

ENGINEERING AND CONSTRUCTION STANDARD**FOR****ONSHORE FACILITIES****FIRST EDITION****FEBRUARY 2012**

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS are based on internationally acceptable standards and include selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran .

Postal Code- 1585886851

Tel: 88810459-60 & 66153055

Fax: 88810462

Email: Standards@ nioc.ir

GENERAL DEFINITIONS

Throughout this Standard the following definitions shall apply.

COMPANY :

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER :

Means the "Company" where this standard is a part of direct purchaser order by the "Company", and the "Contractor" where this Standard is a part of contract document.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR :

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR :

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the "Company" rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

CONTENTS:	PAGE No.
1. SCOPE	4
2. REFERENCES	4
3. DEFINITIONS AND TERMINOLOGY	5
4. UNITS	7
5. GENERAL CONSIDERATIONS	7
5.1 Environmental and Physical Considerations	8
5.2 Operational Considerations	9
5.3 Loads.....	9
5.4 Geotechnical Considerations	11
6. HARBOUR PROTECTION-BREAKWATERS.....	11
6.1 General.....	11
6.2 Types of Breakwaters	12
6.3 Factors Affecting Selection of the Type of Breakwaters	12
6.4 General Design Considerations	12
6.5 Rubble Mound Breakwaters.....	12
6.6 Vertical Face Breakwaters	15
6.7 Composite Breakwaters	15
7. BERTHING STRUCTURES	16
7.1 General.....	16
7.2 Types of structures.....	16
7.3 Choice of Structures.....	16
7.4 Design Situations for Quays and Jetties	16
8. MOORING AND FENDERING SYSTEMS.....	16
8.1 Mooring	16
8.2 Fendering	18
9. SHORE PROTECTION	18
9.1 General.....	18
9.2 Types of Shore Protection	19
9.3 Factors Affecting Selection of the Type of Shore Protection	19
9.4 Seawalls and Bulkheads	19
9.5 Jetties	19
9.6 Groins.....	20
9.7 Revetments.....	20
10. CONSTRUCTION MATERIAL.....	22
10.1 General.....	22
11. CONSTRUCTION PROCEDURES.....	22

1. SCOPE

This Standard covers the minimum requirements and gives guidance and recommendations on general criteria relevant to the planning, design and construction of structures set in the maritime environment, as may be encountered in various civil engineering projects in the field of Petroleum Industries.

The structures to which this Standard is applicable are those that are located at, or are close to the shore. It includes different aspects of planning, design and construction of breakwaters, berthing and mooring facilities, and shore protections.

Offshore structures are not covered by this Standard, although certain aspects may be found to be common in both fields. For offshore facilities refer to [IPS-G-CE-480](#).

This Standard is written in general terms and its application to any particular project may be subject to special requirements of the work under consideration.

Note 1:

This standard specification is reviewed and updated by the relevant technical committee on May. 1999. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No 83 on May. 1999. These modifications are included in the present issue of IPS.

Note 2:

This is a revised version of this standard, which is issued as revision (1)-2012. Revision (0)-1995 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-CE-110	"Engineering Standard for Soil Engineering"
IPS-E-CE-140	"Engineering Standard for Retaining Walls"
IPS-E-CE-500	"Engineering Standard for Loads"
IPS-C-CE-112	"Construction Standard for Earthworks"
IPS-E-CE-130	"Engineering Standard for Piles"
IPS-C-CE-200	"Construction Standard for Concrete Structures"
IPS-M-CE-105	"Material standard for building materials"
IPS-E-GN-100	"Engineering Standard for Units"
IPS-G-CE-480	"Engineering and Construction Standard for Offshore Installations"
IPS-E-TP-740	"Engineering Standard for Corrosion Considerations in Material Selection"

ISIRI (INSTITUTE OF STANDARDS & INDUSTRIAL RESEARCH OF IRAN)

ISIRI No. 519 "Minimum Design Loads in Buildings and Other Structures"

BSI (BRITISH STANDARDS INSTITUTION)

BS 5930: 2010 "Site Investigation"

BS 6349: Part 1: 2000 "Code of Practice for Maritime Structures, Part 1: General Criteria"

BS 6349: Part 2: 2010 "Code of Practice for Maritime Structures, Part 2: Design of Quay Walls, Jetties and Dolphins"

BS 6349: Part 4: 1994 "Code of Practice for Maritime Structures, Part 4: Design of Fendering and Mooring Systems"

BS 6349: Part 7: 1991 "Code of Practice for Maritime Structures, Part 7: Guide to the Design and Construction of Breakwaters"

BS 7361: Part 1: 1991 "Cathodic Protection, Part 1: Code of Practice for Land and Marine Application"

3. DEFINITIONS AND TERMINOLOGY

The following terms are defined for general use in this Standard.

- Anchorage Area:

A place where ships may be held for quarantine inspection, to await docking space, sometimes while removing ballast in preparation for taking on cargo, or to await favorable weather conditions.

- Artificial Harbor:

Harbor protected from the effect of waves by breakwaters or one created by dredging.

- Bollard:

On a quay or vessel, a short upright post round which ropes are secured for purposes of mooring.

- Breakwater:

A structure protecting a shore area, harbor, anchorage, or basin from waves.

- Bulkhead:

A structure separating land and water areas, primarily designed to resist earth pressures. see also Seawall.

- Buoy:

A float; especially a floating object moored to the bottom, to mark a channel, anchor, shoal rock, etc.

- Cofferdam:

A structure, usually temporary, built for the purpose of excluding water or soil sufficiently to permit construction to proceed without excessive pumping and to support the surrounding ground.

- Cellular Cofferdam:

A cofferdam consisting of a series of filled cells of circular or other shape in plan.

- Double-wall Cofferdam:

A cofferdam enclosed by a wall consisting of two parallel lines of sheeting tied together, supporting against external pressure.

- Dock:

A general term used to describe a marine structure for the mooring or tying up of vessels, for loading and unloading cargo, or for embarking and disembarking passengers.

- Dolphins:

Marine structures for mooring vessels. They are commonly used in combination with piers and wharves to shorten the length of these structures and are a principal part of the fixed-mooring-berth type of installation.

- Groin:

A shore protective structure (built usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. See also Jetty.

- Harbour (Harbor):

A water area partially enclosed and so protected from storms as to provide safe and suitable accommodation for vessels seeking refuge, supplies, refueling, repairs, or the transfer of cargo.

- Jetty:

A structure providing a berth on berths at some distance from the shore. A Jetty may be connected to the shore by an access trestle on causeway, or may be of the island type.

- Marginal Berth

A berth parallel to the shore.

- Marine Terminal:

That part of a port or harbor that provides docking, cargo-handling, and storage facilities.

- Offshore Mooring:

Such an anchorage consists of a number of anchorage units, each consisting of one or more anchors, chains, sinkers, and buoys to which the ship will attach its mooring lines. These anchorages are supplemented in most cases by the ship's bow anchors.

- Pier:

A structure extending out into the water from the shore, to serve as a landing place, a recreational facility, etc., rather than to afford coastal protection.

- Port:

A harbor where marine terminal facilities are provided. These consist of piers or wharves at which ships berth while loading or unloading cargo, transit sheds and other storage areas where ships may discharge incoming cargo, and warehouses where goods may be stored for longer periods while awaiting distribution or sailing.

- Quay or Wharf:

A stretch of paved bank, or a solid artificial landing place parallel to the navigable waterway, for use in loading and unloading vessels.

- Quay Wall:

Similar to a wharf which is backed up by ground.

- Ro-Ro (Roll on / Roll off) ramp:

A ramp on bridging structure which enables vehicles to pass between a Ro-Ro ship's vehicle decks and the shore.

- Seawall:

A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. See also Bulkhead.

- Seich:

An apparent tide in a lake due to the pendulous motion of the water when excited by wind.

- Training Wall:

A wall or jetty to direct current flow.

- Tsunami:

A tidal wave caused by an earthquake or volcanic eruption.

4. UNITS

This Standard is based on International System of Units (SI), as per [IPS-E-GN-100](#) except where otherwise specified.

5. GENERAL CONSIDERATIONS

Before starting design activities it is necessary to collect all existing data pertaining to topography, meteorology and climatology, water level, wave, sediment transport, water quality, operational requirements of maritime structures, loads etc. The following paragraphs give short descriptions about the above mentioned items.

5.1 Environmental and Physical Considerations

This Clause describes the various environmental and physical phenomena which should be considered for investigation at a coastal site and gives information and guidance on methods of data collection.

5.1.1 Surveying, bathymetry and topography

Surveying activities should be related to the established land survey system of National Cartographic Center (NCC). Should this not prove possible then a local grid system orientated by azimuth should be established prior to all other site operations, with sufficient permanently monumented survey stations to allow recovery of the survey grid at least during the construction period of the structure.

For further information on the various techniques available and guidance on their application in this respect refer to Clauses 6 and 8 of BS 6349: Part 1: 2000.

5.1.2 Meteorology and climatology

Authoritative meteorological and climatological data can generally be obtained from the Iranian Meteorological Organization.

These data generally consist of information about wind, precipitation, air temperature, humidity, atmospheric pressure and visibility.

Clause 7 of BS 6349: Part 1: 2000 describes the meteorological and climatological considerations which should be taken into account during the data collection, design, construction and operational stages of a proposed maritime structure.

5.1.3 Water levels

Predictions of extreme water levels are required in several aspects of the design of maritime structures, including overtopping, hydrostatic pressures and the level of action of waves, currents, mooring and berthing loads. Values of rates of rise and fall may also be required in relation to soil pore water pressures, flood relief valve discharge capacities and for the prediction of tidal flows.

Details about tidal prediction, observation and analysis and meteorological effects including seiches and different methods of measuring water movements are given in Clauses 10 and 11 of BS 6349: Part 1: 2000.

5.1.4 Waves

Exposure to wave attack can have a profound influence on the selection of sites for maritime structures and the consideration of designs and construction methods requires detailed knowledge and understanding of the wave activity and persistence, in average as well as extreme conditions.

Detailed consideration of wave form, generation, recording, analysis and prediction is included in Section Four of BS 6349: Part 1: 2000.

5.1.5 Sediment transport

In any operation involving the alteration of the inshore hydrodynamic regime, the subsequent effects on sediment movement have to be considered.

A general appreciation of sediment transport in an area can be gained by studying old charts and photographs, including aerial views, and in the case of beaches, by carrying out a preliminary inspection.

For detailed information about sediment transport refer to Clause 14 of BS 6349: Part 1:2000.

5.1.6 Water quality

The effect of water quality on the safe and efficient functioning of the structure should be evaluated and this would require the gathering of the usual data on temperature, corrosive elements, suspended solids, marine growth, etc. For detailed information on different aspects of water quality data including the effects of temperature on corrosion, chemistry, turbidity, marine life and pollution refer to Clause 13 of BS 6349: Part 1: 2000.

5.2 Operational Considerations

The following subjects should be considered for possible individual study in each case:

- a) numbers, types, sizes and shapes of present and/or expected vessels;
- b) provision of tugs, navigational aids and marine traffic control;
- c) pilotage;
- d) berthing and mooring patterns, practices, systems and load measurements;
- e) requirements of cargo handling, roll-on roll-off (ro-ro) traffic, storage and other activities, including the need or otherwise to allow for future change, or flexibility in operational usage;
- f) regulations affecting any of the above operations.

One of the main considerations in this respect is to select a proper design life for the structures.

The design life is significant when assessing:

- 1) time-dependent factors running against the security of the structure such as fatigue loading, corrosion, marine growth and soil strength reductions;
- 2) probability levels for limit state design and for design condition return periods;
- 3) economic feasibility of the project and future developments.

For design life values of various maritime structures refer to Clause 16 of BS 6349: Part 1: 2000.

5.3 Loads

5.3.1 General

In addition to dead loads and soil pressures the other forces which may act upon maritime structures are those arising from natural phenomena such as winds, snow, ice, temperature variations, tides, currents, waves and earthquakes and those imposed by operational activities such as berthing, mooring, slipping, dry-docking and cargo storage and handling.

Guidance is given in this Clause on the selection of relevant design parameters and methods of calculation to derive the resulting direct forces on structures, taking into account the nature and characteristics of the structures.

5.3.2 Soil pressures

General guidance on the calculation of soil pressures is given in [IPS-E-CE-110](#).

For the purpose of calculating soil pressures the following procedure should be followed:

- a) Live loading on surface should be determined as described in Clauses 44 and 45 of BS 6349: Part 1: 2000.
- b) Extreme water levels should be derived as described in Clause 37 of BS 6349: Part 1: 2000.
- c) Ground pore-water pressures should be determined with reference to tidal range, soil

permeability, drainage provisions and any artesian or sub-artesian ground water conditions; refer to [IPS-E-CE-110](#).

d) Allowance should be made for reduced passive resistance due to overdredging and/or scour.

5.3.3 Winds

For values of design wind speeds in different parts of the country appropriate information should be obtained from Iranian Meteorological Department and for guidance on the calculation of wind loads on buildings, plant, equipment and other superstructure, reference should be made to ISIRI 519 or [IPS-E-CE-500](#) "Loads".

5.3.4 Snow and ice

For the coastal areas around the country, accumulated snow is unlikely to affect the design of heavier maritime structures significantly. It should, however, be considered in the design of ancillary structures such as cargo sheds, port buildings and cargo handling installations, for which the appropriate imposed roof loading's recommended in ISIRI 519, or [IPS-E-CE-500](#) should be considered.

In the recent past, loading from floating sea ice has not been a problem around the coastal areas of the country and need not be considered for structures whose design life is of the order of 50 years.

5.3.5 Temperature variations

The loads, or load effects, arising from thermal expansion or contraction of the structure and from temperature gradients in the structure should be considered in the design, taking due account of local climate. Relevant information in this respect may be obtained from Iranian Meteorological Organization.

5.3.6 Tides and water level variations

Maritime structures should be designed to withstand safely the effects of the extreme range of still water level from Extreme Low Water (ELW) to Extreme High Water (EHW) expected during the design life of the structure. These extremes should be established in relation to the purpose of the structure and the accepted probability of occurrence (see Clause 21.4 of BS 6349: Part 1: 2000), but should generally have a return period of not less than 50 years for permanent works.

5.3.7 Currents

The design current speed should be the maximum value expected at the site during the design life of the structure and should be established in relation to the purpose of the structure and the accepted probability of occurrence but should generally have a return period of not less than 50 years for permanent works. Methods of determining water movement are described in Clause 11 of BS 6349: Part 1: 2000.

5.3.8 Waves

Maritime structures should be designed to withstand safely the effects of wave induced loads. Wave induced loads are to be determined by use of generally recognized methods taking proper account of water depth, size, shape and type of structure.

For detailed information on wave characteristics and basic wave properties including wave height, period, frequency, wave length and speed refer to Clauses 21 and 39 of BS 6349: Part 1:2000.

5.3.9 Earthquakes

The effects of earthquakes are to be considered for maritime structures located in seismically active areas.

Detailed information on seismic activity should be obtained according to detailed investigation made on the basis of previous record of earthquake activities, as well as a study of the geological history and the seismic events of the region.

5.3.10 Berthing and mooring

a) Berthing

In the course of berthing a vessel, loads will be generated between the vessel and the berthing structure from the moment at which contact is first made until the vessel is finally brought to rest. The magnitude of the loads will depend not only on the size and velocity of the vessel but also on the nature of the structure, including any fendering, and the degree of resilience they present under impact.

b) Mooring

Mooring loads comprise those loads imposed on a maritime structure by a vessel tied up alongside, both through contact between the vessel and structure or its fendering system and through tension in mooring ropes. They also include loads arising from maneuvers of the vessel at the berth, including casting off, leaving berth, warping and heaving of breast lines during berthing, but exclude the impact and frictional berthing loads discussed under paragraph (a) above.

For detailed information about berthing and mooring loads refer to Clauses 41 and 42 of BS 6349: Part 1: 2000.

5.3.11 Other loadings

In addition to the loads mentioned in Clauses 5.3.1 to 5.3.10, other loadings may be considered necessary when appropriate, such as loads due to cargo storage, rail and road traffic, conveyors and pipelines, etc. For more detailed information refer to Clauses 44 to 46 of BS 6349: Part 1: 2000.

5.4 Geotechnical Considerations

A study of the surface and subsurface conditions at and near the site of proposed works is an essential preliminary to the design of maritime structures.

The study should include assessment of the characteristics of soil or rock formations which may be retained by structures or provide their foundations or which may be incorporated in or affected by earthworks in the form of dredging and reclamation.

General procedures for the investigation of subsurface conditions by means of trial pits, trenches, shafts, boreholes and geophysical surveying for overland investigation are described in [IPS-E-CE-110](#), which is also generally valid in many respects for over-water investigation.

For procedures particular to the maritime situation refer to Clause 49 of BS 6349: Part 1: 2000.

6. HARBOUR PROTECTION-BREAKWATERS

6.1 General

Breakwaters are structures constructed for the purpose of forming a water area so protected from the effect of sea waves as to provide safe accommodation for shipping. Most breakwaters function only to provide protection, but occasionally they serve a dual purpose by becoming part of a pier or supporting a roadway.

The former is termed a breakwater pier or quay and the latter a mole.

6.2 Types of Breakwaters

There are several types of breakwaters depending on materials out of which they are constructed, but they may generally be categorized under three main types:

6.2.1. Rubble mound breakwaters:

Rubble mound breakwaters (natural rock, concrete blocks, combination of rock and concrete blocks, concrete tetrapods and tribars).

6.2.2. Vertical face breakwaters:

Vertical face breakwaters (concrete block gravity walls, concrete caissons, rock filled sheet-pile cells, concrete or steel sheet-pile walls).

6.2.3. Composit breakwaters:

Composite breakwaters (submerged rubble mound foundations or breakwaters surmounted by a vertically faced structure projecting above sea level).

The above-mentioned types are briefly described under Clauses 6.5 to 6.7 of this Standard.

6.3 Factors Affecting Selection of the Type of Breakwaters

The type of breakwaters to be selected is usually determined by the availability of materials at or near the site, the depth of water, the conditions of the sea bottom, its function in the harbor, suitable and available equipment for its construction and construction cost and period.

6.4 General Design Considerations

Generally in the design of breakwaters the following considerations shall be made:

- The relations with waterways and basins, mooring and other facilities;
- the influence exerted on nearby water area, facilities, topography, prevalent and assumed environment conditions after construction of the protective facilities;
- the direction of development of the port facilities in the future.

For details of design considerations related to navigational aspects, wave penetration, wave overtopping, breakwater alignment, etc. refer to Clause 2.2 of BS 6349 :Part 7: 1991.

One of the most important items which should be considered is hydraulic model testing.

Hydraulic model testing is the most reliable method of assessing the hydraulic performance of a breakwater. The reliability of test results depends upon the quality of the input data.

The primary object of testing is to check the stability of the breakwater up to and exceeding the design state and its hydraulic performance in respect of run-up, overtopping, wave transmission and reflection.

For more details on the hydraulic model testing and also physical and computational modelling refer to Clauses 3.6 and 2.2.6 of BS 6349: Part 7: 1991.

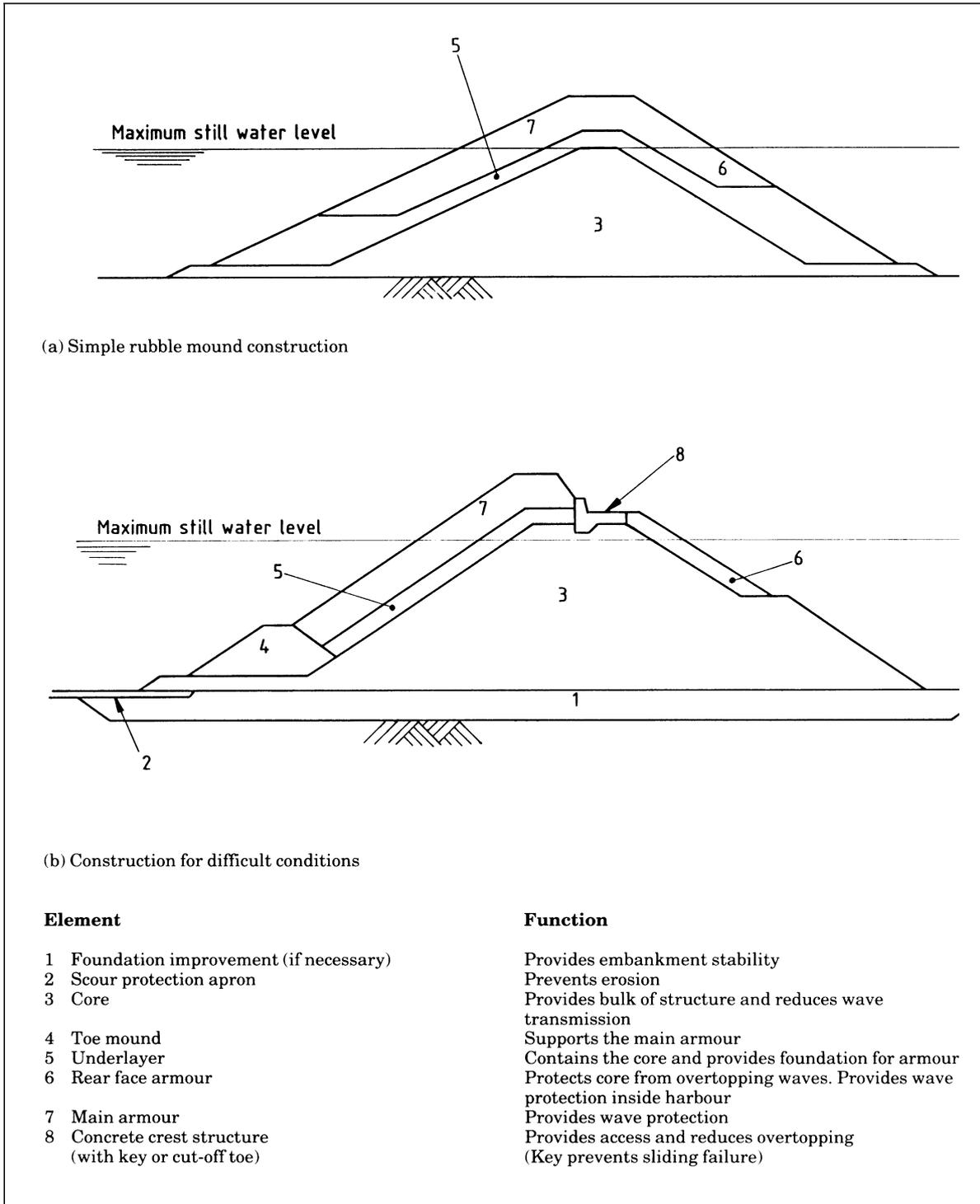
6.5 Rubble Mound Breakwaters

A rubble mound breakwater is a structure composed primarily of rocks dumped or placed upon the sea bed. An outer layer, or layers, of more massive rock or precast concrete units provides an

armor layer to protect the less massive rock core from wave attack. A concrete crest structure which contributes to the function of the breakwater may be constructed on the mound.

Fig. 1 shows the main elements and functions of a typical rubble mound breakwater. It should be however noted that in this figure the general arrangement of elements in the cross-section is given in the most difficult condition, whereas in simpler conditions some simplification may be accepted.

The armor layer is probably the most important feature of a rubble mound breakwater since damage or failure can lead to failure of other parts.



Reference: Fig. 5 BS 6349: Part 7: 1991.

ELEMENTS AND FUNCTIONS OF TYPICAL RUBBLE MOUND BREAKWATERS

Fig. 1

6.5.1 Rock armor

The use of rock armor is limited by the largest size of rock which can be economically produced. This is commonly found to be in the range of 10t to 15t but in many rock formations the limiting size is much smaller and it can be necessary to quarry very large quantities to produce a small percentage of the largest stones.

The size of rock required can be reduced by using flatter slopes but extra quantities of material are then required for core, underlayer and armor.

6.5.2 Concrete armor units

Many different types of concrete armor unit have been developed but few have been adopted for general use. Nearly all are of mass concrete construction and can be broadly classified as random placed or regular pattern placed.

a) Random placed units.

The majority of concrete armor units are of this type, placed normally in two layers but sometimes in a single layer. They range from massive approximately cubical units through intermediate types to the more complex forms (e.g. Tetrapods, Tribars, etc.).

b) Regular pattern placed units

The stability of these units depends upon the placing pattern, the support provided by the toe and crest structures and the preparation of the underlayer. The units are placed in a single layer to form a continuous revetment.

Information on the use of particular armor units should be obtained from literature published by the originator or licensee of the unit.

For more detailed information refer to Clause 4.3.3 of BS 6349: Part 7: 1991.

6.6 Vertical Face Breakwaters

A vertical face breakwater usually prevents transmission through the structure, thus reflecting all the energy from the waves which do not overtop it. In suitable circumstances a breakwater can be made permeable and permit a degree of transmission. A permeable seaward face can be used to absorb wave energy in chambers within an impermeable breakwater for more details refer to section 5 of BS 6349: Part 7: 1991.

6.7 Composite Breakwaters

A composite breakwater is a submerged rubble mound foundation or breakwater surmounted by a vertically faced structure projecting above sea level.

This type of structure can be used as a breakwater in very deep water, when the volume of rock required for a rubble mound structure is not available, and when it is not practicable to design a vertical face structure to carry the design wave loading to the full depth or to reduce the cost.

The vertical face structure can comprise reinforced concrete caissons or precast concrete blockwork. Variations in water depth can be accommodated by the rubble mound, so that the base of the vertical structure can be horizontal throughout the breakwater.

For more detailed information refer to Section 6 of BS 6349: Part 7: 1991.

7. BERTHING STRUCTURES

7.1 General

The detailed design of a particular structure cannot be considered in isolation from the overall planning, which is required to ensure that the structure meets its functional requirements.

For detailed information refer to BS 6349: Part 2: 2010.

7.2 Types of structures

Maritime structures can be either solid or open-piled. An open-piled structure can be either rigid or flexible. Solid structures include all sheet and gravity walls with a solid vertical berthing face. These types of structure are most commonly used for marginal berths where fill material has to be retained, but they are also used for finger piers, jetties and dolphins.

For detailed information refer to BS 6349: Part 2: 2010.

7.3 Choice of Structures

For any structure, a variety of different types should be compared and a choice made on the basis of the structure's functional requirements, including technical feasibility of the considered concept, capital costs, maintenance and or ease of construction.

For detailed information refer to BS 6349: Part 2: 2010.

7.4 Design Situations for Quays and Jetties

A range of design situations should be examined and the sensitivity of the design to changes in design situations checked. The selected design situations should be sufficiently severe and varied so as to encompass all conditions that can reasonably be foreseen to occur during the execution and use of the structure.

For detailed information refer to BS 6349: Part 2: 2010 clauses 5, 7, 8, 9, 10, 11.

8. MOORING AND FENDERING SYSTEMS

8.1 Mooring

8.1.1 General

Present situations often require the ship to be accurately held in place in relation to berth-mounted ship loading or discharging equipment which itself may be very limited in movement, e.g. container cranes and articulated booms.

The principle to be followed, regardless of the size of the vessel, is to restrain movement to within acceptable limits by means of an adequate number of mooring lines, which can be readily handled by the operating personnel, compatible with the conditions of wind, tide, weather and other effects likely to be experienced during the relevant period of vessel stay at the berth.

For detailed information refer to Section 3 of BS 6349: Part 4: 1994.

8.1.2 Mooring patterns

The normal mooring pattern consists of ropes issuing at the extremities of the ship that make horizontal angles of about 45°-90° and -45° to its axis, plus spring lines at about 10° to its axis,

together with breast lines as appropriate.

8.1.3 Forces acting on the moored ship

The principal horizontal forces acting on a moored vessel are generally caused by wind and current. However the mooring system has to be capable of withstanding any combination of forces resulting from the ship's movement to avoid interference with cargo/passenger operations:

- a) wind;
- b) current;
- c) off-quay hydrodynamic forces and hydrodynamic interference from passing ships;
- d) ocean or long swell waves;
- e) waves caused by passing ships in narrow channels;
- f) tidal rise and fall, and change in draught or trim due to cargo operations;
- g) ice.

Normally, if the mooring system is designed to accommodate the maximum wind and current forces the reserve strength will be sufficient to resist other forces that may arise.

However, if appreciable surge, waves, ice or other abnormal conditions exist at the terminal, considerable loads may be developed in the vessels' moorings. These forces are difficult to analyze and model testing or field measurement should be used.

8.1.4 On-shore mooring equipment

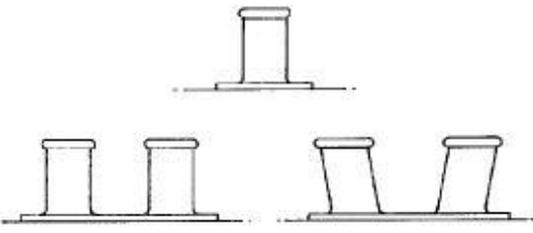
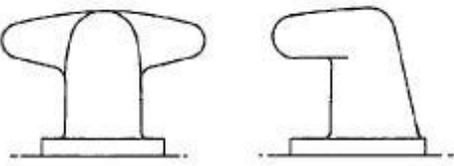
The range of on-shore mooring equipment considered by this standard comprises bollards, quick-release hooks, mooring rings and capstans. Fairleads and cleats may generally be regarded as ship-mounted items and are not therefore included.

8.1.4.1 Bollards

Many bollard designs are commercially available but they may be broadly classified into three categories, as follows:

- a) Pillar type;
- b) Tee-head type;
- c) Twin-head type sloping lobes. These types are illustrated in table 1 together with characteristics and applications.

TABLE 1 - MOORING BOLLARDS

Table 8. Mooring bollards		Normal maximum working load t	Applications
Single and double pillar		200 total	General mooring applications where rope angle is not steep Single pillar type should be used with lines from one ship only Suitable for warping ships along berths, etc.
Tee-head		150	All general mooring applications including steep rope angles Any one bollard should preferably be allocated to lines from one ship only
Sloping lobe		200 total	All general mooring applications including steep rope angles Lines from two ships may be attached without interference

Reference: Table 8- BS 6349: Part 4: 1994.

8.2 Fendering

8.2.1 General

The design should take account of the proposed method of operating the berth with particular reference to the use or non-use of tugs where this can be foreseen. The design should be sufficiently robust to accept without damage relatively small loads in directions or positions not anticipated in the main design analysis.

For detailed information refer to Section 2 of BS 6349: Part 4: 1994.

8.2.2 Types of fender

For more information about The Types of Fender refer to Clause 5 of section 2 of BS 6349: Part 4: 1994.

9. SHORE PROTECTION

9.1 General

This part contains recommendations and guidance about various methods of shore protection as may be required for the protection of land which is being eroded by the sea, of low-lying land against flooding by the sea, or for the purpose of reclaiming land from the sea.

9.2 Types of Shore Protection

Several types of shore protection methods may be considered among which the following may be mentioned:

- Seawalls and bulkheads
- Jetties
- Groins
- Revetments

In the following paragraphs brief description of each type are given.

9.3 Factors Affecting Selection of the Type of Shore Protection

Major considerations for selection of a structural type are as follows:

- foundation conditions;
- exposure to wave action;
- availability of materials;
- costs, including initial and repair costs.

Foundation conditions may have a significant influence on the selection of the type of structure, either from the point of view of foundation material or settlement and possibility of foundation failures.

Wave exposure may control the selection of both the structural type and the details of design geometry.

In areas of severe wave action, light structures such as timber crib or light riprap revetment should not be used. Where waves are high, a curved, re-entrant face wall or possibly a combination of a stepped-face wall with a recurved upper face may be considered over a stepped-face wall.

Availability of materials is related to construction and maintenance costs as well as to structural type. If materials are not available near the construction site, or are in short supply, a particular type of seawall or bulkhead may not be economically feasible. A cost compromise may have to be made or a lesser degree of protection provided. Cost analysis includes the initial costs of design and construction and the annual costs over the economic life of the structure. Annual costs include interest and amortization on the investment, plus average maintenance costs. The best structure is one that provides the desired protection at the lowest annual or total cost. Because of wide variations in the initial cost and maintenance costs, comparison is usually made by reducing all costs to an annual basis for the estimated economic life of the structure.

9.4 Seawalls and Bulkheads

In general seawalls are rather massive structures because they resist the full force of the waves. Bulkheads are next in size; their primary function is to retain fill, and while generally not exposed to severe wave action, they still need to be designed to resist erosion by the wave climate at the site.

Curved-face seawalls and combination of stepped-and curved face seawalls are massive structures and are built to resist high wave action and reduce scour. The stepped-face seawalls are designed for stability against moderate waves.

Rubble-mound seawalls are built to withstand severe wave action.

Bulkheads are generally either anchored vertical pile walls or gravity walls; see [IPS-E-CE-140](#) "Retaining Walls and Slope Protection".

9.5 Jetties

Jetties (a term used in U.S.) are structures extending into a body of water (on open sea coasts)

which are designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouths of rivers or tidal inlets to help deepen and stabilize a channel.

The principal materials for jetty construction are stone, concrete, steel and timber. The general principle for design of jetties may be considered the same as breakwaters.

Note:

Jetties in British usage are equivalent to wharf or pier and should not be mixed with the shore protection structure.

9.6 Groins

Groins are shore protection structures built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. Groins are mainly classified as to permeability, height and length. Groins built of common construction materials can be made permeable or impermeable and high or low in profile. The materials used are stone, concrete, timber and steel.

9.7 Revetments

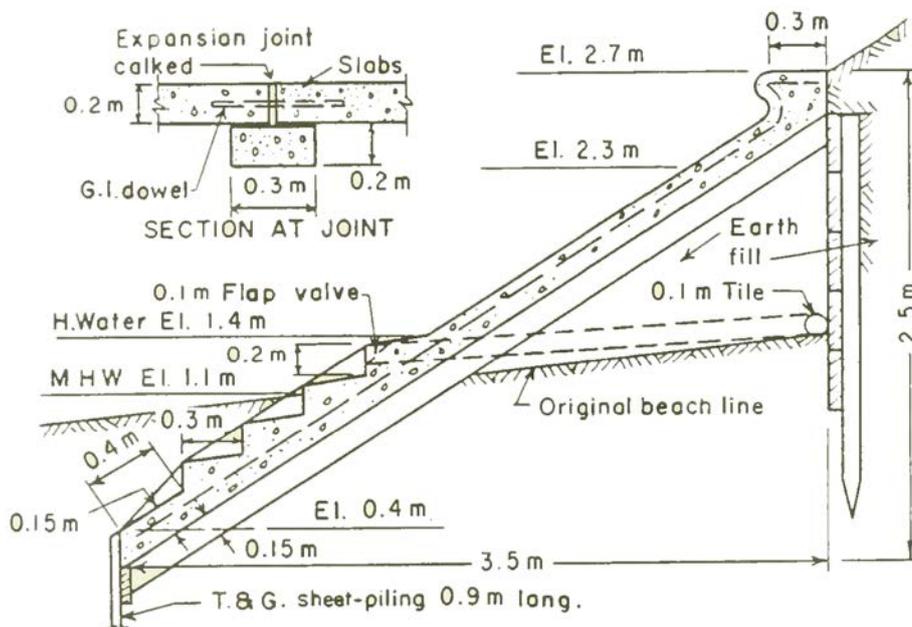
Revetments are facings of stone, concrete etc., built to protect a scarp, embankment or shore structures against erosion by wave action or currents.

There are two types of revetments; the rigid type and the flexible one.

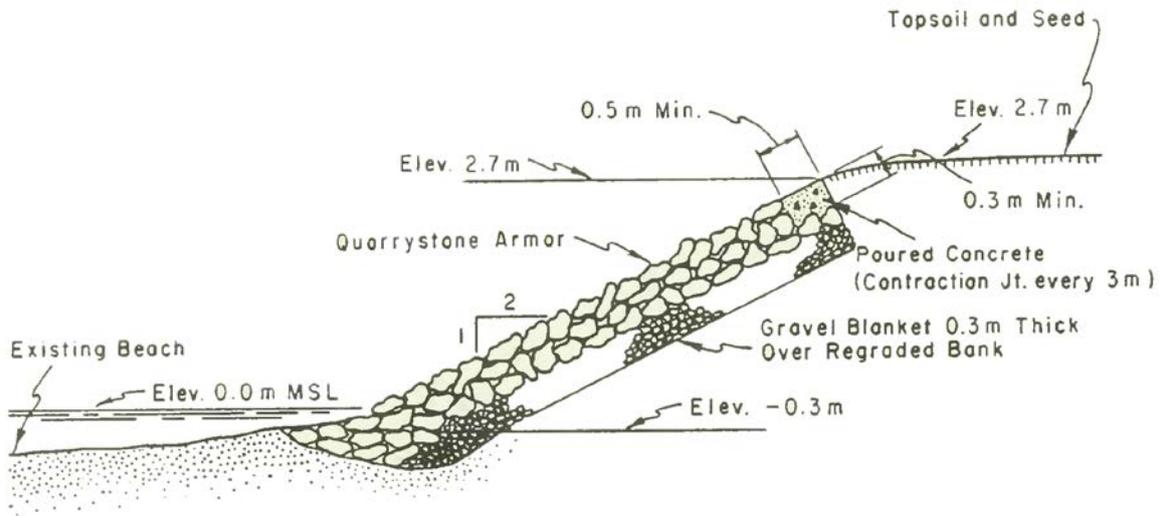
The structural types of revetments are illustrated in Fig. 4. A rigid concrete revetment provides excellent bank protection, but the site must be dewatered during construction so that the concrete can be placed.

A flexible structure also provides excellent bank protection and can tolerate minor consolidation or settlement without structural failure; this is also valid for the quarrystone or riprap revetments and to a lesser extent for the interlocking concrete block revetment.

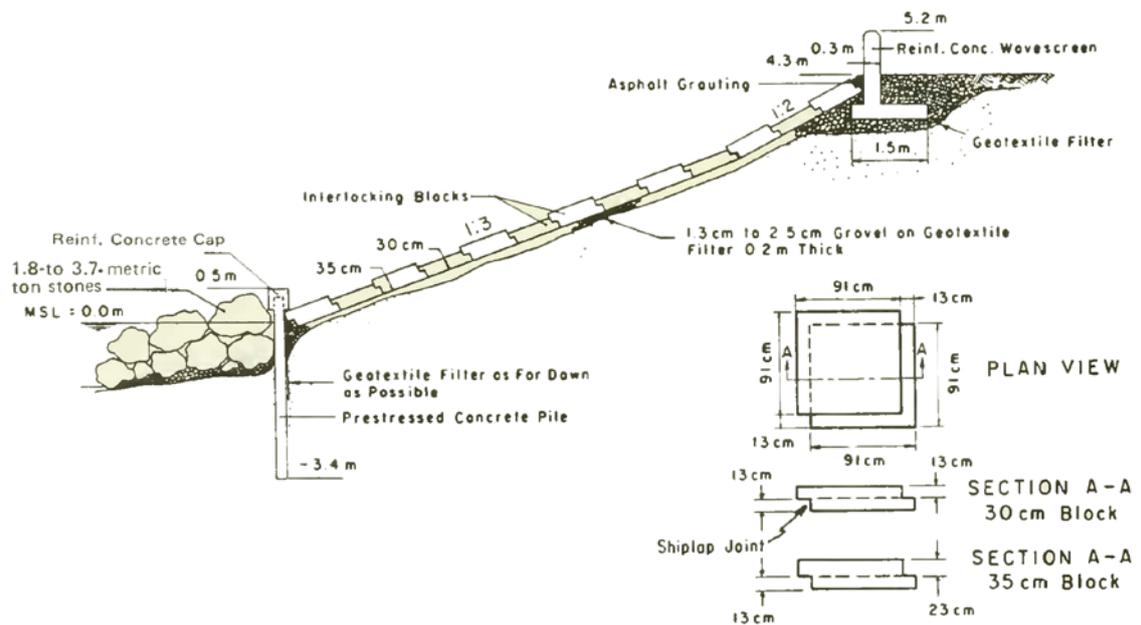
a)



b)



c)

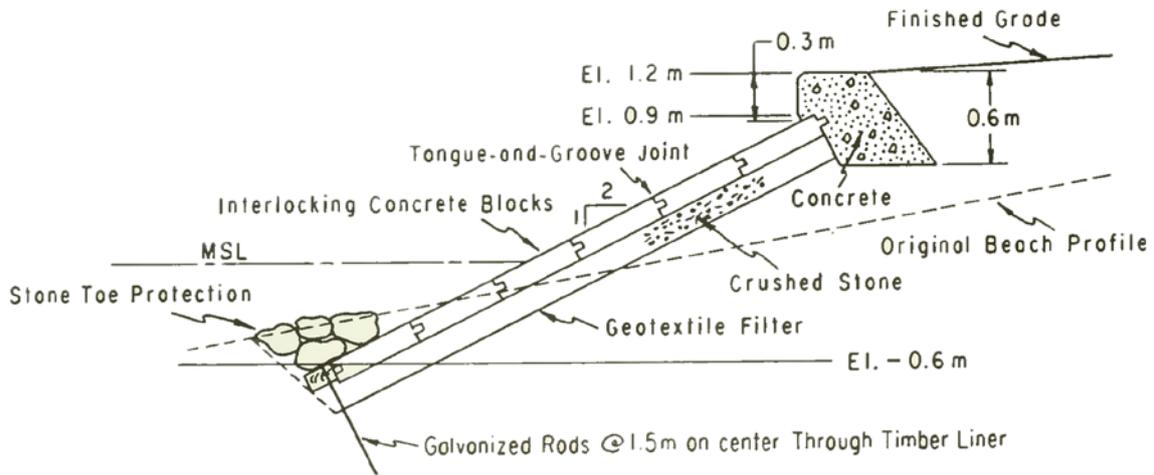


REVETMENTS

Fig. 4

(to be continued)

Fig. 4 (continued)



Reference: Fig. 6-9, 6-10, 6-11, 6-12 SHORE PROTECTION MANUAL VOLUME 2: 1984.

c) & d): Interlocking Concrete-Block Revetment

REVETMENTS (CONCLUDED)

Fig. 4

10. CONSTRUCTION MATERIAL

10.1 General

The materials covered in this section are as follows:

- a) stone for armouring or protection works;
- b) concrete;
- c) structural steel and other metals;
- d) timber;
- e) piles;
- f) pipes;
- g) pavements;
- h) rails;
- i) bituminous materials.

For detailed information refer to section 7 BS 6349-1: 2000.

11. CONSTRUCTION PROCEDURES

For detailed information about Construction Procedures refer to part 2, 4, 7 of BS 6349 "Maritime Structures".