DESIGN OF SEAWALL

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***Abstract* - The main aim of the study is to construct a seawall at Kovalam coast to prevent coastal erosion and destruction of property by the sea waves during high tides. This study work deals with the "Design of Seawall" at Kovalam coast. The seawall is designed for the length of 2100m.This study is prepared with cross section of seawall by using AutoCAD. The seawall is generally designed to consist of three layers that are core, secondary layer and an armour layer. Engineering Manual 1110-2-1614 is used to design seawall element like Water level, Wave period, Armour unit, Layer thickness, Core, Secondary Layer, Toe Protection, and Filter Layer. The design conditions, we had designed for various seawall components are as per engineering manual. The estimation of seawall design is done with PWD schedule of rates guidelines.**

***Keywords*: Seawall, Coastal Erosion, Engineering Manual.**

I. INTRODUCTION

The Earth's climate system is affected due to changing temperature (global warming), ocean levels and rainfall patterns. Thus, sea level rises worldwide and both mean water level and height of waves increases during extreme weather events. It causes coastal erosion along coasts which result in intrusion on shore and affect human activity. Sea wall is the most traditional method used in coastal management. A seawall is a structure built on the beach parallel to the shoreline. Seawalls can be large or small, high or low, and constructed of a range of materials including wood, plastic, concrete, rock, construction rubble, steel, old cars, aluminum, rubber tires, and sandbags.

The aim of the study is to prevent destruction of property by the sea waves during high tides by the construction of a seawall. The study involves design of 2100 m long seawall at the coastline near Kovalam (Covelong), Tamil Nadu. Figure 1 shows site location.

Figure 1 Site location (Source: Google Earth)

II. LITERATURE REVIEW

Seawall Definition

Seawalls are designed to halt shoreline erosion caused by wave action. A seawall works by reflecting incident wave energy back into the sea, thereby reducing the energy and erosion which the coastline would otherwise be subjected to. The design and type of seawall that is appropriate depends on aspects specific to the location, including the surrounding erosion processes.

Types of Seawall

There are three main types of seawalls: Vertical, Curved and Mound.

Vertical Seawall

Vertical seawalls are built in particularly exposed situations. These reflect wave energy. Under storm conditions non-breaking standing wave pattern can from, resulting in a stationary clapotic wave which moves up and down but does not travel horizontally. These waves promotion at the toe of the wall can severe damage to the seawall. Piles are placed in front of the wall to lessen energy slightly. Figure 2 shows vertical seawall.

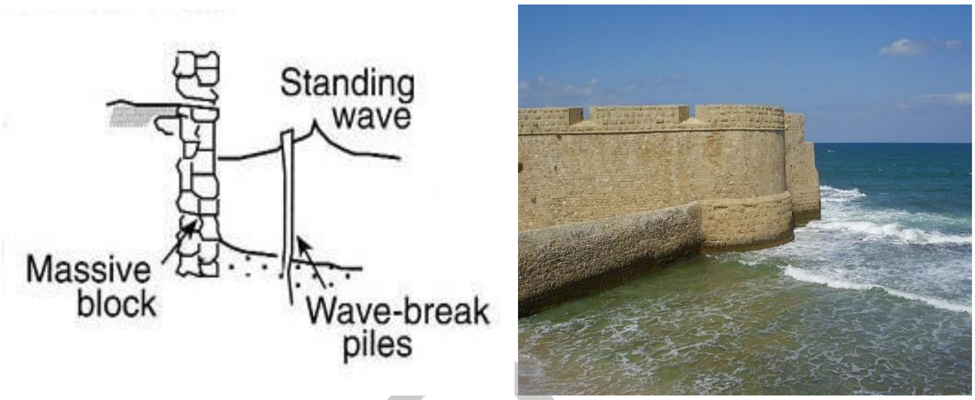

Figure 2 Vertical Seawall

Curved Seawall

Concave structure is a dissipative element. The curve can prevent waves from overtopping the wall and provides extra protection for the toe of the wall. Curved seawalls aim to re-direct most of the incident energy, resulting in low reflected waves and much reduced turbulence. Figure 3 shows curved seawall.

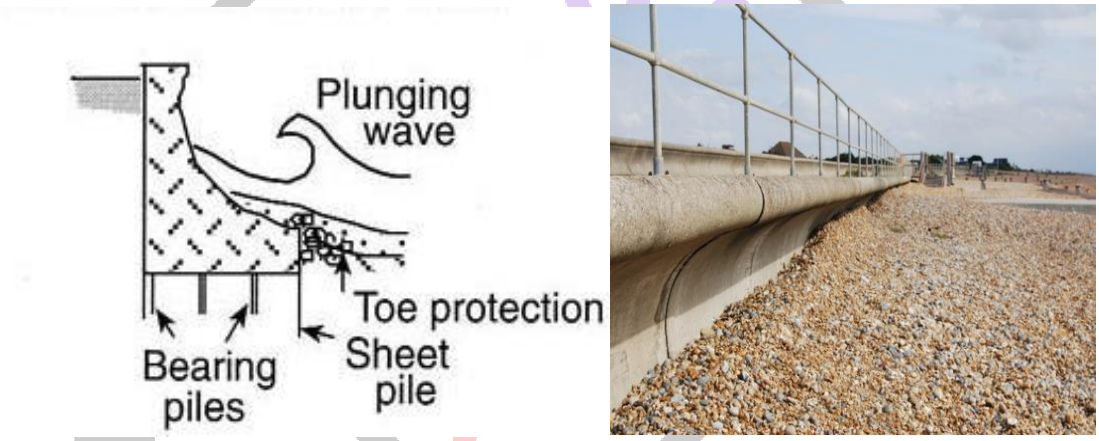

Figure 3 Curved Seawall

Mound Seawall

Mound type seawalls are made using revetments or riprap and are used in less demanding where lower energy erosional processes operate. The least exposed involve the lowest cost bulkheads and revetments of sand bags or geotextiles. These serve to armour the shore and minimize erosion and may be either watertight or porous, which allows water to filter through after the wave energy has been dissipated. Figure 4 shows mound seawall.

Figure 4 Mound Seawall

Reason for Selecting Rubble Mound Seawall

For coastal protection works rigid structures should be avoided. The flexible structures, which dissipate wave energy, should be adopted. The vertical face leads to the reflection and scouring and subsequently failure of the wall. The most important function of the seawall is to dissipate the wave energy and allow formation of beach in front of it. As such, the sloping rubble mound seawall is the most suitable type of seawall.

Rubble Mound Seawall

The rubble mound seawall is generally designed to consist of three layers that are core, secondary layer and an armour layer. A minimum of two layers of stones (units) in the armour and secondary layer is always necessary. The thicknesses of these layers are determined by the size of stones used, the levels including that of the core are determined based on maximum water level, design wave height. Figure 5 shows rubble mound seawall.

Figure 5 Rubble Mound Seawall

III. DESIGN OF RUBBLE MOUND SEAWALL

Study area: Kovalam, Tamilnadu. Covelong(Kovalam) is a fishing village in Chennai, Tamilnadu 40kms south of Chennai on east coast road enroute to mahabalipuram. Figure 6 shows proposed seawall location.

Nature of coastline: Crystalline rocks overlain by sedimentary and alluvial formation (PWD). Rate of erosion in kovalam: 0.81m/year (PWD Tamilnadu).

Length and Location of Seawall

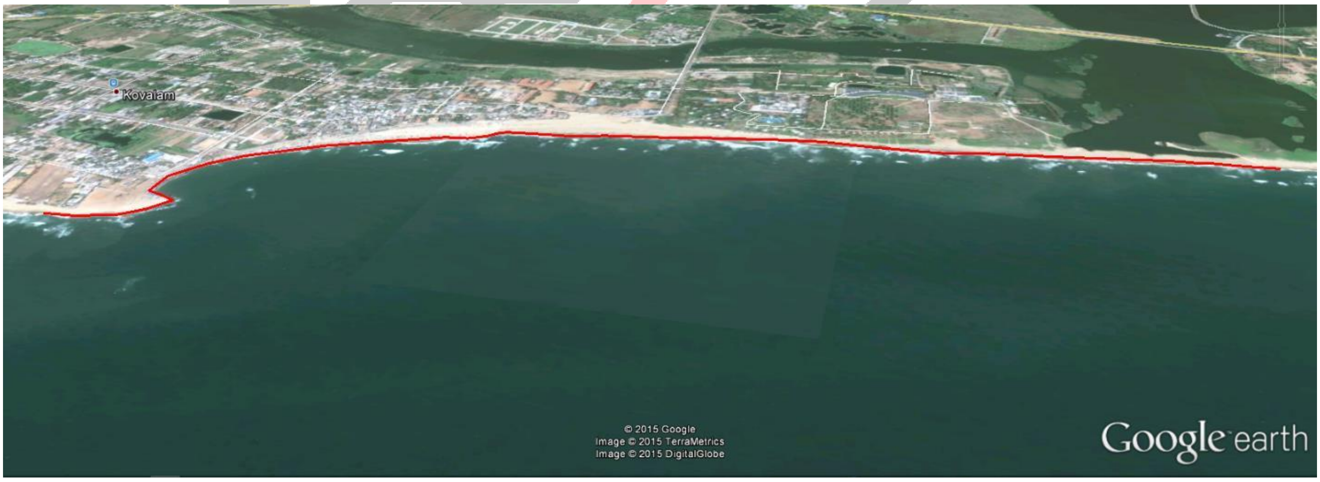

Figure 6 Proposed seawall location (Source: Google Earth)

- Location: India / Tamilnadu / Kovalam
- Length of sea wall: 2100 m
- Latitude and longitude: 12.7925°N 80.2530°E

Reason for Selecting this Site

The area near Kovalam has been selected for the construction of seawall because of the gradual erosion along the coast. The following has been shown with the help of satellite imagery below Fig. 7.

2015 **2012** **2005** **2004**

Figure 7 Proposed area in 2004,2005,2012,2015 (Source: Google Earth)

Determining Significant Wave Height and Wave Period

Significant Wave Height

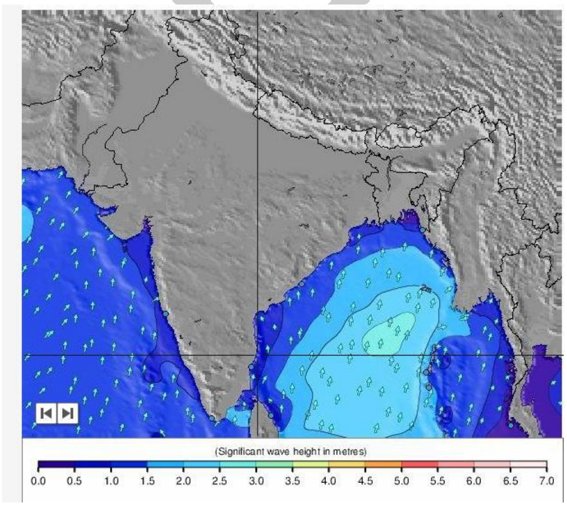

Figure 8 Significant wave height

The wave height obtained is 1.5 m. The significant wave height is obtained by analyzing cumulative data from 2004 to 2015. Figure 8 shows significant wave height

Determining Tide Level

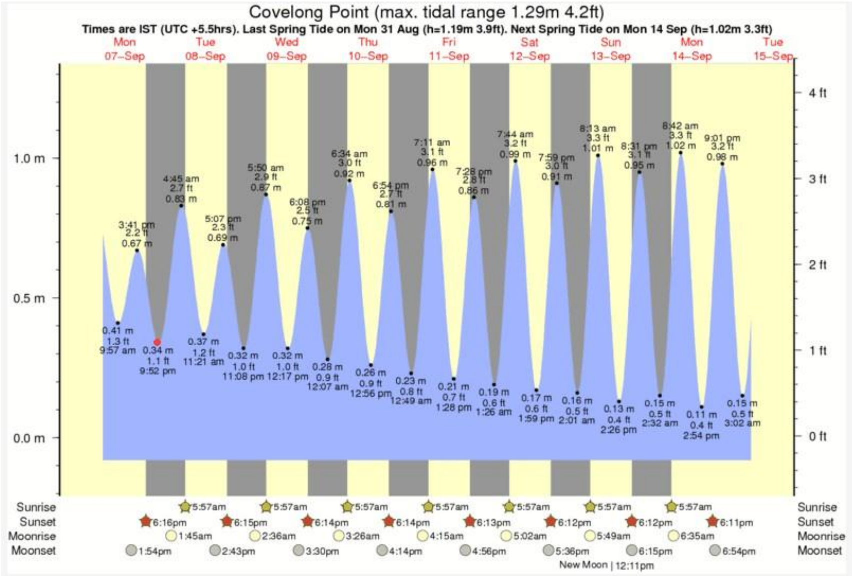

Figure 9 Tide Level

The mean wave period is 8 sec. The wave is determining by analyzing data from 2004 to 2015. Figure 9 shows tide level.

Determining Wave Energy

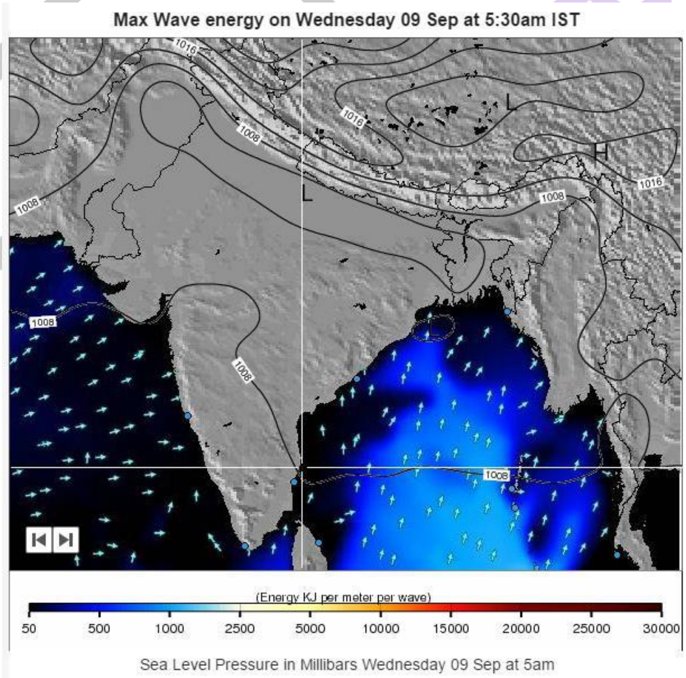

Figure 10 Wave Energy

Design Procedure

Design conditions:

- Significant wave height H_s = 1.5+ 1 = 2.5 m
- Depth of water d = 2.5 m
- Time Period of Approaching waves = 8 sec

- Stability Coefficient K_D = 2 (for rough quarry stone) (Table for K_D value (Source: EM 1110-2-1614))
- Unit Weight of Armour $\boldsymbol{\rho}_a$ = 2.65 T/ m³
- Density of Seawater $\boldsymbol{\rho}_w$ = 1.025 T/m³
- Slope ø = 1 in 1.5
- Cot ø = 1.5
- Length of Seawall = 2100m

1. Armour Design:

Weight of Armour unit:

$$W_a = \frac{\rho_a H^3}{K_D \Delta^3 cot ø}$$

$$= \frac{(2.65 \times 2.5^3)}{(2 \times \{(\frac{2.65}{1.025}) - 1\}^3 \times 1.5)}$$

W_a = 3.46 T

Crest width of armour layer:

$$B = n K_\Delta \left(\frac{W_a}{\rho_a}\right)^{1/3}$$

Where n = number of stones = 3

K_Δ = layer coefficient = 1 (Table for KΔ (Source: EM1110-2-1614))

$$B = 3 \times 1 \left(\frac{3.46}{2.65}\right)^{1/3}$$

= 3 x 1.09

= 3.27 m

Thickness of armour layer:

$$t = n K_\Delta \left(\frac{W_a}{\rho_a}\right)^{1/3}$$

Where n = number of stones = 2

$$t = 2 \times 1 \left(\frac{3.46}{2.65}\right)^{1/3}$$

= 2 x 1.09

= 2.18 m

2. Under Layer Design:

Weight of under layer = W_a /10 to W_a /15 (Where W_a = Wt. of armour unit)

= 3.46/10 to 3.46/15

= 0.346 T to 0.231T

Thickness of under layer = Depth of armour

= 2.18m

3. Core Design:

Weight of core layer = W_a/100 to W_a/400

= 3.46/100 to 3.56/400

= 0.0346T to 0.0356T

4. Toe Berm Design:

Weight of Toe Berm = W_a /10 to W_a /15

= 3.46/10 to 3.46/15

= 0.346 T to 0.231T

Width of toe berm = 2 x H_s = 2x 1.5= 3.0 m

Depth of toe berm = 0.4 x d = 0.4 x 2.5 = 1 m

Depth of core layer = Depth of toe berm

= 1 m

- Structure height = Thickness of armour layer + Thickness of under layer + Depth of toe berm + Thickness of bedding layer

= 2.18 + 2.18 + 1 + 1

= 6.36 m

- Weight of Structure = Weight of armour unit + Weight of under layer + Depth of toe berm + Thickness of bedding layer

= 3.46 + 0.346 + 0.0346 + 0.346

= 4.19 T

Figure 11 shows model of seawall. Table 1 shows total weight of the structure.

Model of Seawall

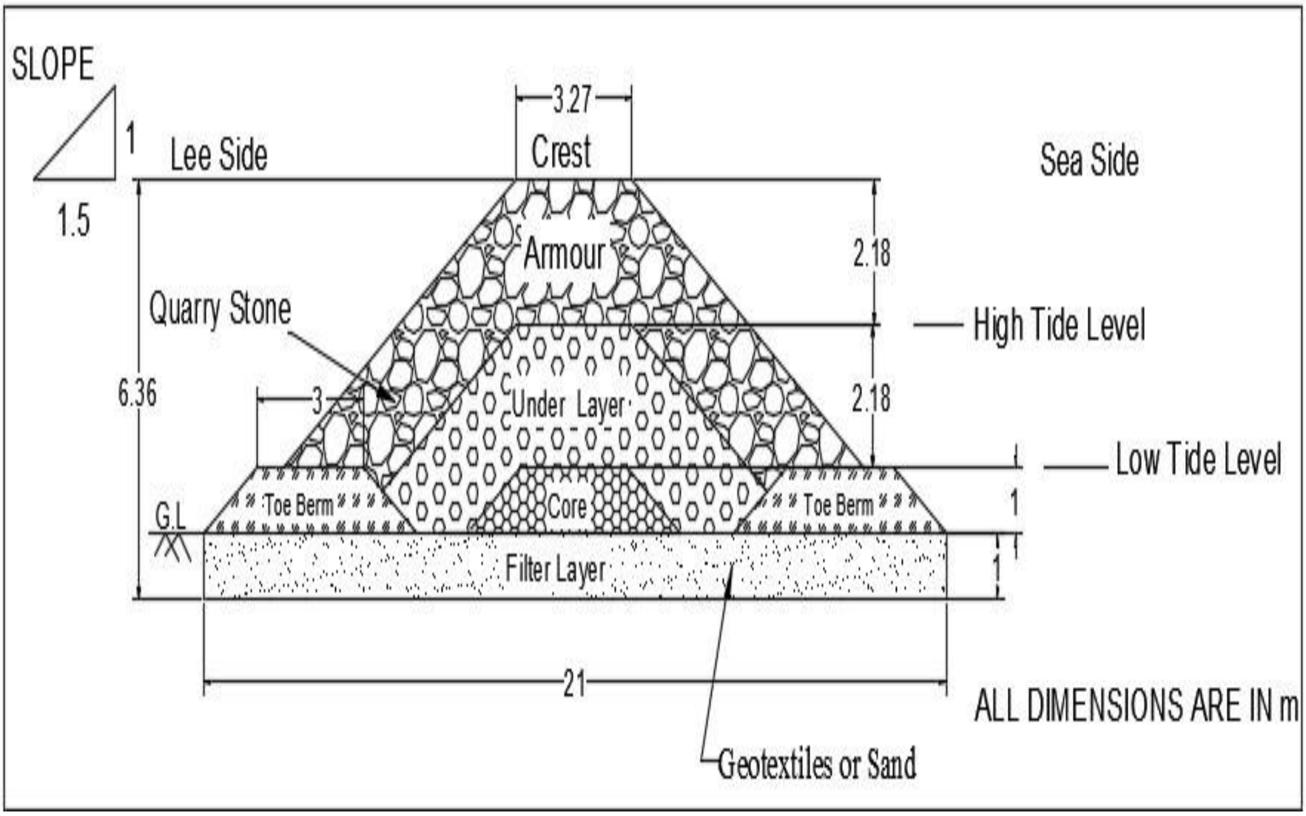

Figure 11 Model of Seawall

Table 1 Total Weight of the Structure

NAME OF LAYER	TOTAL AREA (Based on AutoCAD Drawing) (Sq. m)	LENGTH (m)	Volume (Cu.m)	(After Deduction of Voids 30% for Bedding layer) (Cu.m)	UNIT WEIGHT (T)	TOTAL WEIGHT (T) (Corrected Volume*WT)
Armour Layer	29	2100	60900	42630	3.46	147499.8
Under Layer	20	2100	42000	29400	0.346	10172.4
Core Layer	5	2100	10500	7350	0.0346	254.31
Toe Berm	2*5=10	2100	21000	147000	0.346	50862
Filter Layer	21	2100	44100	30870	0.00346	106.8102

Weight of the structure = 208,895.3 T

IV ESTIMATION FOR SEAWALL

Formation of a seawall with following layers using revetment stones having specific gravity not less than 2.65 of specified size against each layer for seawall as per approved design and drawing including cost and charges for quarrying, loading transporting by tippers/lorries weighing in the electronic weigh bridge for measurement, dumping, placing in position to the required specifying level, profile, and finishing the side slopes with 1:1.5 on both sides as specified with necessary machineries equipment and devices required for carrying out work with me power as per the drawings and specification, etc.

The rate is also inclusive of placing, sectioning and finishing with necessary equipment and devices and hire and operational charges of tools and plants etc.… Weigh bridge for which amount has been provided. Table 2,3&4 shows general cost per MT, detailed estimation and abstract estimate respectively.

Procedure of Estimating

Estimating involves the following steps:

1. Preparing detailed Estimate.
2. Calculating the rate of each unit of work
3. Preparing abstract of estimate

Table 2 General Cost per MT

GENERAL COST ESTIMATE FOR CONSTRUCTION OF SEAWALL AT KOVALAM (As per Schedule of Rates 2015-2016)			
Quarry site: Venkatapuram		50 km + 3 km ct	
1 MT	Cost of Stone	123.77	MT
1 MT	Conveyance Charges including loading and unloading	183.62	MT
1 MT	Handling charges, Placing, Levelling, sectioning to the required profile and work in under sea water condition	293.00	MT
1 MT	Weighing Charges	9.00	MT

	TOTAL Rs.	616.60/MT	

Table 3 Detailed Estimation

I.) Cost of Stone per MT

CONSTRUCTION OF SEAWALL AT KOVALAM		
COST OF QUARRY STONES FOR ALL LAYERS		
For all layer		
1 m^3 quarrying charges (Rough stone for Revetment) (As Per SOR. 35/28 @Pg.16)	Rs.328.00	
Weight of 1 m^3 of Stone	2.65	MT
Rate / MT	Rs.123.77	

II.) Conveyance Charges per MT

CONVEYANCE CHARGES FROM VENKATAPURAM TO SITE (As per Schedule of Rates 2015-2016 ANNEXURE V (A) @ Pg.34)				
Quarry site**:** Venkatapuram		50 km + 3 km ct		
Lead distance in km		Rs	Km	Total (Rs.)
0	10	8.69	10	86.90
10	20	7.44	10	74.40
20	40	6.44	20	128.80
40	50	6.00	10	60.00
3		8.69+20%	3	31.30
	Loading charges	26.30x2		52.60
	Unloading charges	26.30x2		52.60
	Conveyance charges		Rs.	486.60/m^3

Conveyance charges for 1 MT =486.60/2.65	Rs.	183.62/MT

Table 4 Abstract Estimate

S.No	Description	Rate (/MT)	Quantity (T)	Amount in lakhs (Rs.)
1.	Formation of a seawall with following layers using granite stones having specific gravity of not less than 2.65MT of specified size against each layer for each Seawall all as per approved design and drawing including cost and charges for quarrying, loading transporting by tippers/lorries weighing in the electronic weigh bridge for measurement, dumping, placing in position to the required specifying level, profile and finishing the side slopes with 1:1.5 on both sides as specified with necessary machineries equipment and devices required for carrying out work with me power as per the drawings and specification, etc.…The rate is also inclusive of placing, sectioning and finishing with necessary equipment and devices and hire and operational charges of tools and plants, etc.…Weigh Bridge for which amount has been provided.	616.60	208,895.3	1288.00

IV CONCLUSION

As the cost of material, labor differs with time to time. We conclude that there will be difference in theoretical and practical work done in construction of seawall. We had designed for various seawall components are as per engineering manual. The estimation of seawall design is done with PWD schedule of rates guidelines.

- The unit weight of structure is 4.9T. The weight of the structure 208,895.3 T.
- The estimated the cost to be incurred is Rs. 12.88 crores.

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