AN INTRODUCTION TO ONSHORE STRUCTURES' CONSTRUCTION

Kabir Sadeghi[1], Dania AL-Othman[2]

[1]Professor, Faculty of Civil and Environment Engineering, Near East University, Nicosia, North Cyprus, Via Mersin 10, TURKEY;
[2]Ph.D. Candidate, Faculty of Civil and Environment Engineering, Near East University, Nicosia, North Cyprus, Via Mersin 10, TURKEY.

[1]kabir.sadeghi@neu.edu.tr, [2]dania_kittaneh1992@hotmail.com

ABSTRACT

Numerous shorelines are endangered by erosions which instigate cliffs to retreat, beach materials to be lost, and other coastlines being at risk of flooding. For prevention of oceanfront erosion and flooding, the coastal structures have been constructed within the coastal protection schemes. The coastal structures are also targeted to protect the harbor basins and entrances from waves, in addition to maintaining the navigation networks at bays. To protect the coasts, various techniques, have been implemented over time. This paper appropriately classifies the physical progressions which trigger erosions, as well as providing a synopsis of the numerous forms of coastal structures; including seawalls, bulkheads, groins, breakwaters, jetties, and revetments. The main aim of this paper is to deliver an overall understanding and summary of the various forms as well as the design and construction of various seashore structures.

Keywords: Onshore structure, shore protection, seawall, breakwater, groin, revetment.

1. INTRODUCTION

Coastal structures are utilized in coastal protection schemes, which are targeted at averting coastal erosion and flooding of the surrounding areas. Moreover, such structures are able to protect mooring basins and entries from the waves and stabilize the navigation stations at inlets. These structures are constructed for erosion management, routing, beach nourishment, and some allow access to the seawaters. Coastal structures are anything man-made located in the coastal zones and are essentially constructed to protect the shorelines. There are numerous structures which are utilized for the protection of the coasts. They can be classified into three types:

1- Shore protection structures,
2- Berthing and mooring ships structures, and
3- Marine and offshore industry structures.

In this paper, various structures' types including a brief description and advantages of each structure are reviewed as follows.

2. DIFFERENT TYPES OF COASTAL PROTECTION STRUCTURES

2.1 Shore Protection Structures

Coastal protection structures are categorized into many types; seawalls, revetments, groins, and ripraps. This type of structural form is constructed to endure waves, scour and overtopping. The wave makes infrastructure damage, as well as removes the materials behind the structures which leads to the failure of the structure system.

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2.1.1 Seawalls

Generally, seawalls are structures that are located onshore and are parallel to the coast. The main function of such structures is to prevent the erosion of coastal lands as well as the flooding of the built infrastructure beyond the coast, which can occur as a result of intense storms and sea surfs. Seawalls are large coastal protection structures and can be manufactured utilizing various forms of construction materials including reinforced concrete, precast or cast in place concrete blocks or modules, gabions or stone-filled cribs. These structures are constructed vertically, parallel with flat, stepped, or curved surface. The seawalls can be built in several compositions that may be implemented including the stepped face seawall and the curved face seawall. They are designed through the implementation of reinforced concrete sheet piles with tongue-and-groove joints within the structure. The stepped face seawall is composed to resist mild wave movements. This design form confines the wave runup and overtopping. Usually, such structures are slightly smaller in size than curved-face seawalls. Contrarily, curved face seawalls are constructed to acclimatize the effects of high wave movements. The waves are concentrated against the concrete walls in which they are reflected back to the sea. In most cases, in order to resist and redirect the large wave forces, a massive structure with an appropriate foundation and strong toe protection is required. In Figure 1, the typical types of seawall are illustrated.

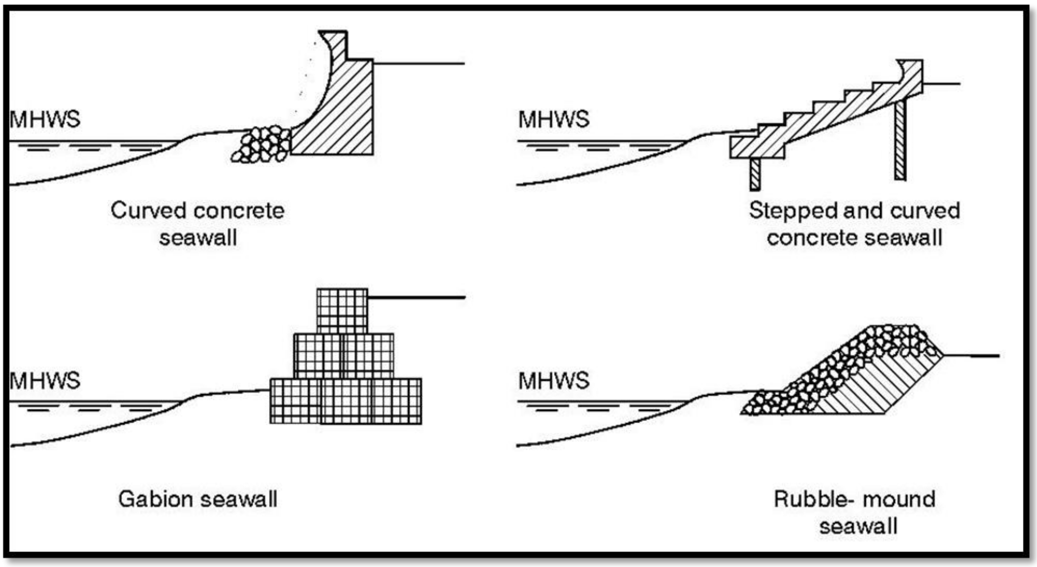

Figure 1. Examples of seawall structures (Karsten, 2007)

2.1.2 Revetments

Revetments can be identified as structures constructed parallel to the shoreline with the main purpose of protecting the coastline from erosions. These structures are designed to absorb and reduce the energy of the waves before they reach the banks. Revetments are generally constructed with materials composed of stone, precast concrete block or asphalt as to armor the natural sloping of shoreline contours. These slopes can either be smooth or rough depending on the structure's design. Revetments are composed of three major elements, which are the armor layer, filter zone, and toe coating. An armor layer is an essential foundation which shelters against the wave action. The filter layer, in turn, sustains the armor permitting the water to pass through the revetment restricting any sediment to be washed through the armor. The toe layer protects the structure and avoids dislodgment of the seaward edge of the structure, as well as offering the necessary support for all the layer components. Generally, the revetment covers the shore area and the

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shallow nearshore, which usually is the same area where beach building is possible. The revetment requires continuous supervision which may involve substituting or relocating the armor units. Figure 2 shows the revetment components.

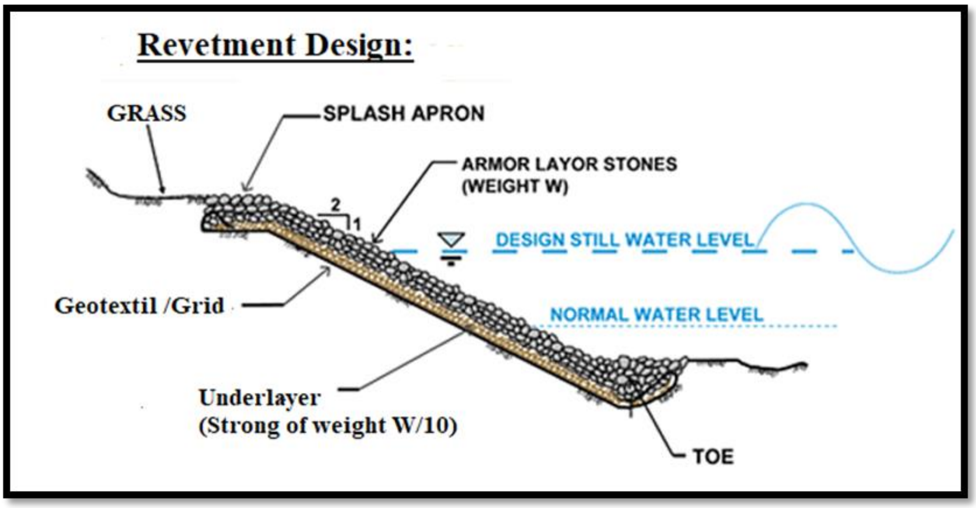


Figure 2. Revetment components (Federal Highway Administration, 2014)

2.1.3 Groins

The groins are the oldest and most ordinary beach stabilization structure. Generally, they are composed of large boulders, but in some cases, it can be composed of concrete, wood or steel. According to Vaidya et al (2015), groins are typically vertical constructions perpendicular to the coast and can either be individual or formed as clusters, referred to as groin fields. Normally, construction of groins utilizes edifices of mounds composed of rubbles, but they are not restricted to such materials. Groins can be found to be created from armor stone, concrete blocks or concrete modules. The purpose of the groin is to minimize the sediment movement along the coast. Groins are especially suitable for regions in which the sediment of the nearshore is sand, where it is highly probable for the creation of beaches. Groins can be categorized into many forms such as normal or straight, inclined or angled, long or short, high or low, submerged, permeable, single, grouped, groin can be T, L or Y shaped structures. These classifications will be briefly reviewed below:

- **Long/short groins**

  Groins, long/short, are categorized relying on the distance they extend beyond the breaker region. If the groin crosses the entire breaker zone, it is considered to be long. If the groin extends some part along the surf region, it is deemed to be short. Such expressions are comparative as a result of the variance of the width for the breaker zone to the water elevation, sea current altitude, and seaside contour. A variety of these edifices are structured resembling the function of short groins so that they are utilized in dangerous and serious sea conditions and as long groins under normal situations.

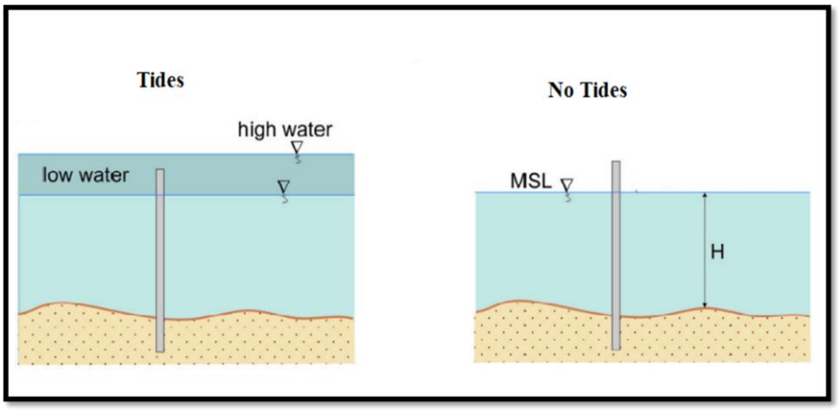
- **High/low groins**

  Relying on the probable transport of sediment across the peak, groins can be categorized as high or low groins. It is possible to reduce cost expenditures by developing groins with an adaptable peak elevation, which succeeds the seaside contour instead of sustaining stable peak altitudes. This form of the structure will be capable of preserving steady transactions and permit inclining quantities of gravel to evade while the sea depth rises. During some time, the groin's peak will become engulfed into the waters.

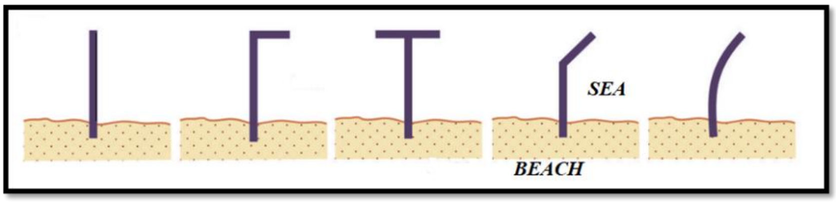
- **Permeable groins**

  Permeable groins are designed similarly to the previous groins, using structures composed of stone and concrete armor components short of subtle material or in other terms rubble-mounds. Permeable groins are edifices composed of piles with no spacing. Such a structure has the advantage of permitting the sediment to be transferred through the structure. In order to expand the permeability of a groin, lower the peak, reduce the seaward extent, minimize the landward extent and utilize material with the spaces. To reduce the permeability through the groin, raise the peak, increase the seaward extent, increase the landward extent and remove the material spacing.

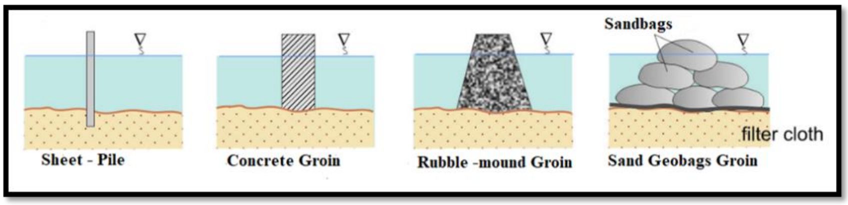
Typically, the altitude of groins impacts the quantity of trapped longshore residue within the edifice. Moreover, groins may be surfaced or inundated structures based on the water altitude alterations resulting from tides and storm upheaves. Taking into consideration the outline of the plan, the structure can either be upright, bent, bowed, L-shaped, T-shaped, or Y-shaped. Figure 3 illustrates the utmost widespread profile and forms for groins. Through structural terminologies, it is possible to differentiate among the various types of groins whether it be wooden, sheet-pile, concrete, rubble-mound (constructed of concrete units or rocks), and last but not least sand-filled bags.



A. Emerged or submerged groin



B. Shapes of groins



C. Types of groins

Figure 3.Types and shapes of groins (Zbigniew, 2006)

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2.1.4 Riprap

Ripraps are found implemented in regions that experience continuous exposure to coastal corrosions. Figure 4 shows the typical cross-section of the riprap. These structures are capable of resisting erosions dependent upon the size of the boulder's used, its density, endurance, as well as the calibration and compactness of the edifices layer. Since the divaricate stones are able to intertwine, they are able to maintain resistance of the individual boulders against displacement in the structure. The fortification necessary for protecting the revetment's toe from damage is determined upon the local scour, which is usually impacted by the attributes of the stream and the seabed substances. Consequently, canal steepness and adjustment, influence the entrenchment of currents on the waterfront and the pneumatic circumstances which the gravels have to endure. Like any other structure, ripraps are prone to failure, in which the four utmost prevailing ruptures include fragment abrasion, impulsive shifting, and altered recession and collapse (Blodgett 1986). In situations involving realignment of riprap blankets, short of toe deterioration, is referred to as an altered recession and is caused by excess inclinations. Collapse, or slumping in other terms, typically exists around elevated, volatile waterfronts that is the result of unsuccessful revolving of the waterfront below the revetment. Generally, the riprap retaining wall is constructed depending on the essentiality of both the waterfront and pneumatic attributes of the design flood for the stream.

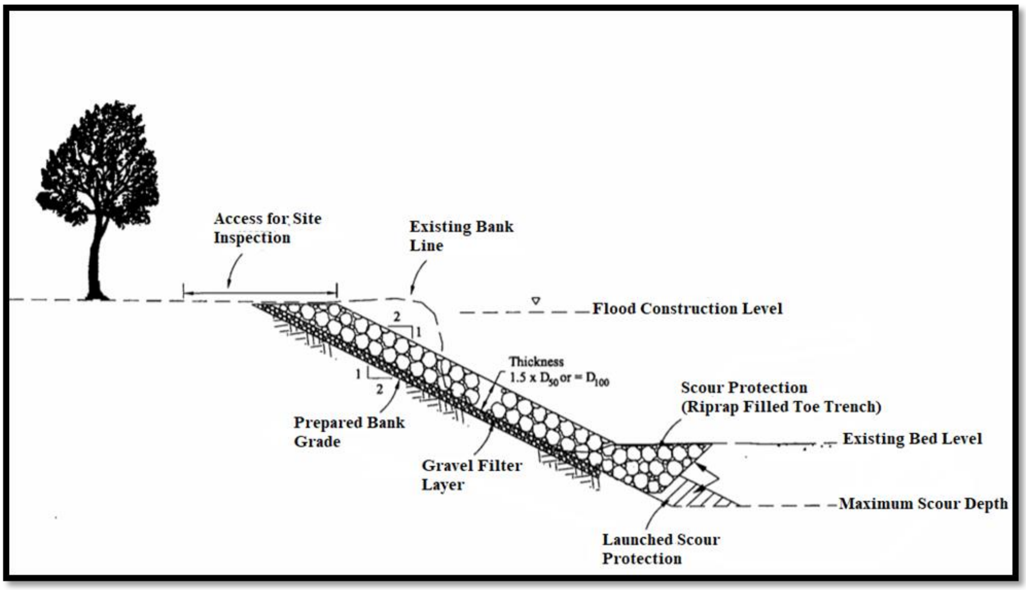

Figure 4. Cross section of typical riprap, (British Columbia Ministry of Environment, 2000)

2.2 Berthing and mooring ships structures

This type of structures is constructed to retain highland sediment and defer alongshore haulage. This form of structure can be divided into the following categories; breakwaters, and jetties. The following section examines in detail these structures and their categories.

2.2.1 Breakwaters

The term breakwaters are structures built of concrete block or rocks, designed to minimize wave activity and also to provide the harbors with an appropriate tranquil environment. Breakwaters can be found linked to the shore or in some cases situated offshore. The breakwaters located near the harbors are generally implemented to protect the harbors and the facilities situated on the harbor, as well as to provide safe ships handling and ship passage. Breakwaters can be found in various forms reliant on the material used for design. They can be constructed using concrete, natural rock or in some conditions a combination of both rock and concrete. These structures can be fixed or floating and impermeable or permeable as to permit the transfer of sediment towards the coast of the structures, where the selection of the structure mainly relies on the water depth and tidal range. Breakwaters can be categorized into many groups, which will be discussed below, and they are as follows; sloping-front, vertical-front, floating, rubble-mound, and caisson breakwaters.

- **Sloping-front Edifices**

  Breakwaters that have a sloping-front structure are composed of rubble-mounds, which are reinforced either from rock or concrete armor units, as to minimize wave impacts, Burcharth et.al, (2003). Rubble-mound structures utilize structural voids as to waste the energy produced from the waves. The armor units found on the external face of the structure, whether rock or concrete, absorb most of the energy, while the gravels/sands restrict the energy from progressing through the core of the structure.

- **Vertical–front Structures**

  In some situations, vertical-front breakwaters can be found to be designed either from caissons filled with sand or massive accumulated concrete blocks, placed over a layer of rubble stones. Typically, caisson structures have vertical slides and are constructed by filling the structure within so that the mass is capable of resisting the overturning impacts produced by the waves. In shallow waters, such a structure is costly to design, however, in deeper waters, they are usually positioned over an elevated dune of rock excavations due to economic purposes. Another term used for these breakwaters is known as composite structures.

- **Rubble-mound breakwater**

  It has been found that the most commonly utilized structures are the rubble-mound type. These structures are composed chiefly of a rubble stone mass, which is acquired from a quarry nearby and is inclined into the ocean adjacent to a preordained profile until the mass surfaces from the water. A rubble-mound edifice is composed of three layers; which are armor, filter, and core. Rubble-mounds are constructed from a core of quarry stone covered by one or two tiers of sizeable stones. For the external armor layer, armor rock or precast components are utilized for sheltering the structure from wave impacts. Above the mound, a crown wall is designed, which serves to avert or minimize wave activities. Breakwaters are structured by an accumulation of assorted natural debris or natural stone. Implementing rubble-mound breakwaters in most situations, such as when water depths are substantial, is considered to be uneconomical, due to the massive capacity of stones needed. In conditions where space is an issue, breakwaters are not appropriate structures to be utilized. Additionally, if the harboring region might be operated for ship docking, it is not suitable to implement rubble-mound breakwaters in that area since these mounds have inclined faces. Therefore, the mound that is laid down into the water is progressively enhanced by the water activity, and an endurably firm composition is attained by the ongoing extent of stone sediments. Rubble-mound breakwaters disperse the energy from the impacted waves by obliging the waves to crash on a slope, resulting in no production of substantial reflection.

- **Caisson breakwaters**

  Normally, caisson breakwaters possess upright edges and are typically constructed in situations where ship docking is anticipated along the structures inner face. The density of the caisson and the fill within the structure are utilized to withstand the overturning forces produced from wave impacts. Erecting such structures in shallow waters is considered to be comparatively costly, contrarily, in deeper waters, such structures are capable of providing considerable cutbacks in comparison to revetment structures. Generally, the typical caisson will be manufactured, carried over the water and submerged into the water until the structure lies on the water bed, in which it will carry out its objective. The water bed must be equipped with a tier of quarry, concrete pad or a ridge, so that the caisson may be placed and avoid disproportionate settlements. The "box caisson", is the term used to refer to the standard caisson form. It has a base sheet, side, and top walls so that it is able to tread water. Mainly, the principal objective of caissons is to retain water/soil as well as transmitting the vertical and horizontal loads onto the subsoil.

- **Floating breakwaters**

  For the areas protected and only there are face mild wave conditions with short-term waves, floating breakwaters are implemented. It is not suitable to use such structures as protection for areas that have a risky or open shoreline and they should never be established in such regions. Floating breakwaters can be designed in several forms, the simplest being the pontoon structures. Generally, the efficiency of such a structure relies primarily on the ratio of the structure's width to the wavelength of the approaching waves. Consequently, floating breakwaters can be found on lakeshores, in which the waves are usually very short and do not exceed 0.5 meter.

2.2.2 Jetties

Jetties are utilized to maintain canals by the river bays as well as tidal coves. A jetty can be identified as structures that connect to the shore and are built parallel to the navigation channel, which can be found perpendicular to the shore. Such structures can be situated on both sides of the bay. Not only do jetties stabilize the channels, but also, they restrict the accumulation of deposit within the channel. Furthermore, jetties can be found in assisting the guidance of vessels by maintaining protection against the wave storms. Similarly, to breakwaters, jetties are mainly built in steel or concrete. In some cases, jetties may contain lighthouses or navigational markers at the lakeward end. To preserve jetty structures, continuous monitoring is essential, and relocating or replacing armor units may be vital to guarantee the proper function of the structure.

2.3 Marine and Offshore Industry Structures

This form of structure can be divided into the following categories; Drydocks and Slipways. The following section examines in detail this type of structure.

2.3.1 Drydock

A drydock is manipulated for constructing, sustaining and renovating various water vessels such as boats, ships, and other crafts. When a vessel is to be berthed, the structure operates by flooding the dock and detaching the gateway. Once the vessel enters the bateau, it is appropriately situated and stabilized, the impermeable gateway is situated in its position and the dock is drained until it is dry, allowing the vessels progressively to lay onto the founding blocks harbored to the ground. Along with is a detachable impermeable gateway, a dry dock gateway can be found in various types and compositions. Figure 5

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shows the cross-section of the drydock. One form is composed of two sections, creating a narrow door pivoted onto the dock's side walls. Another form is composed of an individual sheet door and it is pivoted onto the base ridge so that it can be dropped and permit the vessel to go through. Moreover, the most typically utilized form of a gateway known as the fluctuating gate. When the dock is hollow, the gate maintains its position through its density, and it may be detached merely by drifting it away when the dock is consumed with water. In general, the variety of ship renovations take place out on the anchored dry berths, regardless there also is a variety of maintenances which may be implemented through transportable or drifting erections. The main function of the floating dry berth, which is a channel-shaped intact edifice, is to elevate vessels from the water for evaluation and maintenance. Generally, floating berths are constructed from steel, which utilizes a framing system resembling that of a ship. Other materials such as timber and reinforced concrete can also be implemented within the constructions structure.

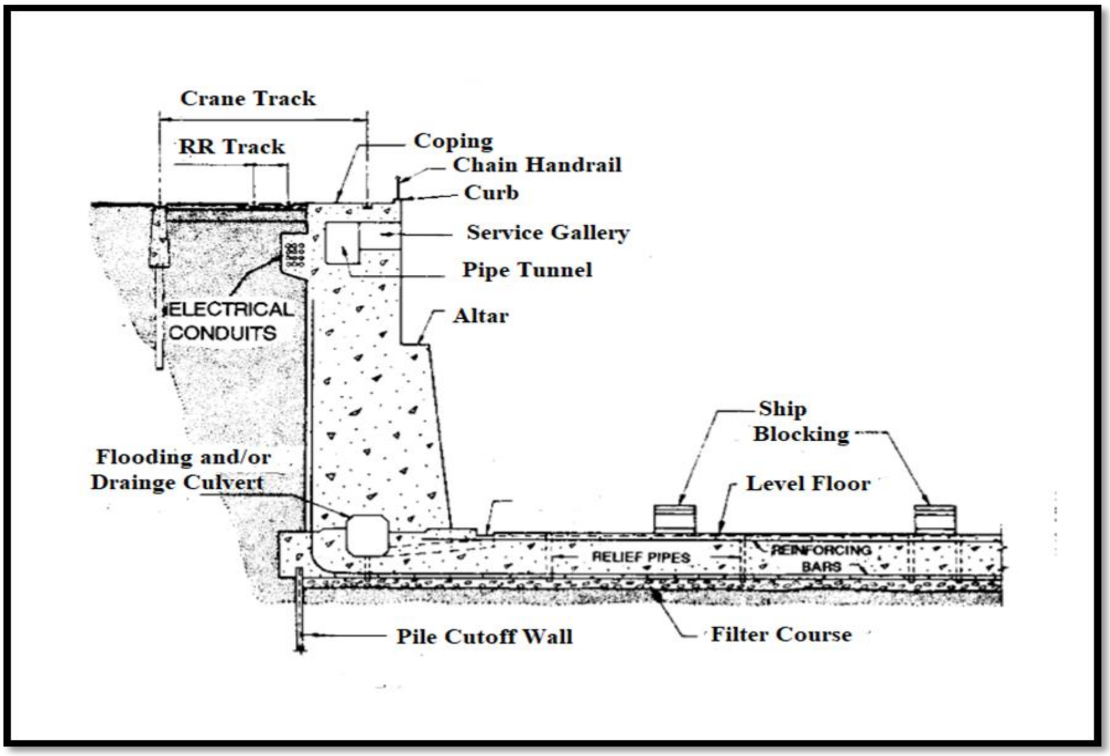

Figure 5 Cross section of drydock (Unified Facilities Criteria, 2012)

2.3.2 Slipways

Traditional slipways still utilize lubricated lumber skids for techniques in redeeming and propelling vessels. Traditional slipways lack mechanistic components as well as sustainment, and the craft inhabits the slipway pending its re-launch following maintenance operations. Normally, the structure is capable of withstanding vessels that weigh up to 5 tons. The vessel typically falls within the dockside. Standardly, the slipway should have a width of 5 meters at least, as well as a water depth no less than 1.5 meters at the foundation. Facilities operating mechanical drifts that dislodge crafts weigh at most 500 tons, can be categorized into three methods and they are as follows; automated slipway; portable platform or mobile lift; and synchro lift or ship lift.

- **An automated slipway**
  This form of slipway consists of a large incline that has two or three corresponding girders extending 4-5 meters under sea level, where each girder hauling a durable

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steel rail. Utilizing a distinct pulley, a steel cradle travels along these rails. The craft that will be slipped is drifted above the cradle and anchored. Subsequently, the cradle is hoisted along the incline until it is vindicated from the water and then secured in the preferred site. The craft remains positioned on the cradle during the maintenance duration while all the repairing takes place on the water's edge.

- **Portable platform or mobile lift**
  This form of facility usually entails a rubber-tired platform that flows above a twin dock structure. The crafts that will be launched drift among the docks and are later pulled from the water thru the portable platform or the mobile lift utilizing polyester bands. The vessel maintenance is executed far off the water's edge in an exposed labor region or in an enclosed workshop. The number of crafts maintained at a given time it depends upon the work areas capacity, regardless of the area is open or enclosed.

- **Synchro lift or ship lift**
  Up until the initiation of high-capacity portable platforms, synchro lifts were considered to be the standard machinery in instituted boatyards. Such facilities are capable of hoisting approximately 1,000 tons and permits any establishment that operates with a synchro lift to provide its facilities to a broader variety of crafts. In this facility, the crafts are drifted above the shifting cradle which rests upon the hoisting gantry. The gantry that holds the cradle and craft above is pulled from the water and leveled onto the transport rails. The cradle is then pushed along the line by a tractor onto the renovating dock, which is either an exposed or enclosed workshop.

3. FURTHER INFORMATION

For extra data on the ecological information together with important equations and the information required for the design of such structures as well the guidelines and information given in references [5-13] and [17-35] can be applied.

4. CONCLUSIONS

In this paper, the breakwaters, jetties, groins and the other types of onshore structures are reviewed. Each structure has its own unique function and situation. Breakwaters can be located surrounding a harbor facility since the primary function of breakwaters is designed to restrict wave activity and protect the harbor facilities. The groins are structures built mainly perpendicular to the coast and are often smaller than jetties. Groins are equipped to lock sediments as a method of erosion management. A principal issue with metals in brackish and saltwater is corrosion, especially in the splash regions, in which the components suffer from the ongoing sequence of wet and dry. Under such circumstance's metals, such as low-carbon steel, would abruptly disintegrate. For various applications, it is useful to utilize corrosion-resistant steel. The term used to refer to the movement of sediments by the waves, forward and backward along the edifices surface, is known as abrasion. Other than utilizing enduring quarry, or in some cases concrete for protecting vital regions, like the foundation of steel piles located near the gravel edge, not much can be performed to avert such compensations.

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