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ABSTRACT

Coastal erosion is a problem faced by all the coastal population in different parts of the world. With a long coast of about 7500 km, the subject of coastal erosion and control in India assumes great importance. This problem calls for the protection of houses, cultivable lands, valuable properties, monuments etc. in the coastal belt. The solution to this problem involves scientific analysis of the same with a view to devise methods for preventing and/or minimizing the damage due to erosion caused by the destructive forces of the waves.

It is well known that the erosion of a coast is mainly due to action of waves in addition to the currents setup by the oblique attack of waves. Erosion of the coast depends on many factors like storm waves, nature of the beach, beach material and the shape of the coast, tidal level changes, movement and quantity of the littoral drift material. Human interference is also an important factor causing coastal erosion. The best natural defense against erosion is an adequate beach on which waves expend their energy. However, provision of an adequate beach is rarely possible due to economical reasons. Resort has therefore, to be taken to provide appropriate engineering structures such as seawalls, revetments, anti-sea erosion bunds, groynes, offshore breakwaters, etc. to prevent beach erosion. Seawalls, revetments and groynes are structures located on the beach, while offshore breakwaters are located away from the beach. Since waves are the prime cause of beach erosion, it is natural that the protective methods are evolved so as to dissipate the energy of waves either by absorbing this energy on the beach or dissipating / diverting the same before the waves approach the beach. Rubble mound seawalls are the most commonly used measure for preventing coastal erosion in India.

CHAPTER:-1 INTRODUCTION

Coastal erosion

- Every land mass on Earth has miles of coast at the interface between the Hydrosphere and the lithosphere. Natural forces such as wind, waves and Currents are constantly shaping the coastal regions. The combined energy of these forces moves land materials. The landward displacement of the shoreline caused by the forces of waves and currents is termed as coastal erosion. Coastal erosion is the wearing a way of land and the removal of beach.

- Coastal erosion is a problem faced by all the coastal population in different parts of the world. Coastal users and managers all over the world are frequently faced with serious erosion of their sandy coasts. Possible causes of erosion include natural processes (i.e. action of waves, tides, currents, sea level rise, etc.) and sediment deficit due to human impact (i.e. sand mining and coastal engineering works). Counter measures for beach erosion control function depend on local conditions of shore and beach, coastal climate and sediment transport. Continuous maintenance and improvement of the coastlines, together with monitoring and studies of coastal processes have yielded considerable experience on various coastal protection measures all over the world.

- In general, a coastal structure is planned as a practical measure to solve an identified problem. Starting with identification of the problem (e.g. shoreline erosion), a number of stages can be distinguished in the design process for a structure: definition of functions, determination of boundary conditions, creating alternatives, geometrical design and the final choice of functional solution. After the choice of functional solution has been made the structural design starts including creating structural alternatives (i.e. using different materials and various execution methods).

- The final choice will be made after verification of various structural solutions in respect to the functional, environmental and economic criteria. The present overview provides information on some available methods for shore stabilization and beach erosion control, with special emphasis on the alternative solutions and novel materials and systems in design implementations.

CHAPTER:-2 MAJOR CAUSES OF COASTAL EROSION

- Natural Causes and
- Anthropogenic Causes

Natural Causes

1 Action of Waves

Waves are generated by offshore and near- shore winds, which blow over the sea surface and transfer their energy to the water surface. As they move towards the shore, waves break and the turbulent energy released stirs up and moves the sediments deposited on the seabed. The wave energy is a function of the wave heights and the wave periods.

2. Winds

Winds acts not just as a generator of waves but also as a factor of the landwards move of dunes (Aeolian erosion).

3. Tides

Tides results in water elevation to the attraction of water masses by the moon and the sun. During high tides, the energy of the breaking waves is released higher on the foreshore or the cliff base (cliff undercutting). Macro-tidal coasts (i.e. coasts along which the tidal range exceeds 4 meters), all along the Atlantic sea (e.g. Vale do Lobo in Portugal), are more sensitive to tide-induced water elevation than micro-tidal coasts (i.e. tidal range below 1 meter).

4. Near-shore currents

Sediments scoured from the seabed are transported away from their original location by currents. In turn the transport of (coarse) sediments defines the boundary of coastal sediment cells, i.e. relatively self- contained system within which (coarse) sediments stay. Currents are generated by the action of tides (ebb and flood currents), waves breaking at an oblique angle with the shore (long-shore currents), and the backwash of waves on the foreshore (rip currents). All these currents contribute to coastal erosion processes.

5. Storms

Storms result in raised water levels (known as storm surge) and highly energetic waves induced by extreme winds (Cyclones). Combined with high tides, storms may result in catastrophic damages such as along the east coast of India (Orissa Super Cyclone, 1999). Beside damages to coastal infrastructure, storms cause beaches and dunes to retreat of tenths of meters in a few hours, or may considerably undermine cliff stability.

6. Catastrophic events

In addition to the daily, slow sculpting of the coast, other events like tsunamis which result in major coastal changes over very short time periods. These are referred to as catastrophic events because of the extensive damage that is caused and the unpredictable nature of the event.

7. Slope processes.

The term “slope processes” encompasses a wide range of land-sea interactions which eventually result in the collapse, slippage, or topple of coastal cliff blocks. These processes involve on the one hand terrestrial processes such as rainfall and water

8. Vertical land movements (compaction)

Vertical land movement – including isostatic rebound, tectonic movement, or sediment settlement – may have either a positive or negative impact on coastline evolution. If most of northern Europe has benefited in the past from a land uplift (e.g. Baltic sea, Ireland, Northern UK)

9. Sea Level Rise

Sea level has risen about 40 cm in the past century and is projected to rise another 60 cm in the next century. Sea level has risen nearly 110 meters since the last ice age. Due to global warming, average rise of sea level is of the order of 1.5 to 10 mm per year. It has been observed that sea level rise of 1 mm per year could cause a recession of shoreline in the order of about 0.5 m per year.

ANTHROPOGENIC CAUSES

Human influence, particularly urbanisation and economic activities, in the coastal zone has turned coastal erosion from a natural phenomenon into a problem of growing intensity. Anthropological effects that trigger beach erosion are: construction of artificial structures, mining of beach sand, offshore dredging, or building of dams or rivers. Human intervention can alter these natural processes through the following actions**:**

- Dredging of tidal entrances
- Construction of harbours in near shore
- Construction of groins and jetties
- River water regulation works
- Hardening of shorelines with seawalls or revetments
- Construction of sediment-trapping upland dams
- Ceach nourishment
- Destruction of mangroves and other natural buffers
- Mining or water extraction

CHAPTER:-3 FACTORS THAT INFLUENCING THE COAST

- **Sand sources and sinks:** Beach material can vary in size from very fine sand (0.005 cm) to small pebbles (1.5 cm). Sand is brought to the shore from the continental shelf, rivers and eroding cliffs, sand dunes, as well as from other beaches through the action of long shore currents.
- Sinks for the sand include continental shelf accumulations of sand that are in water at depths greater than 30 meters (100 feet) and sand that is carried into deep ocean canyons. This sand is below the "reach" of the waves and cannot be moved and returned to the beach. In addition, sand that is blown inland is also lost from the beach.
- **Rising sea level: To** assess the scope of changes in sea level, scientists have developed methods to interpret the geologic record left by prehistoric events.

OTHER FACTORS THAT INFLUENCE SEA LEVEL INCLUDE:

- Size of polar ice caps and valley glaciers which change the amount of water available for oceans and seas
- Expansion and contraction of ocean volume due to changes resulting from plate tectonics
- Rising and sinking of coasts due to plate tectonic changes
- Warming of ocean water which leads to increased volume for the same amount of water
- Increase in total water available in the ocean due to human activities which release groundwater and make it part of the surface water system

SOME BEACH EROSION FACTORS:

- Effects of human impact, such as construction of artificial structures, mining of beach sand, offshore dredging, or building of dams or rivers.
- Loss of sediment offshore, onshore, alongshore and by attrition.
- Reduction in sediment supply due to deceleration cliff erosion.
- Reduction in sediment supply from the sea floor.
- Increased storminess in coastal areas or changes in angle of

wave
approach.

- Increase in beach saturation due to a higher water table or increased
  Precipitation.

CHAPTER:- 4 TYPES OF EROSION & EROSION PROCESS

Cut and Fill Erosion

Cut and fill erosion occurs when loose sediment--sand, gravel, and the like--are swept about by actions of the sea. Human activity can influence the rate of coastal erosion

Permanent Erosion

Permanent erosion occurs along rocky, hard coasts. In these locations the material is not replaced. Four processes cause permanent erosion waves tossing beach material at the base of a cliff, hydraulic action when waves retreat pulling materials out of the cracks in cliffs, rocks and pebbles broken up by wave action and acids in sea water causing erosion in some types of rocky cliffs.

Headland Erosion

Headland erosion is a special type of erosion. A headland is made of hard rock reaching out into the sea causing areas of alternating hard and soft rock. Erosion of the soft rock causes bays to form alongside the headland.

EROSION PROCESS

Waves start by attacking the main points of weakness in the rock such as the joints and any faults that there may be in the rock. The point of weakness is increased until it becomes a cave. The waves continue to attack the cave, which finally results in an arch being formed through the headland. The arch is then attacked by both coastal and sub - aerial erosion and finally the roof of the arch falls into the sea. This then leaves behind a stack, which is then slowly eroded down to become a stump.

Low outcrop of rock formed by the erosion of a coastal stack. Unlike a stack, which is exposed at all times, a stump is exposed only at low tide. Eventually it is worn away completely.

The easiest way of describing the overall effect of coastal erosion is that, if left unchecked, all the coastlines would be, low wave cut platforms. Most erosion takes place around high tide and will be carried out in one of three ways.

The first is Hydraulic erosion which has an effect of a small explosive charge. The sudden impact of a wave on to the cliff face forces air into any cracks that they might be or along the bedding planes, compressing the air briefly then releasing the pressure. The changes in pressure causes the cracks to widen and go further into the cliff, material breaks away and washed out of the cliff by following waves. The debris is washed against the base of the cliff in a process known as corrosion and acts in a grinding motion. In this process, not only does erosion take place at the foot of the cliff but the sediment itself is worn down and rounded in a process known as attrition.

The third type of erosion is chemical, particularly in limestone and chalk cliffs where chemicals within the sea water attack the rocks eroding the weaker sections and gradually causing the cliff to collapse.

Coastal lands may experience long-term erosion under some conditions. For instance, if sea level is rising, the beach may eventually migrate landward or drown. This causes coastal land behind the beach to erode. Also, if the amount of sand from the seaward side is

reduced, a beach will erode the land behind it to maintain a constant sand supply. This creates a condition called coastal erosion.

❖ EFFECTS OF EROSION

- There are two obvious and noticeable effects of beach erosion:

1. The loss of previously available beach area, and
2. The damage to beach property.

❖ EROSION RATE

Erosion rates vary over time and space. These variations occur in response to many factors. Among them are soil slope and composition

- Erodibility of material
- Nearshore seabed shoals and slopes
- Storm wave energy and duration
- Precipitation
- Ground water and soil conditions
- Ice cover
- Shoreline orientation
- Beach composition, width and slope
- Shore protection structures

It has been observed that sea level rise of 1 mm per year could cause a recession of shoreline in the order of about 0.5 m per year.

CHAPTER:- 5 COSTAL EROSION AT DUMAS BEACH

FIG:-1 Location Of Dumas in Indian map

- The Indian coastline is about 7517 km, about 5423 km along the mainland and2094 km the Andaman and Nicobar, and Lakshadweep Islands.
- Gujarat is having 1600 Km long Coastal line. According to newly launched shoreline maps of Gujarat prepared by the Society of Integrated Coastal Management (SICOM) Actual erosion is - 704 km (44 %)

  High erosion – 80 km (5 %) - shoreline moves towards the land more than 25 meters per year

  Medium erosion - 160 km (10 %) - shoreline moves 10-25 m towards the land per year

  Less erosion – 464 km (29 %) - shoreline moves less than 10 m towards the land per year
- Dumas is located at a distance of 18 km from Surat. Total coast line along the Surat is 10km. The Geographical coordinates of Dumas is Latitude 21 06' 00' N, Longitude 72 42' 00'E.

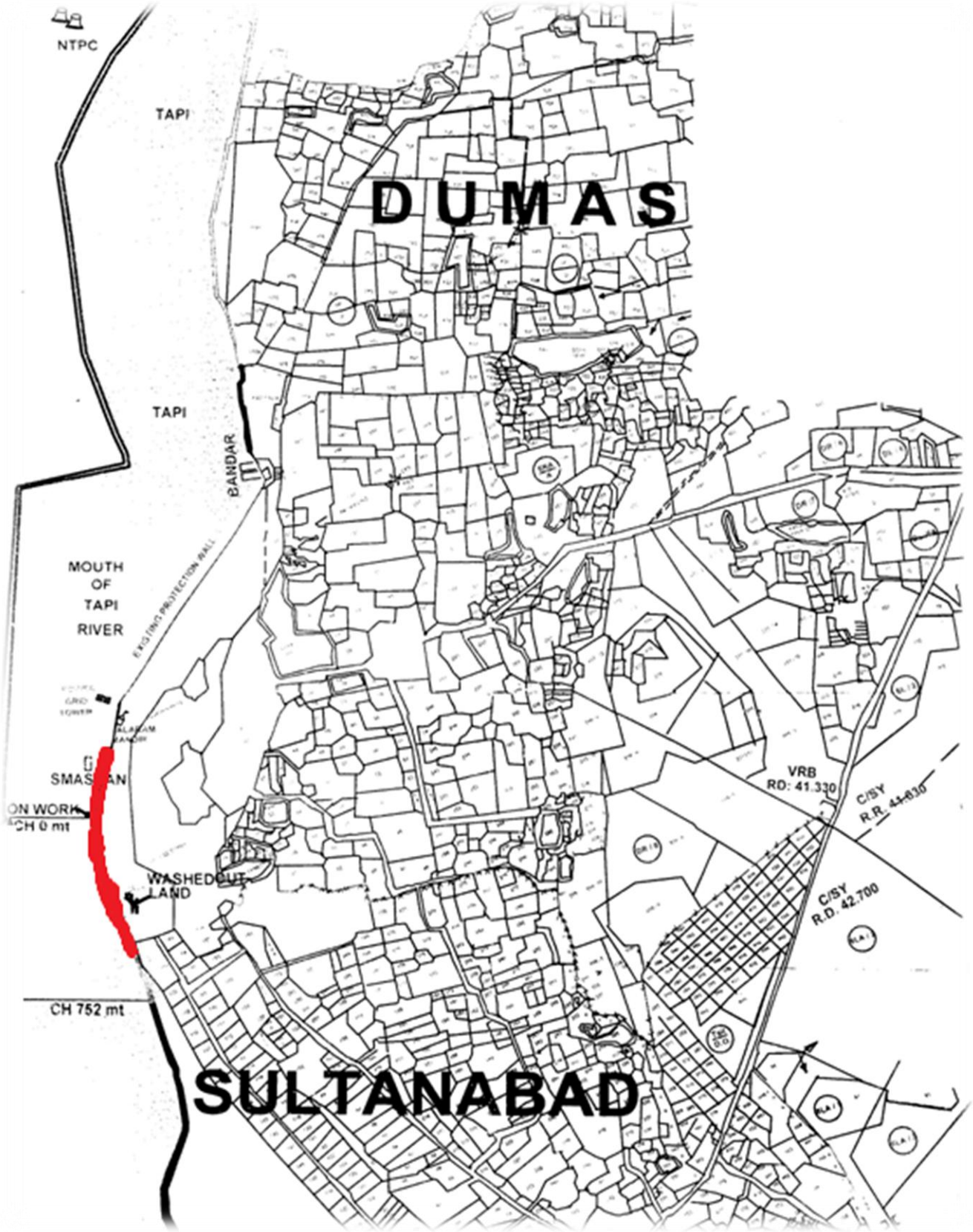


FIG:-2 critical portion of Erosion

In this image, Red line shows the critical portion of Erosion

FIG:-3 Proposed site

- This is the most critical section at Dumas beach by erosion.
- In this image the Arabian coast, Dumas beach, Forest land, Houses at beach, power transmission line etc.

FIG:-4 Dumas beach erosion

- This is the image of Dumas beach erosion.

❖ COASTAL PROTECTION RELATED SURVEY

- Rate of erosion = 0.65 m/ year
- Slope of bed = 1:60 V:H
- Length of land to be Protected = 1957.0m
- High tide level = 8.5m from chart Datum
- Tide Level in Storm Condition: 10.0m from chart Datum
- H.F.L in 2006 during flood = 3.76m from G.L
- Depth water in bore well = 1.5m and 5.5m from G.L
- Ground Water level = 4.5m in Winter

➢ Protection length for this matter is 1957m. But in that 410m is most critical length.

➢ By tachometry survey surveyed 590m length including critical length.

Year	R.L.
2001	10
2003	9.32
2005	8.15
2007	7.05
2009	6.315
2011	5.5

TABEL NO:- 1

SURVEY RELATED TO SOIL & SITE

FIG:-5 SOIL OF BEACH

- Type of soil = Intertidal/muddy coast
- Type of soil eroded = Sand
- Specific Gravity of soil = 2.64 at the depth of 15cm below G.L
- Soil bearing capacity = 7 T/m^2 at the depth 4.0m from G.L

➢ This survey is related to erosion material, density of soil, load bearing capacity, foundation of structure etc

❖ **Related to climate survey:**

- Direction of wind in:
  - Winter =North-East to South-West
  - Summer & Monsoon = South-West to North-East
- Basic Wind Speed = 44 m/ sec (Acc. to I.S 875:1987 part-iii)
- Temperature Range = 10°C in Winter
  40.5°C Summer

FIG:-6 RUBBLE WALL

This wall is situated at the beach. This wall was constructed up to length of 200m.But it is noticeable that, the wall was not constructed in critical length of erosion. It is also noticeable that, this wall was constructed by small rubbles. So it doesn’t work effectively during high tide and rolls down.

.

FIG:- 7 EROTED PIERS

In this image, we can see high tension line, which foundations have been opened.These foundations have been opened due to the erosion of material. Due to high rate erosion, all the piers have been newly constructed.

This is the newly constructed pier of power transmission line. But due to high rate of erosion we can see the open ground beams of new piers as well as pile in the above image.

FIG:-8 PIERS

FIG:-9 EROTED WALL

This wall was constructed in 1952.But now this wall is in damaged condition. The purpose of constructing this wall was to decrease rate of erosion and to protect the houses and properties along the beach. The reason for damage condition of this wall is its less height and thickness, high tides, more intensity of wave, small size of rubble etc.

FIG:-10 FOUNDATION PROTECTION

In this image we can see the house which is situated on beach, which comes in critical erosion portion. Due to high erosion there is a possibility of foundation exposure.

We can see in the image that the temporary protection work has been done to prevent foundation exposure.

This is the Dumas beach image in which, we can the houses which are affected by tidal force of sea water. The foundation of this house has been protected by the small rubble by the owner of the house.

FIG:-11 FOUNDATION PROTECTION BY RUBBLE

FIG:-12 RUBBLE WALL

In this picture, we can see the wall rubble. This wall was constructed by "NARAMADA JALSAMPATTI PANI PURAVATHA AND KALPASAR DEPARTMENT" rubble of 1.0 tone was placed there. Due to the less weight and small size of rubble, this structure has been not worked effectively. During the high tide, this rubble fall down and roll down.

FIG:-13 RUBBLE

In this image, we can see that the small size of rubble which is not work effectively and rolled down and some distance from the temporary protection wall. This rubble is rolled down due to the less size, high intensity of tide, not proper bond between rubble etc.

CHAPTER:- 6 TYPES OF COAST

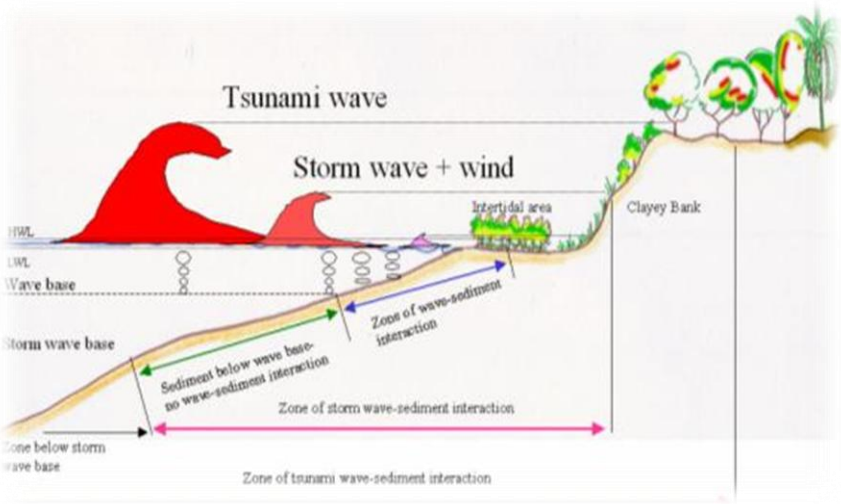


FIG:-14 CLIFF COST

Cliff coast: Cliff coast can be classified as "hard" coast as it was formed from resistant materials such as sedimentary or volcanic rocks. This type of coast typically has a short shore platform that is usually exposed during low tide.

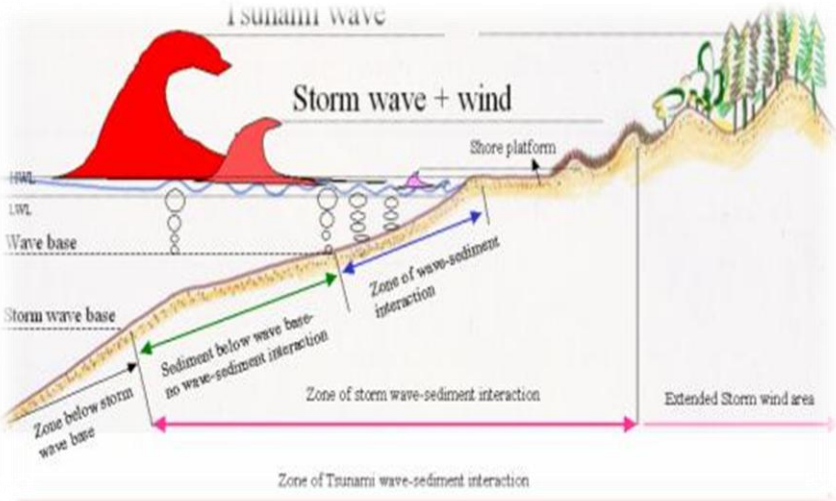


FIG:-15 CLAYEY BANK COAST

Clayey bank coast: This type of coast can be classified as a "semi-hard" coast, consisting of cohesive soils; it is common on estuarine coastlines and often has nearly vertical banks ranging from one to five meters in height.

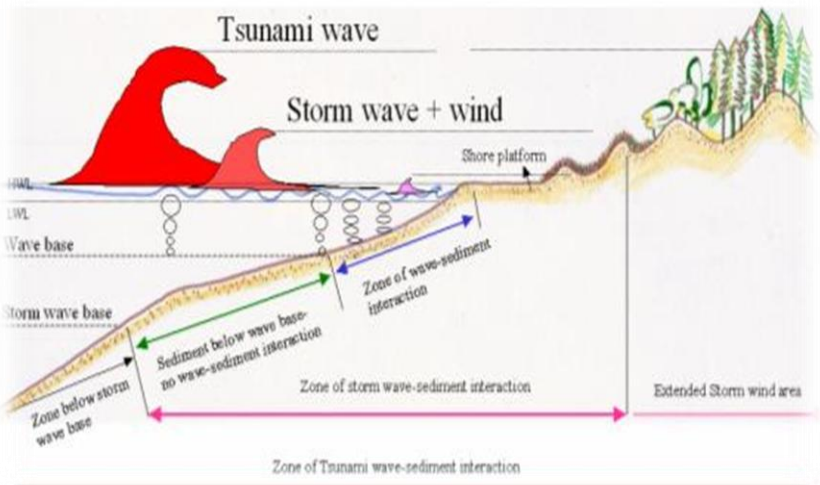


FIG:- 16 SAND DUNE COAST

Sand dune coast: This type of coast consists of unconsolidated material, mainly sand, some pebbles and shells; it can be classified as a soft coast. It has a gentle seaward slope — known as dissipative beaches that have broad fine sand and gradually steep slopes at the backshore/fore dunes.

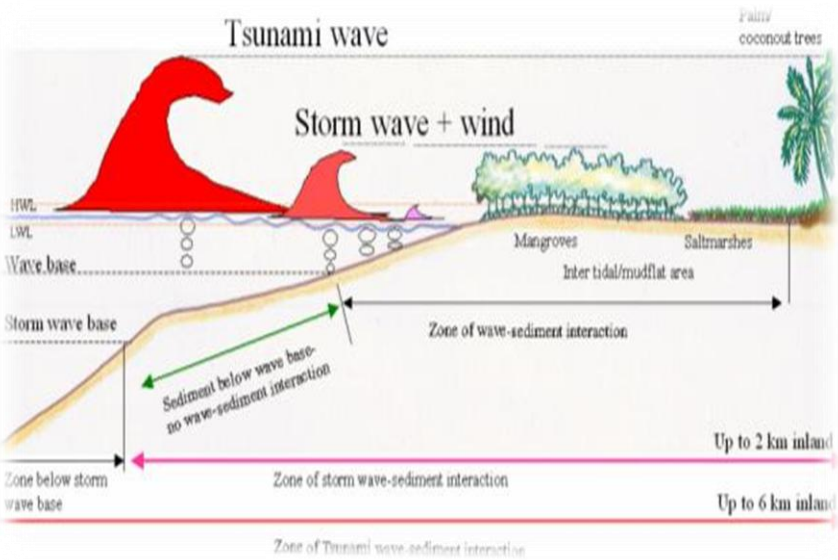


FIG:-17 MUDDY COST

Intertidal/muddy coast: This type of coast is characterized by fine-grained sedimentary deposits, predominantly silt and clay that come from rivers; it can be classified as a “soft” coast. It has a broad gentle seaward slope, known as an intertidal mud flat where mangrove forest, salt marshes, shrubs and other trees are found. Most erosion is generated by river damming that reduces sediment

supply, diminishes vegetation cover and exposes vegetation roots by lowering the mud flat that leads to their final collapse.

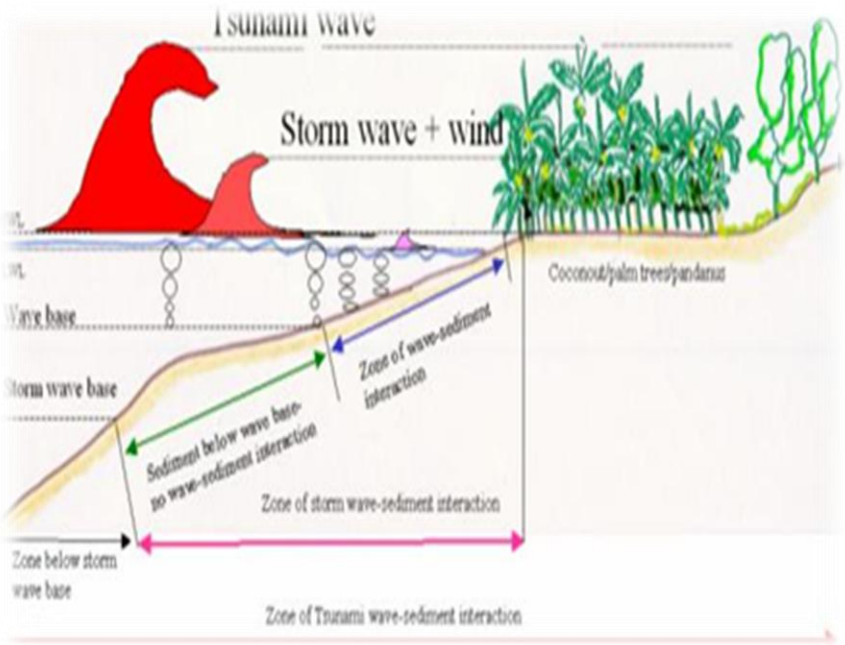


FIG:-18 SNADY COAST

Sandy coast: This type of coast consists of unconsolidated material — mainly sand from rivers and eroded headlands, broken coral branches (coralline sand) and shells from the fringing reefs. It can be classified as a soft coast with reef protection offshore.

CHAPTER:- 7 PREVENTION OF THE COASTAL EROSION

By constructing any structure or other process, reducing the rate of erosion is called erosion prevention.

FIG:-19 Erosion prevention

❖ What is Coastal Protection?

- Coastal protection is protection of beach and village or city to sea water wave and prevents damages to erosion.

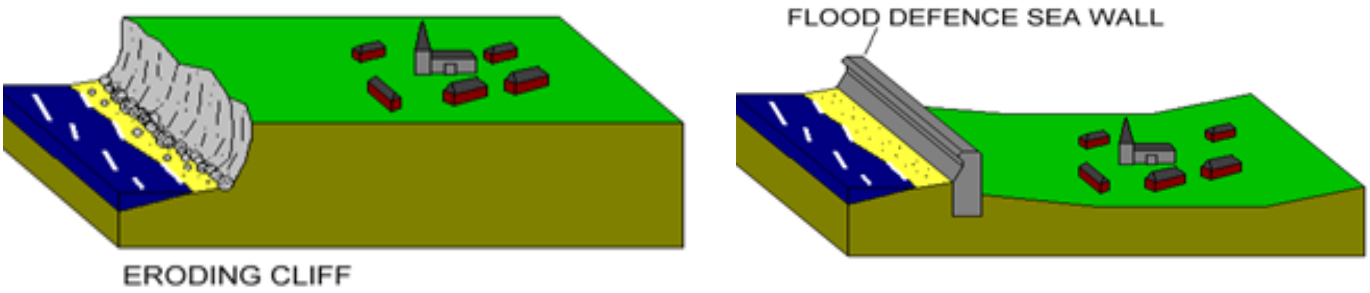


FIG:- 20 ERODING CLIF

- Coastal protection structure is structure make to protection of beach and village or city and prevents damages to sea water wave.
- Main purpose to make coastal protection structure to protection of beach and village or city to sea water wave and prevents damages.

- Why coastal protection is required?
  - Protect harbors (and inlets that are important commercial and military navigation links.
  - Protect shore-based infrastructure.
  - Provide beach and shoreline stability control.
  - Stabilize navigation channels.
  - Protect navigation, coastal communities, roadways, bridges, etc.
  - Provide flood protection.

CHAPTER:-8 VARIOUS COASTAL SHORE PROTECTION STRUCTURES AND TECHNIQUES

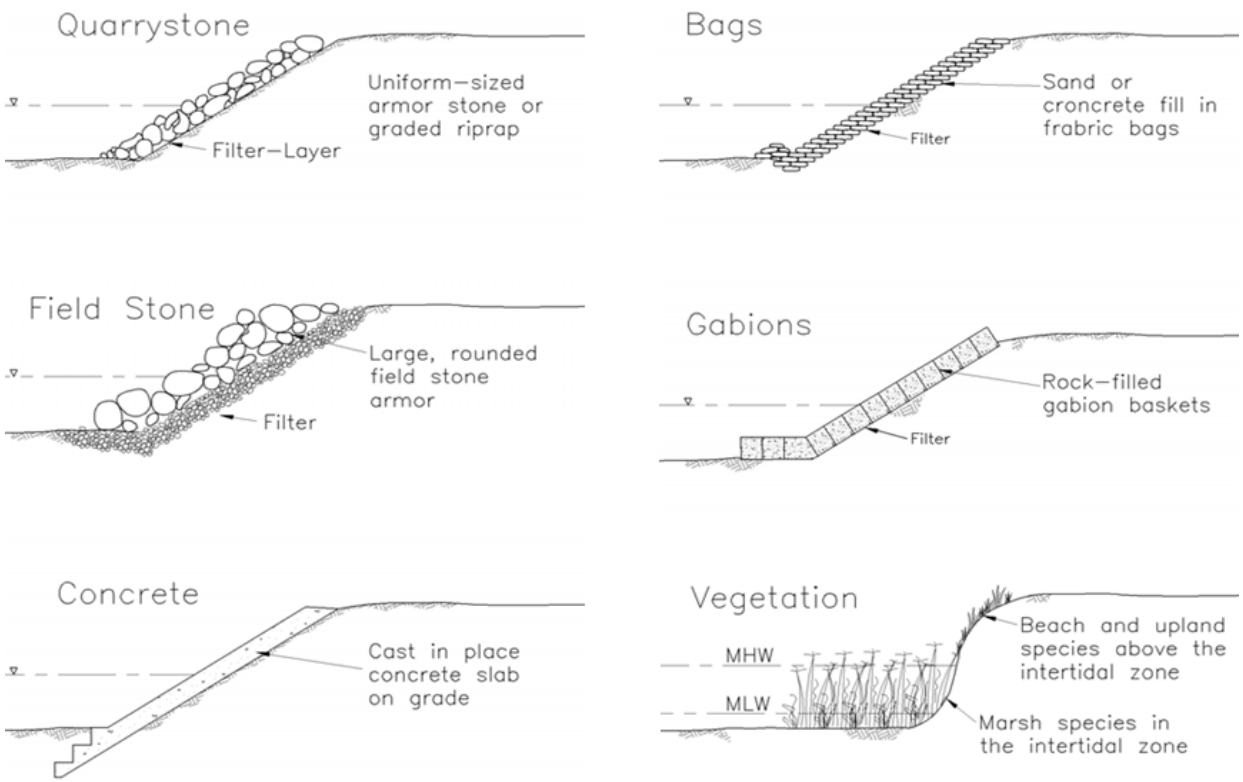
STRUCTURAL METHODS FOR COASTAL SHORE PROTECTION

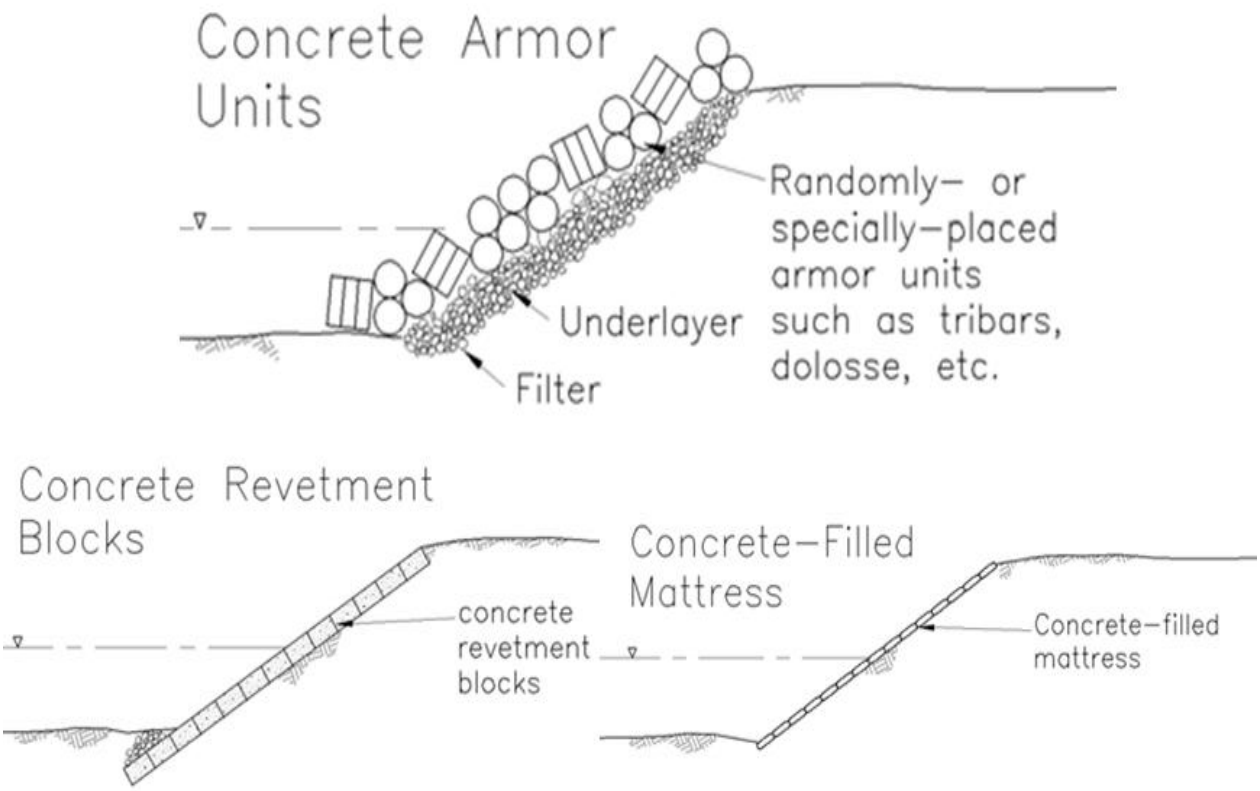
FIG:-21 SEA WALL

Seawalls: Seawalls are the most common form of shore protection structure and also the least effective. Unlike a natural beach that gently dissipates wave energy as a breaking wave rolls up the shore, the vertical face of a seawall will reflect and concentrate the energy of a breaking wave on the beach directly in front of the wall. This concentrated wave energy can rapidly erode and scour the sands in front of the wall, eventually undermining the wall's foundation.

FIG:-22 REVETMENT

Revetments: Revetments are a cover or facing of erosion resistant material placed directly on an existing slope, embankment or dike to protect the area from wave sand and strong currents. Revetment retains on soil. The slope of a revetment will typically have a vertical rise to horizontal run ratio between 1:4 and 1:2. In no case should a revetment be steeper than 1:1.5.





Dikes and Levees: Dikes are typically earth structures (dams) that keep elevated water levels from flooding interior lowlands.And in levee deep excavation is to be done and protect near shore population.

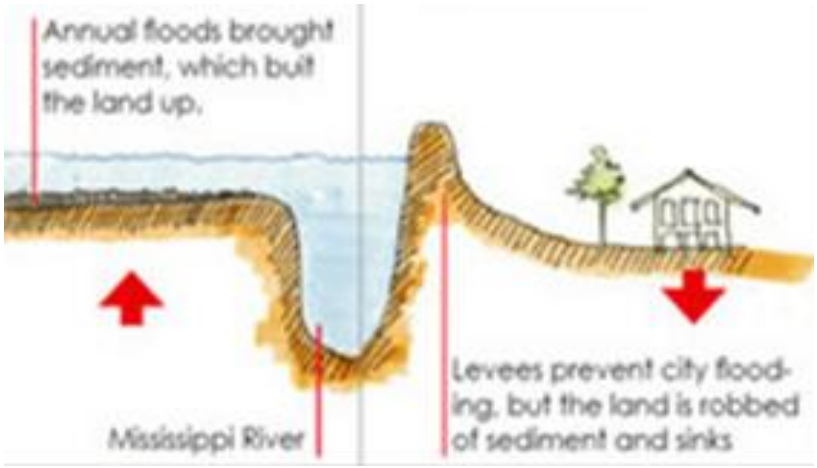


FIG:-23 DIKES & LEVEES

Breakwaters: Breakwaters are generally shore-parallel structures that reduce the amount of wave energy reaching the protected area.

FIG:- 24 BREAK WATER

Groyns: Groins are the oldest and most common shore-connected, beach stabilization structure.

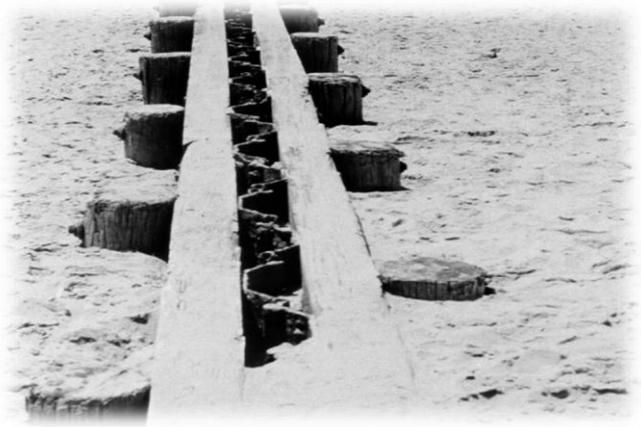


FIG:- 25 GRYON

Sills/Perched Beaches: Construction of a low retaining sill to trap sand results in what is known as a "perched beach," one that is elevated above its original level.

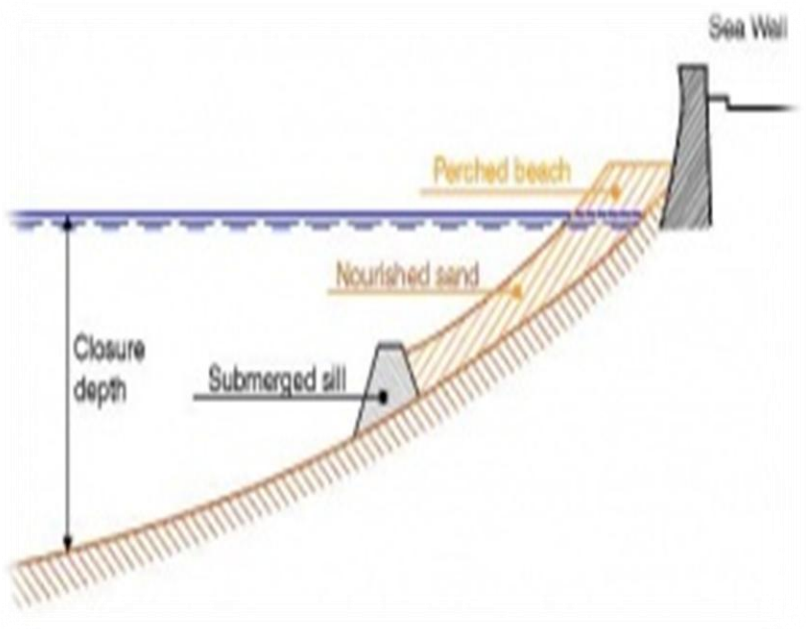


FIG:-26 SILL BEACH

Tetrapod: Sogreah's predecessor, the Laboratoire Dauphinoisd'Hydraulique, was the inventor of the Tetrapod block in 1950-53The tetra pod is no longer entirely a new-comer in the field of marine construction. The sea water intake of the RochesNoires thermic power station at Casablanca, North Africa, the first structure for which tetra pods were used, was constructed nearly four years ago. There are obviously several ways in which tetrapods may be used for building new structures, or for strengthening and repairing existing ones. The Tetrapode was used all over the world, especially in Japan. The Tetrapod was used in a double layer with a unit weight of up to around 50 tons.

FIG:-27 TETRAPODE

Accropode: Blocks are man-made unreinforced concrete objects designed to resist the action of waves on breakwaters and coastal structures. The Accropode is a single-layer artificial armour unit developed by Sogreah in 1981. Accropode concrete armour units are applied in a single layer. It is the most widely used single layer interlocking concrete block in coastal structures. This block was the first interlocking monolithic concrete block used for breakwaters. It enabled structures to be protected with much larger blocks than before, when only natural rock was used (with a unit weight of up to around 10 tons) or concrete cubes.

FIG:-28 ACCROPODE

Stilling wave basin:-

- In order to limit the overtopping discharge the concept of a stilling wave basin is used.
- A stilling wave basin (SWB) is made up of a vertical seaward wall, a basin and a 2nd landward wall.
- Waves hitting the seaward wall are projected upward and “drop dead” in the basin and lose their energy. Since the seaward wall is actually a double row of shifted walls, the evacuation of the overtopped water is possible.
- In case of large overtopping, the water runs back and forth the basin between the seaward and the landward wall, meanwhile losing its energy. The remaining energy is insufficient to overtop the landward wall. An important parameter in this SWB is the blocking coefficient, which is the ratio between the open and the closed part of both rows of shifted walls.

NON-STRUCTURAL METHODS FOR COASTAL SHORE PROTECTION

Vegetation Planting - Vegetation is an effective and inexpensive way to stabilize dunes and protect marshes.

Groundwater Drainage: Groundwater drainage or bluff dewatering is a common practice used to rapidly drain ground and surface waters away from a bluff in order to eliminate or reduce bluff failures initiated by groundwater seepage.

Beach Nourishment: Beach nourishment is the introduction of material along a shoreline to supplement the natural littoral drift.

Sand Bypassing: Sand bypassing is the hydraulic or mechanical movement of sand, from an area of accretion to a down drift area of erosion, across a barrier to natural sand transport.

FIG:-29 SAND BY PASSING

Flood Proofing: One of the most common flood proofing measures is the elevation of homes.

FIG:-30 FLOOD PROFFING

Zoning: Zoning measures involve the implementation and enforcement of planning and zoning by-laws to control development in flood and erosion hazard zones.

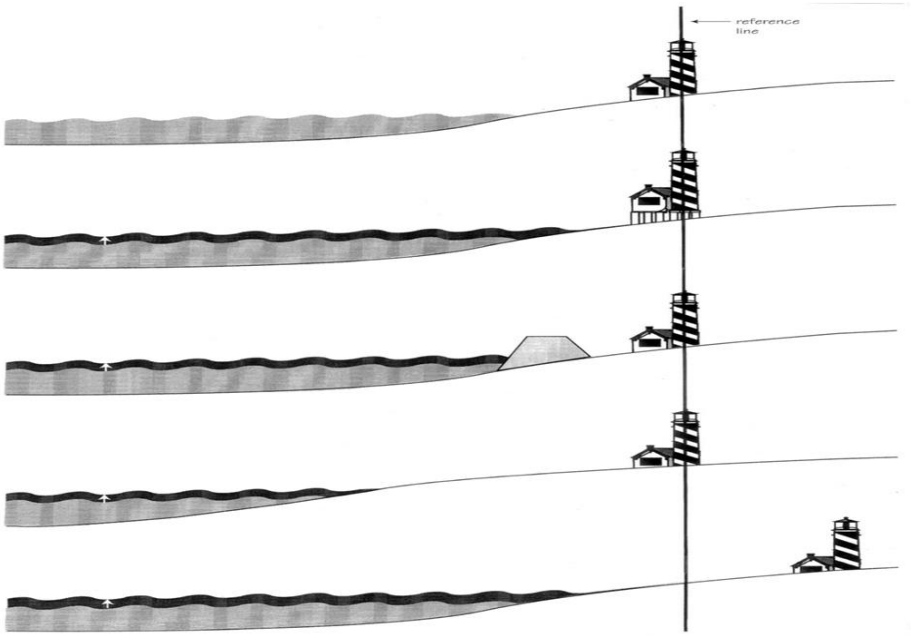


FIG:- 31 ZONING

Retreat: In some cases, it may be less expensive to relocate endangered structures than to invest in large scale shore protection

FIG:-32 RETREAT

Does Nothing: The no action or do nothing approach is commonly used by engineers to help evaluate different courses of action

BENEFITS DATA	
TOTAL PROTECTION LENGTH	1957m
CRITICAL PROTECTION LENGTH	410m
TOTAL BENIFICIAL FAMILIES	AROUND 400 no.
TOTAL BENIFICIAL PEOPLE	AROUND 30,000 PEOPLE
BENIFICIAL FAMILIES AT BEACH	AROUND 35 to 40 no.
BENIFICIAL PEOPLE AT BEACH	AROUND 300 to 350 no.
BENIFICIAL NUMBER OF VILLAGES	3 no.
BENIFICIAL AREA	2700 hector

TABLE:- 2

COASTAL EROSION IN GUJARAT

Along Gujarat coast**,** shoreline erosion is observed at Ghoga, Bhagwa, Dumas, Kaniar, Kolak and Umbergaon, and sediment deposition leading to the formation of sand spits at the estuarine mouths of the Tapti, Narmada, Dhadar, Mahi, Sabarmati, Kim.

State	Sandy Beach	Rocky Coast	Muddy Coast	Marshy Coast	Total length in (Km)	Length of Coast Affected By Erosion in (Km)
Gujarat	28	21	29	22	1214.7	36.4

- According to naval Hydraulic Office

At Surat (Dumas) Erosion is at Critical Stage now there are 2000 People (400 Families) are affected by erosion

CONCLUSION

- The small seawalls and other coastal protection structures which have been constructed on the village shoreline are largely ineffective as protection structures, but are believed to have partially caused and exacerbated the erosion problems.
- 2500 hectare land will get benefit against salinity ingress and will be protected.
- Due to ineffectiveness of other coastal protection structures like Entrapped Rubble in geo textile, Rubble wall etc…. . The sea wall that we have designed is more effective and durable as compared to the rubble with X-block armour unit. Also by carrying out costing of rubble with X-block armour unit is less expensive than other alternate structures.
- So from this we can decrease the Erosion rate and can save the residential lands, cultivable land, valuable properties located on shore.
- After the completion of protection work Valuable forest land will be preserved the Surat Airport is also being developed in near by vicinity which may enhance land development project activities.

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