5.2 COASTAL PROTECTION STRUCTURES

The main and prime reason to construct coastal protection structures is to protect harbor and other infrastructures from sea wave effects such as erosion. Not only are they useful for changing current and sand movements but also to redirect rivers and streams.

Types of Coastal Protection Structures

There are various structures that considered or used as coastal protection structures for example groins, seawalls, bulkheads, break waters, and jetties.
Description and advantages of these structures will be discussed in this article.

1. Seawalls

This large coastal protection structures can be built using different types of construction materials such as rubble mound, granite masonry, or reinforced concrete. Seawalls are commonly built and run along shoreline to prevent coastal structures and areas from the detrimental influence of ocean wave actions and flooding which are driven by storms. There are various arrangements or configurations that might be employed includes curved face seawall, stepped face seawall, rubble mound seawall. These forms will be explained in the following sections:

a- **Curved face seawall**

Curved face seawall is designed to withstand high wave action effects. Foundation materials loss, which might be caused by scouring waves and/or leaching from over topping water or storm drainage underneath the wall, is avoided by employing sheet pile cut off wall. Moreover, the toe of the curved face seawall is built from large stones to decrease scouring.

b- **Stepped face seawall**

Stepped face seawall is used to oppose or resist moderate wave actions. Reinforced concrete sheet piles with tongue- and- groove joints are employed to construction this type of seawall. The spaces which is created between piles is either filled with grout in order make sand proof cut off wall or install geotextile fiber at the back of the sheet pile to form sand tight barrier. Applying geotextile is

beneficial because it allows seeping water through and consequently prevents accumulating hydrostatic pressure.

c- **Rubble Mound Seawalls**

Design and construction this type of seawall configuration might be easier and cheaper. It can resist substantially strong wave actions. Despite scouring of the front beach, quarry stone comprising the seawall could be readjusted and settled without causing structural failure.

2. Bulkheads

Bulkheads can be constructed by concrete, steel, or timber. There two major types which are gravity structures and anchored sheet pile walls. The bulkheads might not have exposed to substantially strong wave actions and its main purpose is to retain earth but scouring at the base of the structure should be considered by the designer. Cellular sheet pile bulkheads are employed for situations where rock is close to the surface and enough penetration cannot be achieved for the anchored bulkhead type. Moreover, sheet pile should be sufficiently reinforced for bending moment, soil conditions, hydrostatic pressures, and support points.

3. Groins

Groins are shore protection structures that decrease erosion affects to the shoreline by changing offshore current and wave patterns. Groins can be built by materials such as concrete, stone, steel, or timber and are categorized depend on length, height, and permeability. Furthermore, groins are commonly constructed vertically to the shoreline and it can either impermeable or permeable.

4. Jetties

Jetties are usually built of materials such as concrete, steel, stone, timber, and occasionally asphalt used as binder. This structure is constructed at river estuary or harbor entrance and extended into deeper water to oppose forming of sandbars and limit currents.

5. Breakwaters

There are three major types of breakwaters namely: offshore, shoreconnected, and rubble mound. Not only are they used to protect shore area, anchorage, harbor from wave actions but also to create secure environment for mooring, operating, and handling ships.

6. RIP-RAP

Rip-rap is a single-layer shore protection structure, which protects the reclaimed land from erosion, wave, current, and tide actions, and leakage of material. It is usually constructed in a less dynamic environment with a shallow seabed. Rip-rap usually has a single stable slope of 1:3 to 1:7 and some graded stones are generally provided between the armor stones and the sand fill. Nowadays the thickness and layers of graded stones have been reduced and a geofabric layer is provided instead. The size of the armor stones is selected based on the expected force of the waves and currents.

7. RETAINING ROCK BUND

A retaining rock bund is usually provided where the seabed is deep and has more dynamic waves and currents. A more systematic layering of graded stones is required for a retaining rock bund. Larger armor stones are also required for protection against the greater dynamic forces expected in the open sea. Rocks used for shore protection works are generally granite or sandstone. Granite is preferred to sandstone. To control the quality of stones, some specifications are deemed necessary. Since a retaining rock bund is usually constructed for a deep seabed, sometimes several berms are required to stabilize the structure.

8. BREAKWATER

A breakwater is usually constructed to break the waves which are directed towards the reclamation. Such structures are long arms protruding from the reclaimed land to protect the land from strong waves and currents. The structure is usually constructed with armor stones. The whole structure has either a rock or sand core with a shell of armor stones depending upon the force of the waves and

currents. The length of the shore protection is generally determined based on the hydraulic model.

9. HEADLAND

Headlands are an alternative for breaking the waves and currents. Headlands are normally constructed perpendicular to the wave direction. Such headlands are provided when beaches are required to be formed at the edge of the reclaimed land. When a headland is provided, tabular shaped beaches are naturally formed in the process of coastal action. When headlands are required, the shore protection structure is constructed only to a certain level, usually under water. Headlands are constructed at the crest of the lower bund and beaches with gentle slopes are formed behind the headlands.

10. VERTICAL WALL

Vertical walls are constructed when there is a constraint in area, such as a limited navigation channel or a deep seabed. When reclamation is carried out for a seaport and jetty, vertical walls are deemed necessary since sufficient draft is required for ship berthing. Several types of vertical walls are described in the following sections.

Cantilever, counterfort and gravity walls:

Cantilever walls are suitable for shallow seabed conditions. These walls are usually placed before the filling at the periphery area. For cantilever walls, sufficient weep holes are required in order to maintain the groundwater level behind the wall to be the same as the sea level in front. Insufficient weep holes would result in poor drainage from the groundwater flow and the wall will have to carry unnecessary additional water pressure. In order to improve the drainage, vertical drainage is usually provided behind the wall. Vertical drainage is formed with geotextile at the drainage core.

11. Sheet pile wall

A sheet pile wall is an alternative type of retaining wall generally used for deep and soft seabed conditions. For a soft seabed condition, sufficient penetration

depth is required for sheet pile installation. The sheet piles are usually supported by raker pipe piles at reasonable intervals. Raker piles give support from the passive side and these piles are usually strengthened again by toe pins.

On the active side the piles are usually pulled back by internal anchors. A typical design of a retaining wall, with raker piles, toe pin, and anchor.

Retaining walls constructed with sheet piles are necessary as protection from corrosion especially when the structure is constructed in a marine environment. Several coats of paint are necessary to protect them from the corrosive action. On top of the coating, catholic protection is usually applied to counteract the corrosion action.

12. Caisson

A caisson is an alternative vertical wall structure. This type of structure is usually used in reclamation for port and harbor construction. Caissons are either circular or square in shape. Inside the caisson are several sub-divided cells and these hollow cells are filled with granular material after the caisson is positioned at predetermined locations. Whenever the foundation is not sufficiently strong, either a sand key, a sand blanket, a rock key, or a rock blanket is provided below the caisson.

13. Box gabion

At some locations where the underlying formation is firm, simple box gabions are used in the retaining structure.

14. QUAY WALL

A quay wall is usually constructed for a port facility. This type of wall is either of masonry or a rock structure. A berthing facility can be constructed in front of a rock structure using pile foundation.

15. COMPOSITE RETAINING STRUCTURES

There are some retaining structures that are constructed with a combination of methods in order to strengthen the foundation or in order to achieve a stable retaining structure. Some retaining structures are constructed after the soft foundation soil has been improved. Some quay wall structures can be constructed

with sand piles behind the wall, which can carry vertical and horizontal loads. There are several combinations of structures to form a wharf or berthing facility depending on the nature of the foundation soil.