponnani fishing harbour		Transitional groin field (185 m)		***
3.	Cheerankadapuram		Transitional groin field (220 m)		**
4.	Angadithodu			Fish landing center / Fishing Harbour	*
5.	Parappanangadi	Rehabilitation (860m)	Extension of existing groins (20m)		***

Photo 7.1. View towards north of Kapprikad showing the existence of beach

Photo 7.2. View towards north of Kapprikad showing the remains of seawall

Photo 7.3.View towards north showing the breakwater of Ponnani fishing harbour

Photo 7.4. View towards south showing light house of Ponnani fishing harbour

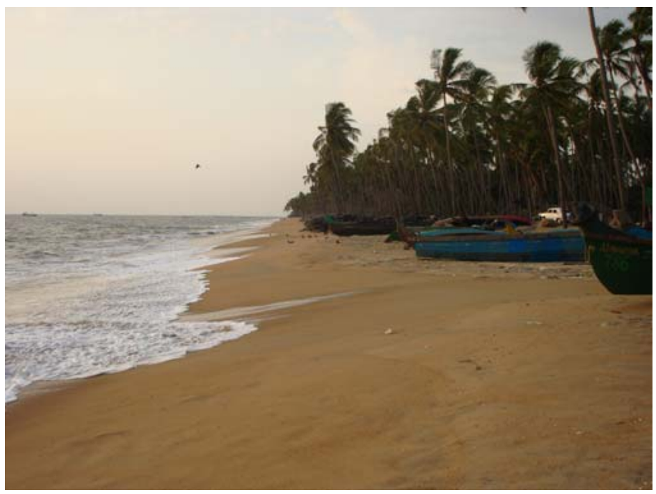


Photo 7.5. View towards north of Cheerankadappuram being used for boat parking

Photo 7.6. View towards south of Cheerankadappuram being showing remains of the seawall

Photo 7.7. View showing north of Angadithodu

Photo 7.8. View showing south of Angadithodu

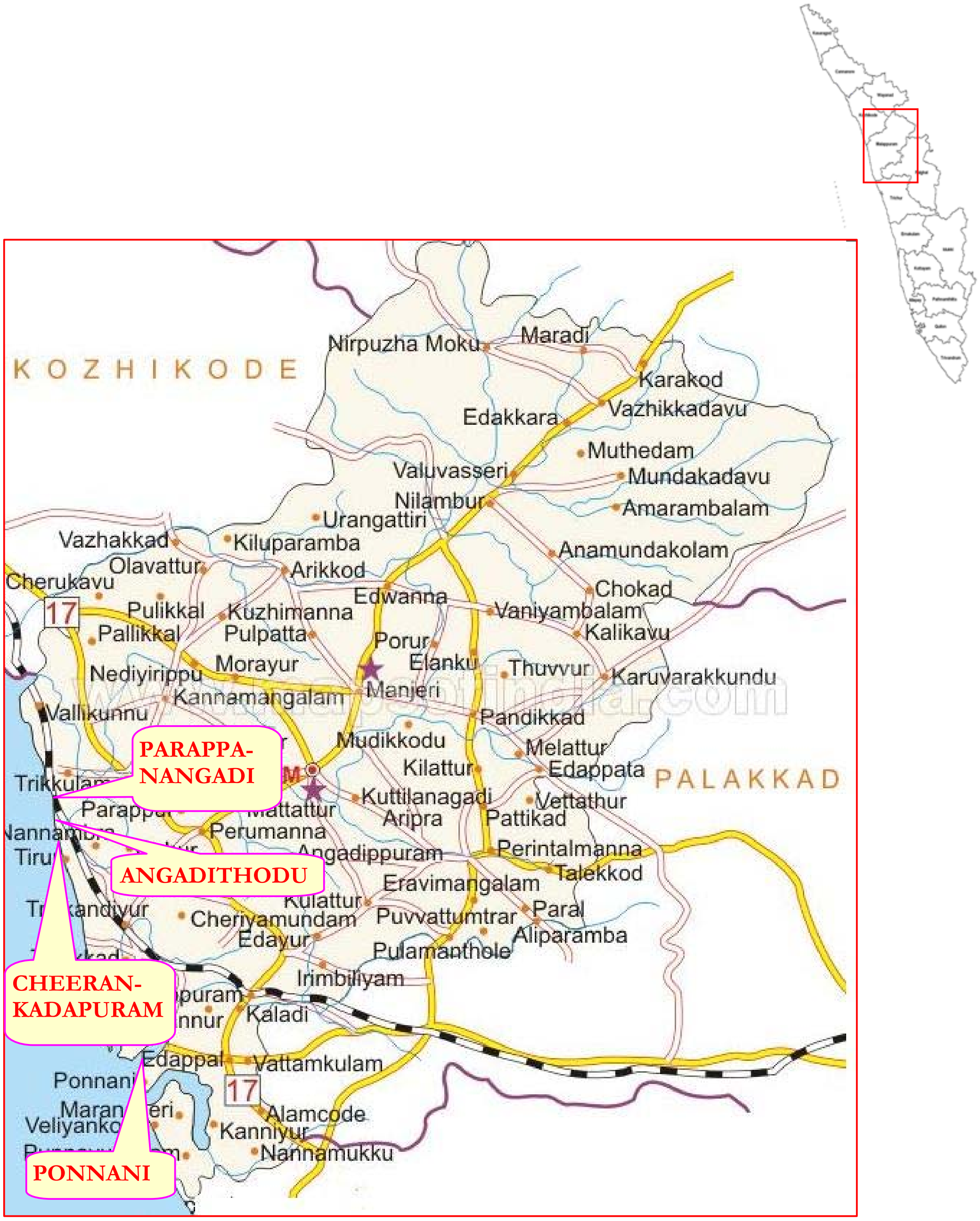


Fig. 7.1. Layout of Malapuram District

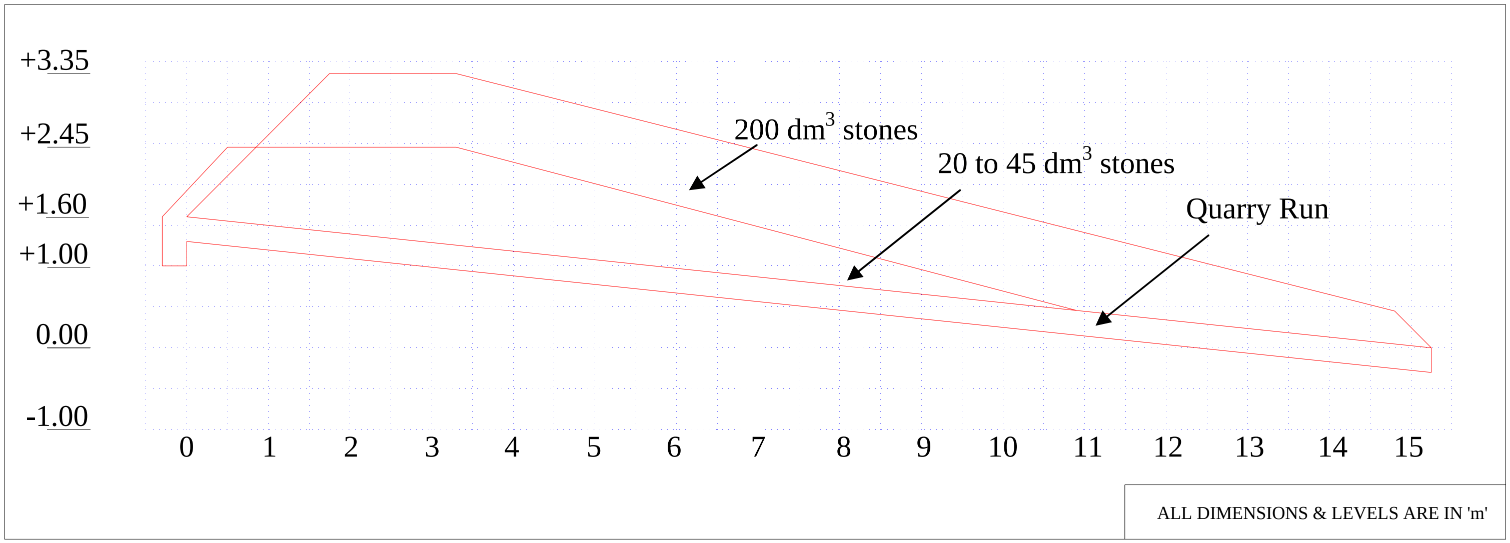


Fig. 7.2 Original Seawall cross section

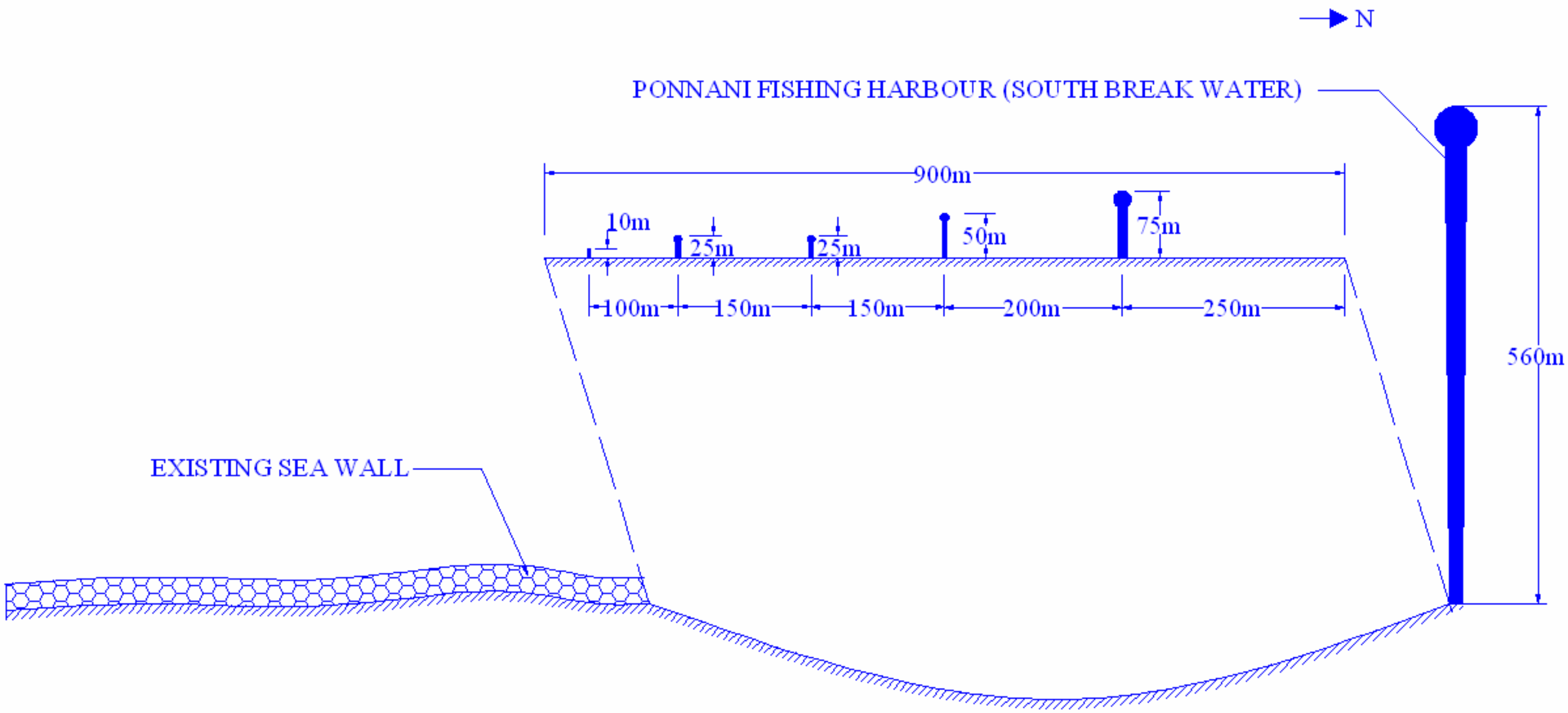


Fig. 7.3. Tentative layout of groin field at South Ponnani

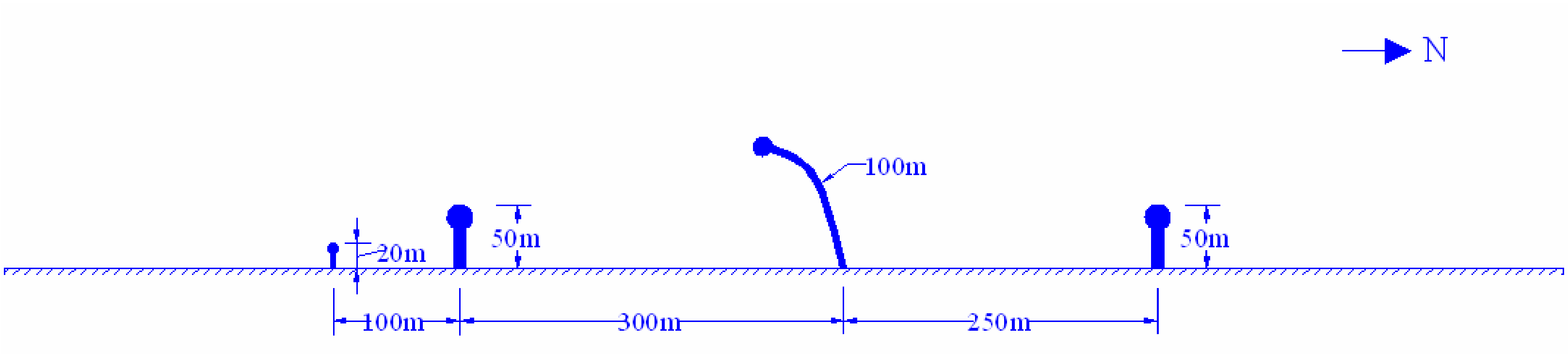


Fig. 7.4. Transition groin field at Cheerankappuram

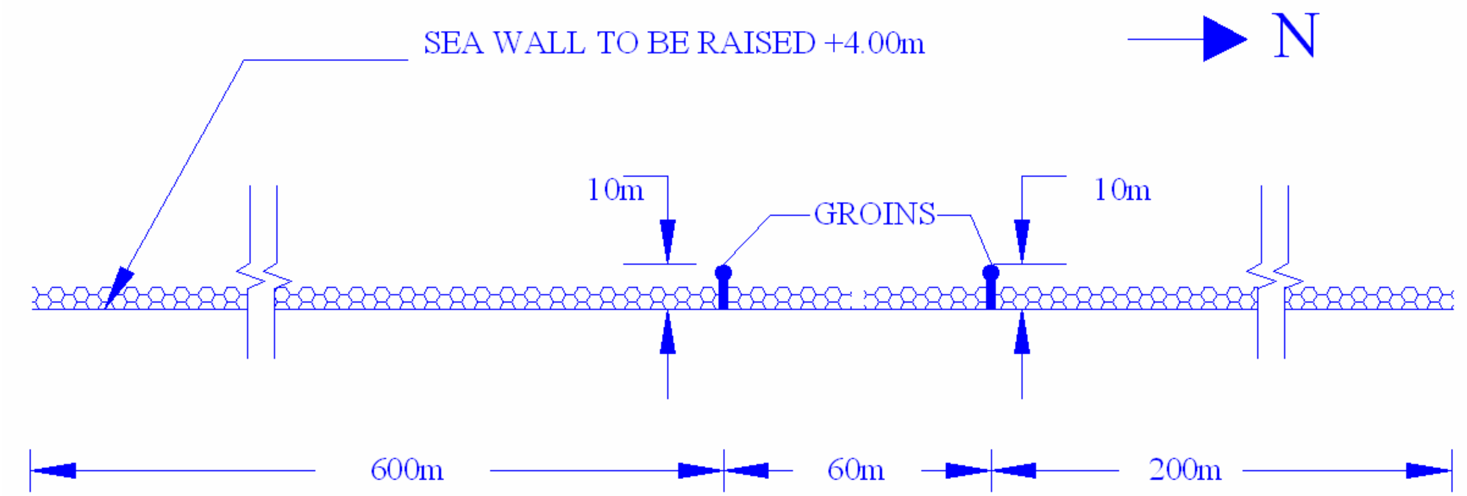


Fig. 7.5. Reformation of existing seawall at Parappanangadi

CHAPTER 8

COASTAL PROTECTION MEASURES ALONG KOZHIKODE DISTRICT

8.1 INTRODUCTION

In order to identify the critically eroded areas along the Kozhikode coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1) Er. T.S. Naushad, Superintendent Engineer
2) Er. M.K. Sebastian, E.E.
3) Er. Tom Joseph, A.E.E
4) Er. T.K. Unnikrishnan, A.E.E
5) Er. Abdul Razak, A.E.
6) Er. O.K. Premanandan, A.E.
7) Er. Mohammed Ashraf, A.E.
8) Er. K.K. Sathyan, A.E.
9) Er. R.D. Girish, A.E.
10) Er. Santhosh Kumar, A.E.
11) Er. T. Vijayan, A.E.

The location map of Kozhikode along with the sites visited is shown in Fig. 8.1. The details of the site visit are presented in the following sections

8.2 KALLAI RIVER (11° 13′ 43.4″N, 75° 46′ 48.2″E)

The entire flood water discharge from Calicut city drains into the Kallai river and in the event of chocking of the river mouth causes perennial problems. Typical views of the river mouth from the bridge under construction across the Kallai River are shown in Photos 8.1 & 8.2. A pair of training walls up to a water depth of about 6.0m is proposed for the prevention of sand bar formation due to the settling of sediment transported along the shore. The layout of the proposed training walls at the river mouth is shown in Fig. 8.2.

8.3 BUTT ROAD BEACH (11° 17′ 28.8″N, 75° 45′ 24.8″E)

This stretch of coast was moderately affected during tsunami and is a severely eroding area. The status of the erosion along this site can be seen through Photos 8.3 & 8.4. This village has to be protected as the houses are just on the shoreline. Seawall should be constructed from this location northward to the temple for a distance of about 600m. The cross-section to be adopted should be with a top level of +4.0m and base width of about 15m. The cross section for this stretch is given in the Fig.A4 of Annexure A.

8.4 KORAPUZHA (11° 20′ 58.8″N, 75° 44′ 5.0″E)

Korapuzha has had been a promising estuary for years which, unfortunately decreased due to the closure of the original mouth. The river mouth got shifted towards south over the years due to the formation of a spit owing to the southerly drift. The location of the old mouth is shown in Photo 8.5 and the existing mouth in Photo 8.6. In order to keep the mouth open there can be only one option which is the construction of a pair of training walls. For this purpose we have two locations mainly,

1) Cut open the original location of the river mouth
2) Cut open the present mouth.

The first option would be preferred as the southerly drift in the presence of the training walls is supposed to erode the southern side of the southern training wall which will not be detrimental in any way to the coast.

On the other hand, construction of the training walls near the existing mouth will lead to erosion of the private property on south which is rich in coconut plantations. Hence, the sand bar formed near the old mouth should be cut open over a width of about 100 m and a water depth of about 3m will be maintained at the site. The northern training wall will extend over up to a water depth of about 5m and the southern training wall up to 3m. The proposed scheme is shown in Fig. 8.3. The existence of an auction hall and a jetty will be an added advantage if the river mouth is kept open. If this project is implemented, the livelihood of the people will raise to greater heights.

Prior to the commencement of the project, a bathymetry survey has to be done and numerical modeling has to be carried out to assess the shoreline changes.

8.5 POOZHITHALA (11° 41′ 24.2″N, 75° 32′ 16.5″E)

This stretch of coast is situated between Mahe on the north and Chombal fishing harbour on the south. This stretch of the coast is facing perennial erosion. Typical views showing the status of erosion at this site are shown in Photos 8.7 & 8.8. the KID has a proposal to protect this stretch of the coast with a seawall. IIT Madras recommends that seawall should not be planned for this stretch. Instead, in order to preserve and enhance the beach formation, a transitional groin field as shown in Fig. 8.4 is recommended.

Table 8.1 Summary of Recommendations by IIT Madras in Kozhikode District

Sl.No	Name of the site	Recommended protection measures			Priority
		Seawall	Groin	Others	
1.	Kallai River			Training walls upto a water depth of 6m	**
2.	Butt road beach	New seawall (600 m)			***
3.	Korapuzha			Training walls upto a water depth of 5m	**
4.	Poozhithala		Transitional groins (190 m)		**

Photo 8.1 Kallai River mouth

Photo 8.2 Sand depositions at the Kallai River mouth

Photo 8.3. View towards North of Butt road beach


Photo 8.4 View towards South of Butt road beach


Photo 8.5 View towards North of Korapuzha


Photo 8.6 View towards South of Korapuzha

Photo. 8.7 View towards north of Poozhithala

Photo 8.8. View towards south of Poozhithala

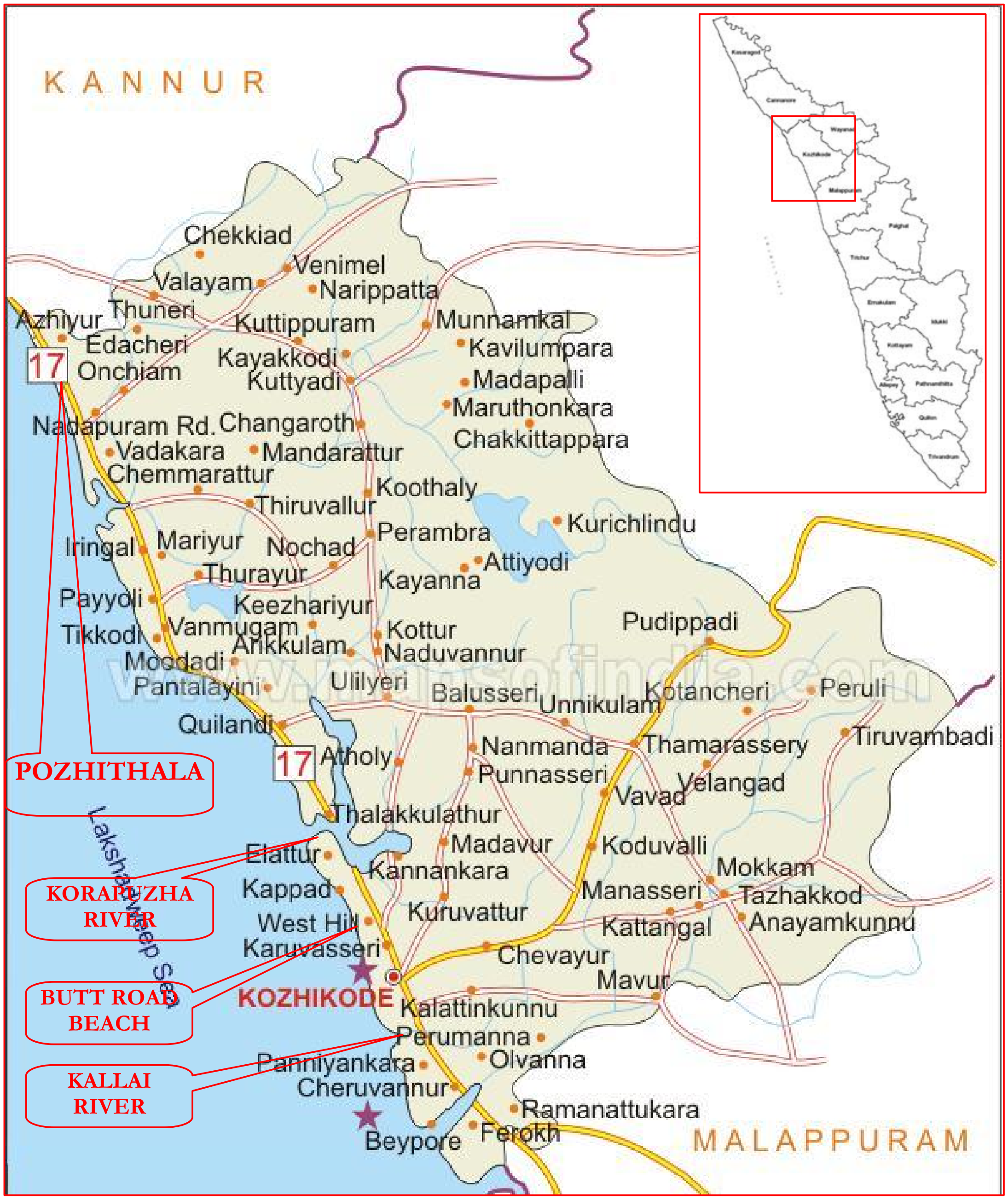


Fig. 8.1. Layout of Kozhikode District

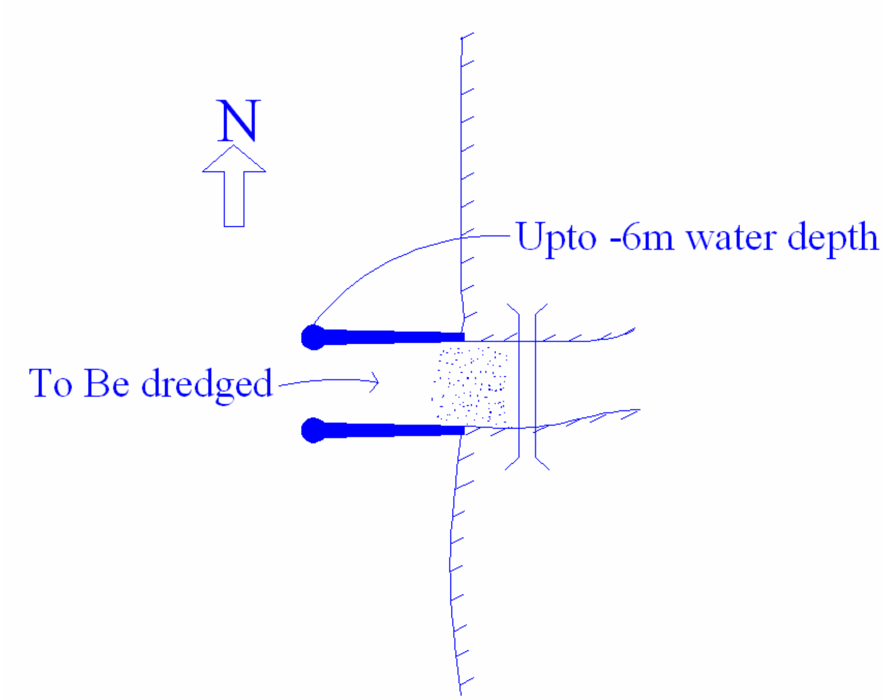


Fig. 8.2. Training Works at Kallai river mouth

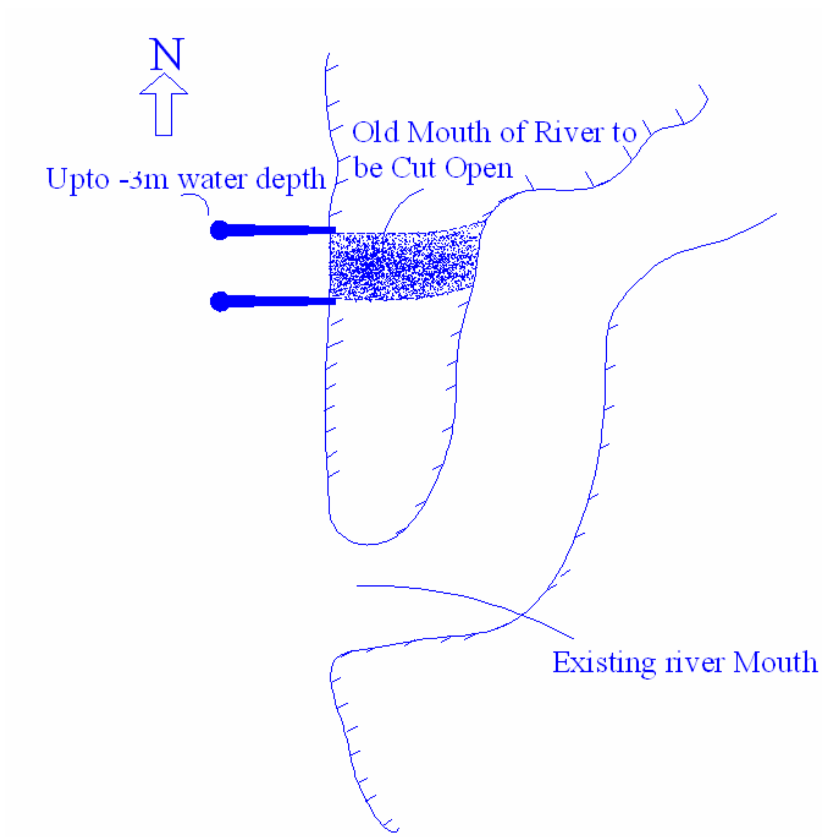


Fig. 8.3. Training works at Korapuzha river

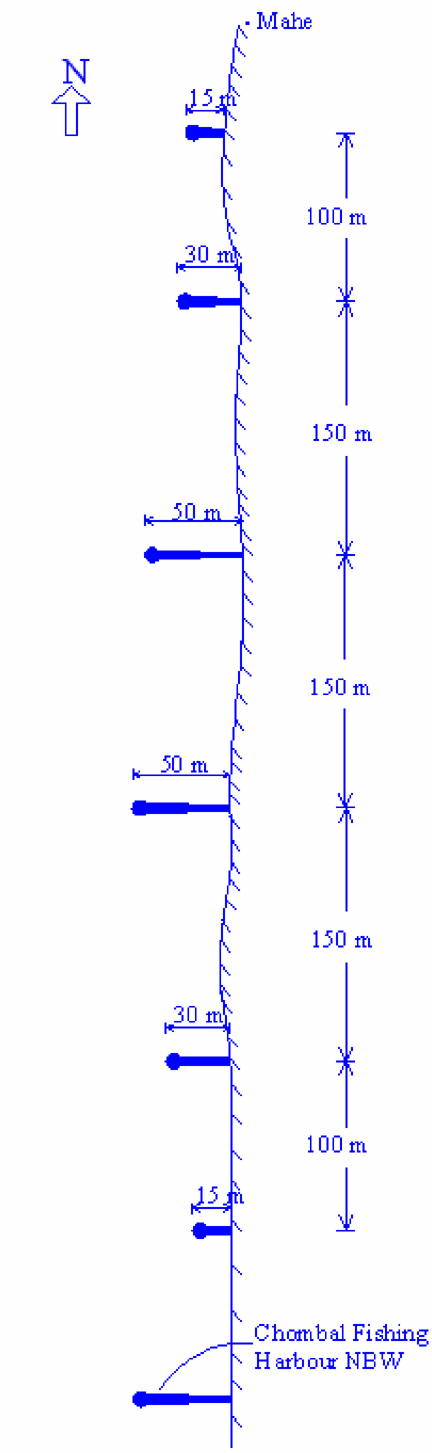


Fig. 8.4. Transition Groin Field at Poozhithala

CHAPTER 9

COASTAL PROTECTION MEASURES ALONG KANNUR DISTRICT

9.1 INTRODUCTION

In order to identify the critically eroded areas along the Kannur coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1) Er. T.S. Naushad, Superintendent Engineer
2) Er. E.V. Saseendran, E.E.
3) Er. T.M. Zubair, A.E.E
4) Er. C. Radhakrishnan, A.E.E
5) Er. M.T. Ramadevi, A.E.
6) Er. K. Santhosh, A.E.
7) Er. Balakrishnan Mannorakkal, A.E.
8) Er. P. Surendran, A.E.
9) Er. I.V. Susheel, A.E.
10) Er. K.M. Sudheer, A.E.

The location map of Kannur along with the places visited is shown in Fig. 9.1. The details of the site visit are presented in the following sections

9.2 PETTIPALEM (11° 43′ 14.9″N, 75° 30′ 54.9″E)

The Thalassery Municipality has a future plan to develop this area. A coastal road is in existence adjoining the seawall. The status of the existing seawall as well as the existing road on its land ward side can be seen in Photos 9.1 & 9.2. The present top level of the existing seawall is +3.64m which has to be raised by +0.4m in order to reduce wave overtopping. The existence of a small groin of about 10m length has clearly demonstrated the advancement of shoreline towards the sea as seen in the above photos. Hence, it is proposed to protect this stretch of coast for a length of about 800 m with a transitional groin field. The schematic representation of the above stretch of the coast along with the details of the proposed scheme of groin field is shown in Fig. 9.2.

9.3 KANNAMPUZHA (11° 50′ 59.7″N, 75° 23′ 27.9″E)

At this location, Kannampuzha river is discharging into the ocean. This site is 1.5 km south of Moplah bay fishing harbour. Typical view towards north of this site showing the headland close to Moplah bay and the existing seawall is shown in Photo 9.3. A view towards the south of this location showing the river mouth and the river (left side of the photo) is presented in Photo 9.4. Formation of sand bar at the confluence point of river and sea is shown in Photo 9.5. During the site visit, it was observed that the presence of the beach in front of the seawall is maintaining its stability to some extent. A coastal road on the landward side of the seawall needs to be protected by raising the top level of the existing seawall (+4.2) by another 1.0 m in order to reduce the continuous wave overtopping especially during monsoons. Reformation of the existing seawall has to be carried out with the KID funds. In addition, construction of two training walls near the mouth of Kannampuzha river will enhance the formation of beach on north of Northern training wall. The two training walls should preferably extend up to a water depth of 5m. The existence of two rocky out crops may also be utilized for this purpose as a part of the training walls. The layout of the training walls is shown in Fig. 9.3. The exact alignment of the training walls can be decided only after detailed numerical modeling and considering the data from KID to run the numerical model.

9.4 CHOOTTAD ESTUARY (12° 1′ 16.2″N, 75° 13′ 54.9″E)

The problem of sand bar formation near the mouth of Chootad estuary is shown in Photo 9.6. Two training walls near the river mouth may be considered for avoiding / minimizing the sand bar formation. However, this might lead to erosion on the southern side of the river mouth which could be restored by the construction of a transitional groin field. The conceptual layout of the proposed scheme is shown in Fig. 9.4. The provision of the groin field can be considered after the construction of training wall and monitoring the shoreline changes. The scheme should be implemented only after a detailed numerical model study which should be carried out as a separate project.

9.5 PUTHIYANKADI KADAPPURAM(12° 1′ 5.8″N, 75° 14′ 13.5″E)

This stretch of coast has a beach of width of about 60 m. Typical views towards north and south of this location showing the existing beach is presented in Photos 9.7 & 9.8. During monsoon seasons, the coast undergoes erosion. However, the shoreline is said to be in dynamical equilibrium readjusting to its original status after monsoon. It is strongly felt that no seawall should be taken up for this stretch of coast.

Table 9.1 Summary of Recommendations by IIT Madras in Kannur District

Sl.No	Name of the site	Recommended protection measures			Priority
		Seawall	Groin	Others	
1.	Pettipalem		Transition groins (120 m)	-	**
2.	Kannampuzha	Raising of seawall by +1m	-	Training Walls of length upto 5m water depth	***
3.	Choottad estuary	-	Transition groins (100 m)	Training Wall of total length of 150m	*
4.	Puthiyankadi Kadappuram	-	-	-	-

Photo 9.1. View towards north showing seawall at Pettipalem

Photo 9.2. View towards south showing the coastal road at Pettipalem

Photo 9.3. View towards north of Kannampuzha

Photo 9.4. View showing the choked mouth of Kannampuzha river

Photo 9.5. View towards south of Kannampuzha

Photo. 9.6. Choked mouth of Choottad estuary

Photo 9.7.View towards North of Puthiyankadi Kadappuram

Photo 9.8.View towards South of Puthiyankadi Kadappuram

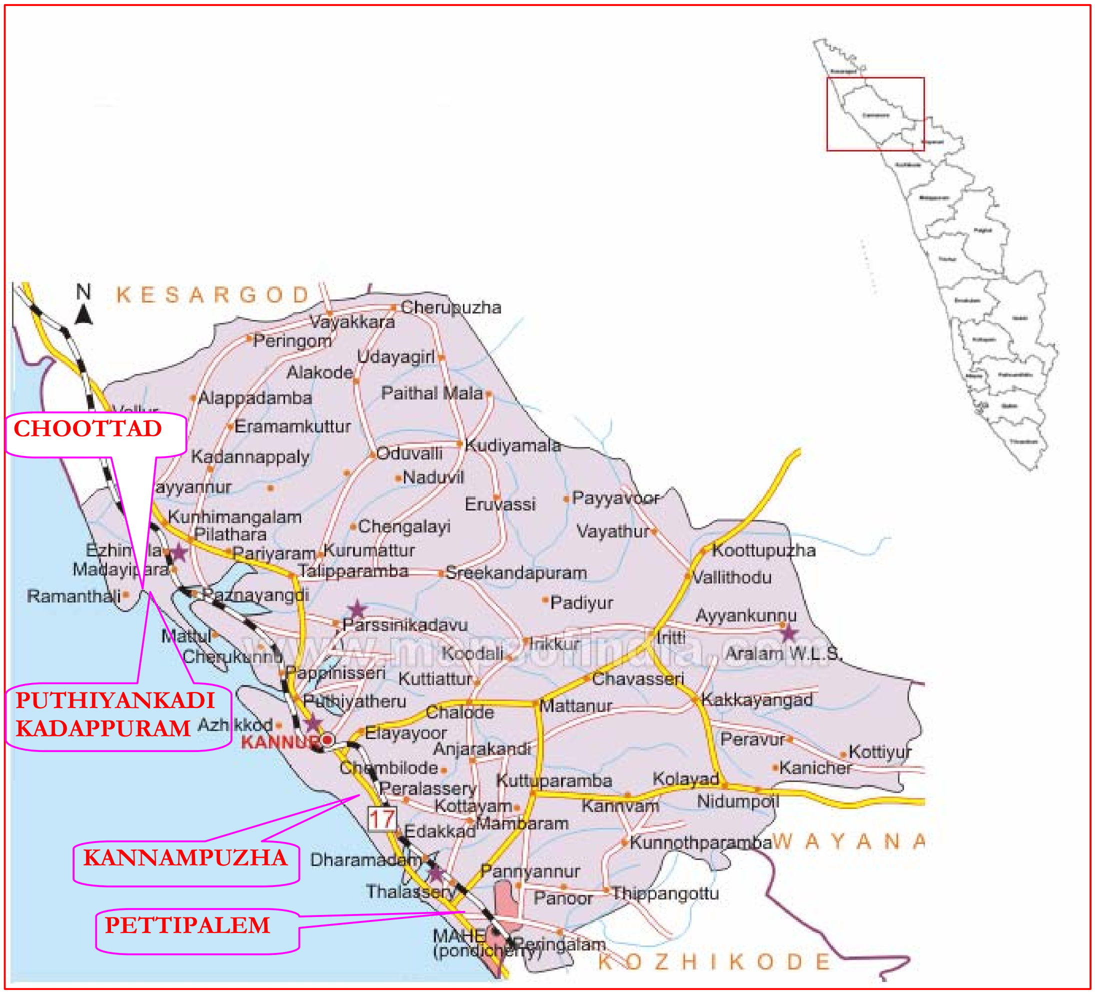


Fig.9.1. Layout of Kannur District

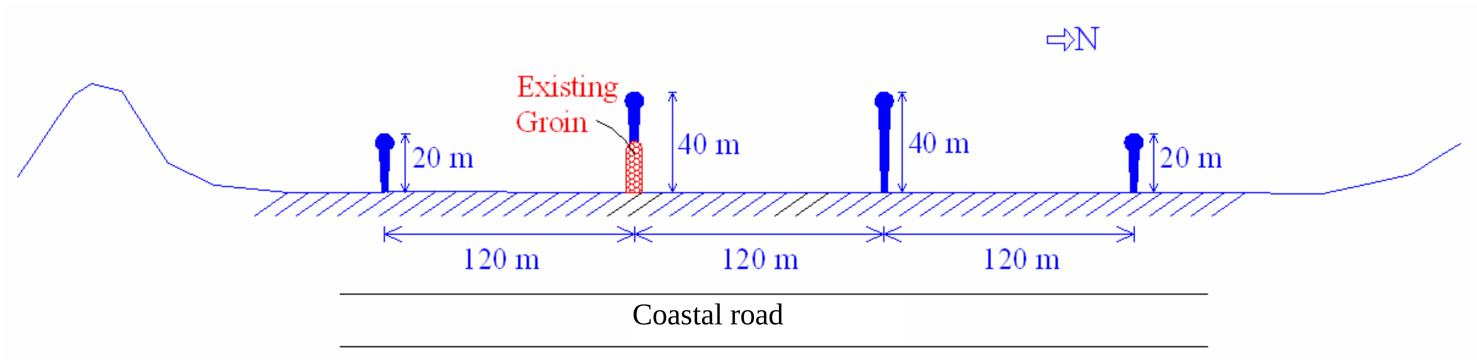


Fig.9.2. Transition groin field at Pettipalem

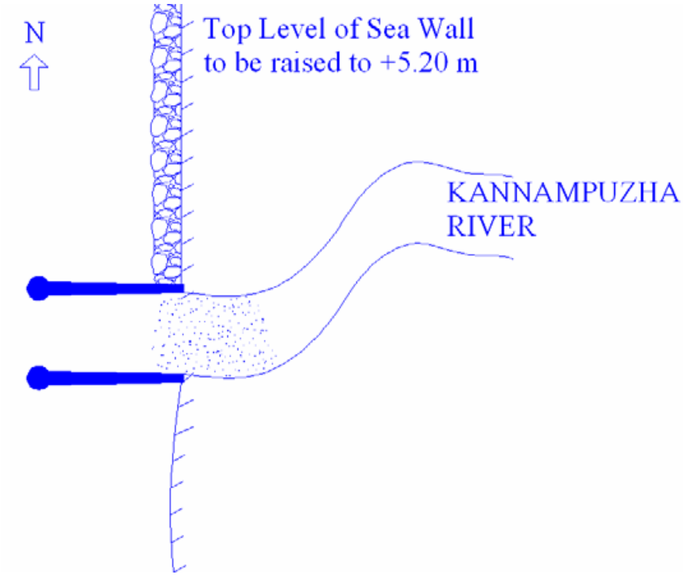


Fig.9.3. Training works at Kannampuzha river mouth

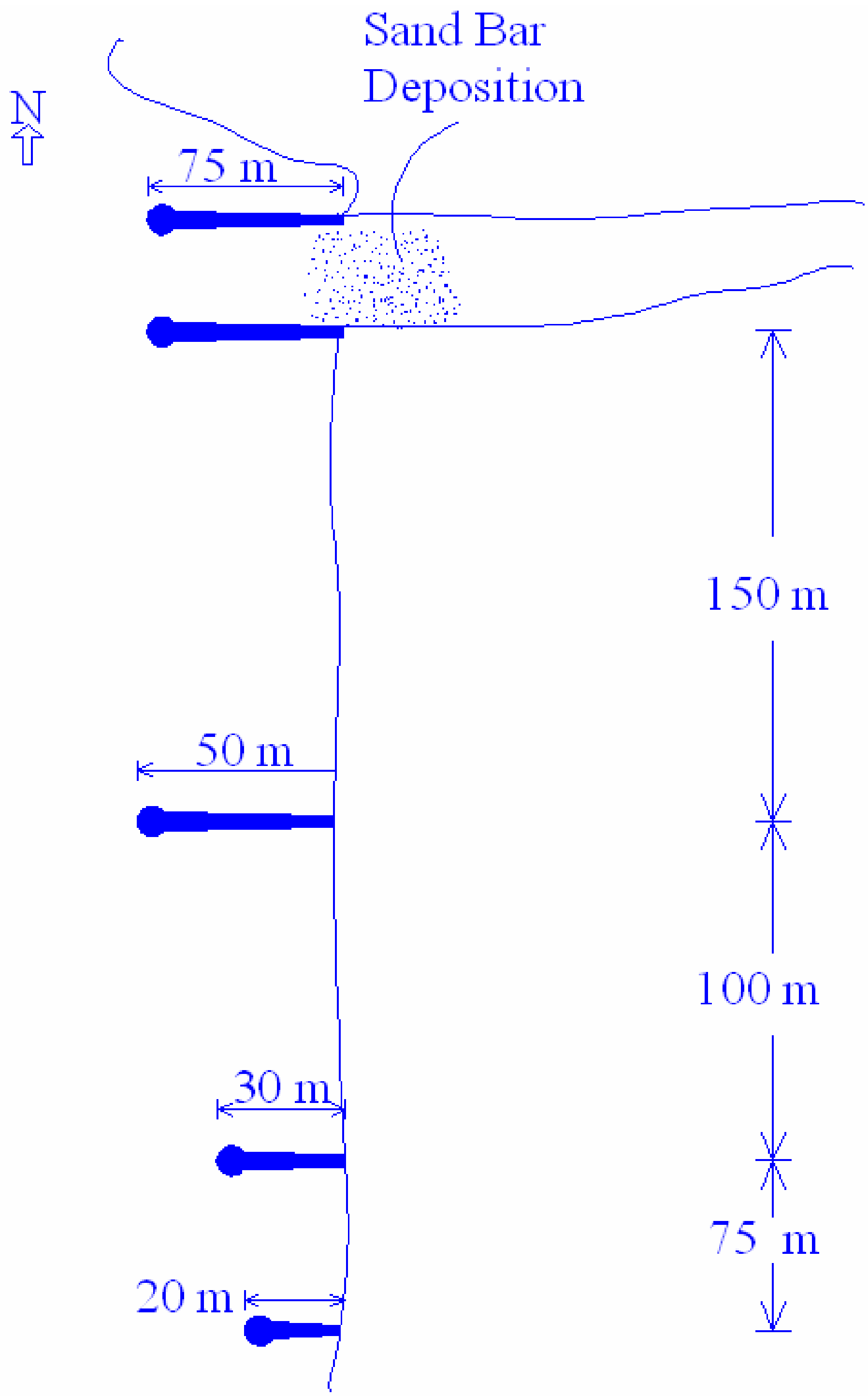


Fig.9.4. Training Walls and Groin Field at Choottad estuary

CHAPTER 10

COASTAL PROTECTION MEASURES ALONG KASARGOD DISTRICT

10.1 INTRODUCTION

In order to identify the critically eroded areas along the Kasargod coast and to suggest appropriate remedial measures, the IITM team visited along with the local engineers listed below:

1) Er. T.S. Naushad, Superintendent Engineer
2) Er. A. Gopa Kumar, Exe. Engineer
3) Er. D. Vinayan, A.E.E
4) Er. Arnold Rajkumar, A.E.E.
5) Er. Shahul Hameed, A.E.
6) Er. P. Rethnakaran, A.E.
7) Er. N.T. Gangadharan, A.E.
8) Er. P. Padmanabha, A.E.

The location map of Kasargod along with the sites visited is shown in Fig. 10.1. The details of the site visit are presented in the following sections.

10.2 HOSDURG KADAPPURAM (12° 18′ 22.9″N, 75° 4′ 40.0″E)

Typical views towards north and south of this site are shown in Photos 10.1 and 10.2. The existence of beach of width of about 80 m with two berms and of height +3.0 m above MSL is shown in Photo 10.3. It is recommended that the existing beach should be preserved and no protection is necessary. To increase the stability of the existing beach, plantations are strongly recommended.

10.3 BEKAL (12° 23′ 45.2″N, 75° 1′ 46.9″E)

This site is located north of Bekal fort as shown in Photo 10.4. About 40m width of beach is formed as can be seen in Photo 10.5. This beach should be preserved as-it-is without any intervention by engineers. If at all overtopping is found to be very severe to the extent of ingress of seawater into near by dwelling units, the top-level of the crown of the existing sunken seawall may be raised by about 0.5m using same size of boulders that exist at the location or with gabions of 1m x 1m cross section. .

10.4 KASABA (12° 29′ 57.1″N, 74° 58′ 30.5″E)

For this stretch, construction of seawall should completely be avoided. The Photos 10.6 & 10.7 depicts the extent of fishing activity along this coast. There can be two options for this stretch:

1) development of a fishing harbour

2) construction of a groin field which will have 4 No.s of groins of which the groins with a maximum length of 75 m will be inclined at an angle of 10° w.r.t. shore normal. The top level of the groins will be +4.0 m. The coastal protection scheme under the suggested option 2 as shown in Fig. 10.2 would enhance the beach build up and there by, protecting the coast from perennial erosion which, from the KID is understood to be severe particularly during monsoon seasons.

Table 10.1 Summary of Recommendations by IIT Madras in Kasargod District

Sl.No	Name of the site	Recommended protection measures			Priority
		Seawall	Groin	Others	
1.	Hosdurg Kadappuram			Plantations	*
2.	Bekal			Raising of Seawall	*
3.	Kasaba		Transition groins (195 m)		***

Photo 10.1. View towards north of Hosdurg Kadappuram

Photo 10.2. View towards south of Hosdurg Kadappuram

Photo 10.3. Height of beach at Hosdurg Kadappuram

Photo 10.4. View towards Bekal fort on south

Photo 10.5. View towards North of Bekal

Photo 10.6 View towards North of Kasaba

Photo 10.7 View towards South of Kasaba

Fig 10.1. Layout of Kasargod District

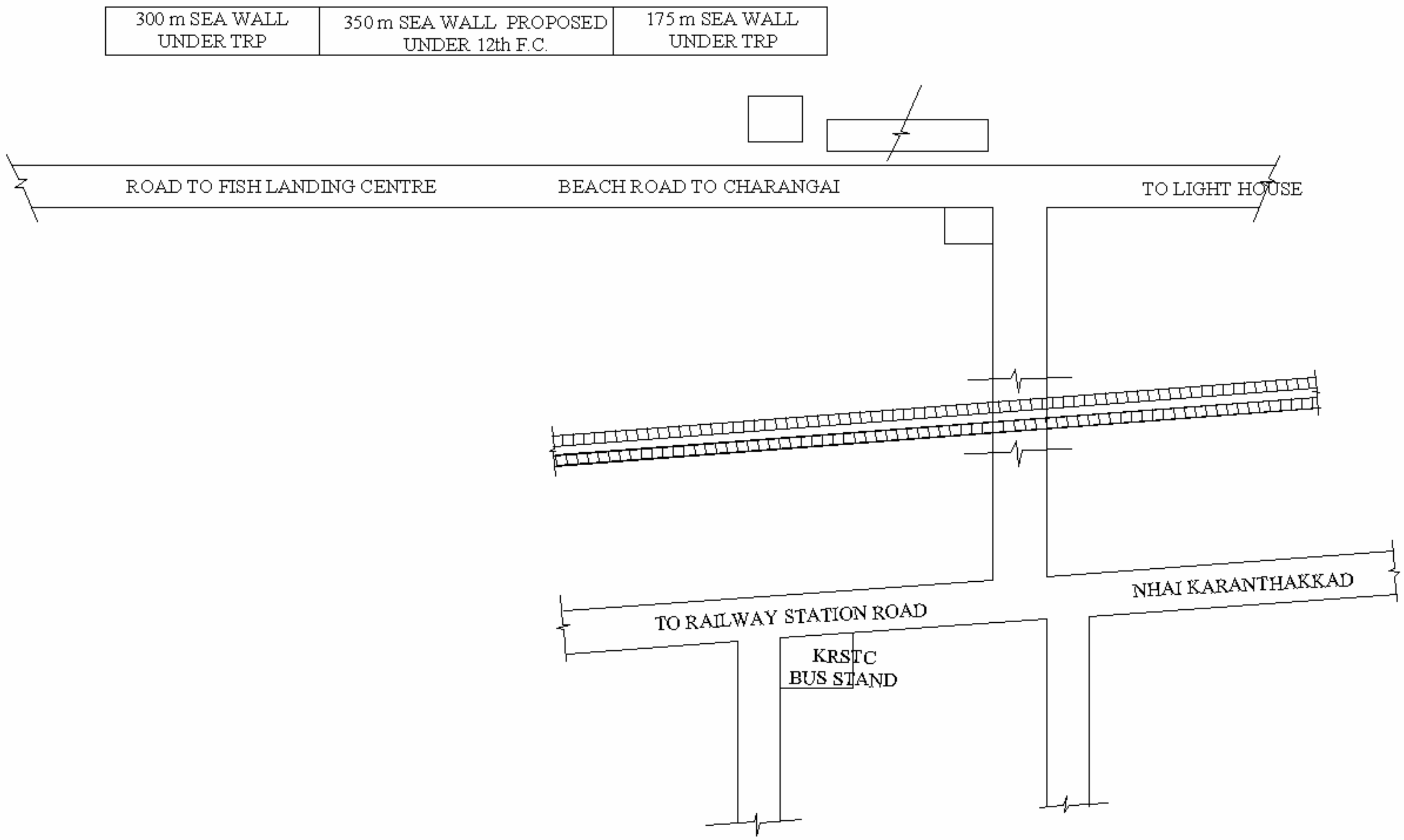


Fig 10.2a. Kasaba Site Plan

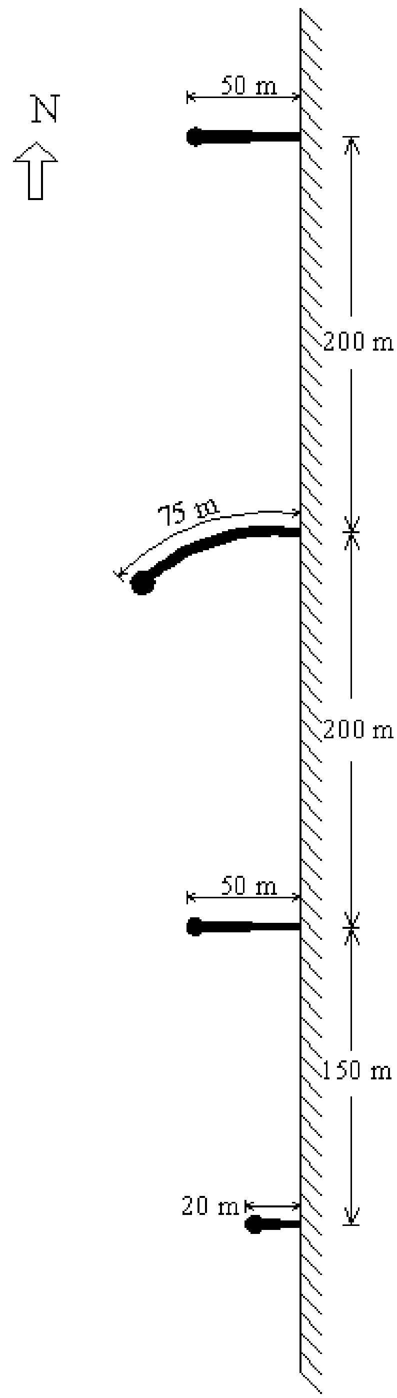


Fig 10.2b. Transition Groin Field at Kasaba

CHAPTER 11

PROPOSALS FOR DEVELOPMENT OF FISH LANDING FACILITIES ALONG THE KERALA COAST

11.1 INTRODUCTION

The Government of Kerala has been concentrating towards the development of fishing harbours / fish landing facilities along its coast in order to exploit the marine living resources and also to provide the fishing community with better opportunities. The Harbour Engineering Department (HED), which is responsible for the development of harbours and fish landing centers has requested the IITM team to visit the stretches along the Kerala coast that are suitable for above said facilities. In this connection, the IITM team has visited selected stretches of coast which were proposed by the HED and are reported in the earlier chapters. The details of the fishing gaps which can be considered for the development of fishing harbour/fish landing facility, independently surveyed by the HED, along the districts of Kollam, Malappuram and Kozhikode are presented in the following Table 11.1. It is advisable that no seawall or any other similar hard measures need to be considered along these stretches and options for development of the area as fish landing centers are to be explored.

Table 11.1. Details of the fishing gaps along the Kerala coast

Sl. No	Name of locations	District	Latitude & longitude GCS WAAS Enabled Differential 12 Sat GPS		Width of gap	Remarks
			E	N		
1	Thekkumbagom	Kollam			300	
2	Chillakkal	Kollam			300	
3	Paravoor Pozhi	Kollam			300	
4	Kulathumpadam	Kollam			300	
5	Eravipuram	Kollam			300	

6	Kakkathoppu	Kollam			300	
7	Mahathmagandhi park	Kollam			2000	Tourism attratction
8	Mukham	Kollam	76° 38′ 32.9″	8° 49′ 23.6″	150	Develop this site as a fish landing facility by constructing a pair of breakwaters, which will then serve as a protection measure as well as a fish landing centre.
9	Valavilthoppu	Kollam	76° 32′ 33.3″	8° 57′ 46.7″	150	This stretch could be developed as a fish landing centre by providing a pair of groins.
10	Pathiankara	Kollam	76° 24′ 26.2″	9° 15′ 30.2″	750	The local community is thriving with fishing activity. Hence, a groin field is proposed, out of which, one of the groins is bent in order to serve as a fish landing facility.
11	Vadackal	Alappuzzha	76 º 19’ 10.1”	9 º 29’ 9.2”	200	A number of country boats operate from this site mainly for fishing. This is an ideal site for development of a fish landing centre for traditional fishing. This has already been proposed by HED under TRP.
12	Kadekadu	Ernakulam	76 º 16’ 30.6”	9 º 48’ 3.5”	350	The fishing gap between the existing seawall, is under erosion particularly, during monsoon seasons. The waves surge onto the beach in this gap, resulting in unfavorable conditions for the fishing vessels. Hence, it is proposed to protect this stretch with a pair of groins.
13	Koorukuzhi	Thrissur	76° 7′ 52.1″	10° 17′ 08.4″		This stretch of coast is flourishing with fishing activity. It is proposed that this site can be developed as a fishing harbour / fish landing facility
14	Palappetty Aspathry Beach	Malappuram	75 56' 55.5"	10 41' 50.2"	100 m	Further developments such as better roads etc are needed
15	Palappertty FLC	Malappuram	75 56' 50.4"	10 42' 05.0"		A fish landing centre exists here. Further developments such as locker rooms etc are needed

16	Beyyam Kayal Puthuponnani	Malappuram	75 55' 58.9"	10 43' 54.4"		This is the mouth of an estuary of width about 300 m. But in summer the mouth is often closed. No facilities exist for proper landing of fish
17	Ponnani Harbour - South Breakwater - Foot	Malappuram	75 54' 67.2"	10 47' 10.6"		The coordinates of Ponnani breakwaters given for information
18	Ponnani Harbour - North Breakwater - Foot	Malappuram	75 54' 31.8"	10 47' 25.3"		
19	Koottai - Tirur Block Panchayath FLC - Kothaparambu	Malappuram	75 53' 38.5"	10 51' 14.8"		Sea wall ends at about 500 m South of this point and no sea wall present up to Unnyal. No facilities provided by government of landing or auctioning of fish
20	Vakkad	Malappuram	75 53' 18.8"	10 52' 44.8"		No facilities provided by government of landing or auctioning of fish
21	Paravanna	Malappuram	75 53' 2.8"	10 54' 9.7"		No facilities provided by government of landing or auctioning of fish
22	Unnyal	Malappuram	75 52' 51.5"	10 54' 50.8"		Sea wall ends at about 500 m North of this point. No facilities provided by government of landing or auctioning of fish
23	Thanur	Malappuram	75 51' 57.7"	10 58' 37.1"	300 m	Proposal for fishery harbour coming up
24	Chappapadi - Parappanangadi	Malappuram	75 50' 36.3"	11 03' 19.2"		Proposal for fishery harbour coming up
25	Alungal Parappanangadi	Malappuram				
26	Kadalundi Rivermouth - South Point	Malappuram	75 49' 27.7"	11 07' 20.2"		Fish landing with NO facilities provided by the government exist here
27	Chaliyam - South of beypore harbour	Kozhikode	75 48' 23.2"	11 09' 42.8"		No facililies are provided for the beach landing of the fish on the northern side of the beypore harbour, which is very much in need
28	Beypore - South Breakwater - foot		75 47' 52.6"	11 09' 30.5"		Coordinate of beypore harbour for information

29	Kallai River mouth (North groyne end top)	Kozhikode	75^{0}46'33.9''	11^{0}13'39.9"	100 m	Fish landing by OBMs and small MPVs are taking pance on the river bank below of the bridge named Kothipalam. No facilities exist as now at this site. Also as the river is also the main carrier of the drain discharge from the city, provision needs to be done to stabilise the river mouth and prevent it from closing during summer season.
30	Vellayil FLC	Kozhikode	75^{0}45'51.1''	11^{0}15'54.3"		A project proposal for establishing a minor fishery harbour at site is in progress
31	Puthiyangadi (Koya road)	Kozhikode	75^{0}45'6.7"	11^{0}17'55.4"		A small fish landing facility exist here, which needs further developments such as construction of locker rooms, shops and canteen etc,
32	Puthiyappa F.H North B/W 0 point	Kozhikode	75^{0}44'41.8''	11^{0}19'00.5"		The coordinates of Puthiyappa breakwaters given for information
33	Puthiyappa F.H South B/W 0 point		75^{0}44'21.4''	11^{0}19'15.8"		
34	Korapuzha Estuary South side	Kozhikode	75^{0}44'05.4''	11^{0}20'50.9"	50m creek(thodu)	This is a small drain like creek where the local fishermen land their catches. The Korappuzha river mouth is about 200 m from this point. There has been persistent demand from a section of the fishermen for the dredging of the Korappuzha river mouth to increase the tidal influx and opposition from another section for such an action.
35	Kannankadavu	Kozhikode	75^{0}43'41.2''	11^{0}21'29.7"	500m	Seasonal beach landing of fish by fisher men of the local community exist in this beach. Provisions such as locker rooms, shops etc are needed here

36	Thuvvapara in Kapad beach	Kozhikode	75^{0}42'44.3''	11^{0}23'37.7"	1.75 Km	Kappad is a famous tourist place where Vasco Da Game Landed. This is a small fish landing beach area where no facilities exist for handling and auctioning of fish
37	Poyilkavu beach (2 gaps)	Kozhikode	75^{0}42'17.2''	11^{0}24'21.8"	40m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
38	Kavalad beach	Kozhikode	75^{0}42'07.07"	11^{0}24'43.5"	54m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
39	Ezhukudikkal	Kozhikode	75^{0}42'1.4"	11^{0}24'54.2"	35m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
40	Valiyamangadu	Kozhikode	75^{0}41'46.7''	11^{0}25'21.8"	32m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
41	Cheriyamangadu	Kozhikode	75^{0}41'40.9''	11^{0}25'31.6"	346m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
42	2nd gap		75^{0}41'39"	11^{0}25'35"	200m	
43	Virunnukandy	Kozhikode	75^{0}41'33.2''	11^{0}25'45.5"	30m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
44	2nd gap				30m	
45	Koyilandy South B/W	Kozhikode	75^{0}41'23.8''	11^{0}25'58.5"		The coordinates of Koyilandi breakwaters given for information
46	Koyilandi North B/W		75^{0}41'14.1''	11^{0}26'14.3"		
47	Kollam		75^{0}40'54"	11^{0}26'44.9"	500m	Seasonal beach landing of fish by the local people. No development or facilities provided by the government
48	Thikkodi	Kozhikode	75^{0}36'54.4''	11^{0}28'38.4"		Seasonal beach landing of fish by the local people. No development or facilities provided by the government
49			75^{0}36'54.8''	11^{0}28'40.2"		

50	Payyoli beach		$75^0$36'24.6''	$11^0$30'41.5"		Seasonal beach landing of fish by the local people. No development or facilities provided by the government
51	Kolavipalam		$75^0$35'34.9''	$11^0$32'53"		Seasonal beach landing of fish by the local people. No development or facilities provided by the government
52	Azhithala (near Vadakara sand banks)		$75^0$35'12.5''	$11^0$34'15.3"		A small extend of area is seen earmarked for the establishment of a Fish Landing Centre by the Municipality. This area needs further developments to establish a full fledged fish landing centre
53	Kuriyadi		$75^0$34'20.4''	$11^0$36'23"		A small fish landing centre exist here which is totally insufficient for the needs. Further developments to make this a full fledged fish landing centre needs to be in corporated. Construction of groynes may be a welcome idea here
54	Chombal South B/W foot)		$75^0$32'57.4''	$11^0$39'39.2"		The coordinates of Chombal breakwaters given for information
55	Chombal North B/W foot)		$75^0$32'50.8''	$11^0$39'52.1"		

CHAPTER 12
SUMMARY AND CONCLUSIONS

12.1 GENERAL

A reconnaissance site investigation was carried out along the coast of Kerala to study the problem of coastal erosion, to identify the critically eroding stretches and to suggest appropriate mitigation measures. The site investigation was carried out in two phases, *Phase 1: Trivandrum – Ernakulam, Phase 2: Ernakulam – Kasargod,* in co-ordination with the Kerala Irrigation Department (KID) and the Harbour Engineering Department (HED). Necessary data related to the wave climate, shoreline status, beach characteristics, littoral sediment transport (direction & magnitude), etc., were collected from the available literature reported by CESS Trivandrum, NIO Goa, and other organizations.

Coastal erosion along the coast of Kerala is perennial in nature. The magnitude of erosion is alarming during the south-west monsoon season (June – September) causing huge loss/damage to the property adjacent to the shoreline. Kerala, being a land for diversified communities of many live along the coast and depend on fishing for their livelihood. Receding from the shoreline (500 m from the shoreline as per the CRZ Act by the coastal regulation authority), even though is the best option for any coastal stretch will not be effective along the Kerala coast due to the reasons stated above. Hence, in order to enhance the security of the people living along the coast, there is an urgent need to construct / rehabilitate the frontline sea defences.

The problem of the coastal erosion at each of the stretches was studied through the details reported in the literature, information provided by the KID, and from local residents at that particular stretch. The various available options for coastal protection viz., seawall (conventional, with polypropylene gabions), groins, combination of groin field and seawall, training works at river mouths, geobags as artificial offshore submerged reef and plantations etc., were considered in the present study. Appropriate protection measures to mitigate the problem of coastal erosion was arrived by taking into consideration the status of the erosion at that particular stretch, density of population, thrust for coastal activities and socio-economic aspects (viz., tourism).

12.2 SUMMARY / CONCLUSIONS

- Coastal erosion is site specific in nature and a common coastal protection measure cannot address the problem. Hence, KID should reconsider their decision of implementing the seawall of same cross-section for all the stretches along the Kerala Coast.
- As most of the stretches are already protected by seawalls and which are in damaged/instable condition should be rehabilitated according to the design proposed by IITM. In the name of "rehabilitation of seawall", mere dumping of stones will not solve the problem, on the other hand may aggravate the problem. Some of the reasons for the failure of the existing seawall and recommendations to be adopted is tabulated in the table below

S. No.	Reasons for failure of seawall	Recommendations to be adopted
1	Smaller size of armour stones adopted. At several locations flanky stones (one of the length being too compared to other dimensions) are adopted	It is preferable to specify the characteristic of the armour stones by weight. The weight of the individual stone is dependent on the prevailing wave climate, slope of the seawall adopted. Flaky stones should be avoided. In the event of a scarcity of larger size boulders, gabions would be the answer.
2	In several locations overtopping is found to be severe as the top level is fixed at +3.3 m above MSL for almost all locations. In the event of ovetopping the undermining of the structure from the land side is more dominant during the monsoons leads to the gradual to sudden breach/failure of seawall.	The top level should carefully be finalized that would depend on the wave run-up, which in turn will depend on the wave height and the slope of the seawall. It is felt that in general the top level has to be raised

3.	The slopes adopted for the seawall are quite steep for the sizes of the stones used.	Where sufficient beach width is available efforts should be to construct seawalls with flatter slope, thus enhancing the taming of waves leading to gradual dissipation of the incident wave energy
4.	At several locations toe protection does not exist which easily facilitates the rolling down of stones.	Toe protection is extremely important and its stability will dictate the stability of the seawall. Two types, namely, toe protection in excavated trench and exposed toe protection are adopted. For the present coast only the later type is being practiced. Flexible gabions could be one of the solutions to counter the failure of toe protection.
5.	Same cross-section of seawall is adopted for several stretches of the coast.	The cross section of the seawall depend on the local wave climate, wave run-up as well as width of the beach available in the eroded areas. Hence it is recommended to have a few standard cross sections as a function of beach width.

- Use of polypropylene gabions are encouraged owing to its stability as well as wave energy dissipation characteristics. Also, the advantage of using gabions over the conventional seawall is that the base width of its cross-section can be redesigned as per the available beach width at a particular stretch.
- The magnitude and direction of littoral sediment transport along the Kerala coast is of complex. The direction of the littoral drift changes from location to location

and with seasons. Hence, before construction of a groin field, IITM recommends to estimate the magnitude and direction of littoral drift more close to the actual in field.

- Existing fishing gaps are to be developed as either fish landing centers or fishing harbours based on the amount of fishing and the interests of the local people. The construction of a pair of groins with one of the groins bent, at the fishing gaps, will serve both as a fish landing centre as well as a coastal protection measure.

Finally, the protection measures suggested in the present report are based on the inputs from the KID, HED and existing literature. Before the implementation of the above recommendations, a detailed investigation related to the stability of the cross-sections in case of seawall, wave tranquility in case of groin field should be carried out in the form of numerical / physical modeling.

(DR. K. MURALI) **(PROF. V. SUNDAR)**

ANNEXURE A

DETAILS OF THE PROPOSED CROSS-SECTIONS OF SEAWALLS

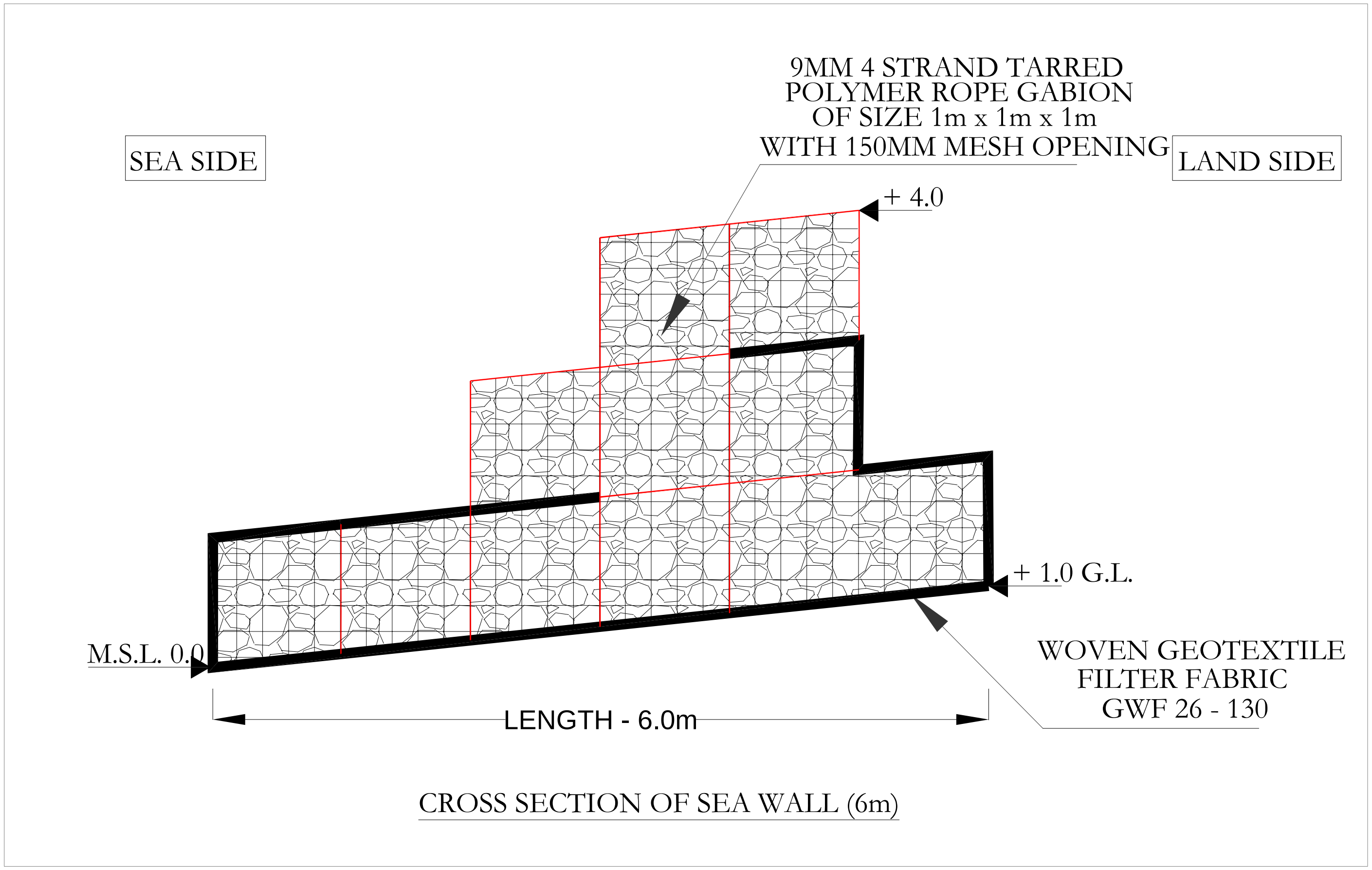


Fig. A1. Cross Section of Seawall of base width 6m

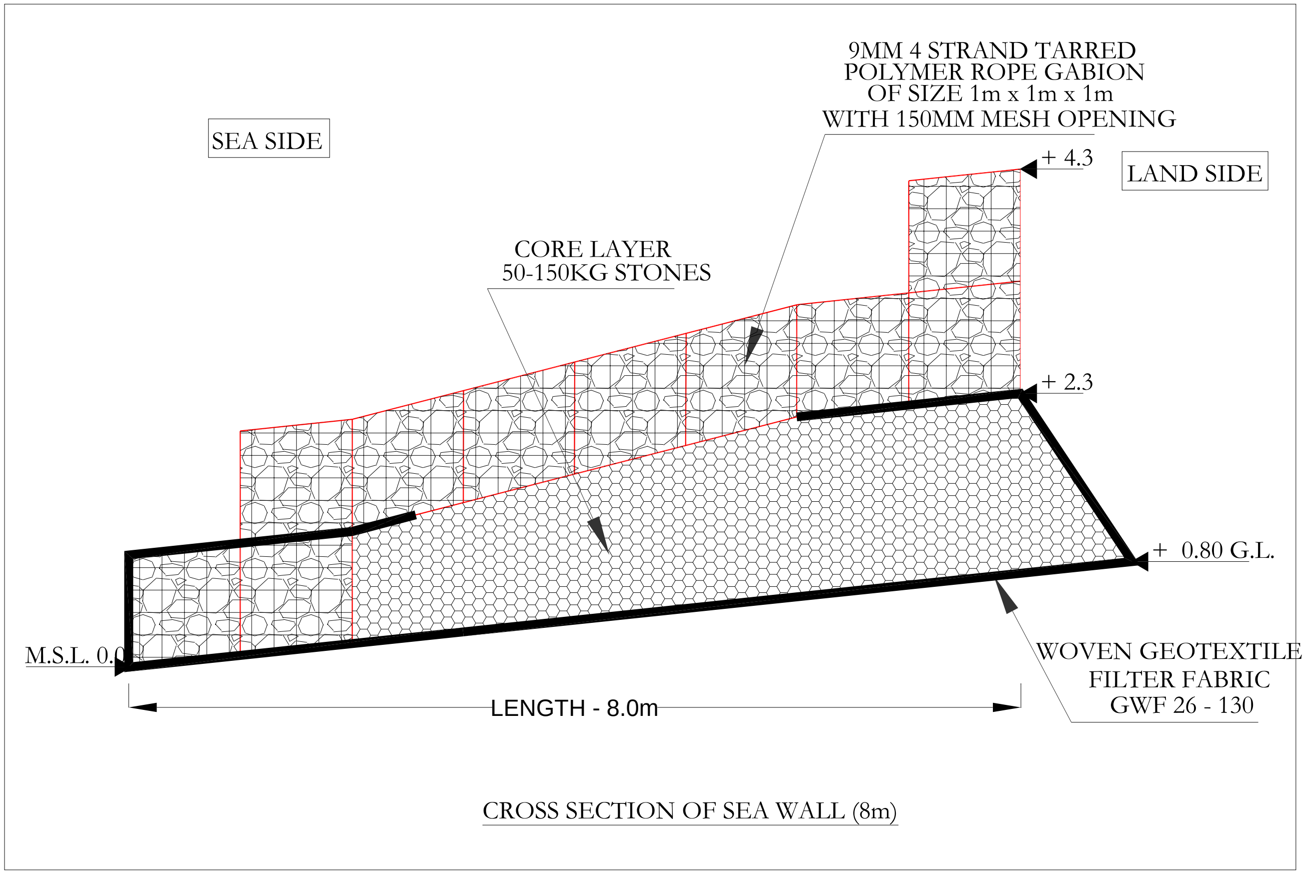


Fig A2. Cross Section of Seawall of base width 8m

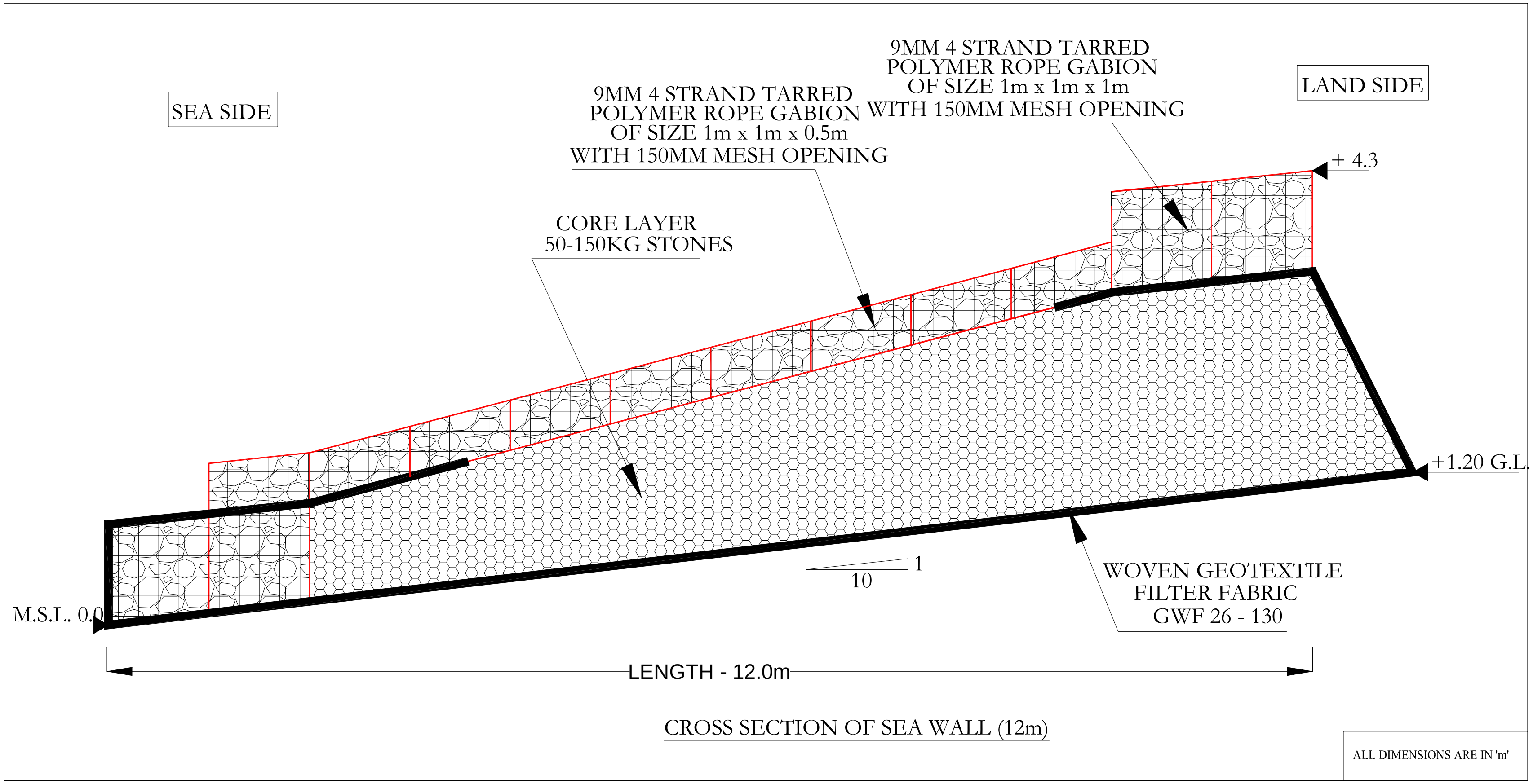


Fig A3. Cross Section of Seawall of base width 12m

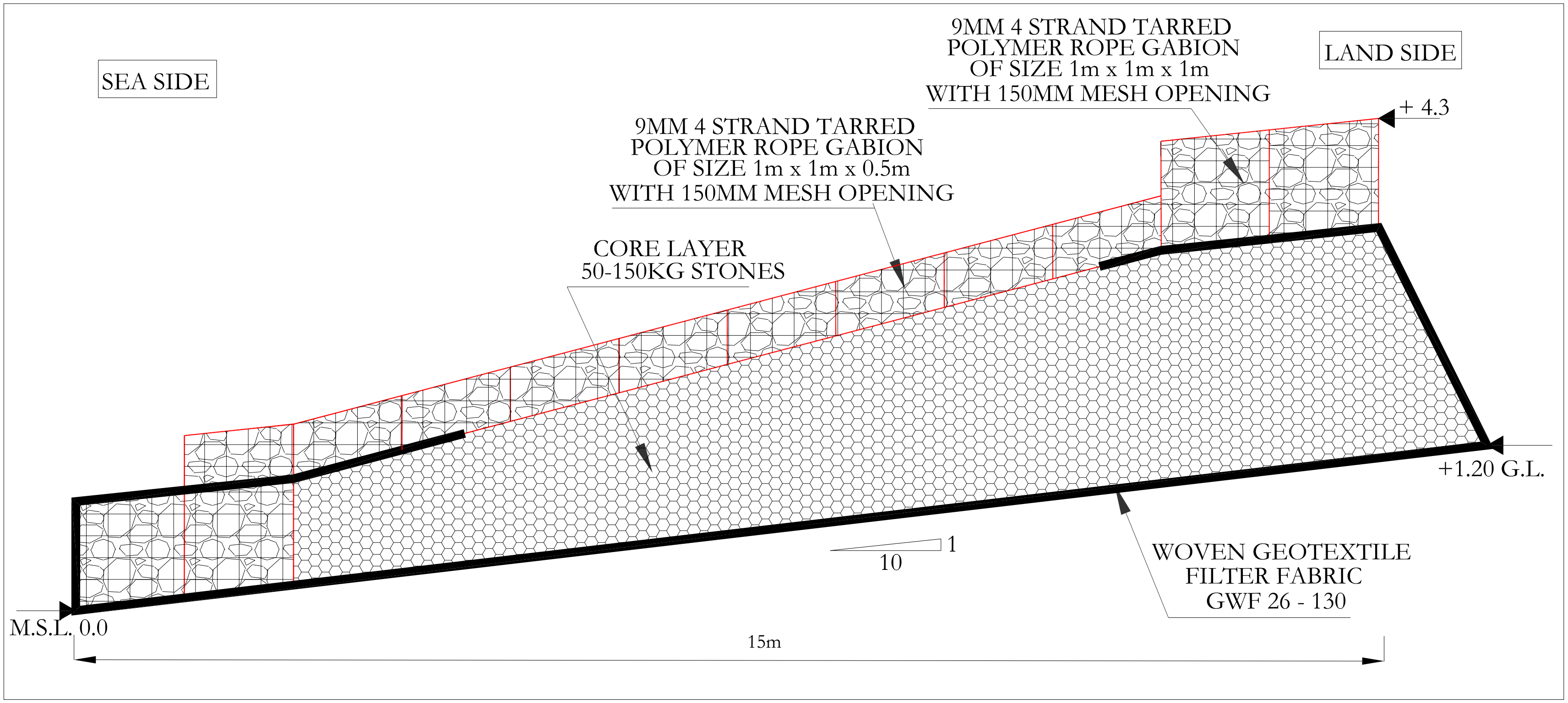


Fig A4. Cross Section of Seawall of base width 15m

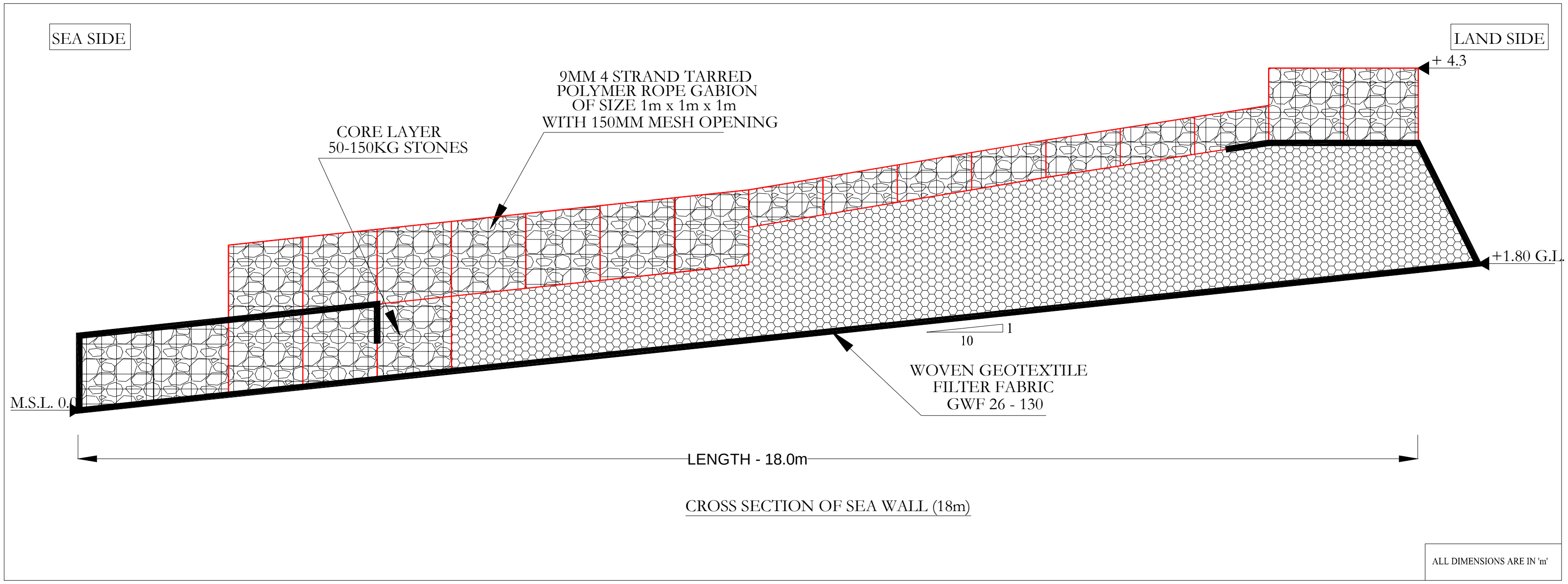


Fig A5. Cross Section of Seawall of base width 18m

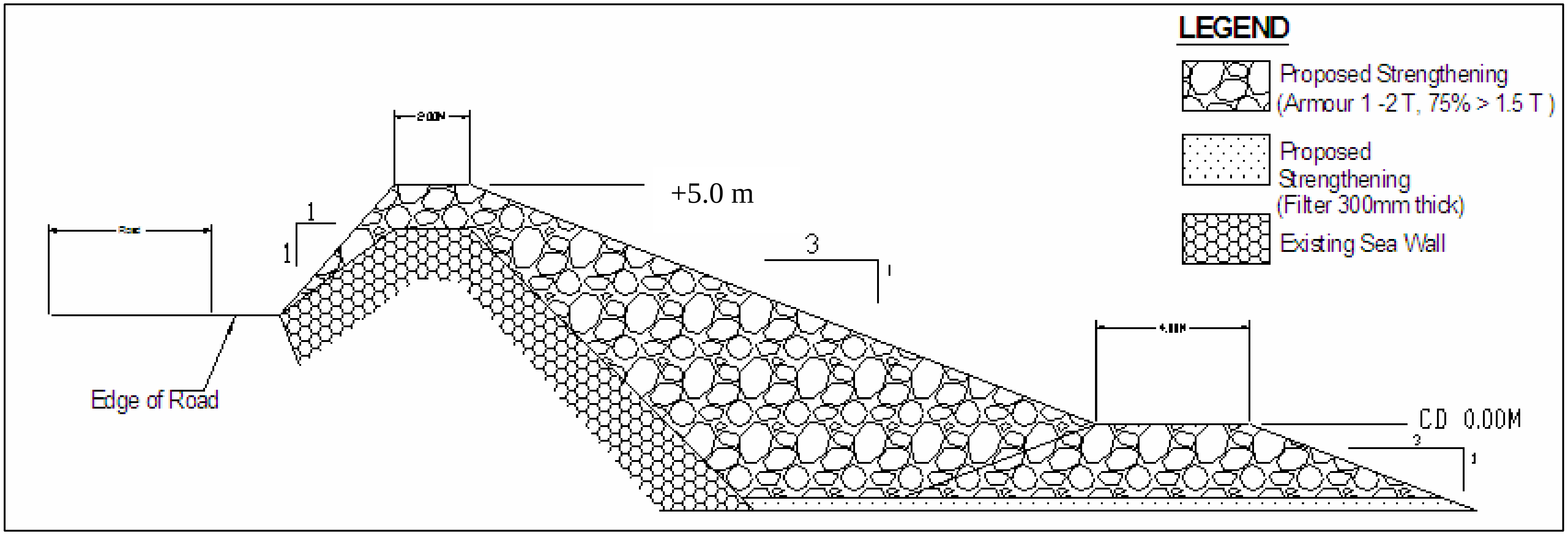


Fig A6. Cross Section of Conventional Seawall of base width 21m

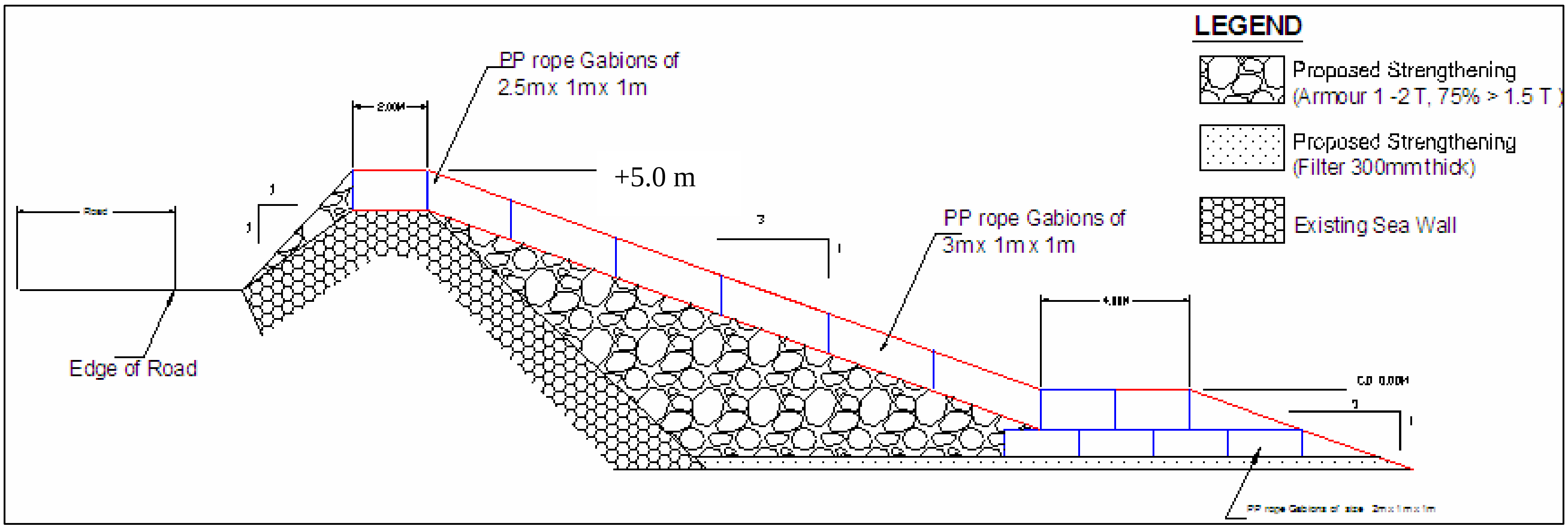


Fig A7. Cross Section of Seawall (with gabions) of base width 21m

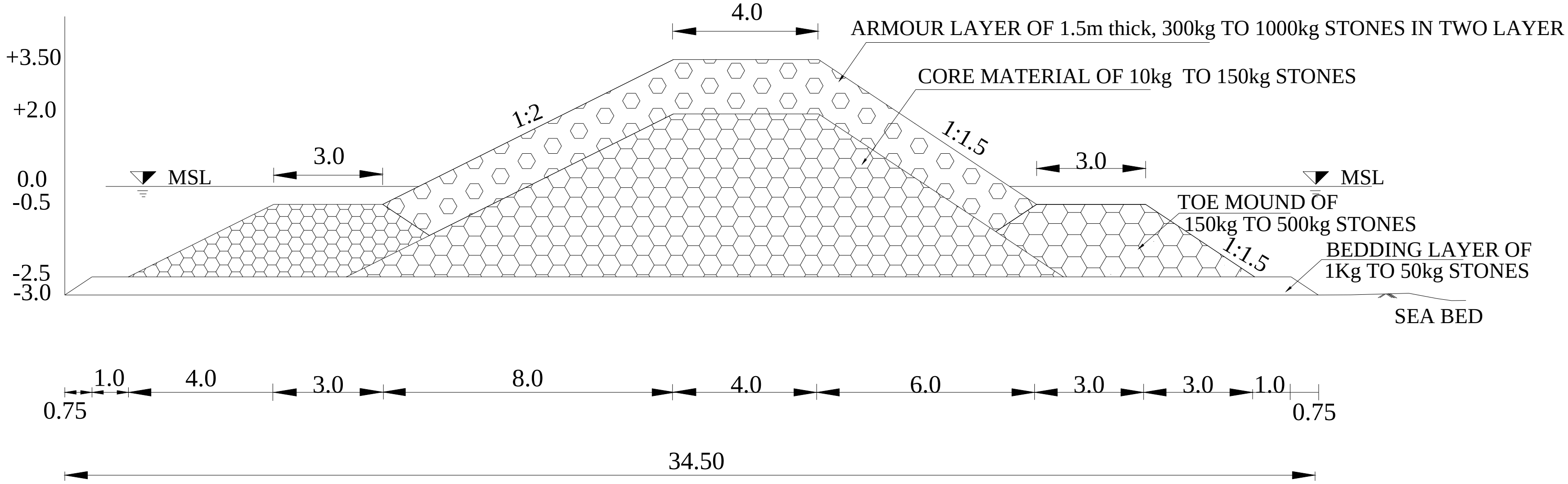


Fig A8. Cross Section of groin for water depth upto 3.0m

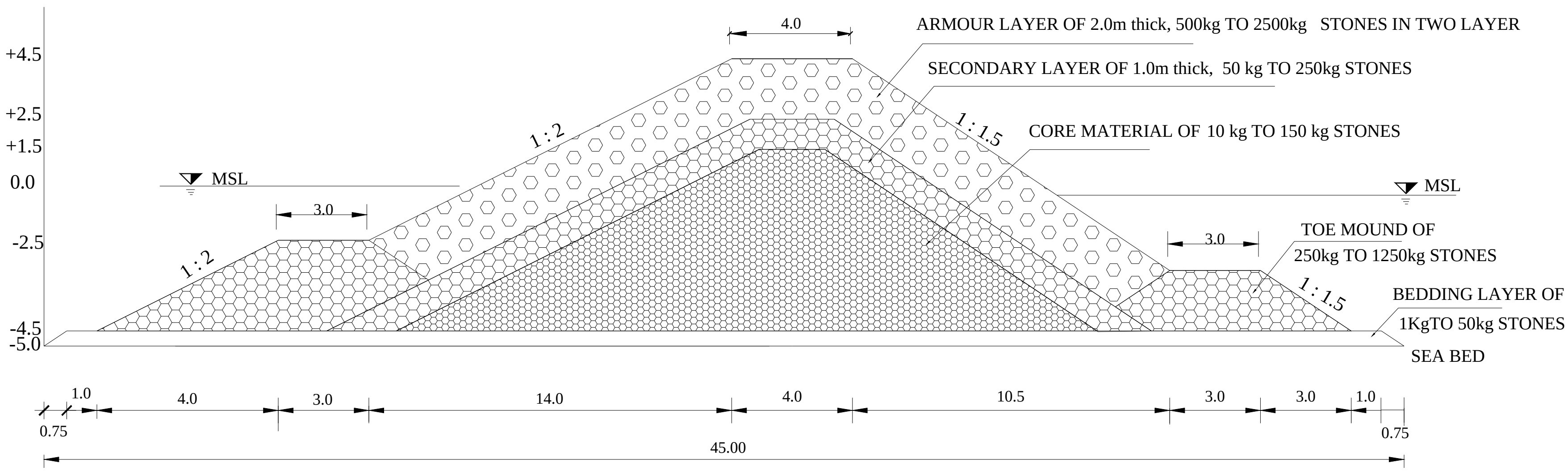


Fig A9. Cross Section of groin for water depth 3.0m to 5.0m

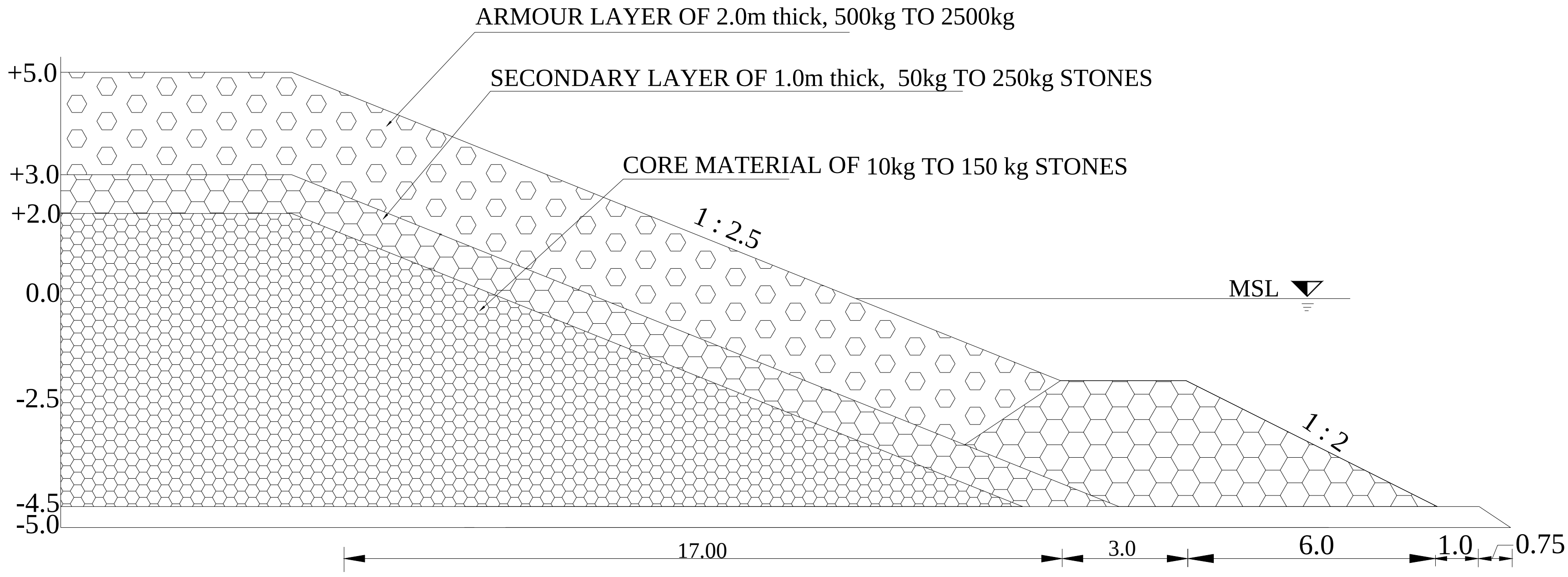


Fig A10. Cross Section of groin at head section for water depth 5.0m

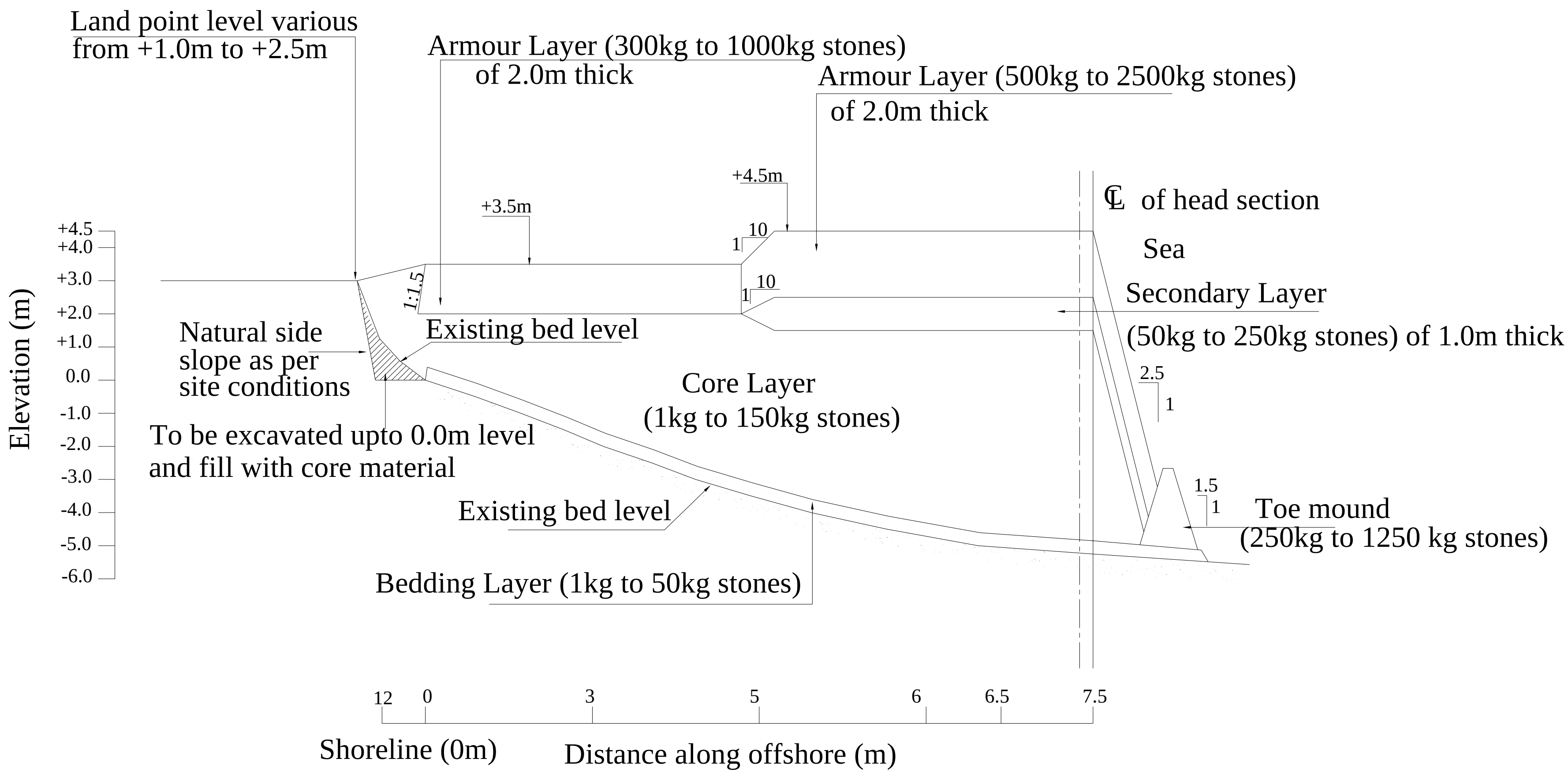


Fig A11. Tentative longitudinal section along the groin

ANNEXURE B

DESIGN OF PROTECTION MEASURE FOR THE COASTAL ENVIRONMENT NORTH OF CHENNAI PORT

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ABSTRACT

The stretch of the coast to be covered in this report is an area of active development. The main problem of continuous coastal erosion on the north of the fishing harbour of Chennai due to the interception of the net northerly littoral drift by the port breakwaters has been a primary concern for a last few decades. In order to combat further erosion, a detailed study of this area was taken to suggest suitable coastal protection measure. The proposed coastal protection scheme consists of shore-connected groins. The details of the design of groin field are discussed in this report. The report also presents the salient results on the shoreline evolution due to the proposed construction of groins. The construction of groin field commenced in May'04 by Tamilnadu road transport company Limited, Chennai, the project called as Ennore Manali road improvement plan (EMRIP) The shoreline advancement in between the groins has proved to yield fruitful results. Beside proving to be structurally stable (damage to the groins is almost nil even during the great Indian Ocean tsunami), in fact the beach formed has considerably reduced the adverse effects of the recent tsunami the results of which are reported herein.

1.0 THE BACKGROUND

The length of the coastline of Tamilnadu is about 950km with a number of inlets connected to the Bay of Bengal. The perennial problems along the coast have been the closure of river mouths, shallowing of approach channels of the major ports at Chennai, Visakhapatnam and Paradeep and erosion of the significant portion of the land mass on the north of the ports. Ever since the construction of the breakwaters for the formation of harbour of Chennai port, the north Chennai coast is being subjected to erosion due to the predominant northerly drift of net annual sediment transport to an extent of about $1.2*10^6$ m^3/year. A part of the existing National Highway and the residential area nearer to this coastline has already been sacrificed to the sea. The Government of Tamilnadu, India has proposed and executed a coastal defense in terms of providing seawall along the Ennore–Manali express highway along the coast north of Chennai port. In spite of the provision of seawall, the erosion continued along few pockets along the coast and the severely affected zones (stretches I and II) are shown in **Fig. 1**. As per the field observations of Institute for Hydraulics and Hydrology (I.H.H) poondi (2002), based on the continuous measurements of the crest of the berm along the coast of Tamilnadu for the period 1978-88, the rates of erosion or accretion are projected in **Table.1**, it is observed that the maximum rate of erosion is about 6.6m per year off Royapuram, in between Chennai and Ennore ports. The measures adopted over the **past five decades** did not solve the problem of coastal erosion. Typical damages and protection measures adopted in the past are shown in **photos. 1a & 1b**. This highway being not only the main link between the ports of Chennai and Manali but also serving as the only link to several Industries with the city that has been experiencing severe traffic congestion, many times to a stand still for hours together mainly due to the sacrifice of part of the highway to the Bay of Bengal explains the importance in protecting this stretch of the coast. Of the several options for the coastal protection, the reasons for adopting groin fields for the stretches I and II have been elaborated by the author in the report of I.H.H poondi (2002).

2.0 THE SOLUTION

2.1 General

The solution for the coastal erosion problem was divided into two categories, a temporary strengthening of the existing seawall and a permanent remedial measure by providing suitable groins.

2.2 Remedial Measures

In the first phase, a detailed bathymetry survey for the measurement of existing cross section of seawall and its status in order to assess its adequacy for the design wave climate were carried out. The wave characteristics were then arrived from the wave atlas of Indian coasts and for an immediate remedial measure, the seawall cross sections were strengthened with suitable armour units. Detailed quantity estimation was also carried out which however, is not reported in this report . The wave data have also been analyzed to obtain the average wave height, wave period and wave direction, from which the average breaking wave characteristics were derived. The monthly sediment transport has been estimated based on Energy Flux method (CERC, 1984), the method of Komar (1969) and by integrating the distribution of sediments within the surf zone as suggested by Komar (1969). The net sediment drift along the Chennai coast is observed to be about $1.2*10^6$ m^3/year towards the North.

In the second phase, as a permanent solution for the coastal erosion problem, ten numbers of shore-connected straight rubble mound groins in the two severely affected stretches as shown in **Fig. 2** and **Fig. 3** were proposed. The length and the spacing between groins were designed based on the recommendations of Shore Protection Manual [-------SPM(1984)].

2.3 Numerical Modeling for Shoreline Evolution

Mathematical modeling to evaluate the shoreline changes due to the proposed groin field was carried out. The mathematical modeling of shoreline evolution essentially relates the change in the beach volume to the rate of material transported from the beach. The methodology for the present numerical model is based on the numerical scheme proposed by Janardanan and Sundar (1994) and the one line model solved by using Crank Nicholson implicit finite difference method. The seabed bathymetry of the proposed location, length of the groins, height of the berm, grain size of the sediments required for the calculation of active depth of the sediment transport and water depth at the tip of the structure are used as inputs for the model. The model predicted a significant advancement of beach over a period of 15 years. **Fig. 4** presents the shoreline progress over the years for stretch 1.

2.4 Design of Groin Sections

Based on the provided bathymetry (in 1999), the cross sections of the groins were designed based on the Hudson formula. In addition, the core layer material, crest width, thickness of layers, crest elevation and structure slope etc., for the proposed groin field was also recommended. In addition, a detailed bathymetry survey for the final design of the groin cross sections was also conducted.

3.0 THE REVIEW

3.1 General

The review of the design of the groins for the sea protection works of Ennore-Manali Road Improvement Project was also done based on the actual bathymetry at the exact locations of groins. In addition, it also aimed in obtaining the optimum dimensions of the groin cross sections that includes slope on both of its sides, its crest elevation, the size of the stones to be adopted for the different layers, the thickness of the various layers (comprising of armour, under layer, core, filter and the toe) and the width of the crest.

3.2 Bathymetry Survey

As per its own recommendations, the bathymetry survey during the month of February 2004 to assess the cumulative effect of southwest and northeast monsoons was carried out by IIT Madras**.** The changes in the seabed profile revealed severe erosion near the study area, based on which the final design was evolved. The survey has been carried out along the corridor of the ten proposed groins up to a distance of about 400m into the sea and 80m parallel to the longitudinal axis of each groin. The bathymetric chart was prepared with respect to the chart datum (CD= 0.0) after tidal elevation corrections. The chart was presented in a scale of 1:1000. The water depths were marked on the chart at 5.0m interval.

3.3 Revised Design

Based on the recent bottom contours, maximum high water spring (MHWS), storm surge and wave set up, a design water level of about +2.1m was considered for the groin design. As per Goda (1985), the design wave height was arrived, using which the necessary weight of armour units were estimated by using Hudson formula. The design details of the trunk section are given in **Table 2**.

The groin head sections were also designed to locate in a water depth of 5.5m. Typical trunk and head sections of the groin are shown in **Fig. 5** and **Fig. 6**, respectively.

4.0 IMPLEMENTATION

The construction of the proposed groin field started in May 2004. Immediate shoreline advancement on the south of the executed groin has been substantiating the most favorable choice and design of the suggested remedial measure. A view of the groin and the resulting shoreline advancement in between the groins shown in **photos 2 and 3** are self explanatory in understanding the effectiveness of the proposal suggested by the author for a problem which has lasted for the past four decades. The approximate beach widths formed due to the groins 6 and 5 are shown in **Fig.7**. It is to be mentioned here that all the groins in stretch 1 are nearing completion which has clearly indicated, that stretch of the coast and the road has been saved from any further damage. This is evident from that fact that the groin field not only withstood the dynamics of the recent tsunami, but also has helped to a very great in reducing the inundation and damage on the landward side of this stretch of coast. Typical views of the groin field after the tsunami are projected in **photo. 4**. The shoreline advancement due to the groin field (6 groins) in stretch 1 after the tsunami in Dec'04 shown in **Fig.8** proves beyond a fraction of doubt the effectiveness of the proposed groin field not only in preventing further erosion, but also has enhanced the formation of beach. The satellite imagery depicting the advancement of the shoreline, thus protecting the coastal environment is shown in **photo.5**.

5.0 CONCLUSIONS

Although the protection of the coast has been a topic of great interest it has become all the more vital particularly after the wrath of the great Indian Ocean tsunami of Dec 2004. The results from the present design serve as a useful background in planning of such protection measures for the peninsular India. From the design and implementation, it is concluded that a perennial problem of coastal erosion swallowing a significant portion of the royapuram coast north of Chennai port, which also happens to be a national highway has been solved. The solution has been arrived after careful and critical investigation that included, design and planning of the protection measure, numerical modeling to assess its effectiveness, design of the groin field, individual groins, bathymetry survey, estimates and sequence of the construction. The sequence of construction of the groins was carefully planned taking into account the seasonal variation in the direction of littoral drift of the Chennai coast. This is a classical example as to how an academician can take up challenging field problems. The achievements made in not only solving the four decade old perennial problem of erosion, but also help in winning the beach in front of the affected area are highlighted in this report. A stretch of the coast of nearly 6km which could never be approached by local public due to severe erosion has resulted in a recreation spot and also serve as a facility for the landing of small boats along the beach formed in between the groins.

6.0 ACKNOWLEDGEMENT

The author wishes to record his thanks to Tamilnadu Road development company Ltd (TNRDC) for entrusting the responsibility to the author of this report for providing the present solution.

7.0 REFERENCES

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4. Janardanan, K., Sundar, V., (1994), Development and application of a Numerical Model for Shoreline Simulation, HYDRO-PORT 94, Yokosuka, Japan, pp. 1141-1156.
5. Komar, P.D., (1976), Longshore currents and sand transport on ocean engineering III, ASCE, pp. 333 – 354.

Table. 1 Rates of Erosion and accretion along the Tamilnadu coast (IHH(2002)

Sl.No.	Location	Length in m	Accretion/ Erosion	Rate in m/year
1	Pulicate	0.71	□	3.20
2	Ennore	3.27	■	1.30
3	Royapuram	5.38	□	6.60
4	Marina	2.97	■	1.70
5	Foreshore	2.3	■	1.09
6	Elliot/Astalakshmi temple site	2.08	□	1.28
7	Kanathur	0.24	□	1.4
8	Kovalam	3.15	□	0.81
9	Mahabalipuram	5.45	■	.25
10	Piondicherry	1.19	□	0.15
11	Cuddalore(North)	1.538	■	8.00
11a	Cuddalore (south)	0.483	■	2.98
12	Poombuhar	1.905	□	0.65
13	Tranquebar	.76	□	1.80
14	Nagapattinam	4.27	□	0.11

Sl.No.	Location	Length in m	Accretion/ Erosion	Rate in m/year
15	Point Calimere	0.966	■	3.40
16	Ammapattinam	3.6	■	0.72
17	Keelakarai	2.9	■	0.29
18	Mandapam	2.19	□	0.25
19	Rameswaram	3.3	■	0.06
20	Tiruchendur	1.53	■	0.33
21	Manappadu	1.6	□	1.10
22	Uvari	2.6	□	0.86
23	Kanyakumari	0.7	□	1.74
24	Manakkudi	3.65	■	0.57
25	Pallam	2.6	□	0.93
26	Muttom	3.0	■	0.17
27	Manavalakurichi	3.5	□	0.60
28	Colachel	1.75	□	1.20
29	Midalam	2.5	□	0.84

□ **Erosion** ■ **Accretion**

Table 2: Design details for trunk section

Trunk section	0m to 1m water depth	1m to 3m water depth	3m to 5.5m water depth
Wave Height	Up to 1.1m	Up to 2.0 m	Up to 3.0 m
Crest elevation	+ 4.2m		
Crest width (m)	4.0m		
Armour layer	500–1000 kg rough quarry stones in 2 layers of thickness 1.30m	1000–2000 Kg Rough quarry stones in 2 layers of thickness 1.40 m	1000-3000 Kg Rough quarry stones in 2 layers of thickness 1.50m
Slope	1:1.5		
Secondary layer	50–100 kg Quarry stones of thickness 0.6m	100–300 kg Quarry stones of thickness 0.7m	100–300 kg Quarry stones of thickness 0.7m
Core layer	1 to 60 kg Quarry stones		
Filter layer	10mm - 50 kg Quarry stones of thickness 0.30 m		
Toe	50 –100 kg Quarry stones	100–300 kg Quarry stones	100-300 kg Quarry stones
Toe width (m)	3.0		
Toe height (m)	1.0		

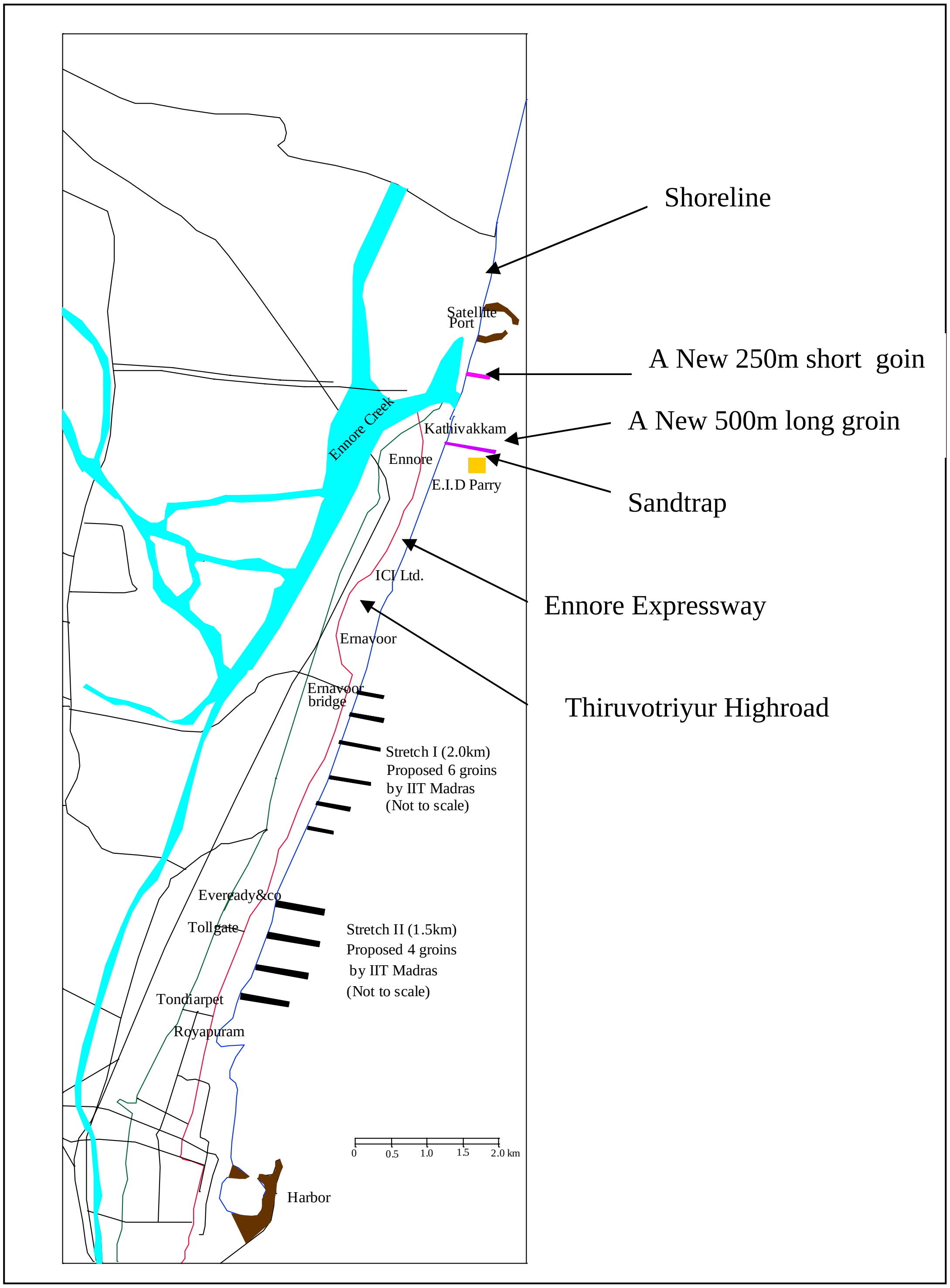

Fig. 1 Layout of Chennai Coast

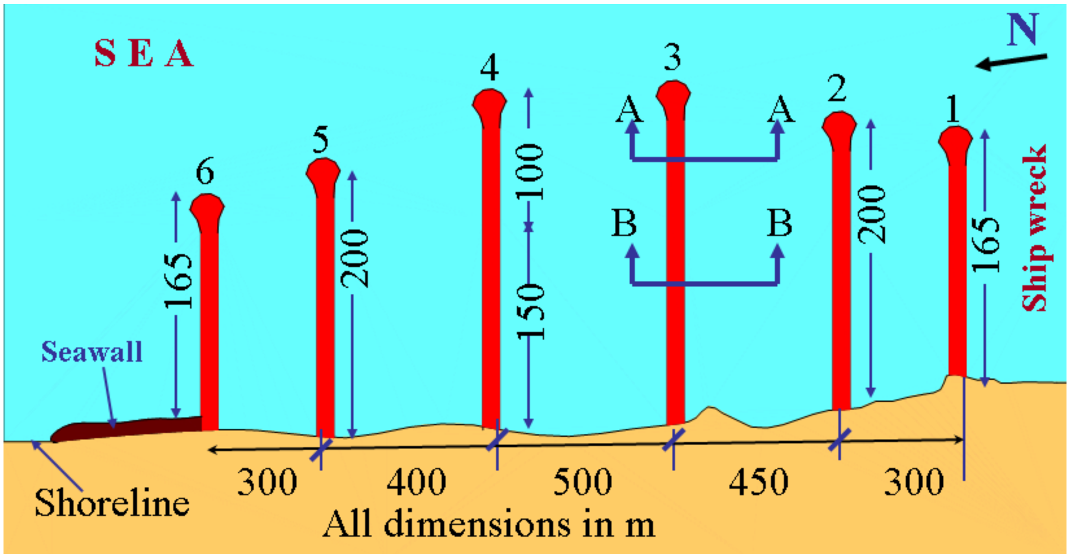

Fig. 2. Layout of groin field for stretch I

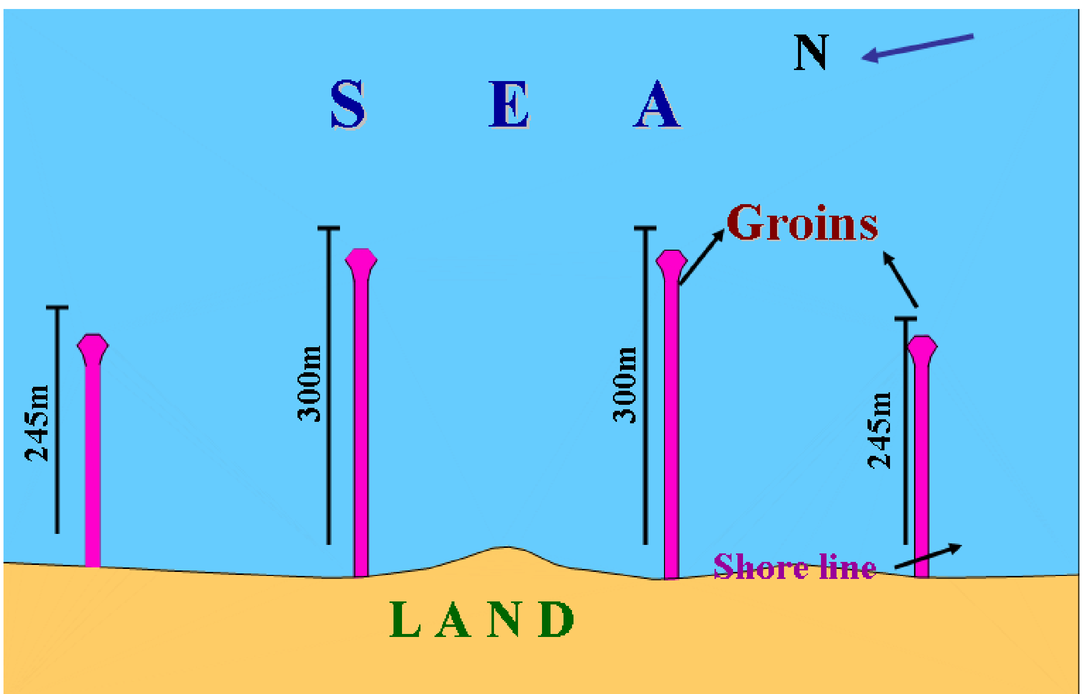

Fig. 3. Layout of grin field for stretch II

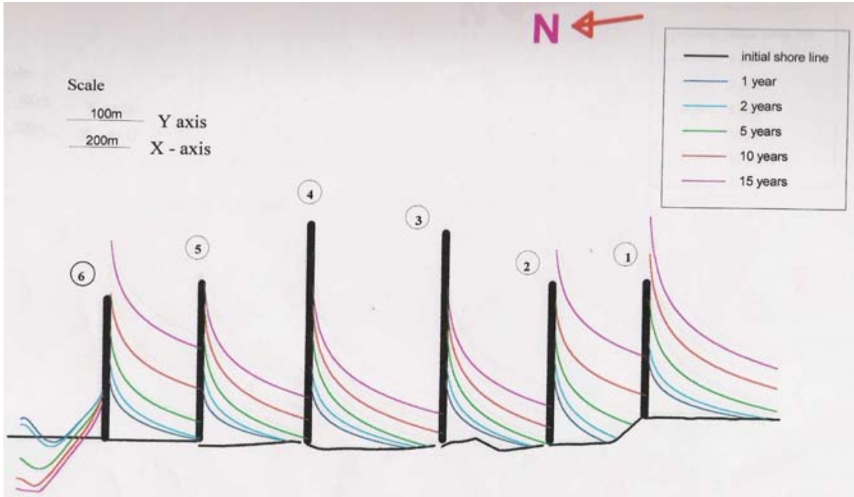

Fig. 4 Typical shoreline evolution predicted for groin field in Stretch-I

	DESCRIPTION	MATERIAL (QUARRY STONE IN KG)	VOLUME (Cu.m)	THICKNESS (m)	TOP LEVEL
	ARMOUR LAYER	1000 - 3000	42	1.5	+ 4.2
	SECONDARY LAYER	100 - 300	31	0.7	+ 2.7
	CORE LAYER	1 - 60	81	5.7 (avg.)	+ 2.0
	FILTER LAYER	10 mm - 50 Kg	12	0.3	- 4.7
	TOE LAYER	100 - 300		1.0	- 3.7

Note:Armour should be two layers with heavier stones on top

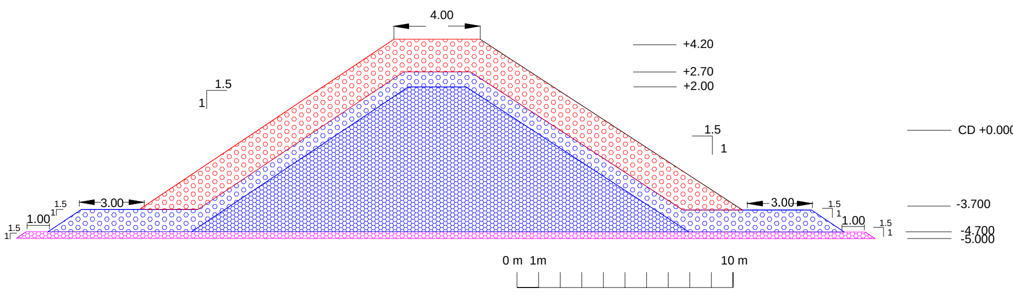

Fig. 5 Cross section of trunk portion between water depths 3 to 5m

	DESCRIPTION	MATERIAL (QUARRY STONE IN KG)	VOLUME (Cu.m)	THICKNESS (m)	TOP LEVEL
	ARMOUR LAYER	2500 - 4000	36	1.8	+ 4.2
	SECONDARY LAYER	100 - 300	22	0.7	+ 2.4
	CORE LAYER	1 - 60	60	6.4 (avg.)	+ 1.7
	FILTER LAYER	10 mm - 50 Kg	8	0.3	- 4.7
	TOE LAYER	100 - 300		1.0	- 3.7

Note:Armour should be two layers with heavier stones on top

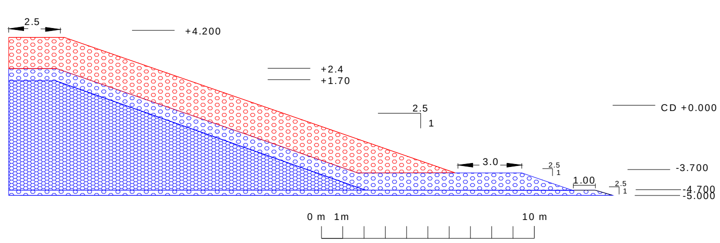

Fig.6. Cross section of head portion in water depth of 5.5m

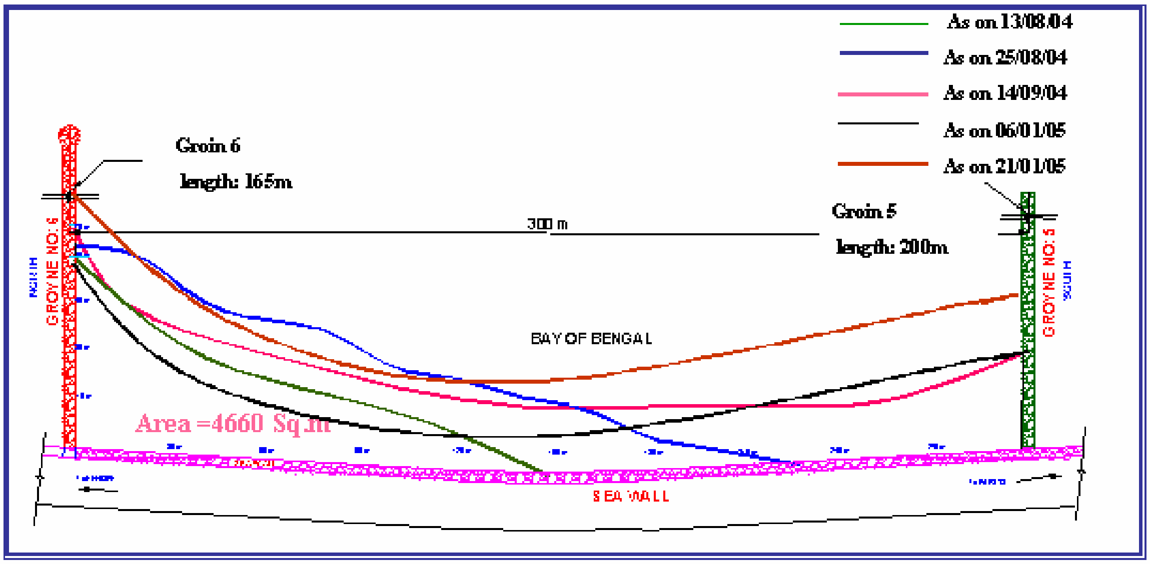

Fig. 7. Shore line advance into the Ocean in between Groins 5 and 6 for different periods

Photo.1a. Typical damages in the study area

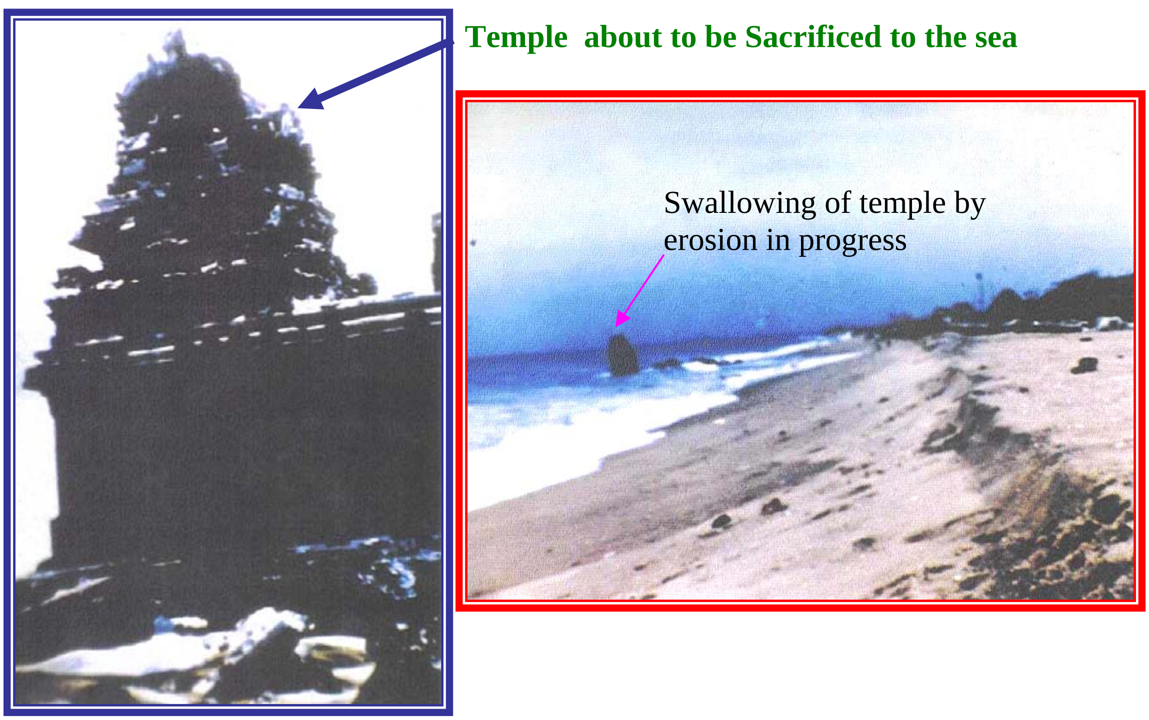

Photo.1b. Temple being sacrificed to the sea

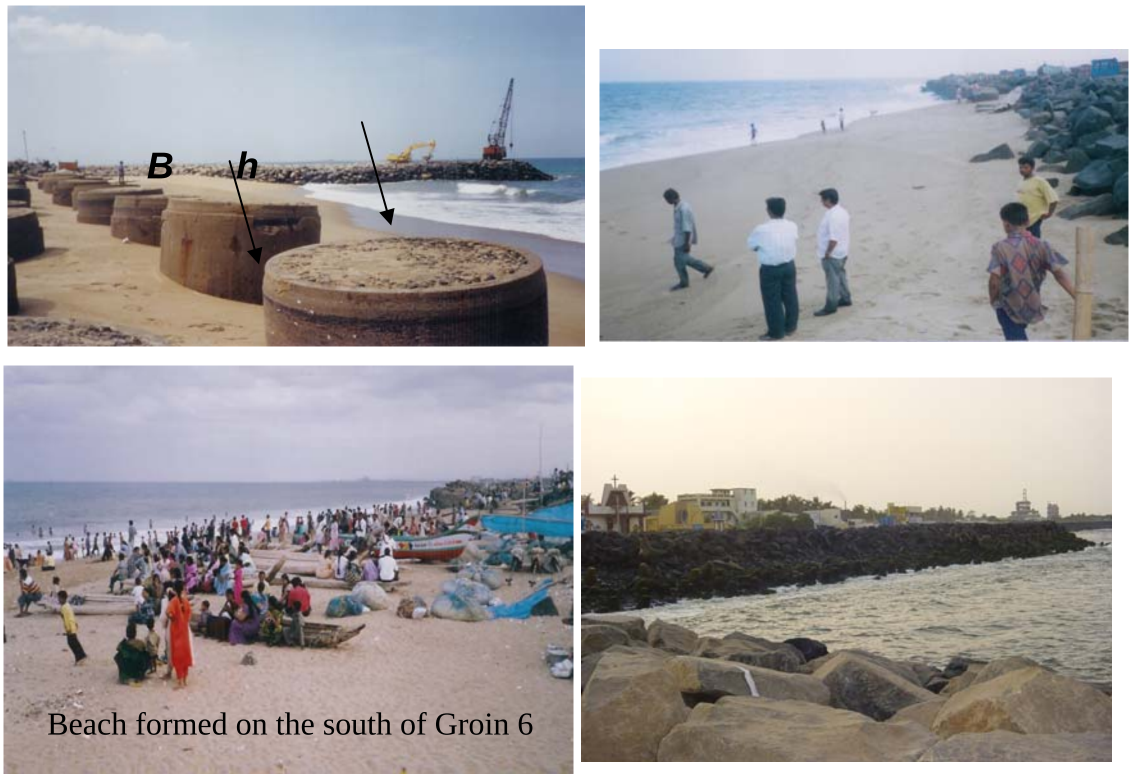

Photo.2. Beach Formation South of Groin 6 (Royapuram)

Photo.3 The beach formation in between groins 5 and 6 and south of groin 4

Photo.4 The status of the beach soon after tsunami

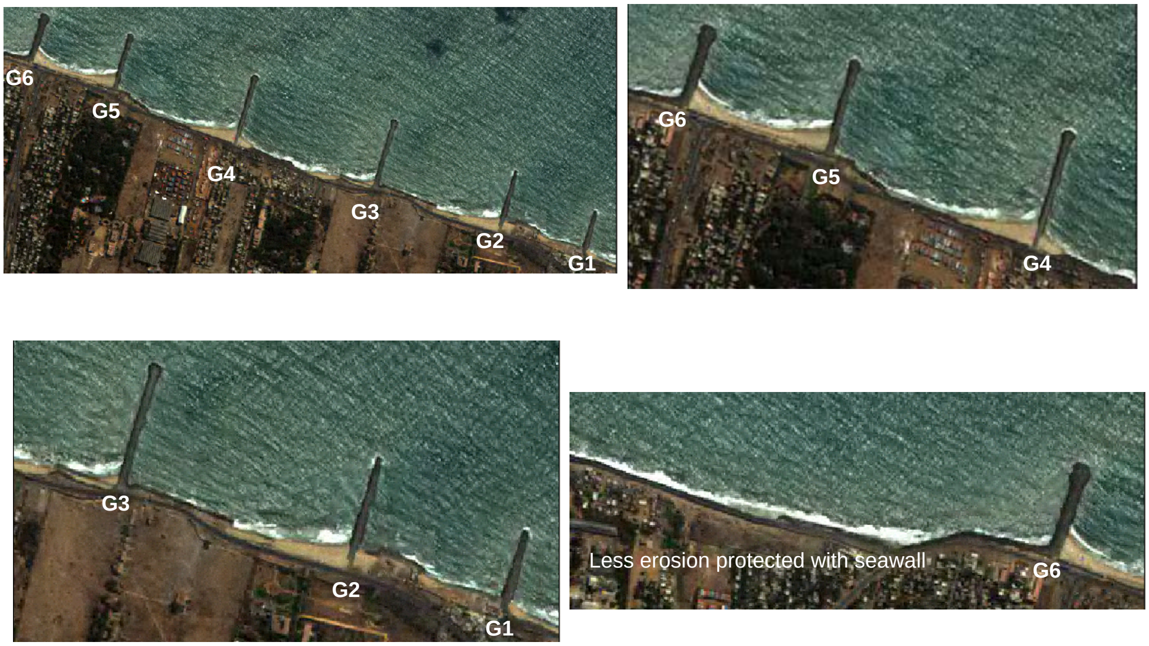

Photo. 5 Satellite Imageries of Stretch I (Royapuram)

ANNEXURE C

ROLE OF GROIN FIELD FOR COASTAL PROTECTION CONSIDERING SOCIO ECONOMIC ASPECTS

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ABSTRACT

A stretch of the south west coast of Indian peninsula of about 3 km had been experiencing the problem of erosion due to high wave action off the Arabian Sea. A groin field for protecting the coast against erosion was designed and implemented by the first quarter of 2004. While executing the project, a decision to bend at least one of the groins yielded fruitful results towards serving as a landing facility for the country boats, thus enhancing the livelihood of the fishing community. The success of this project has been an eye opener leading to a great demand for similar projects at several locations along the coast. These details of the project are discussed and presented in this paper

Keywords: coastal protection, groin field, shoreline changes

1 INTRODUCTION

1.1 General

The coast of Simon Colony, Vaniyakudi and Kurumbanai villages near Colachel of about 3 km stretch had been experiencing the problem of erosion due to high wave action of Arabian Sea particularly during the South west monsoon, i.e., from the month of May to September of every year at a rate of about 0.4m/year. A landmass of about 440 hectares along the coast was affected by erosion over the past 11 years. This had affected the fishermen as they found difficulty in venturing into the sea against the lashing spring waves, which frequently result in heavy casualties. Hence a proper sea protection is adopted and the study of the proposal is vital. Several options for the protection of this coast were discussed and finally a groin field for protecting the fishing villages was suggested and implemented in early 2003. The location of the study area is shown in Fig. 1a. The geographical position of the study area is located at 8^0 11.5’, 77^0 13.5’ E and 8^0 10.3’, 77^0 14.8’ E along the West Coast of India.

1.2 Layouts of groin fields

The first option of the layout consisted of six groins in which two groins at Kurumbanai, one groin at Vaniyakudi, two groins at Kodimunai and one groin at Simon colony. It is felt that this proposal would provide shore protection and also help the fisherman to anchor or tow the boats during the months June to September directly from the location of berthing. The details of this proposal are shown in **Fig. 2a**. The second option consisting of T-groins was basically provided as a shore protection measure to facilitate shore line advance into the sea and beach build up rapidly. The details of this scheme are shown in **Fig 2b**. However, it was decided to proceed with the first option as it is relatively cheaper and easier to construct as the study area has a number of scattered outcrops posing problems.

1.3Data collection

A detailed bathymetry survey for the study area was carried out in June 2002 The area surveyed was for about 3.0 km along the shore and about 1.0 km from the shore into offshore, up to a water depth of (-16.0) m. The appropriate tidal corrections were also incorporated to the water depth values, which are obtained from the tide tables. The seabed contours are found to be almost parallel to the shoreline representing a gradually varied bottom slope. There are several rock outcrops. The groin field was aligned taking into the account the presence of the outcrops.

The wave data (wave height, wave period and wave direction) was taken from the wave atlas published by National Institute of Oceanography (NIO), Goa. NIO (1990) published a wave atlas for Arabian Sea and Bay of Bengal (Latitude: 0^0 – 25^0 N and Longitude: 60^0 – 95^0 E) compiling the ship observed data for 19 years from 1968 to 1986. The coastal region around India is divided into 10 grids, each of size 5^0 latitude and 5^0 longitude as shown in **Fig.3**. The present study area falls under the grid located at 10 – 15^0N and 75 – 80^0E in the wave atlas, representing grid number six. The wave data obtained from wave atlas is for deep-water conditions.

1.4 Data analysis

The monthly distribution of deep water wave heights in terms of percentage of occurrence were and the class interval adopted for the presentation was 0.5m. It was observed from the results that the most frequently occurring wave height is of the order of 1.0m with a percentage of occurrences between 20 to 35% for the months February to May, October and December. The months January and November experiences wave height of about 1.5m with a percentage of occurrences from 20 to 30%. The months June to September experiences wave height of 2.0m with a percentage of occurrences from 20 to 25%. The monthly distribution of wave periods with a class interval of 1sec in terms of percentage of occurrence obtained. From the analysis it was observed that the maximum percentage of occurrence is with waves associated with periods ranging between 5 and 6 sec. The monthly distribution of wave directions with respect to geographic north with a class interval of 10^0 in terms of percentage of occurrence obtained revealed that most frequently occurring direction is 270^0 followed by direction of 180^0.

2 NUMERICAL MODEL STUDY FOR WAVE TRANSFORMATIONS

2.1 Wave transformation

. The mild slope equation is solved by generalized conjugate gradient (GCG) method as it has a fast convergence rate. The combined refraction-diffraction equation derived by Berkhoff (1972) describes the propagation of periodic, small amplitude, surface gravity waves over an arbitrarily varying mild sloped sea bed.

The numerical solution is arrived using generalized conjugate gradient method [Panchang and Pearce (1991), Li (1994)]. The method successfully estimates new approximations to the solution, considering the direction of residual error vector, till the prescribed accuracy is achieved. The offshore boundary is modelled as an open boundary in which case only incident waves and reflected waves are allowed to propagate. The lateral boundaries as well as the shore are considered to absorb the wave energy. The groin or any other obstructions are treated as partially reflecting boundaries by prescribing the reflecting coefficients. The model requires the wave characteristics (wave height, wave period and its direction) and the water depths at all the grid points. It also requires the location of the groin. The model gives the waves characteristics inside the domain.

2.2 Shorline evolution

The shoreline evolution due to the presence of the groins was computed using the methodology of Kraus and Harikai (1983), a numerical scheme to solve the one line model using Crank Nicholson implicit finite difference method.

3. RESULTS AND DISCUSSION

3.1 Wave transformation

Both the above models were executed for the wave characteristics provided in Table.1.The GCG numerical model is applied for the two predominant wave directions to predict the wave transformation due to the presence of groin. The distribution of wave phase and the wave height contours for the wave characteristics H_0=2.0m,T=5sec, θwith respect to, w.r.t Geographic north = 180^0 are shown in **Figs 4** and **5** respectively. The phase distribution shows the wave approach and combined effect of diffraction and refraction due to the presence of groins and rock outcrops. The results indicates that the wave height is of about 1.5m on the upstream side of all the groins, whereas on the downstream side the wave heights are of order of about 2.0m since the waves are directly penetrating. This condition will be occurring for a period of four months in a year. The distribution of wave phase and height contours for the wave characteristics H_0=2.0m,T=5sec, θ w.r.t Geographic north = 270^0 are shown in **Figs 6** and **7** respectively. This condition will be occurring for a period of six months in a year, during the southwest monsoon. The results show that the wave height near the upstream of the groins is about 1.0m. On the downstream side of the groin, the wave height is about 0.25m and this indicates the tranquillity, which is mainly due to the curvature at the groin tip.

3.2 Shoreline Evolution

The numerical model is used to predict the shoreline evolution due to the presence of a groin. The grain size (D_{50}) in this area is assumed as 0.30mm. The depth values were interpolated to the grid size of 10m in both directions of along the shore and towards offshore direction. The numerical model has been run for most frequently occurring wave height, wave period and wave direction for different months. The results of the numerical model for the most frequently occurring wave height, wave period and wave direction is shown in **Fig.8**. The results represent the changes in the shoreline for a period of 20 years. On the up drift side of the groins a beach of width of about 100m is expected after 20 years. On the downstream of groin G11G12, erosion of about 50m near Simon colony is expected after 20 years.

3.3 Revised layout

A revised layout have been suggested and executed considering the advantage of converting the rock outcrops as head section at some locations, requests for landing of country boats from local people, bathymetry restrictions and approach road for the construction of groins. The revised layout is shown in **Fig. 9**

4.0 CONCLUSIONS

The Groin field is functioning well in trapping the long shore sediment. Due to this measure, beach of width of about 100m in between the groins have formed and stabilised. The groin field is serving not only as coastal protection measure for the coast of Simon Colony, Vaniyakudi and Kurumbanai villages but also act as mini fish landing centres. The great Indian Ocean tsunami of 2004, diffracted around the Srilankan island and penetrated along the south western coast of India. The beaches formed due to the present groin field had acted buffers due to which the inundation distance and run-up heights had reduced leading to almost nil damage. The tsunami had exhibit might on the villages adjoining the study area. This success has lead to a great demand for groins along the coastal areas. The aerial views of the groins and shoreline advancement are shown in the **photos. 1 to 5.**

AKNOWLEDGMENTS

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Table 1 Wave characteristics

Month	Wave direction w.r.t North	Wave height (m)	Wave period (sec)
January	3^0	1.5	5
February	3^0	1.0	5
March	180^0	1.0	5
April	180^0	1.0	5
May	270^0	1.0	5
June	270^0	2.0	6
July	270^0	2.0	6
August	270^0	2.0	5
September	270^0	2.0	5
October	270^0	1.0	5
November	180^0	1.5	5
December	180^0	1.0	5

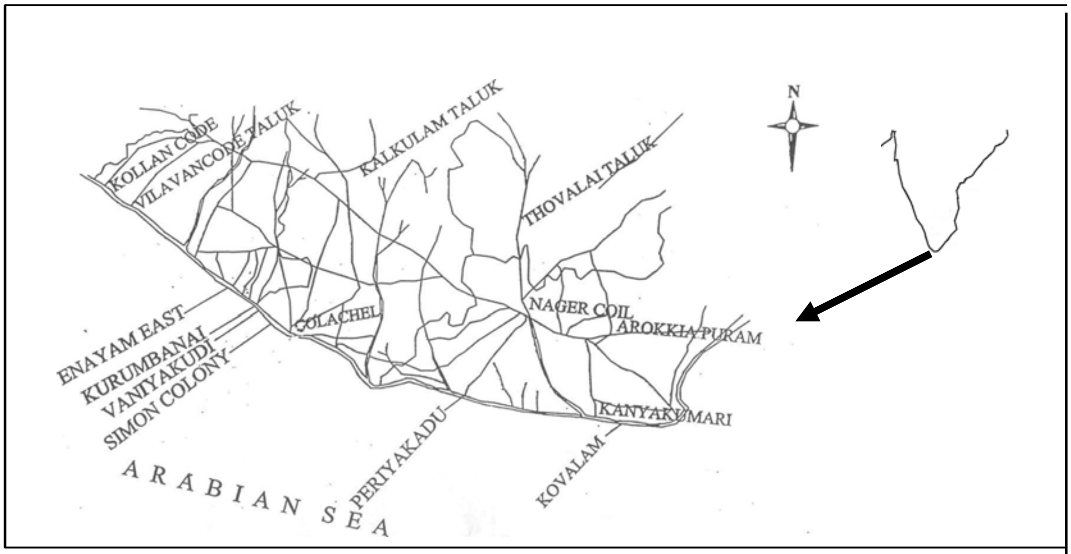


Fig.1. Location of Study area in Kanyakumari district

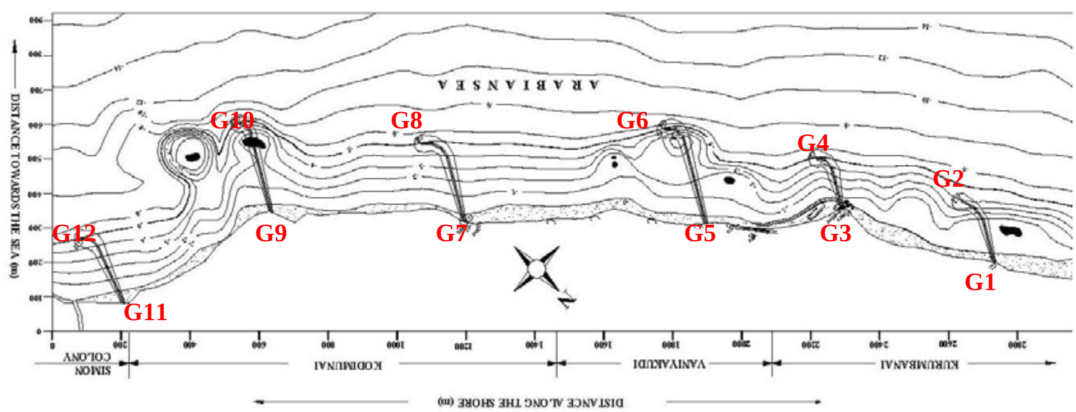


Fig. 2a Layout of the groin superimposed over the bathymetry

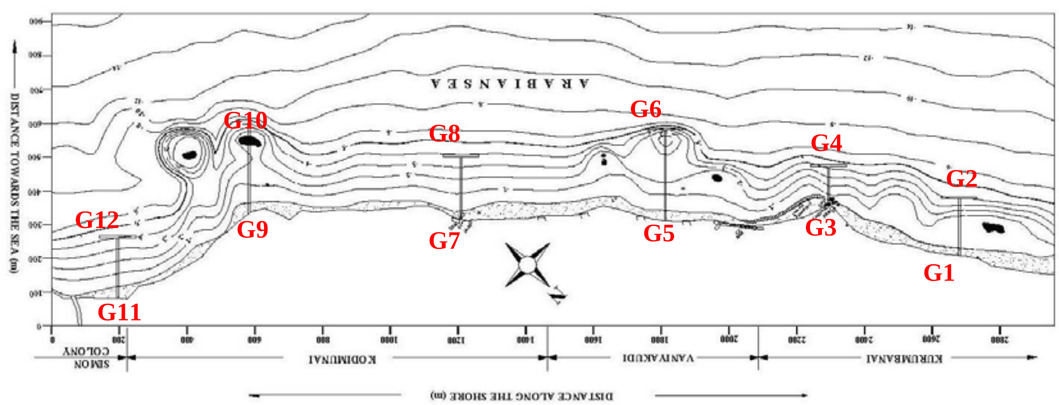


Fig.2b Layout of the T-groins superposed over the bathymetry

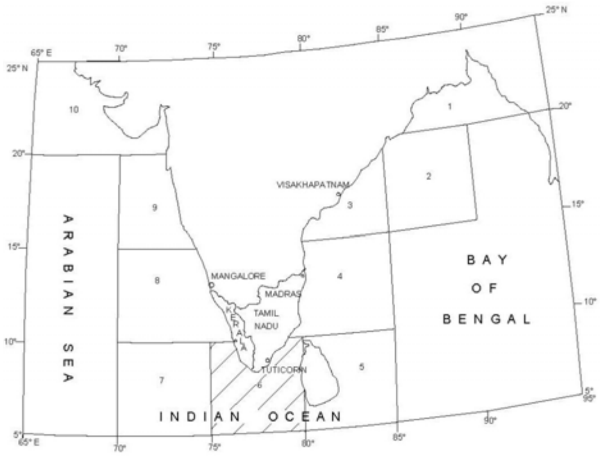
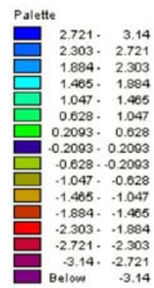


Fig.3 Grid on wave atlas for study area

PREDOMINANT WAVE CONDITIONS

Sl No:	Wave height (m)	Wave period (s)	Wave angle w.r.t.Shore Normal	Wave angle w.r.t.Geographic North
1	2.0	5.0	$+270.0^0$	-40.0^0
2	2.0	5.0	$+180.0^0$	$+35.0^0$



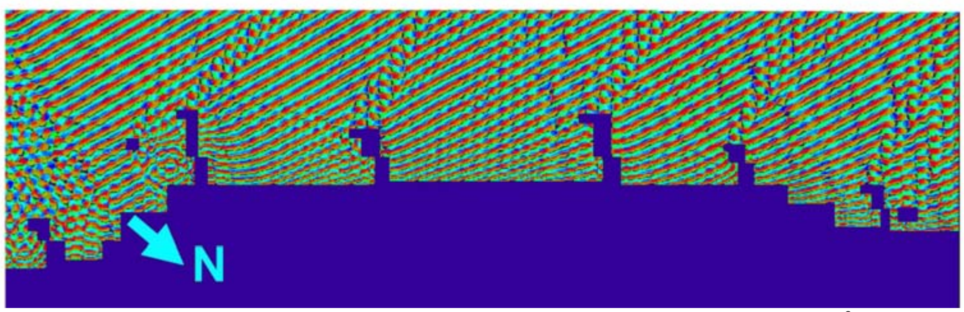


Fig 4. Wave phase distribution (H 2.0m, T = 5sec, θ w.r.t N = 180^0)

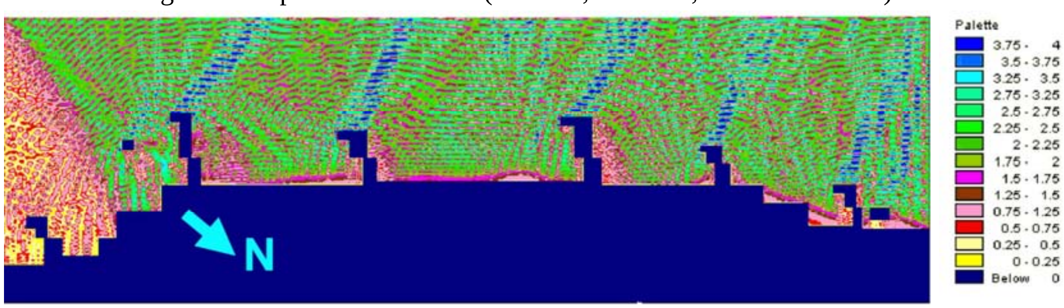


Fig 5. Wave height distribution (H 2.0m, T = 5sec, θ w.r.t N = 180^0)

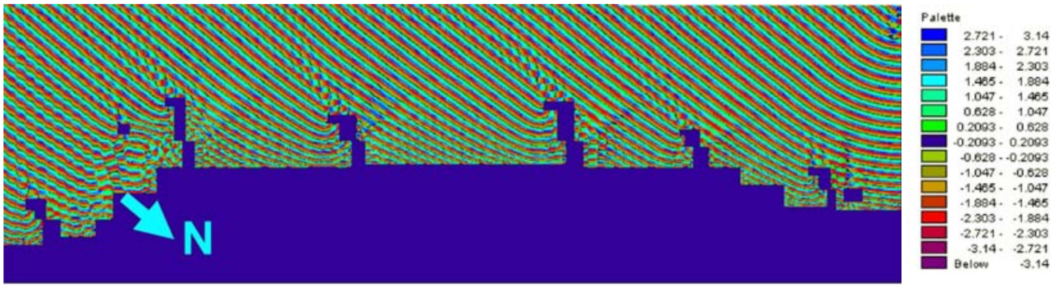


Fig 6. Wave phase distribution (H 2.0m, T = 5sec, θ w.r.t N = 270^0)

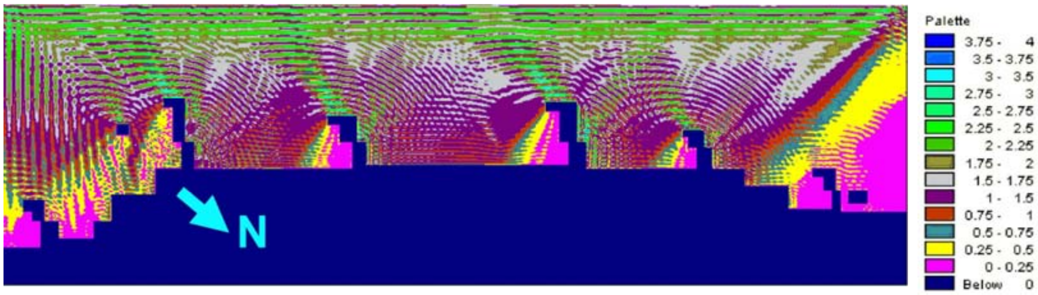


Fig 7. Wave height distribution (H 2.0m, T = 5sec, θ w.r.t N = 270^0)

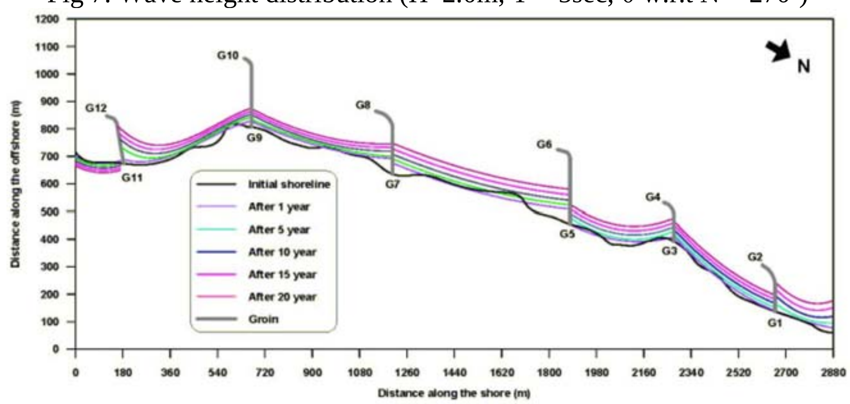


Fig. 8 Shoreline evolution for frequently occurring wave heights

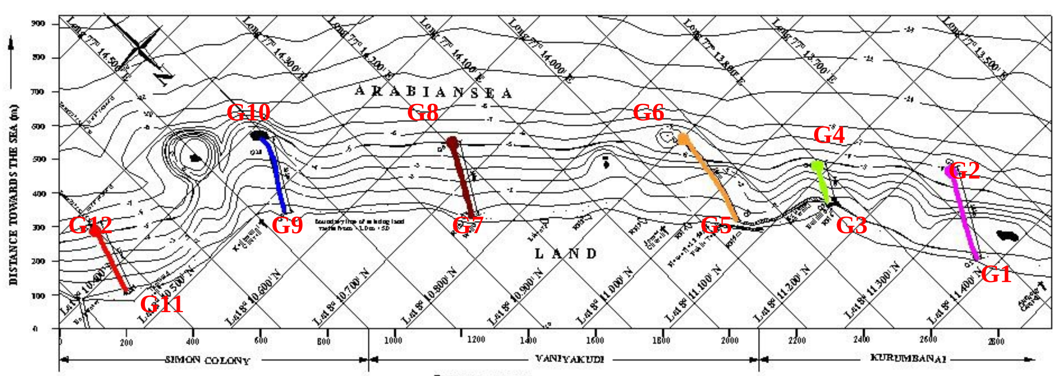


Fig. 9. The Revised layout of groin field for Simon Colony, Vaniyakudi and Kurumbanai villages

Photo.1. Status of the coast prior to protection

Photo. 2. Beach formation between the Groins G3-G4

Photo.3. A view of the shoreline from the eastern of the groins G5-G6

Photo.4. Areal view of groin G9-G10

Photo. 5. A groin at Simon Colony
(designed so as the natural outcrop acts as a head)